

**MODELLING DAILY RETURN VARIATIONS IN
DEVELOPING MARKET CURRENCIES**

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ABSTRACT

This study examines the American Dollar (USD) denominated currency returns of five developing market currencies for the presence of the day-of-the-week effect. Daily data from January 1995 to February 2008 is examined, and is split into two sub-periods, SP1 (1995 – 2002) and SP2 (2003 – February 2008). Currency returns are non-normally distributed across the full data set and SP1, but tend towards normality in SP2. As such non-parametric tests are used to test the equality of the first four moments across days of the week. Tests on the first moment show that two of the currencies do not show any evidence of the day-of-the-week effect. However, evidence of the day-of-the-week effect is found in the other three currencies in SP1, although the effect disappears or weakens significantly in SP2. Little evidence of the day-of-the-week effect is found in tests on the second moment. The hypothesis of equal higher moments across currency returns is rejected for almost all of the weekday pairs for all five currencies in SP1, but in SP2 the hypothesis of equal higher moments can only be rejected for a single pair of weekdays for one currency. This indicates the disappearance of the day-of-the-week effect across higher moments in SP2. Thus, the study finds that the day-of-the-week effect is present across the first moment and higher moments in the returns to most currencies in SP1, but has disappeared for all five currencies in SP2.

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TABLE OF CONTENTS

CHAPTER ONE

1. INTRODUCTION.....	1
----------------------	---

CHAPTER TWO

2. LITERATURE REVIEW	3
2.1. EFFICIENCY IN ASSET PRICE MARKETS.....	3
2.2. CALENDAR ANOMALIES.....	4
2.2.1. The Day-of-the-Week or Weekend Effect.....	5
2.2.2. The Turn-of-the-Month Effect.....	7
2.2.3. The Holiday Effect	8
2.2.4. Advances in the Detection of Calendar Anomalies	9
2.3. THE ROBUSTNESS OF CALENDAR ANOMALIES IN RETURNS	10
2.4. CALENDAR ANOMALIES: HYPOTHESES RELATING TO THEIR PRESENCE IN FINANCIAL DATA	12
2.4.1. Calendar Time and Trading Time Hypotheses	12
2.4.2. Settlement Effects Hypothesis	13
2.4.3. Pricing / Measurement Errors	14
2.4.4. Information Flows Hypothesis.....	14
2.5. SUMMARY.....	15

CHAPTER THREE

3. EMPIRICS.....	17
3.1 DATA	17
3.2 SUMMARY STATISTICS	20

CHAPTER FOUR

4. METHOD	29
-----------------	----

CHAPTER FIVE

5. RESULTS	33
------------------	----

CHAPTER SIX

6. CONCLUSION	44
---------------------	----

REFERENCES	47
------------------	----

APPENDIX.....	52
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LIST OF TABLES

Text Tables:

Table I: Information on currencies.....	18
Table II: Summary statistics of currency returns by weekdays for the full data set...23	
Table III: Autocorrelation tables for each currency in the full data set, SP1 and SP2 with the autocorrelation coefficient, Q-statistic and its probability at one lag.....27	
Table IV: Kolmogorov-Smirnov one-sample test of normality for the distribution of each weekday.....34	
Table V: Non-parametric median test for the equality of medians across weekdays.35	
Table VI: Kruskal-Wallis test for the equality of medians across weekdays.....35	
Table VII: Siegel-Tukey test for the equality of variances across pairs of weekdays in the full data set.....37	
Table VIII: Siegel-Tukey test for the equality of variances across pairs of weekdays in SP1 and SP2.....39	
Table IX: Kolmogorov-Smirnov test of equal distribution between two weekdays using standard scores of currency returns for the full data set.....40	
Table X: Kolmogorov-Smirnov test of equal distribution between two weekdays using standard scores of currency returns, SP1 and SP2.....41	
Table XI: Average pip values for each currency, SP1 and SP2.....42	

Appendix Tables:

Table XII: Summary statistics of currency returns by weekdays (SP1).....52	
Table XIII: Summary statistics of currency returns by weekdays (SP2).....52	

LIST OF FIGURES

Text Figures:

Figure I: Histograms and kernel density estimates for the full data set.....	23
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Appendix Figures:

Figure II: Histograms and kernel density estimates (SP1).....53
Figure II: Histograms and kernel density estimates (SP2).....53

CHAPTER ONE

INTRODUCTION

Time series observations of spot and forward asset prices, and corresponding rates of change, are often periodic at various frequencies. In the case of foreign exchange, which trades nearly continuously across time zones, periodicity is apparent in calendar or seasonal effects. These are among empirical finance's most intriguing anomalies. Common seasonal effects include the time-of-the-day effect and the day-of-the-week effect, for intra-day and daily foreign exchange series respectively (Campbell, et al., 1997).

If these effects exist they can be exploited by speculators, arbitrageurs, hedgers (fund managers) and other financial intermediaries, who can apply market-timing strategies to ensure pecuniary gains (Fama, 1965; Yakob, et al., 2005). Thus, the semi-strong form of the Efficient Markets Hypothesis (EMH) described by Fama et al., (1969) and Fama (1970) could be precluded in the foreign exchange market, which would imply that the currency market are not functioning optimally.

Considerable scrutiny of mature market securities data to find such effects has ensued and empirical evidence of these effects across international securities markets accumulates by the year. However, such effects cannot be regarded as stylised effects of empirical finance given the deficiencies in the data and econometric modelling strategies used (Sullivan, et al., 2001). In particular, the majority of previous studies use parametric modelling techniques, which assume that currency returns are normally distributed, although this has been proven to be false (Westerfield, 1977; Rogalski & Vinso, 1978; Friedman & Vandersteel, 1982; McFarland, Pettit & Sung, 1982; Boothe & Glassman, 1987; So, 1987; Joseph & Hewins, 1992). This implies that the results of the studies, which use parametric techniques dependent on regression analysis, should be reassessed, as their validity may be questionable.

There are fewer studies of whether seasonal effects in developing market currencies, or the absence of them, are systematically related to short-term fluctuations in major currencies due to data constraints. This is of particular importance to international investors seeking arbitrage profits in the international market for foreign currency.

Thus, the aim of this study is to ascertain whether there are seasonal effects in the daily spot value of the Brazilian Real (BRL), Mexican Peso (MXN), South African Rand (ZAR), South Korean Won (KRW) and Polish Zloty (PLN) against the American Dollar (USD) during the January 1995-February 2008 period. This represents an implicit test of semi-strong form efficiency in these countries' spot foreign exchange markets, which are relatively illiquid, compared to the spot market in pairs of major currencies. Such illiquidity is inimical to market efficiency. If these markets are inefficient in the semi-strong form, then unhedged¹ foreign-domiciled owners of financial and real assets in these emerging markets can ascertain the apt day on which to sell their asset and convert the proceeds into USD at a profit, assuming that transactions costs are negligible. Furthermore, the study avoids using parametric tests, which are invalid due to the non-normal distribution of currency returns, and aims to expand the existing research by using non-parametric tests. These tests specifically examine the higher moments of currency returns to find any calendar anomalies that are obscured when only analysing the first two moments.

The remainder of this study is organised as follows. Chapter Two contains a review of past studies on seasonal patterns in currencies. Developing market currencies and the regimes in which they operate as well as the methods used in the empirical analysis are then discussed in Chapter Three. The results of the empirical analysis are discussed in Chapter Four. Chapter Five contains some comments in conclusion.

¹ Investors neither are unhedged in this case if they take neither a long nor a short position in currency forwards/futures on the one hand, and neither purchase nor sell a put or a call option in currency to mitigate or avoid currency risk, on the other.

CHAPTER TWO

LITERATURE REVIEW

In this chapter, the theory of asset market efficiency and its relation to calendar anomalies is described. The forms of calendar anomalies identified in the extant literature are discussed. The evolution of each of these forms in exchange rates from security prices is subsumed in the discussion, together with advances in the detection of these anomalies. Previous studies and the robustness of their results are then examined. Finally, possible reasons for such calendar anomalies being detected are explained.

2.1. EFFICIENCY IN ASSET PRICE MARKETS

Scientists often encounter phenomena that cannot be explained by any prevalent or conventional theory. These phenomena are referred to as anomalies. When applied to the statistical moments of the prices of financial assets, calendar anomalies or seasonal effects contradict the semi-strong form of the EMH. This form of the EMH consists in the idea that asset prices adjust to new, material and publicly available information. Only material public information relevant to an asset's price, such as market announcements², should cause a change in its price and the magnitude of this change depends on the extent to which economic agents attach importance to such information. Thus, the use of fundamental analysis is futile in predicting future prices. This also precludes the exploitation of systematic patterns in asset prices to earn excess returns, as is the practice of chartists or technical analysts (Pearce, 1996). If calendar anomalies cause such market inefficiency, the extent of this inefficiency is measured by, for instance, the difference between returns to a risky financial asset and the risk free rate which is referred to as excess return earned through the use of trading strategies.

² Security prices are affected by company announcements regarding earnings and releases of macroeconomic data, whilst exchange rates are usually affected by macroeconomic announcements in multiple countries.

Thus, evidence of predictable returns might, rather than will, imply market inefficiency for two reasons. First, transaction costs must be less than the excess returns earned by exploiting calendar anomalies to imply market inefficiency (Brooks & Persaud, 2001)³. Second, the apparent differences in returns earned during particular periods of time, such as different days of the week, may be explained by differences in economic agents' need for compensation for bearing risk each day (Brooks & Persaud, 2001). This is known as time-variation in risk premia.

2.2. CALENDAR ANOMALIES

Calendar anomalies were first brought to the attention of financial economists by participants in security markets who were sure that the returns on certain days or during certain periods were greater than average (Fields, 1931; 1934). Since then, most studies of anomalies comprise the analysis of the first two statistical moments of prices and rates of change in the same for listings in mature spot and forward security markets. Given that foreign exchange is considered an asset class in its own right and that these anomalies were detected in securities first, it is natural that during the era of floating exchange rate regimes, when speculation in spot and forward foreign exchange markets increased, more scholars and practitioners would scrutinise spot and forward currency markets to detect such anomalies. However, at this stage, relatively few scholars seek calendar anomalies in exchange rates. Of those that do, spot values of pairs of "majors" - American Dollar (USD), British Pound (GBP) and the Japanese Yen (JPY), are most often analysed. The few extant studies of seasonal effects using developing market currencies as part of a pair are associated with countries situated in the Asia-Pacific region and predominantly spot markets are considered.

Since calendar anomalies are found in security prices which are discrete-time, discrete-variable, it does not follow that calendar anomalies will necessarily be apparent in exchange rates which are continuous-time, continuous-variable because the dynamics according to which each evolves is different. For example, currency

³ A foreign investor would consider transaction costs, their expectation of the exchange rate if cross-border trades are permitted and inflation in their country during the period, to compute the exchange rate-adjusted real return

portfolios held for speculative purposes are often re-balanced by important financial institutions that can influence prices. This will be apparent in the Probability Density Function (PDF) of security prices and exchange rates differing across time periods, depending on the frequency of the data set used.

The kinds of calendar anomalies that are detected in security markets and then sought in the foreign exchange market include the day-of-the-week or “weekend” effect (Cross, 1973; Levi, 1978; French 1980; McFarland, Pettit & Sung, 1982; Keim & Stambaugh, 1984; Rogalski, 1984; Jaffe & Westerfield, 1985; So, 1987; Joseph & Hewins, 1992; Aydogan & Booth, 2003), the turn-of-the-month effect⁴ (Ariel, 1987; Lakonishok & Smidt, 1988; Aydogan & Booth, 2003), and the holiday effect (Fields, 1934; Lakonishok & Smidt, 1988; Baillie & Bollerslev, 1989; Ariel, 1990; Copeland & Wang, 1994; Aydogan & Booth, 2003)⁵. Each of these calendar anomalies is now discussed.

2.2.1. The Day-of-the-Week or Weekend Effect

The day-of-the-week effect refers to the tendency of security and exchange rate returns on Mondays to be negative, with greater returns being earned at the end of the trading week. This phenomenon is also referred to as the “weekend” effect or the “Blue Monday” effect. This effect’s economic impact can be significant for security returns, as it is associated with the 1929 Wall Street Crash, which led to the Great Depression in the United States (Jacobs & Levy, 1988).

This effect was first discovered in the security returns of major indices in stock exchanges in the United States, including the NASDAQ and Dow Jones. Early studies (Cross, 1973; French, 1980; Gibbons & Hess, 1981; Keim & Stambaugh, 1984; Lakonishok & Smidt, 1988) of this effect in stock returns find that returns on Tuesdays through to Fridays are consistently positive, returns on Mondays are negative on average and returns are greater than average, and positive, on Fridays.

⁴ The turn-of-the-month usually subsumes the last few trading days of a given month and the first two trading days of the next month.

⁵ Thaler (1987a, b) first reviews calendar anomalies and Sullivan et al. (2001) discuss a comprehensive range of such anomalies.

Levi (1978) is the first author to investigate calendar anomalies in exchange rates, having recognised the “weekend effect”. The study uses a regression incorporating dummy variables for each day of the week and reveals a drop in prices on a Friday with a nearly commensurate increase on a Monday (Levi, 1978). The same method yields similar results in other studies (McFarland, Pettit & Sung, 1982; Jaffe & Westerfield, 1985; Baillie & Bollerslev, 1989; Copeland & Wang, 1994; Aydogan & Booth, 2003). However, several authors (Westerfield, 1977; Rogalski & Vinso, 1978; Friedman & Vandersteel, 1982; McFarland, Pettit & Sung, 1982; Boothe & Glassman, 1987; So, 1987; Joseph & Hewins, 1992) find that the distribution of exchange rate returns tend to be non-normal, which renders the estimation of dummy variable models to detect seasonalities in currency returns futile. The reason is that the latter approach requires that the distributions of exchange rate returns must follow the normal distribution for the inferences derived from the estimation of dummy variable regressions to be valid.

McFarland, Pettit & Sung (1982) are the first authors to impugn the assumption of the normality of the distribution of the Cumulative Distribution Function (CDF) of exchange rate returns in a test for seasonalities in currency returns and use non-parametric tests. These authors use the Kruskal-Wallis and Siegel-Tukey tests of the hypothesis that the CDF's of currency returns are equal for each day of the week. McFarland, Pettit & Sung (1982) find that average price changes on Mondays and Wednesdays are greater than those on Thursdays and Fridays for almost all currencies in both the forward and spot markets. The higher returns on Monday surpass transaction costs, which is economically important, as a strategy taking these effects into account can generate excess returns (McFarland, Pettit & Sung, 1982).

Joseph & Hewins (1992) find that when specific intervals are considered as an input to foreign exchange models, the choice of period or day of the week can affect expected portfolio returns, as when the Kruskal-Wallis test is applied short term returns are affected by the day-of-the-week effect more than long term returns. In

addition, when the non-parametric Wilcoxon matched-pairs signed-ranks W test, and the overall non-parametric related sample test or Friedman test are applied, the null hypothesis that the day-of-the-week effect is equally strong for all of the currencies in their study is rejected, as the coefficients between the currencies differ in location.

So (1987) is the first author to investigate the presence of the day-of-the-week effect in the higher moments of exchange rate returns. The study uses the simple consistent method developed by McCulloch (1986) to investigate the day-of-the-week effect. The method is based on the estimation of the characteristic exponent, scale, location and skewness of currency returns across the days of the week. So (1987) finds negative Monday returns for most of the currencies in the study but notes that high skewness is also found within each weekday, which may indicate the presence of a day-of-the-week effect in the higher moments of currency returns. Tang (1998) is the most recent author to investigate higher moments for the day-of-the-week effect and finds that the higher moments of equity returns differ across days of the week, indicating that a weekly pattern on the higher moments exists.

In summary, most studies of the day-of-the-week effect apply either an unsuitable model incorporating dummy variables for each day of the week, with the underlying assumption of normality of the distributions, or have investigated only the first two statistical moments with various non-parametric tests.

2.2.2. The Turn-of-the-Month Effect

Ariel (1987) first detects the turn-of-the-month effect in DJIA returns, with returns in the latter part of the month being negative for the period 1963-1983. Lakonishok & Smidt (1988) identify a four day period around the turn of the month for security returns. This includes the last day of the month and the first three days of the following month during which the average return is 0.118 percent compared to 0.025 percent in other trading days in the month. During this four day period, total average returns are 0.473 percent while the average monthly total is only 0.350 percent (Lakonishok & Smidt, 1988). Evidence of the turn-of-the-month effect in the security

markets of the Asia-Pacific region is propounded by Chan, et al., (1996) and Yakob, et al. (2005).

The turn-of-the-month effect in exchange rate returns is only considered by Aydogan & Booth (2003). Using a regression incorporating dummy variables, these authors find that the rate at which currency pairs comprising the TRL change around the turn of the month tends to be lower in the week before the turn of the month. Thereafter, returns are significantly greater during the first five days of the next month.

2.2.3. The Holiday Effect

Fields (1934) first documents the greater than normal returns to DJIA equities on the day before holidays, during 1901-1932. Lakonishok & Smidt (1988) confirm the presence of the holiday effect, as returns on days preceding holidays were on average 0.219 percent, whereas normal weekday returns were on average 0.009 percent. The average cumulative return for the eight days over Christmas is also considerably greater than the January effect found in small capitalisation equities (Jacobs & Levy, 1988). The size of these returns is put into perspective by Lakonishok & Smidt (1988), who find that during the 1897-1986 period, fifty one percent of all DJIA equity returns occur approximately ten days before holidays during a given year. Ariel (1990) finds significantly greater returns during the one hundred and sixty days of the year preceding holidays in comparison to other days during 1962-1982. Similar to Lakonishok & Smidt (1988), Ariel (1990) finds that thirty-five percent of the entire market advance occurs during the eight pre-holiday trading day period each year during this era. Baillie & Bollerslev (1989) measure holiday effects, which are associated with greater volatility, lasting for at least two days using a dummy variable approach. Copeland & Wang (1994) use a similar approach to find that markets are more active when a holiday of duration longer than a weekend is approaching, as there is a greater variance caused by greater trading volumes (Copeland & Wang, 1994). However, unlike the "weekend effect" markets are relatively quiet upon re-opening after a holiday (Copeland & Wang, 1994).

Research on the “holiday effect” in daily data from foreign exchange markets is still sparse, as Aydogan & Booth (2003) use a dummy variable regression to investigate the “holiday effect” and find that the exchange rate changes before holidays. Tang (1998) investigates the holiday effect in the higher moments of ten Asia-Pacific currencies and finds that the returns on holidays differ from those on other days of the week for a number of currencies.

2.2.4. Advances in the Detection of Calendar Anomalies

The only tests of higher moments in currency returns have been performed by Tang (1998), based on a method that Tang (1996) developed for testing higher moments in equity returns. This type of test is important, as daily returns are highly non-normally distributed and if the higher moments differ across weekdays, they could explain the anomalies found in mean returns (Tang, 1998).

Tang (1998) extends Tang (1996) to investigate the weekly pattern in exchange rates in ten Asian-Pacific countries. Currency returns are converted into standard scores in each weekday (i.e. returns minus the mean return and then divided by the standard deviation), after which the non-parametric Kolmogorov-Smirnov (KS) two-sample test is employed to test the hypothesis of equal distribution between weekdays. A rejection of the hypothesis by the KS test would therefore imply that the two distributions have different higher moments, as this procedure converts the mean to zero and the standard deviation to one but has no impact on the skewness and kurtosis. The hypothesis of equal higher moments could not be rejected for one currency but the hypothesis is rejected for at least one pair of weekdays in the other nine currencies and for all of the pairs of weekdays in six of the nine currencies. Tang's (1998) findings therefore support the existence of a day-of-the-week effect on higher moments of currency returns, although no satisfactory explanation of this effect has been found. Weekly patterns on volatility and higher moments cannot help to explain the weekly pattern on mean return in the ten Asian-Pacific countries through the concept of a risk premium (Tang, 1998). However, testing the higher moments in currency returns offers a potentially reliable means of investigating calendar anomalies in exchange rates given the non-normality of returns and Tang

(1998) suggests further research to determine whether they can explain calendar anomalies in other markets.

2.3. THE ROBUSTNESS OF CALENDAR ANOMALIES IN RETURNS

As with the majority of social sciences, economists mainly study non-experimental data and do not have the opportunity to test hypotheses independently of the data that gave rise to them. If this is not taken into account, this exercise, which is known as data mining, can have serious consequences for the reliability and validity of statistical inference (Sullivan, et al., 2001). In the limited sample sizes, which are typically analysed in economics, relationships are sure to occur if the data is analysed thoroughly enough (Sullivan, et al., 2001).

Economic theory predicts the exact opposite, that returns should follow a random-walk Martingale process and that returns should not exhibit any systematic patterns, ruling out seasonal effects unless they can be related to systematic variations in risk premiums (Samuelson, 1965; Sullivan, et al., 2001). However, the effect of variations in risk premiums and the implications for the presence of seasonal effects in returns, has been investigated by numerous researchers, and has not been found to cause the calendar anomalies in equity and foreign exchange markets (Jacobs & Levy, 1988; Ariel, 1990; Brooks & Persaud, 2001; Yakob, et al., 2005).

Studies, which have investigated this topic all focus on equity markets but the results are relevant to studies on foreign exchange, as they talk to assumptions made on the underlying data set. Thus it is likely that any criticism of the findings in a study of seasonalities in foreign exchange markets will be based along similar lines of argument, as those discussed in equity markets. The following discussion highlights these points and the importance of recognising any potential pitfalls when examining a data set for any seasonalities in foreign exchange returns.

Connolly (1989) evaluates the statistical assumptions under which previous studies had been conducted, as few had ever been evaluated systematically. Results show that all of the maintained statistical assumptions are rejected by the data, and also shows that inferences depend on these assumptions. The majority of the assumptions, which are rejected, revolve around assumptions of normality for the distribution of the data. Thus, Connolly (1989) finds that claims of equity market anomalies should be treated sceptically until a sensitivity analysis is performed. Similarly to Connolly (1989), Chang, et al., (1993) examine seasonal effects using sample size or error term adjustments. The robustness of international day of the week returns on twenty-three international indices is examined. Chang, et al., (1993) find that day-of-the-week effect in the US become insignificant with the adjustments, but that equities in seven European countries, Canada and Hong Kong continue to exhibit day-of-the-week effects that are robust to sample size or error term adjustments. However, even in countries where the day-of-the-week effect is most robust, the effect is not uniformly strong across calendar weeks, as it is statistically significant in not more than two weeks out of the month (Chang, et al., 1993).

Sullivan, et al., (2001) offer the most comprehensive analysis of calendar anomalies in equity markets. Systematic seasonal patterns in equity returns imply a rejection of market efficiency and the study focuses on whether this is true or they are just a result of a large, collective data-mining exercise (Sullivan, et al., 2001). It is found that the statistical significance of the best calendar effects in equity markets is not robust to data-mining effects. Therefore it is shown that the strength of evidence on calendar effects is much weaker than thought and that no calendar rule appears capable of outperforming the benchmark market index (Sullivan, et al., 2001).

As stated, research on the robustness of calendar anomalies in exchange rate returns is scarce but it can be assumed that similar issues affect studies on foreign exchange markets. Thus it appears that calendar effects in equity returns are a very controversial topic, with no single agreed answer as to their existence or lack thereof. However, what has been made clear is that any future study investigating these calendar anomalies or seasonal effects in financial markets needs to have extensive

testing procedures in place to ensure that any effects found in the data can be justified.

2.4. CALENDAR ANOMALIES: HYPOTHESES RELATING TO THEIR PRESENCE IN FINANCIAL DATA

The causes of calendar anomalies in the foreign exchange market in particular are discussed and evaluated.

2.4.1. Calendar Time and Trading Time Hypotheses

Researchers have examined two alternative models of the process generating equity returns.

The first model is the calendar time hypothesis, which suggests that returns are generated by a process, which operates at a constant rate during calendar time (Joseph & Hewins, 1992). The validity of the calendar time hypothesis can be validated if Monday returns and their variances are three times larger than that of other days of the week (Fama, 1965). As for the days following holidays, their returns and variances would be larger, the size of which would depend on the duration of the holiday (Joseph & Hewins, 1992). The calendar time hypothesis is rejected for the calendar anomalies found in equity returns by researchers including Cross (1973), French (1980), Keim & Stambaugh (1984) & Rogalski (1984), as returns and variances are not as large as hypothesised.

Joseph & Hewins (1992) also reject the calendar hypothesis for exchange rate returns for both the day-of-the-week effect and the holiday effect, as the returns do not match those predicted by the hypothesis.

Secondly, the trading time hypothesis states that the return generating process only operates when the market is open, so returns are only generated during active trading so that expected return is the same for every day of the week (Jacobs & Levy, 1988). In the case of equity market returns Cross (1973), French (1980) and Keim &

Stambaugh (1984) rejected this hypothesis, but Rogalski (1984) found some support for it, attributed to acknowledging the non-trading weekend effect. The trading time hypothesis is completely rejected for exchange rate returns by Joseph & Hewins (1992), as they find that returns and variances vary over the different days of the week. Neither of these hypotheses can therefore provide an explanation or any rationale for the existence of calendar anomalies

2.4.2. Settlement Effects Hypothesis

The settlement effects hypothesis refers to the impact on the market of the initiation of a transaction and the time that elapses before the settlement of the transaction (Joseph & Hewins, 1992).

Lakonishok & Levi (1982; 1985) and Dyl & Martin (1985) propose trade settlement rules as part of an explanation for equity value movements across the week. However, they reject this hypothesis as calendar anomalies predate the settlement procedures in place at the time of their studies. As such this hypothesis is rejected for equity market returns in America. However, Theobald & Price (1984) and Board & Sutcliffe (1988) showed that the institutional arrangements in the British equity market appear to explain the negative Monday returns on equity.

This has received some attention in foreign exchange markets. Levi (1978) finds that in the case of the USD and Canadian Dollar (CAN) exchange rate, the difference between settlement of domestic transactions and the settlement of international transactions affects the value of the USD over the weekend. The dual-payments system used in America affects foreign exchange markets, which is consistent with the settlement effects hypothesis, resulting in calendar anomalies (Levi, 1978). McFarland, Pettit & Sung (1982) state that the higher returns on Wednesday and the lower returns on Thursday are consistent with the Wednesday effect that emanates from settlement procedures in foreign exchange markets. This is corroborated by Joseph & Hewins (1992) for the British foreign exchange market, as they find that while the settlement hypothesis does not explain the negative returns on Monday it does account for the negative returns on Wednesdays. Furthermore Joseph &

Hewins (1992) state that there is stronger empirical support for the settlement hypothesis in the British market than that professed by McFarland, Pettit & Sung (1988) in the American foreign exchange market.

Thus, in both the American and British foreign exchange markets this hypothesis may be consistent with price patterns. There is considerable scope for further research into the explanatory powers of this hypothesis in other international markets.

2.4.3. Pricing / Measurement Errors

Patterns in returns in financial markets may be caused by pricing or measurement errors. In equity markets, Keim (1985; 1987) reports that this effect appears stronger in smaller equities, however, this is refuted by Cross (1973), Gibbons & Hess (1981), Keim & Stambaugh (1984), Jaffe & Westerfield (1985), Harris (1986) and Smirlock & Starks (1986). Within foreign exchange markets, Joseph & Hewins (1992) reject this hypothesis using Spearman Rank correlation and a multiple parametric correlation test. The pricing / measurement error hypothesis therefore has little support in both equity and foreign exchange markets.

2.4.4. Information Flows Hypothesis

The frequency and timing of the release of new information about company earnings and government policy, for instance, may affect returns to financial assets.

Penman (1987) finds that aggregate corporate earnings news arriving at the market in the first half of the month tends to be good, whereas those arriving later tend to be bad. Furthermore good earnings news announcements are released quickly. Thus, greater returns around the turn-of-the-month reflect a clustering of positive earnings announcements. While Penman (1987) establishes that good earnings news announcements are predominant in the first half of the month, they are not concentrated in the first few days when the turn-of-the-month effect occurs. Ariel's (1987) exclusion of earnings report months attenuates this effect so the

information flows hypothesis is rejected as an explanation for calendar anomalies in American equity markets.

On the other hand, this hypothesis is apt to foreign exchange markets. McFarland, Pettit & Sung (1982) state that much of the relevant information released by governments is made available to the public in recurring patterns, such as more active information flows on the weekend being reflected in Monday's prices. Baillie & Bollerslev (1989) find the day-of-the-week effect in six currencies, which is ascribed to the rate at which information arrives in the market. Copeland & Wang (1994) also find the financial markets are relatively quiet before the announcement of important news, when there is less volatility, and that markets are most volatile immediately following the announcement of important news.

It therefore appears that information flows do not provide a satisfactory explanation in equity markets but may be for currency pairs including the USD. However, more research is needed before any conclusions are reached.

2.5. SUMMARY

While all of these calendar anomalies have been well recognised in the last eight decades they have still not been arbitrated away by investors. This is supported by the continued publication of studies on calendar anomalies and seasonal effects globally. As they appear to be well recognised and relatively easy to exploit, their continued existence is an anomaly in itself.

The major reason is that calendar anomalies are difficult to exploit as an individual source of investment strategy due to transaction cost considerations (Jacobs & Levy, 1988). However, in foreign exchange markets McFarland, Pettit & Sung (1982) show that for major currencies the higher returns on Monday are larger than any transaction costs so a strategy taking these effects into account can generate excess returns.

Despite the fact that these anomalies are well known, their robustness remains a controversial issue given that earlier studies use less advanced econometric techniques, which are reliant on the assumption that currency returns are normally distributed (Pearce, 1996: 69) and focus on seasonalities in mean returns and variances. Thus, not only the mean return and variance, but higher moments and non-parametric tests should be involved in empirical studies when investigating data for these effects (Tang, 1998).

Given the relative scarcity of studies pertaining to exchange rates, there is minimal evidence of calendar anomalies in exchange rates, which impels the empirical work, which is now discussed.

CHAPTER THREE

EMPIRICS

The underlying data for the currency returns of all five currencies is examined in this chapter. First, any macroeconomic or environmental factors, which may have played a role in influencing the daily return variations of the currencies, are discussed. Secondly, the summary statistics of the currency returns are analysed. This is of significance, as the method to be followed when investigating currency returns for the presence of any daily return variations is highly dependent on the distribution of the underlying data

3.1 DATA

The daily direct quote from the developing country's perspective of the closing spot values of the Brazilian Real (BRL), Mexican Peso (MXN), Polish Zloty (PLN), South Korean Won (KRW) and South African Rand (ZAR) against the USD⁶, is analysed for the presence of seasonal effects in this paper for the January 1995-February 2008 period. These are considered emerging currencies, since each is relatively illiquid - in 2007 approximately less than one percent of daily turnover in the spot market is associated with trades in these currencies (Table I).

Macroeconomic developments for these emerging markets are captured by Moody's sovereign bond ratings, with the change from an inferior (especially sub-investment grade) rating of sovereign debt at one point in time to a superior (especially investment grade) rating likely to imply an expected appreciation in the emerging currency. With the exception of Poland, all emerging markets receive better investment ratings over time, which should imply the appreciation of these countries' currencies against the USD. The ratings for South Korea and South Africa improve from speculative grade to investment grade (B to A) and Mexico is on the verge of becoming investment grade. Despite the significant improvement in Brazil's rating, Brazilian gilts are still rated as speculative. The changes from a fixed exchange rate

⁶ ZAR/USD in this study means the number of ZAR requisite for the purchase of USD 1.00.

Table I: Information on currencies

Country	Currency	Exchange Rate Regime (1 = Free Float and year of introduction, 2 = Managed float and year of introduction)	Inflation Targeting Regime (1 = Yes and year of introduction, 2 = No)	Rating of Benchmark Sovereign Bonds (1995,2005) ^{###}	Currency Bid-Ask Spread (1995 – 2008 Average Pips) ^{^^}	Continuous Linked Settlement (1 = Yes and year of introduction, 2 = No)	Average Daily Turnover of Foreign Exchange in Domestic Spot Market, 2007 (USD Billion) [^]
Brazil	Real (BRL)	2, 1999 [*]	1, 1999 ⁷	B2, Ba3	19.33	2	5 (0.1%)
Mexico	Peso (MXN)	2, 1994 ^{**}	1, 1994 ⁸	Baa3, Baa1	110.32	1, 2008	15 (0.4%)
Poland	Zloty (PLN)	2, 1999 ^{***}	1, 1999 ⁹	A2, A2	59.89	2	9 (0.2%)
South Africa	Rand (ZAR)	1, 2000 [#]	1, 2000 ¹⁰	Baa1, A2	161.01	1, 2004	14 (0.3%)
South Korea	Won (KRW)	2, 1997 ^{###}	1, 1998	Baa1, A3	9,144.16	1, 2004	33 (0.8%)

Sources: ^{*}Bank for International Settlements Triennial Survey in April 2007, and refers to the average daily turnover in the domestic foreign exchange market, with the global share of turnover in brackets next to the absolute amount

[^]Lyrio & Dewachter, 2000; Banco Central Do Brazil, 2008

^{**}Bannier, 2006; Bank of Mexico, 2008

^{***}National Bank of Poland, 2008

[#]Saayman, 2006; South African Reserve Bank, 2008

⁷Economist, 2003; The Bank of Korea, 2008

⁸Moody's, 2006; The bond ratings are those for domestic currency sovereign bonds issued at the time closest to the year listed above

^{^^}Bloomberg, 2008

regime to a managed or freely floating regime, as well as the adoption of inflation targeting that appear in Table I, can affect the dynamics of the spot exchange rate, with the switch to inflation-targets and freely-floating exchange rates by a country representing the ideal for currency traders. Thus, the latter country's currency would be expected to appreciate against the USD in the short term.

A proxy for transaction costs in an emerging currency is the bid-ask spread measured in currency pips, which appear in Table I. Minimal (maximal) pip values indicate minimal (maximal) transactions costs (Oanda, 2008). Greater pip values detract from the returns to the investment in a particular emerging currency. The pip values are substantial for each of the currencies, especially KRW, particularly when in view of most currency dealers offering pip values of less than one for major

currency pairs comprising the USD. Campbell et al. (1997) suggest that bid-ask spreads comprise order processing costs, inventory costs and adverse-selection costs. Order processing costs for the more liquid currencies in the sample should diminish since the KRW and ZAR are exchanged in the spot interbank market electronically through Continuous Linked Settlement during the latter part of the sample period. The most important component of the bid-ask spread for these currencies would be the adverse selection costs associated with the market maker's lacking the capacity for distinguishing between informed and uninformed traders, in which case the market maker can lose. Thus, the market maker must be compensated for such losses so a portion of the bid-ask spread represents their charge in taking the other side of potential information-based trades. Inventory costs may also be of importance but this information is not available.

Given that seasonality in the rate of change of a given currency's values are sought, the percentage currency returns are expressed as $R_t = \ln(P_t/P_{t-1}) \times 100$, where \ln denotes the natural logarithm and $P_t(X/USD)$ is the spot exchange rate expressed as the number of units of an emerging currency (X) requisite for the purchase of USD 1.00 at time t and $t-1$ respectively. When R is positive (negative), the emerging currency depreciates (appreciates) against the USD. An emerging currency's depreciation (appreciation) would be to the detriment (benefit) of an unhedged American-domiciled investor purchasing financial or real assets in one of the emerging markets studied here, if the proceeds from their investment are repatriated. While the sign of R is important, its magnitude is also of interest, as it will reveal the extent to which the foregoing investor will gain or lose from the transaction. The values of P are assumed to follow the lognormal distribution and the transformation using the logarithmic first difference in values of P will yield normally distributed currency returns. However, it remains a matter of considerable controversy as to whether currency returns transformed in this way follow the normal distribution (Johnston & Scott, 1999).

3.2 SUMMARY STATISTICS

Several authors (Pena, 1995; Seow Kuan Tan & Nee Tat, 1998; Mehdian & Perry, 2002) identify seasonal patterns in stocks that may be unstable over time, but for exchange rates these issues have seldom been examined. Thus, each currency series used in this study is split into two sub-samples based on time periods, to incorporate the effects of macroeconomic trends and changes in institutional regimes which affect the evolution of spot exchange rates. The first of these sub-periods is the January 1995-December 2002 period, which will henceforth referred to as SP1, and the second is the January 2003-February 2008 period which will henceforth referred to as SP2.

The reason for the split in 2003 is that the repercussions of the East Asian financial crisis affected currency markets during SP1 and it was during SP1, that ZAR depreciated at an unprecedented rate. In addition, during SP2 each of these country's central banks managed their respective exchange rates in a similar way and Continuous Linked Settlement, which could enhance a currency's liquidity, was adopted during SP2.

Thus, SP1 is a time of financial instability, as well as less alignment in the management frameworks for each currency, while SP2 is a time of greater financial stability in conjunction with the tendency towards similar management frameworks. It is acknowledged that the discrepancy in the length of time spanned by each sub-period may bias the results in the absence of the estimation of statistical moments from rolling series, given that important information may be lost. As a result, the results of the analysis will be interpreted with caution. The same methods of analysis, to be discussed later, are applied to both data sets.

It is apparent from Table II that during the entire period that on average every currency, except the BRL, appreciates against the USD on a Friday. Thus, an unhedged American-domiciled holder in most of these emerging markets' assets would lose, if after the sale of the asset held, the proceeds from this investment were

converted on any other day of the week into USD, ignoring transactions costs and American headline consumer price inflation. The absolute value of the average depreciation in the BRL and KRW is maximal on a Tuesday while the absolute value of the average depreciation in the MXN, PLN and ZAR currency returns is maximal on a Thursday (Table II).

During SP1⁷, most of the emerging currencies depreciate against the USD across most days of the week but during SP2⁸ most of the currencies appreciate across days of the week, which may be consistent with risk aversion in respect of emerging market investments being greater during SP1. In SP1 Thursday still has the largest average depreciation, which is consistent with the full data set for four of the currencies (BRL, MXN, KRW and ZAR) and only shifts for PLN to a Wednesday. In contrast, during SP2 the day of largest average depreciation shifts for four of the currencies (BRL, MXN, KRW and ZAR) and only remains constant for one currency (PLN). For those currencies that change, the greatest average depreciation of three currencies (BRL, MXN and ZAR) occurs on a Monday, and on a Friday for one currency (KRW). However, of more interest is that the absolute magnitude for the day of greatest average depreciation drops significantly for every currency between SP1 and SP2. For example, the largest average value for the depreciation of currency returns during any day in the week in SP2 drops 12% for BRL, 10% for MXN, 3.6% for PLN, 7.3% for KRW and 7.6% for ZAR from SP1.

None of the results for the whole data set are consistent with those found in previous studies of developed market currencies (McFarland, Petit & Sung, 1982; Jaffe & Westerfield, 1985), which find Monday and Wednesday to exhibit the greatest depreciation. However, the average value for the depreciation of PLN during SP1 and BRL, MXN and ZAR during SP2 are highest on a Wednesday and Monday's respectively, and matches the results of McFarland, Petit & Sung (1982) and Jaffe & Westerfield (1985). Overall, the day of largest depreciation for each of the currencies is different, as found by Tang (1998) for ten Asian-Pacific currencies. This means that the "calendar time and trading time hypotheses", which have been suggested as the

⁷ See Table XII in the Appendix for detailed information

⁸ See Table XIII in the Appendix for detailed information

cause of seasonalities in equity markets, are not valid for these exchange rates, as the returns on Monday do not appear to be consistently larger than those on any other day of the week.

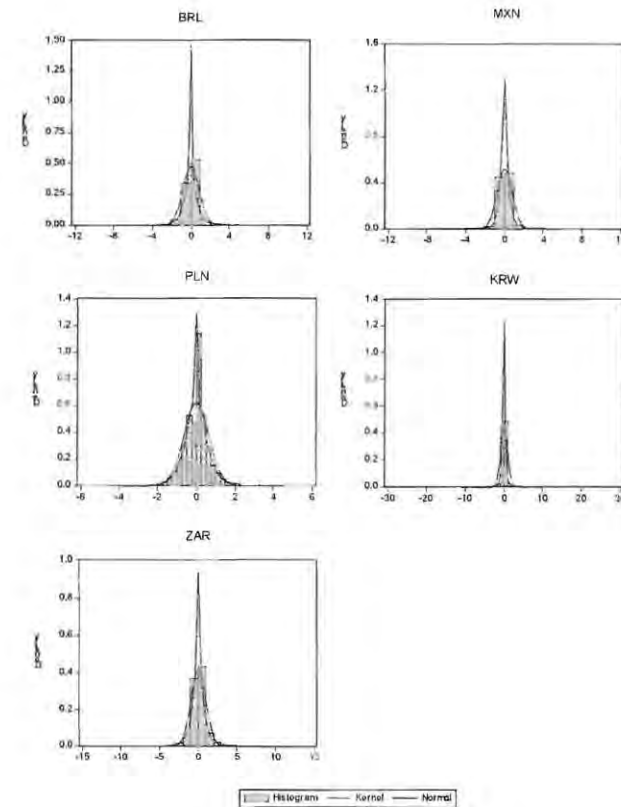
In SP2, every currency except the MXN, appreciates on a Tuesday and Wednesday. Table I shows that four of the currencies (MXN, PLN, KRW and ZAR) have the highest average value for appreciation on a Friday and on a Thursday for BRL. These results match those found by McFarland, Petit & Sung (1982) and Jaffe & Westerfield (1985), and to a lesser extent by Tang (1998). During SP1, the day of the greatest appreciation shifts for BRL, MXN and PLN from a Thursday or Friday to a Monday, while the day of largest appreciation remains constant for the other two currencies (KRW and ZAR). During SP2, the day exhibiting the greatest appreciation for BRL, MXN and PLN is a Friday, for KRW a Thursday, and for ZAR a Wednesday. While the shift in the magnitude of appreciation of currency returns between SP1 and SP2 for each of the currencies is not as significant as it was for the level of depreciation (BRL shifts from there being no day on which it appreciates on average, to one where the average value for the appreciation of currency returns is 10%, while MXN increases 5.1%, PLN increases 5.7%, KRW shows no change, and ZAR increases 2.9%), the number of days of appreciation increase for all of the currencies with the exception of MXN (BRL increases from 0 to 5 days of appreciation, PLN changes from 1 to 3 days, KRW changes from 1 to 4 days and ZAR changes from 1 to 3 days).

In summary, most of the currencies depreciate on average during SP1 and appreciate on average during SP2. The absolute values for the depreciation and appreciation for the currencies vary to a significant extent between periods although on average Tuesdays and Thursdays exhibit the greatest depreciation, while Fridays show the greatest appreciation. Only BRL and MXN match the dispersion of the day of greatest depreciation and appreciation seen in previous studies of developed currencies (McFarland, Petit & Sung, 1982; Jaffe & Westerfield, 1985) during SP2, while the remainder tend to follow the fairly random and widely dispersed patterns observed by Tang (1998).

Table II: Summary statistics of currency returns by weekdays for the full data set

Moment	Day	BRL	MXN	PLN	KRW	ZAR
Mean (%)	Mon	0.007969	-0.001619	-0.015012	0.016418	0.043404
	Tue	0.058394	0.014874	0.000415	0.035001	0.018278
	Wed	0.035603	0.044217	0.006850	-0.002581	0.008335
	Thu	-0.002973	0.090166	0.030608	-0.001763	0.062933
	Fri	0.000342	-0.034543	-0.028946	-0.021739	-0.021083
Standard Deviation (%)	Mon	0.791463	0.787348	0.666835	0.948157	0.846220
	Tue	0.866871	0.778468	0.672097	0.996904	0.969004
	Wed	0.873054	0.682628	0.636694	0.726737	0.921947
	Thu	0.768898	0.723071	0.657946	0.779223	1.000636
	Fri	0.930275	0.889754	0.603635	1.076695	1.054391
Skewness	Mon	0.787187	3.477140	-0.151688	0.991989	-0.192508
	Tue	-0.171349	-0.665562	0.326594	5.003551	-0.131308
	Wed	1.522238	0.114313	0.669560	1.236593	0.931858
	Thu	0.302235	1.737009	0.519297	4.934879	1.131145
	Fri	0.457960	-1.019492	0.278831	-10.90291	-1.462809
Kurtosis	Mon	10.37763	61.63989	6.682719	49.32189	6.861364
	Tue	27.27783	64.43509	6.026205	84.35814	6.912359
	Wed	21.26714	24.90541	6.166395	41.61753	7.370284
	Thu	15.42873	27.63617	5.905955	64.57019	14.04128
	Fri	43.72870	53.35835	9.277593	197.2698	40.34915

Figure I: Histograms and kernel density estimates for the full data set



The Probability Density Function (PDF) of currency returns is estimated with a histogram and kernel density estimator. The latter is a preferred estimator of the PDF due to histograms lacking smoothness and being dependent on the end-point of bins and the width of bins. Kernel density estimators on the other hand are, smooth, without end points and depend on an assumed bandwidth which is set with reference to the number of observations in the currency return series, sample inter-quartile range and the standard deviation of these returns.

The normal kernel is chosen to represent the uni-modal PDF of currency returns in this study and is defined by:

$$\frac{1}{\sqrt{2\pi}} \exp\left(-\frac{1}{2}u^2\right),$$

where u is the argument of the kernel function and the expression is taken to be a standard Gaussian function with a mean of zero and a variance of 1. This function is selected as it tests the assumption that log currency returns deviate from normality.

Figure I superimposes the kernel density estimates on the histograms for each of the currency returns for the full data set⁹ and indicates non-normality of the distribution for four of the currencies (BRL, MXN, KRW and ZAR) in particular, which confirms a stylised fact of empirical finance consisting in currency returns being non-normally distributed (Westerfield, 1977; Rogalski & Vinso, 1978; Friedman & Vandersteel, 1982; McFarland, Pettit & Sung, 1982; Boothe & Glassman, 1987; So, 1987; Joseph & Hewins, 1992), in spite of the returns being transformed using logarithmic first differences. This is consistent with the fact that the rates of change in emerging market currencies fluctuate considerably due to risk aversion on the part of, for example, foreign exchange dealers taking speculative positions and investors in these countries' securities markets.

The second panel of Table II shows the volatility of currency returns across the weekdays (expressed in percentages). The ZAR is the most volatile currency across all days of the week during the entire period, which is to be expected given that it is

⁹ See Figure II and III in the Appendix for more detailed information

the only currency in the sample, which freely floats for most of the sample period. This volatility is conspicuous during SP2 when the ZAR is the only freely floating currency in the sample.

For the full data set four of the currencies (BRL, MXN, KRW and ZAR) are most volatile on a Friday while PLN is most volatile on a Tuesday. This is consistent for the four currencies across SP1 and PLN shifts from Tuesday to Monday. However, in SP2 there is a substantial shift in the days exhibiting the largest volatility as BRL is most volatile on Monday, MXN on Wednesday, PLN and ZAR on Tuesday, and KRW on Thursday. The results for the full data set and SP1 are the same as those found by Harvey & Huang (1991) who find that return volatilities are largest on Fridays.

However, there does not appear to be a consistent relationship between the pattern in daily volatility and mean return for most currencies. In the full data set and SP2 low returns match low volatility for PLN on Fridays but the only other currency to show this pattern is BRL for the full data set. The largest mean return only matches the highest volatility for BRL on Mondays in SP2. However, the lowest mean returns are matched by the highest volatility for MXN, KRW and ZAR on Fridays in the full data set, for KRW and ZAR (Fridays) and PLN (Mondays) in SP1 and for KRW on Thursdays in SP2. On the contrary the largest mean returns are matched by the lowest volatility for PLN during SP1 (Wednesdays) and KRW during SP2 (Thursdays). Overall, the results indicate that the weekly patterns in mean returns versus volatility are very diverse across the currencies and that no clear trend is discernible.

Panel III in Table I shows the skewness of currency returns by weekdays. Results show that no currencies are positively skewed in the full data set or in SP1, although BRL and MXN are both positively skewed across all weekdays in the second sub-period. There is a very different pattern in the skewness of all five of the currencies across the three time periods. Only PLN maintains Wednesday and MXN maintains Friday, as the day on which it is most positively skewed in all three time periods. For the remainder of the currencies there is no consistency in the levels of skewness

across the first and second sub-periods. It also appears that skewness is not the same across weekdays for each of the currencies, as for example, the largest difference in skewness between days for PLN is 15.9.

The fourth panel in Table I shows the kurtosis of each of the currencies across the days of the week. All kurtosis in the full data set are larger than 3, which indicates that the distributions are highly flat tailed and that there is a high prevalence of extreme values. This also applies to both SP1 and SP2 although all kurtosis values are much lower during SP2. These results are consistent with those of previous studies, which indicate that the distributions of currency returns are non-normal (McFarland, Petit & Sung, 1982; Akgiray & Booth, 1988; Tang, 1998; Aydogan & Booth, 2003). In the full data set and SP1 the most extreme values for the returns of four currencies (BRL, PLN, KRW and ZAR) are on Fridays whereas the most extreme values of MXN occur on a Tuesday. The day with the most extreme values for each of the five currencies occurs evenly across the days of the week during SP2 (Thursday for BRL, Monday for MXN, Wednesday for PLN, Tuesday for KRW and Friday for ZAR). The day with the smallest kurtosis, and the lowest prevalence of extreme values, for all of the currencies, shows a similar pattern with the same distribution across the full data set and SP1 for four of the currencies (BRL, MXN, KRW and ZAR). However, there is a shift in the day with the smallest kurtosis in SP2 for four currencies (BRL, MXN, PLN and KRW), which indicates a shift in the distribution of currency returns. In the full data set there is a large difference in the kurtosis across the weekdays for all of the currencies, which suggests that the kurtosis is highly unlikely the same across all weekdays. However, during SP2, the differences are much smaller and the likelihood of the kurtosis differing across the weekdays is smaller.

A point of interest is that the magnitude of kurtosis for the ZAR returns are neither consistently greater nor less than for most of the other currency returns for each day of the week across the entire sample or during the sub-sample periods, which is anomalous. It would have been expected that the kurtosis of a freely floating exchange rate's returns would be greater than for its managed counterparts,

especially during SP2, given that the central bank avoids intervention in the foreign exchange market, which precludes extreme returns of either sign. The only explanation is that there may be seasonalities in bid-ask spreads, which measure transactions costs. However, an investigation into the presence of seasonalities in bid-ask spreads is beyond the scope of this study, so further research is required. Based on these descriptive statistics the distributions of returns are non-normal across all five of the currencies in all three of the time periods under examination, although PLN returns tend towards normality during SP2.

Short-run weak form efficiency in the currency markets of the five countries in the sample is then tested with the Ljung-Box Q-statistic, at one lag with corresponding probability values appearing in Table III. Values for AC and the Ljung-Box test are only computed for one lag, given the assumption that in foreign exchange markets information is impounded in prices within a trading day, rather than during a longer period.

Table III: Autocorrelation tables for each currency in the full data set, SP1 and SP2 with the autocorrelation coefficient, Q-statistic and its probability at one lag

Data Set	Variable	BRL	MXN	PLN	KRW	ZAR
Full Data Set	AC	0.153	-0.055	-0.000	0.147	-0.046
	Q-Stat	80.518	10.333	0.0001	73.843	7.3877
	Probability	0.000	0.001	0.992	0.000	0.007
SP1	AC	0.172	-0.054	-0.007	0.168	-0.035
	Q-Stat	61.794	6.1762	0.0899	2.6290	2.6290
	Probability	0.000	0.013	0.764	0.000	0.995
SP2	AC	0.098	-0.061	0.001	-0.092	-0.059
	Q-Stat	12.896	4.9788	0.0012	11.396	4.6310
	Probability	0.000	0.026	0.973	0.001	0.031

The autocorrelation coefficient (AC) of the currency returns (R) at lag k is defined by:

$$\Gamma_k = \frac{\sum_{t=k+1}^T (R_t - \bar{R})(R_{t-k} - \bar{R})}{\sum_{t=1}^T (R_t - \bar{R})^2},$$

where \bar{R} is the sample mean of R . This is the correlation coefficient for values of the series k periods apart. If Γ_k is non-zero it means that the series is first-order serially

correlated. The values for AC in Table III, at $k = 1$, are non-zero across all of the currencies, with the exception of PLN, in the full data set, SP1 and SP2, which indicates that the series for the log returns of BRL, MXN, KRW and ZAR are first-order serially correlated. The Q-statistic then tests the null hypothesis that there is no autocorrelation up to order k , and is computed as:

$$Q_{L,B} = T(T+2) \sum_{j=1}^k \frac{r_j^2}{T-j},$$

where r_j is the j -th autocorrelation and T is the number of observations. A statistically significant Q-statistic is found in four currencies (BRL, MXN, KRW, ZAR), which are white noise processes but is rejected for PLN. During SP1 and SP2, the same results are obtained for all five currencies, although the level of statistical significance falls from 1% to 5% for MXN and 1% to 10% for ZAR. These results are consistent with the studies of McFarland, Pettit & Sung (1982) and Aydogan & Booth (2003) which detect autocorrelation in currency returns.

The underlying currency return data for all five of the currencies therefore appears to display similar characteristics. Macroeconomic influences are similar across all of the currencies, as they all have inflation targeting regimes and some form of floating exchange rate. However, more importantly the currency returns of all five of the currencies are non-normally distributed, which means that the parametric tests, dependent on a regression analysis, are not suitable for modelling daily return variations and alternative non-parametric tests are required.

CHAPTER FOUR

METHOD

As currency returns are non-normally distributed, it is necessary to use non-parametric tests when testing the data for the presence of any seasonalities, in order to avoid the pitfalls suggested by Sullivan, et al. (2001) and avoid basing any inferences on unsound assumptions for the underlying data. Five non-parametric tests are used to test the data, beginning with testing the normality of the distributions and then investigating for the presence of seasonalities in each of the first four moments (mean, variance, skewness and kurtosis).

First, the Kolmogorov-Smirnov (KS) one-sample test is used to test for the normality of the distribution of currency returns in each weekday. The test compares the observed CDF of currency returns on each day of the week for each currency with a theoretical normal distribution. The KS Z-statistic is then computed from the largest difference (in absolute value) between the observed and theoretical cumulative distribution functions. This goodness-of-fit test tests the null hypothesis that the distribution of currency returns in each day of the week comes from a normal distribution. Thus a significant Z-statistic rejects the null hypothesis and indicates that the distribution being tested does not fit a normal distribution.

The next three tests test the equality of the first two moments, namely the mean and variance of the currency returns, across the days of the week for each currency. First the Median test is used to test the null hypothesis that the median of currency returns is the same across days of the week, while assuming nothing about the distribution. To test this hypothesis each day of the week is divided into two sub-groups, those days with returns above the median and those days with returns below the median. This allows for a chi-square test of independence between the days of the week and the proportion of returns above and below the median. If there is a low relationship between the median and the day of the week the chi-squared test statistic will be significant and the null hypothesis will be rejected.

Secondly the Kruskal-Wallis (KW) test is also used to test the null hypothesis that the median of currency returns is the same across days of the week. However, the KW test employs a different method and is a one-way analysis of variance by ranks. The KW test ranks the individual values from every day of the week in a single group. Once each value has been ranked, the ranks of the individual values in each day of the week are summed in order to get a rank value for each day of the week. The KW test statistic measures how the rank value for each day of the week compares to the average rank value of every day of the week. A chi-squared statistic is then obtained by squaring each day of the week's distance from the average of all ranks, weighting by its sample size, summing across days of the week, and multiplying by a constant. A significant chi-squared statistic will reject the null hypothesis, meaning that currency returns are different for each day of the week.

The third test is the Siegel-Tukey test and is used to test the null hypothesis that the variances of currency returns are equal across days of the week. This test assumes that days of the week are independent and have equal medians. The test statistic is obtained using the same steps as those described for the KW test with a different assignment of ranks, as the assignment of ranks alternates from the lowest to the highest value for every other rank. In a similar fashion to the KW test a chi-squared statistic is obtained, although in this case every pair of weekdays is tested. If the chi-squared statistic is significant, the null hypothesis of equal variances between days of the week will be rejected.

While statistical tests of the equality of the mean and the variance of distributions are often done in the seasonal literature, there is no standard non-parametric test for the equality of skewness or kurtosis across samples. Following Tang (1996; 1998) the equality of these higher moments are tested across the days of the week. This is done by first converting the currency returns for each day of the week into standard scores by subtracting the mean for each day of the week from the return for each day in the sample. This value is then divided by the standard deviation of the corresponding day of the week. This converts the mean to zero and the standard deviation to one for each weekday, but has no effect on the skewness and kurtosis.

Next, the Kolmogorov-Smirnov (KS) two-sample test of the hypothesis of equal distribution between each pair of weekdays for each currency is applied. This tests any differences in the mean, variance, skewness and kurtosis between two sample distributions without assuming that the returns follow any particular distribution, given that it was found earlier that the returns to each of the currencies in this study's sample do not follow the normal distribution. As the currency returns have been standardised, it means they will have the same mean and standard deviation so that any difference between the two distributions will be attributed to skewness and kurtosis. Thus, the rejection of the null hypothesis that the distributions of returns for a given pair of days in the week are equal, will imply that the skewness and kurtosis are not equal. Similarly to tests of equality in the first two moments, which find inequality in the mean or standard deviation between weekdays, a result indicating that the distributions of returns for a given pair of weekdays are not equal will disprove the efficient markets hypothesis, as the result would point to the existence of daily return variations.

When calculating the test statistic, the KS two-sample test follows a similar process to the one-sample test, and uses the maximum vertical difference between the two CDF's of returns as the test statistic (however, in this case both samples are the empirical distributions, whereas on the one-sample KS test one is theoretical and the other empirical). This is:

$$\max_x | F_m(x) - G_n(x) |,$$

where F_m and G_n are the sample CDF's of returns for a single currency during any two given days of the week (e.g. Monday vs. Tuesday for BRL or Wednesday vs. Friday for ZAR), and m and n are the respective number of return observations.

These tests are repeated for the full data set, SP1 and SP2 for each of the five currencies.

The method will therefore be focused on using non-parametric statistical tests, due to the non-normal distribution of currency returns. This method will ensure a more robust means of investigating the data for any evidence of daily return variations and avoid the pitfalls created by erroneous statistical assumptions regarding the underlying data, which have been highlighted in previous studies (Connolly, 1989).

CHAPTER FIVE

RESULTS

Having used basic statistical techniques to establish the non-normality of returns for the five currencies under examination, this section aims to investigate the data for evidence of daily return variations using a series of non-parametric tests, which do not rely on regression analysis.

Prior to testing the data for the presence of calendar anomalies, a non-parametric test is used to confirm the non-normality of the currency returns. Table III presents the results of the KS one-sample test for normality. For the full data set the KS Z-statistic is statistically significant at a 1% level, which indicates that all of the distributions are non-normal. The same results are obtained for SP1 across all weekdays for the five currencies. However, in SP2 the KS Z-statistic is statistically insignificant for a number of weekdays across the currencies. For BRL the Z-statistic is insignificant for Wednesday and for MXN it is insignificant for Tuesday. The Z-statistic is insignificant for three days for KRW (Monday, Wednesday and Friday) and for four days for ZAR (Every day except Friday). However, for PLN the Z-statistic is insignificant across all five days of the week. Thus it appears that a shift in the distribution of currency returns, from non-normal to normal, has taken place in the SP2 for all of the currencies and PLN, ZAR and KRW in particular.

The non-normality of currency returns found for all of the currencies in the full data set and SP1 is consistent with the findings of previous papers (Westerfield, 1977; Rogalski & Vinso, 1978; Friedman & Vandersteel, 1982; McFarland, Pettit & Sung, 1982; Boothe & Glassman, 1987; So, 1987; Joseph & Hewins, 1992). However, these results are all derived from data in the last four decades of the previous century. The tendency of the distribution of currency returns to tend towards normality is therefore a new phenomenon, as more recent studies such as Tang (1998) and Aydogan and Booth (2003) found that the currencies examined in their papers maintained a non-normal distribution towards the end of the previous decade.

Table IV: Kolmogorov-Smirnov one-sample test of normality for the distribution of each weekday

Data Set	Weekday	BRL	MXN	PLN	KRW	ZAR
Full Data Set	Mon	3.899	4.560	2.712	5.388	2.333
		0.000	0.000	0.000	0.000	0.000
	Tue	4.744	3.935	2.544	6.030	2.907
		0.000	0.000	0.000	0.000	0.000
	Wed	3.960	3.671	2.688	4.526	2.961
		0.000	0.000	0.000	0.000	0.000
	Thu	3.929	3.870	2.566	4.962	3.613
		0.000	0.000	0.000	0.000	0.000
	Fri	4.292	4.477	2.295	6.413	3.793
		0.000	0.000	0.000	0.000	0.000
SP1	Mon	3.973	4.094	3.538	4.923	2.535
		0.000	0.000	0.000	0.000	0.000
	Tue	4.897	3.774	2.950	5.197	3.195
		0.000	0.000	0.000	0.000	0.000
	Wed	4.550	3.424	3.230	4.180	2.932
		0.000	0.000	0.000	0.000	0.000
	Thu	4.290	3.928	2.958	4.328	3.881
		0.000	0.000	0.000	0.000	0.000
	Fri	4.939	3.991	2.959	5.956	3.321
		0.000	0.000	0.000	0.000	0.000
SP2	Mon	1.503	1.485	0.622	1.265	1.032
		0.022	0.024	0.833	0.082	0.237
	Tue	1.376	0.971	0.785	1.375	1.001
		0.045	0.302	0.569	0.046	0.269
	Wed	1.032	1.630	1.184	1.168	1.154
		0.237	0.010	0.121	0.130	0.139
	Thu	1.381	1.572	0.936	1.490	1.139
		0.044	0.014	0.345	0.024	0.149
	Fri	1.583	1.137	0.619	0.974	2.018
		0.013	0.151	0.837	0.299	0.001

Upper row shows the value of KS Z-statistic; the lower rows shows the asymptotic significance; all values in bold are NOT significant at a 5% level

Overall, the movement towards normality among currency returns is a phenomenon which requires further research, particularly among the developing market currencies.

The results of the first of the non-parametric tests for the equality of moments, the median test, are presented in Table V. PLN and KRW cannot reject the chi-squared statistic at the 5% level for any weekday, suggesting that the median is equal across

the days of the week. ZAR rejects H_0 at a 1% level in SP1 but fails to reject it at a 5% level for the full data set and SP2. BRL rejects H_0 at the 1% level for the full data set and SP1, but cannot reject the hypothesis at the 5% level in SP2. However, MXN rejects H_0 at the 1% level in the full data set and SP1 and at the 5% level in SP2. Thus it appears that the day-of-the-week effect has disappeared in SP2 for two (BRL and ZAR, but not MXN) of the three currencies, in which it was present in SP1.

Table V: Non-parametric median test for the equality of medians across weekdays

Data Set	BRL	MXN	PLN	KRW	ZAR
Full Data Set	13.905	17.332	1.269	3.711	7.509
	0.008	0.002	0.867	0.446	0.111
SP1	16.534	32.729	3.147	3.326	13.158
	0.002	0.000	0.555	0.505	0.009
SP2	0.854	9.838	5.134	2.263	5.158
	0.931	0.043	0.274	0.688	0.272

Upper row shows the value of the chi-squared statistic; the lower row shows the asymptotic significance; all values in bold are NOT significant at a 5% level

Table VI: Kruskal-Wallis test for the equality of medians across weekdays

Data Set	BRL	MXN	PLN	KRW	ZAR
Full Data Set	5.711	22.567	2.017	6.607	8.089
	0.222	0.000	0.733	0.158	0.088
SP1	10.312	34.914	2.303	6.761	9.551
	0.035	0.000	0.680	0.149	0.049
SP2	2.189	11.045	4.641	2.059	4.283
	0.701	0.026	0.326	0.725	0.369

Upper row shows the value of the chi-squared statistic; the lower row shows the asymptotic significance; all values in bold are NOT significant at a 5% level

The results of the Kruskal-Wallis (KW) test are presented in Table VI and are very similar to those of the median test in Table IV. PLN and KRW cannot reject H_0 at the 5% level for any day of the week and MXN rejects H_0 at the 1% level for the full data set and SP1 but only at the 5% level in SP2. ZAR still cannot reject H_0 at the 5% level for the full data set or for SP1 and rejects H_0 at the 5% level in SP2. The results for BRL are slightly different, as BRL does not reject H_0 for the full data set at the 5% level and can only reject H_0 at the 5% level, rather than the 1% level, in SP1. The results clearly show that median is not equal across weekdays in BRL, MXN and ZAR in SP1, indicating the presence of the day-of-the-week effect. However, it appears that it has become significantly weaker in recent years, as it is no longer present in either BRL or ZAR, while it is considerably weaker in MXN.

The results for BRL and ZAR, which indicate the presence of the day-of-the-week effect in SP1, may align with the findings of Joseph and Hewins (1992) who found that when the KW test is applied, short term data sets are more affected by the day-of-the-week effect than longer term data sets. However, the disappearance of the day-of-the-week effect in SP2, which is an even shorter data set, implies that this argument is not valid and the presence of the day-of-the-week effect in SP1 for BRL and ZAR must be attributable to other factors influencing currency returns during the time periods incorporated in SP1 and SP2.

Table VII and VIII present the results of the Siegel-Tukey test across pairs of weekdays for the full data set. BRL and PLN cannot reject H_0 at the 5% level of significance for any pair of weekdays in the full data set, SP1 or SP2. ZAR fails to reject H_0 at the 5% level for any pair of weekdays in the full data set or SP1 but rejects H_0 at the 5% level for three pairs of weekdays in SP2. KRW rejects H_0 at the 5% level for one pair of weekdays in the full data set, for four pairs of weekdays in SP1 and does not reject H_0 at the 5% level for any pair of weekdays in SP2. The four pairs of weekdays, which have different variances, all include Fridays indicating that the volatility of currency returns on a Friday was greater than other days of the week for KRW in SP1, although this no longer is the case. MXN rejects H_0 at the 5% level for two pairs of weekdays (both paired with Fridays) in the full data set, for three pairs

of weekdays in SP1 (all paired with Fridays) and for two pairs of weekdays in SP2 (both paired with Monday's). The results show that there is little to no difference in the variance of currency returns across weekdays, although the variance or volatility of MXN and KRW returns on a Friday used to be different to those in the rest of the week.

Table VII: Siegel-Tukey test for the equality of variances across pairs of weekdays in the full data set

Weekday	BRL	MXN	PLN	KRW	ZAR
Mon – Tue	1.351	1.784	1.466	0.405	1.512
	0.1766	0.074	0.142	0.684	0.131
Mon – Wed	0.199	1.277	0.038	0.886	1.830
	0.842	0.2016	0.969	0.375	0.067
Mon – Thu	0.779	0.393	0.833	0.341	0.231
	0.435	0.693	0.404	0.732	0.817
Mon – Fri	0.427	3.068	0.302	2.120	0.029
	0.669	0.002	0.762	0.034	0.978
Tue – Wed	1.275	0.552	1.535	0.529	0.022
	0.202	0.580	0.124	0.598	0.982
Tue – Thu	0.395	1.278	0.654	0.003	1.350
	0.692	0.201	0.513	0.998	0.177
Tue – Fri	0.549	0.997	1.841	1.606	1.766
	0.582	0.318	0.065	0.108	0.077
Wed – Thu	1.047	0.844	0.854	0.519	1.491
	0.294	0.398	0.393	0.604	0.136
Wed – Fri	0.678	1.628	0.262	1.224	1.951
	0.497	0.103	0.793	0.221	0.051
Thu - Fri	0.380	2.170	1.178	1.688	0.263
	0.703	0.030	0.238	0.092	0.793

Upper row shows the value of the chi-squared statistic; the lower row shows the asymptotic significance; all values in bold are NOT significant at a 5% level

The results of non-parametric tests on the mean and variance follow a similar pattern to the results of the KS test on the normality of the distributions, as the median, Kruskal-Wallis and Siegel-Tukey tests all begin to lose significance in SP2 at varying levels for the five currencies. Thus it appears that the day-of-the-week effect found in the first two moments by the numerous studies (Cross, 1973; Levi, 1978; French

1980; Boothe and Glassman, 1982; McFarland, Pettit & Sung, 1982; Keim & Stambaugh, 1984; Rogalski, 1984; Jaffe & Westerfield, 1985; So, 1987; Joseph & Hewins, 1992; Aydogan & Booth, 2003) carried out on currency returns are no longer present in the five emerging market currencies examined here.

Thus, the results of these three non-parametric tests of currency returns across different days of the week reveal that in earlier years there is a difference between currency returns on different days of the week for BRL, MXN and ZAR, although this appears to have diminished in the past eight years. However, there has never been a significant difference in volatility across weekdays for BRL, PLN and ZAR and while the volatility of currency returns for MXN and KRW used to be different on Fridays, in comparison to the rest of the week, this has also disappeared.

Table IX and XI show the results of the two-sample KS test for the full data set, sub-period one and sub-period two. PLN rejects H_0 at the 5% level for every pair of weekdays in the full data set and sub-period one, clearly indicating that a weekly pattern on higher moments does exist. BRL fails to reject H_0 at the 5% level in one pair of weekdays in the full data set but rejects H_0 at the 5% level for all pairs of weekdays in SP1. MXN fails to reject H_0 at the 5% level for two pair of weekdays in the full data set and for one pair of weekdays in SP1. ZAR fails to reject H_0 at the 5% level in three pairs of weekdays in the full data set and only one pair of weekdays in SP1. KRW fails to reject H_0 at the 5% level for the same three pairs of weekdays in the full data set and SP1. Thus, the standard scores of currency returns have very different distributions across the different days of the week in the full data set and SP1.

However, the results for SP2 are different, as ZAR is the only currency that can reject H_0 at the 5% level for one pair of weekdays and BRL is the only currency that can reject H_0 at a 10% level for one pair of weekdays. The other three currencies (MXN, PLN and KRW) are not able to reject H_0 at the 10% level for a single pair of weekdays.

Table VIII: Siegel-Tukey test for the equality of variances across pairs of weekdays, SP1 and SP2

	SP1							SP2					
	Weekday	BRL	MXN	PLN	KRW	ZAR		Weekday	BRL	MXN	PLN	KRW	ZAR
SP1	Mon – Tue	1.379	0.643	1.969	0.715	0.014	Mon – Tue	0.768	2.348	0.094	1.811	2.723	
		0.168	0.520	0.049	0.475	0.989		0.443	0.019	0.925	0.070	0.007	
	Mon – Wed	0.814	0.259	0.230	0.287	0.895	Mon – Wed	0.562	2.225	0.253	1.657	1.862	
		0.412	0.795	0.812	0.774	0.371		0.574	0.026	0.800	0.098	0.063	
	Mon – Thu	1.030	0.936	1.101	0.292	0.446	Mon – Thu	0.002	1.792	0.135	1.334	1.030	
		0.303	0.349	0.271	0.770	0.656		0.998	0.073	0.893	0.182	0.303	
	Mon – Fri	1.071	2.525	0.585	2.255	0.505	Mon – Fri	0.250	1.786	1.379	0.637	0.433	
		0.284	0.012	0.559	0.024	0.614		0.803	0.074	0.168	0.524	0.665	
	Tue – Wed	0.265	0.629	1.863	0.655	0.755	Tue – Wed	1.442	0.307	0.204	0.016	1.171	
		0.791	0.530	0.063	0.513	0.450		0.149	0.759	0.838	0.987	0.242	
	Tue – Thu	0.290	1.588	0.913	0.425	0.450	Tue – Thu	0.622	0.528	0.198	0.426	1.584	
		0.772	0.112	0.361	0.671	0.653		0.534	0.598	0.842	0.670	0.113	
Tue – Fri	0.052	1.501	1.449	2.755	0.118	Tue – Fri	0.340	0.731	1.178	1.131	3.186		
	0.958	0.134	0.147	0.006	0.906		0.734	0.465	0.239	0.258	0.001		
Wed – Thu	0.118	0.712	0.853	0.160	1.266	Wed – Thu	0.763	0.281	0.352	0.532	0.597		
	0.906	0.477	0.394	0.873	0.206		0.445	0.779	0.725	0.595	0.550		
Wed – Fri	0.247	2.092	0.361	2.304	0.682	Wed – Fri	1.112	0.037	0.925	1.039	2.263		
	0.805	0.036	0.718	0.021	0.495		0.266	0.971	0.355	0.299	0.024		
Thu - Fri	0.179	2.763	0.492	2.393	0.805	Thu - Fri	0.254	0.167	1.365	0.655	1.396		
	0.858	0.006	0.623	0.017	0.421		0.800	0.867	0.172	0.512	0.163		

Upper row shows the value of the chi-squared statistic; the lower row shows the asymptotic significance; all values in bold are NOT significant at a 5% level

The results in SP1 and SP2 are therefore significantly different, as the weekly pattern on higher moments that was in evidence in SP1 disappears in SP2. These findings confirm that while a pattern on higher moments existed in SP1 (1995 – 2002) it has disappeared in SP2 (2003 – Feb 2008), which indicates that the day-of-the-week effect does not exist in SP2 in the higher moments of any of the five currencies examined. This is consistent with the results found when testing the equality of the first two moments across weekdays, as the day-of-the-week effect was present in SP1 for BRL, MXN and ZAR but not in SP2. Similarly to the other tests carried out the results are inconsistent with those of previous literature (Tang, 1998), which tests two sub-periods and finds the day-of-the-week effect to be consistent across both of the sub-periods investigated between 1986 and 1996.

Table IX: Kolmogorov-Smirnov test of equal distribution between two weekdays using standard scores of currency returns for the full data set

Weekday	BRL	MXN	PLN	KRW	ZAR
Mon – Tue	2.578	1.286	3.603	1.822	1.956
	0.000	0.073	0.000	0.003	0.001
Mon – Wed	1.552	1.930	3.792	1.209	1.228
	0.016	0.001	0.000	0.107	0.098
Mon – Thu	2.657	2.039	3.684	1.209	1.418
	0.000	0.000	0.000	0.107	0.036
Mon – Fri	2.997	2.484	3.294	2.889	1.674
	0.000	0.000	0.000	0.000	0.007
Tue – Wed	2.428	2.050	3.075	1.700	1.106
	0.000	0.000	0.000	0.006	0.173
Tue – Thu	3.318	2.239	3.102	1.700	1.969
	0.000	0.000	0.000	0.006	0.001
Tue – Fri	3.901	1.659	3.279	3.576	1.369
	0.000	0.008	0.000	0.000	0.047
Wed – Thu	2.536	1.349	2.968	1.214	1.376
	0.000	0.053	0.000	0.105	0.045
Wed – Fri	2.983	2.387	3.387	2.713	1.237
	0.000	0.000	0.000	0.000	0.094
Thu – Fri	1.119	2.711	3.332	2.928	1.632
	0.163	0.000	0.000	0.000	0.009

Upper row shows the value of the KS Z-statistic; the lower row shows the asymptotic significance; all values in bold are NOT significant at the 5% level

Thus, while the day-of-the-week effect used to be present in the currency returns of BRL, MXN and ZAR in particular, it has disappeared in recent years. The disappearance of the day-of-the-week effect and the movement of currency returns towards normality could be as a result of a reduction in the asymmetry of information in world currency markets since the turn of the century due to increased market efficiencies resulting from the increase in the number of players in the market and the higher volumes of foreign exchange traded. Corresponding technological innovations may also play a role, as the introduction of CLS occurred as the distribution of currency returns for both KRW and ZAR tended towards normality and the day-of-week effect disappeared. In addition, MXN only introduced CLS in the last month of the data set considered in this study, which could account for the continued presence of the day-of-the-week effect in the first moment. This theory is supported by the “settlement effects” hypothesis (Joseph and Hewins, 1992), as the introduction of CLS has caused this hypothesis to become invalid, as any lags in settlement have been removed thus leading to the disappearance of any seasonalities. However, the tendency of the distribution of PLN and BRL's currency returns to move towards normality and the disappearance of the day-of-the-week effect cannot be explained by this theory, as CLS has yet to be adopted.

It is also unclear whether the introduction of liberal floating exchange rate regimes have had any influence on the distribution of returns or the presence of seasonalities, as BRL introduced a managed float in 1994 and has seen the smallest movement towards normality among the five currencies under examination.

Table XI: Average pip values for each currency, SP1 and SP2

Currency	SP1	SP2
BRL	17.59	22.68
MXN	124.09	82.96
PLN	67.48	46.87
KRW	11,556.97	5,640.70
ZAR	91.28	247.34

Table X: Kolmogorov-Smirnov test of equal distribution between two weekdays using standard scores of currency returns, SP1 and SP2

	SP1							SP2					
	Weekday	BRL	MXN	PLN	KRW	ZAR		Weekday	BRL	MXN	PLN	KRW	ZAR
SP1	Mon – Tue	4.343	1.123	4.240	2.129	1.989	Mon – Tue	1.059	1.062	0.528	0.534	0.676	
		0.000	0.160	0.000	0.000	0.001		0.212	0.209	0.943	0.938	0.751	
	Mon – Wed	4.363	1.593	4.432	1.281	1.420	Mon – Wed	1.297	0.746	0.675	0.638	0.697	
		0.000	0.013	0.000	0.075	0.036		0.069	0.634	0.752	0.810	0.716	
	Mon – Thu	2.874	2.008	4.259	1.316	2.182	Mon – Thu	1.039	0.492	0.547	0.720	0.461	
		0.000	0.001	0.000	0.063	0.000		0.230	0.969	0.926	0.678	0.984	
	Mon – Fri	2.632	1.385	4.398	3.878	2.389	Mon – Fri	1.146	1.148	0.499	0.582	0.964	
		0.000	0.043	0.000	0.000	0.000		0.144	0.143	0.964	0.887	0.311	
	Tue – Wed	1.604	1.851	3.997	1.918	1.745	Tue – Wed	0.798	1.227	0.667	0.414	0.791	
		0.012	0.002	0.000	0.001	0.005		0.547	0.098	0.765	0.995	0.559	
	Tue – Thu	3.757	2.194	3.823	1.920	2.404	Tue – Thu	0.498	1.093	0.598	0.453	0.752	
		0.000	0.000	0.000	0.001	0.000		0.965	0.183	0.867	0.987	0.624	
Tue – Fri	4.278	2.024	3.963	4.586	1.334	Tue – Fri	0.776	0.604	0.604	0.690	1.380		
	0.000	0.001	0.000	0.000	0.057		0.584	0.860	0.860	0.728	0.044		
Wed – Thu	4.017	1.939	4.328	1.073	1.558	Wed – Thu	0.904	0.861	0.430	0.602	0.947		
	0.000	0.001	0.000	0.199	0.016		0.338	0.449	0.993	0.861	0.332		
Wed – Fri	4.363	2.424	4.121	3.601	2.008	Wed – Fri	0.760	1.140	0.748	0.625	0.938		
	0.000	0.000	0.000	0.000	0.001		0.610	0.149	0.631	0.829	0.342		
Thu - Fri	1.489	2.528	3.982	3.740	2.770	Thu - Fri	0.923	1.137	0.666	0.617	0.804		
	0.024	0.000	0.000	0.000	0.000		0.361	0.151	0.767	0.841	0.538		

Upper row shows the value of the KS Z-statistic; the lower row shows the asymptotic significance; all values in bold are NOT significant at the 5% level

The transaction costs associated with trading each of the currencies also need to be considered when evaluating the presence of the day-of-the-week effect. Excess returns resulting from trading based on a strategy incorporating day-of-the-week effects may be possible for PLN, as the average pip values (Table X) indicate that daily variations in the currency may be large enough to generate excess returns. However, the average pip values for KRW, ZAR, MXN and PLN (Table X) are all high in SP1 and SP2, and would effectively prevent any excess returns from trading based on a strategy devised from any findings on the day-of-the-week effect. This occurs as the variation in daily currency returns resulting from the day-of-the-week effect, would not be large enough to account for the wide bid-ask spread in each of these currencies. Thus, even during the periods for which the day-of-the-week effect is present in these developing market currencies, high transaction costs will effectively detract from or eliminate any excess returns.

Thus the results of the non-parametric tests confirm the non-normality of currency returns, although there does appear to be a shift towards normality in SP2. The use of these tests was therefore found to be applicable in this study, as the use of parametric tests, which depend on regression analysis, would have been invalid. Daily return variations appear to have been present for all currencies during SP1, however of particular interest are the results that indicate that these daily return variations largely disappeared in SP2. Furthermore it appears that even during SP1, when daily return variations were present in currency returns, traders would not have been able to generate excess returns due to high transaction costs. The results therefore indicate that the efficient markets hypothesis holds for the currency market in which these five developing market currencies are traded.

CHAPTER SIX

CONCLUSION

This paper adds to the literature by examining the first four moments of the currency returns, for five developing market currencies, for the day-of-the-week effect using non-parametric tests. The use of the non-parametric tests is first justified testing the normality of the distributions of each of the currency returns. The first two moments are tested with recognised non-parametric tests used in previous studies (Boothe and Glassman, 1982; McFarland, Pettit and Sung, 1982; Joseph and Hewins, 1992). However, the test on higher moments proposed by Tang (1996; 1998) has only been used in a single study focused on foreign exchange markets.

Using data from January 1995 to February 2008 it is shown that the daily returns of all currencies are non-normally distributed. However, when the currencies are split into two sub-periods based on the stability of the five exchange rates and the management systems put in place by the respective central banks during these periods, a shift in the results is discovered. The distributions of the currency returns in SP1 (1995 – 2002) are similar to those of the full data set, as all of the distributions are non-normal. In contrast, the results in SP2 (2003 – February 2008) show that the distribution of the currency returns for three of the currencies in particular (PLN, ZAR and KRW) tend towards normality, while the other two currencies display the emergence of a similar trend.

The Median, Kruskal-Wallis and Siegel-Tukey non-parametric tests are used to test the first two moments of the currency returns for seasonalities in each of the time periods described above. Evidence for the day-of-the-week effect in the first moment is found for MXN in all time periods and for BRL and ZAR in SP1, although it disappears in SP2. No evidence of the day-of-the-week effect is found in the currency returns of PLN or KRW. The day-of-the-week effect did not appear to be consistently present in the second moment of the distributions for any of the currencies, as while all of the currencies, with the exception of BRL, rejected the null hypothesis of equal

distributions across pairs of weekdays this was limited to a maximum of four pairs (KRW in SP1 and MXN in SP2).

Tang's (1998) test on the equality of the higher moments of the currency returns across all pairs of weekdays yielded interesting results. All of the currencies rejected the hypothesis of equal higher moments for the majority of the weekday pairs in the full data set and SP1, indicating that the day-of-the-week effect was present in the higher moments of all five currencies. However, only ZAR was able to reject the hypothesis of equal higher moments for a single pair of weekdays in SP2, which means that the day-of-the-week effect in the higher moments of the currency returns for these five currencies has disappeared in the past five years.

However, even with the presence of seasonal effects in the currency returns of these five developing market currencies, high transaction costs appear to prevent the generation of any excess returns. These findings therefore indicate that the foreign exchange market is efficient, as market participants would be unable to generate excess returns based on any daily return variations.

Overall, the results indicate that there has been a fundamental shift in currency returns since 2002, which appears to have led to the distributions of returns to these five developing market currencies tending towards normality, while the day-of-the-week effect has disappeared. While no completely satisfactory explanation can be found for this phenomenon, it is postulated that developments in the global market for foreign exchange over the past five years, which have led to increased market efficiency, have caused this effect. This includes technological innovations, such as the introduction of Continuous Linked Settlement, and the adoption of free-floating currencies by central banks.

The findings of this study should be interpreted with caution for several reasons. First, the two sub-periods were of different lengths as a result of macroeconomic influences, which may have biased the results. Second, due to the nature of the political situation in each of the countries, holidays tended to change over the time

period based on the government in place and as such were not removed from the full data set. This is not expected to have had a significant impact on the results but did not allow for the holiday effect to be tested. Holidays should be removed from the data set if possible, to be examined separately against other days of the week for the holiday effect. Third, the data set should be divided into more sub-periods in order to better understand trends in currency returns. Fourth, the bid-ask spreads or pip values of the currencies under investigation should also be tested for the presence of any seasonalities, to determine whether changes in transaction costs cause seasonalities in currency returns. Finally, further research could extend the investigation of this phenomenon to incorporate developed market currency pairs to determine whether it is a widespread trend and whether it is consistently linked with the market developments described above.

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APPENDIX

Table XII: Summary statistics - currency returns by weekdays (SP1)

Moment	Day	BRL	MXN	PLN	KRW	ZAR
Mean (%)	Mon	0.017653	-0.026423	-0.033343	0.032589	0.046934
	Tue	0.110741	0.016395	0.037786	0.074651	0.032799
	Wed	0.109244	0.060556	0.051467	0.006062	0.069041
	Thu	0.038932	0.136727	0.040493	0.020860	0.113617
	Fri	0.066503	-0.007110	0.010404	-0.036510	-0.050716
Standard Deviation (%)	Mon	0.782013	0.947911	0.634277	1.165100	0.739399
	Tue	0.955084	0.934798	0.610496	1.234100	0.784358
	Wed	0.931235	0.785521	0.553332	0.878514	0.769741
	Thu	0.772128	0.840167	0.606513	0.934845	0.869675
	Fri	1.014719	1.078521	0.593773	1.339761	1.001847
Skewness	Mon	0.692261	3.327172	-0.395760	0.831496	-0.551942
	Tue	-0.440287	-0.655209	0.843130	4.245936	-0.794597
	Wed	1.733506	-0.034897	1.055224	1.110145	1.530040
	Thu	-0.375773	1.660011	0.901167	4.686463	3.082032
	Fri	0.428470	-1.015163	0.517885	-9.311385	-3.766045
Kurtosis	Mon	12.83434	48.47369	9.797496	35.49560	10.42185
	Tue	29.62810	50.91179	8.214576	58.50219	10.48504
	Wed	23.98077	23.04455	7.578821	31.95837	12.58655
	Thu	18.18697	24.29500	9.028707	50.64486	25.87634
	Fri	49.38394	40.71988	13.56539	135.1552	72.07742

Table XIII: Summary statistics - currency returns by weekdays (SP2)

Moment	Day	BRL	MXN	PLN	KRW	ZAR
Mean (%)	Mon	-0.007099	0.036973	0.013509	-0.008743	0.037912
	Tue	-0.022947	0.012510	-0.057655	-0.026611	-0.004286
	Wed	-0.074724	0.018810	-0.058267	-0.013548	-0.080329
	Thu	-0.067692	0.018255	0.015342	-0.036704	-0.015346
	Fri	-0.102221	-0.077068	-0.089946	0.001160	0.024855
Standard Deviation (%)	Mon	0.807189	0.430904	0.714839	0.432465	0.991271
	Tue	0.702338	0.437631	0.755496	0.409714	1.202241
	Wed	0.761809	0.483643	0.742035	0.389959	1.111033
	Thu	0.760775	0.482851	0.731225	0.441490	1.172028
	Fri	0.772222	0.463578	0.614753	0.419519	1.131422
Skewness	Mon	0.925148	0.215710	0.089815	0.366860	0.057347
	Tue	0.602713	0.284708	-0.023213	0.388108	0.199745
	Wed	0.725545	0.798104	0.524183	0.372392	0.700468
	Thu	1.396856	0.452025	0.189553	-0.410797	-0.061157
	Fri	0.249110	0.193403	-0.029146	0.939245	1.005528
Kurtosis	Mon	7.008374	5.631943	3.445852	4.947112	4.329177
	Tue	5.172032	3.917256	4.030980	11.95546	4.553374
	Wed	9.138100	4.480789	4.870578	6.647871	4.446159
	Thu	11.80248	5.010866	3.246052	10.56461	6.530113
	Fri	6.478088	5.271214	3.450749	8.618382	8.485748

Figure II: Histograms and kernel density estimates (SP1)

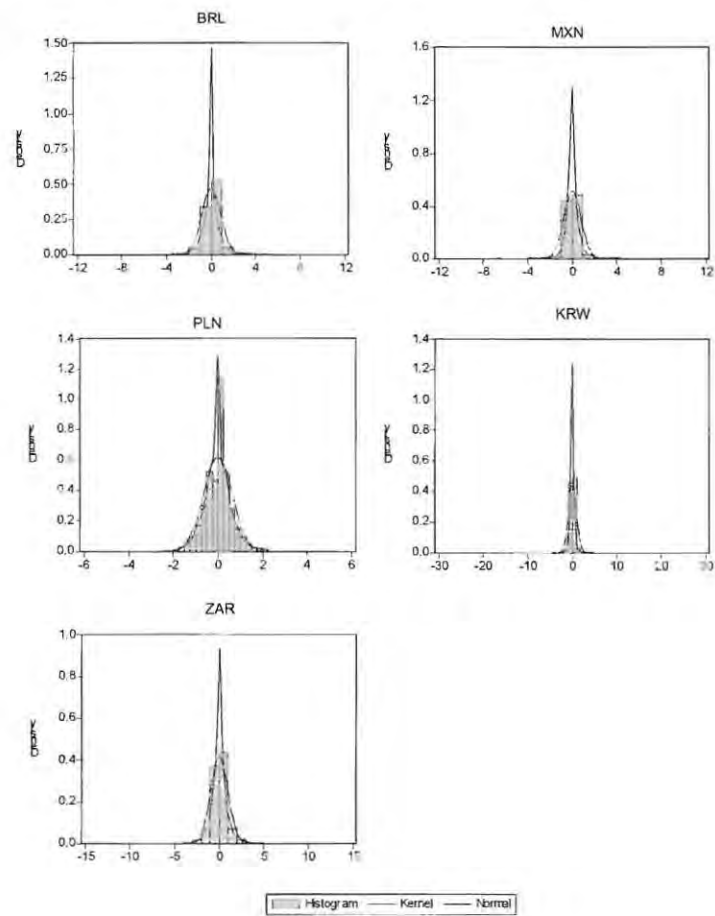
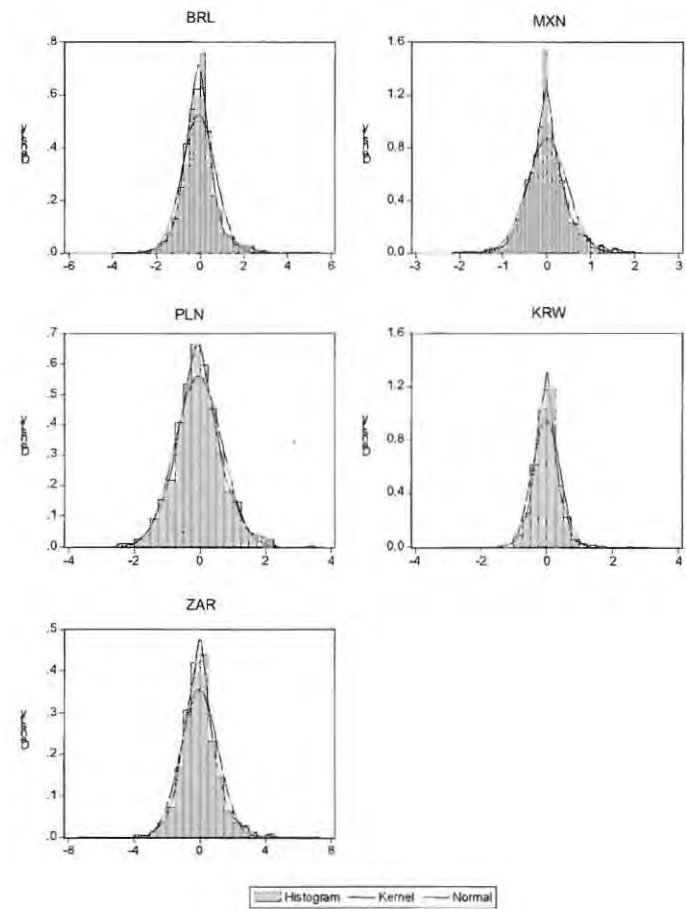


Figure III: Histograms and kernel density estimates (SP2)



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