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An Evaluation of South African Vehicle Prices and Domestic Market Size

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ABSTRACT

This study set out to identify what relationship exists between vehicle pricing and market size in a South African context. The research project's design revolves around a quantitative method, consisting of a non-experimental strategy, with a longitudinal retrospective time horizon. The Box-Jenkins Method was used with auto regression and autocorrelation and partial autocorrelation functions for testing stationarity. The test involved the Rand's changes against major currencies being related to increases in the advertised new vehicle price. The results of these tests showed weak correlations for the period 2008 to 2016. The conclusion was that no significant correlation exists between the Rand's exchange rate against major currencies, influencing the increase in new vehicle pricing. No significant correlation exists between the changes in the new pricing of vehicles and the new vehicles sold. Certain limitations have been identified and recommendations have been made for future studies regarding the project.

INTRODUCTION

The South African motor industry is a vital business model in an emerging third world country who is a member of the group BRICS (Brazil, Russia, India, China and South Africa) countries. As at 2010, South Africa had employed 228,000 people in the direct manufacturing, retail and aftermarket activities in the automotive environment (South Africa's automotive industry, 2017). The industry is further accountable for retailing close to 550,000 new vehicles for the 2016 year, adding massive revenue to the country's Gross Domestic Product (GDP) (SA car sales, 2017). The South African market consists of approximately 52 brands and close to 2,600 model derivatives competing in an intensely competitive business environment for a share of the domestic market (Drop in SA, 2017).

South Africa is an import dependent economy on products like oil and motor vehicles (Cokayne, 2015). The negative influence on the Vehicle Price Inflation (VPI) caused by the local currency's strain against other major currencies, has put direct pressure on new vehicle pricing (Smith, 2013). The weakening of the overall confidence in many emerging markets' is due to volatile environments within their macro-economic indicators, having affected Exchange Rate Pass-Through (ERPT) to a large degree (Aron, MacDonald and Muellbauer, 2014). South Africa is an emerging market that uses Producer Currency Pricing (PCP) for its motor industry pricing on their imported vehicles and components.

Even with new vehicle margins decreasing in South Africa, often used to maintain market share, the local buyers have turned their purchase power to the pre-owned offerings instead. With this sort of strained buying power by the consumer, gives an indication of an economy being under pressure.

The price elasticity of demand is still the most regularly used technique to calculate consumers' sensitivity to pricing variations (Anderson, McLellan & Wolfram, 1997). Additionally, to price elasticity, income elasticity has a positive measure where a consumers' income increases, which leads to an increase demand for a specific item like a motor vehicle (Stevens, 2009). However, Hess (1977) concluded that when it came to vehicles, income had neither a numerical or sufficiently volatile impact on behaviour for demand. In more recent times, the consideration of quality characteristics for existing aggregate models of automobiles has been adopted in the income and price elasticities of demand for new vehicles (McCarthy, 1996).

After the global economic crisis of 2007, many corporations had heavily redirected their attention towards pricing strategies (Piercy, Cravens and Lane, 2010). Consumers who found to be very price sensitive were willing to alter their timing of a new vehicle purchase, if they were not completely satisfied with the transaction (Copeland, 2014).

This study aims to evaluate what relationship would exist between the new vehicle pricing fluctuations and its effects to the South African domestic market. The study would further aim to analyse the collected data and clarify if the sensitivity of demand exists to new vehicle pricing changes in the South African context. Three hypotheses have been created for this project, where the first hypothesis is to identify whether changes in the Rand's value against major currencies are related to increases in the advertised prices of new vehicles. The second hypothesis will see if changes in pricing gaps of the advertised price of new vehicles are related to the average selling price of new vehicles. The last hypothesis will identify whether the changes in the average selling price in new vehicles are related to the volume changes in new vehicles sold in the South African domestic market.

The research project applied a longitudinal retrospective study based in the variety of data collected from 2008 to 2016. The Box-Jenkins Method which includes autocorrelation, partial autocorrelation and cross correlation are the chosen statistical models to be utilised to prove the created hypotheses. Before this model is appropriately applied, a calculation will be completed too identify whether a stationery series exists in the collected data (Applied Time Series Analysis, 2017). If the data is not found to be stationery the model would then not be applicable. The autocorrelation function (ACF) is used to identify the autocorrelation for time where any lag remains the same regardless (Applied Time Series Analysis, 2017). The historical information has been collected in a methodical manner, where the independent and dependent variables are identified, allowing for the mentioned hypotheses to be tested, evaluated and concluded accordingly.

Literature Review

Many world markets who entered global integration and the transference of inflation from exchange fluctuations on local prices experienced exchange rate pass-through (Aron *et al*, 2014). The countries with low-inflation classifications showed lower reactions to ERPT as indicated by Chang and Tsong (2014). Developing and Emerging Markets show greater exchange rate pass-through due to unpredictability and floating currencies in the market. When markets were unable to balance their respective pass-through from a product, then an exit from market would be considered.

The law of economic demand has found that consumers will change their purchasing habits and buy less if prices are increased (San Diego County, 2017). The most regularly used method to calculate customers' responsiveness to pricing, is the price elasticity of demand (Anderson *et al*, 1997). Brassington and Pettitt (2013), describe a ratio of being a percentage change in volume demanded divided by the percentage change in price. The angle of a demand curve when analysing price is steeper when a sensitivity to price exists versus a shallower curve due to less sensitivity being present.

There has been an additional method described for calculating the demand for motor vehicles, which is known as income elasticity of demand (Steven, 2009). On applying this model to the motor industry, a consumer's increased income causes a desire to purchase a vehicle higher up the attraction list, the opposite also being applicable. De Janosi (1959), found that the ability to measure probable consumer income as being the most important. Yet Hess (1977) concluded that when it came to vehicles, income had neither a numerical or sufficiently volatile impact on behaviour of demand.

Trandel (1991) successfully argued that the different varieties of motor vehicle which exist, are distinguished by price as well as quality. Levinsohn (1988) as well as Trandel (1991) statistically included quality variables in their models. The quality variables were regarded not only as quantitatively important, but the inclusion also had major impacts on price coefficients on items. However, McCarthy (1996), found that removing perceived quality from the equation of price elasticity of demand versus Trandel's model, showed very similar results. The results of demand for McCarthy (1996) for a 1989 survey yielded a similar result to Levinsohn's (1988) results using the same data.

Since the global economic crisis of 2007, many companies had to place a renewed direction on pricing strategically (Piercy *et al*, 2010). Price is not only a generator of income, but also an important creator and retainer of customers, with an intention of making profit (Brassington and Pettitt, 2013). Meckes and Gehring (2010), found that vehicles from mass auto manufacturers are discretionary items and their attributes are very similar, causing the brand to choose which product gets a higher price tag. Consumers who are price sensitive were very prepared to alter the timing of the new vehicle purchase, until satisfied with the transaction (Copeland, 2014).

Foreign Exchange Influencing Pricing of Vehicles in South Africa

South Africa is an economy which is to a great degree import dependent versus export, on products like oil and motor vehicles (Cokayne, 2015). According to Smith (2013), the South African Rand is a currency which has been under significant pressure from the major currencies of the world. The Rand's strain caused a negative influence on the VPI in the South African market, which put direct pressure on new vehicle pricing (Smith, 2013). The Rand's weakness would most likely cause the transfer of costs onto various commodities including that of automobiles. This is confirmed specifically to the vehicle pricing of complete imported vehicles as well as locally assembled vehicles, which rely extensively on imported components (Cokayne, 2015). With consistent changes in the behaviour patterns in recent times of exchange rates in general, a great and insistent digression from the 'law of one price' has become more apparent (Goldberg and Knetter, 1997).

In the 2016 year the National Association of Automobiles Manufacturers of South Africa (NAAMSA) stated that the pressure on new vehicle pricing was caused from inflationary volatility associated directly with the lowering value of the Rand currency (Drop in SA, 2017). The

inflationary pressures on new vehicle pricing has allowed the total domestic market for sales to decrease in the South African context (Drop in SA, 2017). TransUnion Auto CPI in South Africa has confirmed that vehicle prices had risen in accordance with the depreciation of the Rand against the US Dollar (Smith, 2013). This analysis was compiled by TransUnion, who found that the average transaction value specifically in new vehicles had increased by 11% on the 2012 average transaction value for motor vehicle sales. If the South African Rand has the dependency of being volatile where it depreciates against major currencies, it also has the tendency to strengthen. NAAMSA utilising the Purchasing Managers' Index (PMI) a leading indicator used by the South African Reserve Bank, found that the Rand's strengthening against other currencies would positively influence new car pricing and should have beneficial results in new vehicle sales (NAAMSA Media Release, 2017).

The Rand's depreciation must be sustained for a long period of time for the impact to be materially felt in the economy (Cokayne, 2015). South African motor industry experienced pre-emptive purchasing of automobiles in 2013 due to the weakening Rand exchange rate (Smith, 2013). This anticipated purchasing was caused by the effect of the Rand exchange rate and customers having expectations of new vehicle pricing changes (Smith, 2013).

Exchange Rate Pass-Through (ERPT)

With global integration and many countries participating throughout the world, the expansion of the worldwide transference of inflation and economic cycles caused by exchange rate shifts to a country's local prices is known as ERPT (Aron *et al*, 2014). The US Dollar is regarded as the vehicle currency of the world and is utilised to administer massive international exchange transactions between many countries (Devereux and Shi, 2013). The purpose of a vehicle currency like the US Dollar has for a long time been acknowledged as the solution to the problematic issues of transaction costs between various currencies (Devereux and Shi, 2013).

The ERPT is cited as being the percentage change in import prices of a specific domestic currency in reaction to a one percent variance in the exchange rate, also known as Stage 1 ERPT (Aron *et al*, 2014). ERPT research emphasises the change of price to an exchange rate for dealings with either an importing and exporting nation or nations (Goldberg and Knetter, 1997). Two additional definitions have since been developed, where overall ERPT is the result of exchange rate activities on producer pricing and Stage 2 ERPT is where the effect of an alteration in import prices of producer pricing exists (Aron *et al*, 2014). The link between ERPT and macroeconomic factors created the hypothesis pioneered by Taylor (2000), that low-inflation situations were created by better monetary policies which reduced domestic prices being effected by the amount of ERPT. Industrial countries with low-inflation classifications showed a rather lower reaction to exchange rate pass-through, than emerging countries from a variety of groups, which showed high rates of pass-through (Chang and Tsong, 2014).

Developing and Emerging Markets (DEM) have been connected to experiencing greater ERPT with their exchange rate unpredictability and floating currencies (Aron *et al*, 2014). Currencies previously used to be at a fixed rate and moved over to the floating exchange rate policy causing interest in the pass-through query, where the element of external adjustment and the transmission of inflation was resolved (Goldberg & Knetter, 1997). DEM countries like South Africa have floating currencies and their exchange rate variances are volatile. Many emerging markets in the global arena have volatile environments where their macro-economic issues such as commodity pricing

shocks, weakening overall confidence and or global risk avoidance affects ERPT to a large degree (Aron *et al*, 2014). These factors that have been mentioned all contribute to the foreign exchange rate unpredictability in DEM markets. These markets usually have inadequate hedging opportunities, causes increased ERPT where the exporters pricing remains stable in their own currencies.

The vehicles and imported components in the South African motor industry are priced according to PCP versus that of Local Currency Pricing (LCP). PCP is where prices of items like motor vehicles or imported components have their prices fixed around the exporter's currency (Aron *et al*, 2014). These fluctuations around the exchange rate keeps the exporter's pricing in their country's currency unaffected, yet the market prices near its end destination will vary with the exchange rate. This was confirmed by Chang and Tsong (2014), who found that when a currency began to depreciate and the exchange rate weakened, the foreign exporters usually kept their exports prices untouched, creating an escalation of import pricing.

Price Sensitivity

An incredibly important gauge for measuring the South African economy, is the strength of the motor industry (Osbourne, 2016). But many locals have turned their purchase power to the pre-owned market, even with new vehicle margins decreasing. This sort of buying pattern is an indication of the economy being under pressure as the buying power of the consumer is strained.

The frequency of purchasing a motor vehicle is irregular and risky, so the buyer looks deeper into the value for money aspects of the offering (Brassington & Pettitt, 2013). If the pricing is not conducive to the consumer, the replacement of the old vehicle will be delayed for the short term or indefinitely. The law of demand shows us that if the prices of vehicles increase, the quantity will decrease (The Demand, 2017). This situation can create three possible substitutes to be chosen by a consumer, if pricing is too extreme (The Demand, 2017). These substitutes allow the potential buyer to postpone the purchase until later, or where another category vehicle like a pre-owned option is selected or lastly the buyer does not purchase a vehicle at all and chooses another mode transportation.

People throughout the world purchase vehicles because of the need for transportation, however many homes apply a household's decision rule where the purchase of a vehicle happens if the valuation of the product less its price equals a buyer's surplus (The Demand, 2017). Due to there being a potential for the purchase of a new vehicle being delayed, the demand for such items in the short term are rather elastic (Anderson *et al*, 1997). The elastic results for automobiles in the short-term range between 1.2 and 1.5. But this scenario changes for automobiles in rural areas, as over the long term the demand becomes inelastic, which is due to fewer alternatives in transportation existing (Anderson *et al*, 1997). The inelastic results for automobiles in the long term were -0.2.

Pricing Strategy and Timing

Since the global economic crisis from 2007 until early 2010, many companies had to place a lot more renewed direction on pricing strategically (Piercy *et al*, 2010). The purpose of the strategy was to maintain or at least protect market share as many buyers had dropped their buying levels. The distributors and dealers within the auto sector were found to have a constant dependence on reoccurring pricing campaigns which were not proving effective (Piercy *et al*, 2010). The findings indicated that even the most hard-pressed consumer was removing him/herself from the new vehicle

market and either buying pre-owned vehicles or just remained in a status quo. This was confirmed by Meckes and Gehring (2010), where at times many automakers tried to stimulate sales using pricing wars and discounting campaigns.

The economic downturn once again showed markets the critical importance of competitive pricing, which has remained a traditional tactic among many businesses (Piercy *et al*, 2010). For a long period of time there have been apprehensions in marketing where pricing is the most ignored, even though it has a massive impact on profitability (Piercy *et al*, 2010). Price is not only a generator of income, but also an important creator and retainer of customers, with the intention of making profit (Brassington & Pettitt, 2013).

Customers use price as a comparison indicator where items are judged according to the value of money and quality (Brassington & Pettitt, 2013). The organisations on the other hand use price as a communicator, a bargaining tool and lastly as a viable defence to competitors. The strategic thinking towards price has only in recent times converted to the vital buyers' concerns with value, from the sellers' concerns about cost (Piercy *et al*, 2010).

Methodology

This research project applied a longitudinal retrospective study that focused on data collected from 2008 to 2016. The variable information was collected at specific and consistent points in time and extract the required statistics and other relatively important features needed in the study. In terms of the second dimension proposed by Johnson (2001), which revolved specifically around the time frame in which data was collected in non-experimental research studies. The time frames were classified into two categories namely Prospective and Retrospective. The prospective research would be collected on numerous occasions, beginning with the present and moving into the future (Johnson, 2001). The retrospective research allows the researcher to look back in time using existing data to explain an existing occurrence (Johnson, 2001).

The project's design revolves around a quantitative method consisting of a non-experimental strategy, with a longitudinal retrospective time horizon. The statistical model will involve utilising the Box-Jenkins Method. This method was developed in 1970 and refers to a methodical method of recognising, fitting and inspecting by using auto regressive (AR) time series models (Ljung, Ledolter & Abraham, 2014). Before this model is applied we must calculate whether there is a stationery series for the collected data, otherwise this model would not be applicable to the study (Applied Time Series Analysis, 2017). The ACF and PACF is used to identify the autocorrelation and the partial autocorrelation for time where any lag remains the same regardless (Applied Time Series Analysis, 2017). Once stationarity is achieved in the data, the CCF is used to test the cross correlation of two variables in a time series. The "Box-Jenkins Method" was successfully utilised in the study relating to the "Dynamic Relationship Analysis of US Gasoline and Crude Oil Prices" (Liu, 1991, p.521).

Research Questions

The broader research question for this project is to identify what relationship exists between vehicle pricing and market size in a South African context. Through the utilisation of the Hourglass notion, the question has been narrowed down to concentrate on the hypotheses which need to be investigated. The Hourglass notion for research commences with a broad question or questions

which are tapered down to focus in and operationalise, observe and examine data to reach conclusions which generalise back to the question or questions (Prasad, Rao & Rehani, 2001).

The hypotheses consist of the following for this study:

Hypothesis 1: Changes in the Rand's value against the major currencies are related to increases in the advertised prices of new vehicles.

Hypothesis 2: Can changes in pricing gaps of the advertised price of new vehicles are related to the average selling of new vehicles.

Hypothesis 3: Changes in the average selling price in new vehicles are related to the volume of new vehicles sold in the domestic market.

Data Collection

The historical information has been collected in a methodical way, with the independent and dependent variables been identified, so to allow the stated hypotheses to be tested and evaluated to give concluded outcomes. The data regarding this study consists of numerical material which has been accumulated over eight years (2008 – 2016). The information relates to historical trends of the exchange rates between the South African Rand, US Dollar and the Euro. The data further consists of information relating to the advertised new vehicle prices as well as average selling price of new vehicles for the domestic market. Lastly the information has been collated regarding the new vehicle market volumes of retailed units in the South African context. All this data will be analysed according to the generated statistical models to identify a null or alternative hypothesis result.

The data relating to the advertised and average selling new vehicle prices as well as the retail sales in the domestic market, have been collected from Renault South Africa. This reputable importer of new vehicles in South Africa has allowed the data to be stored with the BDO Cyber and Forensic Lab. The accumulated data is of high quality which has been categorised in monthly periods and utilised by both parties in alternative studies in the South African motor vehicle industry. The historical exchange rates have been retrieved from UKForex Limited a registered company, which is also registered with Her Majesty's Revenue and Customs (HMRC) and the Financial Conduct Authority (FCA) in the United Kingdom.

The identified data has been collected to potentially establish the ideal variable pattern, especially over the extended period of eight years. If the quality of data is of a poor standard and incorrectly accumulated, it will compromise the research project causing poor conclusions (Cleverism, 2017). There is a risk with information from extended periods of time, leading to potential data dilution reducing reliability.

Reliability and Validity

This project's collected data relates to the variables of advertised prices of new vehicles, the average selling price of new vehicles and the retail units sold in the domestic market. This information was acquired by Renault South Africa for research within motor industry in a South African context. The historical exchange rates have been retrieved from a reputable company in the United Kingdom who is registered with the appropriate regulators regarding foreign exchange. The content validity of the selected instrument with the assistance of the BDO Forensic and Cyber Lab should cover the entire domain related to the mentioned variables.

The consistency of the measure used by the instrument is vital to the reliability of the study. The homogeneity of the data will be assessed using the autocorrelation function which will test the points detached by time lags. A high reliability is noted if the correlations are found to be strong from the data that has been analysed (Heale & Twycross).

Findings

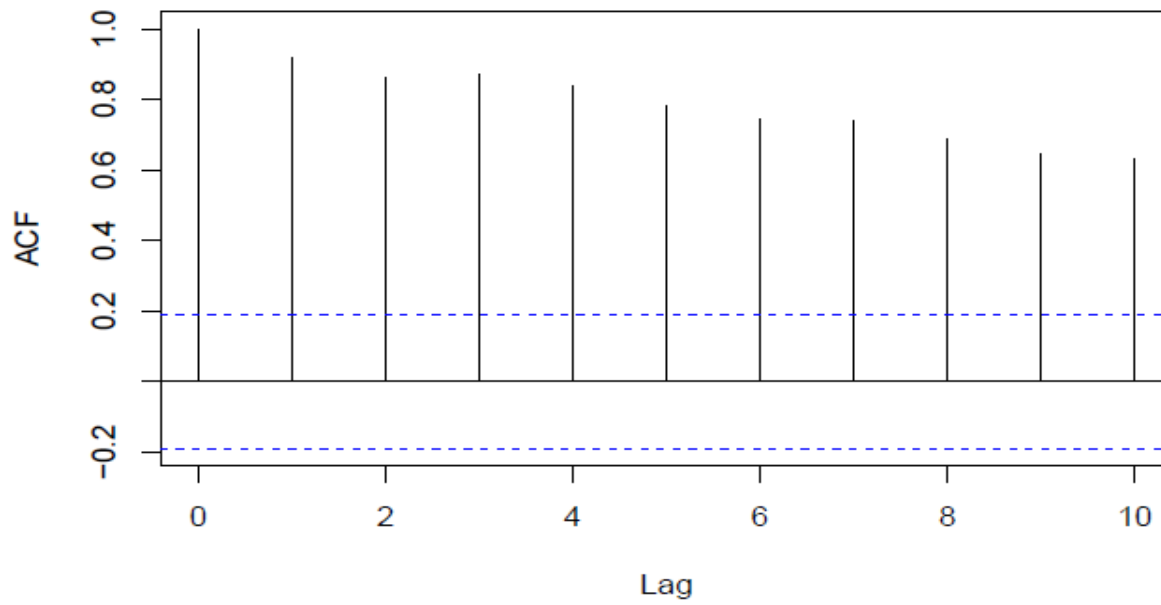
This study evaluated the relationship between the fluctuations of new vehicle pricing and its effect in the South African domestic market. The study aimed to analyse the collected data and understand whether the sensitivity of demand exists to pricing changes in the South African motor industry. The collected data was imputed into the appropriate statistical models to test the hypotheses. The R Statistical Software was utilised to administer the applicable R language to create the graphical representations of the ACF, PACF and CCF models. ACF is known as Auto Correlation Function, with PACF meaning Partial Auto Correlation Function and lastly CCF is known as Cross Correlation Function.

Hypothesis 1

Hypothesis 1 says that changes in the Rand's value against the major currencies are related to increases in the advertised prices of new vehicles. We could accumulate the sales volume of vehicles sold in the South African market for the period January 2008 to December 2016.

The first objective was to test the correlations of the Rand US Dollar and Rand Euro using the ACF for AR (1) to identify the strength of the correlation of the data in itself and to see if the data appeared to be stationery. The strength of the correlation is marked on the *y-axis* of the auto correlation plots and the *x-axis* representing the time lags of the imputed data. This exercise was repeated on the price of new vehicles in the South African market, where the ACF for AR (1) was to also identify the strength of the autocorrelation of the data and to see if the data appeared to be stationery. Once the above results had been concluded the Rand US Dollar and Price were applied to the Cross-Correlation Function (CCF) model to identify the statistical significance of autocorrelation between the two variables in a time series. This exercise was repeated for the Rand Euro and Price to identify its statistical significance of autocorrelation between those two variables in a time series. Through the ACF and PACF methods we will identify the statistical significance of the autocorrelation of the Rand against the US Dollar and Euro and ensure that the data is stationery to be applied to the CCF model.

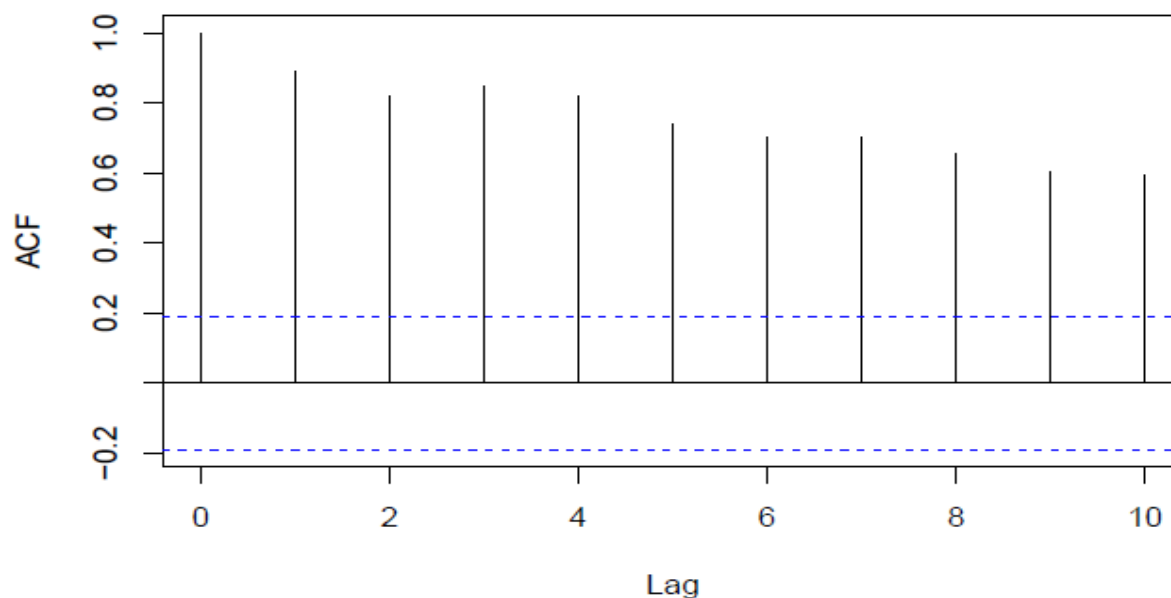
Figure 1: Autocorrelation Function for Auto regression (1) – Rand US Dollar exchange rate



Source: R-Statistical Program

When referring to Figure 1 the ACF for AR (1) specifically relates to the Rand US Dollar exchange rate for 10 lags in the model. Each lag is representative of a single month. The ACF for AR (1) clearly shows that there is statistical significance as the spikes for all 10 lags stay above the dash lines of 0.2 and -0.2. The dash lines are an indicator for the strength of autocorrelation in the US Dollar and as shown, is highly correlated. In majority of the statistical forecasting models, it is assumed that the data can be approximately stationarized (Stationarity and differencing, 2017). The autocorrelation with lag 0 will always equal 1.0 (Anderson & Semmelroth, 2017). This is due the Rand US Dollar being the same variable at lag 0. Figure 1 shows that from lag 1 until lag 10 the spikes diminish slowly and end at 0.6, which is statistically significant due to being above the dash lines indicating high correlation. Therefore, this data is nonstationary and unable to be imputed to the CCF model.

Figure 2: Autocorrelation Function for Auto regression (1) - Rand Euro exchange rate

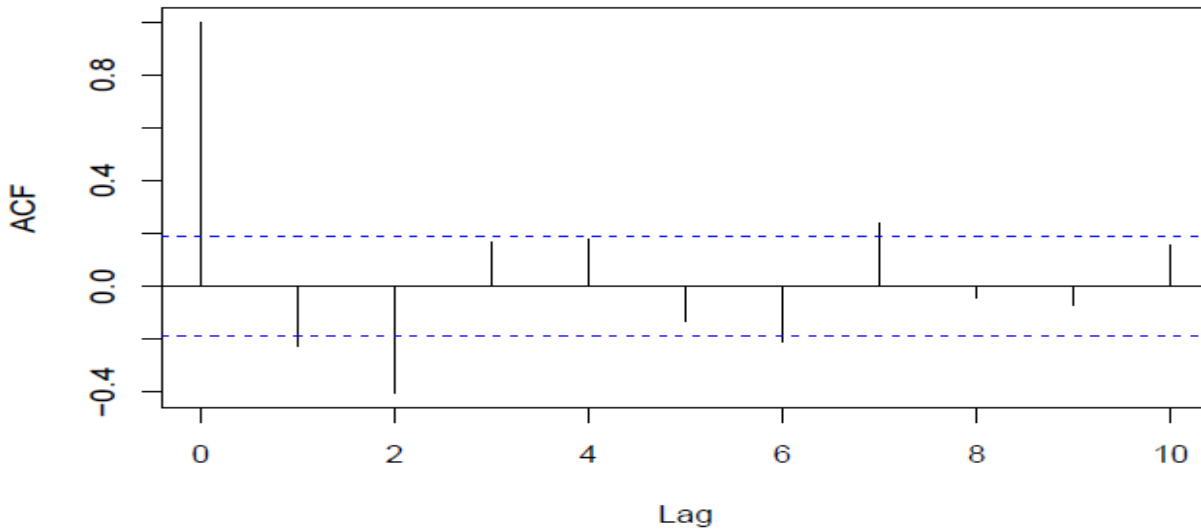


Source: R-Statistical Program

When referring to Figure 2 the ACF for AR (1) specifically relates to the Rand Euro exchange rate for 10 lags in the model. The ACF for AR (1) clearly shows that there is statistical significance as the spikes for all 10 lags stay above the dash lines of 0.2 and -0.2.

The Rand Euro like the Rand US Dollar are shown to be highly correlated. Figure 2 shows that from lag 1 until lag 10 the spikes diminish slowly and end at 0.6, which is statistically significant due to being above the dash lines indicating high correlation. The nonstationary residuals show that their numerical properties like correlations with each other are constant over time cannot be assumed (Sample ACF, 2017). Therefore, this data is nonstationary and unable to be imputed to the CCF model. The Rand US Dollar and Rand Euro exchange rate data were re-entered into the ACF, however on this occasion the difference in the Rand US Dollar and Rand Euro exchange rates were implemented and yielded the following results.

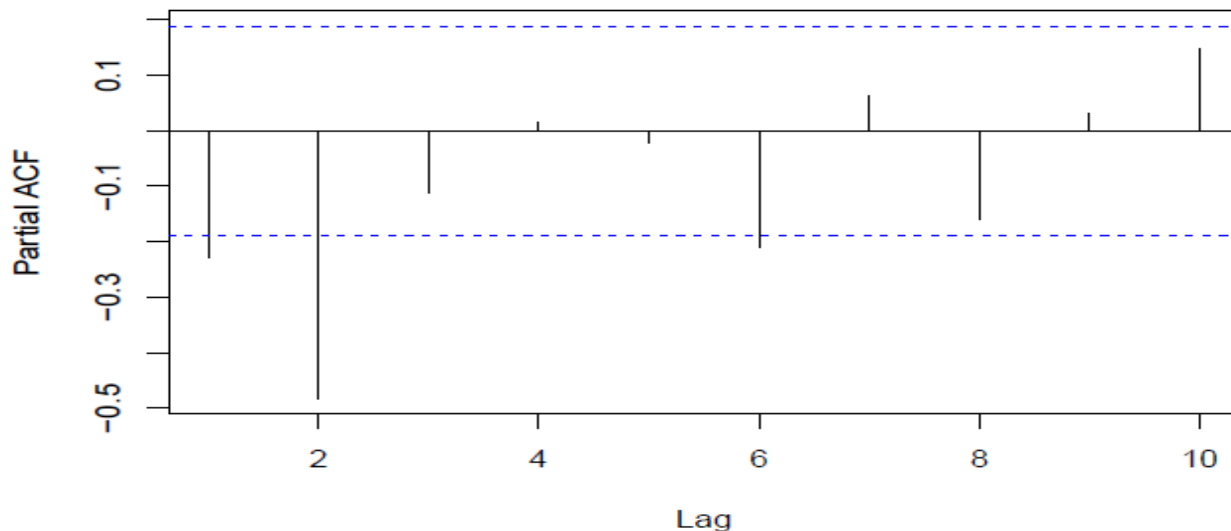
Figure 3: Autocorrelation Function for the difference in Rand US Dollar exchange rate



Source: R-Statistical Program

Regarding Figure 3, the spikes for the lags 1, 3 to 10 do not show statistically significant autocorrelation results. These spikes are all within the standard error or normal noise range. Only lag 2 seems to show some significance with a reading of approximately -0.4. The reading for lag 2 is random and isolated, as it does not appear in the remaining lags in this model. The data was applied to the PACF model to calculate the strength of the correlation independently. A PACF model is a summary of the association between an observation in a time series with observations at previous time steps or lags, where the relationships of intervening observations are removed (Partial Autocorrelation Function, 2017).

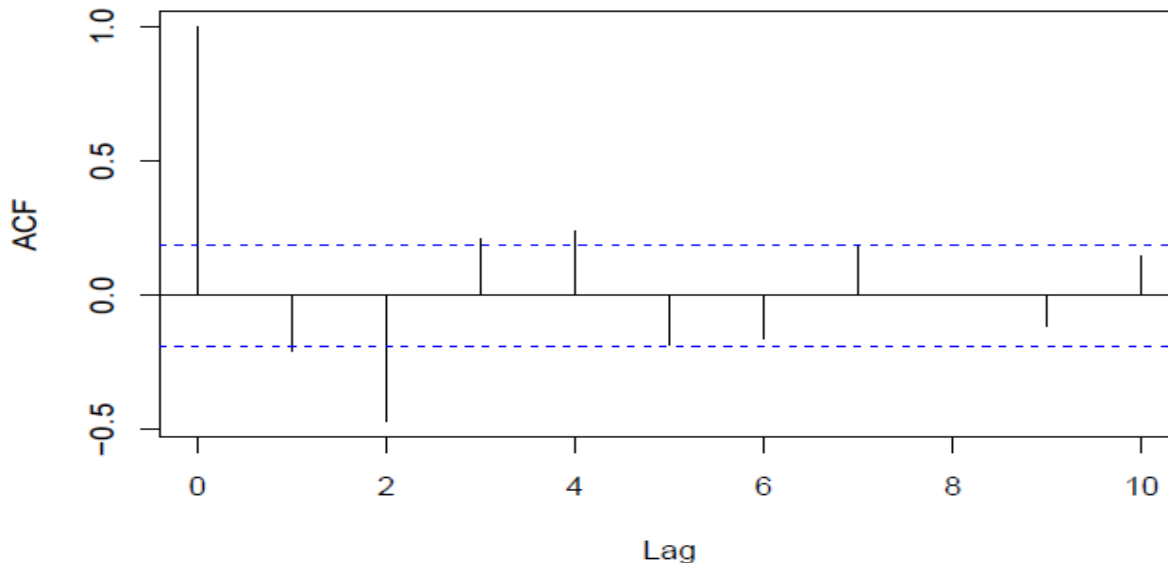
Figure 4: Partial Autocorrelation Function for the difference in Rand US Dollar exchange rate



Source: R-Statistical Program

The results displayed in Figure 4 reiterates the findings concluded in Figure 3 where only in lag 2 did the correlation go beyond the dash lines to be classified as statistically significant. The spike in lag 2 came just short of -0.5 in correlation, however the reading is also random and isolated, with no sign of random walks with corresponding lags. The remaining spikes displayed normal noise in the partial autocorrelation. The findings in both the ACF and PACF models shows the data to be stationery and can be applied to the CCF model.

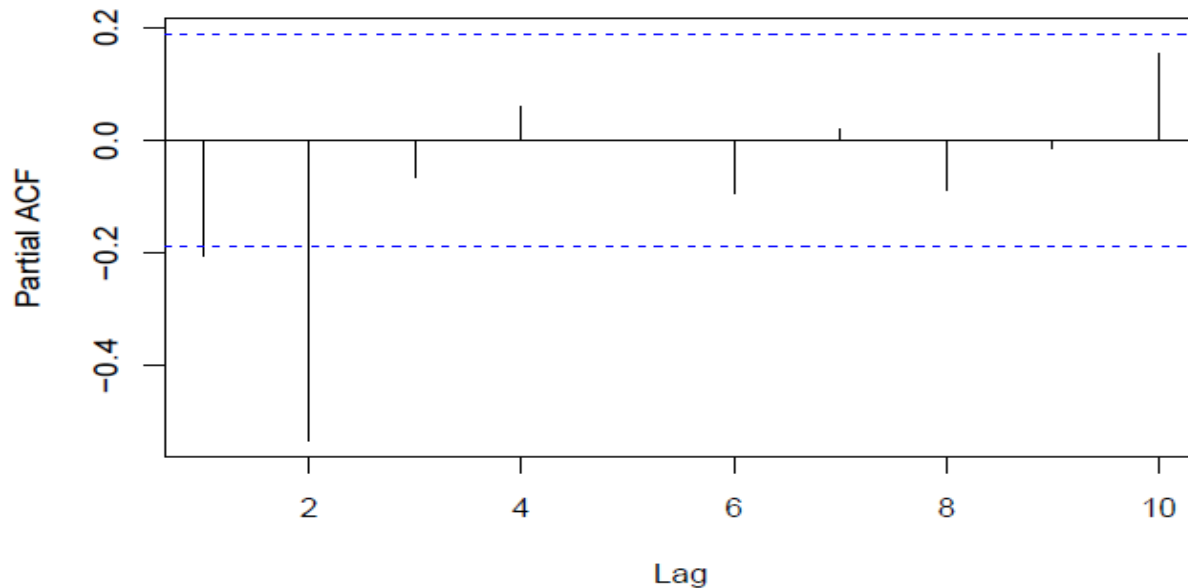
Figure 5: Autocorrelation Function for the difference in the Rand Euro exchange rate



Source: R-Statistical Program

Regarding Figure 5, the spikes for the lags 1, 3 to 10 do not show statistically significant autocorrelation results. There spikes are all within the normal noise range as the correlations are within the dash lines of 0.2 and -0.2. Only lag 2 seems to show some significance with a correlation just short of -0.5. The reading for lag 2 is random and isolated as it does not appear in the remaining lags in this model and shows a very similar pattern to the Rand US Dollar exchange rate. The selected data was then applied to the PACF model to calculate the strength of the correlation independently.

Figure 6: Partial Autocorrelation Function for the difference in Rand Euro exchange rate



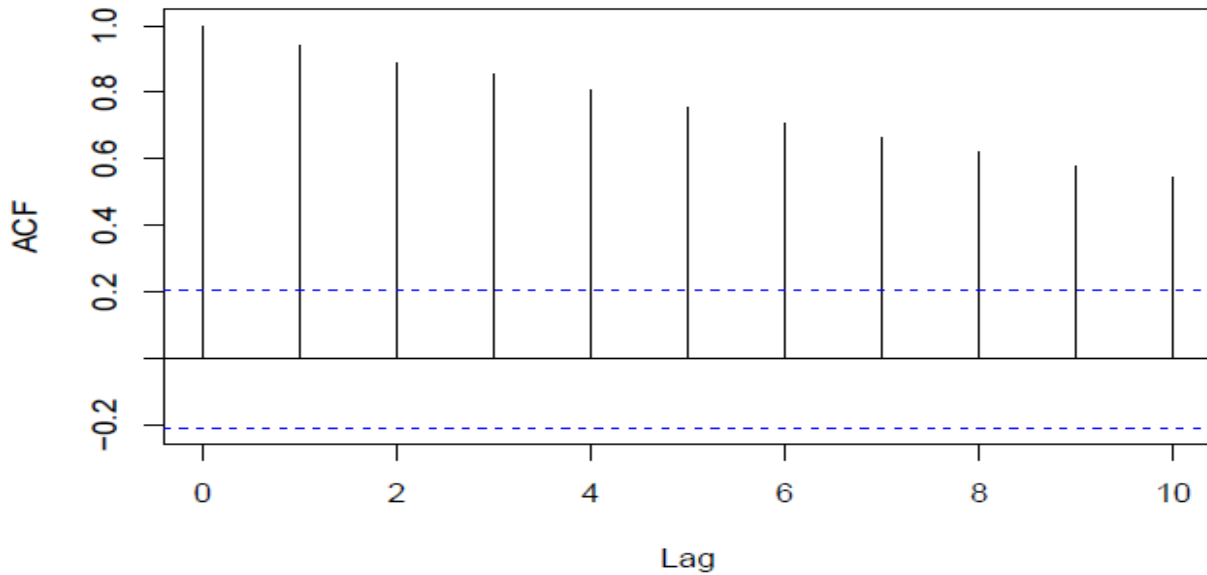
Source: R-Statistical Program

The results displayed in Figure 6 reiterates the findings concluded in Figure 5 where only in lag 2 did the correlation go beyond the dash lines to be classified statistically significant. The spike in lag 2 came just over of -0.5 in correlation, however the reading is also random and isolated, with no random walks appearing in the corresponding lags. The remaining spikes displayed normal noise in the partial correlation. The findings in both the ACF and PACF models show the data to be stationary and can be applied to the CCF model.

Advertised Price of New Vehicles in the South African Motor Industry

The collected data of new vehicle prices required stabilizing, this was to ensure the reliability and validity of the information to be imputed into the ACF for AR (1). The initial data showed that the new vehicle prices of every brand and or model was not properly represented throughout the period from 2008 to 2016. Of the 69 models of motor vehicles sold in South Africa, 22 models yielded 92 months of prices, while another three models yielded 89 months of prices. The historical data of the remaining 44 models was between one to two months, deeming it insignificant to the study. The applicable 25 models of vehicle prices were tested using ACF for AR (1) time series. The purpose was to then apply stationary data to the CCF model as the other variable to the Rand US Dollar and Rand Euro exchange rates.

Figure 7: Autocorrelation Function for Auto regression (1) - Price of New Vehicles



Source: R-Statistical Program

In Figure 7 the same process of applying 10 lags to the autocorrelation, with the spikes from lag 1 to 10 diminishing slowly over the time series. Due to the lags being outside the dash lines of 0.2 and -0.2 the autocorrelation is regarded as statistically significant. The nonstationary residuals show that their numerical properties like correlations with each other are constant over time cannot be assumed (Sample ACF, 2017). The new vehicles prices were re-entered into the ACF, however on this occasion the difference in the price of new vehicles was implemented and yielded the following results.

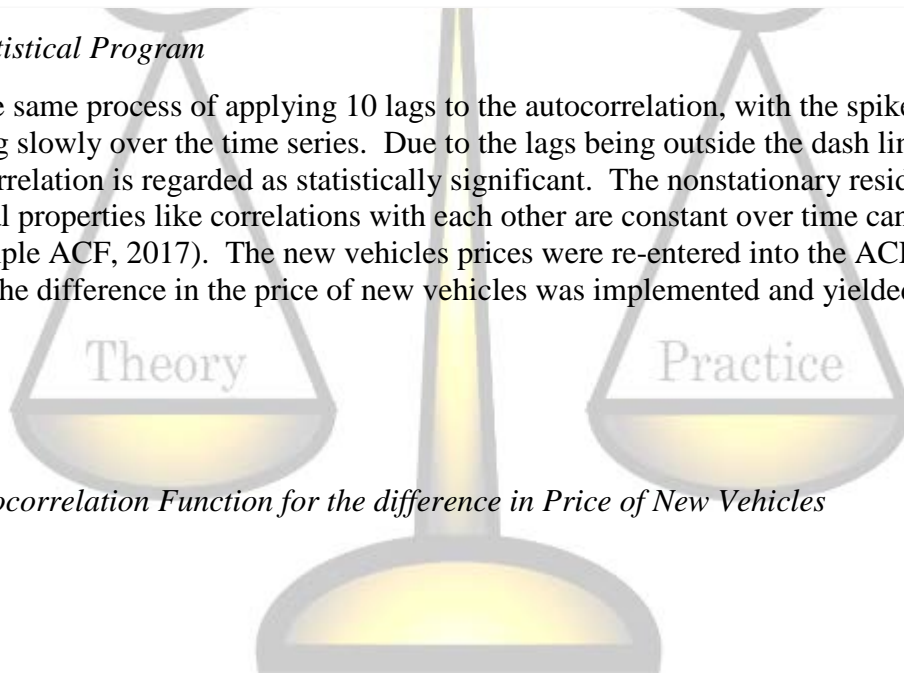
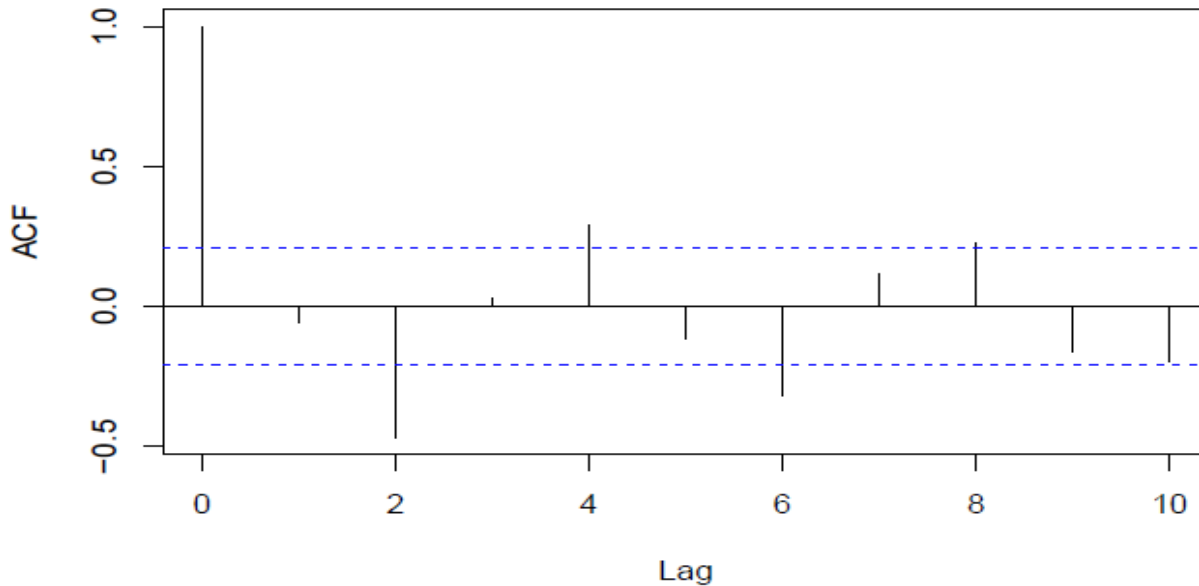


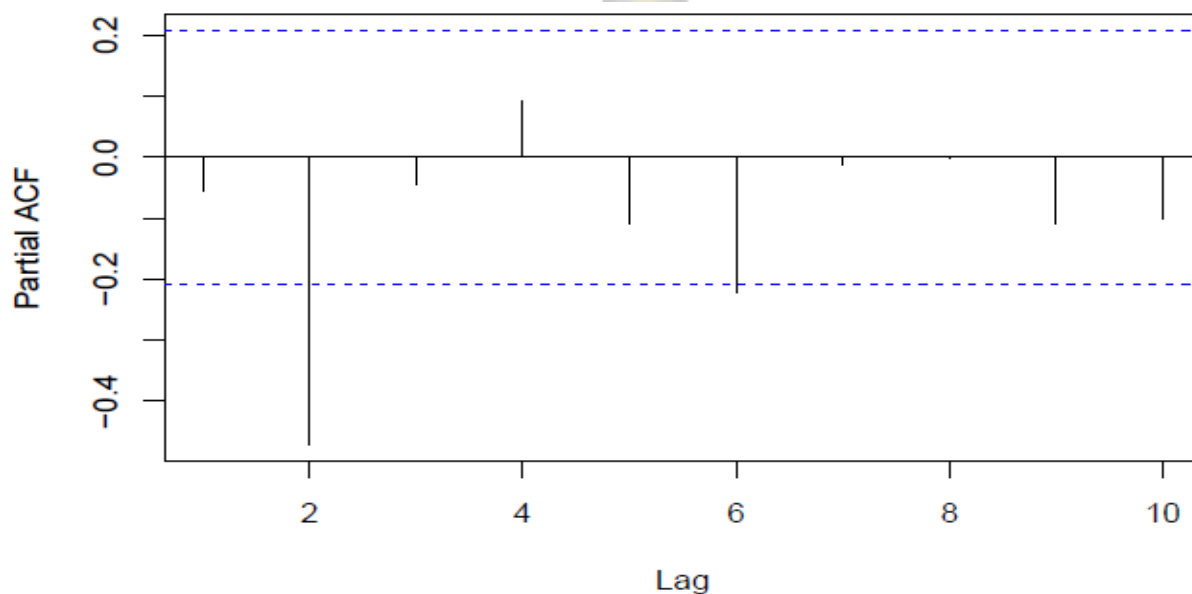
Figure 8: Autocorrelation Function for the difference in Price of New Vehicles



Source: R-Statistical Program

In Figure 8 the spikes for the lags 1, 3, 5, 7, 8, 9, 10 do not display statistically significant autocorrelation results, showing normal noise. Lag 4 and 6 had correlations of approximately of 0.3 and -0.3 respectively, being slightly above the dash lines of 0.2 and -0.2. The only spike to being highly correlated is in lag 2 where the residual shows a correlation close to -0.5. This result is random and isolated with no signs of random walks with the corresponding lags in the ACF. The new vehicle price was then applied to the PACF model to calculate to the strength of the correlation independently. The PACF will consider the correlation among each of the intermediate lagged points.

Figure 9: Partial Autocorrelation Function for the difference in Price of New Vehicles

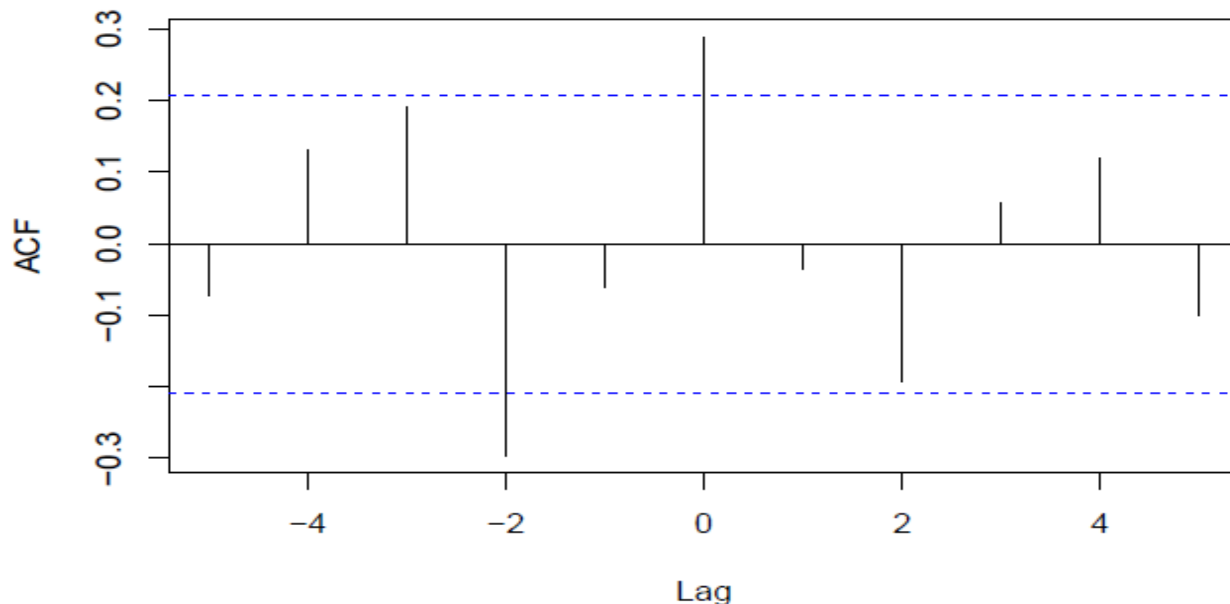


Source: R-Statistical Program

The results displayed in Figure 9 reiterates the findings concluded in Figure 8 on lag 2 where the spike again went beyond the dash line indicating the correlation to be statistically significant at just below -0.5. Once again the spike is seen to be random and isolated from the other lags in the model, with no random walks in the corresponding lags. The remaining spikes displayed normal noise range in the partial autocorrelation. The findings in both the ACF and PACF models are stationary and can be applied to the CCF model.

The CCF model is utilised to recognise the relationships between two-time series namely the y-axis and x-axis (Cross Correlation Functions, 2017). These relationships can be positive or negative, where CCF is a collection of test correlations between $xt+h$ and yt for $h = 0, \pm 1, \pm 2, 3\pm$, and so on (Cross Correlation Function, 2017).

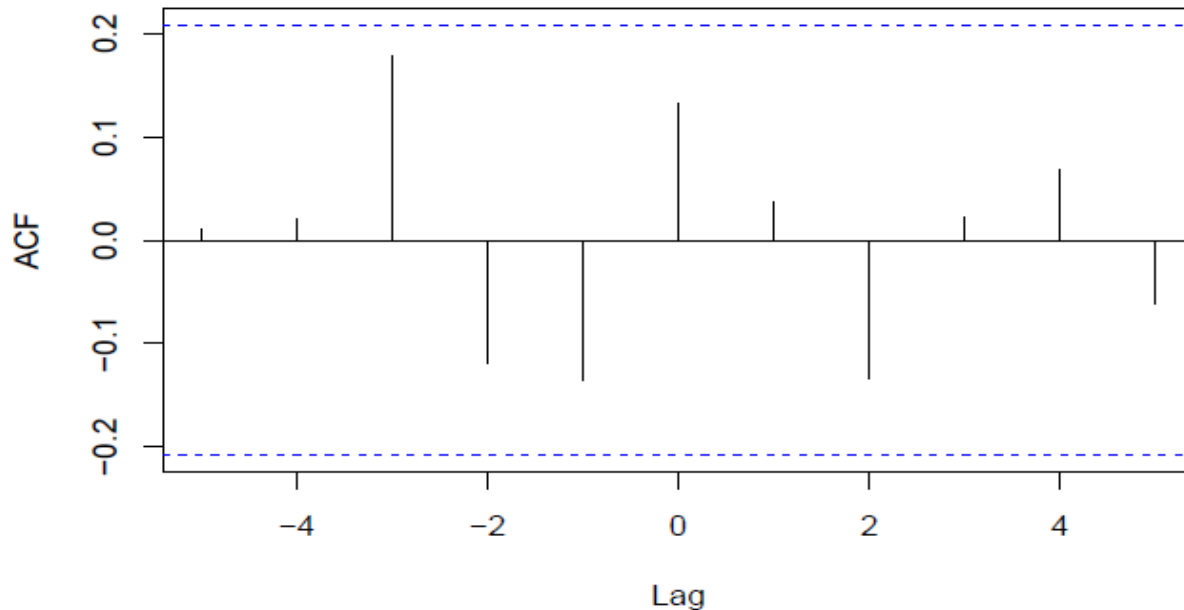
Figure 10: Cross Correlation Function for difference in Rand US Dollar and New Vehicle Price



Source: R-Statistical Program

The cross correlation for CCF in Figure 10 shows there to be a slight positive and negative correlation between the Rand US Dollar and new vehicle prices. The four biggest spikes are lags -3, -2, 0 and 2, where the correlations achieved a residual of approximately 0.2, -0.3, 0.3 and -0.2 respectively. The remaining positive and negative lags have correlations around 0.1 and -0.1 indicating no statistical significance. If the correlations had a $r = \pm 0.4$ it would be classified as a weak correlation, if $r = \pm 0.5$ to ± 0.8 the result would be regarded as a medium correlation and if $r = \pm 0.8$ the result would be recognised as a strong correlation. There seems to be no statistically significant correlation between the difference in the Rand US Dollar and the difference in new vehicle prices for the tested period.

Figure 11: Cross Correlation Function for difference in Rand Euro and New Vehicle Price



Source: R-Statistical Program

The cross correlation for CCF in Figure 11 shows there to be a slight positive and negative correlation between the Rand US Euro and new vehicle prices, which is similar the correlations of the Rand US Dollar. The five biggest spikes are at lags -3, -2, -1, 0, and 2, where the correlations achieve a reading of approximately 0.2, -0.1, -0.1, 0.1 and -0.1 respectively.

The remaining positive and negative lags have correlations below 0.1 and -0.1 indicating no statistical significance. There seems to be no statistically significant correlation between the difference in the Rand Euro and the difference in new vehicle prices for the tested period.

Findings for Hypothesis 2

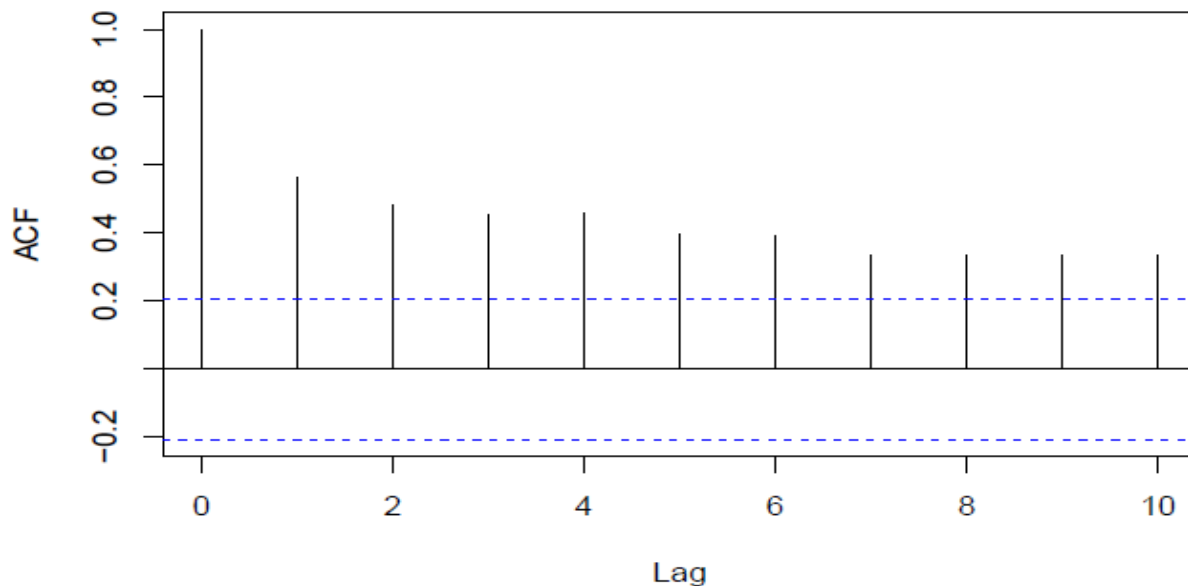
Hypothesis 2 which states that changes in pricing gaps of the advertised price are related to the average selling price of new vehicles. The study was unable to accumulate sufficient consistent data for the hypothesis to be adequately tested to produce a result.

Findings for Hypothesis 3

Hypothesis 3 states that changes in the advertised selling price in new vehicles are related to the volume of new vehicles sold in the domestic market. This shows the sales volume of vehicles sold in the South African market for the period January 2008 to December 2016.

The first objective in this study was to test the correlations of the new vehicle data using the ACF for AR (1) to identify the strength of the correlation of the sales data itself and to identify if it appeared to be stationary. The strength of the correlation will be measured according to the same methods and techniques used in hypothesis 1 showing consistency in the study. This exercise has already been conducted on the price of new vehicles in the South African market for hypothesis 1, where the ACF for AR (1) was utilised to find the strength of the autocorrelation of the data and if it appeared to be stationary. Once the above results had been concluded, the new vehicle price and domestic sales volumes were applied to the CCF model. The CCF model calculated the statistical significance of autocorrelation between the two variables in a time series.

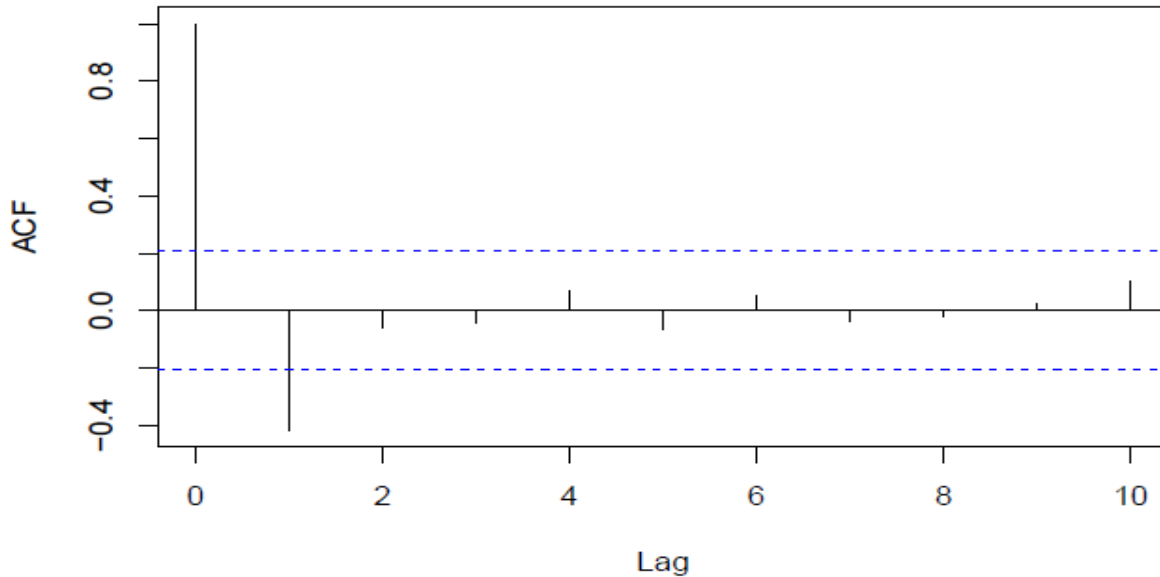
Figure 12: Autocorrelation Function for Auto regression (1) - Domestic New Vehicle Sales



Source: R-Statistical Program

In Figure 12 the same process was followed as in hypothesis 1 of applying 10 lags to the autocorrelation, with the spikes from lag 1 to 10 diminishing slowly over the time series. In time lag 0 to lag 1 the spike diminished to a correlation of 0.6 and dropping to its lowest correlation of just below 0.4. Due to the spikes in the lags being above the dash lines of 0.2 and -0.2 the autocorrelation is regarded as statistically significant. The nonstationary residuals show that their numerical properties like correlations with each other are constant over time cannot be assumed (Sample ACF, 2017). Therefore, this data is nonstationary and unable to be imputed to the CCF model. The South African domestic new vehicle sales data was re-entered into the ACF, however on this occasion the difference in the new vehicle sales was implemented and yielded the following results.

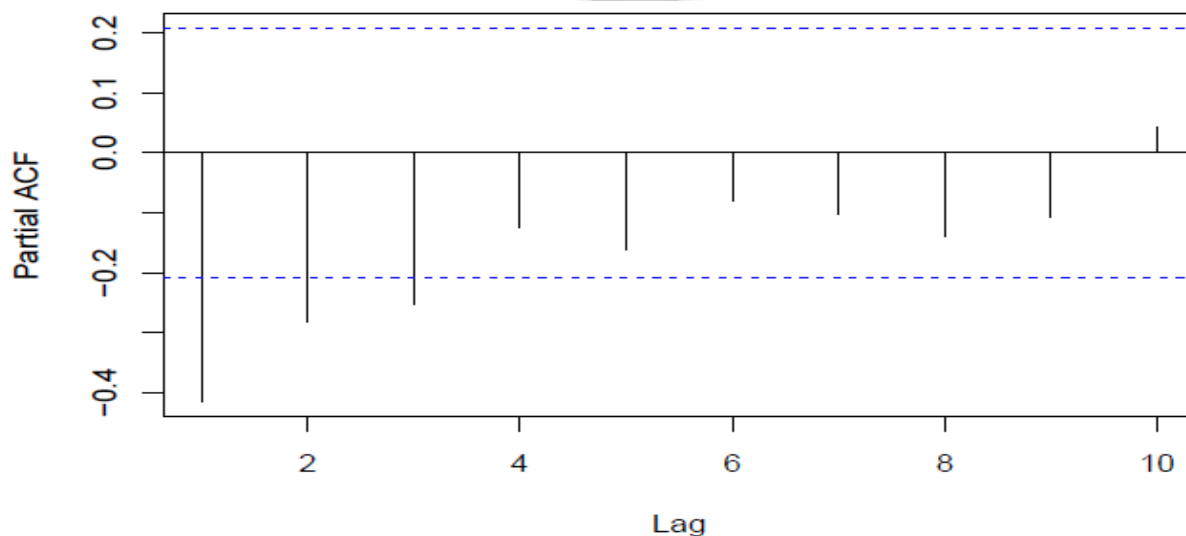
Figure 13: Autocorrelation Function for the difference in Domestic New Vehicle Sales



Source: R-Statistical Program

Regarding Figure 13, the spikes for the lags 2 to 10 do not show statistically significant autocorrelation results. These spikes are all within the standard error or normal noise range, which is 0.2 for positive correlation or -0.2 for negative correlation. Only the spike in lag 1 seems to show some significance with a reading of approximately -0.4. The reading for lag 2 is random and isolated, as it does not appear in the remaining lags in this model. The data was then applied the PACF model to calculate the strength of the correlation independently. A PACF model is a summary of the association between an observation in a time series with observations at previous time steps or lags, where the relationships of intervening observations are removed (Partial Autocorrelation Function, 2017). Essentially PACF considers the correlation among each of the intermediate lagged points.

Figure 14: Partial Autocorrelation Function for the difference in Domestic New Vehicle Sales



Source: R-Statistical Program

The results displayed in Figure 14 reiterates the findings concluded in Figure 13 where only in lag 1 did the correlation go beyond the dash lines to be classified statistically significant at -0.4. The spikes in lag 2 and 3 also show correlations that have gone just beyond the dash lines with approximate readings of -0.2. The spikes for lags 1, 2, 3 seem to show signs of a random walk, but this diminishes from lag 4 to 10. The spikes for lag 4 to 10 display normal noise in this partial autocorrelation. The findings in both the ACF and PACF models shows the data to be stationery and can be applied to the CCF model.

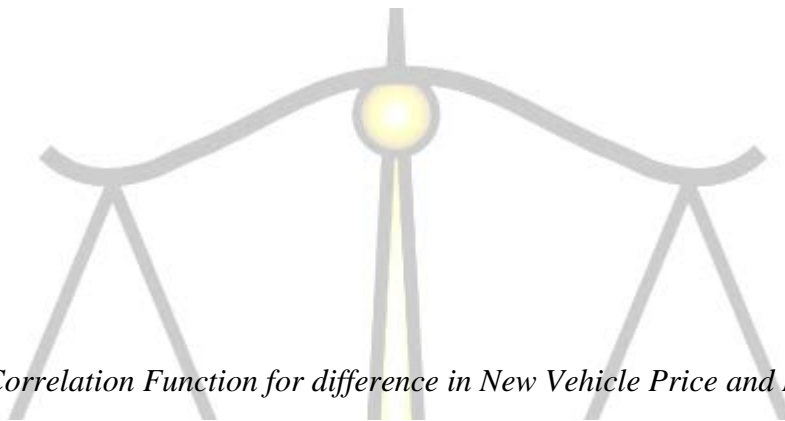
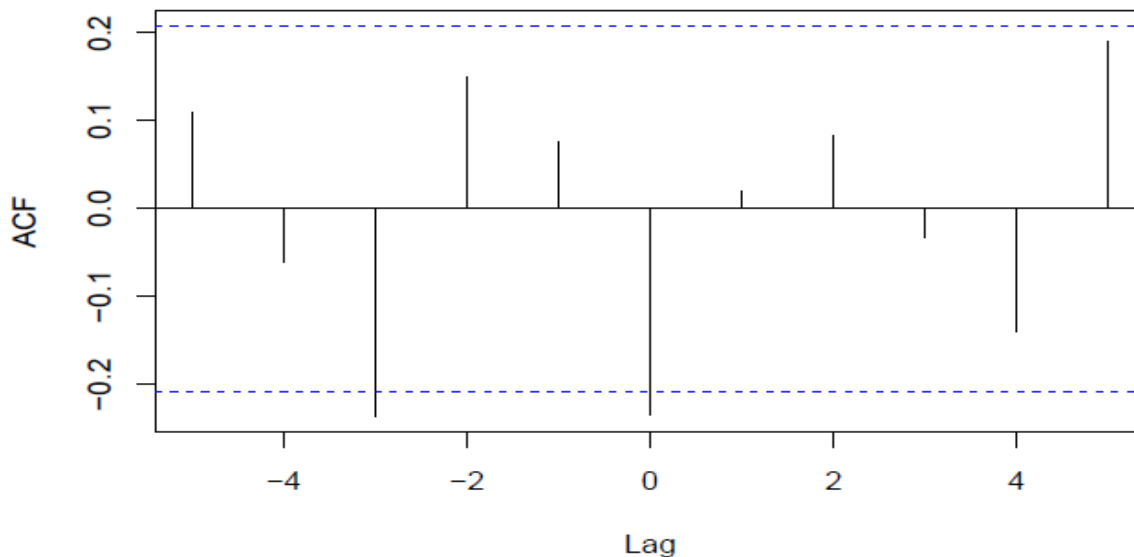


Figure 15: Cross Correlation Function for difference in New Vehicle Price and New Vehicle Sales



Source: R-Statistical Program

The cross correlation for CCF in Figure 15 shows there to be a slight positive and negative correlation between new vehicle prices and new vehicle sales in a South African context. The five biggest spikes are lags -3, -2, 0, 4 and 5, where the correlations achieved a residual of approximately -0.2, 0.15, -0.2, 0.15 and 0.2 respectively. The remaining positive and negative lags have correlations below or around 0.1 and -0.1 indicating no statistical significance. If the correlations

had an $r < \pm 0.4$ it would be classified as a weak correlation, if $r = \pm 0.5$ to ± 0.8 the result would be regarded as a medium correlation and if $r > \pm 0.8$ the result would be recognised as a strong correlation. There seems to be no statistically significant correlation between the difference in new vehicle prices and the difference in new vehicle sales for the tested period.

Conclusion

Hypothesis 1

The applicable data relating to the Rand US Dollar, the Rand Euro and advertised new vehicle prices were all independently plotted on the ACF for AR (1) times series for 10 lags. The objective was to test the autocorrelation of the data itself and conclude stationarity. All data showed statistically significant correlations above the dash lines indicating non-stationarity. The difference in the Rand US Dollar, Rand Euro and advertised new vehicle prices were re-imputed into the ACF and PACF models. The autocorrelation of the spikes in the lags showed normal noise of around 0.2 to -0.2. The data was deemed as having stationarity and able to be imputed into the CCF model. The CCF model was used to identify the strength of the cross correlation between the difference in the Rand US Dollar and the Rand Euro against the difference in the advertised new vehicle prices. The cross correlation yielded slight positive and negative correlations for the positive and negative lags in the model. Both the results from the cross-correlation tests yielded no medium or strong cross correlations. Therefore, the results show that the correlation is not strong enough to prove the hypothesis.

Hypothesis 2

No data was tested specifically for this hypothesis; therefore, no results could be concluded.

Hypothesis 3

The applicable data relating to the advertised new vehicle and new vehicle sales were all independently plotted on the ACF for AR (1) times series for 10 lags. The objective was to test the autocorrelation of the data itself and conclude stationarity. All data showed statistically significant correlations above the dash lines indicating non-stationarity. The difference in the advertised new vehicle prices was already tested in hypothesis 1 and the results were available for the testing in hypothesis 3. However, the new vehicle sales were re-imputed into the ACF and PACF models. The autocorrelation of the spikes in the lags showed normal noise of around 0.2 to -0.2. The data was deemed as having stationarity and able to be imputed into the CCF model. The CCF model was used to identify the strength of the cross correlation between the difference in advertised new vehicle and the difference in the new vehicle sales. The cross correlation yielded slight positive and negative correlations for the positive and negative lags in the model. The results from the cross-correlation test yielded no medium or strong cross correlations. Therefore, the results show that the correlation is not strong enough to reject the null hypothesis.

Recommendations

There is an opportunity for this study to be taken further with an emphasis of gaining statistically stronger correlation results. The future project could consider focusing the study on one specific brand or importer in the South African market. This would allow for more specific and complete data which could be imputed into the same statistical models for testing autocorrelation and partial autocorrelation of stationarity. Thereafter applying the cross-correlation model to the stationary

data to test the positive or negative correlation in positive or negative lags in a two-time series. The brand or importer should contribute materially to the volumes sold in the South African domestic market. The results would be beneficial to the management of the chosen brand or importer so an understanding in the opportunities and threats that exist between foreign exchange, price and sales.

However, if the study had to be changed, the following would have to be considered. The consideration of accounting for hedging when testing the Rand exchange rate against other major currencies and price. Hedging could allow the significance in an exchange rate variation to be delayed from the pricing mechanism of new vehicles. This result could potentially alter the statistical significance of the correlation between the Rand exchange rate against price. Further the incorporation of current importer and dealer stock levels where inventory is potentially valued at older prices. This has the potential to delay the influence of pricing variations to the volume of vehicles sold in the domestic market.

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