An Augmented Macroeconomic Linear Factor Model of South African Industrial Sector Returns

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ABSTRACT

Purpose

This study investigates the impact of the macroeconomic environment on South African industrial sector returns.

Design/methodology/approach

Using standardized coefficients derived from time series models, we quantify the impact of macroeconomic influences on returns. We analyse resultant residual correlation matrices to establish the extent of factor omission and apply a factor analytic augmentation to address this.

Findings

Global influences are the most important drivers of returns and industrial sectors are highly integrated with the global economy. Specifications that comprise macroeconomic factors and proxies for omitted factors in the form of residual market factors are likely underspecified. We demonstrate that a factor analytic augmentation is an effective approach to ensuring an adequately specified model.

Research limitations/implications

Our findings are of interest to investors, econometricians and researchers. While our study focuses on a single market, the South African stock market as represented by the Johannesburg Stock Exchange (JSE), it is a highly developed and globally integrated market. In terms of market capitalization, it exceeds the Madrid Stock Exchange, the Taiwan Stock Exchange and the BM&F Bovespa. Yet, there is a limited number of studies that investigate the macroeconomic drivers of this market.

Practical implications

Investors should be aware that while the South African domestic environment, especially political risk, has an impact on returns, global influences are the most important determinants. No industrial sectors are insulated from global influences, limiting the potential for diversification. We present researchers with an alternative set of macroeconomic factors that may be used in further analysis and asset pricing. From an econometric perspective, we demonstrate the usefulness of a factor analytic augmentation as a solution to factor omission.

Originality/value

We provide insight into a large and well-developed yet understudied financial market while considering a much broader set of macroeconomic factors than in prior studies. We make a methodological contribution by using standardized coefficients to discriminate between the impact of domestically and internationally driven factors. We show that should coefficients not be standardized, inferences relating to the relative importance of factors will differ. Finally, we unify an approach of using pre-specified factors with a factor analytic approach to address factor omission that ensures a valid and readily interpretable specification.

Keywords: macroeconomic factors, factor models, return generating process, global factors, time-series, standardized coefficients

JEL classification: C01, C13, C32, C58, G12, G15

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1. Background

The South African stock market, the Johannesburg Stock Exchange (JSE), is a highly developed and globally integrated market. In terms of market capitalization, it exceeds the Madrid Stock Exchange, the Taiwan Stock Exchange and the BM&F Bovespa (Brazil) (Moolman & Du Toit, 2005; Szczygielski & Chipeta, 2015; Desjardins, 2017). Yet, there is a limited number of studies that investigate the macroeconomic drivers of this stock market. Examples of notable studies are those of Van Rensburg (1995; 1996; 2000), Moolman and Du Toit (2005) and Szczygielski and Chipeta (2015). The conceptual basis of these time-series models is the linear (multi)factor model that underpins the Arbitrage Pricing Theory (APT) (Ross, 1976; Ross & Roll, 1980; Chen, Roll & Ross, 1986; Liow, 2004; Sadorsky, 2008).

Van Rensburg (1995; 1996) identifies four factors that drive returns on the JSE All Share Index (JSE ALSI), the market aggregate. These are the unanticipated changes in the Rand gold price, returns on the Dow Jones Industrial Average (DJIA), unexpected inflation and changes in the term structure. Together, these factors explain 30% of the variation in returns. In a subsequent article, Van Rensburg (2000) undertakes a more extensive investigation of the return generating process. Returns on the JSE ALSI are explained by returns on the DJIA, the 10-year government bond rate, the Rand gold price, growth in All Share Indexed Earnings and changes in gold and foreign reserves. Together, these factors explain just under 30 percent of the variation in returns. Moolman and Du Toit (2005) use six factors to explain returns on the JSE All Share Index in the short-term. These are changes in short-term interest rates, the rand dollar exchange rate, the gold price, a risk premium and returns on the S&P500. Together, these factors explain of 58% of movements on the JSE. Returns on the S&P 500 have a positive and highly significant impact on returns on the JSE ALSI. This can be attributed to South Africa being a small and open stock market that follows global markets and points towards integration (see Moolman, 2003). Mensi, Hammoudeh, Reboredo and Nguyen (2014) investigate the impact of global stock markets and commodity prices on BRICS' stock markets. Using quantile regression, they find that oil and gold prices (commodities) and returns on the S&P 500 exert a generally significant influence on the South African stock market. Explanatory power ranges between over 11% to almost 16%, depending upon the quintile considered. Szczygielski and Chipeta (2015) use seven factors to explain returns on the JSE ALSI. These are changes in the inflation rate, inflation expectations, building plans passed, growth in the money supply, changes in the oil price, fluctuations in the exchange rate and innovations in the business cycle. Assuming integration with global markets, they include the FTSE All World Index in their specification to capture the impact of global influences. The unrestricted model explains 56% of the variation in returns. In further analysis, the influence of factors is decomposed by estimating restricted versions of the unrestricted specification. Returns on the JSE ALSI are mostly driven by movements of the FTSE All World Index, with this single factor explaining almost 42% of the variation in returns. The remaining factors explain almost 22% of variation. This is attributed to the high levels of integration of the South African stock market with global markets. What emerges from these studies is that the South African stock market can be explained by macroeconomic factors. This is not always the case for all markets (see Bilson, Brailsford & Hooper, 2001). Furthermore, the South African stock market is integrated with global markets. Global macroeconomic news and events, mostly reflected in global equity indices, have an impact on the South African stock market.

In this paper, we set out to further develop the literature on the macroeconomic drivers of the South African stock market. Our study differentiates itself in that it considers a much broader set of macroeconomic factors than similar studies of the South African stock market. We consider a total of 52 *unique* factors in the screening of potential return drivers. We also contribute by using an updated sample that spans the period January 2001 to December 2016. This contrasts with Szczygielski and Chipeta's (2015) study that spans the period July 1995 to March 2011. Our sample therefore includes the immediate aftermath of 2007-2009 Global Financial Crises. We use data for 26 South African industrial sectors. This contrasts with previous South African studies, notably those of Van Rensburg (1995; 1996; 2000) and Szczygielski and Chipeta (2015), which use returns on the JSE ALSI, a limited number of industrial sectors or a sample of individual stocks. Our study also makes a methodological contribution. We work with the explicit assumption that the South African stock market is integrated with global markets. Therefore, we assume that global economic news impacts returns (Pal & Mittal, 2011; Georgiadis, 2016). Accordingly, we estimate standardized coefficients to discriminate between the impact of domestically and internationally driven factors. The benefit of using standardized coefficients is that they permit a direct scale-free comparison of the influences of different casual factors within a factor set (Fabozzi, 1998; Menard, 2011). Should coefficients not be standardized, inferences relating to the relative importance of factors will differ. Finally, the study applies a factor analytic augmentation and tests its efficacy in addressing the poor ability of macroeconomic factors to proxy for the pervasive influences in returns. In doing so, it unifies an approach of using pre-specified factors with a factor analytic approach to address factor omission and ensures a valid and readily interpretable specification (Meyers, 1973; Van Rensburg, 1997; also see Northfield Information Services (NIS), 2015).

We begin our study by screening 52 unique macroeconomic factors and identifying a set of factors that are important for South African industrial sector returns. These are (innovations in) the number of building plans passed, a domestic composite cyclical leading indicator of economic conditions, a measure of domestic business activity, fluctuations in the Rand-Dollar exchange rate, world metal prices, long-term government bond yields and a leading economic indicator for South Africa's trading partners. We regress returns onto the identified factor set. Using standardized coefficients, we find that the most important drivers of returns are either of a global nature or determined by global macroeconomic conditions. This confirms that the South African stock market is highly integrated with global markets. The recommendation is that South African investors should be more concerned about global influences and events outside of South Africa, especially those impacting the economies of South Africa's trading partners, than domestic events. Finally, we show that a factor analytic augmentation effectively accounts for residual co-movement attributable to the presence of omitted and unspecified factors. Consequently, our model incorporates macroeconomic factors which by themselves are likely to be associated with underspecification but is adequately specified with the pairwise residual correlation matrix approximating the diagonality assumption (Van Rensburg, 2000; Middleton & Satchel, 2001).

We proceed by outlining the data and methodology is Section 2. In Section 3, we present our findings. Section 4 concludes.

2. Data and Methodology

2.1. Data

Monthly industrial data is obtained from the IRESS Expert database, comprising industrial sectors of the JSE and spans the period January 2001 to December 2016. Only industrial sectors with a full data history are included in the sample. Therefore, our sample comprises 26 sectors out of a total of 33 at the time of writing. Month-end data is used and the risk free rate used to derive excess returns is the closing yield on the R186 government bond.[1] Table 1 lists the industrial sectors comprising the sample and the economic sectors to which they belong, together with corresponding JSE index codes.[2] Continuously compounded total monthly returns are used, R_{it}, defined as the natural logarithm of industrial sector index levels.

We recognize that the exclusion of sectors may pose a limitation. However, three of the excluded sectors are capped property (J254), property unit trusts (J255) and property loan stock (J256). Being similar, their inclusion is likely to impact the emergence of pseudo-factors – sector specific factors – and not systematic factors which are of interest in this study. Others have short histories unlikely to impact the analysis. For example, leisure goods (J374) overlap our sample between January 2001 and December 2007. Furthermore, we require each macroeconomic factor to be correlated with the JSE All Share Index, a proxy for the well-diversified market portfolio which reflects purely systematic influences (see discussion that follows). Finally, the sample represents almost 80% of industrial sectors. Therefore, the factors identified are likely to also explain movements in the excluded sectoral indices, given their systematic nature.

[1] This specific proxy for the risk-free rate finds support in both academia and in practice (Nel, 2011: 5342; PWC, 2015; 44).

[2] Descriptive statistics for the return series are reported in Table A1 and Table A2 of the Supplementary Appendix.

Table 1. List of industrial sectors

Economic Sector	Industrial Sector	Index Code
Basic Materials	Chemicals	J135
	Forestry & Paper	J173
	Ind. Metals & Mining	J175
	Mining	J177
Industrials	Constr. & Materials	J235
	General Industrials	J272
	Elec. & Elec. Equip.	J273
	Indust. Engineering	J275
	Indust. Transp.	J277
	Support Services	J279
Consumer Goods	Automobiles & Parts	J335
	Beverages	J353
	Food Producers	J357
Health Care	Health Care Equip. & Services	J453
	Pharm & Biotech.	J457
Consumer Services	Food & Drug Retailers	J533
	General Retailers	J537
	Media	J555
	Travel & Leisure	J575
Telecommunication	Fixed Line Telecoms.	J653
Financials	Banks	J835
	Non-life Insurance	J853
	Life Insurance	J857
	General Financial	J877
	Equity Investment Instruments	J898
Technology	Software & Comp. Serv.	J953

2.2. Factor derivation and identification

The Quantec EasyData database is used to obtain macroeconomic factors.[3] As macroeconomic factors should enter models as innovations/unanticipated changes (Azeez & Yonezawa, 2006; Bessler & Kurmann, 2014), we derive innovations for each factor. An autoregressive time series model is estimated to remove predictive components up to the 12 order by incorporating significant lags. The residuals are taken as a representation of the unexpected components of a factor series. Innovations are derived using a sample that includes an additional 12 months of data, to ensure that the construction of innovations does not consume degrees of freedom (Van Rensburg, 2000).

In the spirit of macroeconomic factor model literature, the dividend discount model is used in the preliminary screening of factors. Factors that can reasonably be seen as

[3] Descriptive statistics for the macroeconomic data are reported in Table A3 of the Supplementary Appendix.

impacting expected cash flows or the discount rate or both are considered in our broad factor set (Azeez & Yonezawa, 2006). For ease of reference and for the purposes of model construction, each factor is classified under an expanded classification (see Table A3 in the Supplementary Appendix). We classify factors representative of real activity, prices, cyclical indicators, exchange rates, monetary factors, commodities, interest rates and trade. We then narrow down the macroeconomic factors. Each factor is required to have a systematic impact by 1) being correlated with at least half of the return series in the sample and 2) being correlated with returns on the market aggregate, the JSE ALSI. As macroeconomic data is often subject to revisions and/or lags in announcements, each factor enters the factor-return correlation matrix contemporaneously and with up to three lags (Bilson et al., 2001; Panetta, 2002), yielding a total of 208 (non-unique) factors. In instances where factors are correlated with more than half of the return series but not with returns on the JSE All Share Index, the Bai-Perron test is applied to test for breakpoints (Bai & Perron, 1998; Hansen, 2012). This is to ensure that a *seeming* lack of correlation is not solely attributable to structural changes in the relationship between aggregate returns and a specific factor. Macroeconomic factor-return correlations are tested using Pearson's (ordinary) correlation. Correlations between returns on the JSE All Share Index and macroeconomic factors are also confirmed using non-parametric Spearman's (rank) correlation coefficients (Bishara & Hittner, 2012).[4] Factors that meet the two conditions set out above are taken forward in the analysis (see Table A4 in the Supplementary Appendix for the results of the factor-return correlation analysis). Finally, all factors are regressed onto a set of factor scores derived from the return series to confirm that the selected macroeconomic factors proxy for the systematic drivers of returns (see Table A5 in the Supplementary Appendix).

By following this approach, we identify and confirm seven macroeconomic factors that drive South African stock returns. These are the number of building plans passed, BP_{t-1}, the domestic composite cyclical leading indicator $LEAD_{t-1}$, business

[4] The use of an additional measure of correlation is motivated by a preliminary observation that in some instances, a factor is significantly correlated with a number of industrial sectors but uncorrelated (often marginally insignificant) with the JSE All Share Index. For examples of the use of Spearman's correlation with economic data, see Liow, Ibrahim and Huang (2006) and Naifar and Al Dohaiman (2013).

activity, BUS_t, fluctuations in the Rand-Dollar exchange rate, USD_t, world metal prices, MET_t, long-term government bond yields, LTY_t and a leading indicator for South Africa's trading partners, TLI_t. Following preliminary (unreported) analysis, we orthogonalise USD_t against LTY_t and MET_t, and orthogonalize TLI_t against MET_t to control for potentially problematic multicollinearity (Wurm & Fisicaro, 2014). The residuals of these series, $USD\varepsilon_t$ and $TLI\varepsilon_t$, are used in place of the original innovation series in further analysis.

To show that our factors outperform those employed in previous studies, we follow the summative approach of Szczygielski, Brummer, Wolmarans and Zaremba (2020). We regress macroeconomic factor sets onto orthogonal factor scores derived from returns. The factor scores summarize shared variance attributable to systematic influences. The number of factors is determined by the minimum average partial (MAP) test which is congruent with the assumption of uncorrelated residuals, $E(\varepsilon_{it}, \varepsilon_{jt}) = 0$ underlying linear factor models (Zwick & Velicer, 1986). We then quantify and compare the approximative power of macroeconomic factor sets, as measured by $\bar{R}^2$, without the need to estimate models for each of the 26 industrial sectors. Results are reported in Table A5 of the Supplementary Appendix and confirm that our macroeconomic factors exhibit greatest approximative power relative to factor sets considered in other studies (see Section 1). [5]

[5] We restrict ourselves to only the consideration of macroeconomic factors and exclude equity-related factors such as All Share Indexed Earnings (Van Rensburg, 2000) and volatility related factors (Mensi *et al.,* 2014). This is in line with the scope and focus of our study. Where factor series have been discontinued, such as the banker's acceptance rate used in Van Rensburg (1996), we use the next available related proxy such as yield on three month treasury bills, $3TB_t$.

Table 2. Descriptive Statistics

Factor	Form	Notatio	Mean	Std Dev.	LM Test	$Q(12)$	Lags	ADF	PP
Building Plans Passed	DL	BP_t	-0.002	0.108	1.156	8.885	1-2, 4	-14.418***	-14.475***
Leading Indicator	DL	$LEAD_t$	-3.07E-05	0.008	1.036	6.536	1-3, 6, 11-12	-13.615***	-13.618***
Business Activity	DL	BUS_t	0.000	0.087	0.583	5.071	1 – 2, 7, 9,	-14.501***	-14.568***
Rand-Dollar Ex. Rate	DL	USD_t	-0.001	0.036	0.609	8.168	1,8	-13.522***	-13.518***
Metal Prices (US$)	DL	MET_t	0.000	0.047	0.678	6.324	1	-13.752***	-13.759***
Long-Term Gov. Bond Yields	D	LTY_t	3.97E-05	0.003	0.990	8.453	1-2, 7	-13.935***	-13.941***
Trading Partner Lead. Index	DL	TLI_t	9.30E-05	0.005	0.568	7.938	1, 3, 6	-13.516***	-13.518***
JSE All Share Index	DL	R_{Mt}	0.005	0.048	0.397	7.956	-	-13.991***	-14.056***
MSCI World Index (US$)	DL	R_{IMt}	0.001	0.044	0.923	7.986	1,3	-13.363***	-13.355***

Notes: The asterisks, ***, ** and *, indicate statistical significance at the respective 1%, 5% and 10%% levels of significance. Form indicates the method of differencing used to derive changes in a given factor, where FD=First Difference, FDL=First Logarithmic Differences and PC=Percentage Changes. Notation refers to the formulaic notation used to abbreviate each factor. Mean and Std Dev. are the respective mean and standard deviation values for each factor series. LM Test is the Breusch-Godfrey LM test statistic for 12th order serial correlation in a factor series. $Q(12)$ are Ljung-Box Q-statistics indicating whether the first 12 serial coefficients for a given factor series are jointly equal to zero. Lags indicates the lag orders that are retained in the autoregressive model in equation used to derive innovations in the factor series. ADF and PP are the respective test statistics for the Augmented Dickey-Fuller and Phillips-Perron unit root tests of stationarity.

Table 3. Correlation Matrix

	BP_{t-1}	$LEAD_{t-1}$	BUS_t	USD_t	MET_t	LTY_t	TLI_t	R_{Mt}	R_{IMt}
BP_{t-1}	1.000								
$LEAD_{t-1}$	0.155**	1.000							
BUS_t	0.079	-0.001	1.000						
USD_t	0.029	-0.027	-0.081	1.000					
MET_t	0.188***	0.039	0.074	-0.349***	1.000				
LTY_t	-0.031	0.126*	0.015	0.447***	-0.072	1.000			
TLI_t	0.193***	0.178**	0.138*	-0.215***	0.352***	0.016	1.000		
R_{Mt}	0.226***	0.279***	0.116	-0.114	0.208***	-0.044	0.497***	1.000	
R_{IMt}	0.127*	0.251***	0.101	-0.380***	0.214***	-0.120*	0.556***	0.684***	1.000

Notes: The asterisks, ***, ** and *, indicate statistical significance at the respective 1%, 5% and 10% levels of significance. Correlation coefficients are ordinary (Pearson's) correlation coefficients.

2.3. Model specification and estimation methodology

2.3.1. Model specification

Having identified macroeconomic factors which are likely to drive returns (and having confirmed that these are proxies for systematic influences in stock returns), we specify the following model:

$$R_{it} = \alpha + b_{iBP}BP_{t-1} + b_{iLEAD}LEAD_{t-1} + b_{iBUS}BUS_t + b_{iUSD\varepsilon}USD\varepsilon_t + b_{iMET}MET_t + b_{iLTY}LTY_t + b_{iTLI}TLI\varepsilon_t + b_{iM\varepsilon}M\varepsilon_t + b_{iIM\varepsilon}IM\varepsilon_t + \varepsilon_{it} \quad (1)$$

where the factors are as defined in Section 2.2., the b_i's are the sensitivities to innovations in the respective macroeconomic factors and the two residual market factors and the ε_{it} are the residuals. As macroeconomic factors by themselves are poor proxies for pervasive influences in stock returns, (Van Rensburg, 1997, 2000; Middleton & Satchell, 2001; Spyridis, Sevic & Theriou, 2012), we incorporate two residual market factors to proxy for omitted factors (Burmeister & Wall, 1986). The first residual market factor, $M\varepsilon_t$ in equation (1), is derived by regressing returns on the JSE ALSI (R_{Mt}) onto the macroeconomic factors. The second residual market factor, $IM\varepsilon_t$, is derived from returns on the MSCI World Market Index (R_{IMt}) by regressing returns on this index onto the macroeconomic factors and returns on the JSE ALSI.

Equation (1) is estimated using the least squares methodology. The resultant residuals are factor analysed to derive common omitted, transient and unidentified factors that are unaccounted for by the factor set in equation (1) (Van Rensburg, 1997, 2000; NIS, 2015). Extracted factors comprising the factor analytic augmentation are then appended to equation (2):

$$R_{it} = \alpha + b_{iBP}BP_{t-1} + b_{iLEAD}LEAD_{t-1} + b_{iBUS}BUS_t + b_{iUSD\varepsilon}USD\varepsilon_t + b_{iMET}MET_t + b_{iLTY}LTY_t + b_{iTLI}TLI\varepsilon_t + b_{iM\varepsilon}M\varepsilon_t + b_{iIM\varepsilon}IM\varepsilon_t + \sum_{j=1}^{J} b_{ij}f_{jt} + \varepsilon_{it}^{*} \quad (2)$$

where all parameters are as before, with the exception of $\sum_{j=1}^{J} b_{ij}f_{jt}$ which represents the factor analytic augmentation comprising *j* common factors extracted from the residuals of equation (1) and the associated sensitivities, the b_{ij} s. ε_{it}^{*} is the idiosyncratic error term, adjusted for omitted common factors by applying the factor analytic augmentation (Burmeister & McElroy, 1991). As the interpretation of the statistical factors is not of interest, only factors that are statistically significant in the factor analytic augmentation for each series are retained.[6] This is to avoid overspecification (Studenmund, 2014: 186-187).

2.3.2. Estimation methodology

Equation (2) is estimated using maximum likelihood estimators with ARCH(*p*) and GARCH(*p,q*) errors (see Andersen, Bollerslev, Diebold and Vega, 2003; Hamilton, 2010):

$$h_{it} = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{it-p}^2 \tag{3}$$

$$h_{it} = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{it-p}^2 + \sum_{i=1}^{q} \beta_i h_{it-q} \tag{4}$$

where h_{it} is the conditional variance underlying return series *i*, ω is the unconditional variance, ε_{it-p}^2 are the squared residuals conditional on model specification and h_{it-q} is the previous forecast of the conditional variance and its associated GARCH coefficient, β_i (Engle, 2004: 412).

Andersen *et al.* (2003) and Hamilton (2010) argue that although volatility dynamics and residual serial correlation can be handled using least squares with Newey and West (1987) heteroscedasticity and autocorrelation consistent (HAC) standard errors or White's (1980) heteroscedasticity-corrected standard errors (White standard errors), the suggested approach will result in more efficient and accurate coefficient estimates relative to the least squares methodology in the presence of non-normality in the form of excess kurtosis and non-linear dependence (see also Bera, Bubnys & Park, 1988).

In specifying the ARCH(*p*) or GARCH(*p,q*) process, the approach of Armitage and Brzeszczyński (2011) is followed. An ARCH(1) model with conditionally normal

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[6] As a robustness check, significance is cross-referenced using ordinary and rank correlation coefficients.

errors is initially estimated. If there are any remaining ARCH effects, as established by applying the ARCH LM test at lower and higher orders (ARCH(1) and ARCH(5)), and/or the residuals continue to exhibit non-linear dependence indicative of non-stationary variance, as established by applying Ljung-Box *Q*-statistics at the first and fifth orders ($Q(1)$ and $Q(5)$), an ARCH(2) or GARCH(1,1) model is estimated (see Engle, 1982). The number of *p* (ARCH) and *q* (GARCH) terms is increased until residuals are free of ARCH effects and non-linear dependence. As a divergence of the normal distribution from the true error distribution may result in an increase in the variance of the estimated coefficients and may lead to inconsistent estimates of model parameters (Varga & Rappai, 2002; Fan, Qi & Xiu, 2014), quasi-maximum likelihood (QML) estimates with Bollerslev-Wooldridge robust standard errors and covariance are obtained if a post-estimation Jarque-Bera (JB) normality test reveals that residuals are non-normal.

2.3.3. Coefficient standardization

To establish which factors are most influential, factor exposure profiles are estimated for each industrial sector. However, as the factors considered have different scaling, the importance of specific factors can be compared across sectors but not against other factors within a model. To address this, we derive standardized coefficients, b_{ik}^{*}, from equation (2) as follows:

$$b_{ik}^{*} = \frac{b_{ik}\sigma_k}{\sigma_i} \tag{5}$$

where b_{ik}^{*} is the point estimate of a coefficient on factor *k* for series *i* (the factor set in equation (2)) , multiplied by the standard deviation of factor *k*, σ_k, divided by the standard deviation of return series *i*, σ_i (Menard, 2004: 219; Menard, 2011). Standardization yields scale-free coefficients permitting comparisons of relative influence. The mean of the standardized coefficients is estimated for each factor across the 26 sectors and these are used to construct factor exposure profiles. Factors that are associated with larger standardized coefficients can now be interpreted as more important relative to other factors (Fabozzi, 1998; Nimon & Oswald, 2013).

2.4. The factor analytic augmentation and the diagonality assumption

Next, we consider the effectiveness of the factor analytic augmentation and the adequacy of our final specification, equation (2), by comparing the residual correlation matrix to that of equation (1). An optimal factor structure should minimise pairwise residual correlation, indicating that all common factors are reflected in the model (Meyers, 1973; Elton, Gruber, Brown and Goetzmann, 2014).

The first step involves the application of factor analysis and partially follows the seminal work of Meyers (1973). The minimum average partial (MAP) test is applied to gain insight into the structure of pairwise residual correlation matrices. The MAP test seeks to derive the number of factors for which the residual correlation matrix of a specification most closely resembles an identity matrix, approximating the diagonality assumption (Zwick & Velicer, 1986). No factors should be reflected in the residual dependence structure if a factor model is valid (Meyers, 1973). To determine whether the relevance of any of the extracted factors is limited to specific time periods or is transitory in nature, residual correlation matrices are also factor analysed over two subperiods. Each subperiod comprises half the sample; January 2001 (2001M01) to December 2008 (2008M12) and January 2009 (2009M01) to December 2016 (2016M12). This is repeated for the other tests (below). Measured communalities reflect how much co-movement remains in the residuals after incorporating macroeconomic factors and the residual market factors in equation (1) and then these factors and the factor analytic augmentation in equation (2) (Yong & Pearce, 2013; Elton *et al.,* 2014: 157).

The second step relies upon the Kaiser-Meyer-Olkin (KMO) index. The KMO index is bounded between 0 and 1 and values between 0.8 and 1 are indicative of desirable sampling adequacy (Kaiser, 1974; Madaree, 2018):

$$KMO = \frac{\sum_{i}\sum_{i \neq j} r_{ij}^2}{\sum_{i}\sum_{i \neq j} r_{ij}^2 + \sum_{i}\sum_{i \neq j} \alpha_{ij}^2} \tag{6}$$

where r_{ij}^2 is the pairwise correlation matrix of residuals derived from equations (1) and (2) and α_{ij}^2 is the anti-image partial correlation matrix. Instances where r_{ij}^2 is large and α_{ij}^2 is small will yield values that are close to 1, indicating that pairwise correlation between residuals is high. If the factor analytic augmentation accounts for omitted, transient and unspecified factors, the KMO index should be low, ideally below 0.5, indicating low levels of interdependence.

The final step utilizes the Jennrich test, which, by testing the normalized difference between two matrices, establishes the equality or lack thereof of two correlation matrices (Jennrich, 1970; McElroy & Burmeister, 1988). This test takes into account the number of observations and follows an asymptotic chi-squared (χ^2) distribution. A significant χ^2 statistic implies that two correlation matrices differ significantly (Eichholtz, 1996; Jondeau, Poon & Rockinger, 2007). The residual correlation matrix obtained from equation (1), R_{26} (where the 26 subscript is the dimension), is tested for equality with the residual correlation matrix derived from equation (2), U_{26}. Residual interdependence will differ if the factor analytic augmentation accounts for co-movement associated with common factors that would otherwise be relegated to the residuals.

3. Results

3.1. Model results and economic interpretation

Abridged (unstandardized) results are presented in Table 4 (see Table A7 in the Supplementary Appendix for unabridged results). For the seven macroeconomic factors, 119 of 182 (65.38%) estimated coefficients are statistically significant. This is comparable to similar (seminal) studies by McElroy and Burmeister (1988) and Berry, Burmeister and McElroy (1988: 3) on the U.S. stock market and Van Rensburg (1997) on the South African stock market in terms of the proportion of significant coefficients.[7]

[7] Van Rensburg (1997) reports that 107 of the 144 (73.30%) macroeconomic factor coefficients in a five-factor model relating returns on individual mining and financial stocks to two pre-specified macroeconomic factors (non-index and factor analytic) are statistically significant.

Table 4. Summary of benchmark model results

Factor	Mean Coeff.	$b_{ik} > 0$	$b_{ik} = 0$	$b_{ik} < 0$	Total Sig.
Panel A: Coefficient and significance summary					
Intercept	0.006	13	13	-	13
BP_{t-1}	0.037	10	16	-	10
$LEAD_{t-1}$	0.905	17	9	-	17
BUS_t	0.079	18	8	-	18
$USD\varepsilon_t$	-0.180	1	10	15	16
MET_t	0.155	13	12	1	14
LTY_t	-3.920	-	6	20	20
$TLI\varepsilon_t$	2.865	24	2	-	24
$M\varepsilon_t$	0.664	26	-	-	26
$IM\varepsilon_t$	0.217	15	-	1	16
f_{1t}	-	16	-	4	20
f_{2t}	-	20			20

	Mean	Minimum	Maximum
$\bar{R}^2$	0.504	0.171 Fixed line telecom.	0.941 Mining

Notes: The asterisks, ***, ** and *, indicate statistical significance at the respective 1%, 5% and 10% levels of significance. In Panel A, Mean Coeff. is the mean value of the intercept and the coefficients associated with each factor. $b_{ik} > 0$ and $b_{ik} < 0$ indicate the respective number of coefficients that are statistically significant and have a positive or negative impact. Total Sig. is the total number of statistically significant coefficients associated with each factor across the return series in the sample. In Panel B, Mean is the arithmetic mean of the $\bar{R}^2$. The Minimum and Maximum values correspond to the lowest and highest values observed and the associated sectors for which they are observed. All factors are in innovations, defined as follows: BP_{t-1} - number of building plans passed, $LEAD_{t-1}$ - domestic composite cyclical leading indicator, BUS_t - business activity, $USD\varepsilon_t$ - (orthogonalized) fluctuations in the Rand-Dollar exchange rate, MET_t - world metal prices, LTY_t - long-term government bond yields, $TLI\varepsilon_t$ - (orthogonalized) leading indicator for South Africa's trading partners, $M\varepsilon_t$ - the residual market factor orthogonal to the macroeconomic factor set, derived from returns on the JSE All Share Index, $IM\varepsilon_t$ - a second residual market factor orthogonal to the macroeconomic factor set and $M\varepsilon_t$. f_{1t} and f_{2t} are the statistically derived factors that comprise the factor analytic augmentation.

This comparison suggests that the current specification has acceptable descriptive validity for the South African stock market. However, descriptive validity may be somewhat weaker in the absence of the factor analytic augmentation (Bilson *et al.,* 2001).[8]

Innovations in the number of building plans passed, BP_{t-1}, have an overall positive but seemingly limited impact on returns. Moolman (2003) views this factor as a

[8] Bilson *et al.* (2001: 412-413) suggest that APT-type multifactor models may not have descriptive validity for all markets. For example, the authors find that the $\bar{R}^2$ for a five-factor model incorporating returns on the MSCI World Index, the money supply, consumer prices, industrial production and exchange rates is either 0 or close to zero for seven developing markets in the sample, namely Argentina, Brazil, Colombia, Greece, India, Jordan and Venezuela.

reflection of economic agents' long-term expectations. A positive impact is expected; improvements (deterioration) in expectations relating to the macroeconomic environment will translate into increased (decreased) expected cash flows. Szczygielski and Chipeta (2015) also find that this factor has a positive and statistically significant impact on returns on the JSE ALSI. Van Rensburg (1996) reports no impact for this factor. Table 3 indicates that BP_{t-1} is significantly correlated with $LEAD_{t-1}$, MET_t and TLI_t. Consequently, the lack of widespread significance may be attributable to multicollinearity. Alternatively, its impact is weak and is subsumed in a multifactor setting (see Connor, 1995).

According to Moolman (2003), the composite leading indicator, $LEAD_{t-1}$, is a predictor of turning points in the business cycle. This factor has greatest predictive power three months ahead, suggesting that it reflects short-term expectations (Venter, 2005). In contrast to BP_{t-1}, $LEAD_{t-1}$'s favourable performance is evident from a significant and positive relationship with 17 industrial sectors. An advantageous characteristic of this factor is that it is readily interpretable, meaningful and easy to monitor (see Venter & Pretorius, 2004: 68 for a discussion of composition). Niemira (1993) proposes that the impact of leading indicators on stock prices is through an anticipation of changes in earnings. Anticipated changes in the business cycle, such as an end of a recession or the nearing of a recession, lead to changes in the sales cycle suggesting an associated improvement or deterioration in future earnings. The discrepancy between the ability of BP_{t-1} and $LEAD_{t-1}$ to explain returns is potentially related to investors placing a greater focus on short-term expectations. Investors appear to be more concerned with short-term expectations and near-term changes in the economic state, reflected by $LEAD_{t-1}$ (Pilinkus, 2010).

Unanticipated changes in business activity, BUS_t, are derived from a constituent of the Purchasing Managers' Index compiled by the Bureau for Economic Research (BER) (2015).[9] BUS_t impacts returns on 18 industrial sectors positively. The BER

[9] The Purchasing Managers Index (PMI) is compiled by the Bureau for Economic Research (BER) and is sponsored by ABSA, a large South African bank. This version of the PMI is based upon the PMI of the Institute for Supply Management (ISI) in the US. The PMI is compiled on a monthly basis with a focus on the manufacturing sector and is considered a general indicator of business conditions (BER, 2015).

(2015: 5) measures business activity by production volumes, units of work accomplished, person-hours worked, sales volumes and other non-monetary measures. Similarly, to BP_{t-1} and $LEAD_{t-1}$, this factor may be viewed as a composite index with a specific interpretation. Harris (1991: 65) argues the PMI and its constituents represent an "imperfect but useful addition to our knowledge of *curre*nt (emphasis added) economic conditions."[10] Kauffman (1999) examines the relationship between constituents of the PMI and US GNP and finds that the production (analogous to business activity) and new orders components coincide with and are highly correlated with GNP growth. The complementary usefulness of a business activity measure (to that of BP_{t-1} and $LEAD_{t-1}$) is apparent; BUS_t captures coincident changes in the macroeconomic state reflected by less frequent measures of aggregate economic activity. The level of real economic activity, as measured by the GNP and proxied by BUS_t, is likely to influence stock prices through an impact on corporate profitability (Wongbangpo & Sharma, 2002). An increase (decrease) in output will increase (decrease) expected future cash flows and thereby raise (lower) stock prices. The positive relationship observed between returns and BUS_t supports this proposed transmission mechanism.

The impact of exchange rates on stock prices is widely studied and can differ across industries. A depreciation (appreciation) in the domestic currency improves (hinders) the competitiveness of exporting firms and increases (decreases) foreign demand and sales, benefitting (harming) exporting firms and export orientated industries. For importing firms, an appreciation (depreciation) in the domestic currency translates into an increase (decrease) in the firm's receivables or accounts payable denominated in a foreign currency and thereby increases (decreases) future profits. Also, firms may be impacted by changes in input prices driven by fluctuations in exchange rates (Griffin & Stultz, 2001; Pan, Fok & Liu, 2007). Additionally, the exchange rate reflects local and political risk suggesting that it is a partial proxy for a changing domestic political environment (Lim, 2003: 2). The impact of unanticipated changes in the exchange rate is overwhelmingly negative; $USD\varepsilon_t$ impacts on 15

[10] The version of the PMI discussed by Harris (1991) has roughly the same components as the BER PMI. For the version discussed by Harris (1991), manufacturing production may be seen as analogous to business activity in BER's PMI.

industrial sectors negatively. The sole positive and statistically significant impact is for the mining industry (see Table A7 of the Supplementary Appendix). According to Antin (2013), the majority of South African mining output in the form of minerals is designated for export. For this sector, this finding supports the hypothesis that exporting firms gain from a depreciation of the domestic currency. Nevertheless, the predominantly negative relationship provides support for the general hypothesis that a depreciation is associated with higher input costs and heightened political risk..

Unanticipated changes in metal prices, MET_t, have a predominantly positive impact, impacting 13 industrial sectors positively and significantly. Partalidou, Kiohos, Giannarakis and Sariannidis (2016) state that metal commodities constitute a significant source of export earnings for developing countries and that increases in metal prices are an indicator of economic growth. As South Africa is an emerging market, metal prices are likely to be relevant.Chen (2010) states that global economic growth has increased the demand for commodities which, in turn, is responsible for rising metal prices suggesting that metal prices are a proxy for global economic conditions. Moolman (2003) states that South Africa is a small, open economy that is vulnerable to changes in economic conditions in the rest of the world, implying that changes in metal prices will impact South African stock returns and the domestic economy in general through trade channels. Edwards and Alves (2006) show that metal exports and related products (iron ingots, aluminium, iron ore, pig iron, etc.) are positioned amongst South Africa's top 20 exports. Metal prices may therefore be viewed as a proxy for global economic conditions and will impact the South African stock market through trade channels, supporting the observed positive impact.

Innovations in interest rates, LTY_t, measured by the yield on government bonds with long maturity periods, negatively impact returns on 20 industrial sectors. The transmission mechanism of interest rates has been widely studied. Muradoglu, Taskin and Bigan (2000) propagate a standard explanation; the impact of increasing (decreasing) interest rates is to raise (lower) the discount rates used in valuing stocks. This has a negative (positive) impact on returns. Wongbangpo and Sharma (2002) suggest an opportunity cost effect; higher (lower) rates motivate investors to substitute equity holdings for other assets and therefore have a negative (positive) impact on stock prices. Also, rising (declining) interest rates may negatively (positively) impact financing costs and thereby reduce (increase) profitability. Thorbecke (1997: 638) argues that increasing (decreasing) interest rates impact a firm's net worth and consequently, a firm's ability to invest. While in the present case the transmission mechanism may be attributable to a mixture of reasons, the overall negative impact of LTY_t is as expected.

The final factor, $TLI\varepsilon_t$, is the innovation series of the composite index of leading indicators for South Africa's trading partners. Moolman (2003) and Moolman and Du Toit (2005) suggest that given the small size and the open nature of South Africa's economy, South Africa is impacted by changes in economic conditions in the rest of the world, especially those experienced by South Africa's trading partners, the US and developed European economies. Furthermore, Moolman (2003) argues that vulnerability to external economic conditions has increased during the post 1994 transition and with increasing globalisation. However, Moolman (2003) finds that this factor is a poor predictor of turning points. Nevertheless, given that $TLI\varepsilon_t$ is significantly and positively associated with returns on 24 industrial sectors and has an overall positive impact, it is possible that this factor has become increasingly important due to growing international economic integration. A Gauteng Provincial Treasury (2013) report on the impact of business cycles on the South African economy supports for this argument. Between 2004 and 2011, the value of South African exports more than doubled and was accompanied by an increase in GDP. However, both GDP and exports decrease between 2008 and 2009 during the global financial crisis, suggesting a link between the health of South African economy and the broader global economy.[11] The report proposes that global economic events impact South Africa through trade channels and that domestic output fluctuations are often driven by external economic events.. These arguments suggest that $TLI\varepsilon_t$ impacts stock prices by proxying for and predicting changes in the economic conditions experienced by South Africa's trading partners which are reflected by the domestic business cycle. Changes in the external economic climate will impact the domestic economy through trade channels and indirectly have an

[11] See the Gauteng Provincial Treasury (2013) Quarterly Bulletin, Figure 7.

impact on confidence, affecting expectations of future corporate profitability. This will impact domestic stock prices and the hypothesised direction of impact is support by the results.

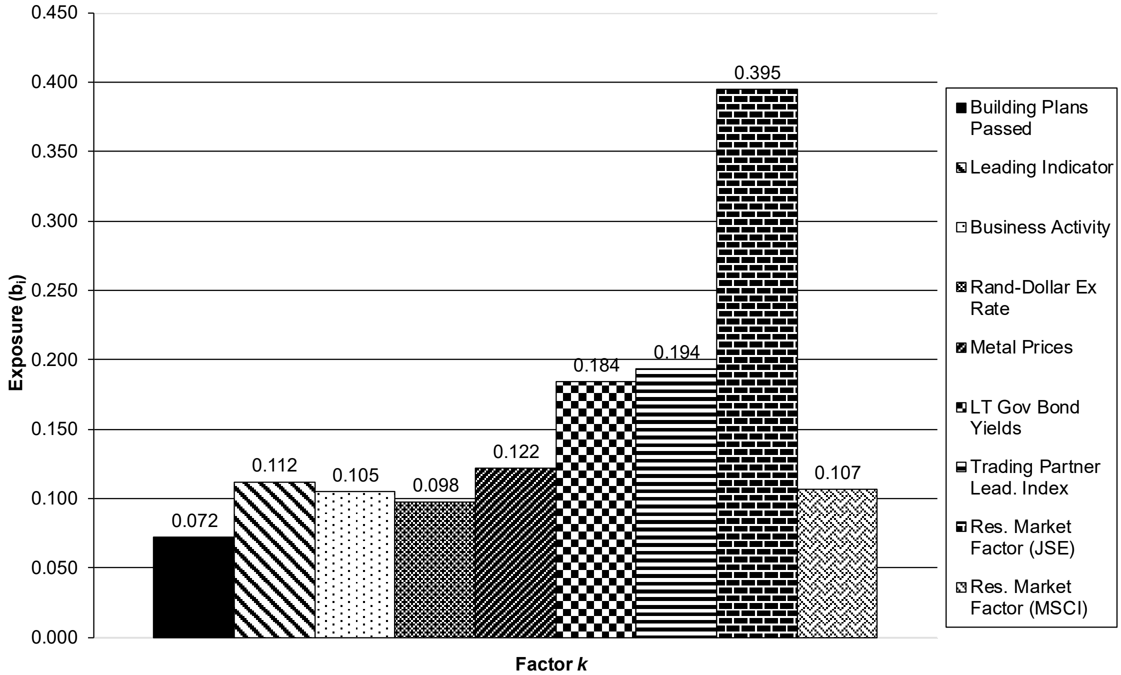
Our results suggest that South African industrial sector returns can be summarized by seven macroeconomic factors. These are the number of buildings plan passed (to a lesser extent), BP_{t-1}, domestic composite cyclical leading indicator, $LEAD_{t-1}$, business activity, BUS_t, the Rand-Dollar exchange rate, $USD\varepsilon_t$, world metal prices, MET_t, long-term government bond yields, LTY_t, and a leading indicator for South Africa's trading partners, $TLI\varepsilon_t$. Other unspecified factors are reflected by the residual market factors, $M\varepsilon_t$ and $IM\varepsilon_t$ and the factor analytic augmentation. These may be macroeconomic factors that do not enter our initial factor set and/or sentiment-related factors (Deetz, Poddig, Sidorovitch & Varmaz, 2009; Czaja, Scholz, & Wilkens, 2010). Encouragingly, coefficient signs meet *a priori* expectations and the model, on average, explains over half of the variation in returns as evident from an $\bar{R}^2$ of 0.504. Notably, these results suggest that South African industrial sectors are highly integrated with the global economy. Two factors, MET_t and $TLI\varepsilon_t$, are almost entirely reflective of global macroeconomic conditions and $TLI\varepsilon_t$ is statistically significant for almost all sectors. This is expected; the last 20 years have seen increased capital mobility, reduced legislative barriers, increasing market integration and greater levels of cross-border trade. Also, South Africa has entered the global economic arena following the post 1994 transition. Next, we investigate which of these factors are most influential.

3.2. Exposure Profiles

Figure 1 reports the exposure profiles, constructed by averaging standardized coefficients associated with each pre-specified factor in equation (2) (see Section 3.3.3).[12]

[12] We exclude the two statistical factors as these are an econometric correction for factor omission without a direct interpretation.

Figure 1. Exposure profiles (standardized coefficients)



(Source: Author's own)

The residual market factor, $M\varepsilon_t$, has the largest standardized coefficient (0.395). This implies that there are other influences that are not reflected by the seven macroeconomic factors in equation (2) (Wei, 1988; Van Rensburg, 1995; Czaja *et al.,* 2010). This is to be expected; there is no optimal or unique set of factors and any set has the potential to explain returns. Another factor of interest is the second residual market factor, $IM\varepsilon_t$, derived from returns on the MSCI World Market Index, R_{IMt}, a widely-used proxy for general global influences (Abugri, 2008; Brown, Hiraki, Arakawa & Ohno, 2009). Relative to the other factors, this factor does not appear to be important. This is contradictory to the findings of Szczygielski and Chipeta (2015) who find that returns on the FTSE All World Index, another global market index, account for over 40% of the variation in returns on the JSE ALSI. The relatively minor importance of this proxy for global factors in this study does not mean that global influences are not important. Szczygielski and Chipeta (2015), unlike in this study, do not use an orthogonalised version of a global market index to proxy for global influences. Here, we orthogonalise returns on the MSCI World Market Index against the seven macroeconomic factors and the JSE ALSI. This controls for global influences that would, in the absence of orthogonalisation, be reflected in R_{IMt} but are now reflected the macroeconomic factors and $M\varepsilon_t$. That global influences reflected in R_{IMt} are also reflected in a number of the macroeconomic factors is evident from the high and significant correlations between R_{IMt} and the following factors; TLI_t, (corr. 0.556), USD_t (-0.380), $LEAD_{t-1}$ (0.251) and MET_t (0.214) (Table 3). The influence of these factors is extracted by the orthogonalisation process and therefore the exposure to $IM\varepsilon_t$ represents remaining residual global influences not reflected by the seven macroeconomic factors and $M\varepsilon_t$.

Interestingly, the exposures in Figure 1 show that the factors that are highly correlated with R_{IMt} in Table 3, namely $TLI\varepsilon_t$ and MET_t (s.coeff of 0.194 and 0.112), are the first and third most influential factors in the macroeconomic factor set, respectively. This suggests that international influences *are* important to South African industrial sector returns. The importance of $TLI\varepsilon_t$ suggests that the investors should be mindful of economic conditions experienced by South African's trading partners, which will have an impact on foreign demand for South African goods and services (exports) (Baier & Bergstrand, 2001; Vogt, 2008). Also, the demand for metals is determined by global demand for commodities and therefore MET_t is a proxy for global economic conditions (Chen, 2010). Surprisingly, although $USD\varepsilon_t$ (after orthogonalisation against LTY_t and MET_t) is significantly and highly correlated with R_{IMt} (-0.312), its importance is relatively minor. It may be that $USD\varepsilon_t$ reflects other influences, such as domestic short-term political uncertainty, which are less important relative to global economic conditions (Lim, 2003). $LEAD_{t-1}$ is the fourth most important factor (s. coeff 0.112). Again, this factor is also significantly correlated with R_{IMt}. It is likely that this factor reflects a mixture of domestic and international influences, with economic cycles in South African partly dependent upon global economic cycles (Moolman, 2003; Gauteng Provincial Treasury, 2013).

The remaining factors, namely BP_{t-1}, BUS_t and LTY_t, are weakly correlated with R_{IMt}. LTY_t, is the second most important macroeconomic factor (s. coeff 0.184). Huang, Wu, Yu and Zhang (2015) argue that government bond yields are proxies for international political risk. Baldacci, Gupta and Mati (2011), suggest that bond yields are proxies for political risks and fiscal risks. Given that the correlation between LTY_t and R_{IMt} is low (0.120), LTY_t is most likely a proxy for domestic political risks and fiscal conditions. BUS_t is the fourth most important factor and, as observed in Table 3 and Figure 1, the least. It is also weakly correlated R_{IMt} (0.101).

As a final test of an emerging hypothesis that the most important factors for the South African stock market are global in nature, we apply the Granger causality test to test the null hypothesis that macroeconomic factors are themselves driven by changes in global conditions. As the MSCI World Market Index comprises only developed markets, we treat this index as a summary of global economic conditions that does not reflect domestic conditions (see Clare & Priestley, 1998; Wu & Zhang, 2014).[13] We therefore restrict our test to causality running from general global economic conditions to a specific macroeconomic factor.

Table 5. Causality tests

Hypothesis	**F-stat**
R_{IMt} does not cause BP_t	1.055
R_{IMt} does not cause $LEAD_t$	1.159
R_{IMt} does not cause BUS_t	4.822***
R_{IMt} does not cause $USD\varepsilon_t$	0.690
R_{IMt} does not cause MET_t	10.652***
R_{IMt} does not cause LTY_t	1.541
R_{IMt} does not cause $TLI\varepsilon_t$	4.843***

Notes: The asterisks, ***, ** and *, indicate statistical significance at the respective 1%, 5% and 10% levels of significance. All factors are in innovations, defined as follows: BP_t - number of building plans passed, $LEAD_t$ - domestic composite cyclical leading indicator, BUS_t - business activity, $USD\varepsilon_t$ - (orthogonalized) fluctuations in the Rand-Dollar exchange rate, MET_t - world metal prices, LTY_t - long-term government bond yields, $TLI\varepsilon_t$ - (orthogonalized) leading indicator for South Africa's trading partners. R_{IMt} are the returns on the MSCI World Market Index, our proxy for general global macroeconomic conditions. The Granger causality test is conducted 3 lags. Factors enter the test without lags.

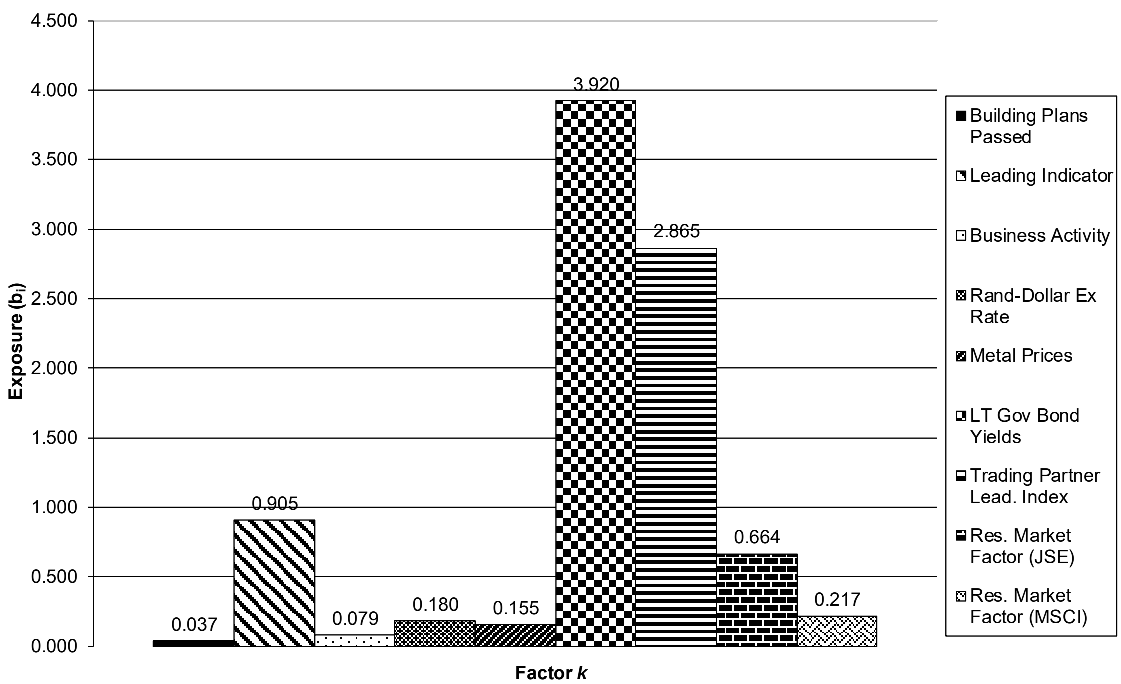
The results in Table 5 suggest that three of the four most important factors, namely $TLI\varepsilon_t$, MET_t and BUS_t are driven by global economic conditions. In contrast, the second and sixth most important factors, LTY_t and $USD\varepsilon_t$ respectively, are not driven by global economic conditions.

[13] See the MSCI website for constituent markets: https://www.msci.com/world

Our analysis of the exposure profiles leads to two important conclusions. Global economic conditions, as measured by factors and that are correlated with and driven by the global macroeconomic environment, as measure by R_{IMt}, a proxy for global influences, are the most important drivers of South African industrial sector returns. Domestically, political and fiscal risks, reflected by LTY_t and $USD\varepsilon_t$, are the most significant determinants of returns.

Next, we construct an exposure profile that does not use standardized coefficients to demonstrate the erroneous conclusions that would be reached in the absence of coefficient standardization. This exposure profile is based upon the absolute (unstandardized) coefficients in Table 4.

Figure 2. Exposure profiles (unstandardized coefficients)



The exposure profile in Figure 2 suggests that LTY_t, $TLI\varepsilon_t$, $LEAD_{t-1}$, $USD\varepsilon_t$, MET_t, BUS_t and BP_{t-1} are the most influential macroeconomic factors in respective order. This contrasts with the order indicated by the standardized coefficients in Figure 1, $TLI\varepsilon_t$, LTY_t, MET_t, $LEAD_{t-1}$, BUS_t, $USD\varepsilon_t$ and BP_{t-1} respectively. Inferences relating to the relative importance of specific factors drawn upon the basis of unstandardized coefficients will be erroneous and produce a different result from those based upon standardized coefficients. Researchers should consider standardizing coefficients if assessing the relative importance of factors in a multifactor context.

Finally, we test the stability of the macroeconomic factors by following the summative approach outlined in Section 2.2. of relating factor scores to the macroeconomic factors. Specifically, we estimate breakpoint least squares regressions, with breakpoints identified using the Bai-Perron test (Bai & Peron, 1998; Hansen, 2012). An attractive characteristic of this test is that it identifies the timing of breaks and estimates parameters associated with each segment (Carlson, Craig & Schwarz, 2000). We restrict ourselves to estimating equation (1) but exclude the two residual market factors as our primary concern is the stability of the macroeconomic factors. We relegate the results to Table A6 of the Supplementary Appendix. For our first and most important extracted factor, $F_{1t},$ which reflects 41.2% of shared variance, results are encouraging. No structural breaks are identified. BP_{t-1} , $LEAD_{t-1}$, BUS_t , $USD\varepsilon_t$, LTY_t and $TLI\varepsilon_t$ are stable drivers of returns. The results for the second factor, F_{2t}, which approximates 7.2% of shared variance, are somewhat more revealing. Leading up the financial crisis (2005M10 to 2008M09), the only significant factors are two of those representative of global economic conditions, BUS_t and $TLI\varepsilon_t$. The aftermath of the financial crisis (2008M10-2011M02) features both factor types, BUS_t , MET_t , $LEAD_{t-1}$,$USD\varepsilon_t$ and LTY_t and the largest number of significant factors, suggesting that macroeconomic fundamentals become more important. In the next segment (2011M03-2014M05), only factors representative of global economic conditions matter. For this factor, the importance of global influences is demonstrated by a finding that macroeconomic factors representative of global economic conditions are statistically significant across five of the six identified segments. Similarly, for F_{3t}, which explains 5.8% of shared variance, the dominant factors leading up to the global financial crisis (2006M10-2009M06) are those representative of global influences, namely MET_t and $TLI\varepsilon_t$. Only a single factor is statistically significant in the aftermath of the financial crisis (2009M07-2012M04), MET_t. Factors representative of global economic conditions continue to matter, being statistically significant in four of six segments. In summary, the factor regressions for F_{2t} and F_{3t} lead to two conclusions. The first is that internationally orientated macroeconomic factors are both dominant and important drivers of returns. The second is that factors representative of global economic conditions feature prominently in the lead up to the financial crises and are either part of the significant factor set following the global financial crisis (F_{2t}), or the only factors that matter (F_{3t}). Our overall conclusion remains as before; global economic conditions appear to be more important than domestic economic conditions, especially around and during crisis times.

3.3. Omitted factors and the factor analytic augmentation

We now investigate the effectiveness of the factor analytic augmentation in accounting for omitted factors and the presence of omitted factors in a specification that does not include the factor analytic augmentation. In doing so, we test whether equation (1) and the augmented model in equation (2) are adequately specific (Section 3.4.).

The results in Panel A of Table 6 for the augmented model in equation (2) are encouraging. A single factor is extracted from the residual correlation matrix, accounting for 6.6% of variation in the residuals (mean communality). The KMO index value is 0.052. Kaiser (1974: 35) views index values below 0.50 as "unacceptable" for factor analysis. This is in contrast to the residuals of equation (1), from which two factors are extracted, with a mean communality of 0.248. Furthermore, the KMO index is 0.780 suggesting that the level of residual correlation in equation (1) warrants the extraction of factors that will account for co-movement not accounted for by the macroeconomic factor set and the two residual market factors (Elton *et al.,* 2014; Madaree, 2018). The relevance of the factor analytic augmentation in equation (2) is confirmed by a significant Jennrich test statistic, which suggests that the inclusion of the statistical factors impacts the structure of the residual correlation matrix.

Table 6. Summary of model residual analysis

Eq	Factors extracted	Mean Communality	Mean Uniqueness	KMO
Panel A: Full Period Analysis				
Eq	**Factors extracted**	**Mean Communality**	**Mean Uniqueness**	**KMO**
(1)	**2**	0.248	0.752	0.780
(2)	**1**	0.066	0.934	0.052
Jennrich χ^2 $(U_{26} = R_{26})$		663.927***		
Panel B: Subperiod Analysis				
Period: 2001M016 to 2008M12				
Eq	**Factors extracted**	**Mean Communality**	**Mean Uniqueness**	**KMO**
(1)	**2**	0.309	0.691	0.761
(2)	**0**	-	-	0.062
Jennrich χ^2 $(U_{26} = R_{26})$		902.687***		
Period: 2009M01 to 2016M12				
Eq	**Factors extracted**	**Mean Communality**	**Mean Uniqueness**	**KMO**
(1)	**3**	0.286	0.714	0.659
(2)	**1**	0.097	0.903	0.087
Jennrich χ^2 $(U_{26} = R_{26})$		796.375***		

Notes: Mean Communality is the mean proportion of common variance explained across return series by the statistical factors extracted on the basis of the MAP test. Mean Uniqueness is the mean proportion of variance across return series attributable to the return series themselves and not to systematic factors. For the Jennrich test of matrix equality, ***, ** and *, indicate statistical significance at the respective 1%, 5% and 10% levels of significance. The null hypothesis tested is the hypothesis of the equality of two matrices. χ^2 Statistic is the resultant test statistic with (325 degrees of freedom) for the Jennrich test. R_{26} denotes the residual correlation matrix derived from equation (1) and U_{26} denotes the residual correlation matrix derived from the equation (2).

The subperiod analysis in Panel B supports inferences derived from the results in Panel A. Two factors are extracted from the residuals of equation (1) over the 2001M01 to 2008M12 period, with a mean communality of 0.309. The KMO index is 0.761. This is in contrast to equation (2), for which no factors are extracted and the KMO index is 0.062, suggesting that residual correlation is negligible. Similarly, three factors with a mean communality of 0.286 are extracted for the 2009M01 to 2016M12 period for equation (1) and the KMO index of 0.659 is indicative of remaining common factors in the residuals. For equation (2), a single factor is extracted, with a mean communality of 0.097. The KMO index is 0.087. That a single factor is extracted from the residuals of equation (2) over the 2009M01 to 2016M12 period and no factors are extracted over the 2001M016 to 2008M12 period suggests that the factor extracted over the entire period is attributable to the existence of a transient factor during the 2009M01 to 2016M12 period. The existence of such factor will not invalidate a specification (Meyers, 1973). For both subperiods, the

Jennrich test confirms that the factor analytic augmentation accounts for information relegated to the residuals.

Macroeconomic factors and the two residual market factors in equation (1) do not reflect all pervasive influences in returns. Co-movement attributable to unspecified factors is relegated to the residuals. This presents a violation of the diagonality assumption, challenging the validity of factor models (Meyers, 1973; Van Rensburg, 2002). It confirms that, as argued in Van Rensburg (2000) and Middleton and Satchell (2001), models that incorporate macroeconomic factors are likely to be underspecified. Importantly, the residual market factors, considered to be proxies for omitted factors and used as a solution for factor omission in the literature, fail to account for omitted factors. Van Rensburg (2002) postulates that there is a lack of awareness of the consequences of violating the diagonality assumption as a result of underspecification. The omission of factors, as in equation (1), may result in coefficient bias, inflated residual variance, induced impure heteroscedasticity and serial correlation in the residuals, potentially impacting inferences (Dominguez, 1992; Brauer & Gómez-Sorzano, 2004; Van Rensburg, 2002; Bucevska, 2011). Our results favour the use of a factor analytic augmentation. A factor analytic augmentation accounts for omitted factors and ensures an adequately specified model that is reliable in interpretation.

4. Conclusion

In this study, we extend the literature on the factor modelling of the South African stock market. We identify seven macroeconomic drivers of returns, namely the number of building plans passed, BP_{t-1}, a domestic composite cyclical leading indicator, $LEAD_{t-1}$, business activity, BUS_t, fluctuations in the Rand-Dollar exchange rate, USD_t, world metal prices, MET_t, long-term government bond yields, LTY_t and a leading indicator for South Africa's trading partners, TLI_t. This presents an alternative and more up-to-date macroeconomic factor set relative to other studies on the South African stock market, namely those of Van Rensburg (1995, 1996, 1997, 2000), Moolman (2003) and Szczygielski and Chipeta (2015). A notable finding is that a number of these factors are highly correlated with returns on the MSCI World Market Index and are driven by global economic conditions. Exposure profiles constructed from standardized coefficients indicate that amongst the influential factors are those reflect and are driven by global economic conditions. Macroeconomic factors and two proxies for omitted influences in the form of residual market factors, do not account for all residual co-movement. This implies that there are other unspecified factors, which can be accounted for by using a factor analytic augmentation.

These findings have a number of implications of interest to investors, econometricians and researchers. Investors should be aware that while the domestic environment, especially political risk, has an impact on returns, global influences are the most important determinants. Almost no sectors are insulated from the global economy, as evident from the importance of $TLI\varepsilon_t$ and its widespread significance. This limits the scope for international diversification as investments in specific domestic industrial sectors will be impacted by global economic conditions, although to a varying extent. This study presents researchers with an alternative set of macroeconomic factors that may be used in further analysis and asset pricing. They also confirm and statistically quantify what is widely observed and commented upon by financial market analysts, namely that the South African stock market is highly sensitive to developments in the global economic arena. These results also show that there are numerous other factors that drive returns, reflected in the residual market factors and the factor analytic augmentation. The identity of these factors presents an avenue for further research. A further avenue for research is related to factors that are purely representative of global influences, regional and foreign influences as opposed to a mix of of global and domestic factors. For example, of broad set of global macroeconomic factors could be compared against a set representative of economic conditions experienced by major regional and individual economic powerhouses, namely North America (particularly the U.S), Europe (particularly the United Kingdom) and Asia (particularly China). This would shed light as to which regions and countries are information leaders for the South Africa stock market.

Finally, from an econometric perspective, this study suggests that macroeconomic factor models will be underspecified even if residual market factors are incorporated into such specifications. Factor analysing the residuals of a specification will can reveal the adequacy of a specification by revealing the amount of common variation unaccounted for by a given factor set. Augmenting such specifications with statistical factors derived from the residuals may be a method for arriving at theoretically and econometrically optimal descriptions of the return generating process without the need to specify unparsimonious and complex models.

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