

The reaction of South African dual-listed stock prices to international public announcements

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ABSTRACT

It is well known that globalisation effects have resulted in increased information transmission, where information is able to influence stock prices across international markets. This study examines the extent to which information, released through public announcements, influence the Anglo American Plc., dual-listed stock price, listed on both the Johannesburg Stock Exchange (JSE) and the London Stock Exchange (LSE). The use of dual-listed stocks provides the unique opportunity to examine how information is able to influence the same stock listed on two different international markets. This study examined the effect of five random public announcements, which entailed a new joint venture, a capital investment, negotiations with mining labour unions, the reporting of annual financial results, and changes to the composition of its Board of Directors. This study obtained substantial evidence which confirmed that all five public announcements caused a volatility spill-over effect, which triggered stock price misalignments. However, the size of the volatility spill-overs and price misalignments were not significant to ensure profitable arbitrage opportunities, though most exhibited long-lasting characteristics. Even so, from all the announcements under evaluation, the announcement regarding the change in the Board of Directors caused the largest volatility spill-over effect and largest price difference, providing the greatest potential to realise a profitable arbitrage opportunity.

Keywords: *Arbitrage, co-movement, dual-listed stock, EGARCH model, Granger causality, information transmission, Johansen co-integration model, price misalignment, public news announcements, Variance Decomposition model, Vector Error Correction model, volatility spill-over effect.*

OPSOMMING

Dit is welbekend dat die effekte van globalisasie bygedra het tot verhoogde informasie transmissie, waar informasie 'n invloedryke uitwerking op internasionale aandeelpryse kan hê. Hierdie studie ondersoek die mate waartoe informasie, vrygestel deur openbare aankondigings, die dubbelgenoteerde aandeel van Anglo American Plc., gelys op die Johannesburg Aandelebeurs (JSE) en die London Aandelebeurs (LSE), kan beïnvloed. Die gebruik van dubbelgenoteerde aandele bied die unieke geleentheid om vas te stel hoe informasie dieselfde aandeel kan beïnvloed wat op twee verskillende internasionale markte gelys is. Hierdie studie het vyf ewekansige openbare aankondigings gekies met die oog om die uitwerking daarvan op die dubbelgenoteerde aandeelprys te meet. Die vyf openbare aankondigings sluit in 'n nuwe gesamentlike onderneming, 'n kapitaalbelegging, onderhandelinge met mynbou-vakbonde, verslagdoening van die jaarlikse finansiële resultate, asook veranderinge in die samestelling van die Raad van Direkteure. Hierdie studie het beduidende bewyse bekom wat bevestig dat al vyf openbare aankondigings gelei het tot 'n volatiliteit oorspoel-effek, wat bygedra het tot prysverskille tussen die twee aandeelpryse. Maar die resultate het verder ook bevestig dat die volatiliteit oorspoel-effek en die prysverskille nie sal lei tot beduidende arbitrasiegeleenthede nie, hoewel hulle langdurend karaktereienskappe getoon het. Met die bogenoemde in ag geneem, het die aankondiging rakende die veranderinge in die samestelling van die Raad van Direkteure die grootste volatiliteit oorspoel-effek en prysverskille veroorsaak, wat ook sodoende die meeste potensiaal bied om wins deur arbitrasie te verwesenlik.

Sleutelwoorde: Arbitrasie, samelopende, dubbelgenoteerde aandele, EGARCH model, Granger oorsaaklikheid, informasie transmissie, Johansen koïntegrasie model, prysverskille, openbare nuusaankondigings, Variansie ontbinding model, Vektor-foutaanpassings model, volatiliteit oorspoel-effek.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

International markets have become more integrated in recent times, as evidenced by higher levels of correlation between markets (Berben *et al.*, 2005:833). The increase in market integration is facilitated by more advanced financial innovations, liberalisation of capital controls and globalisation effects (Berben *et al.*, 2005:833). Globalisation effects have resulted in increased information transmission, where information is able to influence stock prices across international markets (Ong, 1997:1). The flow of almost costless information has increased the ability of foreign international markets to react promptly to news events (public news announcements) originating in domestic markets (Singh & Kumar, 2008:1). The study by Ross (1989:16) accentuates this notion by arguing that there is a strong relationship between the information contained within these news announcements and volatility, where volatility is defined as the fluctuations occurring in a stock's price. Once the new information is released to the market, stock prices will start to fluctuate (volatility) as this information is incorporated into its prices (Bala & Premaratne, 2002:6). Moreover, since information can be transmitted across markets, it is possible that information can influence volatility in the domestic market, as well as in the foreign market. As a result it can be argued that a stock's volatility in one market can influence a stock's volatility in another market (Bauwens *et al.*, 2006:79), which can be referred to as the volatility spill-over effect (Flemming *et al.*, 1998:117).

Evidence of volatility spill-over effects was reported by Eun and Shim (1989:241-256), who confirmed that volatility spill-overs did occur between Australia, Japan, Germany, France, the United States (U.S.) and the United Kingdom (U.K.). Similar results were also reported by Hamao

et al. (1990:281), who found that volatility spill-overs were present between the U.S., the U.K. and the Japanese market. Another study emphasised that the U.S. market was the most influential market and that volatility which originated in this market would tend to spill over to the U.K. and Japan (Ng, 2000:207). Evidence of volatility spill-overs between African markets was also reported by Lamda and Otchere (2001:25), who found that volatility spill-overs were present between the South African and Namibian market. Similar results were found by Piesse and Hearn (2005:53), who reported that volatility spill-overs did occur between Botswana, Namibia, Nigeria and South Africa. They further stated that out of these African markets, the South African and Nigerian markets were the most dominant and influential markets.

1.2 MOTIVATION

The study by Xiaoqing and Hung-Gay (2002:563) stated that the notion of volatility spill-overs holds further consequences for stock prices, especially for dual-listed stocks¹. This statement is based on their results which indicated that volatility spill-overs could lead to the violation of the single market hypothesis, stating that the same asset should trade at identical prices regardless of its trading location (Ip & Brooks, 1996:53). However, in reality the single market hypothesis does not hold, indicating the presence of price misalignments (Angelini & Guazzarotti, 2010:5). If this is the case, a situation may arise where an investor can execute an arbitrage trade by buying the same (dual-listed) stock at a lower price in one market and selling it at a higher price in another market, and by doing so locking in a profit.

1.3 PROBLEM STATEMENT AND RESEARCH QUESTION

In light of the explanation above, the following problem statement can be formulated: Is it worth the effort for an investor to analyse dual-listed stocks and how they react to international public announcements in an attempt to take advantage of possible arbitrage opportunities? Furthermore,

¹ Dual-listed stocks are stocks that are listed on more than one stock exchange (Marx *et al.*, 2006:25).

will the volatility spill-over effects be large enough to cause sizable price misalignments, allowing the investor to make a profit from an arbitrage trade?

Given this problem, the following research question can be formulated: *Can information released through international public announcements influence dual-listed stock prices to such an extent that price misalignments occur, leading to possible arbitrage opportunities?*

1.4 RESEARCH GOAL

The main goal of this study is to examine how information released through public news announcements will influence the Anglo American Plc., dual-listed stock prices and whether it will cause significant price misalignments that will pose viable arbitrage opportunities.

1.5 OUTSIDE SCOPE OF STUDY

The following topics will fall outside of the scope of this study and will not be incorporated:

- The testing of market efficiency;
- Examining the effects of market efficiency on the extent of price misalignments;
- Incorporating risk-adjusted performance measures to justify the performance of the dual-listed stock under evaluation;
- Examining the effects of exchange rates on price misalignments; and
- Examining the effects of transaction costs on possible arbitrage opportunities, caused by price misalignments.

1.6 RESEARCH METHOD

This study consists of a literature study as well as empirical analysis, where the prior commences with a theoretical background on dual-listed stocks. The use of dual-listed stocks provides a unique opportunity to investigate how a stock that is listed on two different markets will react to the release of new information. The release of new information may lead to stock price fluctuations (causing volatility) as it incorporates the information into its price. Consequently, the literature

study therefore attempts to link the concepts of information and stock price volatility, where it elaborates on the relationship between these two concepts. Moreover, the literature study also indicates that this relationship should not only be restricted to the domestic market, as volatility can spill-over to other international markets. This phenomenon is referred to as a volatility spill-over effect and is also discussed in more depth.

The aim of the empirical analysis is to determine how dual-listed stock prices react to the information released through public announcements and whether this information can cause a volatility spill-over effect. Moreover, the empirical analysis also determines the extent of the volatility spill-over effect and indicates if these spill-overs are able to cause price misalignments, which may lead to possible arbitrage opportunities. These arbitrage opportunities can be exploited by investors in an attempt to lock-in a profit.

1.7 CHAPTER LAYOUT

1.7.1 Chapter 2: Dual-listed stocks and stock price decomposition

Chapter 2 commences with a background on dual-listed stocks, the purpose and reasons for dual-listed stocks (Section 2.2.1), as well as the factors influencing these stock prices (Section 2.2.2). Section 2.2.2 highlights that one of the main factors to influence dual-listed stock prices are supply and demand forces, which is partly generated by the investor's decision-making process. Hence, this chapter also discusses the fundamentals of the investor decision-making process in more detail, where the trade-off between risk and expected return is discussed (Section 2.3.1 & Section 2.3.2). Lastly, in order to elaborate on the expected return, sections on asset pricing models are also included (Section 2.4, Section 2.5 & Section 2.7).

1.7.2 Chapter 3: The impact of information on international stock markets

Chapter 3 commences by elaborating on the importance of information with regards to stock markets, where the concepts of order flow (Section 3.2.1) and information transmission (Section

3.2.2) are discussed. This chapter further continues by discussing the Efficient Market Hypothesis (EMH) (Section 3.3), which elaborates on how new information is incorporated into stock prices. This is followed by Section 3.3.2 which elaborates on the relationship between information and stock price volatility. Moreover, Section 3.3.2 indicates that this relationship should not be restricted to the domestic market, as information can be transmitted to other international markets and by doing so influencing volatility in both the local and the foreign market (volatility spill-over effect). This chapter also highlights that it is more likely for a volatility spill-over effect to occur between markets which are closely linked (co-movement) (Section 3.4). Lastly, this chapter also elaborates on the concept of the volatility spill-over effect (Section 3.5) and the effect thereof (Section 3.6).

1.7.3 Chapter 4: Methodology

The objective of Chapter 4 is to discuss the steps, as well as the models that will be used during the empirical analysis (Chapter 5). The first step of the empirical study will be to analyse the data that will be used during the empirical analysis (Section 4.2), which entails elaborating on the different public news announcements under investigation, as well as the timeframes thereof. The timeframe of each announcement will be determined with the help of an Impulse Response Model (IMP), as this model has the ability to determine the approximate duration of a shock. This will be followed by Section 4.2.1, which will discuss the steps and models used in the data-screening process. This process will examine the descriptive statistics, as well as determining the level of integration/stationarity of each announcement period under evaluation. Section 4.3 will then continue discussing the Johansen (1991) co-integration test, which will indicate if the two markets under evaluation co-move, as this will increase the likelihood of a volatility spill-over effect. To confirm the presence of volatility spill-overs an Exponential Generalised Auto Regressive Conditional Heteroskedasticity (EGARCH) model, as well as the Granger causality test will be consulted, which will be discussed in Section 4.4 and 4.5, respectively. The EGARCH model will verify the existence of a volatility spill-over effect and the Granger causality test the direction

thereof. Section 4.6 will then discuss the Vector Error Correction (VEC) model, which will be able to establish if the announcements under investigation caused any price misalignments. Lastly, Section 4.7 will discuss the Variance Decomposition (VDC) model, which will be able to determine the size of the spill-overs.

1.7.4 Chapter 5: Empirical results

The objective of Chapter 5 will be to review the results found after performing the empirical analysis. The empirical results confirmed the presence of co-movement between the JSE and LSE, indicating that these two markets are closely linked. Thus, the presence of co-movement increased the likelihood of a volatility spill-over effect between these two markets. This was confirmed by the EGARCH model results, where the VEC model results also confirmed the presence of price misalignments. However, according to the VDC model results, the size of the volatility spill-overs was relatively small and did not have a significant impact on the two markets. The volatility spill-overs were also not able to cause significant price misalignments between the JSE and LSE, as the actual price differences (in ZAR terms) between the two markets was relatively small, limiting the potential arbitrage profit.

1.7.5 Chapter 6: Conclusion

This chapter concludes this study by providing a brief summary of the final results. In addition, this chapter also provides recommendations for future research.

CHAPTER 2

DUAL-LISTED STOCKS AND STOCK PRICE DECOMPOSITION

2.1 INTRODUCTION

The focus of this study is to investigate how international public announcements influence dual-listed stock prices. The reason for examining dual-listed stocks in this study is to determine whether these stocks are able to incorporate the arrival of new information in a similar fashion, as dual-listed stocks are listed on two different stock exchanges (Marx *et al.*, 2006:25). According to the single market hypothesis, identical assets must have the same price regardless of its trading location (Ip & Brooks, 1993:53). This implies that dual-listed stocks must have the same prices otherwise it will lead to price misalignments that can result in possible arbitrage² opportunities. This statement can be supported by the Gordon growth model (also referred to as the dividend growth model), which can be used to determine the value of a stock (Correia *et al.*, 2003:6-12). The Gordon growth model can be formulated as follows (Correia *et al.*, 2003:6-12):

$$V_0 = \frac{D_1}{k-g}, \quad (2.1)$$

where:

- V_0 represents the value of the share;
- D_1 represents the next period's dividend;

² Arbitrage is defined as the exploitation of pricing differentials in order to generate risk-free profits (Van Zyl *et al.*, 2009:467).

- k represents the required rate of return; and
- g represents the growth rate in future dividends.

By applying this model, it is possible for investors to determine which stocks will be attractive and provide the highest future returns. However, investors must remember that the growth rate (g) of both dual-listed stocks should be the same, as different growth rates can cause price misalignments. Hence, when the prices of both dual-listed stocks are not perfectly aligned, it may result in arbitrage opportunities.

However, before a detailed investigation on price misalignments and arbitrage can be done, it is important to firstly understand how the stock prices are determined and how dual-listed stocks originated. This chapter therefore starts by discussing the purpose and reasons for dual-listed stocks (Section 2.2 & Section 2.2.1) and also which factors can influence dual-listed stock prices (Section 2.2.2). One of the main factors to influence dual-listed stock prices is supply and demand forces, which are generated to some extent by the investor's decision-making process. It is, therefore, necessary to also investigate the fundamentals of the investor's decision-making process that is based on the investor's preferences regarding the risk involved for investing in an asset (Section 2.3.1) and the compensation (return) (Section 2.3.2) for taking on the risk. This risk-return trade-off relationship is further explained with the help of the Markowitz Efficient Frontier (Section 2.3.2), which demonstrates that investors who take on more risk will expect higher returns, whereas, investors taking lower risk will expect lower returns. This implies that a certain level of risk will also lead to a certain level of expected returns.

2.2 DUAL-LISTED STOCKS

Over the past twenty years international markets have become more integrated as they have shown increased levels of correlation (Berben *et al.*, 2005:833). This higher level of integration can be justified by the more advanced financial innovation, liberalisation of capital controls and

globalisation effects (Berben *et al.*, 2005:833). Furthermore, Karolyi (2004:2) argued that the speed of globalisation has influenced the financial market in such a way that it has become easier to trade stocks all around the world, which also contributes to increased cross-border capital flows. As a result, domestic stock exchanges are required to compete against various other international stock exchanges, making the world markets more competitive (Karolyi, 2004:2). Amongst other things, this implies that stock exchanges have to attract more international listings to ensure that their trading volumes are as competitive as possible. One way of being more competitive is to encourage companies to dual-list their stocks on more than one exchange, as this will attract more investors and increase capital flows (Pagano *et al.*, 2001:770-782). The next section highlights some of the reasons why companies decide to dual-list, which is followed by a discussion on the factors that can influence dual-listed stock prices (Section 2.2.2).

2.2.1 Reasons for dual-listings

The first reason why companies will decide to dual-list is because multiple listings will provide the opportunity to increase a company's shareholder base (Pagano *et al.*, 2001:770-782). For example, dual-listing on larger stock markets might increase market reputation, which will attract more investors (Bancel & Mittoo, 2001:213-236). An increase in the shareholder base also reduces the risk of the company, seeing that the risk is shared by a wider range of shareholders and ultimately reduces the cost of capital of the firm (Chau, 2010:14). Secondly, a dual-listing provides a company with the opportunity to increase the familiarity of its brand or product. This concept is extremely important for a company as investors only invest in assets of which they are aware of (Merton, 1987:483-510). This argument is justified by the investor recognition hypothesis, which states that not all investors have access to the same information, causing investors to invest only in assets that are known to them (Merton, 1987:483-510). Thirdly, according to the liquidity hypothesis companies may decide to dual-list their stocks in order to increase the overall liquidity of both stocks (Plagge, 2013:7). However, evidence suggests that

the liquidity of dual-listed stocks tends to change as the liquidity shifts to the market in which stock is primarily listed (Pietersz, 2009b:1). The disadvantage of this liquidity shift is that one market is then more liquid than the other which may cause stocks to trade at a discount (Pietersz, 2009a:1).

The fourth reason to engage in dual-listings relates to taxation advantages. Not all countries have the same taxation laws, which allow companies to exploit these differences in order to reduce the tax burden (Lynch, 2002:4). The fifth reason relates to shareholder protection where companies want to attract investors through good corporate governance. According to Coffee (2002:1762) countries with poor corporate governance will tend to dual-list their stock in other countries that have strong corporate governance qualities. This argument was confirmed by Reese and Weisbach (2002:66), as they found that better investor protection through corporate governance was one of the reasons why companies would decide to dual-list their stock. In this way firms commit themselves to higher standards and may attract investors which otherwise would not have invested in the company. The sixth reason is that the problem of flowback³ is partially eliminated. Flowback is often found in traditional merger deals, where the targeted company will be de-listed and taken over by a foreign company (Lynch, 2002:4). The take-over by a foreign company can possibly cause a situation where the targeted company can lose its current investor base as shareholders sell their shares, which leads to selling pressures. By using a dual-listed structure, it is possible to prevent the occurrence of flowback (Lynch, 2002:4).

The seventh reason relates to the market segmentation hypothesis, which states that dual-listings aid investors in avoiding some of the barriers involved with cross-border investments (Tan, 2006:44). These barriers arise due to regulatory restrictions and difficulties in obtaining sufficient information (Merton, 1987:501). The market segmentation hypothesis states that dual-listings

³ Flowback occurs when investors dump or sell-off a company's shares after a merger has taken place (De Jong *et al.*, 2004:1).

contribute to an increase in stock prices, while the subsequent expected returns decrease (Foerster & Karolyi, 1999:982). The last reason focuses on changes in the information environment, where it is assumed that some form of information asymmetry exists (Tan, 2006:46). For example, when companies decide to dual-list on a market with a strict disclosure requirement regime, it indicates that the company is of high quality and will attract investors (Tan, 2006:46). The New York Stock Exchange (NYSE) is associated with increased media attention and analyst coverage, hence, there is more information to be analysed by investors (Baker *et al.*, 2002:518). This increase in media and analyst coverage enables a company to heighten their public profile and attract potential investors (Page, 2010:8).

2.2.2 Factors affecting dual-listed stock prices

This section describes various factors which can influence dual-listed stock prices. These factors include company specific factors (Section 2.2.2.1), index exposure (Section 2.2.2.2), regional broker expectations (Section 2.2.2.3) and macroeconomic factors (Section 2.2.2.4), which are briefly discussed accordingly.

2.2.2.1 Company specific factors effecting stock prices

Company specific factors can include dividends, the book value, the Price-to-Earnings (P/E) ratio and leverage. Dividends are regarded as the portion of the profit a company makes after taxes, which is then distributed to the shareholders as a compensation for the risk they took on by buying the company's shares (Sharma, 2011:54). Dividend pay-outs are very attractive for investors as they can earn additional income from their investment, therefore, investors are willing to pay more for stocks where a company declares a dividend to be paid out. This results in an increase in the demand for that specific stock, implying that there is a positive relationship between dividends and stock prices (Nirmala *et al.*, 2011:126). Another factor to consider is the book value of a company. The book value, also known as net asset value per share, is calculated as the sum of

equity share capital plus reserves, which is divided by the total number of equity shares outstanding (Sharma, 2011:55). A high book value indicates that the company exhibited good historical performance, which in turn results in a higher demand for these stocks, causing the stock price to increase (Sharma, 2011:55). The P/E ratio of a company is also one of the most common ratios investors look at before they make their investment decisions. The P/E ratio of a company is the reciprocal of the earnings yield of a company and serves as an indication of the relationship between the price and the earnings per share of a company's stock (Goodspeed *et al.*, 2009:485). The P/E ratio is a valuable tool to use when an investor wants to compare companies in the same sector, as a higher P/E ratio is indicative of a more attractive company. A high P/E ratio therefore increases the demand of a stock, implying that there is a positive relationship between the P/E ratio and stock prices (Nirmala *et al.*, 2011:126).

The final factor that is discussed includes leverage, which measures the debt-to-equity ratio of a company and provides a view on the proportion of a company's assets which is financed by debt. A high debt-to-equity ratio indicates that a company is funding a large portion of its assets with debt (Hovakimian *et al.*, 2001:2). The higher the debt the more vulnerable the company will be to interest rate changes, as an increase in interest rates means that more interest will be paid on debts. On the long-run this can have a negative effect on the cash flows and future earnings of a company, causing the demand for such stock to fall. As the demand decreases, so will the stock price, which justifies the negative relationship between leverage and stock prices (Nirmala *et al.*, 2011:126).

2.2.2.2 Index Exposure

When stocks are dual-listed it is possible that both stocks can occupy different weightings in different indices, where each index forms part of either the local or foreign market (Lynch, 2002:8). The risk involved with this is that it is very easy for investors to get a misperception of the

performance of a dual-listed stock when it is linked to an index. Investors might argue that, if the index does not perform well, so will the dual-listed stock. However, this might not be the case, as the dual-listed stock only has a small weighting in the index when compared to the overall index. It might, therefore, be possible that the dual-listed stock performs well and that the rest of the stocks which make up the index are the actual cause of the fall. Nonetheless, this misperception can cause the price of a dual-listed stock to fall in one exchange, resulting in a price misalignment between the two exchanges (Lynch, 2002:8).

2.2.2.3 Regional Broker Expectations

Investors normally assume that the fundamental analysis is the same for both markets in which a dual-listed stock is listed. However, such assumption might not be correct as it is possible that the brokers' earnings expectations are different in the primary and secondary market. This might lead to different recommendations in the two markets, causing one stock to outperform the other (Roosenboom & Van Dijk, 2009:1898).

2.2.2.4 Macroeconomic factors

Macroeconomic factors which can have an impact on stock prices include exchange rates, inflation and interest rates, just to name a few (Goodspeed *et al.*, 2009:346). Exchange rates can influence the way in which investors perceive the market and influence their investment decisions. For example, investors might argue that a depreciation in a currency might be linked to an unstable market environment, which makes investors more hesitant to invest in that market. If this is the case, it is assumed that the demand for the stock in the unstable markets will fall, which will ultimately have a negative influence on stock prices (Fang, 2002:195-199).

Another factor to consider is inflation, as changes in inflation can have a direct influence on the investor. For example, an increase in inflation can cause the level of real income to decline,

causing investors to sell their assets (including stocks) to generate funds to boost their buying power (Abdulrahim, 2011:25). On the other hand, low inflation indicates that investors have more funds available, which they can allocate towards investments, causing the demand and ultimately the price of the stock to increase. This implies that there is a negative relationship between inflation and stock prices (Ralph & Eriki, 2001:1-10).

It is also necessary to consider how the interest rate, which is generally considered as the cost of capital, can influence prices. For borrowers, interest rates are the cost at which money is borrowed, whereas for lenders it is the fee they charge for lending money (Uddin, 2009:43). For borrowers, an increase in interest rates means that interest paid on the money borrowed will also increase. The result will be that fewer funds will be available for dividend payments that will consequently have a negative impact on stock prices (Martinez-Moya *et al.*, 2013:7). Moreover, if banks increase the interest being paid to depositors, it is possible that investors might move their capital from the stock market to the bank, causing the demand of the stock to decrease and ultimately pushing the price of the stock down and *vice versa* (Uddin, 2009:43). This argument is also supported by Arango (2002:835-842), who has found that there is an inverse relationship between stock prices and interest rates.

In addition to the explanation above, it is also necessary to understand how demand (buy) and supply (sell) decisions influence stock prices. The demand curve shown in Figure 2.1 represents the set of investors who have the intention to buy the stock. The supply curve, on the other hand, represents either the set of investors who already own the stock and are willing to sell it at the right price or it can represent a company who offers new shares in order to raise capital. The supply and demand curves are constantly fluctuating as they respond to macroeconomic news, company specific news or any other factors which can have an effect on the investor, such as discussed above (Subiri, 2010:137-147).

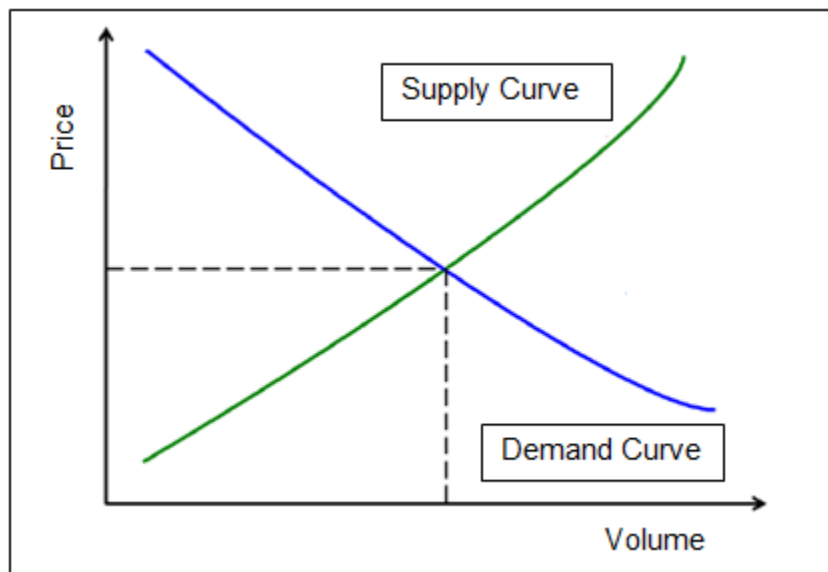


Figure 2.1: Supply and Demand of an Individual Stock

Source: Compiled by author.

Individual stocks are very responsive to news and react differently pending on whether it is positive news or negative news (Subiri, 2010:137-147). For example, positive news, such as company specific news where a company is projecting large profits, will cause the demand curve to shift to the right as the stock has become more attractive to potential buyers. Hence, more investors will start to compete for the stock which will increase the demand and ultimately the stock price. On the other hand, the supply curve might shift slightly to the left, because some investors who currently own the stock are now less inclined to sell it as it has become more attractive (Martti *et al.*, 2004:95-104). In contrast, negative news, such as an announcement declaring a drop in company revenues, will cause the supply curve to shift to the right as investors who currently own the stock will want to reduce their exposure by selling it. On the other hand, the demand curve will also decline slightly as fewer investors will want to purchase the stock due to it not being as attractive as before (Nirmala *et al.*, 2011:126).

To summarise; by accounting for these factors it is possible for an investor to gain more insight why the dual-listed stock prices can differ in the two exchanges. To elaborate more on this topic,

it is also necessary to briefly evaluate the markets in which dual-listed stocks can be listed on. This study specifically focusses on the Johannesburg Stock Exchange (JSE) and the London Stock Exchange (LSE). Both exchanges are the largest in Africa and Europe respectively, making it attractive for companies to dual-list. Although there are stocks which are currently dual-listed on these two markets, this study will specifically focus on Anglo American Plc., which is primarily listed on the LSE and secondarily on the JSE. The next section provides a brief overview of the JSE and LSE, where after a section on Anglo American Plc., follows.

2.2.3 Overview of the Johannesburg Stock Exchange (JSE)

The JSE was found in 1887 just after the discovery of the Witwatersrand gold fields. During this period the need for trade increased and the JSE was able to provide facilities which enabled investors to buy and sell shares (JSE, 2014). During the 1990's the competitiveness between international exchanges increased due to the technological developments in financial markets. To stay competitive the JSE was forced to reduce costs and develop more efficient trading, clearing and settlement systems (Mabhunu, 2004:13). This led to the development of the automated trading system, known as the Johannesburg Equities Trading (JET) system, which replaced the open outcry-trading floor trading in 1996. However, during 2002 the JET system was replaced by the JSE Stock Exchange Trading System (SETS), as this system was able to increase the transparency and liquidity of the JSE. Furthermore, in 2003 the JSE launched the Alternative Exchange (AltX) to provide small and medium size companies the opportunity to list and thereby gain access to capital. Since its inception more than 106 companies have been listed on the AltX, with 20 of these companies migrating to the larger Main Board, indicating the potential for future growth (JSE, 2014).

In addition, the JSE currently has 387 companies listed on its main board which trade in various sectors, where the industrial sector is the largest (24%), followed by the consumer goods and

services sector (21%) and resource sector (20%) (JSE, 2014). The current market capitalisation for the JSE stands at US\$ 866 171 million (28 April 2014), with a market turnover of US\$ 29 130 million, making it the 18th largest exchange in the world (JSE, 2014). The JSE is also the largest exchange in Africa, which provides investors with a gateway to invest in quality listed African companies (JSE, 2014).

2.2.4 Overview of the London Stock Exchange (LSE)

The LSE was established in 1698 and is one of the world's largest stock exchanges which plays a pivotal role in the wider European market. In 1853 the LSE had 850 traders on the floor where open outcry-trading was taking place, however, in 1986 the LSE switched from the open outcry way of trading to electronic-screen based trading (LSE, 2014). The LSE, just like the JSE, also has a smaller market which allows small and medium-sized companies to list on the exchange, known as the Alternative Investment Market (AIM). AIM was launched in 1995, which provided these small and medium-sized companies with the opportunity to raise capital. Nonetheless, another technological advancement took place in 1997, as the Stock Exchange Electronic Trading System (SETS) was implemented which automatically matched and executed buy and sell orders (LSE, 2014).

In addition, the LSE currently has 2938 companies listed on its main board with a current market capitalisation of US\$ 3 266 trillion and a market turnover of US\$ 1.7 trillion, making it the fourth largest exchange in the world (LSE, 2014). When comparing these statistics to those of the JSE, it is evident that the LSE is the bigger of the two stock exchanges. The LSE is also the largest exchange in Europe, allowing investors to invest in some of the biggest listed companies of the world (LSE, 2014). In addition, the LSE is known for having a good reputation due to their respected and balanced regulatory environment (LSE, 2014). For these reason, companies

consider a dual-listing on the LSE as it is able to provide a larger investor base which makes it easier for companies to gain access to capital.

Table 2.1: Dual-listed stocks which are listed on the JSE and the LSE

Dual-listed Stock	Primary/Secondary listing on JSE	Dual-listed Stock	Primary/Secondary listing on JSE
African Eagle Resources Plc.	Secondary	Impala Platinum Holdings Limited	Primary
African Rainbow Minerals Limited	Primary	Investec Plc.	Secondary
Anglo American Plc.	Secondary	Ipsa Group Plc.	Secondary
AngloGold Ashanti Limited	Primary	Jubilee Platinum Plc.	Primary
Anglo Platinum Limited	Primary	Kiwara Plc.	Primary
Aquarius Platinum Limited	Secondary	Liberty International Plc.	Secondary
Barloworld Limited	Primary	London Finance and Invest. Group Plc.	Secondary
BHP Billiton Plc.	Secondary	Lonmin Plc.	Secondary
Braemore Resources Plc.	Primary	Lonrho Plc.	Secondary
British American Tobacco Plc.	Secondary	Metorex Limited	Primary
Central Rand Gold Limited	Secondary	Mondi Plc.	Secondary
Datatec Limited	Primary	Old Mutual Plc.	Secondary
Diamondcorp Plc.	Primary	Pan African Resources Plc.	Secondary
Dimension Data Holdings Plc.	Secondary	SABMiller Plc.	Primary
Drdgold Limited	Primary	SAPPI Limited	Primary
Gold Fields Limited	Primary	Stilfontein Gold Mining Company Limited	Primary
Harmony Gold Mining Company Limited	Primary	Tongaat Hulett Limited	Primary

Source: JSE (2014).

The current companies which are dual-listed on the JSE and LSE are listed in Table 2.1 above. Table 2.1 illustrates that there are 34 dual-listed stocks available to trade on the JSE and LSE. However, this study only considers the dual-listed stock of Anglo American Plc., where the next section provides a brief background on the company.

2.2.5 Anglo American Plc.

Anglo American Plc. was incorporated in the United Kingdom during 1999 when a strategic decision was made to combine the Anglo American Corporation with Minorco. The operations of Anglo American Corporation were primarily located within South Africa where they were listed on the JSE (Anglo American, 2015:1). The operations of Minorco were entirely outside of South Africa and had listings in Luxembourg, London and Paris. The combination of the Anglo American Corporation and Minorco provided the opportunity to have a more global market presence and consequently Anglo American Plc. applied to have their primary listing on the LSE and their secondary listing on the JSE (Anglo American, 2015:1). This restructure of the group created one of the world's largest mining companies.

Currently Anglo American Plc. is active in various commodity classes, namely iron ore and manganese, coal, copper, nickel, platinum and diamonds (Anglo American, 2015:1). Through these operations they were able generate \$2 billion in profits for 2013 and employed 158,900 people worldwide (Anglo American, 2015:1). Anglo American Plc. had a market capitalisation of \$7,75 billion as at December 2014 securing them the 7th position on the JSE Top 40 index (Anglo American, 2015:1). The P/E ratio for Anglo American Plc. stands at 11.2, which is lower than the 11.8 calculated for the sector. This lower P/E ratio is largely influenced by the strikes⁴ at the platinum mines which have put the company under financial strain. This is evident in the 2013 annual financial results were they announced that the total company earnings were down by 35%⁵. However, even with the bleak financial outlook, Anglo American has assured their

⁴ These strikes relate to the third announcement mentioned in Section 5.2 and occurred on 12 September 2012.

⁵ The 2013 annual financial results relate to the fourth announcement in Section 5.2 and occurred on 19 April 2013.

shareholders that they are working towards maintaining their interim dividend of 32 U.S. cents per share.

To summarise; this section started by discussing the purpose of dual-listed stocks and elaborated on the reasons behind dual-listings and what advantages it holds for companies. This was followed by a section which identified some of the factors that can influence the prices of dual-listed stocks and highlighted that supply and demand is regarded as one of the main factors to influence dual-listed stock prices. Furthermore, the forces behind supply and demand are partly generated by the investors' decision-making process in which the investors decide to either buy or sell a stock. The next section elaborates on the fundamentals of the investors' decision-making process, which is based on the trade-off between risk and return.

2.3 THE INVESTOR'S DECISION-MAKING PROCESS

Investors continuously evaluate possible investment opportunities by comparing the risk and return incorporated in the investment possibility. Some investors are considered to be more risk averse compared to other investors, which implies that more compensation is required for the risk that is taken (Marx *et al.*, 2006:3). The level of risk can be calculated by estimating the standard deviation, covariance and correlation (Hirschey & Nofsinger, 2010:100-102). The higher the level of risk the higher the compensation (expected return), indicating that there is a trade-off between risk and return (Marx *et al.*, 2006:3). The expected return can be calculated with the help of asset pricing models such as the CAPM (Section 2.4). However, the CAPM has some limitations in predicting future returns and as a result additional models, such as the APT (Section 2.5) and ICAPM (Section 2.7) were developed (Hirschey & Nofsinger, 2008:126-127). This next section starts by elaborating on the risk-return relationship, where the risk component (Section 2.3.1) and the return component (Section 2.3.2) are discussed, respectively.

2.3.1 Risk

The total risk of an investment can be divided into two distinct groups, namely systematic and unsystematic risk, graphically illustrated in Figure 2.2 (Alexander *et al.*, 1993:174). Systematic risk can be defined as the portion of risk that is inherent to market related factors, such as changes in interest rates or inflation rates (Hirschey & Nofsinger, 2008:132). Unsystematic risk, on the other hand, is the portion of the stock's price movements (volatility) which is caused by factors directly related to the company or the industry itself.

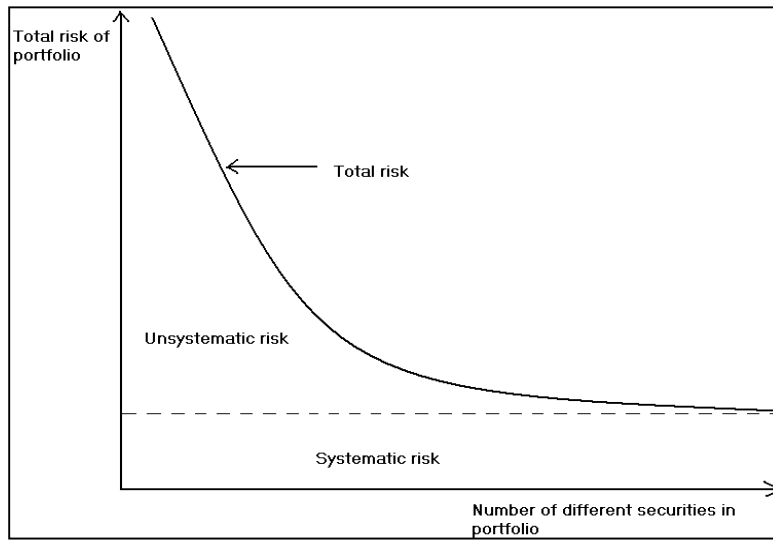


Figure 2.2: Systematic and unsystematic risk

Source: Marx *et al.* (2006:35).

In addition, the total risk can be calculated by consulting three measures, which include the standard deviation, covariance and correlation (Hirschey & Nofsinger, 2010:100-102). The first measure of risk is standard deviation⁶ and can be calculated as follows (Marx *et al.*, 2006:8):

$$\sigma = \sqrt{\sum_{n=1}^n (k_i - \bar{k}_i)^2 \times P_{ki}} , \quad (2.3)$$

where:

- σ represents the standard deviation;

⁶ The standard deviation (σ) is the square root of the variance (σ^2) of a distribution (Marx *et al.*, 2006:8).

- n represents the number of possible states;
- $\bar{k}_i$ represents the expected return;
- k_i represents the outcome associated with the i^{th} state; and
- P_{ki} represents the probability associated with the i^{th} outcome.

The level of standard deviation is indicative of the amount of risk, where a high standard deviation represents large variations in return, indicating higher risk (Marx *et al.*, 2006:8). After the standard deviation have been calculated it is possible to determine the extent to which two securities are correlated, which is the second measure of risk. Correlation can be calculated as follows (Marx *et al.*, 2006:250):

$$Correlation (r) = \frac{Covariance_{(A,B)}}{(\sigma_A \times \sigma_B)}, \quad (2.4)$$

where:

- σ_A represents the standard deviation of security A ; and
- σ_B represents the standard deviation of security B .

The correlation coefficient (r) can take any value between +1.0 to -1.0, where the signs (+ or -) indicate whether or not two securities/assets are moving together or inversely (Marx *et al.*, 2006:250). A positive correlation coefficient indicates that two securities are moving together, whereas a negative correlation coefficient indicates the two securities/assets are moving inversely (Marx *et al.*, 2006:250).

The third measure of risk is covariance and can be defined as the absolute measure which evaluates to what extent two securities move together (Marx *et al.*, 2006:250). The covariance measure can range from $+\infty$ to $-\infty$ and can be calculated as follows (Marx *et al.*, 2006:250):

$$Covariance_{(A,B)} = \sum probability \times (return_A - k_A) \times (return_B - k_B), \quad (2.5)$$

where:

- $return_A$ represents the real return of security A ;
- $return_B$ represents the real return of security B ;
- k_A represents the expected return of security A ; and
- k_B represents the expected return of security B .

The total risk of an investment can be reduced by means of diversification, which is a method used by investors to reduce the unsystematic risk of a portfolio (Marx *et al.*, 2008:34). Investors normally diversify portfolios by purchasing different kinds of securities (for example: stocks, bonds and real estate) in different industries or companies (Hodvedt & Tedder, 1978:135). In order to achieve effective diversification, investors should be aware of how individual securities can influence the overall portfolio risk (standard deviation). The standard deviation of the overall portfolio is a weighted combination of the standard deviations of the individual securities and by combining securities with high and low standard deviations allows the investor to have a balanced portfolio (Karamanidis, 2013:9). This implies that the investor can build a portfolio according to his risk preferences. Furthermore, investors may include securities which are negatively correlated with each other, as this will improve diversification (Hirschey & Nofsinger, 2010:100-102). Investors should also consider the covariance of securities when diversifying a portfolio. For optimal diversification, investors want to build a portfolio in which the securities have a low covariance (Hagstrom, 2001:1). After portfolio diversification the only risk which will remain is systematic risk and this will be the risk for which the investor must be compensated for (Hirschey & Nofsinger, 2008:132). The investor must decide if he is comfortable with the level of risk which remains after diversification and whether the risk-return relationship of the investment is acceptable. A successful investment is one which has the best possible risk-return combination

(Gitman & Joehnk, 1990:697–698). In order to elaborate more on the relationship between risk and return the next section discusses the Markowitz efficient frontier.

2.3.2 The Markowitz efficient frontier

The Markowitz efficient frontier represents a set of portfolios which has the highest possible return for a given level of risk (Markowitz, 1952:82). Figure 2.3 provides a graphical illustration of the Markowitz efficient frontier, with the expected return on the Y-axis and risk (standard deviation) on the X-axis. A portfolio must be allocated on the efficient frontier line in order to be efficient, for example portfolio A, B or C (Marx *et al.*, 2006:35). Portfolios which lie below the efficient frontier, such as portfolio F and G, are regarded as inefficient portfolios (Marx *et al.*, 2006:35).

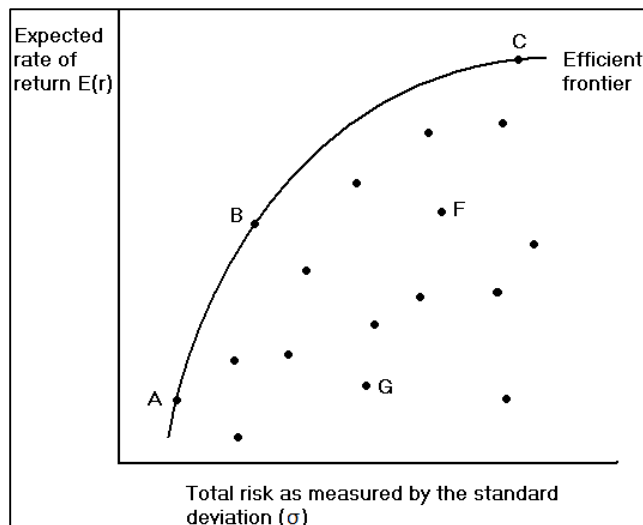


Figure 2.3: The efficient frontier.

Source: Francis (1993:608).

A portfolio allocated on the efficient frontier, such as portfolio A, B and C will be held by rational investors (Van Dyk, 2008:13). However, not all investors have the same risk preference and will, therefore, choose an efficient portfolio according to their risk appetite. For example, a more risk-averse investor will select portfolio A, where the expected returns are associated with lower risk (Francis, 1993:608-609). A moderate investor will choose portfolio B with a balance between relative risk and return. On the other hand, a more aggressive investor will be willing to take more

risk in order to achieve higher returns and will, therefore, choose portfolio C. The risk involved with portfolio A, B and C can be illustrated with the help of probability distributions, as illustrated in Figure 2.4.

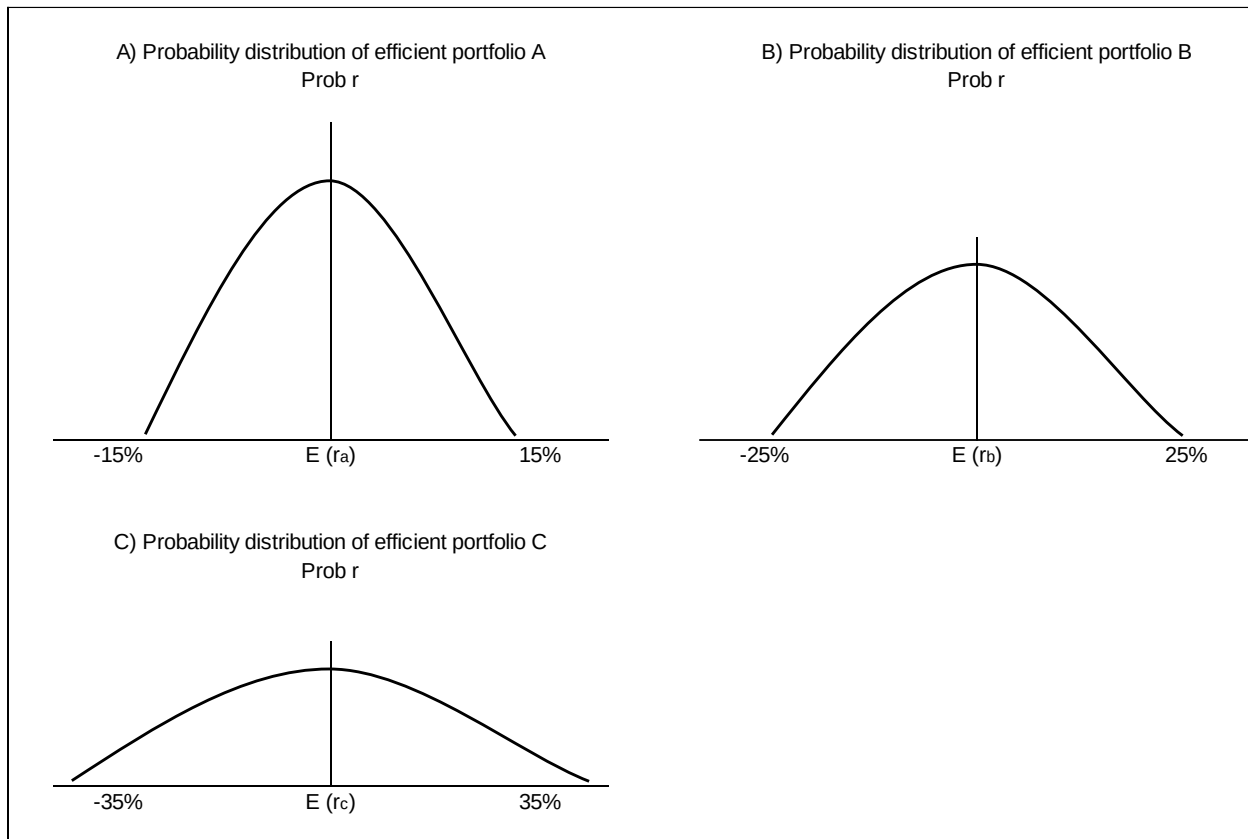


Figure 2.4: Probability distribution of each efficient portfolio.

Source: Francis (1993:608).

Figure 2.4 is able to demonstrate the significance of the standard deviation (σ) as a measure of risk (Mittra & Gassen, 1981:118). The greater the σ the wider the distribution of the rate of return will be, which implies more risk and increased uncertainty regarding an investment's rate of return (Marx *et al.*, 2006:9). Portfolio A, as indicated in Figure 2.4, has a smaller probability distribution which indicates a lower level of risk. The probability distribution of portfolio B is slightly wider and indicates that there is more risk involved for each level of expected return. Overall, portfolio C is

deemed as the most risky portfolio as it has the widest probability distribution, indicating more risk for each level of expected returns.

To summarise; this section explained that investors are constantly faced with a trade-off between risk and return. Investors will, therefore, want to construct their portfolios in such a way that they can achieve maximum expected returns for the level of systematic risk, which cannot be eliminated by portfolio diversification. In order to determine the expected return it is necessary to discuss asset pricing models, as these models are able to calculate the expected return. This leads to the next section that elaborates on the Capital Asset Pricing Model (CAPM) (Section 2.4), and also includes a discussion on beta (Section 2.4.1), the Security Market Line (Section 2.4.2) and the Capital Market Line (Section 2.4.3).

2.4 THE CAPITAL ASSET PRICING MODEL

Following on the Markowitz efficient frontier, Sharpe (1964:425-442) and Lintner (1965:13-39) developed the CAPM to calculate the expected return of an asset. This model is based on the fundamental premise that investors are only rewarded for systematic risk, since unsystematic risk can be diversified away through diversification strategies (Goodspeed, 2009:28). The CAPM, therefore, forecasts the relationship between the expected return and the systematic risk of an asset. The CAPM can thus also be seen as a model which is able to describe the trade-off between risk and return (Gitman & Joehnk, 1996:165). However, the CAPM is subjected to certain assumptions and in order to fully understand the construction of CAPM it is necessary to first discuss these assumptions. The following assumptions underline the CAPM (Reilly & Brown, 2003:239):

- Investors are considered to be rational mean-variance optimisers (Bodie *et al.*, 1998:199);
- Investors are able to borrow or lend money at the risk-free rate (RFR) of return (Marx *et al.*, 2006:36);

- The risk-free rate is standard for all investors (Alexander *et al.*, 1993:218);
- All investors have the same economic views and analyse securities in the same way. Investors, therefore, exhibit homogeneous expectations and this result in the estimation of identical probability distributions of future rates of return (Bodie *et al.*, 1998:199);
- All investors plan for a similar one-period time horizon. This behaviour ignores anything that might take place after the identical holding period (Marx *et al.*, 2006:36);
- It is possible to buy or sell fractions of an asset or a portfolio, making investments perfectly liquid (Marx *et al.*, 2006:36);
- Investors pay no transaction costs on trades and there are no taxes on returns. In reality, trading is costly and depends on the size of the trade. Furthermore, investors fall in different tax brackets which also influence their decision to invest in certain assets (Alexander *et al.*, 1993:218);
- Investors are not able to affect prices of individual trades (Bodie *et al.*, 1998:199);
- Investors are able to anticipate any changes in the inflation rate (Hirschey & Nofsinger, 2008:128);
- Capital markets are in equilibrium, thus all assets are properly priced according to the amount of risk they carry (Marx *et al.*, 2006:36); and
- Information is instantly and freely available to all investors (Bodie *et al.*, 1998:199).

Besides the above-mentioned assumptions that form the foundation of CAPM, and thus of portfolio decisions, is the beta another important component of the CAPM which should be considered. As mentioned before, a competent investor is able to utilise diversification strategies in such a way that only systematic risk remains. All portfolios have their own level of non-diversifiable risk (systematic risk) that can be measured by calculating the beta and will be discussed in the next section.

2.4.1 Calculating and interpreting the Beta

The beta (β) of a stock is used to measure risk and can be defined as a standardised measure of systematic risk (Reilly & Brown, 2003:1014). It is also able to measure market risk and can provide insight regarding the impact which market changes have on the expected rate of return (Gitman & Joehnk, 1996:165). In order to calculate the beta the basic equation of the CAPM must first be derived as follows (Marx *et al.*, 2006:36):

$$E(R_i) = R_f + \beta_i(km - R_f), \quad (2.4)$$

where:

- $E(R_i)$ represents the expected rate of return;
- R_f represents the risk-free rate of return;
- km represents the return of the market; and
- β_i represents the beta of the security.

In addition, the beta can be calculated as follows (Marx *et al.*, 2006:36):

$$\beta = \frac{\text{Systematic risk of security } i}{\text{Market risk}}, \quad (2.5)$$

or

$$\beta = \frac{\text{Covariance}_{i,m}}{\text{Variance}_m}, \quad (2.6)$$

or

$$\beta = \frac{\text{Correlation}_{i,m} \sigma_i \sigma_m}{\sigma_m^2}. \quad (2.7)$$

The higher the beta value, the more sensitive the security's price will be to changes occurring in the market (Gitman & Joehnk, 1990:197). The beta can either have a positive or negative sign, where a positive beta indicates that the security moves in the same direction as the market and a negative beta indicates that the security moves in the opposite direction of the market (Gitman & Joehnk, 1996:164). The beta value of the market is one, therefore, a security with a beta greater than that of the market is identified as an aggressive stock, since the price of the security is more sensitive and carries more risk (Blake, 2000:494). In contrast, if a security has a beta less than that of the market, it is identified as a defensive stock, since the security is less sensitive and has a lower risk (Blake, 2000:494). A summary of how to interpret the beta value is also provided in Table 2.2 below.

Table 2.2: Interpreting the beta value

Beta	Direction of movement	Interpretation
2	Stock and market move in the same direction.	Stock has twice the volatility of the market.
1		Stock has the same volatility and risk as the market.
0.5		Stock has half of the volatility of the market.
0	Stock is unaffected by market movements.	
-0.5	Stock and market move in the opposite direction.	Stock has half of the volatility of the market.
-1		Stock has the same volatility and risk as the market.
-2		Stock has twice the volatility of the market.

Source: Gitman & Joehnk (1990:198).

Additionally, the CAPM equation (Equation 2.4) can be graphically illustrated with the use of the Security Market Line (SML), where the slope of the SML is represented by the beta (Gitman & Joehnk, 1996:164). A beta value greater than one will indicate that a security is very sensitive to market changes and will therefore, be more risky, thus causing the slope of the SML to be steeper. On the other hand, a beta value of less than 1 will be less sensitive and carry less risk, making the slope of the SML flatter. A high beta will have more risk and, therefore, the expected return should also be higher and *vice versa*. The next section will elaborate more on the SML, as it

provides additional info regarding the relationship between non-diversifiable risk (beta) and expected returns.

2.4.2 The Security Market Line

The SML indicates the most promising combination of risk and return for various investments (Marx *et al.*, 2006:33), which can be illustrated by Figure 2.5. Since the CAPM assumes that all stocks are fairly priced, it is possible to use the SML as a benchmark tool in which investors can measure the return potential of a new investment (Hirschey & Nofsinger, 2008:128).

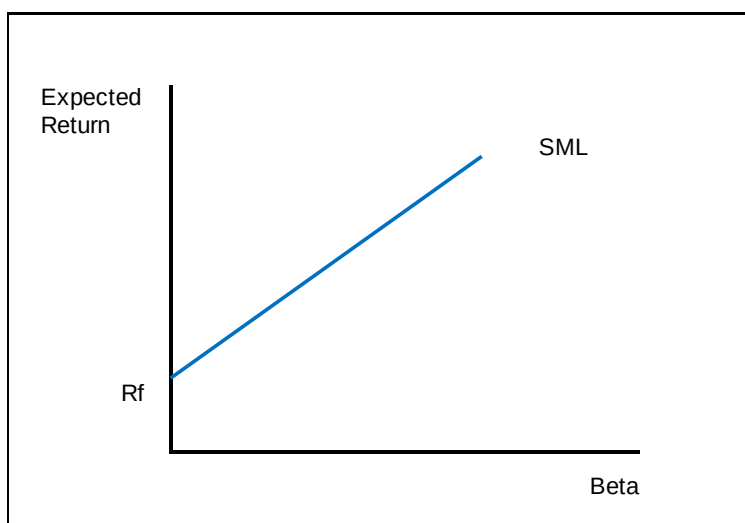


Figure 2.5: The Security Market Line

Source: Reilly & Brown (2003:248).

In order to measure the return potential of a stock, it is required to determine if the stock is under- or overvalued by plotting it against the SML (Figure 2.6). By using the stock's alpha, which is the difference between the estimated return and expected return of a stock, it is possible to determine if the stock is miss-valued (Reilly & Brown, 2003:251). If the alpha is positive, the stock will be undervalued which means that the expected rate of return is higher than the return estimated by the CAPM. In contrast, if the alpha is negative the stock will be overvalued which then means that the expected rate of return will be lower than the return estimated by the CAPM (Reilly & Brown, 2003:251).

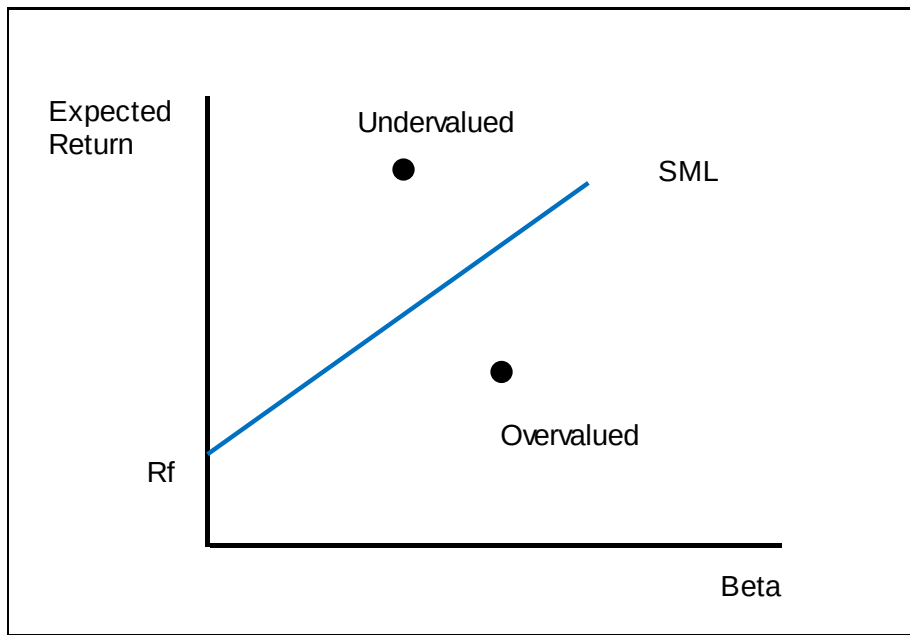


Figure 2.6: Over- and undervalued stocks

Source: Reilly & Brown (2003:251).

As stated earlier, investors have different views on how they perceive risk, which implies that each investor has his own risk preference that can be illustrated by the risk indifference curve as illustrated in Figure 2.7 below (Marx *et al.*, 2006:33). Figure 2.7 illustrates two efficient portfolios (portfolio A and B), where the indifference curves intersect with the SML. The point of intersection indicates that the investor is comfortable with the amount of risk (preference) he is taking. Portfolio A will be held by more risk-averse investors, since the risk associated with this portfolio is low and thus a lower return will be expected. Portfolio B, on the other hand, will be held by less risk-averse investors, since the risk associated with this portfolio is high and thus the expected return will be also be high (Marx *et al.*, 2006:33). The same concept can also be illustrated by Figure 2.8, which further emphasises the ability of the SML as a benchmark to illustrate the trade-off between risk and return for various types of investments.

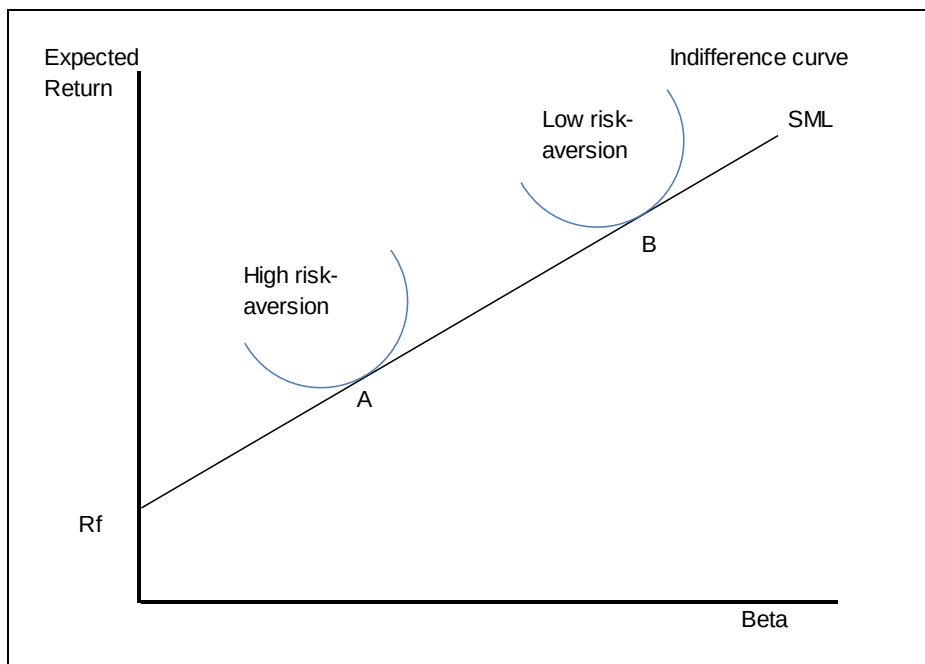


Figure 2.7: The SML and risk indifference curves

Source: Marx et al. (2006:33).

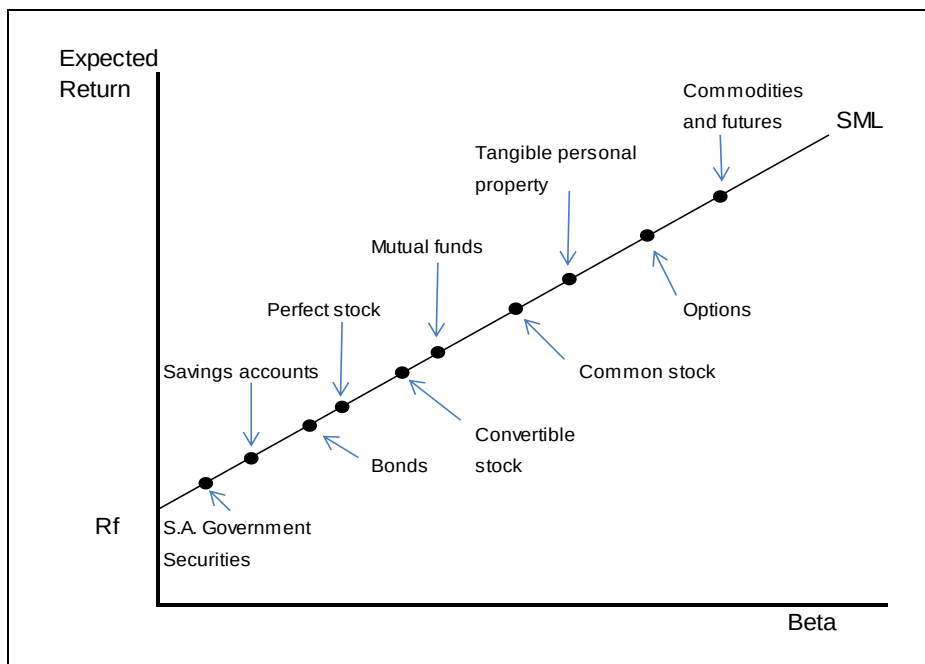


Figure 2.8: The trade-off between risk and return of various types of investments

Source: Gitman & Joehnk (1990:202).

The high risk-averse investor aims to build a less risky portfolio and will, therefore, acquire lower risk investments, such as government securities or bonds. On the other hand, the low risk-averse investor is willing to take on more risk and will thus aim to build a portfolio which will include higher

risk investments, such as commodities or tangible personal property, as illustrated by Figure 2.8 above.

However, a disadvantage of the SML is that it fails to incorporate lending and borrowing as an investment instrument in the efficient portfolio (Marx *et al.*, 2006:37). A new efficient frontier must therefore be considered in order to include lending and borrowing capabilities. This new efficient frontier is known as the Capital Market Line (CML) and is discussed in the following section.

2.4.3 The Capital Market Line

The CML, like the SML, represents the relationship between the risk and the expected return of a portfolio and is able to incorporate additional investment opportunities such as borrowing and lending at the risk-free rate (Luenberger, 1988:165). These borrowing and lending opportunities can be illustrated in Figure 2.9, where the market portfolio M that includes risky assets is allocated on the CML.

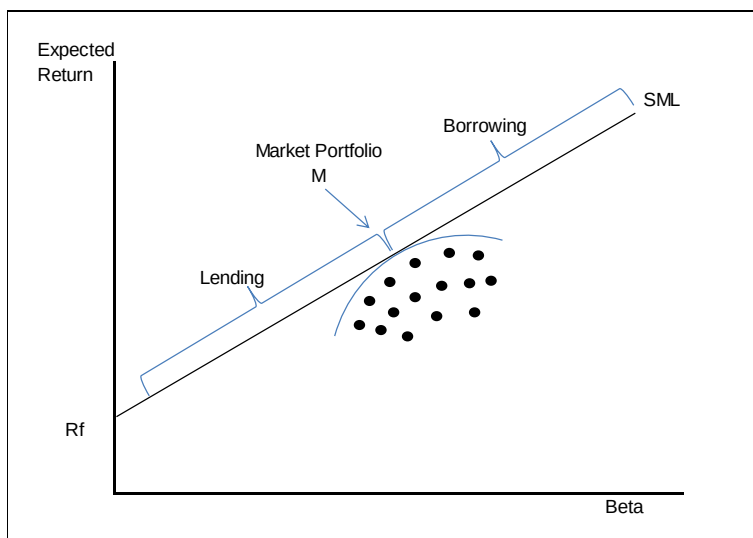


Figure 2.9: The CML assuming borrowing and lending at the risk-free rate

Source: Reilly & Brown (2003:243).

Although the CAPM is used to help determine the expected return of an asset it still has some drawbacks, as the beta calculation within the CAPM does not seem to explain the entire variation in expected returns (Hirschey & Nofsinger, 2008:140). The assumption behind the CAPM is that

the beta explains the overall systematic risk, while in actual fact it only reflects one of the many risks which a company must face, implying that the CAPM is only a single-factor model (Luenberger, 1998:205). This suggests that a more complex model is needed which will be able to incorporate additional risk factors. As a result, the Arbitrage Pricing Theory (APT) model, a multi-factor model, was developed to incorporate a wider set of risks in the calculation of the expected rate of return. The following section explains the characteristics of the APT and how it derives the expected rate of return.

2.5 THE ARBITRAGE PRICING THEORY

The APT links the factor sensitivities of an asset to its expected return, thereby highlighting the importance of factor risk in asset pricing (Gilles & Leroy, 1991:213). It is also able to provide a characterisation of the expected return of an asset by following a factor structure and assumes that arbitrage opportunities are not present (Gilles & Leroy, 1991:1). The fundamental principle of the APT is that there can be a number of risk factors which can influence the expected return (Cuthbertson, 2004:61). The APT considers a k factor model which implies that the number of risk factors that can be used in the APT is unlimited (Marx *et al.*, 2008:39). It considers a linear combination of the k number of factors under the following assumptions (Van Rensburg, 1997:60):

- A perfect competitive and frictionless capital market prevails (Altay, 2003:1);
- Investors are risk averse and will prefer more wealth to less wealth; and
- Competitive forces will eliminate the opportunity for arbitrage (Paavola, 2006:7).

The k number of risk factors included in the APT model can also be categorised into two components, namely systematic and unsystematic risk (Section 2.3.1). Systematic risk is the risk which arises due to market related factors and cannot be diversified away (Paavola, 2006:7). These market related forces are those macroeconomic variables that can influence the expected

cash flows and the discount factor (Shaharudin & Fung, 2009:101). Unsystematic risk, on the other hand, is the risk which is related to each individual asset (Paavola, 2006:7).

The APT can be seen as an alternative to the CAPM with the added advantage that the APT can be applied to a subset of investments (Solnik, 1996:234). The APT assumes that the return (R_{it}) of the i^{th} security is generated by a multi-index model, which can be formulated as follows (Paavola, 2006:7):

$$R_{it} = \alpha_i + b_{t1}F_{t1} + \dots + b_{ij}F_{jt} + e_{it} \quad i = 1, 2, \dots, N, \quad (2.8)$$

where:

- F_{jt} represents factors ($j = 1, 2, \dots, J$);
- b_{ij} represents the factor sensitivities; and
- e_{it} represents a normally distributed random error term which has a mean of zero.

Equation 2.8 indicates that each individual security (i) has its own level of sensitivity to each F_{jt} . The F_{jt} of each stock has similar values and any F_{jt} will affect more than one stock (Paavola, 2006:8). The APT model can, therefore, be expressed as the relationship between the expected return and the factor sensitivities which can be illustrated as follows (Paavola, 2006:7):

$$E(R_{it}) = \lambda_0 + \lambda_1 b_{t1} + \lambda_2 b_{t2} + \dots + \lambda_j b_{ij} + \varepsilon_{it}, \quad (2.9)$$

where:

- $E(R_{it})$ represents the expected return on the stock;
- λ_0 represents the risk-free rate of return; and
- λ_1 represents the expected return of a portfolio with a unit sensitivity to factor j and zero sensitivity to all of the other factors (Cheng, 1995:130-131).

The assumption is made that arbitrage opportunities are not present and that the average of a random sample from a large population will be closely aligned to the average of the entire population (Paavola, 2006:7). Equation 2.9 indicates that λ_1 represents the additional return which is expected because of the stock's sensitivity to the i^{th} attribute of the stock. However, one downside of the APT model is that the F_{jt} term is not defined, in other words, there is no specific structure in place within the theory that stipulates the correct number of factors to be used in the APT model (Azeez & Yonezawa, 2006:576). The study by Berry *et al.* (1998:30) provides a framework to help determine which type of variables will qualify as potential risk factors. These potential risk factors must possess certain characteristics: firstly, the factors must have an influence on stock returns; secondly, the factors must be unpredictable at the start of the period; and thirdly, the factors must possess non-zero prices as each factor must be able to influence the expected return.

In addition, the study by Paavola (2006:10) examined two methods that can be used to determine the most appropriate number of risk factors to be included in the APT equation. The first method is based on a multivariate statistical model introduced by Gehr (1978:95), which follows a two-step approach. The first step makes use of a sample of time series data in order to estimate a set of factor loadings for each asset. In other words, factor-analysis techniques are used to estimate common factors. The second step starts by regressing the sample mean returns on the factor loading with the use of a cross-sectional regression in an attempt to conclude which factors to be used (Paavola, 2006:10). The second method is based on Fama and MacBeth's (1973:614) two-step procedure, where the correct set of macroeconomic variables must be able to explain asset returns. Moreover, the actual returns should correlate with the sensitivities of these variables, while the factors display non-zero APT prices (Berry *et al.*, 1988:31). The study by Azeez and Yonezawa (2006:570) also argue that the second method is more beneficial than the first,

because of the fact that economic interpretations can be linked to the individual factors and to the APT prices.

However, even if the number of risk factors to be included into the model is known, it is still difficult to identify the mix and nature of the variables to be used (Bodie *et al.*, 2010:213). The study by Chen *et al.* (1986:385) provides guidelines in deciding which factors to include in the APT. They argue that a correct set of factors can be acquired by means of empirical and theoretical justification. The empirical justification of candidate factors should effectively explain asset returns and must comply with the necessary statistical tests in order to qualify as APT factors. The theoretical justification of candidate factors can be explained by examining the Gordon growth model (Section 2.1). Any variable that can influence the degree of D_1 , k and g is important to consider, as it is instrumental in explaining price levels (Chen *et al.*, 1986:385).

In addition, the study of Türsoy *et al.* (2008:52) identifies some risk factors which have been used in previous research, in an attempt to find the perfect set of variables to be included in the APT calculation. These macroeconomic variables are summarised in Table 2.3 below.

To summarise; the biggest drawback of the APT is that there is no formal theoretical guidance which specifies the set of macroeconomic variables to be used in the APT model. Despite this, the APT model still provides some advantages which cannot be captured within the CAPM. The next section briefly discusses the deficiencies of the CAPM by comparing the APT model to the CAPM.

Table 2.3: Macroeconomic variables used in previous APT studies

Macroeconomic variables	Previous studies that used the indicated variables
Industrial production	Özcam (1997), Altay (2003)
Inflation	Chen & Jordan (1993), Altay (2003)
Oil price	Chen & Jordan (1993), Clare & Thomas (1994)
Money Supply	Özcam (1997), Altay (2003)
Exports	Beenstock & Chan (1988)
Interest rate	Özcam (1997), Altay (2003)
Gross domestic product	Kryzanowski & Zhang (1992), Cheng (1995)
Gold price	Yörük (2000), Clare & Thomas (1994)
Imports	Altay (2003)
Exchange rate	Özcam (1997)
Unemployment rate	Clare & Thomas (1994)

Source: Türsoy *et al.* (2008:52).

2.6 A COMPARISON BETWEEN THE CAPITAL ASSET PRICING MODEL AND THE ARBITRAGE PRICING THEORY

The CAPM is a single-factor model which assumes that the risk premium only depends on systematic risk, as it is argued that unsystematic risk can be diversified away (Marx *et al.*, 2008:34). By only including a single systematic risk factor (beta) the CAPM is not able to identify some of the other factors which can also have an impact on the expected return (Head, 2008:52). Another disadvantage of using the beta to predict expected returns is that it can lead to the under- or overestimation of a stock. A third disadvantage of the CAPM is the number of unrealistic assumptions and empirical shortcomings, such as the underestimation of the market risk premium and the overestimation of the risk-free rate (Paavola, 2006:15). Also, the CAPM assumes that

stock returns are normally-distributed random variables (Mandelbrot & Hudson, 2004:60). However, evidence found by Mandelbrot and Hudson (2004:60) shows that prices on equity markets are not always normally distributed, proving that the assumption of normal distributions is invalid.

Unlike the CAPM, the APT has no assumptions about the empirical distribution of asset returns. Also, the assumptions of the APT are more relaxed than those of the CAPM, as it only has three major assumptions (see Section 2.5) and tries to consider a market which is more aligned with reality (Pavola, 2007:28). The APT model is also able to incorporate a wider set of risk factors, which improves the forecasting ability of the model (Paavola, 2006:15; see also Table 2.4). However, even though the APT is able to include more risk factors it still has a limitation, as there is no formal guidance to determine which of the risk factors to include in the model or the appropriate number of risk factors that should be considered (Bodie *et al.*, 2010:213).

Table 2.4: Comparing the APT model to the CAPM

APT model	CAPM
Considers a wide variety of risk factors which can influence expected returns (Marx <i>et al.</i> , 2006:40).	Considers the beta as the single risk factor which can influence expected returns (Marx <i>et al.</i> , 2006:40).
Makes the assumption that unique risk is diversified away in a large portfolio (Marx <i>et al.</i> , 2006:40).	Makes the assumption that unique risk can be diversified away in a large portfolio (Marx <i>et al.</i> , 2006:40).
The APT is seen as a “supply-side” model (Chen <i>et al.</i> , 1986:385).	The CAPM is seen as a “demand-side” model (Chen <i>et al.</i> , 1986:385).
Only considers a few assumptions, making it a less restrictive model (Paavola, 2006:15).	Considers a large number of assumptions where some are considered to be too unrealistic (Paavola, 2006:15).

Source: Compiled by author.

In addition to the comparison of Table 2.4, Dhankar and Esg (2005:14) argue that the APT model is superior to the CAPM, as it is able to provide a better estimate of a stock’s risk, which in turn

provides a more clear indication of an investor's expected rate of return. The study by Josev *et al.* (2001:158) and Elton *et al.* (2003:32) also emphasise the superiority of the APT model.

From the above evidence it can be argued that the APT model is deemed a better model than the CAPM. However, there is an extended model which was developed in order to eliminate some of the shortcomings of the CAPM and APT, especially for portfolios which incorporate international cross-border listed assets. An investor who considers an international investment must be aware of the additional risks, such as exchange rate risk (Solnik, 1973:8). For this reason the International Capital Asset Pricing Model (ICAPM) was developed as it incorporates exchange rate risk in the model and is discussed in the next section.

2.7 THE INTERNATIONAL CAPITAL ASSET PRICING MODEL

The study by Wu (2008:175) explains that the ICAPM differs from the CAPM, as it is able to address the problem of exchange rate risk when Purchasing Power Parity (PPP) does not hold. The PPP theory states that exchange rates should adjust accordingly in order to compensate for price differentials. This implies that the price of a certain stock should be the same in all countries when converted to a common currency (Vionea, 2013:2). However, if the PPP does not hold the real return, any asset will differ across countries, leading to exchange rate risk (Wu, 2008:175). This also means that investors from different countries will evaluate the return of a single asset in different ways (Ng, 2004:191), thereby violating the CAPM assumption that investors have homogeneous expectations of returns.

In addition, the ICAPM theory further differs from the CAPM in that it is able to consider a world market portfolio instead of only a domestic market portfolio (Adler & Dumas, 1983:925-984). Also, unlike the CAPM, the ICAPM incorporates wealth and state variables that forecast changes in the distribution of future expected returns (Cochrane, 2001:166). Furthermore, the ICAPM is able to

generate linear discount factor models consisting of state variables and determines the maximisation of an investor's portfolio decision (Cochrane, 2001:166). However, one drawback of the ICAPM is that it is not able to describe these state variables (Cochrane, 2001:171). The ICAPM is also limited in explaining the returns in a cross-section of national value portfolios (Fama & French, 1998:1984). The ICAPM makes the assumption that an investor ignores the nominal return in the currency of their home country and rather focuses on the real return the asset provides per unit of risk (Vaihekoski, 2000:72). Nonetheless, the ICAPM is still an improvement on the CAPM, as it is able to capture an international environment where investors can invest funds across borders and in different currencies (Stulz, 1981:383-406), which can be formulated as follows⁷ (Wu, 2008:177):

$$R - F = \alpha + \beta_1(M - F) + \beta_2(X - F) + \varepsilon_t \quad (2.10)$$

where:

- R represents the expected return of a domestic stock;
- F represents the risk free rate of return;
- M represents the global market return;
- X represents the foreign exchange rate;
- α represents the constant parameter;
- β_1 and β_2 represent the coefficients; and
- ε_t represents the error term at time t .

⁷ The study by Dumas and Solnik (1995:445-479) argued that exchange rate risk is significantly different from zero and, therefore, the exchange rate risk should be incorporated in the pricing of assets. These findings were also supported by De Santis and Gerard (1998:375-412).

Equation 2.10 is based on the study of Wu (2008:177) in which the standard CAPM is expanded to include exchange rate risk. Wu (2008:177) further stated that if an investor holds a foreign investment for two periods, in which the investment is expressed in two currencies, the return on the security must be converted back to the domestic currency. The domestic returns on a foreign security can be calculated as follows (Wu, 2008:177):

$$Return = \frac{S_1(1+i_2)}{S_2} \quad (2.11)$$

where:

- S_1 represents the foreign exchange rate at the end of the holding period;
- S_2 represents the domestic exchange rate as the end of the holding period; and
- $(1 + i_2)$ represents the return on the security.

Furthermore, for an investor to obtain continuous net returns, the returns must be converted into a natural logarithm format (Wu, 2008:177). If the $\ln(\frac{S_1}{S_2})$ is positive, the investor will receive higher returns than the foreign risk-free returns. However, if it is negative the investor will receive lower returns than the foreign risk-free returns. The study by Wu (2008:177) further argued that with the risk-free rate (F) (see Equation 2.10) being relatively constant, the returns of an investment will largely reflect the exchange risk that is present, which can be incorporated in a more accurate asset pricing process, using the ICAPM. To further prove the superiority of the ICAPM, the next section briefly discusses findings by past studies.

2.7.1 Historical empirical studies of the ICAPM

The study by Solnik (1974:502) was one of the first to develop the ICAPM and made the following assumptions:

- There are no international capital flow constraints;
- Investors only invest in their domestic country;
- All investors have the same economic views and thus have homogeneous expectations regarding currency types and exchange rate fluctuations (Elton & Gruber, 1999:346);
- The world exchange rate is flexible;
- Capital markets are in equilibrium;
- Capital markets are perfect with no tax or transaction costs;
- Assets can be sold short; and
- A market exists in each country where investors can borrow or lend money at the same rate.

The study by Solnik (1974:520) further provides mutual fund theorems, stating that all investors are indifferent in selecting a portfolio. Moreover, the mutual fund theorems assume that investors are indifferent when choosing between the following: a risk-free asset in the investors' home country; a portfolio of bonds (used to speculate in the exchange rate dimensions); or a portfolio of stock (used to hedge against exchange rate risk).

Following the study of Solnik (1974), Grauer *et al.* (1976) developed an ICAPM⁸ which included the following assumptions (Grauer *et al.*, 1976:254):

- A linear relationship is present between the world market portfolio of assets and the real rate of asset returns;
- There is a unrestricted and costless international exchange of assets and goods; and

⁸ The ICAMP developed by Grauer *et al.* (1976) differed from Solnik (1974), as it did not include exchange rate risk, but instead incorporated a world market index which captured the international environment (Peerbhai, 2011:6).

- There are multiplicative, multi-commodity utility functions which exist.

Grauer *et al.* (1976:254) further argued that a country's demand for riskless capital and risk depends on the risk preferences of both domestic and foreign investors, the world real rate of interest and on the market value of the securities held relative to the market value of all securities. This emphasises the importance of having an asset pricing model which does not only take the domestic environment into account, but also the international environment (Korajczyk & Viallet, 1989:553-585). The study by Korajczyk and Viallet (1989:553-585) further stated that asset pricing models, like the ICAPM developed by Solnik (1974) and Grauer *et al.* (1976) which takes the international environment into account, are able to outperform the CAPM which only caters for the domestic market. This statement was also confirmed by Chan *et al.* (1992:137-167), who found that the CAPM was insufficient in capturing international risks and that the ICAPM was the best model to be used in an international setting. These findings were further supported by O'Brien and Dolde (2000:7) when they argued that international listed stocks were more exposed to international risks and that local asset pricing models, like the CAPM, would not be able to capture these risks. Later studies by Koedijk and Van Dijk (2004:468) and by Wu (2008:177)⁹ also confirmed that the ICAPM is the best model to use for a multi-national portfolio, as it includes exchange rate risk.

As an alternative to the CAPM, the study by Fama and French (1998:1997) developed a three-factor model in an attempt to capture the risks involved in international investments. They argued that their three-factor model has the ability to explain the premium in international returns, whereas the standard CAPM cannot. However, even if the three-factor model is considered to be

⁹ The countries examined in the study by Wu (2008:177) included Australia, Belgium, Canada, France, Germany, Hong Kong, Italy, Japan, Netherlands, Norway, Singapore, Spain, Sweden, Switzerland, the U.K. and the U.S.

superior to the CAPM, it still assumes that capital markets are fully integrated and that investors are not concerned if the PPP holds or fails. These results were also confirmed by Dahlquist and Sallstrom (2002:3145) and Zhang (2006:289), in which both studies revealed that although the Fama and French (1998) three-factor model outperforms the CAPM, it is not able to outperform the ICAPM.

To summarise; this section concluded that the CAPM is not efficient in capturing the risks associated with a multi-national portfolio. Moreover, the CAPM includes a beta coefficient which is not able to incorporate all the factors that have the ability to influence the expected return of an investment. This limitation of the CAPM led to the development of the APT, which is able to incorporate a wider range of risk factors. However, one drawback of the APT and the CAPM is that it is not able to include the additional risk (exchange rate risk) faced by investors who invests across borders. This led to the development of the ICAPM, which is able to incorporate the exchange rate risk in the pricing of assets, where its superiority over the traditional CAPM, APT and Fama and French's (1998) three-factor model was also confirmed by several past studies.

2.8 CHAPTER SUMMARY

The main goal of this study is to examine how information released through public news announcements will influence dual-listed stock prices and whether it will generate arbitrage opportunities. The use of dual-listed stocks provides the opportunity to compare how the same stock in two different markets will react to newly released information. As markets absorb information in different manners (Section 3.3), the stock price in the two markets can behave in an unequal manner, thus leading to price misalignment and possible arbitrage opportunities. However, before such an investigation could begin it was necessary to first understand how stock prices were determined and how dual-listed stocks originated.

This chapter, therefore, commenced by discussing the concept of dual-listed stocks (Section 2.2) and the reasons for dual-listings (Section 2.2.1). This was followed by Section 2.2.2 which elaborated on the factors which could affect stock prices. In this section it was revealed that one of the greatest factors affecting stock prices is the supply and demand forces, which are driven by the investor decision-making process. Investors base their decisions on the trade-off between risk and return, where more risk will require a higher expected return (Section 2.3). In order to determine the expected return it was necessary to discuss the different asset pricing models, as these models elaborate on the different approaches available for estimating expected returns. The CAPM (Section 2.4) was the first model to be discussed and it was found that the CAPM was not suitable to be used for multi-national portfolios. Furthermore, it was revealed that the beta used in the CAPM is limited in explaining risk, since it is not able to incorporate various other risk factors which can influence the expected return of an investment. This limitation of the beta led to the development of the APT model (Section 2.5), which includes additional risk factors that can also effect the expected return. However, even though the APT is able to include more risk factors compared to the CAPM, it still lacks the ability to capture the risk involved with cross-border investments. Cross-border investments carry exchange rate risk, which should also be incorporated in the pricing of assets. This led to the development of the ICAPM (Section 2.7) which is best suitable when considering a multi-national portfolio.

The section on asset pricing models (Section 2.4, Section 2.5 & Section 2.7) indicated that if an asset is exposed to more risk it should be priced in such a way that it compensates for the additional risk. For this study it is of particular importance that the daily realised stock prices of dual-listed stocks are priced appropriately, as the single market hypothesis states that two identical assets should be priced the same. However, in reality there are instances in which the prices of dual-listed stocks are not the same. One reason why these price misalignments occur can be assigned to increased volatility (risk). Increased volatility arises as new information enters

the market, causing the dual-listed stock prices to adjust and incorporate the new information into its price. This leads to the next chapter which elaborates more on how new information can influence stock prices and volatility. It also explains that not all markets are equally efficient in incorporating new information into prices (Section 3.3). Since dual-listed stocks are listed on two different markets it is imperative that both markets have the same level of efficiency, or else a situation may arise where one stock reaches its equilibrium price before the other, giving rise to price misalignments. These price misalignments can lead to possible arbitrage opportunities and this concept is also explained in Section 3.6.

CHAPTER 3

THE IMPACT OF INFORMATION ON INTERNATIONAL STOCK MARKETS

3.1 INTRODUCTION

This study focuses on how public news announcements influence dual-listed stock prices and whether opportunities of arbitrage can be exploited. Announcements contain valuable information, which influences stock price behaviour as stock prices need to adjust upon the arrival of the new information (Mak, 2006:3). Stock prices take time to adjust as the new information must be captured in the new equilibrium price, giving rise to lagged adjustments (Angelini & Guazzarotti, 2010:5), as illustrated by Figure 3.1.

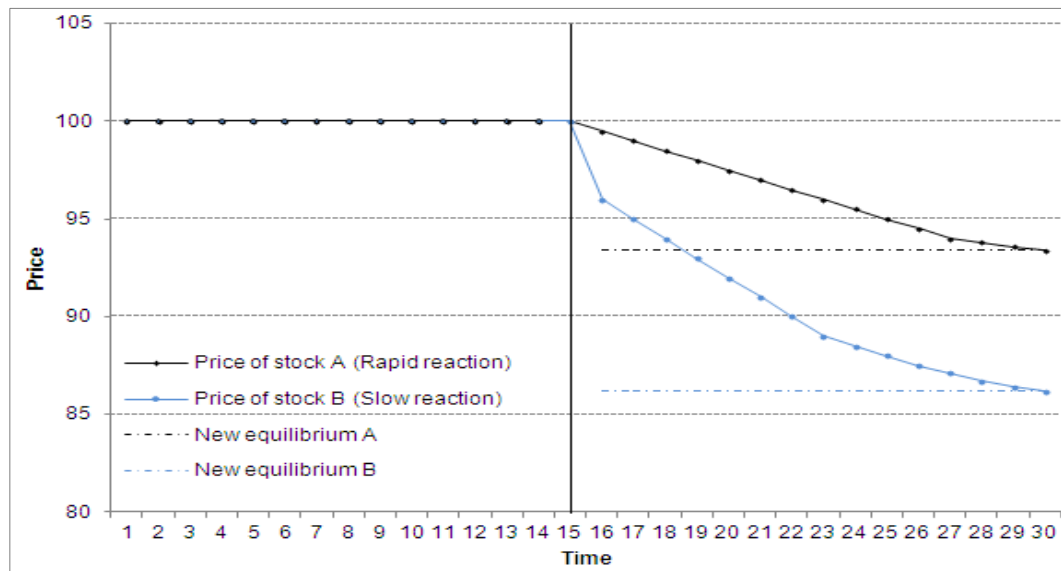


Figure 3.1: The reaction of stock prices to new information

Source: Angelini & Guazzarotti (2010:7).

If information is incorporated slowly, opportunities may develop to earn excessive returns, as stock prices will take more time to reach its new equilibrium level. In contrast, if stock prices are able to incorporate information more rapidly it will minimise the chances of excessive returns,

which ultimately reduces the chances of arbitrage (Mustafa, 2008:7). Figure 3.1 illustrates how a dual-listed stock, represented by stock A and stock B, reacts to the arrival of new information. It illustrates that stock A reacts rapidly to the new information, whereas stock B has a slower reaction. The concluding result of the different reaction speeds is that the two stocks reach two different equilibrium levels, which provides possible opportunities for arbitrage, as it violates the single market hypothesis. The single market hypothesis states that the same asset should trade at identical prices regardless of the stock exchange on which it is listed (Ip & Brooks, 1996:53).

The aim of this chapter is, therefore, to evaluate this possibility as illustrated by Figure 3.1. More specifically, to understand the theory on how stock prices and volatility levels can be influenced by new public information (announcements) and to what extent. In reality the prices of dual-listed stocks differ on each exchange, which implies that the price differences may contain market expectations that can enable an investor to identify possible arbitrage opportunities. This statement is also emphasised by the study of Agmon (1972:849), who found that there was a relationship between stock prices and the stock price information on different stock exchanges, especially if it was dual-listed. One of the possible reasons for the price differences was already explained by the Gordon growth model as discussed in Section 2.1, which revolved around the possibility of different growth trends in the different exchanges. This chapter elaborates further on how and to what extent new public information (announcements) will cause dual-listed stock prices to differ on the two exchanges.

In addition, new information does not only influence the growth trends of the stock price itself, but also other stock characteristics such as stock price volatility. The study of Ross (1989:16) provides evidence that a strong relationship exists between information and volatility, whereas volatility is recognised as a measure for the fluctuations occurring in a stock's price, as it adjust to the arrival of new information (Bala & Premaratne, 2002:6). Another study further postulates

that information is able to influence stock prices across international markets (Ong, 1997:1). This phenomenon is referred to as information transmission as information from domestic markets is able to transmit over to foreign markets. As a result it can be argued that a stock's volatility in one market can influence a stock's volatility in another market (Bauwens *et al.*, 2006:79), which is often referred to as volatility spill-overs (Flemming *et al.*, 1998:117).

This chapter therefore starts by elaborating on the importance of information with regards to stock markets (Section 3.2) and how order flow (Section 3.2.1) and market integration play a role in information transmission (Section 3.2.2). The chapter then continues by discussing the Efficient Market Hypothesis (EMH) (Section 3.3), that concerns on how markets incorporate new information into stock prices as the arrival of new information contributes to market fluctuations. Also, because it can be argued that information has a direct impact on the level of stock price volatility, this chapter investigates the relationship between information and volatility. Section 3.3.2 then continues by reporting findings of previous studies in which it describes the relationship between information and volatility and what effect this relationship had on international markets. This is followed by Section 3.4, which elaborates more on the relationship between information and volatility, by discussing the phenomenon called co-movement (Section 3.4). Through the analysis of co-movement, the effects of information and volatility become more visible as patterns of volatility (directly influenced by information) and volatility spill-overs can be identified in co-moving markets. Section 3.5 then elaborates on how volatility spill-overs occur and what effect co-movement has on volatility spill-overs. As volatility spills over from one market to the next, stock prices are influenced, sometimes leading to misaligned stock prices and possible arbitrage opportunities. The last section of this chapter therefore discusses the phenomenon called arbitrage and the factors influencing it (Section 3.6).

3.2 THE IMPORTANCE OF INFORMATION IN STOCK MARKETS

As an investor of dual-listed stocks it is important to understand the significance of information flows, as newly released information will impact the dual-listed stock prices in both the domestic and foreign stock exchanges (Bae *et al.*, 1999:710). This section, therefore, commences by discussing how order flow (Section 3.2.1) and information transmission (Section 3.2.2) affects stock prices.

3.2.1 Order Flow

Order flow can be defined as the transaction volume indicated by either a positive (+) or negative (-) sign, depending on whether a stock is bought or sold (Lyons, 2002:52). The existing literature¹⁰ of market wide order flow suggests that it is of great advantage to investigate movements and patterns in order flow, as it can provide additional information regarding future stock price levels. The studies by Brandt and Kavajez (2004:2623) and Pasquariello and Vega (2006:1975-2019) investigated how order flow influenced U.S. Treasury market yields. The study by Brandt and Kavajez (2004:2623) investigated the process of price discovery and found that almost 30% of the variations in the yields of Treasury securities were explained by order flows for days where no public announcements were made. Similarly, Pasquariello and Vega (2006:1975-2019) also found that in the U.S. Treasury bond market order flow had a significant and persistent impact on changes occurring in bond yields. Their study found similar results for both public announcement and non-public announcement days, with stronger effects during times when public announcements were noisy. These findings, therefore, imply that order flow can explain some variation of yield movements and can be seen as an information aggregator, as it gathers additional information from trading orders and provide insight of market changes.

¹⁰ See for example Green (2004:1201-1233) and Brandt and Kavajecz (2004:2623-2654).

In addition, the study of Lyons (2002:53) explains that, under the information approach (see Figure 3.2), order flow, as an information aggregator, can be divided into three categories that entail public information, dispersed information and a combination of the two (hybrid).

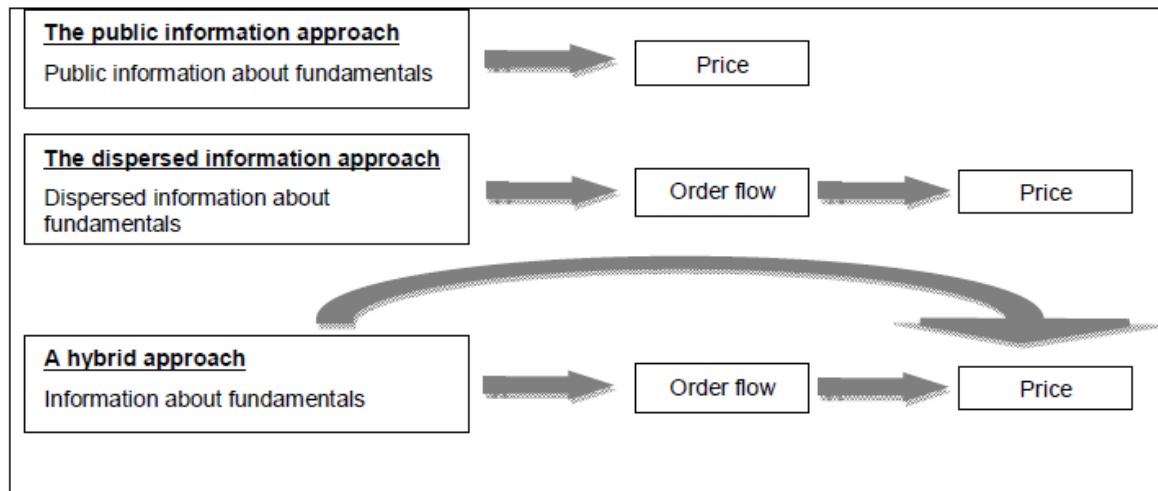


Figure 3.2: Three information approaches for pricing a stock

Source: Lyons (2002:53).

The public information approach states that all information regarding fundamentals is publicly known and is swiftly incorporated into stock prices. As a result it is argued that price adjustments are instant and direct. The dispersed information approach differs from the public information approach in the sense that fundamental information is not publicly known. Fundamental information only becomes noticeable once orders are placed and transformed into order flows, where after it is used as a signal to the price setters, indicating that prices need to adjust. The last information approach represents a hybrid approach, which is a combination of the two previous approaches, as it accommodates information that affects prices directly and indirectly (Lyons, 2002:52-53). A further study by Underwood (2008:25) also analysed how order flow influenced stock prices, with the main objective being to determine whether order flow in one market could influence order flow in another market (cross-market order flow). His study revealed that cross-market order flow was indeed informative of stock returns, which indicated that information in one market could transmit to another market. This phenomenon, where information flows from one

market to another, is called information transmission. The following section provides a brief elaboration on the importance of this phenomenon.

3.2.2 Information transmission

The study by Ong (1997:1) explained that investors use the occurrence of information transmission to their advantage in order to gain additional insight into future price movements in their local market. Investors analyse how stock prices in foreign markets behave upon the arrival of information, as this behaviour might be relevant in their local markets, due to the transmission of information. If the economic fundamentals, which drive the fluctuation in prices in the foreign market, are the same as in the local market it can be expected that fluctuation patterns of prices will be transmitted to the local market (Ong, 1997:1). Once information is transmitted to another market it is believed that stock prices adjust to a new equilibrium level without any time lags (Kao & Wan, 2009:152). However, in real world market conditions, lags occur due to market frictions (for example transaction costs) that contribute to a lead-lag relationship between markets (Kao & Wan, 2009:152). The differences in the reaction time between markets are a key aspect for investors to consider when making investment decisions, as it can lead to price misalignments and thus arbitrage opportunities. Although, in a fully efficient market, all information transmitted from one market to another is instantly incorporated into prices and as a result no price misalignments should occur (Mabhunu, 2004:8). This implies that the level of market efficiency must also be evaluated alongside information transmission to fully understand the possibility of price misalignment, which is discussed in the following section.

To summarise; order flow can be of great significance when evaluating stock price movements and patterns. It can explain some variation of yield movements and can be seen as an information aggregator, as it gathers additional information from trading orders to provide insight of market changes. Also, past evidence has indicated that cross-market order flow is present and can

explain some fluctuations in domestic stock prices, if economic fundamentals are similar to that of the foreign country. Thus, once information is transmitted from the foreign to the domestic country, the domestic country's stock prices will adjust to a new equilibrium level with or without any time lags, depending on the level of market efficiency. The difference between the level of market efficiency within the domestic and foreign country can, therefore, contribute to price misalignment and thus possible arbitrage opportunities. For this reason it is important to investigate market efficiency, which is discussed in the following section.

3.3 THE EFFICIENT MARKET HYPOTHESIS

The Efficient Market Hypothesis (EMH) states that, in an operational efficient stock market, the trading process should be free from frictions (Mabhunu, 2004:1). An efficient stock market should be externally and informatively efficient and all information pertaining to the stock's future cash flows and risk should be incorporated into its price (Reilly & Brown, 2003:57). Hence, stock prices should, at any point in time, be unbiased and reflect all available information related to a specific stock. If all available information is incorporated in a stocks' price its market value will reflect the true value of a stock, which can be calculated as follows (Mahbunu, 2004:25):

$$P_t \cong V_t \equiv \sum_{i=1}^{\infty} \frac{E_t(D_{t+1})}{(1+r)^i}, \quad (3.1)$$

where:

- V_t represents the stock's fundamental value at time t ,
- $E_t(D_t + 1)$ represent the expected dividend,
- r represents the risk-adjusted discount rate relative to the expected risk stream,
- P_t represents the current equilibrium price, and
- i represents the number of traders.

If the value of a stock can be accurately calculated by the above formula, investors can utilise the stock to its maximum, as they know that all information is incorporated in the price (Mabhunu, 2004:25). This will lead to a more competitive market environment where investors are all equal when competing for a particular stock and it will contribute to a more efficient market (Mabhunu, 2004:18). The study of Knie (2010:10) also argues that there are three particular conditions which will contribute to a market being competitive and completely efficient. The first condition is grounded on the fact that investors need to behave in a rational manner. All investors must respond correctly when they encounter new information and all information is instantly incorporated into prices. The second condition analyses investor behaviour and specifies that some stocks are under- or over-valued (Knie, 2010:10). If an investor underestimates the value of a stock, another investor will attach an overestimated value to the same stock and the under- and over-estimated amount will be exactly the same for both investors. This argument, therefore, implies that if under- or over-valued stocks are identified it will simultaneously offset each other, suggesting an efficient market (Knie, 2010:11). The third condition originates from the reasoning that investors aim to identify possible arbitrage opportunities. Some investors in the market have an advantage over the rest of the market participants, as they have access to superior information. In these circumstances investors want to lock-in arbitrage profits by purchasing undervalued stocks and selling overvalued stocks. In order for arbitrage to occur, the market must react to information, which drives prices up and down in such a way that price fluctuations cause price misalignments (Lobo, 2000:1125-1144). Hence, the argument is that once arbitrage occurs it will be offset by the market as investors will exploit the arbitrage opportunity until the market reaches its new equilibrium price, thus eliminating any further arbitrage (Knie, 2010:11).

To summarise; the EMH states that, in an efficient market, stock prices adjust rapidly to the arrival of new information, hence, all available information is captured in that price. However, not all markets have the same level of efficiency, where different levels of information are incorporated

into stock prices, at different speeds and on different exchanges, which can lead to price misalignment. To understand the extent to which information is incorporated into stock prices, it is important to understand the three levels of market efficiency, which are discussed in the following section.

3.3.1 Different levels of the EMH

The study by Fama (1970:382-417) was the first to explain the concept of market efficiency by introducing the concept of a 'fair game model'. This model assumes that investors can be confident that all available information influencing a particular stock is captured in its market price. However, the form and speed of information (historical information, public information and private information) that reaches the market influences the price composition of the stock. The study by Fama (1970:383-417), therefore, divided the concept of the EMH into three distinct groups, based on the level of information absorption in the market. These three groups entail the (i) weak form (Section 3.3.1.2), (ii) the semi-strong form (Section 3.3.1.2) and (iii) the strong form (Section 3.3.1.3), which are discussed in the following sections (see also Figure 3.3).

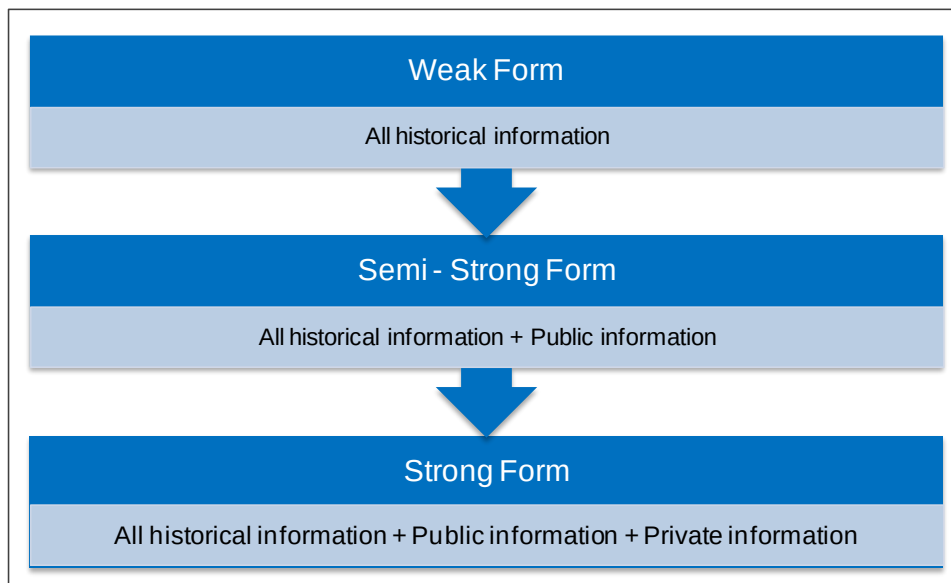


Figure 3.3: Different forms of the EMH

Source: Stråhle (2011:11).

3.3.1.1 Weak form

The most important criterion of the weak form is that all past information is reflected in a stock's price (Knie, 2010:12). This means that today's prevailing price is determined by historical information. Such historical information can include past rates of returns, past trading volume data and other market related information (Reilly & Brown, 2003:178). This implies that technical analysts¹¹ will have a great advantage in a market that exhibits of a weak form efficiency. Literature studies from the mid 1970's suggest that it is possible to use technical analysis to outperform the market. One such study was done by Jammie and Hawkins (1974:43), where they investigated the efficiency of the Johannesburg Stock Exchange (JSE). Their findings suggested that price movements did not follow a random walk (weak form efficient) and therefore they concluded that technical analysis could be used in order to make profits. Studies conducted in the 1980's include those of Sweeny (1986:163-182), who examined the efficiency of the U.S. and Dutch markets and found evidence which indicated that technical analysis could be used to beat the market. During the 1990's similar studies emerged which were against the efficient market hypothesis, as they constructed technical trading rules to beat normal market performance. An example of one such study is the study of Hudson, Dempsey and Keasey (1996:1121-1132), who proved the significant application of technical analysis in the Madrid Stock exchange and the U.K. Stock exchange. Other studies during the 2000's also evaluated the potential of technical analysis to generate abnormal profits. For example, Metaghachi and Chang (2003:433-450) applied a number of moving average rules in their analysis and found that these technical trading rules were profitable in the Taiwanese and the Italian stock markets. Another study by Loh (2007:1003) combined normal trend indicators with confirming indicators which illustrated that technical analysis could be used to gain excess profits in the Japanese, Hong Kong, South Korean and Singapore markets.

¹¹ Technical analysts use statistical and mathematical models to identify signals in the market which will indicate whether to buy or sell a stock.

In addition to the above findings, there are also many contradicting studies which argue that technical analysis cannot be used to predict future prices. For example, the study by Radikolo (2009:5) argued that, if the market is efficient in the weak form, it means that all historical prices movements (trends) are already incorporated into stock prices and as a result it is not possible to use technical analysis to predict future price movements. This statement is also motivated by Goodspeed *et al.* (2009:22), as they explain that technical analysis is of no use as it uses historical price patterns in an attempt to predict future price movements. Sharma and Mahendru (2009:136-144) also tested whether it was possible to gain excessive profits through technical analysis, by evaluating eleven securities that were listed on the Bombay Stock Exchange. The authors found that the use of technical analysis did not reap any profits, as the stock price at the time of this study already incorporated the effects of historical prices. Similar results were found by Dixon (2005:1), as he also stated that the use of common technical trading techniques, filter rules and moving averages were unprofitable in the U.S., U.K. and Japanese markets, especially after accounting for transaction costs. To further elaborate on these findings and the efficiency of markets, the next two sections briefly discuss the semi-strong form (Section 3.3.1.2) and the strong form (Section 3.3.1.3) market efficiency, respectively.

3.3.1.2 Semi-strong form

The semi-strong form states that stock prices are able to adjust rapidly to all available public and historical information (Mahbunu, 2004:7). Public information can include information such as rates of return, trading volumes, dividend announcements, macroeconomic announcements and other company specific announcements (Reilly & Brown, 2003:178). Once information reaches the market and becomes publicly available, traders react on this newly released information, which results in immediate prices adjustments (Knie, 2010:13). Past studies that have observed how stock prices are influenced by macroeconomic announcements events are most commonly linked to the semi-strong form, as this type of news are made publicly available (Mahbunu, 2004:7). One

such study was conducted by Bhana (1989:119), where he analysed the JSE and how it was influenced by public announcements. The results of his study revealed that the stock market did not adjust effectively once the public information was released. The study of Bhana (1989:119) further argued that the stock prices tended to overreact to negative information and that the reaction was significant enough for investors to be able to lock-in arbitrage profits. This study also postulated that the time span of the overreactions tended to differ according to the type of news that was absorbed by the market. Overreactions to positive news was normally short-lived, whereas overreaction to negative news was dragged out over a far longer time period, giving arbitrageurs an even better chance to exploit these price misalignments. In some cases the overreaction to negative news continued for two years after the event (Bhana, 1989:119-128).

In addition to macroeconomic announcements, the study by Bhana (1987:198) also investigated how information regarding takeovers influenced the South African market. His results revealed that the market started to react around 15 days before the announcement of a takeover. This reaction was also significantly visible even 5 days after the announcement, which implied that the market reacted very slowly to this information. The study by Bhana (1987:198) further explained that the visible reaction seen before the announcement date could be as a result of insider trading, which means that the South African market was not efficient in the strong form.

There were also alternative studies, which evaluated the semi-strong form efficiency in the U.S. market by examining how the market would react to company earnings announcements. One such study were conducted by Jones and Bacon (2007:43-48) where they investigated how the market reacted to positive company earnings announcements. Their results revealed that stock prices did adjust rapidly to the positive news, which indicates that the U.S. market was efficient in the semi-strong form. Similar results were also found by Gersdorff and Bacon (2009:69) where they found that the U.S. market reacted swiftly to merger and acquisition announcements,

indicating that the U.S. market is semi-strong efficient. Other studies also investigated whether European markets were efficient in the semi-strong form. One such study was conducted by Gillette (2005:1-77), who revealed that the German market was efficient in the semi-strong form, as the market reacted quickly to announcements and ultimately restricted the possibility of making excessive profits. Furthermore, evidence was found of semi-strong efficiency for the Hungarian market and for the Turkish markets by Mihalev (2002:749-758) and by Yalama and Selik (2008:1), respectively. Other studies, however, turned their attention to the Asian markets as they investigated whether these markets were semi-strong efficient. For example, the study by Gupta (2003:38-59) found that the Indian market was efficient in the semi-strong form, whereas Dhar *et al.* (2008:2) found that the Indian market was not semi-strong efficient.

3.3.1.3 Strong form

The strong form of the EMH entails that all available information (historical, public and private information) are reflected in a stock's price (Mabhun, 2004:8). The study by Dimson and Marsh (1984:1257-1292) tested the validity of the strong form hypothesis, as they analysed a sample of 200 companies listed on the British capital market. Their results indicated that the forecasted returns did not correlate with the actual realised returns, indicating that analysts were unable to predict future price movements. Another study by Cjekaz *et al.* (2001:133) investigated the efficiency of the Warsaw Stock Exchange (Poland) and found that, although sensitive information was available to fund managers, they were not able to achieve abnormal returns, which supported the hypothesis that the Warsaw Stock Exchange was efficient in the strong form.

In addition to the above findings, other studies were more concerned about the efficiency of the disclosure of information rather than the pricing efficiency of a stock. For example, the study by Lakonishok and Lee (2001:79-111) investigated how informed insider trades really were. Their results revealed that insiders' trading activities allowed some degree of predictability of future

price movements, which can be explained as follows. Firstly, in order to earn abnormal returns, insiders must have access to information, which is not released to the market. Secondly, it might be that all inside (private) information is released to the market, however, there is a time lag in the speed in which the market incorporates this information in its stock price. It is, therefore, possible to take advantage of this time lag, as investors can insert a trade before the market reaches its new equilibrium price (Knie, 2010:14).

To summarise; from Section 3.2.2 the presence of cross-market order flow has been confirmed, which implies that, with similar macroeconomics fundamentals, order flow from the foreign market can influence the domestic market's stock price. Although, the level of efficiency of each market (the level in which information is absorbed) will also contribute to the speed and to the level to which prices adjust. From this section it is evident that the South African stock market is at best semi-weak form efficient, thus emphasising that stock prices will not adjust rapidly, leading to the possibility of obtaining abnormal profits. As an investor of dual-listed stocks it is also imperative that both markets, in which the stocks are listed, do not possess the same level of market efficiency in order for arbitrage opportunities to develop. However, the goal of this study is not to determine the level of market efficiency, but to determine the possibility of arbitrage opportunities that may develop with new public announcements. This implies that this study focuses more on the stock price volatility that will develop with the introduction of new information. This leads to the next section that elaborates on the impact of new information on stock price volatility.

3.3.2 The effect of information on stock price volatility

The study by Clark (1973:135-156) was the first to conduct research regarding the relationship between information and volatility, where he found that information was an underlying variable which drove stock price volatility. This statement is also supported by the study of Bala and Premarante (2002:6), who claimed that volatility can be used to measure the degree of stock price

fluctuations once new information enters the market. Moreover, the impact of new information can be further evaluated from a micro and macro level, whereas micro level focuses on the effect, such as company earnings announcements on stock prices volatility and macro level focus on the effects, such as interest and inflation rates on stock price volatility (Nguyen, 2010:2). One of the earliest studies, which analysed how company earnings announcements influenced stock price volatility, was conducted by Beaver (1968:67-92). His study specifically focused on how the stock prices reacted to annual earnings announcements and found that stock price volatility tended to increase during the time of the announcement. These results were confirmed by Patel and Wolfson (1984:223) as they investigated how earnings and dividend announcements influenced volatility levels and revealed that significant spikes in volatility were evident once new information was released to the market. A similar study by Landsman and Maydew (2001:797-808) analysed how quarterly earnings announcements affected stock prices and found that stock price volatility were higher during the time of the announcement. A more recent study by Afego (2011:17) also conducted a similar investigation on how earnings announcements influenced stock price movements and found that stock price volatility started to increase even before the announcement took place.

In addition, other authors such as Ederington and Lee (1993) turned their focus away from micro level variables and evaluated how macro level variables influenced stock price behaviour. The study by Ederington and Lee (1993:1161) investigated what impact macroeconomic news announcements, such as inflation, had on local markets and found that volatility levels tended to be lower at times leading up to announcements, while spikes of volatility were still evident even after the announcement had taken place. Furthermore, a more comprehensive study was conducted by Boyd *et al.* (2005:649–672), where they tested how various macroeconomic announcements influenced stock prices and found that news about growth expectations, risk-free

rate of interest and equity risk premiums were the three factors which caused the most fluctuations (volatility) in stock prices.

Besides the findings as discussed above, some authors argue that macroeconomic announcements can be further analysed by classifying these announcements into two groups, namely: scheduled and unscheduled announcements. The study by Ederington and Lee (1996:513-539) investigated how scheduled macroeconomic announcements influenced volatility levels in stock option markets and found that volatility had started to increase prior to the scheduled announcements, where market participants could anticipate the information. Similar results were found by Campbell and Lewis (1998:1) as their results concluded that the market could predict the information, causing volatility to increase prior to the announcement. Results by Ellerman and Wallestam (2007:1) also indicated that, although stock price volatility had started to adjust prior to the scheduled macroeconomic announcements, the lasting effect of this adjustment was normally short-lived as most of the price adjustments (volatility) occurred directly after the announcement took place. On the other hand, different results for unscheduled macroeconomic announcements were observed as previous empirical results indicated that volatility did not tend to increase prior to the announcement. The empirical results from the study of Ederington and Lee (1996:513-539) explained that higher levels of volatility, together with more persisting trends, were visible after the announcement was made. This evidence is supported by Bomfim (2003:133-151), where he argues that unexpected macroeconomic announcements cause a significant increase in volatility after the surprise announcement has taken place.

Other authors such as Belgacem and Lahiani (2012:1-21) also examined what impact macroeconomic announcements had on domestic and foreign markets. Their study investigated how U.S. macroeconomic announcements influenced the French and German markets and found that the information captured within the U.S. announcements would influence not only the volatility

levels in the U.S. market but also in the two European markets (Belgacem & Lahiani, 2012:1-21). Their results, therefore, confirmed that information transmission was present between these three markets and that the presence of co-movement could be regarded as the main underlying factor which allowed information, captured within U.S. announcements, to influence stock price volatility on the two European markets. From these findings the conclusion can be made that the presence of co-movement can have a significant effect on the degree in which new information can influence stock markets, especially with the increase in market integration (Berben *et al.*, 2005:833).

To summarise; this section provided some evidence which indicate that there is a relationship between information and volatility. Moreover, this section also confirmed that new information released through public news announcements would cause stock price fluctuations. As a result it can be argued that information is regarded as one of the main drivers behind stock price volatility. Further findings suggest that the relationship between information and volatility should not be restricted to the domestic market as information transmission occurs between international markets. This implies that information can influence volatility in both the domestic and foreign market. This section also provided evidence which confirmed that co-movement can influence the degree of information transmission and established that international markets can also influence each other. This leads to the next section where a further elaboration on co-movement and the various factors which drive the level of co-movement is given.

3.4 STOCK MARKET CO-MOVEMENT¹²

Over the past 25 years, correlation patterns between international stock markets have increased considerably as a result of more integrated markets¹³, increased financial innovations, advanced communications methods, globalisation and the liberalisation of capital controls (Berben *et al.*, 2005:833). The studies by Lee and Kim (1993:89-102), Karolyi and Stultz (1996:951-986) and Forbes and Rigobon (2002:2223-2261) argue that correlation patterns between equity market change over time and can become stronger and weaker depending on the forces which drive co-movement. According to the study by Pauldof (2011:5) stock market co-movement is driven by two main factors, namely fundamental and behavioural factors. Fundamental factors include bilateral trade linkages and contagion effects¹⁴, with the former referring to an environment where two countries depend on each other for trade, which increases the level of interdependence between markets (Pretorius, 2002:91). This implies that sound bilateral trade linkages between countries can increase the degree of co-movement between those countries' stock markets (Pretorius, 2002:91). The study by Holden (2003:2) explains that from a trade perspective, an economic union is considered as the most advanced form of economic integration, due to the fact the member countries are required to partake in trade agreements and complement each other's economic environment. This argument is emphasised by Holden (2003:2), who supports the findings of an earlier study by Pretorius (2002:91), where it was argued that a higher degree of co-movement was visible between union countries.

¹² Stock market co-movement refers to the tendency of two stock markets to move together in a similar fashion, which indicates that their price movements are positively correlated (Poldauf, 2011:3).

¹³ When markets are integrated it means that the underlying fundamentals influencing stock prices in one market will also influence the stock price in the other market (Werner & Kleidon, 1996:20).

¹⁴ Contagion can be defined as an increase in the correlation levels of international stock markets during times of financial unrest (Bonfigliolo & Favero, 2005:1003).

The second factor that drives co-movement, namely contagion, occurs when two international stock markets are averagely correlated during times of financial stability and as financial stress increases, so does the level of correlation (Bonfigliolo & Favero, 2005:1003). The study by Goldstein (1998:1-77) labelled this event as the 'wake-up call' phenomenon where an investor's investment view could be influenced during times of a financial crisis. The reasoning behind this statement is as follows: assuming an investor has invested in countries A, B and C where countries B and C share a common weakness with country A. If a crises occurs in country A, investors might feel that they need to reassess their views which they have on country B and C, as the crisis originating in country A can spread to country B and C (Goldstein, 1998:1-77). Hence, investors might lose confidence in their investments and withdraw their investments from country A, B and C, which will result in all three countries experiencing the same deteriorating trends, causing co-movement (Goldstein, 1998:1-77). The 'wake-up call' phenomenon as explained by Goldstein (1998:1-77), directly relates to investor's behaviour as it shows that the behaviour of investors can influence stock market co-movement which is linked to the second driver of co-movement, namely behavioural factors.

The study by Poldauf (2011:8) argues that investor behaviour, such as herd behaviour, is a possible cause of stock market co-movement. Herd behaviour can be defined as a situation where an investor's decision-making process is influenced by the actions of other investors (Bikhchandani & Sharma, 2001:280). For example, smaller investors argue that bigger investors have access to better information and as a result they try to emulate the actions of bigger investors, thus causing co-movements (Poldauf, 2011:8). Yan (2009:1) has confirmed that herd behaviour can cause co-movement between two stock markets and that there is a strong positive correlation between herd behaviour and stock price volatility. From these finding a conclusion can be drawn that co-movement between stock markets can trigger the effect of volatility spill-overs (Pretorius, 2002:90). In order to elaborate more on the theory of stock market co-movement the

next section reports on past empirical studies which found evidence of co-movement between different market types.

3.4.1 Historical studies on stock market co-movement

This section commences by firstly investigating the presence of a co-movement between developed and developing/emerging markets (Section 3.4.1.1), after which co-movement between developing markets (Section 3.4.1.2) and between developed markets (Section 3.4.1.3) is discussed.

3.4.1.1 Co-movement between developed and developing markets

The study by Eun and Shim (1989:241-256) incorporated a Vector- Autoregressive (VAR) model to investigate the degree of co-movement between five developed¹⁵ and one developing¹⁶ markets and found that these markets did co-move. Another study used the Johansen (1991) cointegration analysis and found evidence of strong co-movement between the U.S. and East Asian markets (Chung & Liu, 1994:259). Similar results were also found by Masih and Masih (1997:74), who used the Johansen (1991) cointegration analysis to confirm the presence of co-movement between Germany, Japan, Singapore, South Korea, Taiwan, U.K. and the U.S. markets. Additionally, by applying both the Johansen (1991) cointegration analysis and a VAR model, Chinzara and Azaikpono (2009:115) found evidence of co-movement between the South African, German, U.S. and U.K. markets.

Alternative models have also been used, for example, Darrat and Benkato (2003:1089-1114) estimated the Johansen and Jesulius (1990) cointegration analysis together with a Generalised Auto Regressive Conditional Heteroskedasticity (GARCH) model to test for the presence of co-

¹⁵ The developed markets include Australia, Japan, U.S., U.K. and Switzerland.

¹⁶ The developing market includes China.

movement. Their results revealed that strong co-movement existed between the Turkish market and developed markets, like the U.S. and Japan. Another study which made use of an unconventional model was conducted by Boujir and Lahrench (2008:113-123), where they incorporated a Dynamic Conditional Correlation GARCH (DCC-GARCH)¹⁷ model which revealed that there was limited co-movement between the U.S. and Moroccan markets.

3.4.1.2 Co-movement between developing/emerging markets

With the estimation of a Johansen (1991) cointegration test, Ratanapakorn and Sharma (2002:108) found evidence of co-movement that was present between Latin American and Asian countries. Identical results were also found by Floros (2005:178) who applied a Granger causality model which revealed that co-movement was present between Latin American and Asian countries. Other studies investigated if Latin American countries¹⁸ and African countries¹⁹ co-moved together. For example, Aligidede (2009:11) applied the Johansen (1991) cointegration analysis and found little evidence to indicate that co-movement was present between Latin American countries²⁰ and African countries²¹.

There are also many other studies which specifically investigated the co-movement effect between African countries. One such study was conducted by Agathee (2008:17), where he used the Johansen (1991) cointegration analysis to reveal that Mauritius, Botswana, Namibia, South Africa, Zambia and Zimbabwe did co-move. A similar model was used by Onour (2009:11) who found results which indicated that co-movement was present between Morocco, Egypt and

¹⁷ A Dynamic Conditional Correlation-GARCH model is a multivariate GARCH model together with parsimonious parametric models for the correlation present (Engle, 2000:11).

¹⁸ These countries include Brazil and Mexico.

¹⁹ These countries include South Africa, Egypt, Nigeria and Kenya.

²⁰ These countries include Brazil and Mexico.

²¹ These countries include South Africa, Egypt, Nigeria and Kenya.

unisia. Evidence of co-movement between Egypt, Kenya, Mauritius, Morocco, Nigeria and Zimbabwe were also found by Biekpe and Collins (2003:194)²².

3.4.1.3 Co-movement between developed markets

The study by Taylor and Tanks (1989:265-272) used the Engle and Granger (1987) co-integration tests to determine if co-movement existed between the U.K., U.S., Netherlands, Japanese and German stock markets. By analysing monthly stock market indices they found that a long-run co-moving relationship was present between these markets. Similar results were also found by Koutmos and Booth (1995:747-762), where they used a Multivariate EGARCH (MGARCH) model that revealed that co-movement was present between the U.S., U.K and Japanese stock markets. These results were confirmed by Hassan and Naka (1996:387-405), where they used the Johansen (1991) cointegration analysis together with a VEC model to confirm that there was a strong degree of co-movement between the U.S., U.K and Japanese stock markets. There were also additional studies that investigated whether co-movement existed between the U.S. market and the European market. One such study was conducted by Meric and Meric (1997:152) who used the Johansen (1991) cointegration analysis to test for co-movement between the U.S. market and twelve European markets²³, and found that co-movement was present between these markets. By using a VEC approach, Bonfiglioli and Favero (2005:1316) also revealed that co-movement existed between the U.S. and German market. These results were verified by Meric *et al.* (2008:177), as they used Granger causality tests together with Principle Component Analysis (PCA)²⁴ to confirm that the U.S., U.K., German and French markets did co-move.

²² The study by Biekpe and Collins (2003:194) used a Pearson correlation analysis to test for co-movement.

²³ These markets include: Austria, Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland and the U.K.

²⁴ PCA is a mathematical procedure that can transform correlated observations into uncorrelated variables, called principle components (Pearson, 1901:560).

To summarise; this section provided the necessary evidence to indicate that co-movement is present between international markets and that it is mainly driven by fundamental and behavioural factors, as already mentioned in Section 3.4. Additionally, findings from this section indicate that there are stronger and weaker levels of co-movement which supports the conclusion made in Section 3.3.2, that co-movement can be influenced by the degree of information transmission. This statement together with the fact that information transmission can influence volatility in both domestic and foreign markets (see Section 3.3.2) confirm that co-movement can facilitate volatility spill-overs. To further elaborate on this topic, the next section discusses the concept of the volatility spill-overs.

3.5 VOLATILITY SPILL-OVERS

The study by Chen *et al.* (1986:300) postulates that volatility spill-overs have a direct influence on stock prices movements. This statement is confirmed by the study of Xiaoqing and Hung-Gay (2002:563), who found evidence that volatility spill-overs could cause fluctuations in dual-listed stock prices. Also, their study revealed that these volatility spill-overs could lead to the violation of the single market hypothesis²⁵, which would result in the misalignment of dual-listed stock prices and possible arbitrage opportunities. However, before the concept of arbitrage can be further exploited it is necessary to first investigate the presence of volatility spill-overs among different countries. This leads to the next section which reports the findings of past empirical studies.

3.5.1 Historical studies on volatility spill-overs

This section begins by firstly investigating if volatility spill-overs occur between developed and developing/emerging markets (Section 3.5.1.1), after which the presence of volatility spill-overs

²⁵ See Section 3.3

between emerging markets (Section 3.5.1.2) and between developed markets (Section 3.5.1.3) are determined.

3.5.1.1 Volatility spill-overs between developed and developing/emerging markets

The study by Park and Fatemi (1993:49) analysed the volatility spill-over effect between Pacific-Basin countries²⁶, the U.S., the U.K. and Japan. By using a VAR model their results revealed that volatility spill-overs were present between most of these countries. These results were supported by Janakiramanan and Lamba (1998:155) and Ng (2000:207), where both studies also found the presence of spill-overs between these markets. Furthermore, they found that the U.S. market were the most influential market, where most of the volatility originated in the U.S. and spilled over to the other markets.

Alternative models have also been used to test for the presence of volatility spill-overs. For example, the study of Lee (2004:12) used a variance decomposition model to establish the presence of volatility spill-overs between Japan, Germany, India and the U.S. Other studies, like Chinzara and Aziakpono (2009:119), applied a GARCH model to found evidence of volatility spill-overs between South Africa and Australia. The study by Tastan (2005:17), however, argued that a DCC-GARCH model was more superior to a standard GARCH model, as it was also able to determine the extent to which the Turkish, Australian, Chinese and U.S. markets were interrelated by taking into account the time-varying variance-covariance structure. His results revealed that volatility spill-overs were present between these markets, with the U.S. market being the most dominant (Tastan, 2005:17).

²⁶ These countries include: Singapore, Hong Kong, Thailand, New Zealand, Australia and Korea.

3.5.1.2 Volatility spill-overs between developing/emerging markets

By applying a VAR model, Liu and Pan (1997:47) revealed that volatility spill-overs did occur between Japan and other Asian-Pacific markets²⁷. The presence of volatility spill-overs between Asian markets²⁸ were confirmed by Sheng and Tu (2000:346), after estimating a variance decomposition model. Similar results were found by Kim *et al.* (2001:87-96), where the evidence from the EGARCH model illustrated that volatility spill-overs occurred between Japan, Korea and Thailand. These results were also confirmed by Worthington and Higgs (2004:80) and by Sola *et al.* (2002:77), who used a GARCH model and a bivariate Markov switching model, respectively, to confirm the presence of volatility spill-overs between the Asian-Pacific countries²⁹.

Other studies also examined the volatility spill-over effect between African countries. One such study includes Lamda and Otchere (2001:25), who used a VAR model to confirm the presence of volatility spill-overs between South Africa and Namibia. By using an Exponential GARCH (EGARCH) model, Piesse and Hearn (2005:53) also found evidence of volatility spill-overs among Sub-Saharan Africa markets³⁰, with South Africa and Nigeria being the most dominant and influential markets (Piesse & Hearn, 2005:53).

Additional studies also investigated whether volatility spill-overs were present between European markets. One such study includes Booth *et al.* (1997:817), who used an EGARCH model to establish whether volatility spilled over from one European stock market to the next. Their results revealed that moderate volatility spill-overs did occur between the Danish, Finnish, Swedish and Norwegian markets. Furthermore, by applying a VAR-GARCH and a constant correlation MGARCH model, Scheicher (2001:27-39) found that volatility spill-overs were also visible

²⁷ These countries include Hong Kong, Japan, Singapore, Taiwan and Thailand.

²⁸ These markets include Bangkok, China, Kuala Lumpur, Singapore, Taiwan and Thailand.

²⁹ These countries include Indonesia, Korea, Malaysia, the Philippines, Taiwan, and Thailand.

³⁰ These markets include Botswana, Namibia, Nigeria and South Africa.

between Hungary and Poland. Similar results were found by Berbecaru (2008:41), where a component GARCH model was used to confirm that volatility spill-overs were present between Bulgaria and Romania.

3.5.1.3 Volatility spill-overs between developed markets

There are a number of authors who have indicated that volatility spill-overs are present between some of the world's most dominant markets. For example, Eun and Shim (1989:241-256) incorporated a VAR and impulse response analysis in their study to reveal that volatility spill-overs were present between Australia, Japan, Germany, France, U.S. and the U.K. A similar study was conducted by Hamao *et al.* (1990:281), who used an Autoregressive Conditionally Heteroscedasticity (ARCH) model to reveal that volatility spill-overs were present between U.S., U.K. and the Japanese markets. The results found by Hamao *et al.* (1990:281) were confirmed by Lin *et al.* (1994:507-538), where they used a GARCH model to conclude that significant spill-overs were present between these three markets.

By incorporating an EGARCH model, Koutmos and Booth (1995:762) also found that volatility spill-overs did occur between the U.K., U.S. and Japanese markets. They further proposed that the EGARCH model should be used when evaluating the effect news events could have on volatility spill-overs. The reason for this notion is that, unlike the general GARCH model, the EGARCH model allows for news to have a larger impact on volatility and it determines if good or bad news had the most influential effect (Engle & NG, 1993:1753). A later study by Booth *et al.* (1997:817) also used an EGARCH model to conclude that volatility spill-overs were present between the Danish, Swedish, Finnish and Norwegian markets.

In addition, other studies used alternative models to the EGARCH model, such as the Multivariate GARCH (MGARCH) model, to determine the presence of volatility spill-overs between markets.

For example, Theodossiou *et al.*, (1997:220) verified that volatility spill-overs did occur between the U.K., U.S. and Japanese markets. By using a similar MGARCH model, Colavecchio and Funke (2008:647) also confirmed the presence of volatility spill-overs between China and seven Asian countries³¹.

To summarise; this section provides evidence from past empirical studies which confirmed that volatility spill-overs did occur between international markets. This further justifies the notion that one market's volatility can influence another, which can ultimately lead to the violation of the single market hypothesis. This implies that a dual-listed stock, which is listed on two different exchanges can have different prices during a certain time horizon, therefore, implying the presence of price misalignment and the possibility of acquiring arbitrage opportunities during that time period. This leads to the following section, which elaborates more on the concept of arbitrage from an investor's perspective.

3.6 ARBITRAGE THEORY

The EMH (Section 3.3) assumes that investors can identify mispriced stocks and implement trading strategies which will allow them to trade profitably for a short time period. This type of trading strategy is known as arbitrage, where investors can take advantage of price misalignments by simultaneously buying and selling the same asset (Koch & Macdonald, 2003:866). The most common arbitrage strategy involves multi-market trading, where stocks are traded across borders. Dual-listed stocks are an example of multi-market trading, as these stocks are traded across different international exchanges (Marx *et al.*, 2006:25). Several historical studies confirmed the presence of arbitrage opportunities between dual-listed stocks. For example, Jorion and Schwartz (1986:603-614) indicated in their study that arbitrage opportunities were present between

³¹ These countries include Hong Kong, Indonesia, Malaysia, Philippines, Singapore, South Korea and Taiwan.

Canadian and U.S. dual-listed stocks. Similar results were found some years later by Ip and Brooks (1996:53) and by Eun and Sabherwal (2003:549), who confirmed that some Canadian and U.S. dual-listed stocks were misaligned, leading to arbitrage opportunities. Other studies also found evidence of arbitrage between U.S. and London dual-listed stocks (Froot & Dabhora, 1995:189-216), as well as between the U.S. and Mexican markets (Domowitz *et al.*, 1995:1059-1085).

However, arbitrage is not limited to dual-listed stocks only, as other authors indicated that arbitrage opportunities could also arise within different financial environments. For example, arbitrage opportunities can arise from company mergers and acquisitions, which involves capturing the spread between the price paid for the takeover company before the merger or acquisition and the price at which the takeover company trades after the deal has been made. In this situation the arbitrageur buys the stocks of the main takeover company and in order to lock in the spread sells the stocks of the acquiring company (Baker & Savasoglu, 2002:1). Furthermore, arbitrage can also be present in the bond market, where investors can have convertible bonds that provides the bondholder the option to exchange the bond for company shares (Choi *et al.*, 2009:227). Investors can identify mispriced convertible bonds and exploited them by taking a long position³² in the undervalued convertible bond and at the same time having a short position³³ in the equity (Choi *et al.*, 2009:227).

To summarise; the findings discussed above indicate that the single market hypothesis (Section 3.5) does not always hold true and that arbitrage opportunities can be present. However, although

³² A trader will take a long position if he wants to purchase a stock with the expectation that the stock's price will rise in the future (Marx *et al.*, 2008: 223).

³³ A trader will take a short position in a stock if he expects that the stock's price will fall in the future, which will enable him to buy the stock at a lower price (Marx *et al.*, 2008:222).

arbitrage opportunities can exist there are also some limitations involved with arbitrage trading (Liebenberg, 2011:44) which must still be discussed. The next section identifies some of the limitations involved with arbitrage trading.

3.6.1 Limitations of arbitrage trading

Arbitrageurs identify arbitrage opportunities and try to profit from them without taking on too much risk (Koch & Macdonald, 2003:866). Although, Bentum (2009:9) argued that if there were no risk or limitations involved with arbitrage, then all arbitrage opportunities would be exploited instantly without any lags. However, this is not the case as Bentum (2009:9) provides examples where mispricing has persisted over time. One well known example of persisting mispricing includes the merger between Royal Dutch Petroleum Company (Royal Dutch) and Shell Transport Trading Plc (Shell) during the early 1900's. The two companies agreed on a 60:40 merger, which would result in an increase in the market value of Royal Dutch, 1.5 times the value of Shell. However, this was not the case as prices persistently diverged away from parity, as Royal Dutch traded at a 30% discount during the 1980's and at a 15% premium during the 2000s (Froot & Dabora, 1999:189-210). Hence, when Royal Dutch traded at a discount arbitrageurs were able to buy Royal Dutch stocks and sell the Shell stocks (Bentum, 2009:8). Nonetheless, if arbitrage trading was this simple and riskless, then all arbitrageurs would have taken a position and instantly lock-in a profit. This would cause the demand for the stock to increase, causing the stock price to move back to its fundamental value, leaving no persisting trends. Although, as indicated in the example of Royal Dutch and Shell, mispricing can persist over time which justifies the argument that there are limitations to arbitrage trading (Bentum, 2009:4). These limitations include transaction costs (Section 3.6.1.1), time zones (Section 3.6.1.2), execution risk (Section 3.6.1.3), fundamental risk (Section 3.6.1.4), noise trader risk (Section 3.6.1.5), synchronisation risk (Section 3.6.1.6) and liquidity risk (Section 3.6.1.7), which are discussed in the following sections.

3.6.1.1 Transaction costs

Transaction costs is probably the most obvious limitation involved with arbitrage trading, as these costs influence the attractiveness and profit potential of the trade (Bentum, 2009:14). One example of transaction costs is brokerage fees, where brokers charge a fee for assisting investors and providing them with additional information regarding a specific trade (Olkkonen, 2009:14). If the brokerage costs is too high it will prevent arbitrageurs to take full advantage of misaligned prices (Olkkonen, 2009:14).

3.6.1.2 Time zones

Timing differences between markets can also be seen a limitation to arbitrage (Gagnon & Karolyi, 2004:10). Different time zones of markets are likely to influence arbitrage trades as some stock markets might be open and others closed at a specific point in time. This implies that overlapping trading sessions of markets will make it easier for a trader to engage in arbitrage, as stocks are simultaneously priced on both markets. However, as a result of different time zones and trading sessions some delays in global markets occur as market prices adjust to new information, thus limiting arbitrage trading (Gagnon & Karolyi, 2004:11).

3.6.1.3 Execution risk

An arbitrage strategy involves the simultaneous buying and selling of misaligned stocks (Koch & Macdonald, 2003:866). These stocks are traded on electronic platforms where prices are fully observable and traders know exactly at what price a stock trades (Perlin *et al.*, 2010:2). Due to technological innovations, such as advanced computer software, the speed at which trading takes place has increased considerably which allows arbitrageurs to exploit arbitrage opportunities in a millisecond (Kozhan, 2011:2). This increases the competitiveness in the market as arbitrageurs have less time to execute a trade, while at the same time competing against other arbitrageurs for the same arbitrage opportunity. This poses a risk for an arbitrageur, known as execution risk,

where a situation arises in which one leg of an arbitrage trade remains open while the other part is closed (Kondor, 2009:632). The result of this will be that an arbitrageur will move from a once profitable position to an inevitable loss position due to the failure to execute the trade (Kondor, 2009:632).

3.6.1.4 Fundamental risk

Fundamental risk is described as the risk which arises when bad news (information) arrives to the market after a stock purchase has been made (Herschberg, 2012:15). The risk for an arbitrageur is that bad news can drive mispriced stock prices in the wrong direction before the arbitrageur can close out his arbitrage strategy. This risk can be eliminated by taking an opposite position in a similar stock, known as a substitute stock (Wurgler & Zhuravskaya, 2002:583-608). However, finding a perfect substitute in the market is very difficult and therefore it is almost impossible to completely remove fundamental risks (Wurgler & Zhuravskaya, 2002:583-608).

3.6.1.5 Noise trader risk

Past historical studies, such as De Long *et al.* (1990:703:738), recognised that not all investors made rational investment decisions when it came to their investments. They argued that investors could be broken down into two groups, namely rational and irrational investors. Rational investors are investors which make calculated investment decisions according to their rational expectation of asset returns, while irrational investors make uninformed and irrational investment decisions (Perlin *et al.*, 2010:4). These irrational investors are referred to as noise traders³⁴, as they react irrationally to new information with the expectation of gaining an edge over other investors. The risk with regards to noise traders is that stock prices will fluctuate and deviate away from its fundamental value (Grant, 2007:11). This deviation in stock prices is driven by the pessimistic or

³⁴ Noise traders do not use fundamental data to make investment decisions and generally seem to make their investment decision by observing security price movements (De Long *et al.*, 1990:707).

optimistic behaviour of noise traders and can put an arbitrageur at risk (De Long *et al.*, 1990:705). For example, suppose noise traders today are pessimistic about a stock and has driven its price down, arbitrageurs who are buying the stock must bear in mind that noise traders might become even more pessimistic tomorrow and drive prices even lower. The risk for the arbitrageur is that he might incur a loss if he has to liquidate before prices revert back to their fundamentals (De Long *et al.*, 1990:705). On the other hand, an arbitrageur who wants to sell a stock short while optimistic noise traders have pushed prices up must keep in mind that noise traders might have a more optimistic view tomorrow, driving prices even higher. The arbitrageur must take this into consideration and take a position in the stock which will account for the risk when he has to buy back the stock (De Long *et al.*, 1990:705). This will put the arbitrageur's investment strategy at risk and could eventually suffer a loss (Bentum, 2009:9).

3.6.1.6 Synchronisation risk

Synchronisation risk originates from the uncertainty of not knowing when the market will correct itself (Grant, 2007:14). Even though the market reveals possible arbitrage opportunities, the trader does not know when equilibrium prices will be reached and as a result is faced with synchronisation costs (Perlin *et al.*, 2010:4).

3.6.1.7 Liquidity risk

Shleifer and Vishny (1997:50) define liquidity risk as the risk that develops due to the inability of a trader to provide additional capital when needed. If a trader uses leverage strategies³⁵ to gain more profits and is subjected to margin payments³⁶, a situation may occur where the trader may run out of capital to be paid into the margin account. For example, a trader of dual-listed stocks

³⁵ Leverage strategies are strategies which allows an investor to gain an economic exposure which is greater than the investors' initial capital (Goodspeed *et al.*, 2009:480).

³⁶ Also referred to as a margin call and occurs when the cash balance required from a trader is not adequate anymore and a request for extra margin (cash) is needed (Hull, 2008:530).

who buys a dual-listed stock in one market and sells a dual-listed stock in another market is also confronted by liquidity risk. This risk can arise when there are no buyers for the stock which the trader wants to sell, which will leave the trader in an open position and that can result in a loss (Kondor, 2009:633).

To summarise; arbitrageurs want to take advantage of misaligned prices and use arbitrage trading to lock-in profits. Theoretically this seems like a straight forward and easy achievable strategy in which arbitrageurs can have no risk and still produce profits. However, arbitrageurs are constantly faced with limitations and risks which restrict the size of the arbitrage opportunity. With the use of empirical analysis it may be possible to measure the size of the arbitrage opportunity, which is discussed in the next section.

3.7 CHAPTER SUMMARY

The main goal of this study is to examine how information released through public news announcements influences dual-listed stock prices and whether it generates arbitrage opportunities. To assist in achieving this goal, this chapter examined the effect which information can have on stock prices. However, in order to understand how information influences stock prices, knowledge of information transmission and market efficiency was required. This chapter, therefore, started by explaining the two concepts of order flow (Section 3.2.1) and information transmission (Section 3.2.2). These two sections highlighted that new information which originates in the local market is able to flow over to foreign markets through the transmission effect. This entails that stocks, in both the local and foreign market, need to incorporate this new information into its prices and adjust accordingly. The speed at which these prices incorporate new information into stock prices is directly linked to market efficiency. The EMH (Section 3.3) has been able to provide more detail regarding the efficiency at which markets incorporate new information into stock prices and has concluded that not all markets have the same level of

efficiency. When markets have different levels of efficiency the chances of price misalignments are bigger, which implies the possibility of short-term arbitrage opportunities.

The EMH, therefore, gives valuable insight on how swiftly new information is incorporated into prices, but it does not explain what affect information has on stock price movements (volatility).

To bridge this gap, Section 3.3.2 explained that information is the main driver behind stock price fluctuations, indicating that there is a clear relationship between information and stock price volatility. This section further indicates that this relationship should not be restricted to the local market, since information originating in domestic markets can also influence stock prices in foreign markets (information transmission). Both the domestic and foreign stock prices can react to the same information and it is, therefore, possible that both dual-listed stocks on the different exchanges can have more or less the same reaction. If this is the case it might be possible that the two different markets can co-move. Hence, information transmission can be considered as one of the main drivers of co-movement and this, together with the conclusion made that information can influence volatility, justifies the notion that co-movement can contribute to volatility spilling over from the domestic market to the foreign market (Section 3.5). This phenomenon is called the volatility spill-over effect which can cause fluctuations in stock prices and can even lead to the violation of the single market hypothesis. If the single market hypothesis does not hold true it means that the prices of two identical stocks, such as dual-listed stocks, will not be the same. Theoretically, it will lead to arbitrage opportunities in which arbitrageurs will look to make a risk-less profit by buying the stock at the lower price and selling it at the higher price. However, to prove that arbitrage opportunities are present between dual-listed stocks it is necessary to do an empirical investigation. The next chapter discusses the empirical methods which were applied to determine if arbitrage opportunities did exist between dual-listed stocks during public announcement events.

CHAPTER 4

METHODOLOGY

4.1 INTRODUCTION

The focus of this study is to investigate how international public announcements influence dual-listed stock prices. The use of dual-listed stocks provides a unique opportunity to investigate how a stock that is listed on two different markets reacts to the release of new information. Once new information enters the market, stock prices might potentially start to fluctuate (causing volatility) as it incorporates the information, where after the price might reach a new equilibrium level. It is during this fluctuation period that a situation may arise where the dual-listed stock prices are not perfectly aligned, violating the single market hypothesis³⁷. The violation of the single market hypothesis entails that the dual-listed stock will trade at two different prices in the two markets, giving rise to possible arbitrage opportunities (Angelini & Guazzarotti, 2010:5). The aim of this study is, therefore, to examine the possibility of price misalignments caused by international public announcements. This examination will be in the form of an empirical study, where the Anglo American Plc. dual-listed stock, listed on both the JSE and LSE, will serve as the investment proxy. The empirical study³⁸ will comprise of two chapters, where this chapter will discuss the methodology and Chapter 5 will report the results found.

The first step of the empirical study will be to analyse the data that will be used during the empirical investigation (Section 4.2). This entails elaborating on the different public announcement proxies under investigation, the timeframe of each announcement and a data screening process, which

³⁷ The single market hypothesis states that dual-listed stocks must have the same price regardless of its trading location (Ip & Brooks, 1993:53).

³⁸ The empirical study will be performed by using the EViews 7 econometric software (QMS, 2007).

will discuss the descriptive statistics, as well as the level of integration/stationarity of each announcement period (Section 4.2.1). The next step will be to consult the Johansen (1991) co-integration test (Section 4.3), which will identify if there is a long-run co-moving relationship present between the two markets. The presence of co-movement will imply that markets are closely linked, increasing the likelihood of a possible volatility spill-over effect, where a shock occurring in one market can spill-over to another market (Ali *et al.*, 2011:396). In order to establish whether volatility spill-overs are present, it is necessary to consult the Exponential GARCH (EGARCH) model (Section 4.4), as well as the Granger causality test (Section 4.5). The EGARCH model will be able to verify the presence of a volatility spill-over effect, whereas the Granger causality test will elaborate on the direction of the spill-overs. In order to gain more insight regarding the volatility spill-over effect, it is necessary to consult a VEC model (Section 4.6), as this model will be able to; firstly, establish if price misalignments occurred and; secondly, elaborate on the time it will take for markets to adjust once an announcement has been made. Finally, in order to elaborate on the extent of the volatility spill-overs a Variance Decomposition (VDC) model (Section 4.7) will be consulted. However, the models mentioned above are not able to elaborate on the specific size of the price misalignments caused by the shock (announcement), which is why the actual price difference between the JSE and LSE (in ZAR terms) will also be examined in Section 5.6.

4.2 THE DATA

This study will use the daily closing prices of the Anglo American Plc. dual-listed stock, which is listed on the JSE, as well as the LSE, where the former is quoted in South African Rand (ZAR) and the latter in British Pounds (GBP)³⁹. Before commencing with the empirical analysis it will be

³⁹ The data used in this study were obtained from the Reuters database (Reuters, 2014).

required to convert the LSE listing into ZAR terms⁴⁰. Once the conversion has been completed the next step will be to identify five random public announcements, where the selection process will be guided by an extensive literature study. The announcements as explained in the literature study entail a new joint venture, a capital investment, negotiations with mining labour unions, the reporting of annual financial results, and changes to the composition of its Board of Directors, which will be further discussed in Section 5.2.

After the five announcements have been identified, it is required to determine the timeframe which will be used to analyse each of the announcements, respectively. This will be achieved by consulting an Impulse Response Model (IMP), which indicates the reaction of any dynamic system in response to external changes and can be formulated as follows (Beag & Singla, 2014:291):

$$IMP_Y(n, \delta, \omega_{t-1}) = E[Y_{t+n}|\delta, \omega_{t-1}] - E[Y_{t+n}|\omega_{t-1}], \quad (4.1)$$

where:

- Y represents a random vector;
- n represents 0, 1, 2, 3...;
- δ represents the current shock; and
- ω_{t-1} represents the particular history chosen as the basis for comparison of the two realisations.

The IMP is designed to determine the effect that a shock δ , entering the system at time t , will have on the system at time $t + n$. In particular, the IMP is able to trace the response of a one-time shock in the VAR-framework, where it is able to determine the approximated duration of the shock

⁴⁰ The daily ZAR/GBP exchange rate series was obtained from the South African Reserve Bank's (SARB) website (SARB, 2014).

(Xu, 2010:14). When a shock is applied, the effects upon the whole VAR-system can be graphically illustrated over time (see Appendix A), and if the system is stable the shock will gradually fade away (Gu, 2008:14).

In the context of this study, the IMP will only serve as a benchmark to determine the timeframe to be used for each announcement (see Section 5.2). Once the timeframes have been determined it is possible to examine the underlying data of each announcement period with the help of the data-screening process.

4.2.1 The data-screening process

The first step of the data-screening process is to provide an overview of the descriptive statistics for each of the individual announcement periods. The first descriptive statistic to be discussed is the skewness, which measures the asymmetry of the probability density function of prices around their mean and can be formulated as follows (QMS, 2007:318):

$$S = \frac{1}{N} \sum_{i=1}^N \left(\frac{Y_i - \bar{Y}}{\hat{\sigma}} \right)^3, \quad (4.2)$$

where:

- N represents the sample size;
- $\bar{Y}$ represents the sample mean;
- Y_i represents the i^{th} observation; and
- $\hat{\sigma}$ represents the standard deviation.

The skewness of a normal distribution, or any other perfect symmetric distribution, will be zero (Mbululu & Chipeta, 2012:50). Although, if the skewness is positive it will imply that the right tail of the distribution is longer, whereas a negative skewness will imply that the left tail is longer (Mbululu & Chipeta, 2012:50), as illustrated by Figure 4.1 below. Moreover, investments which

exhibit negative skewness are more likely to carry downside surprises (Lamm, 2003:9), which traditional risk measures, such as the standard deviation fail to capture. Thus, it is very important for investors to consider the skewness of a distribution, as this may have a direct impact on how risk is perceived during the investor's decision-making process (Pownall & Koedijk, 1999:853-870).

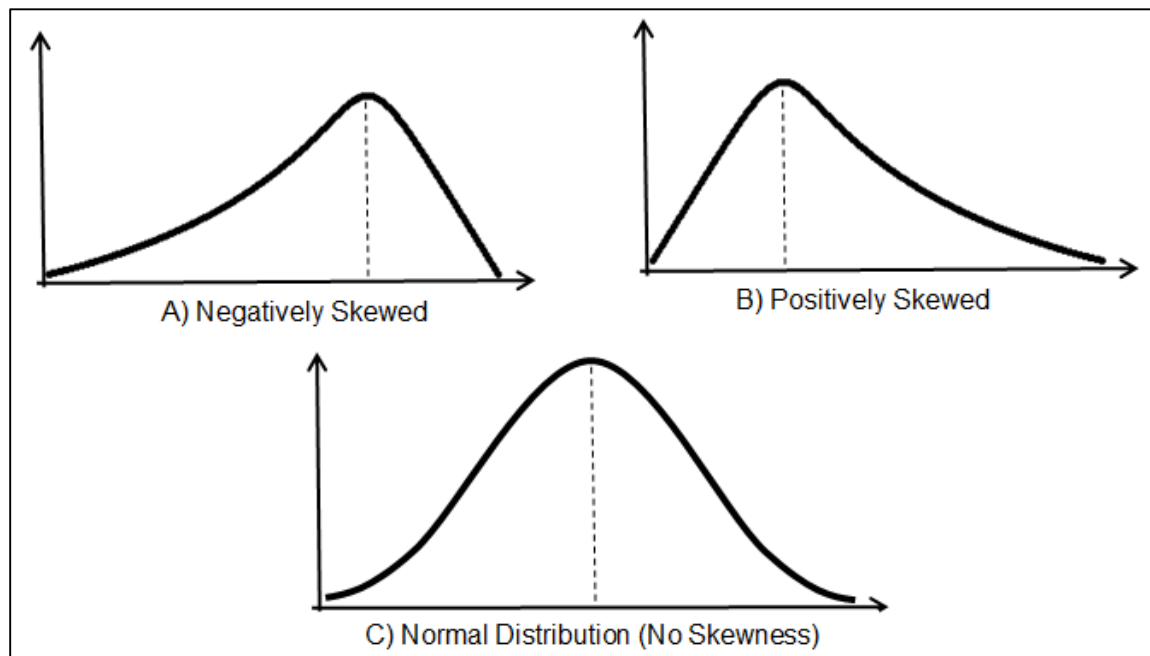


Figure 4.1: Skewness

Source: Gujarati (2006:6).

The second descriptive statistic to be discussed is the kurtosis, which measures the peakedness of the distribution and can be formulated as follows (QMS, 2007:318):

$$K = \frac{1}{N} \sum_{i=1}^N \left(\frac{Y_i - \bar{Y}}{\hat{\sigma}} \right)^4, \quad (4.3)$$

where:

- N represents the sample size;
- $\bar{Y}$ represents the sample mean;
- Y_i represents the i^{th} observation; and
- $\hat{\sigma}$ represents the standard deviation.

A kurtosis value of three will represent a normal distribution and will mirror a normal bell-curve shape (Gujarati, 2006:66). However, a kurtosis value of less than three will represent a distribution with thin tails (platykurtic), whereas a kurtosis value higher than three will represent a distribution with fat tails (leptokurtic) (Gujarati, 2006:66). These two different distribution characteristics can be graphically illustrated by Figure 4.2.

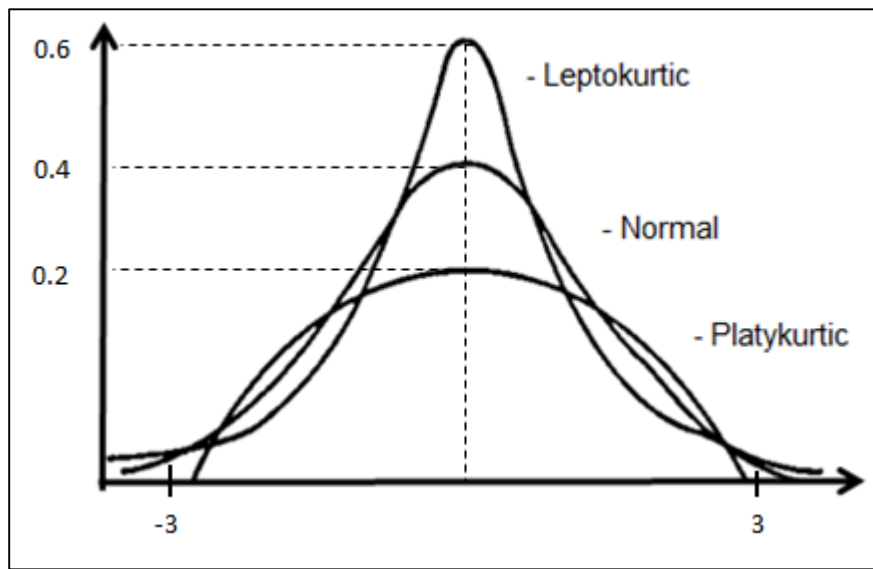


Figure 4.2: Kurtosis

Source: Gujarati (2006:66).

To elaborate on the findings that will be provided by the skewness and kurtosis, the Jarque-Bera (JB) test will also be consulted, which will establish if normality/non-normality is present within the data series under evaluation. According to the study by Mangani (2005:10), it is important not to assume that return data are normally distributed, as non-normal return distributions tend to exhibit significant skewness and kurtosis, which will influence the creditability of traditional risk measures, such as the standard deviation. As the standard deviation only measures the dispersion of returns around its historical average and penalises positive and negative deviations from the historical average in a similar manner, the presence of higher moments will lead to a misperception of actual risk (Lhabitant, 2004:1-329). In this instance, the standard deviation will not serve as a reliable descriptive statistic, as it will cause traditional performance measures, such as the Sharpe

ratio to overestimate the real risk inherent in the asset class under evaluation (Brooks & Kat, 2002), leading to flawed investment decisions.

To test normality, the Jarque-Bera (JB) test makes use of both the skewness and kurtosis, which can be formulated as follows (Gujarati, 2003:192):

$$JB = \frac{N}{6} \left[S^2 + \frac{(K-3)^2}{4} \right], \quad (4.4)$$

where:

- N represents the sample size;
- S represents the skewness; and
- K represents the kurtosis.

The second step in the data-screening process is to test the level of integration/stationarity⁴¹ of both dual-listed stock price series (of the JSE & LSE). Only if both return series have a unit root, $I(1)$, can the Johansen (1991) co-integration test (see Section 4.3) be estimated, as the same order of integration is a prerequisite to measure the level of co-integration between the two markets under evaluation (Granger, 1986:216). This study will consult the Augmented Dickey-Fuller (ADF) test to determine the order of integration of each announcement series (Y_t), where the rejection of the null hypothesis will indicate that a unit root is not present and that the data are stationary. Consider the following autoregressive process of order one, AR(1), (QMS, 2007:92):

$$Y_t = pY_{t-1} + X_t'\delta + \varepsilon_t, \quad (4.5)$$

where:

- X_t represents the optional exogenous regressor, which consist of a constant and trend or only a constant;

⁴¹ Stationarity refers to data whose statistical properties remain unchanged over time (Fielitz, 1971:1025).

- p and δ represents the parameters to be estimated; and
- ε_t is assumed to be a white noise.

If $|p| < 1$, the Y_t series will be considered to be trend-stationary. However, if $|p| \geq 1$, then the Y_t series will be considered as non-stationary, where the variance of Y_t will increase with time until it approaches infinity. Thus, the null and one-sided alternative hypothesis can be illustrated as $H_0: p = 1$ and $H_1: p < 1$, respectively, where the null hypothesis will be rejected if the absolute p value is smaller than 0.05 (QMS 2009:348), as indicated in Table 4.1.

Table 4.1: Interpretation of the p value

p value	Reject null hypothesis?	Presence of unit root?	Conclusion
$p < 0.05$	Reject null hypothesis	No unit root present	Data are stationary
$p > 0.05$	Do not reject null hypothesis	Unit root is present	Data are not stationary

Source: Compiled by author.

In order to determine if the p value is statistically equal to 1, it is required to regress Y_t on its lagged value. By subtracting Y_{t-1} on both sides of Equation 4.5, the following equation can be estimated (QMS, 2009:384):

$$\Delta Y_t = \alpha Y_{t-1} + X_t' \delta + \varepsilon_t, \quad (4.6)$$

where:

- α is equal to $p - 1$.

Consequently, the null and alternative hypothesis can be illustrated as $H_0: \alpha = 0$ and $H_1: \alpha < 0$, respectively (QMS, 2009:384). Thus, if the α in Equation 4.6 is equal to zero, it will imply that $p = 1$, indicating that the time series is non-stationary (Gujarati, 2003:814). Equation 4.6 also

includes an error term, ε_t , where the Dickey-Fuller test assumes that this term is a white noise⁴². However, if ε_t is correlated an Augmented Dickey-Fuller (ADF) test can be used that can be formulated by means of a parametric correction for a higher-order correlation. By assuming that the Y_t series follows an $AR(p)$ process and by adding p lagged difference terms of the dependent variable Y_t to the right-hand side of the test regression, the following equation can be formulated (QMS, 2007b:93):

$$\Delta Y_t = \alpha Y_{t-1} + X'_t \delta + \beta_1 \Delta Y_{t-1} + \beta_2 \Delta Y_{t-2} + \cdots + \beta_p \Delta Y_{t-p} + v_t, \quad (4.7)$$

The augmented specification formulated above will then test Equation 4.6 by using the t -ratio from Equation 4.8, where the asymptotic distribution of the t -ratio for α is independent of the number of lagged first differences that are included in the ADF regression.

$$t_\alpha = \frac{\hat{\alpha}}{se(\hat{\alpha})}, \quad (4.8)$$

where:

- $\hat{\alpha}$ represents the estimate of α ; and
- $se(\hat{\alpha})$ represents the coefficient standard error.

The ADF unit root test will be performed by using the EViews 7 econometric software (QMS, 2007), where the following three model assumptions (Equation 4.9 to 4.11) may be used to test for the presence of a unit root (Asteriou *et al.*, 2007:297):

$$\Delta Y_t = \gamma Y_{t-1} + \sum_{i=1}^p \beta_i \Delta Y_{t-i} + \varepsilon_t, \quad (4.9)$$

$$\Delta Y_t = a_0 + \gamma Y_{t-1} + \sum_{i=1}^p \beta_i \Delta Y_{t-i} + \varepsilon_t, \quad (4.10)$$

⁴² White noise refers to a random process or a random sample of variables (Diebold, 2007:324).

$$\Delta Y_t = a_0 + \gamma Y_{t-1} + a_2 t + \sum_{i=1}^P \beta_i \Delta Y_{t-1} + \varepsilon_t, \quad (4.11)$$

where:

- a_0 represents the intercept; and
- $a_2 t$ represents the deterministic trends.

Equation 4.9 includes no intercept or trend, where Equation 4.10 includes only an intercepts, and Equation 4.11 includes both an intercept and a deterministic time trend. By consulting the ADF unit root test it will be possible to determine if the return series under investigation have the same order of integration, as only variables that are $I(1)$ can be used in the Johansen (1991) co-integration test (King & Watson, 1997:69). The Johansen (1991) co-integration test will be discussed in the next section, where it will be able to verify if there is a long-run co-moving relationship present between the two markets under investigation. The presence of a long-run co-moving relationship will imply that the two markets are closely linked, suggesting that a shock (announcement) in one market can spill-over to another market, causing a volatility spill-over effect (Ali *et al.*, 2011:396).

4.3 THE JOHANSEN (1991) CO-INTEGRATION TEST

Before an estimation of the Johansen (1991) co-integration test can commence it is required to establish if the VAR-model is stable by consulting an AR root graph. The AR root graph describes the inverse roots of the characteristic AR polynomial and will be considered stable when all the roots' modules are smaller than one and lie within the unit circle (QMS, 2009:384). In addition to this, it is also required to determine the appropriate lag length with the help of the Schwartz criterion (SC), the Akaike information criterion (AIC), and the Final Prediction Error (FPE). Only after the optimal lag length has been established will it be possible to estimate the Johansen

(1991) co-integration test, which is based on an estimated VAR-model, of the order p , formulated as follows (QMS, 2010:685):

$$Y_t = A_1 Y_{t-1} + \dots + A_p Y_{t-p} + B X_t + \varepsilon_t, \quad (4.12)$$

where:

- Y_t represents a k vector of $I(1)$ non-stationary variables;
- X_t represents a d -vector of deterministic variable; and
- ε_t represents a $n \times 1$ innovative vector.

By rewriting the VAR-model (Equation 4.12), the following equation can be formulated:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + B X_t + \varepsilon_t, \quad (4.13)$$

where:

$$\Pi = \sum_{i=1}^p A_i - I, \quad (4.14)$$

and

$$\Gamma_i = -\sum_{j=i+1}^p A_j, \quad (4.15)$$

Granger's representation theorem postulates that if the coefficient matrix Π has reduced rank ($r < k$), then there exist $k \times r$ matrices, α and β , both with rank r so that $\Pi = \alpha\beta'$ and $\beta'Y_t$ is $I(0)$ (QMS, 2010:686). Consequently, the β will represent the co-integrating vector, the α will represent the adjustment parameter in the VEC model, which will be discussed in Section 4.6, and the r will represent the number of co-integrating relationships present (QMS, 2010:686). In order to determine the number of co-integrating relationships (r) it is required to interpret two different test statistics (the Trace test and the Maximum Eigenvalue test), which has the following hypotheses (Asteriou & Hall, 2007:324):

$$H_0: r = 0 \text{ (no co-integration relationship present)}, \quad (4.16)$$

$$H_1: r \leq 1 \text{ (one co-integration relationship present),} \quad (4.17)$$

$$H_2: r \leq 2 \text{ (two co-integration relationship present).} \quad (4.18)$$

The first test statistic is the Trace statistic, where the null hypothesis indicates that r is the maximum number of co-integrating vectors. Hence, the rejection of the first null hypothesis, $r \leq k - 1$, where k represents the number of endogenous variables, will imply that $r \geq 1$, while alternative hypothesis will be $r \leq k$ and will reduce until $r = k$. This process will carry on until the null hypothesis is not rejected (Burke & Hunter, 2005:103). The Trace statistic can be illustrated as follows (Johansen, 1991:1555):

$$-2\ln Q = -T \sum_{i=r+1}^{p=2} (1 - \lambda_i), \quad (4.19)$$

where:

- $\lambda_{r+1}, \dots, \lambda_p$ represents the $p - r$ smallest Eigenvalues.

The second test statistic is the Maximum Eigenvalue (L-max) statistic, which tests the null hypothesis of r co-integrating vectors $r = 0$ against the alternative of $r + 1$ co-integrating vectors. The original $r + 1$ co-integrating vector ($r = 1$) is then tested against the other alternative $r + 1$ co-integrating vector ($r = 2$) and so forth (Burke & Hunter, 2005:100). The Maximum Eigenvalue (L-max) statistic can thus be illustrated as follows (Burke & Hunter, 2005:100):

$$-2\ln Q = -T \ln(1 - \lambda_{r+1}). \quad (4.20)$$

When executing the Johansen (1991) co-integration test in EViews 7, there are five different model options to choose from (QMS, 2007). The first option omits a deterministic trend in the data and no intercepts are included in the co-integrating equation. This option is exercised when the Y_t series has a zero mean, and can be formulated as follows (QMS, 2007:687):

$$H_2(r): \Pi Y_{t-1} + B X_t = \alpha \beta' Y_{t-1}. \quad (4.21)$$

The second option includes intercepts in the co-integrating equation and excludes a deterministic trend in the data. This option is exercised when none of the series has a trend, and can be formulated as follows (QMS, 2007:687):

$$H_1^*(r): \Pi Y_{t-1} + BX_t = \alpha(\beta' Y_{t-1} + \rho_0). \quad (4.22)$$

The third option includes a linear trend in the data Y_t , but the co-integration equations include only intercepts. This option is exercised when the trends in the series are stochastic, and can be formulated as follows (QMS, 2007:687):

$$H_1(r): \Pi Y_{t-1} + BX_t = \alpha(\beta' Y_{t-1} + \rho_0) + \alpha_{\perp} \gamma_0. \quad (4.23)$$

The fourth option includes a linear trend in the level data Y_t , as well as in the co-integrating equations. This option is exercised when the trends of the series seem to be stationary, and can be formulated as follows (QMS, 2007:687):

$$H^*(r): \Pi Y_{t-1} + BX_t = \alpha(\beta' Y_{t-1} + \rho_0 + \rho_1 t) + \alpha_{\perp} \gamma_0. \quad (4.24)$$

The final option (Equation 4.25) includes quadratic trends in the level data Y_t and linear trends in the co-integrating equations. This option may produce a good in-sample fit, however, it may also produce implausible estimates in the case of out-sample forecasts (QMS, 2007:687):

$$H(r): \Pi Y_{t-1} + BX_t = \alpha(\beta' Y_{t-1} + \rho_0 + \rho_1 t) + \alpha_{\perp} (\gamma_0 - \gamma_1 t). \quad (4.25)$$

The terms $\alpha_{\perp}$ represents the deterministic terms, which lie outside the co-integration relations. Johansen (1995:167) argues that the $\alpha_{\perp}$ term is the null space of α , such that $\alpha' \alpha_{\perp} = 0$.

Once the appropriate model assumption has been selected it is possible to interpret the output of the Johansen (1991) co-integration test results. If the test results are able to verify the existence

of only one co-integrated relationship it will imply that the two markets under investigation will move together over the long-run. If this is the case, the two markets will be closely linked and exhibit similar trend behaviour, increasing the chances of a possible volatility spill-over effect between the JSE and LSE. In order to test for the presence of a volatility spill-over effect it will be required to consult an EGARCH model, which will be discussed in the next section.

4.4 THE EXPONENTIAL GARCH (EGARCH) MODEL

The EGARCH model, developed by Nelson (1991:347), has been used in several previous studies to capture the asymmetric impact of shocks on volatility. One such study includes that of Miyakoshi (2005:3), who argued that the EGARCH model is more suitable than its rival models, such as the ARCH and GARCH models, to capture the effect that news announcements can have on volatility. He argued that the EGARCH model has two distinct advantages; firstly, its ability to allow immanent news to have a larger influence on volatility levels; and, secondly, its ability to determine if good news or bad news will generate the most volatility. The test results of Miyakoshi (2005:3) emphasised the importance of these advantages, as he reported that the type of news (good news or bad news) has different effects on volatility, as well as the persistence thereof.

The basic EGARCH (1,1) model, as proposed by Nelson (1991), consist of two equations, namely the return equation and the variance equation, where the prior can be illustrated as follows (St Pierre, 1998:168):

$$R_t = \alpha_0 + \sum_{i=1}^p \phi_i R_{t-i} + \delta \sigma_t^2 + \varepsilon_t, \quad (4.26)$$

$$\varepsilon_t | \Omega_{t-1} \sim N(0, \sigma_t^2), \quad (4.27)$$

where:

- R_t represents the daily return for day t ;
- α_0 represents the intercept;

- ϕ_i represents the autocorrelation in the daily returns;
- δ represents the degree of correlation relationship between daily returns and the conditional variance; and
- ε_t represents the error term;
- Ω_{t-1} represents the relevant set of information available at time t ; and
- σ_t^2 represents the variance on day t .

The second equation is the variance equation and can be illustrated as follows (Ogum *et al.*, 2002:109):

$$\ln(\sigma_t^2) = \theta_0 + \theta_1 \left\{ \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| - \sqrt{\frac{2}{\pi}} \right\} + \frac{\gamma \varepsilon_{t-1}}{\sigma_{t-1}} + \beta \ln(\sigma_{t-1}^2), \quad (4.28)$$

where:

- θ_1 measures of the impact of innovation on conditional volatility at time t ;
- γ measures the asymmetric response of conditional variance to innovations; and
- β measures the persistence of the shock.

The variance equation includes three important variables, which are able to elaborate on the volatility spill-over effect. The first variable is the θ_1 , which will indicate if the impact of the innovation causes a volatility spill-over effect. The second variable is the γ , which will indicate if stock prices will have a greater reaction to positive or negative news. A γ value smaller than 0 will imply that negative news will have a greater influence on volatility, whereas a γ value greater than 0 will imply that positive news will have a greater influence on volatility (Ogum *et al.*, 2002:11). The third variable is the β , which will measure the persistence of the shock. A β value close to 0 will indicate that the volatility within the market will be short-lived and will fade away at a quick pace. On the other hand, a β value closer to 1 will indicate that the volatility in the market will persist and that it will take a longer time to die out (Van Wyk, 2012:65).

From the interpretations above it can be concluded that the EGARCH model will be able to verify the existence of volatility spill-overs between the JSE and LSE. If evidence of volatility spill-overs is found, the next step will be to determine the direction of causality.

4.5 THE GRANGER (1969) CAUSALITY TEST

The study by Pretorius (2002:90) explains that it is not uncommon for volatility to spill-over from one market to the next (volatility spill-over effect). The direction of such a volatility spill-over effect can be determined with the help of causality tests. Causality can be defined as a situation where the value of variable X_t can be better predicted by using historical values of variable Y_t (Asteriou & Hall, 2007:281). The causality relationships as set out by Granger (1969) can be illustrated as follows (Wooldridge, 2006:650):

$$E\left(\frac{Y_t}{I_{t-1}}\right) \neq E\left(\frac{Y_t}{J_{t-1}}\right), \quad (4.29)$$

where:

- I_{t-1} includes past information of Y_t and X_t , and
- J_{t-1} includes past information of Y_t .

If Equation 4.29 is deemed to be true, it will imply that the past values of Y_t and X_t will be useful in the prediction of Y_t . If this is the case, the conclusion can be made that X_t granger causes Y_t (Wooldridge, 2006:650). To illustrate the Granger causality test statistically, consider the following VAR-model (Asteriou & Hall, 2007:281):

$$Y_t = \alpha_1 + \sum_{i=1}^n \beta_i X_{t-i} + \sum_{j=1}^m \gamma_j Y_{t-j} + \varepsilon_t, \quad (4.30)$$

where:

- Y_t represents the dependant variable;
- X_t represents the independent variable;
- X_{t-i} represents the lagged value of X_t ;
- Y_{t-j} represents the lagged value of Y_t ;
- α_1 represents the intercept coefficients;
- β_i and γ_j represent the slope coefficient;
- ε_t represents the error term.

Equation 4.30 represents an unrestricted model which can be expanded into Equation 4.31 and by doing so converting it to a restricted model. The restricted Equation 4.31 only contains the lagged value of Y_t and is illustrated as follows (Asteriou & Hall, 2007:282):

$$Y_t = \alpha_3 + \sum_{j=1}^m \gamma_j Y_{t-j} + \varepsilon_t, \quad (4.31)$$

where:

- Y_t represents the dependant variable;
- Y_{t-j} represents the lagged value of Y_t ;
- α_3 represents the intercept coefficients;
- γ_j represents the slope coefficient; and
- ε_t represents the error term.

After describing the unrestricted and restricted models, it is now possible to determine the F-statistic with the help of Residual Sum of Squares (RSS). The calculation of the F-statistic can be illustrated as follows (Asteriou & Hall, 2007:283):

$$F = \frac{(RSS_R - RSS_u)/m}{RSS_u/(n-k)}, \quad (4.32)$$

where:

- RSS_R represents the residual sum of squares for the restricted model (Equation 4.31);
- RSS_U represents the residual sum of squares for the unrestricted mode (Equation 4.30);
- n represents the number of observations;
- k represents the number of explanatory variables; and
- $m = k - n - 1$.

Once the F-statistic has been calculated it will be used to test the null hypothesis, which can be illustrated as follows (Asteriou & Hall, 2007:282):

$$H_0: \sum_{i=1}^n \beta_i = 0, \quad (4.33)$$

and

$$H_1: \sum_{i=1}^n \beta_i \neq 0, \quad (4.34)$$

where:

- Equation 4.33 illustrates that X_t does not cause Y_t ; and
- Equation 4.34 illustrates that X_t does cause Y_t .

The null hypothesis will be rejected if the F-statistic is greater than the F-critical value, thus indicating that X_t granger causes Y_t (Asteriou & Hall, 2007:283). In the context of this study, the Granger causality test will be able to indicate if the LSE granger causes the JSE or *vice versa*. Once the presence of a volatility spill-over effect and the direction thereof has been verified, the next step will be to consult a VEC model (Section 4.6), as well as a VDC model (Section 4.7). The VEC model will be discussed in the next section and elaborate on the duration of the volatility spill-over effects, whereas the VDC model will elaborate on the extent of the volatility spill-over effects.

4.6 THE VECTOR ERROR CORRECTION (VEC) MODEL

The VEC model builds on the unrestricted VAR-framework of an order $(n \times 1)$ established during the Johansen (1991) co-integration test (Section 4.3). The VEC model is a restricted VAR that is used for non-stationary variables, which are known to be integrated and can be illustrated as follows (Johansen, 1988:232):

$$Y_t = \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \dots + \Pi_k Y_{t-k} + u_t, \quad (4.35)$$

where:

- $Y_t = (n \times 1)$ represents the vector of $I(1)$ variables;
- $\Pi_i = (n \times n) i = 1, 2 \dots, k$ represents the matrix of unknown parameters to be estimated;
- u_t represents the independent and identically distributed (i.i.d) $(n \times 1)$ vector of error terms; and
- $t = 1, 2 \dots, m$ subsequent observations.

By incorporating $\Delta = (1 - L)$, where L represents a lag operator, Equation 4.35 can be parameterised in an error correction form, which can be illustrated as follows (Johansen & Juselius, 1990:170):

$$\Delta Y_t = \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \Pi Y_{t-k} + u_t, \quad (4.36)$$

where:

- ΔY_t represents a $I(0)$ vector;
- $\Pi = \sum_{j=1}^k \Pi_j - I$;
- $\Gamma_i = \sum_{j=1}^{k-1} \Pi_j - I$, where $i = 1, 2 \dots k - 1$; and
- I represents a $(n \times n)$ identity matrix.

The $(n \times n)$ matrix Π can be illustrated as the product of two matrices, α and β both with an order rank of r , in order for $\Pi = \alpha\beta'$. In this case the adjustment parameter is represented by the α and the co-integrating vector by every β column (Johansen & Juselius, 1990:169). It is, therefore, possible to rewrite Equation 4.36 and illustrate it as follows (Johansen & Juselius, 1990:169):

$$\Delta Y_t = \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + (\alpha\beta')Y_{t-k} + u_t, \quad (4.37)$$

Note that the r number of co-integrations will already have been determined by the Trace (Equation 4.19) and L-max (Equation 4.20) statistics (see Section 4.3), based on the model options provided by Equation 4.20 to 4.25, respectively.

It is also important to note that the VEC model can also be rewritten to include both short-run and long-run effects, illustrated as follows (Asteriou & Hall, 2007:312):

$$\Delta Y_t = \gamma_0 \Delta X_t - (1 - \alpha) \left[Y_{t-1} - \frac{\alpha_0}{1 - \alpha_1} - \frac{\gamma_0 + \gamma_1}{1 - \alpha_1} X_{t-1} \right], \quad (4.38)$$

where:

- γ_0 represents the short-run effect of Y_t after a change in X_t ;
- $\frac{\gamma_0 + \gamma_1}{1 - \alpha_1}$ represents the long-run elasticity of X and Y ;
- it is assumed that $\alpha_1 < 1$ in order for the short-run model to convert to a long-run solution;
and
- $(1 - \alpha_1)$ represents the speed of adjustment.

The adjustment parameter (α) will always lie between 0 and 1 and will serve as an indication of the time it will take for stock prices to converge back to the steady state once an announcement has been made. If $\alpha = 1$ it will mean that 100% adjustment will take place in one time period and if $\alpha = 0$ it will mean that no adjustment will occur. Hence, if the VEC results reveal that prices do

not adjust instantly, it might be possible that a situation arise where the price quoted on the JSE will differ from the price quoted on the LSE (in ZAR terms), causing possible arbitrage opportunities.

In order to conclude the empirical analysis, the last step will be to consult the Variance Decomposition (VDC) model, which will be able to elaborate on the size of the volatility spill-overs.

4.7 VARIANCE DECOMPOSITION (VDC) MODEL

The VDC model is an adjusted VAR-model which can be used to analyse volatility linkages between markets. The normal VAR follows the influence of a single endogenous shock, where the VDC model splits the endogenous variable's variation into component shocks (QMS, 2007:470). Therefore, the VDC model traces the effects of a single endogenous shock in one variable on to other variables (QMS, 2007:470).

The study by Weiss (2005:385) states that if X_t and Y_t variables are on the same probability space and deemed random, then the VDC model of Y_t can be illustrated as follows:

$$var(Y_t) = E\left(\frac{varY_t}{X_t}\right) + varE\left(\frac{Y_t}{X_t}\right), \quad (4.39)$$

where:

- $var(Y_t)$ represents the variance of variable Y_t ;
- $E\left(\frac{varY_t}{X_t}\right)$ represents the unexplained component of the variance Y_t ; and
- $varE\left(\frac{Y_t}{X_t}\right)$ represents the explained component of the variance Y_t .

The interpretation⁴³ of the VDC model is focused on the response variable Y_t , where it traces the proportion of the movements in the dependent variable, which are due to own shocks versus shocks from the independent variable (Xu & Sun, 2010:15). The VDC model will, therefore, be able to indicate the extent of the spill-overs generated by each of the announcements under evaluation. It will also be able to illustrate which market (JSE or LSE) will have the most significant effect on the domestic and international market.

4.8 CHAPTER SUMMARY

The main goal of this chapter was to discuss the process which will be followed during the empirical analysis. The first step in the empirical analysis will be to analyse the underlying data which will be used (Section 4.2). This will be achieved by elaborating on different public announcements under investigation, the timeframe of each announcement, as well as a data screening process, where the descriptive statistics and the level of integration/stationarity of each announcement period was discussed (Section 4.2.1). Once the level of integration/stationarity has been determined, the next step will be to consult the Johansen (1991) co-integration test (Section 4.3), which will indicate if the two markets shows signs of a long-run co-moving relationship, as this will increase the likelihood of a volatility spill-over effect. In order to establish if a volatility spill-over effect is present, the next step will be to consult an EGARCH model (Section 4.4), as well as a Granger causality test (Section 4.5), where the prior will verify the presence of volatility spill-overs and the latter the direction of the spill-overs. Lastly, it will also be required to consult a VEC model (Section 4.6) and a VDC model (Section 4.7), as these two models will be able to; firstly, elaborate in the occurrence of price misalignments and, secondly, elaborate on the

⁴³ When interpreting the output of the VDC model it is important to keep in mind that this model is based on the Cholesky factor, meaning that the VDC model output can change considerably if the ordering of the variables is changed (QMS, 2010:470). The Cholesky factor factors a symmetric, positive-definite matrix into the product of a lower triangular matrix and its conjugate transpose (Watkins, 1991:84).

size of the volatility spill-overs. The next chapter will discuss the results obtained from the process discussed above.

CHAPTER 5

EMPIRICAL RESULTS

5.1 INTRODUCTION

The focus of this study is to investigate how international public announcements influence dual-listed stock prices. These announcements contain valuable information that can influence the behaviour of stock prices. Once new information enters the market, stock prices will need to adjust, as it incorporates the additional information to reach a new equilibrium price (Mak, 2006:3). However, according to the Efficient Market Hypothesis (Section 3.3) not all markets have the same level of efficiency when incorporating new information into stock prices. This implies that two markets can have different reaction speeds at which they incorporate new information. In terms of dual-listed stocks, it is imperative that the reaction speeds in both the dual-listed markets are exactly the same in order for the single markets hypothesis⁴⁴ to hold. However, in reality the single market hypothesis does not always hold, implying the possibility that price misalignments might occur (Angelini & Guazzarotti, 2010:5). These price misalignments can give rise to arbitrage opportunities in which an investor can make a profit by buying the same stock at a lower price in one market and selling it at a higher price in another market. The main goal of this chapter is, therefore, to determine how dual-listed stock prices react to the information released through public announcements and whether this information can cause these prices to be misaligned for a certain time period. In this chapter it is also determined what the extent of the price misalignments are and whether it can lead to arbitrage opportunities possibilities. However, note that the evaluation of the level of market efficiency falls outside the scope of this study.

⁴⁴ The single market hypothesis states that the same stock should trade at the same price, irrespective of its trading location (Ip & Brooks, 1996:53).

In order to achieve these goals, this chapter conducts an empirical study on the Anglo American Plc. dual-listed stock as the investment proxy, which is listed on both the JSE and LSE. The first step of the empirical study will be to analyse the data that will be used in the empirical analysis (Section 5.2). This entailed elaborating on the different public announcement proxies under investigation, the timeframe of each announcement and a data screening process, which will discuss the descriptive statistics, as well as the level of integration/stationarity (Section 5.2.1). This is followed by a Johansen (1991) co-integration test (Section 5.3), which tests if co-integration is present between these two markets and will, therefore, establish if there is a long-run relationship between them.

The presence of a long-run relationship will confirm that these markets are closely linked, which implies that they will exhibit similar share price trends (Ali *et al.*, 2011:395). This will, therefore, suggest that a shock in one market can spill-over to another market, causing a volatility spill-over effect (Ali *et al.*, 2011:396). In order to test for the presence of a possible volatility spill-over effect an Exponential GARCH (EGARCH) model (Section 5.4) is consulted, where this model will verify if a volatility spill-over effect is present between the JSE and LSE. If the presence of a volatility spill-over effect can be verified, the next step is to estimate a Granger causality test (Section 5.5), which will be able to indicate the direction of the volatility spill-overs. Finally, a Vector Error Correction (VEC) model (Section 5.6) and a Variance Decomposition (VDC) model (Section 5.7) is also consulted. These two models will be able to, firstly, establish if there is a presence of price misalignments; secondly, elaborate on the time it takes (duration) for the markets to adjust after a news announcement occurred and; finally, be able to elaborate on the extent of the volatility spill-overs. However, these two models still fail to determine the specific size of the price misalignments caused by these volatility spill-overs, which is why the price difference between the two markets (JSE & LSE) in ZAR terms will also be examined in Section 5.6. By evaluating the extent of the price misalignments and the time it takes (duration) these two

markets to adjust after an announcement (shock) occurred will help to determine what type of announcement will offer the best chance to realise an arbitrage opportunity. Although, transaction costs may still influence the desirability to benefit from such an arbitrage opportunity, but due to the unavailability of data this study will not include transaction costs or examine the effect thereof.

5.2 THE DATA

The data that are used in this study range from 28 June 2010 to 8 August 2014 and was obtained from the Reuters database (Reuters, 2014). This study used the daily closing prices of the Anglo American Plc. dual-listing on the JSE (JSE:AGL) and on the LSE (LON:AAL). However, since the JSE listing is quoted in South African Rand (ZAR) and the LSE listing quoted in British Pounds (GBP), it was necessary to convert the LSE listing to ZAR terms before further empirical studies could be conducted. In order to achieve this, the daily closing ZAR/GBP exchange rate series was obtained from the South African Reserve Bank's (SARB) website (2014) in order to realise the ZAR conversion for each date in the data range. After the conversion had been completed it was possible to identify the public news announcements, which were examined in this study. The five random public announcements which were examined as proxies in this study are listed in Table 5.1.

Table 5.1: List of public news announcements

	Date of announcement	Timeframe used for empirical analysis
1st Announcement	18 February 2011	02 February 2011 to 11 July 2011
2nd Announcement	29 March 2012	24 January 2012 to 10 August 2012
3rd Announcement	19 September 2012	15 August 2012 to 09 December 2012
4th Announcement	19 April 2013	12 April 2013 to 09 June 2013
5th Announcement	21 February 2014	03 January 2014 to 27 June 2014

Source: Compiled by author.

The 1st announcement occurred on the 18th of February 2011, was when a new joint venture between Anglo American Plc. and Lafarge U.K. was announced. The joint venture created a

leading U.K. construction material company, where the profits from this joint venture were estimated to be \$90 million per annum (Anglo American, 2014). The 2nd announcement took place on the 29th of March 2012, when Anglo American Plc. announced that a total capital investment of \$517 million would be injected in order to open new mines (Anglo American, 2014)⁴⁵. The 3rd announcement occurred on the 19th of September 2012, when Anglo American Plc. announced that negotiations with mining labour unions would commence, as striking workers in the North-West province (South Africa) demanded higher wages (Anglo American, 2014)⁴⁶. The 4th announcement took place on the 19th of April 2013, when the directors of the company shared the annual financial results with its shareholders. The results indicated that operating profits were down by 44% and that the total earnings were down by 35% (Anglo American, 2014)⁴⁷. The 5th announcement occurred on the 21st of February 2014, in which Anglo American Plc. announced that there would be two changes to the composition of its Board of Directors (Anglo American, 2014)⁴⁸.

Table 5.1 also reports the timeframes which were used to analyse each of these announcements, respectively. The timeframe of each announcement was determined by consulting several impulse response models (Section 4.2), which served only as a benchmark in determining the appropriate duration of each timeframe (see Appendix A for results). However, the study by Bhana (1987:198) argues that one should not only include the reaction days after the announcement, but also several days leading up to the announcement. This argument is based on the fact that

⁴⁵ The study of Baker *et al.* (2003:969) states that capital investments are positively correlated with stock markets.

⁴⁶ The study by Harvey (2013:3) states that there is a negative relationship between labour tensions and the attractiveness of stock prices.

⁴⁷ The study by Kama (2009:32) states that there is a positive relationship between stock markets and company earnings announcement.

⁴⁸ The study by Warner *et al.* (1988:461) explains that changes in top management is inversely related to stock price performance.

investors can anticipate certain announcements, causing the market to react before the announcement takes place (Bhana, 1987:198). For this reason, the timeframe for each announcement included several days leading up to the announcement, as well as several days after the announcement, as reported in Table 5.1.

Once the timeframe for each announcement had been determined it was important to firstly examine the underlying data for each of the announcement periods (Section 5.2.1). The study by Mangani (2005:10) and Cruz (2007:41) argues that it is important to identify how the underlying data are distributed, as the assumption of normality can lead to flawed investment decisions. This statement is supported by Henry (2002:727) and Clark and Troskie (2006:66), who argue that stock price data tends to exhibit significant high moments (skewness & kurtosis) that will cause the standard deviation to provide a bias perception of actual risk (Harlow, 1991:28), which can lead to different portfolio allocations (see for example, Brooks & Kat, 2002:26-44; Amin & Kat, 2003:251-274). This is because the standard deviation only measures the dispersion of returns around its historical average and penalises positive and negative deviations from the historical average in a similar manner (Lhabitant, 2004:1-329), implying the inability to differentiate between downside and upside risk (De Wet, Krige & Smit, 2008:69-83; Harding, 2002:2). For this reason, and due to the results found in Section 5.2.1, the standard deviation is not discussed in the following section, which elaborates on the details of the data-screening process.

5.2.1 The data-screening process

The first step of the data-screening process is to provide an overview of the descriptive statistics (see Table 5.2) for each of the individual announcements, which was done by using EViews 7

software⁴⁹ (QMS, 2009). Table 5.2 reports both the skewness and kurtosis of all five announcements, where the former measures the asymmetry of the probability density function of prices around their means (Mbululu & Chipeta, 2012:50). The results pertaining to the skewness revealed that the data were negatively skewed for all five announcement periods under evaluation. This implies that the left tail of the distributions is longer and that the majority of the values lie to the left (Mbululu & Chipeta, 2012:50). The presence of a negative skewness indicates that there may be a probability for the presence of downside surprise (Lamm, 2003:9), which traditional risk measures, such as the standard deviation, does not incorporate. This statement is emphasised by Pownall and Koedijk (1999:853-870), who argue that downside surprises are more common during times of turmoil market conditions, where unforeseen shocks are more likely to occur and can result in larger losses.

Table 5.2 also reports the kurtosis for all five announcements and reveals that the kurtosis is less than three, which implies that the distributions are relatively flat (platykurtic) and that the majority of the observations are tightly positioned around the mean (QMS, 2007:318; Doan, 2011:3). To emphasise these results and to establish if normality/non-normality is present within the data series under investigation, the Jarque-Bera test was also consulted. The results revealed that the null hypothesis, stating that the data are normally distributed, is rejected for all five announcement periods, thus implying that the Anglo American Plc. dual-listed stock prices are not normally distributed on both exchanges. These results are similar to the findings of Aparicio and Estrada (2001:1-21) who argue that new information does not always arrive linearly to the markets and that investors do not react immediately to this information, thus implying that price misalignment might be a possibility. These findings also imply that financial analysts should be cautious when

⁴⁹ EViews 7 provides sophisticated data analyses, regression and forecasting tools that enables the user to conduct financial analysis, scientific data analysis, data evaluations, macroeconomic forecasting, sales forecasting, cost analysis, and simulations (QMS, 2007a).

consulting traditional risk-adjusted performance measures, such as the Sharpe ratio and Treynor ratio, as the presence of non-normality corrodes the accuracy of their performance rankings (Van Heerden, 2015:14). The evaluation of the extent this will influence the performance rankings of dual-listed stocks and will make an interesting topic for future studies.

Table 5.2: Descriptive statistics of the different announcements

	1 st Announcement		2 nd Announcement		3 rd Announcement	
	JSE	LSE	JSE	LSE	JSE	LSE
Mean	34733.00	34739.25	27676.19	27620.05	25396.45	25326.63
Maximum	39570.00	40059.95	31530.00	31450.56	27700.00	27878.92
Minimum	30870.00	30714.51	24320.00	23985.38	23311.00	23242.64
Std. Dev.	2150.26	2278.67	1760.28	1766.59	1067.54	1080.39
Skewness	-0.52	-0.55	-0.16	-0.19	-0.02	-0.14
Kurtosis	2.44	2.57	2.29	2.30	2.21	2.38
Jarque-Bera	6.04*	6.17*	2.61*	2.79*	2.10*	1.55*
	4 th Announcement		5 th Announcement			
	JSE	LSE	JSE	LSE		
Mean	22040.16	22036.03	26770.67	26839.40		
Maximum	24951.00	25239.69	28670.00	28693.54		
Minimum	18519.00	18309.28	24860.00	24673.09		
Std. Dev.	1561.32	1582.64	822.92	871.38		
Skewness	-0.42	-0.39	-0.01	-0.04		
Kurtosis	2.59	2.58	2.60	2.54		
Jarque-Bera	3.63*	3.19*	0.54*	0.74*		

*Reject the null hypothesis that the data are normally distributed at the 95% level of statistical significance.

Note: Daily prices are quoted in cents and Std. Dev. denotes standard deviation.

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

The second step of the data-screening process is to determine the level of integration/stationarity of both dual-listed stock price series, as only variables that are I(1) can be used in the Johansen (1991) co-integration test (King & Watson, 1997:69). The Augmented Dickey-Fuller (ADF) test (Section 4.2.1) was consulted where the data was tested in level format, with the following three model assumptions respectively: with an intercept; with an intercept and trend; and without an intercept and trend (see Appendix A). The result revealed that the null hypothesis, stating that a unit root is present, could not be rejected for all five announcements under all three model assumptions. To confirm these results the data were also tested in I(1) format, which revealed that the null hypothesis is rejected for all of these announcements, thus indicating that no unit root

is longer present (see Table 5.3 for summary). This verified that both dual-listed stock price series (JSE & LSE) of all the announcements under investigation are I(1), which is a prerequisite for performing the Johansen (1991) co-integration test, where the results of this test will be discussed in the next section.

Table 5.3: Summary of the ADF unit root tests for all five announcements

		Model assumptions:					
		Intercept		Intercept and Trend		No Intercept or Trend	
1st Announcement	JSE	I(0) [0.68]	I(1) [0.00]*	I(0) [0.26]	I(1) [0.00]*	I(0) [0.26]	I(1) [0.00]*
	LSE	I(0) [0.57]	I(1) [0.00]*	I(0) [0.31]	I(1) [0.00]*	I(0) [0.70]	I(1) [0.00]*
2nd Announcement	JSE	I(0) [0.52]	I(1) [0.00]*	I(0) [0.18]	I(1) [0.00]*	I(0) [0.25]	I(1) [0.00]*
	LSE	I(0) [0.41]	I(1) [0.00]*	I(0) [0.46]	I(1) [0.00]*	I(0) [0.33]	I(1) [0.00]*
3rd Announcement	JSE	I(0) [0.11]	I(1) [0.00]*	I(0) [0.23]	I(1) [0.00]*	I(0) [0.45]	I(1) [0.00]*
	LSE	I(0) [0.12]	I(1) [0.00]*	I(0) [0.13]	I(1) [0.00]*	I(0) [0.46]	I(1) [0.00]*
4th Announcement	JSE	I(0) [0.72]	I(1) [0.00]*	I(0) [0.90]	I(1) [0.00]*	I(0) [0.79]	I(1) [0.00]*
	LSE	I(0) [0.68]	I(1) [0.00]*	I(0) [0.88]	I(1) [0.00]*	I(0) [0.80]	I(1) [0.00]*
5th Announcement	JSE	I(0) [0.07]	I(1) [0.00]*	I(0) [0.23]	I(1) [0.00]*	I(0) [0.43]	I(1) [0.00]*
	LSE	I(0) [0.26]	I(1) [0.00]*	I(0) [0.11]	I(1) [0.00]*	I(0) [0.34]	I(1) [0.00]*

* Reject the null hypothesis that the data has a unit root at the 95% level of statistical significance.

Note: [] represents the t-probability.

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

5.3 THE JOHANSEN (1991) CO-INTEGRATION TEST

Before estimating the Johansen (1991) co-integration test it is required to determine if the VAR-framework is stable. The results of the stability test (see Appendix B for results) revealed that the VAR-framework is stable, implying that the VAR is suitable to use for further analyses. Furthermore, before the Johansen (1991) co-integration test can be estimated it is also required to determine the most appropriate lag structure. The results reported in Appendix B indicates that

the most statistically significant results for the 1st announcement will be found by using either two or three lags. The results for the 2nd and 3rd announcements also indicated that the optimal lag length is equal to five lags, whereas two lags will be most optimal for the 4th and 5th announcement.

Once the stability tests and lag structure tests have been performed the next step is to estimate the Johansen (1991) co-integration test. The Johansen (1991) co-integration test makes use of the Trace (Tr) and the maximum eigenvalue (L-max) statistics to determine the number of co-integrating relationships present (Hawtrey, 1997:341), which has the following hypotheses:

$$H_0: r = 0 \text{ (no co-integration relationship present)} \quad (4.16)$$

$$H_1: r \leq 1 \text{ (one co-integration relationship present)} \quad (4.17)$$

$$H_2: r \leq 2 \text{ (two co-integration relationship present)} \quad (4.18)$$

From the results reported in Table 5.4 the conclusion can be made that a long-run co-movement between the JSE and LSE exists, which is also in accordance with the findings of Chinzara and Azaikpono (2009:115). The results for all five of the announcements revealed that the H_0 hypothesis can be rejected, but the H_1 hypothesis cannot be rejected for all five announcements. This implies that there is only one co-integrating relationship present between the Anglo American Plc. dual-listed stock listed on the JSE and the LSE. The presence of a long-run co-moving relationship between the JSE and LSE indicates that these two markets are closely linked over the time period under investigation. This implies that shocks (announcements) from one market can spill over to the other, causing stock price adjustments and possible price misalignments to occur. In order to test for a possible volatility spill-over effect between the JSE and LSE the EGARCH model was consulted, with the results reported in the following section.

Table 5.4: Johansen (1991) co-integration test results

1ST ANNOUNCEMENT: A joint venture in the U.K.			
Hypothesised	Trace	0.5 Critical Value	t-prob.
$H_0: r = 0$	33.28	25.32	0.00*
$H_1: r \leq 1$	9.87	12.25	0.12
Hypothesised	L-Max	0.5 Critical Value	t-prob.
$H_0: r = 0$	23.41	18.96	0.00*
$H_1: r \leq 1$	9.87	12.25	0.12
2ND ANNOUNCEMENT: A capital investment in the U.K.			
Hypothesised	Trace	0.5 Critical Value	t-prob.
$H_0: r = 0$	67.39	25.87	0.00*
$H_1: r \leq 1$	9.48	12.52	0.15
Hypothesised	L-Max	0.5 Critical Value	t-prob.
$H_0: r = 0$	57.91	19.38	0.00*
$H_1: r \leq 1$	9.48	12.52	0.15
3RD ANNOUNCEMENT: Labour negotiations in South Africa			
Hypothesised	Trace	0.5 Critical Value	t-prob.
$H_0: r = 0$	56.49	25.87	0.00*
$H_1: r \leq 1$	9.3	12.52	0.16
Hypothesised	L-Max	0.5 Critical Value	t-prob.
$H_0: r = 0$	47.19	19.38	0.00*
$H_1: r \leq 1$	9.3	12.52	0.16
4TH ANNOUNCEMENT: Overall poor financial performance			
Hypothesised	Trace	0.5 Critical Value	t-prob.
$H_0: r = 0$	54.84	25.32	0.00*
$H_1: r \leq 1$	8.85	12.25	0.12
Hypothesised	L-Max	0.5 Critical Value	t-prob.
$H_0: r = 0$	45.98	18.96	0.00*
$H_1: r \leq 1$	8.85	12.25	0.12
5TH ANNOUNCEMENT: Change in the Board of Directors			
Hypothesised	Trace	0.5 Critical Value	t-prob.
$H_0: r = 0$	32.11	25.87	0.00*
$H_1: r \leq 1$	9.88	12.52	0.13
Hypothesised	L-Max	0.5 Critical Value	t-prob.
$H_0: r = 0$	22.22	19.38	0.00*
$H_1: r \leq 1$	9.88	12.52	0.13

Model assumption: Intercept and trend were allowed in the co-integration, but not in VAR.

* Reject hypothesis at the 95% confidence level.

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

5.4 THE EXPONENTIAL GARCH (EGARCH) MODEL

The first step is to determine if the EGARCH(p, q) model of each announcement is properly specified and estimated. The latter entails examining the level of stationarity and the transformation of the data if necessary before estimating the EGARCH model. This study evaluated various formats to make the data stationary, where the first differential format yielded the best results for all five announcements (see also Table 5.3). It is also required that the

EGARCH(p, q)⁵⁰ model is properly specified in terms of the p^{th} order autoregressive GARCH term and the q^{th} order moving average ARCH term. Different specifications for the EGARCH model were examined, where the Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC) were used to indicate the best model for each of the five announcements (see Table 5.5).

Table 5.5: Best EGARCH(p, q) model

	Best EGARCH(p, q) model specification	AIC	SIC
1 st Announcement	EGARCH(1,1)	14.56	14.71
2 nd Announcement	EGARCH(1,2)	14.08	14.21
3 rd Announcement	EGARCH(1,1)	14.10	14.28
4 th Announcement	EGARCH(2,1)	13.82	13.91
5 th Announcement	EGARCH(2,1)	14.14	14.14

Note: The model specifications with the smallest AIC and SIC were chosen.

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

From Table 5.5 it is evident that little variation in model specifications were found, where the appropriate p^{th} order autoregressive GARCH term and the q^{th} order moving average ARCH term were never larger than two. These models were also tested for serial correlation and autocorrelation, but no evidence was found for serial correlation⁵¹. The Ljung-Box test⁵² emphasised these findings, as the Q-statistic of each announcement was not rejected at one lag length, indicating that no autocorrelation was present in the error terms (see Figure C1-C5 in Appendix C for results). These findings confirm that the model specifications reported in Table 5.5 are suitable to test for the volatility spill-over effect within the time span of each announcement

⁵⁰ In an EGARCH(p, q) model, p is a non-negative integer, indicating the number of lagged log conditional variances included in the EGARCH model, and q is a non-negative integer indicating the number of lagged standardised innovations included in the EGARCH model. If p is greater than zero, then q must also be greater than zero (Mathworks, 2012:1).

⁵¹ The correlogram and Ljung-Box Q-statistic are reported in Appendix C.

⁵² The Ljung-Box test is performed to test whether any of a group of autocorrelations of a time series is different from zero (Ljung & Box, 1978:297).

under investigation. The results of each of the EGARCH models are summarised in Table 5.6, which reports the θ_1 coefficient, the γ parameter and the beta (β).

Table 5.6: Results summary of the EGARCH models

1ST ANNOUNCEMENT: A joint venture in the U.K.		
Variable	Coefficient	Interpretation of coefficient
θ_1	1.08*	Volatility spill-over effect verified.
γ	0.33*	Positive shocks will generate more volatility than negative shocks.
β	0.70*	Volatility will fade out the second fastest of all the announcements.
2ND ANNOUNCEMENT: A capital investment in the U.K.		
Variable	Coefficient	Interpretation of coefficient
θ_1	0.35*	Volatility spill-over effect verified.
γ	0.13*	Positive shocks will generate more volatility than negative shocks.
β	0.41*	Volatility will fade out the fastest of all the announcements.
3RD ANNOUNCEMENT: Labour negotiations in South Africa		
Variable	Coefficient	Interpretation of coefficient
θ_1	0.80*	Volatility spill-over effect verified.
γ	0.26*	Positive shocks will generate more volatility than negative shocks.
β	0.71*	Volatility will fade out the third slowest of all the announcements.
4TH ANNOUNCEMENT: Overall poor financial performance		
Variable	Coefficient	Interpretation of coefficient
θ_1	1.09*	Volatility spill-over effect verified.
γ	0.32*	Positive shocks will generate more volatility than negative shocks.
β	0.77*	Volatility will fade out the second slowest of all the announcements.
5TH ANNOUNCEMENT: Change in the Board of Directors		
Variable	Coefficient	Interpretation of coefficient
θ_1	0.80*	Volatility spill-over effect verified.
γ	0.63*	Positive shocks will generate more volatility than negative shocks.
β	0.98*	Volatility will fade out the slowest of all the announcements.

* Statistically significant at the 99% level.

Model assumption: Asymmetric order of one.

Complete results are reported in Appendix C (see Table C1).

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

The results reported in Table 5.6 illustrate that the variables are statistically significant for all five announcement periods, where the results of θ_1 indicate that volatility spill-overs are present between the JSE and LSE. Tough, the direction of the volatility spill-overs is still unknown, which will be examined in Section 5.5, along with elaborating on the duration (see Section 5.6) and extent (see Section 5.7) of the volatility spill-over effect. In addition to the results found on θ_1 ,

Table 5.6 also reports that the γ parameter was greater than zero for all five announcements, suggesting that stock prices have a greater reaction to positive shocks than to negative shocks⁵³. Lastly, by interpreting the β (persistence of volatility) it is clear that the 2nd announcement has the smallest β value, implying that the volatility caused by the capital investment announcement will be short-lived and that the market will converge to the steady state at a quick pace. On the other hand, the β value for the 1st, 3rd and 4th announcements are higher, indicating that the volatility caused by joint ventures, labour negotiations and poor financial results will remain in the market for a longer period, where the market will be slow to converge back to its steady state. Lastly, the results pertaining to the 5th announcement indicated that this announcement had the highest β value of all of the announcements. This implies that the announcement regarding the change in the Board of Directors seems to cause more uncertainty, as the volatility caused by this announcement will remain for an extended period, leading to the slowest convergence back to steady state.

To summarise; the results from the EGARCH model illustrated that most of the shocks (announcements) under evaluation were relatively long-lived, except for the capital investment announcement (2nd announcement), which was short-lived. However, though the presence of volatility spill-overs between the JSE and LSE have been confirmed by the EGARCH, the direction of these spill-overs is still unknown. For this reason this chapter will estimate a Granger causality test to determine the direction of the volatility spill-overs. Moreover, the Granger causality test results will also justify that the correct dependant variables are used in the other empirical models.

⁵³ The study by Hassan *et al.* (2003:62-85) found similar results for JSE listed stocks.

5.5 THE GRANGER (1969) CAUSALITY TEST

The Granger causality test is an econometric model based on the standard F-statistic framework, which determines if one time series can be used to predict the future of another time series (Xu & Sun, 2010:13). The first step of the Granger causality test was to determine the number of lags to be used, which were already determined in Section 5.3 (see also Appendix B), thus making it possible to estimate the Granger causality test as reported in Table 5.7.

Table 5.7: The Granger causality test

1ST ANNOUNCEMENT: A joint venture in the U.K.			
Direction of causality	F-statistic	t-prob.	Reject the null hypothesis?
LSE => JSE	3.10	0.02*	Yes
JSE => LSE	5.63	0.59	No
2ND ANNOUNCEMENT: A capital investment in the U.K.			
Direction of causality	F-statistic	t-prob.	Reject the null hypothesis?
LSE => JSE	5.39	0.02*	Yes
JSE => LSE	1.08	0.29	No
3RD ANNOUNCEMENT: Labour negotiations in South Africa			
Direction of causality	F-statistic	t-prob.	Reject the null hypothesis?
LSE => JSE	0.27	0.76	No
JSE => LSE	3.65	0.03*	Yes
4TH ANNOUNCEMENT: Overall poor financial performance			
Direction of causality	F-statistic	t-prob.	Reject the null hypothesis?
LSE => JSE	5.04	0.02*	Yes
JSE => LSE	0.01	0.96	No
5TH ANNOUNCEMENT: Change in the Board of Directors			
Direction of causality	F-statistic	t-prob.	Reject the null hypothesis?
LSE => JSE	5.01	0.02*	Yes
JSE => LSE	0.78	0.38	No

* Reject hypothesis at the 95% confidence level.

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

Table 5.7 reports that the null hypothesis for the LSE not granger causing the JSE can be rejected for the 1st, 2nd, 4th and 5th announcement, therefore, signifying that the direction of causality is from the LSE to the JSE, making the JSE the dependent variable and thus justifying the correct estimation of the Johansen (1991) co-integration tests (see Table 5.4), the EGARCH models (see Table 5.6), the VEC models (see Table 5.8), and the VDC model (see Table 5.10). The direction

of causality for these announcements can be rationalised by the fact that these announcements were released by the Anglo American Plc. head office in the U.K. However, different results were found for the 3rd announcement, where the null hypothesis for the LSE not granger causing the JSE could not be rejected, implying that the JSE granger causes the LSE, making the LSE the dependent variable. This finding was also expected, since this announcement was released in South Africa and specifically related to the uncertainty in the South African labour market.

To summarise; the Granger causality test results confirmed that the majority of the volatility spill-overs, with the exception of the 3rd announcement, moved from the LSE to the JSE, which accentuates the findings of Koutsoyiannis (1977:660)⁵⁴. In addition, the results also confirmed that the correct dependent variables were used in the empirical models. With the presence of volatility spill-over effects and the direction of these spill-overs verified, the next step is to consult a VEC model (Section 5.6) and a VDC model (Section 5.7). The VEC model will elaborate on the duration of the volatility spill-over effects, whereas the VDC model will elaborate on the extent of the volatility spill-over effect. This will also be accompanied by an examination of the price difference between the two markets (JSE & LSE) in ZAR terms (Section 5.6) to further elaborate on the size of the price misalignments caused by these spill-overs.

5.6 THE VECTOR ERROR CORRECTION (VEC) MODEL

A VEC model is able to estimate the speed of adjustment to equilibrium of two co-integrated variables (Asteriou & Hall, 2007:310), where the presence of co-integration was already proven in Section 5.3. This implies that the VEC model is able to elaborate on the duration of a shock (announcement), by examining the speed of adjustment estimate (α) in Table 5.8. The long-run

⁵⁴ The study of Koutsoyiannis (1977:660) argues that since the LSE is one of the world's largest stock exchanges it is expected that the direction of spill-overs is from the LSE to the JSE.

coefficient (β) in Table 5.8 is also able to elaborate on the presence of a long-run relationship between the JSE and LSE (Asteriou & Hall, 2007:312-314).

Table 5.8: The Vector Error Correction (VEC) model

1ST ANNOUNCEMENT: A joint venture in the U.K. (JSE as dependent variable)						
	Long-run coefficient (β)	t-statistic of β	Speed of adjustment (α)	t- statistic of α	R ²	Adjusted R ²
JSE	1	-	-0.11	0.06*	0.47	0.36
LSE	-1.01	0.03*	4.93	2.37	0.62	0.55
2ND ANNOUNCEMENT: A capital investment in the U.K. (JSE as dependent variable)						
	Long-run coefficient (β)	t-statistic of β	Speed of adjustment (α)	t- statistic of α	R ²	Adjusted R ²
JSE	1	-	-0.09	0.02*	0.29	0.26
LSE	-1.09	0.04*	2.31	4.93	0.41	0.31
3RD ANNOUNCEMENT: Labour negotiations in South Africa (LSE as dependent variable)						
	Long-run coefficient (β)	t-statistic of β	Speed of adjustment (α)	t- statistic of α	R ²	Adjusted R ²
LSE	1	-	-0.12	0.01*	0.47	0.42
JSE	-0.98	0.02*	4.38	3.75	0.55	0.51
4TH ANNOUNCEMENT: Overall poor financial performance (JSE as dependent variable)						
	Long-run coefficient (β)	t-statistic of β	Speed of adjustment (α)	t- statistic of α	R ²	Adjusted R ²
JSE	1	-	-0.14	0.02*	0.23	0.20
LSE	-0.95	0.02*	1.95	3.52	0.34	0.32
5TH ANNOUNCEMENT: Change in the Board of Directors (JSE as dependent variable)						
	Long-run coefficient (β)	t-statistic of β	Speed of adjustment (α)	t- statistic of α	R ²	Adjusted R ²
JSE	1	-	-0.23	0.02*	0.58	0.51
LSE	-1.12	0.04*	2.81	2.11	0.63	0.56

Model assumption: Intercept and trend were allowed in co-integration equation, but not in VAR.

* Statistically significant at the 95% level.

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

From Table 5.8 it can be concluded that the β coefficient is statistically significant for all the announcements, which justifies the presence of a long-run relationship between the JSE and LSE and, therefore, emphasising the results already reported in Table 5.4. The β coefficients for all the announcements also suggest the presence of an inverse relationship between the Anglo American Plc. dual-listing on the JSE (JSE:AGL) and on the LSE (LON:AAL). The 5th announcement exhibited the largest relationship reaction (a 1:-1.12 relationship) of all of the

announcements, suggesting that a 1% price increase of AGL (on the JSE) would lead to a 1.12% price decrease of AAL (on the LSE). The 1st announcement, on the other hand, exhibited the smallest relationship reaction (a 1:-1.01 relationship) of all of the announcements, suggesting that a 1% price increase of AGL (on the JSE) would lead to a 1.01% price decrease of AAL (on the LSE). These results, therefore, confirms that the two markets are very closely linked and that any price deviations during any of the announcement periods will be small, which is similar to the results found by the VDC model, which will be reported in Table 5.10 in Section 5.7.

In addition to the β coefficient, Table 5.8 also reports that the speed of adjustment estimate (α) is statistically significant for all the announcements, making α viable for further interpretations to follow. The α provides an indication of how long it takes for stock prices to converge back to the steady state once an announcement has been made. Thus, the α is able to establish if price misalignments were caused by the announcements (shocks) under evaluation and also determine the duration of these price misalignments. The results in Table 5.8 verify the presence of price misalignments and report that an announcement concerning a change on the Board of Directors (5th announcement) will cause the longest price misalignment period (18 days) to occur. The results further revealed that it would take 13 days for prices to return back to equilibrium after the 4th announcement (poor financial results)⁵⁵ had been made. This was followed by the 1st announcement (joint venture in the U.K.) and the 3rd announcement (labour negotiations), which revealed that it would cause a price misalignment period of 12 days after each of these announcements had been made respectively. Lastly, the results reported that the 2nd announcement, relating to capital investments in the U.K, would lead to the smallest price misalignment period of 9 days.

⁵⁵ This announcement reports on the financial earnings of Anglo American Plc. The study by Swart (2011:138) revealed that JSE listed stock prices react significantly to earnings announcements and that it can take up to 20 days for the stock prices to converge back to equilibrium.

From the results reported above it is evident that stock prices do not adjust instantly, as it takes several days for stock prices to return back to a steady state once a shock (announcement) occurred. These results, therefore, suggest the presence of price misalignments, where the prices quoted on the JSE might differ from the prices quoted on the LSE (in ZAR terms). In order to further justify the presence of price misalignments, it is necessary to look at the actual price differences in ZAR terms between the two markets in order to determine the size of the price misalignments (see Table 5.9). The largest price difference (R2.28) was recorded during the duration of the 5th announcement and the smallest price difference (R1.40) during the duration of the 2nd announcement. From these results it can be argued that the overall size of the price differences is relatively small. These results accentuate the outcomes drawn from the β coefficients (see Table 5.8) and therefore confirm that the closely linked markets offered small price differentials and would limit the arbitrage opportunities to generate a convincing profit, even if the α estimates (see Table 5.8) reported the presence of price misalignments. The only possibility to realise a profit from these small price differentials would be to trade high volumes of these stocks.

However, even with large trade volumes the investor should still consider the transaction costs involved, as these costs may limit (or even eliminate) any possible arbitrage opportunity. Unfortunately, due to the unavailability of data this study will not include transaction costs or examine the effect thereof. It is also important to remember to acknowledge the effects of the changing ZAR/GBR exchange rate as an international investor, as this will lead to inconsistencies in these price differentials and can have a significant effect on the viability of generating a profit from these price misalignments. However, this falls outside the scope of this study, but will certainly be an interesting topic for future studies.

Table 5.9: Price differences

	Price difference (in ZAR terms)
1ST ANNOUNCEMENT: A joint venture in the U.K.	R1.70
2ND ANNOUNCEMENT: A capital investment in the U.K.	R1.40
3RD ANNOUNCEMENT: Labour negotiations in South Africa	R1.76
4TH ANNOUNCEMENT: Overall poor financial performance	R1.83
5TH ANNOUNCEMENT: Change in the Board of Directors	R2.28

Source: Compiled by author.

To summarise; at this stage of the empirical analysis the results verified the existence of volatility spill-overs between the JSE and LSE (see Table 5.6), where the VEC model also elaborated on the duration of the volatility spill-over effects (see Table 5.8). The VEC model results revealed that it would take between 9 and 18 days for stock prices to return back to equilibrium after an announcement (shock), depending on the type of announcement. These findings, therefore, indicated that prices did not adjust instantly after an announcement had been made, which might give rise to possible price misalignments that could lead to arbitrage opportunities. The results from Table 5.9 further emphasised the presence of price misalignments, but illustrates that the price differentials may be too small to realise a viable profit if transaction costs are accounted for. In order to conclude the empirical analysis, the last step is to consult the VDC model (Section 5.7), which will provide a final elaboration on the size of the volatility spill-overs.

5.7 THE VARIANCE DECOMPOSITION (VDC) MODEL

The VDC model traces the proportion of the movements in the dependent variable which are due to own shocks versus shocks from the independent variable (Xu & Sun, 2010:15). The results of the VDC model are reported in Table 5.10 below, where the first row represents the time period and the second column the S.E value. The S.E. value indicates the variation between current and future values of the endogenous variable caused by a shock, where a higher value will signify that "own shocks" have greater influence, thus implying a smaller volatility spill-over to the other market.

Table 5.10: Variance Decomposition (VDC) model

1ST ANNOUNCEMENT: A joint venture in the U.K.										
Period	1	2	3	4	5	6	7	8	9	10
S.E.	578.64	582.20	589.54	589.74	590.17	590.31	590.33	590.34	590.35	590.35
JSE	100.00	98.81	97.88	97.86	97.78	97.74	97.74	97.74	97.73	97.73
LSE	0.00	1.19	2.12	2.14	2.22	2.26	2.26	2.26	2.27	2.27
2ND ANNOUNCEMENT: A capital investment in the U.K.										
Period	1	2	3	4	5	6	7	8	9	10
S.E.	441.46	444.01	448.57	448.66	448.85	448.85	448.86	448.86	448.86	448.86
JSE	100.00	99.36	99.27	99.24	99.21	99.21	99.21	99.21	99.20	99.20
LSE	0.00	0.64	0.73	0.76	0.79	0.79	0.79	0.79	0.80	0.80
3RD ANNOUNCEMENT: Labour negotiations in South Africa										
Period	1	2	3	4	5	6	7	8	9	10
S.E.	566.28	587.59	589.34	589.50	589.86	596.12	598.02	598.19	598.29	598.34
LSE	100.00	93.77	93.53	93.50	93.39	91.69	91.16	91.15	91.13	91.12
JSE	0.00	6.23	6.47	6.50	6.61	8.31	8.84	8.85	8.87	8.88
4TH ANNOUNCEMENT: Overall poor financial performance										
Period	1	2	3	4	5	6	7	8	9	10
S.E.	538.46	561.00	562.05	564.93	565.89	565.92	565.97	566.00	566.00	566.00
JSE	100.00	92.40	92.37	91.45	91.14	91.14	91.12	91.11	91.11	91.11
LSE	0.00	7.60	7.63	8.55	8.86	8.86	8.88	8.89	8.89	8.89
5TH ANNOUNCEMENT: Change in the Board of Directors										
Period	1	2	3	4	5	6	7	8	9	10
S.E.	409.09	524.68	596.15	654.04	708.91	780.93	796.01	813.44	825.44	835.30
JSE	100.00	96.59	95.89	95.56	93.16	89.98	88.28	87.27	86.88	86.47
LSE	0.00	3.41	4.11	4.44	6.84	10.02	11.72	12.73	13.12	13.53

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

From the results reported in Table 5.10 it is evident that all the variation in the JSE (and LSE when referring to the 3rd announcement) during the first period was due to own shocks, where the market normally “runs” itself endogenously. From the second period onwards it was evident that there was an increase in the influential ability of the LSE on the JSE (referring to the 1st, 2nd, 4th and 5th announcement) and from the JSE to the LSE (referring to the 3rd announcement). However, the results revealed that the influential ability of the LSE was relatively small, where the 2nd announcement (capital investments in the U.K) exhibited the smallest volatility spill-overs (0.8%) and the 5th announcement (change in the Board of Directors) the largest volatility spill-overs (13.53%). The results pertaining to the 3rd announcement, where the direction of spill-overs

was from the JSE to the LSE, also reported that small spill-overs (8.88%) were evident, indicating that the announcement of labour negotiations did not cause large volatility in the LSE.

To summarise; the results reported that the size of the volatility spill-overs were relatively small across all of the announcement periods under evaluation, where the LSE had little influential ability on the JSE and *vice versa*, when referring to the 3rd announcement. Hence, the results confirm that the volatility spill-overs might not be large enough to cause extreme price deviations, which accentuate the results from Table 5.8 and 5.9.

5.8 CHAPTER SUMMARY

The main goal of this study is to examine how information released through public news announcements would influence dual-listed stock prices and whether it would generate arbitrage opportunities. In order to achieve this goal it was required to conduct an empirical analysis, where a summary of the empirical results of all five public news announcements under evaluation are reported in Table 5.11.

The empirical analysis commenced by determining if there was a long-run co-moving relationship between the JSE and LSE. The Johansen (1991) co-integration test results verified the existence of a long-run relationship between the JSE and LSE, over the time horizon under investigation. Moreover, the presence of co-movement implied that the two markets were closely linked, making it more viable for shocks (announcements) to spill-over from one market to the next (volatility spill-over effect). In order to determine if volatility spill-overs did occur between the JSE and LSE it was necessary to consult an EGARCH model, where the results confirmed the presence of a volatility spill-over effect. The EGARCH results also revealed that the 2nd announcement was short-lived, whereas the results illustrated that the 5th announcement might have caused more uncertainty, causing the stock prices to convergence slowly back to steady state (see Table 5.11).

The next step was to determine the direction of the volatility spill-overs, where the Granger causality test reported that the majority of the volatility spill-overs, with the exception of the 3rd announcement, moved from the LSE to the JSE. In order to gain more insight regarding the extent of the volatility spill-overs a VEC model was consulted. The results from the VEC model confirmed the presence of price misalignments and reported that the 2nd announcement had the shortest price misalignment period (9 days), whereas the 5th announcement had the longest price misalignment period (18 days), as indicated by the rankings in Table 5.11.

Table 5.11: Summary of the empirical results

	LONG-RUN RELATION- SHIP PRESENT?	SPILL-OVER EFFECT PRESENT?	ORIGIN OF SPILL- OVERS?	RANKINGS (5 = largest; 1 = smallest)		
				SIZE OF SPILL- OVER	DURATION OF SPILL- OVER EFFECT	SIZE OF PRICE MISALIGN- MENT
MODELS :	JOHANSEN & VEC	EGARCH	GRANGER	VDC	EGARCH & VEC	PRICE DIFFEREN CE
1st ANNOUNCEMENT: A joint venture in the U.K.	Yes	Yes	LSE	2	2	2
2nd ANNOUNCEMENT: A capital investment in the U.K.	Yes	Yes	LSE	1	1	1
3rd ANNOUNCEMENT: Labour negotiations in South Africa	Yes	Yes	JSE	3	3	3
4th ANNOUNCEMENT: Overall poor financial performance	Yes	Yes	LSE	4	4	4
5th ANNOUNCEMENT: Change in the Board of Directors	Yes	Yes	LSE	5	5	5

Note: A ranking = 1 indicates that the particular announcement had the smallest spill-overs / the shortest spill-over duration / the smallest price differences.

Note: A ranking = 5 indicates that the particular announcement had the largest spill-overs / the longest spill-over duration / the largest price differences.

Source: Compiled by author.

From these results the conclusion could be derived that prices did not adjust instantly, which implied the possibility for price differences to occur between the JSE and LSE in ZAR terms. The results reported in Table 5.9 confirmed the presence of price misalignments between the two markets under evaluation, where the 2nd announcement period exhibited the smallest price difference (R1.40), as indicated by the ranking in Table 5.11. The 5th announcement, on the other hand, exhibited the largest price difference (R2.28) and was ranked as the announcements with the greatest possibility to realising a profitable arbitrage opportunity (see Table 5.11). These results were also confirmed by the VDC model, which revealed that the 2nd announcement generated the smallest volatility spill-overs and the 5th announcement the largest in the JSE (see Table 5.11).

To conclude; from the results reported above it is evident that the announcements under evaluation did generate volatility spill-overs between the JSE and LSE. However, the size of the volatility spill-overs was relatively small across all of the announcement periods, where the LSE and JSE had little influence on each other and *vice versa*. Moreover, the results confirmed that the small spill-overs were not able to cause extreme price deviations, as the actual price differences recorded during each of the announcement periods were relatively small. Even so, from all the announcements under evaluation, the 5th announcement (change in the Board of Directors) exhibited the greatest potential to realise a profitable arbitrage opportunity. However, the influential effect of transaction costs and of a changing ZAR/GBR exchange rate must still be acknowledged, as they can have a significant effect on the viability of a profitable arbitrage opportunity. Though, examining the influential effect of the exchange rate fall outside the scope of this study, and due to the unavailability of trading cost data, this study was not able to examine the impact thereof.

CHAPTER 6

CONCLUSION

6.1 INTRODUCTION

The main goal of this study was to examine how information released through public news announcements will influence the Anglo American Plc. dual-listed stock prices and whether it causes significant price misalignments that pose viable arbitrage opportunities. This chapter will provide a summary to illustrate how this research goal was achieved by providing a brief overview of both the literature and empirical studies (Section 6.2). This will be followed by Section 6.3, where the concluding remarks and recommendations for futures studies will be provided.

6.2 SUMMARY OF THE LITERATURE AND EMPIRICAL RESULTS

From the literature it was evident that the release of new information has a direct impact on stock prices and the behaviour thereof. Once new information is released into the market, stock prices will start to fluctuate as it incorporates the new information into its prices until a new equilibrium price is reached. Hence, it is evident that there is a strong relationship between information and volatility, where volatility is defined as stock price fluctuations. Moreover, the literature indicated that information is not only restricted to the domestic market, as it is able to flow from one international market to the next (information transmission). The flow of information across international markets is facilitated by globalisation effects, making it possible for information to not only influence stock prices in the local market, but in the foreign market as well, which lead to a volatility spill-over effect. The literature also indicated that volatility spill-overs hold further consequences for stock prices, where it can lead to the violation of the single market hypothesis. If this is the case, it might be possible for a situation to arise where the prices of a dual-listed stock are misaligned in two markets. Furthermore, these price misalignments can lead to arbitrage

opportunities, where a trader can make a profit by buying the same stock at the lower price in the one market and selling it at the higher price in the other market.

To establish if this is true, an empirical study was conducted, where the Anglo American Plc. dual-listed stock (listed on both the JSE and LSE) was chosen as the investment proxy. The effect of five random public announcements on Anglo American Plc. was then examined. These announcements entailed a (i) new joint venture, (ii) a capital investment, (iii) negotiations with mining labour unions, (iv) the reporting of annual financial results, and (v) changes to the composition of its Board of Directors.

The empirical study commenced with a Johansen (1991) co-integration test (Section 5.3), which confirmed the presence of a long-run co-moving relationship between the JSE and LSE. The presence of co-movement suggested that the two markets moved closely together, increasing the chance of a possible volatility spill-over effect. The results from the EGRACH model (Section 5.4) confirmed this notion, where the Granger causality test (Section 5.5) also revealed that the majority of these spill-overs, with the exception of the 3rd announcement (labour negotiations in South Africa), moved from the LSE to the JSE. With the presence and direction of the volatility spill-overs verified it was possible to determine if these volatility spill-overs caused significant price misalignments. The VEC model (Section 5.6) reported that the 2nd announcement (capital investments in the U.K) had the shortest price misalignment period (9 days), whereas the 5th announcement (change in the Board of Directors) had the longest price misalignment period (18 days). These results illustrated that there was a lag in the time it took for stock prices to return back to equilibrium, which may lead to price misalignments. The presence of price misalignments was confirmed, where further results reported that the 2nd announcement (capital investments in the U.K) had the smallest price difference (R1.40) and the 5th announcement (change in the Board of Directors) the largest price difference (R2.28). The VDC model (Section 5.7) confirmed that the

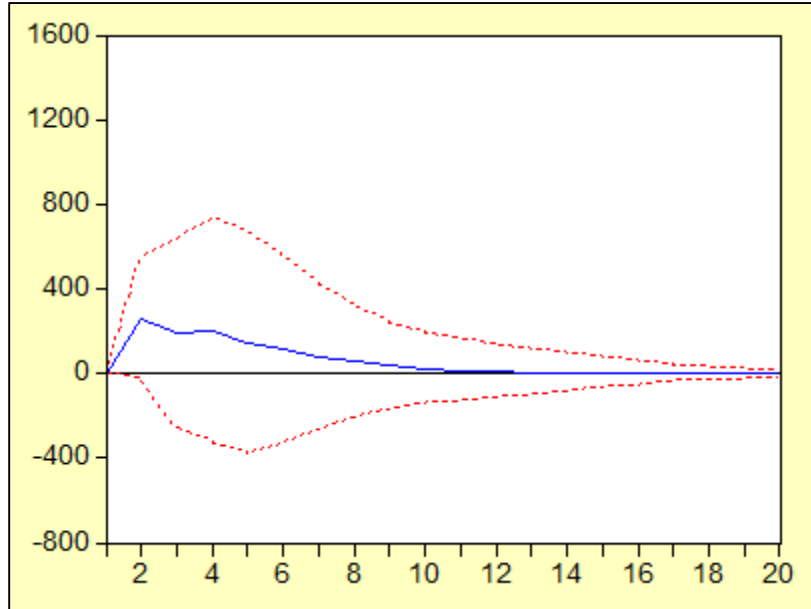
2nd announcement (capital investments in the U.K) generated the smallest volatility spill-overs, whereas the 5th announcement (change in the Board of Directors) the largest.

6.3 CONCLUDING STATEMENT AND RECOMMENDATION

This study obtained substantial evidence which confirmed that the international public announcements under evaluation did generate volatility spill-overs between the JSE and LSE. However, the size of these volatility spill-overs was relatively small and did not cause significant price misalignments between the JSE and LSE. Consequently, the small price differences limit the arbitrage opportunities, making it difficult for an investor to obtain a substantial profit. From these results it can be argued that in order for an investor to make a profit it will be required to trade these stocks at high volumes. However, even with large trade volumes the investor should still consider the transaction costs involved, as these costs may limit (or even eliminate) any potential profits. Unfortunately, due to the unavailability of data this study did not examine the limiting effect of transaction costs. However, it is recommended that if this data were to become available, it will make an interesting future study, as it will provide a more realistic view of the significance of potential arbitrage opportunities due to price misalignments. In addition, it is also recommended that future studies acknowledge and include the effects of the changing ZAR/GBR exchange rate in their analysis. The volatility of the exchange rate may lead to inconsistencies in the price differentials and can have a significant effect on the viability of generating a profit from an arbitrage trade. Lastly, it is also recommended that futures studies evaluate the effect of market efficiency on price differences, as international markets are not equally efficient when incorporating new information into stock prices.

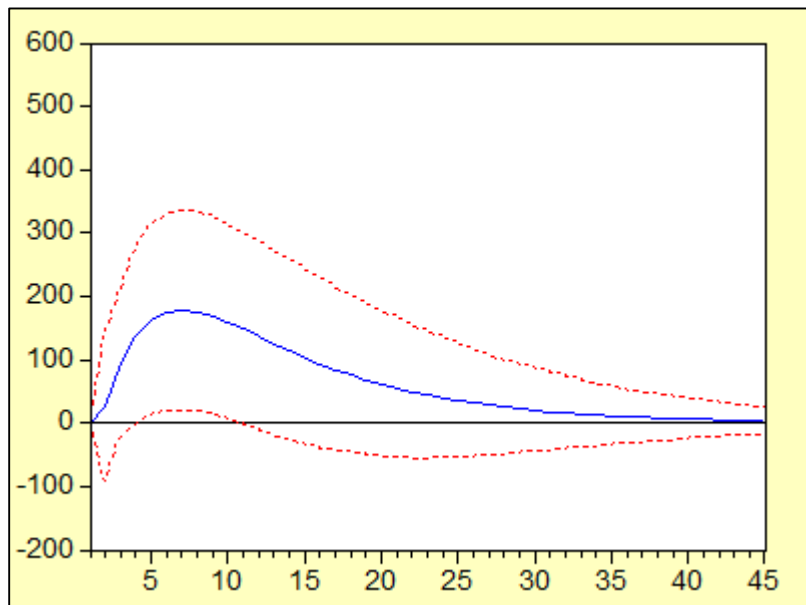
APPENDIX A

Figure A1: Impulse Response of the 1st Announcement (Response of JSE to LSE)



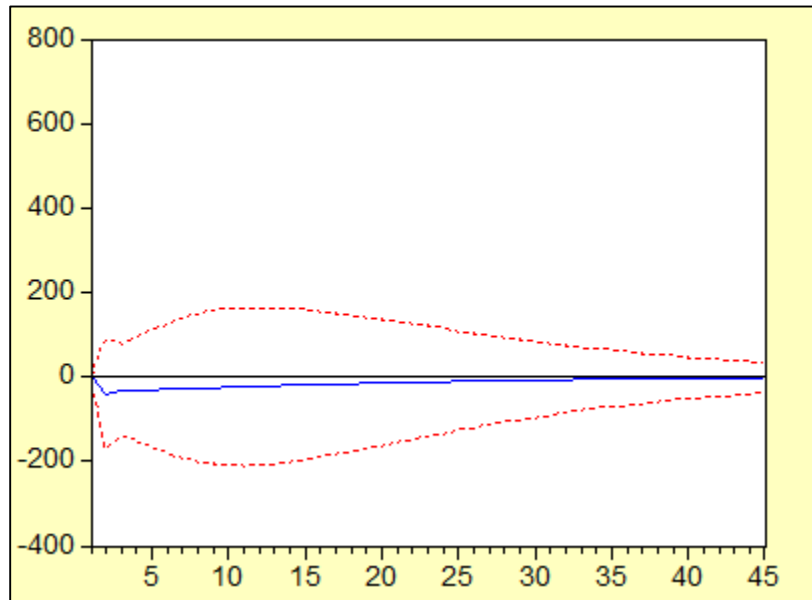
Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Figure A2: Impulse Response of the 2nd Announcement (Response of JSE to LSE)



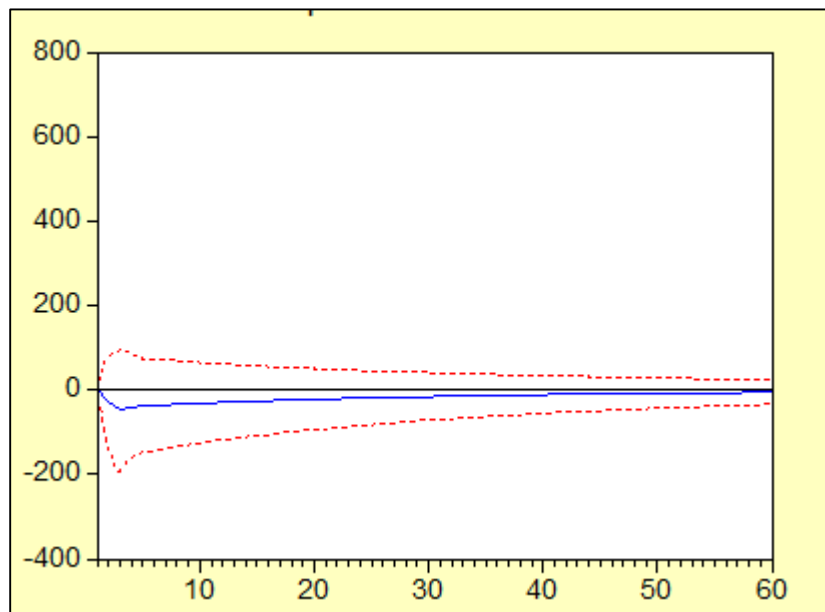
Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Figure A3: Impulse Response of the 3rd Announcement (Response of LSE to JSE)



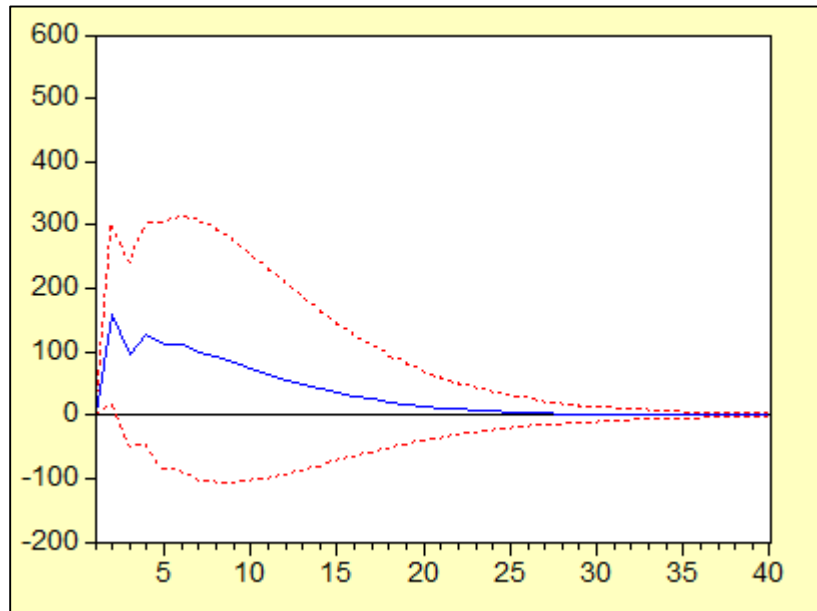
Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Figure A4: Impulse Response of the 4th Announcement (Response of JSE to LSE)



Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Figure A5: Impulse Response of the 5th Announcement (Response of JSE to LSE)



Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Table A1: Unit Root tests (Level format, with intercept)

1 st Announcement		t-statistic	t-probability
JSE	ADF test statistic	-1.17	0.68
	1% level	-3.50	
	5% level	-2.89	
	10% level	-2.58	
LSE	ADF test statistic	-1.41	0.57
	1% level	-3.50	
	5% level	-2.89	
	10% level	-2.58	
2 nd Announcement		t-statistic	t-probability
JSE	ADF test statistic	-1.52	0.52
	1% level	-3.50	
	5% level	-2.89	
	10% level	-2.58	
LSE	ADF test statistic	-1.72	0.41
	1% level	-3.50	
	5% level	-2.89	
	10% level	-2.58	
3 rd Announcement		t-statistic	t-probability
JSE	ADF test statistic	-2.53	0.11
	1% level	-3.49	
	5% level	-2.89	
	10% level	-2.58	
LSE	ADF test statistic	-2.50	0.12
	1% level	-3.49	
	5% level	-2.89	
	10% level	-2.58	
4 th Announcement		t-statistic	t-probability
JSE	ADF test statistic	-1.07	0.72
	1% level	-3.49	
	5% level	-2.89	
	10% level	-2.58	
LSE	ADF test statistic	-1.17	0.68
	1% level	-3.45	
	5% level	-2.87	
	10% level	-2.57	
5 th Announcement		t-statistic	t-probability
JSE	ADF test statistic	-2.74	0.07
	1% level	-3.50	
	5% level	-2.90	
	10% level	-2.59	
LSE	ADF test statistic	-3.16	0.26
	1% level	-3.50	
	5% level	-2.90	
	10% level	-2.59	

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

Table A2: Unit Root tests (Level format, with intercept and trend)

1 st Announcement		t-statistic	t-probability
JSE	ADF test statistic	-1.05	0.26
	1% level	-4.05	
	5% level	-3.45	
	10% level	-3.15	
LSE	ADF test statistic	-0.91	0.31
	1% level	-4.05	
	5% level	-3.45	
	10% level	-3.15	
2 nd Announcement		t-statistic	t-probability
JSE	ADF test statistic	-2.84	0.18
	1% level	-4.05	
	5% level	-3.45	
	10% level	-3.15	
LSE	ADF test statistic	-3.48	0.46
	1% level	-4.05	
	5% level	-3.45	
	10% level	-3.15	
3 rd Announcement		t-statistic	t-probability
JSE	ADF test statistic	-2.69	0.23
	1% level	-4.04	
	5% level	-3.45	
	10% level	-3.15	
LSE	ADF test statistic	-3.03	0.13
	1% level	-4.04	
	5% level	-3.45	
	10% level	-3.15	
4 th Announcement		t-statistic	t-probability
JSE	ADF test statistic	-1.20	0.90
	1% level	-4.05	
	5% level	-3.45	
	10% level	-3.15	
LSE	ADF test statistic	-1.27	0.88
	1% level	-4.05	
	5% level	-3.45	
	10% level	-3.15	
5 th Announcement		t-statistic	t-probability
JSE	ADF test statistic	-2.71	0.23
	1% level	-4.07	
	5% level	-3.46	
	10% level	-3.15	
LSE	ADF test statistic	-3.12	0.11
	1% level	-4.07	
	5% level	-3.46	
	10% level	-3.15	

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

Table A3: Unit Root tests (Level format, without intercept and trend)

1 st Announcement		t-statistic	t-probability
JSE	ADF test statistic	-1.05	0.26
	1% level	-2.58	
	5% level	-1.94	
	10% level	-1.61	
LSE	ADF test statistic	-11.36	0.70
	1% level	-2.58	
	5% level	-1.94	
	10% level	-1.61	
2 nd Announcement		t-statistic	t-probability
JSE	ADF test statistic	-1.07	0.25
	1% level	-2.58	
	5% level	-1.94	
	10% level	-1.61	
LSE	ADF test statistic	-0.88	0.33
	1% level	-2.58	
	5% level	-1.94	
	10% level	-1.61	
3 rd Announcement		t-statistic	t-probability
JSE	ADF test statistic	-0.61	0.45
	1% level	-2.58	
	5% level	-1.94	
	10% level	-1.61	
LSE	ADF test statistic	-0.57	0.46
	1% level	-2.58	
	5% level	-1.94	
	10% level	-1.61	
4 th Announcement		t-statistic	t-probability
JSE	ADF test statistic	-0.39	0.79
	1% level	-2.58	
	5% level	-1.94	
	10% level	-1.61	
LSE	ADF test statistic	-0.41	0.80
	1% level	-2.58	
	5% level	-1.94	
	10% level	-1.61	
5 th Announcement		t-statistic	t-probability
JSE	ADF test statistic	-0.64	0.43
	1% level	-2.58	
	5% level	-1.94	
	10% level	-1.61	
LSE	ADF test statistic	-0.85	0.34
	1% level	-2.58	
	5% level	-1.94	
	10% level	-1.61	

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

Table A4: Unit Root tests (first differential format, with intercept)

1 st Announcement		t-statistic	t-probability
JSE	ADF test statistic	-10.57	0.00*
	1% level	-3.49	
	5% level	-2.89	
	10% level	-2.58	
LSE	ADF test statistic	-11.36	0.00*
	1% level	-3.49	
	5% level	-2.89	
	10% level	-2.58	
2 nd Announcement		t-statistic	t-probability
JSE	ADF test statistic	-11.24	0.00*
	1% level	-3.48	
	5% level	-2.88	
	10% level	-2.58	
LSE	ADF test statistic	-12.40	0.00*
	1% level	-3.48	
	5% level	-2.88	
	10% level	-2.58	
3 rd Announcement		t-statistic	t-probability
JSE	ADF test statistic	-8.74	0.00*
	1% level	-3.52	
	5% level	-2.90	
	10% level	-2.59	
LSE	ADF test statistic	-9.10	0.00*
	1% level	-3.52	
	5% level	-2.90	
	10% level	-2.59	
4 th Announcement		t-statistic	t-probability
JSE	ADF test statistic	-15.30	0.00*
	1% level	-3.45	
	5% level	-2.87	
	10% level	-2.57	
LSE	ADF test statistic	-16.41	0.00*
	1% level	-3.45	
	5% level	-2.87	
	10% level	-2.57	
5 th Announcement		t-statistic	t-probability
JSE	ADF test statistic	-10.37	0.00*
	1% level	-3.50	
	5% level	-2.90	
	10% level	-2.59	
LSE	ADF test statistic	-11.49	0.00*
	1% level	-3.50	
	5% level	-2.90	
	10% level	-2.59	

* Reject the null hypothesis that the data has a unit root at the 95% level of statistical significance.

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

Table A5: Unit Root tests (first differential format, with intercept and trend)

1 st Announcement		t-statistic	t-probability
JSE	ADF test statistic	-9.06	0.00*
	1% level	-4.07	
	5% level	-3.46	
	10% level	-3.15	
LSE	ADF test statistic	-9.98	0.00*
	1% level	-4.07	
	5% level	-3.46	
	10% level	-3.16	
2 nd Announcement		t-statistic	t-probability
JSE	ADF test statistic	-9.45	0.00*
	1% level	-4.04	
	5% level	-3.45	
	10% level	-3.15	
LSE	ADF test statistic	-11.53	0.00*
	1% level	-4.04	
	5% level	-3.45	
	10% level	-3.15	
3 rd Announcement		t-statistic	t-probability
JSE	ADF test statistic	-11.08	0.00*
	1% level	-4.03	
	5% level	-3.44	
	10% level	-3.15	
LSE	ADF test statistic	-11.78	0.00*
	1% level	-4.04	
	5% level	-3.45	
	10% level	-3.15	
4 th Announcement		t-statistic	t-probability
JSE	ADF test statistic	-10.23	0.00*
	1% level	-4.05	
	5% level	-3.45	
	10% level	-3.15	
LSE	ADF test statistic	-10.51	0.00*
	1% level	-4.05	
	5% level	-3.45	
	10% level	-3.15	
5 th Announcement		t-statistic	t-probability
JSE	ADF test statistic	-10.32	0.00*
	1% level	-4.07	
	5% level	-3.47	
	10% level	-3.15	
LSE	ADF test statistic	-11.43	0.00*
	1% level	-4.08	
	5% level	-3.47	
	10% level	-3.16	

* Reject the null hypothesis that the data has a unit root at the 95% level of statistical significance.

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

Table A6: Unit Root tests (first differential format, without intercept and trend)

1 st Announcement		t-statistic	t-probability
JSE	ADF test statistic	-9.04	0.00*
	1% level	-2.59	
	5% level	-1.94	
	10% level	-1.61	
LSE	ADF test statistic	-10.01	0.00*
	1% level	-2.59	
	5% level	-1.94	
	10% level	-1.61	
2 nd Announcement		t-statistic	t-probability
JSE	ADF test statistic	-9.43	0.00*
	1% level	-2.58	
	5% level	-1.94	
	10% level	-1.61	
LSE	ADF test statistic	-11.54	0.00*
	1% level	-2.58	
	5% level	-1.95	
	10% level	-1.61	
3 rd Announcement		t-statistic	t-probability
JSE	ADF test statistic	-11.16	0.00*
	1% level	-2.58	
	5% level	-1.94	
	10% level	-1.61	
LSE	ADF test statistic	-11.87	0.00*
	1% level	-2.59	
	5% level	-1.95	
	10% level	-1.62	
4 th Announcement		t-statistic	t-probability
JSE	ADF test statistic	-10.19	0.00*
	1% level	-2.59	
	5% level	-1.94	
	10% level	-1.61	
LSE	ADF test statistic	-10.47	0.00*
	1% level	-2.59	
	5% level	-1.95	
	10% level	-1.62	
5 th Announcement		t-statistic	t-probability
JSE	ADF test statistic	-10.37	0.00*
	1% level	-2.59	
	5% level	-1.94	
	10% level	-1.61	
LSE	ADF test statistic	-11.49	0.00*
	1% level	-2.59	
	5% level	-1.95	
	10% level	-1.61	

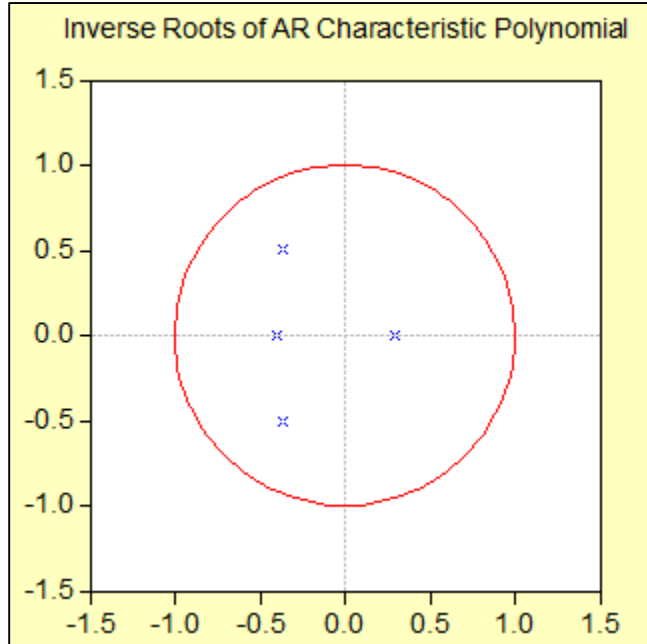
* Reject the null hypothesis that the data has a unit root at the 95% level of statistical significance.

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

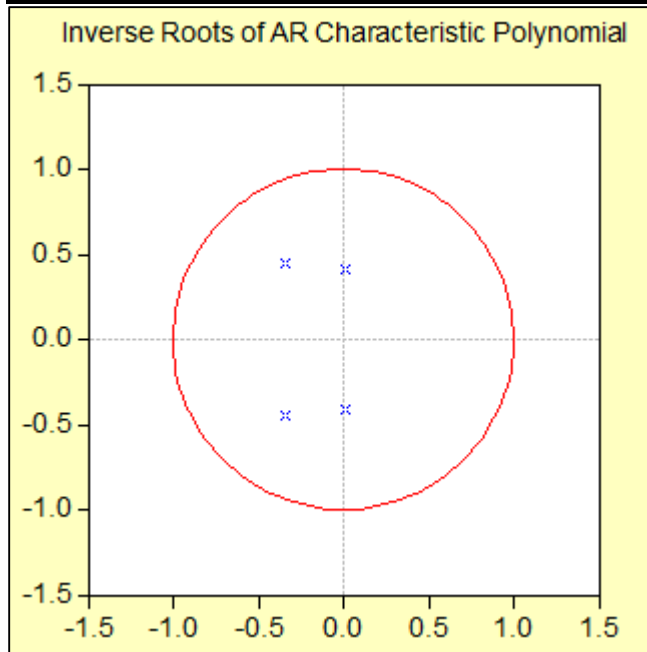
APPENDIX B

Figure B1: 1st Announcement: Inverse roots of AR Characteristic Polynomial



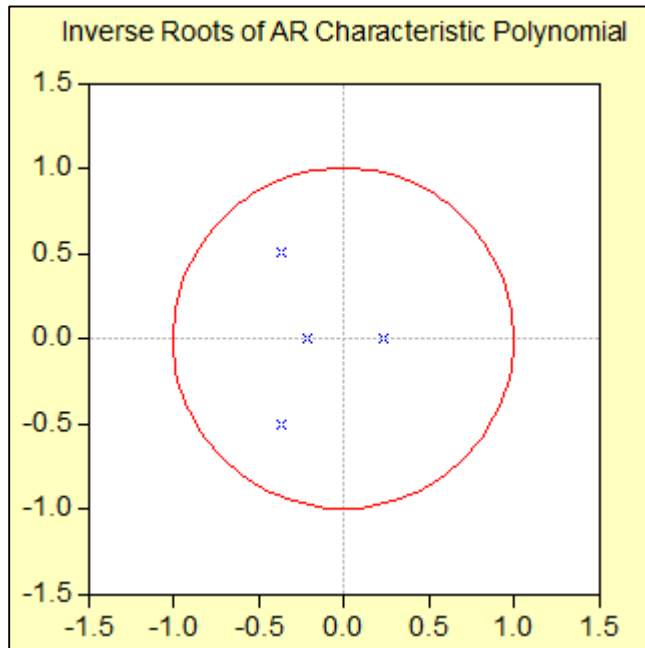
Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Figure B2: 2nd Announcement: Inverse roots of AR Characteristic Polynomial



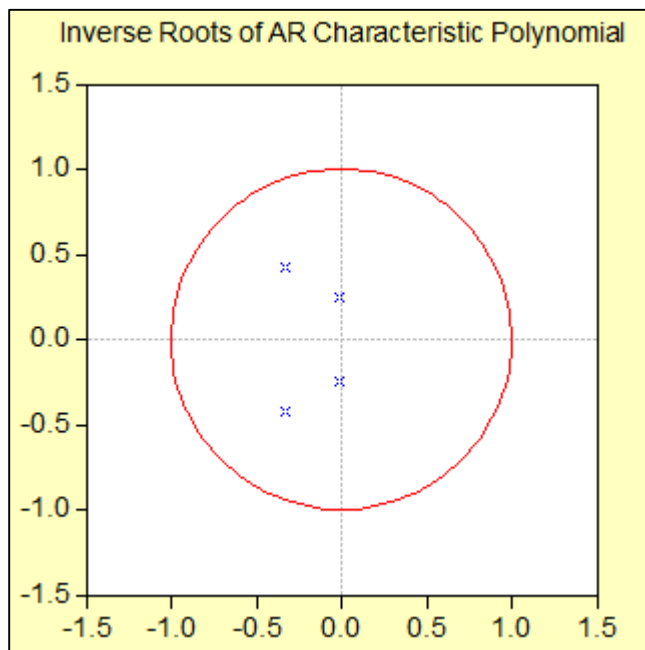
Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Figure B3: 3rd Announcement: Inverse roots of AR Characteristic Polynomial



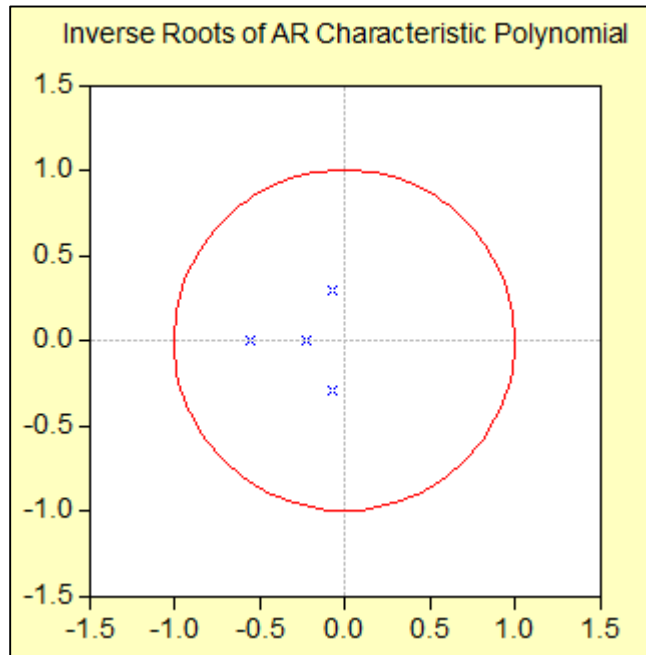
Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Figure B4: 4th Announcement: Inverse roots of AR Characteristic Polynomial



Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Figure B5: 5th Announcement: Inverse roots of AR Characteristic Polynomial



Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Table B1: Lag Length Criteria

1 st Announcement						
LAG	LOGL	LR	FPE	AIC	SC	HQ
0	-1506.41	NA	5.88	30.47	30.53	30.49
1	-1488.46	34.82	4.43	30.19	30.35	30.25
2	-1478.17	19.53	3.91	30.06	30.32*	30.17
3	-1470.89	13.54*	3.66*	29.99*	30.36	30.14*
4	-1469.07	3.31	3.82	30.04	30.51	30.23
5	-1466.95	3.77	3.97	30.08	30.66	30.31
2 nd Announcement						
LAG	LOGL	LR	FPE	AIC	SC	HQ
0	-1446.75	NA	1.76	29.27	29.32	29.29
1	-1429.64	33.17	1.35	29.00	29.16*	29.07
2	-1422.09	14.35	1.26	28.93	29.19	29.04
3	-1413.50	15.96	1.15	28.84	29.21	28.98*
4	-1409.02	8.15	1.14	28.83	29.30	29.02
5	-1403.12	10.49*	1.09*	28.79*	29.37	29.02
3 rd Announcement						
LAG	LOGL	LR	FPE	AIC	SC	HQ
0	-1104.57	NA	3.34	29.91	29.97	29.93
1	-1092.42	23.31	2.68	29.69	29.87*	29.76
2	-1085.96	12.04	2.51	29.62	29.93	29.74*
3	-1080.72	9.49	2.43	29.59	30.02	29.76
4	-1076.07	8.18	2.39	29.57	30.13	29.79
5	-1070.43	9.59*	2.29*	29.52*	30.21	29.80
4 th Announcement						
LAG	LOGL	LR	FPE	AIC	SC	HQ
0	-1446.51	NA	8.31	30.82	30.87	30.84
1	-1335.85	21.24*	8.59*	28.55*	28.71*	28.61*
2	-1334.47	2.63	9.09	28.61	28.88	28.71
3	-1332.20	4.21	9.43	28.64	29.02	28.80
4	-1331.13	1.93	10.01	28.70	29.19	28.90
5	-1329.86	2.25	10.70	28.76	29.36	29.00
5 th Announcement						
LAG	LOGL	LR	FPE	AIC	SC	HQ
0	-1133.16	NA	2.19	29.48	29.55	29.51
1	-1102.96	58.03*	1.11*	28.80*	28.98*	28.87*
2	-1101.96	1.88	1.20	28.88	29.19	29.00
3	-1096.76	9.46	1.16	28.85	29.28	29.02
4	-1096.52	0.41	1.28	28.95	29.50	29.17
5	-1091.12	9.26	1.24	28.91	29.58	29.18

* Indicates optimal lag length.

Note: Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

APPENDIX C

Figure C.1: 1st Announcement: Correlogram with Ljung-Box Q-statistic

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
* .	* .	1	-0.118	-0.118	1.4969	0.221
* .	* .	2	-0.076	-0.091	2.1192	0.347
. .	. .	3	-0.024	-0.045	2.1815	0.536
. *	. *	4	0.151	0.139	4.7211	0.317
* .	* .	5	-0.098	-0.069	5.7983	0.326
. .	. .	6	-0.009	-0.007	5.8068	0.445
. *	. *	7	0.083	0.080	6.6008	0.472
. .	. .	8	-0.040	-0.050	6.7873	0.560
. .	. *	9	0.063	0.093	7.2457	0.612
. .	. .	10	0.018	0.030	7.2841	0.698
* .	* .	11	-0.146	-0.167	9.8375	0.545
* .	* .	12	-0.082	-0.088	10.646	0.560
. .	. .	13	0.014	-0.059	10.668	0.639
. *	. .	14	0.090	0.068	11.673	0.633
. .	. .	15	-0.031	0.043	11.791	0.695
* .	* .	16	-0.084	-0.099	12.676	0.696
. .	. .	17	-0.010	-0.038	12.689	0.757
. .	. .	18	-0.027	-0.056	12.782	0.804
. .	. .	19	0.003	-0.000	12.783	0.849
. .	. *	20	0.050	0.112	13.114	0.872
. *	. *	21	0.124	0.150	15.178	0.814
. .	. .	22	0.031	0.071	15.312	0.849
* .	* .	23	-0.068	-0.083	15.949	0.857
. *	. *	24	0.129	0.092	18.258	0.790
. *	. *	25	0.078	0.142	19.115	0.792
. .	. .	26	-0.030	0.048	19.246	0.826
. .	. .	27	0.015	0.045	19.280	0.860
. .	* .	28	-0.049	-0.173	19.633	0.877
. .	. .	29	0.043	-0.050	19.900	0.896
. .	. *	30	0.045	0.085	20.208	0.911
. .	. .	31	-0.003	0.020	20.210	0.931
. .	. *	32	0.010	0.142	20.227	0.947
* .	* .	33	-0.116	-0.157	22.311	0.920
. *	. .	34	0.114	-0.019	24.384	0.888
. .	. .	35	-0.024	0.035	24.479	0.908
. .	. .	36	-0.058	-0.008	25.030	0.915

Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Figure C.2: 2nd Announcement: Correlogram with Ljung-Box Q-statistic

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
. .	. .	1 -0.042	-0.042	0.1947	0.659
* .	* .	2 -0.090	-0.092	1.0740	0.584
. .	. .	3 -0.032	-0.040	1.1865	0.756
* .	* .	4 -0.102	-0.115	2.3361	0.674
* .	* .	5 -0.087	-0.107	3.1775	0.673
. *	. .	6 0.075	0.042	3.8087	0.703
. .	. .	7 0.041	0.021	4.0042	0.779
* .	* .	8 -0.112	-0.121	5.4503	0.709
. *	. *	9 0.195	0.182	9.9215	0.357
. *	. *	10 0.099	0.111	11.071	0.352
. .	. .	11 -0.061	-0.010	11.510	0.402
* .	* .	12 -0.194	-0.198	16.035	0.190
. .	. .	13 -0.035	-0.038	16.187	0.239
. .	. *	14 0.054	0.095	16.549	0.281
* .	* .	15 -0.090	-0.131	17.571	0.286
. *	. .	16 0.098	0.001	18.787	0.280
. .	. .	17 -0.041	-0.043	18.999	0.329
. .	. .	18 0.002	0.032	19.000	0.392
. *	. *	19 0.146	0.122	21.782	0.295
. .	. .	20 0.049	0.009	22.105	0.335
* .	. .	21 -0.117	-0.017	23.947	0.296
. .	. *	22 0.041	0.132	24.174	0.338
. *	. *	23 0.127	0.134	26.398	0.282
. .	. .	24 -0.013	0.031	26.420	0.332
. .	. .	25 0.013	-0.028	26.444	0.384
. .	. .	26 -0.046	-0.016	26.749	0.423
. .	. .	27 -0.046	0.005	27.052	0.461
. *	. *	28 0.117	0.098	29.057	0.410
. .	. .	29 0.030	-0.051	29.191	0.455
. .	. .	30 -0.014	-0.005	29.221	0.506
. .	. *	31 -0.023	0.079	29.301	0.554
. .	. .	32 0.006	0.003	29.306	0.604
. *	. *	33 0.112	0.105	31.270	0.553
* .	* .	34 -0.146	-0.149	34.655	0.437
. .	. .	35 -0.065	-0.005	35.339	0.452
* .	* .	36 -0.098	-0.074	36.917	0.426

Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Figure C.3: 3rd Announcement: Correlogram with Ljung-Box Q-statistic

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
. .	. .	1 -0.046	-0.046	0.1771	0.674
. .	. .	2 -0.003	-0.005	0.1777	0.915
. .	. .	3 0.072	0.072	0.6242	0.891
. *	. *	4 0.086	0.094	1.2697	0.867
. *	. *	5 0.102	0.113	2.1841	0.823
. *	. *	6 0.171	0.183	4.7711	0.573
* .	* .	7 -0.104	-0.097	5.7511	0.569
. .	. .	8 -0.017	-0.054	5.7759	0.672
. .	* .	9 -0.050	-0.111	6.0068	0.739
. *	. *	10 0.153	0.120	8.2044	0.609
. .	. .	11 -0.031	-0.030	8.2930	0.687
. *	. **	12 0.203	0.240	12.269	0.424
* .	. .	13 -0.111	-0.063	13.465	0.413
* .	* .	14 -0.077	-0.090	14.051	0.446
. .	. .	15 0.024	-0.056	14.107	0.517
. .	* .	16 0.023	-0.073	14.160	0.587
. .	. .	17 -0.048	-0.037	14.401	0.639
. .	* .	18 -0.045	-0.083	14.613	0.688
* .	. .	19 -0.082	0.045	15.333	0.701
. *	. *	20 0.139	0.176	17.437	0.624
* .	. .	21 -0.076	-0.018	18.072	0.644
. .	* .	22 -0.004	-0.067	18.074	0.702
. .	. .	23 -0.041	-0.054	18.271	0.743
. *	. *	24 0.111	0.086	19.715	0.713
* .	** .	25 -0.196	-0.230	24.281	0.503
* .	** .	26 -0.162	-0.223	27.450	0.386
* .	* .	27 -0.118	-0.155	29.164	0.353
* .	* .	28 -0.099	-0.083	30.400	0.344
. .	. *	29 -0.011	0.099	30.414	0.394
* .	. .	30 -0.079	-0.028	31.225	0.404
** .	. .	31 -0.207	-0.029	36.958	0.213
. *	. *	32 0.129	0.142	39.243	0.177
* .	. .	33 -0.118	-0.055	41.182	0.155
. .	. .	34 0.033	-0.016	41.341	0.181
. .	. .	35 -0.003	-0.058	41.342	0.213
. .	. .	36 0.000	0.020	41.342	0.249

Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Figure C.4: 4th Announcement: Correlogram with Ljung-Box Q-statistic

Autocorrelation		Partial Correlation		AC	PAC	Q-Stat	Prob	
* .		* .		1	-0.090	-0.090	0.8332	0.361
* .		* .		2	-0.101	-0.110	1.8910	0.388
* .		* .		3	-0.109	-0.131	3.1206	0.373
. .		* .		4	-0.064	-0.105	3.5505	0.470
. *		. *		5	0.168	0.127	6.5540	0.256
. *		. *		6	0.122	0.131	8.1464	0.228
. *		. **		7	0.173	0.237	11.412	0.122
* .		. .		8	-0.130	-0.019	13.270	0.103
. .		. *		9	0.043	0.132	13.473	0.142
* .		* .		10	-0.140	-0.124	15.660	0.110
. .		* .		11	-0.004	-0.066	15.662	0.154
. *		. .		12	0.101	-0.034	16.842	0.156
. .		* .		13	-0.031	-0.088	16.951	0.202
. .		. .		14	0.037	-0.034	17.114	0.250
** .		** .		15	-0.275	-0.267	26.097	0.037
. .		. .		16	0.037	-0.026	26.265	0.050
. .		. .		17	0.021	0.007	26.318	0.069
. .		* .		18	-0.058	-0.111	26.727	0.084
. .		. .		19	0.034	0.020	26.870	0.108
* .		. .		20	-0.081	0.008	27.703	0.117
* .		. .		21	-0.075	-0.047	28.424	0.129
. .		. *		22	-0.016	0.078	28.459	0.161
. .		. .		23	0.034	-0.002	28.612	0.194
* .		* .		24	-0.112	-0.075	30.299	0.175
. .		. .		25	0.008	-0.046	30.307	0.213
. .		* .		26	-0.031	-0.093	30.440	0.250
* .		* .		27	-0.112	-0.116	32.177	0.226
. .		* .		28	0.022	-0.105	32.244	0.265
. .		. .		29	-0.008	-0.058	32.254	0.309
. *		. *		30	0.124	0.097	34.479	0.262
* .		. .		31	-0.067	-0.020	35.134	0.279
* .		. .		32	-0.079	-0.000	36.059	0.284
* .		* .		33	-0.156	-0.173	39.724	0.195
. .		. .		34	0.033	-0.020	39.896	0.224
. .		* .		35	0.056	-0.089	40.383	0.245
. *		. .		36	0.116	0.032	42.506	0.211

Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Figure C.5: 5th Announcement: Correlogram with Ljung-Box Q-statistic

Autocorrelation		Partial Correlation		AC	PAC	Q-Stat	Prob	
* .		* .		1	-0.112	-0.112	1.3418	0.247
. .		. .		2	0.008	-0.004	1.3494	0.509
. *		. *		3	0.108	0.110	2.6155	0.455
** .		* .		4	-0.221	-0.202	8.0048	0.091
. .		. .		5	0.021	-0.025	8.0553	0.153
. .		. .		6	-0.036	-0.045	8.2025	0.224
* .		* .		7	-0.105	-0.076	9.4477	0.222
. **		. *		8	0.222	0.174	15.094	0.057
* .		. .		9	-0.081	-0.043	15.858	0.070
. .		. .		10	0.063	0.053	16.327	0.091
. .		. .		11	0.067	0.011	16.860	0.112
* .		. .		12	-0.114	-0.033	18.422	0.103
* .		* .		13	-0.077	-0.134	19.138	0.119
. .		. .		14	-0.051	-0.052	19.462	0.148
. .		. .		15	-0.055	-0.011	19.837	0.178
. .		* .		16	-0.020	-0.082	19.889	0.225
. .		. .		17	0.015	0.012	19.918	0.278
. .		. .		18	0.060	0.026	20.383	0.312
. .		* .		19	-0.041	-0.072	20.597	0.359
. .		. .		20	0.051	0.032	20.945	0.400
* .		* .		21	-0.116	-0.110	22.721	0.359
. .		. .		22	-0.024	-0.020	22.801	0.413
. .		. .		23	-0.033	-0.053	22.950	0.464
. .		. *		24	0.016	0.079	22.986	0.521
. .		. .		25	0.032	-0.016	23.129	0.570
. *		. *		26	0.112	0.096	24.908	0.524
. .		. .		27	0.009	0.020	24.920	0.579
. **		. *		28	0.217	0.196	31.763	0.284
. .		. .		29	-0.045	0.006	32.063	0.317
. .		. .		30	-0.058	-0.038	32.567	0.342
. .		. .		31	0.003	-0.009	32.568	0.390
* .		. .		32	-0.087	-0.027	33.715	0.384
. .		. *		33	0.073	0.103	34.553	0.394
. .		. .		34	0.021	-0.025	34.625	0.438
* .		* .		35	-0.087	-0.085	35.833	0.429
. *		. .		36	0.143	0.017	39.168	0.330

Source: Estimation conducted by author using Eviews 7 (QMS, 2009).

Table C1: The EGARCH models

1st Announcement : Return Equation				2nd Announcement : Return Equation			
Variable	Coefficient	Z-statistic	Prob.	Variable	Coefficient	Z-statistic	Prob.
ϕ_i	0.84	42.12	0.00*	ϕ_i	0.71	18.89	0.00*
Variance Equation				Variance Equation			
θ_0	3.31	0.88	0.00*	θ_0	20.21	28.40	0.00*
θ_1	1.08	5.31	0.00*	θ_1	0.35	1.74	0.08*
γ	0.33	1.97	0.01*	γ	0.13	2.72	0.00*
β	0.70	2.51	0.00*	β	0.41	1.78	0.01*
Descriptive Statistics				Descriptive Statistics			
DW	3.03			DW	2.81		
AIC	14.56	SIC	14.71	AIC	14.08	SIC	14.21
R ²	0.46	Adjusted R ²	0.45	R ²	0.65	Adjusted R ²	0.64
3rd Announcement : Return Equation				4th Announcement : Return Equation			
Variable	Coefficient	Z-statistic	Prob.	Variable	Coefficient	Z-statistic	Prob.
ϕ_i	0.93	25.42	0.00*	ϕ_i	0.71	18.20	0.00*
Variance Equation				Variance Equation			
θ_0	18.31	16.97	0.00*	θ_0	15.53	7.68	0.00*
θ_1	0.80	3.03	0.00*	θ_1	1.09	3.63	0.00*
γ	0.26	1.97	0.01*	γ	0.32	0.59	0.01*
β	0.71	9.91	0.00*	β	0.77	2.70	0.00*
Descriptive Statistics				Descriptive Statistics			
DW	2.6			DW	2.98		
AIC	14.10	SIC	14.28	AIC	13.82	SIC	13.91
R ²	0.62	Adjusted R ²	0.61	R ²	0.63	Adjusted R ²	0.63
5th Announcement : Return Equation							
Variable	Coefficient	Z-statistic	Prob.				
ϕ_i	0.71	19.46	0.00*				
Variance Equation							
θ_0	-0.58	-0.43	0.00*				
θ_1	0.80	3.43	0.00*				
γ	0.63	2.82	0.00*				
β	0.98	7.80	0.00*				
Descriptive Statistics							
DW	3.29						
AIC	14.14	SIC	14.31				
R ²	0.59	Adjusted R ²	0.58				

* Statistically significant at the 99% level.

Note: R² denotes R-squared statistic; Adjusted R² denotes adjusted R-squared statistic.

Note: Model assumption: Asymmetric order of one. Analysis performed in Eviews 7 (QMS, 2009).

Source: Compiled by author.

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