RESEARCH REPORT

The Term Structure as a predictor of Economic Activity

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DECLARATION

I declare that the thesis entitled, "The Term Structure as a predictor of Economic Activity" at the University of Witwatersrand" is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

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Abstract

The principal aim of this paper is to assess the relationship between the term structure and economic activity and correspondingly to evaluate the forecast strength of the term structure on economic activity for the following countries; South Africa, Poland, China, Chile and Brazil. The motivation is due to the existent of numerous studies conducted to investigate the predictive strength in developed countries but not nearly as much for developing countries.

The simple probit model that estimates probability of an economic activity downswing directly suggested by Estrella and Mishkin (1996) is used. The results from this model are compared with a modified probit model Dueker (1997) proposed. The modified version of the model strives to eliminate the serial correlation which may possibly be present among error terms by an addition of an independent variable equivalent to a lagged dependent variable in the simple probit model. Furthermore the study employs the Generalised Method Moments as an estimation technique on the basis of it being viewed as superior from an efficiency perspective when compared to the Ordinary Least Squares (OLS) methods.

The findings revealed that the term structure prediction of economic activity is still reliable for both policymakers and private investors, though the predictive strength is not as robust when compared to the developed countries. Similarly the GMM performs relevantly well in comparison with the OLS methods utilised.

1. Introduction

1.1. Research Context and Problem Statement

As recognised by Estrella and Mishkin (1996), Nel (1996) and Stajanovic and Vaughan (1997), significantly informative material is implanted in the term structure as observed in the empirical evidence. The informative substance is viewed to be an essential tool for forecasting economic activity in advanced such as inflation and recession. Accordingly to Estrella and Mishkin (1998), the theory underlying the capability of the term structure to predict economic activity lies in the theory of expectations. In their research Estrella and Mishkin (1998) demonstrated, that the term structure is an important prediction tool for both, the real economic activity and inflation, the forecast power does however become low and near non-existing in the short horizons. The precision of the forecast strongly increases for longer horizons. Even though the term structure's forecast quality of performing consistently well came under scrutiny numerous times, the study Greenspan (2005) undertook asserts the appropriateness of the significance of the instrument predominantly lies in its forecast power. He also ascertains that the yield curve accomplished the desired outcome of illustrating the economic conditions in the United States (US) throughout 1992 to 1995.

The research problem identified is that whilst there exist substantiate evidence of the forecast power of the term structure on economic activity, the majority of the studies carried out sits in countries classified as developed namely being the United Kingdom (UK) and the US. Hence this paper selects five countries considered to be developing to examine the term structure as a predictor of economic activity. Correspondingly the paper seeks to identify which estimation technique is superior for assessing the term structure's predictive strength.

1.2. Study Goal and Significance

The main purpose of the study is to assess the term structure and real economic activity relationship in the following developing countries: Brazil, Chile, China, Poland and South Africa. The research additionally strives to thoroughly assess the forecast strength of the term structure. The importance of the research from a financial market's standpoint, lies in the criticality of spotting variations within financial markets environment well in advanced to ensure the security selection by the investors avoid losses and yield profitable returns. An error-free forecast of the future economic activity using the term structure serves as a signal to switch or invest in appropriate assets classes.

From a goods market perspective, in order to achieve economic stability and protections from internal and external shocks, policy makers examine different alternatives to secure a healthy real economy. Thus being able to correctly forecast future economic activity in advance is of great importance. Failure to identify future economic activity timeously by policy makers could result in an incorrect policy being implemented. An accurate forecast of future economic activity is invaluable given that most policies and investment decisions are informed by future economic activity. Furthermore the ability to use an estimation technique which yields the best results in terms of accurate becomes powerfully valuable.

1.3. Motivation and Contribution

The motivation of the study is driven from the scarcity of the term structure and economic output phenomena in developing countries hence the paper analyses five countries viewed to be developing across various regions. This paper's contribution will mainly be through the assessment of the predictive strength of the term structure using three estimation techniques. Given the importance of the relation and its identification as one of the superior economic indicators, its accuracy becomes extremely critical for policy makers and markets to be able to successfully perform their roles in the economy. Therefore the ability to confidently produce verifiable evidence will be distinctly valuable.

The paper is ordered in the following structure: the theoretical framework of the term structure and economic activity is presented then the empirical literature of the term structure and economic activity overview is assessed in section two. Set out in section three is the methodology utilised and section four provides an analysis of the empirical results. Section five concludes by reviewing the summary of findings and recommendations.

2. Literature Review

2.1. Introduction

The major objective for the literature review is delivering an elucidation of term structure theory and similarly a theoretical framework of the term structure and economic activity. This chapter also aims to review various literatures on the factual documentation on the significance of the role of the term structure in the real economy. Correspondingly the aim of the review is to provide a holistic view of where the paper is located in the literature and why the reviewed literature below is critical for the paper.

2.2. The Term Structure Theory

The term structure is considered the representative for the relation among yields of bonds which have non-identical maturities (Browne and Manasse, 1990). Graphing the yield bonds versus differing maturities will result in the term structure.

The term structure is the graphical representation of the relation among yields of bonds with varying terms to maturity as referred to by Mishkin (2001) which have matching features namely: liquidity, risk profile and tax considerations. Mishkin (2001) states that this specified yield curve explains the term structure for a particular set of bonds such as the long term 10 year bond and the short term, 3 month bond.

There exists a general consensus in the investments world that the yield curve form is usually reflective of the expectations of the market about upcoming interest rates. The yield curve slope variation is as follows; a positively sloped form means that the short term rates are lower than long term rates. Similarly it can be negatively sloped in this case, the short term rates are higher than long term rates. Level simply means the short term and long term rates equivalent.

A robust term structure theory explains three fundamental discoveries with regards to the yield curve as identified by Mishkin and Eakins (1998). Mainly: the rates on bonds with unalike terms to maturity usually moving jointly together over time, the shape of the yield curve normally positively sloped and lastly high short term rates are associated with a yield curve that becomes downward sloping, the converse holds true. Mishkin (2001) highlighted the core hypothesises describing term structure are; the theory of expectations, liquidity premium theory and segmented market. The core theories are reviewed next. The theories will clearly illustrate the literature which is paramount to this study especially for developing countries which tend not to utilise monetary policy.

The Expectations Theory

The theory of expectations asserts the yield on the long term bond equals the averaged anticipated rates on short term bonds (Mishkin, 1999). According to (Van Zyl et al., 2003) the theory of expectations motivated by an element of long term rates averages current and anticipated upcoming one year rates The research conducted by Dodds and Ford (1974) views the hypothesis of expectations the classic term structure hypothesis and carries a viewpoint that the yield curve slope is reliant entirely on expectations of the capital markets on upcoming rates.

The undertaking crucial to the hypothesis lies in the treatment option of securities placed inside particular risk classes specific to their maturities as absolute replacements. This translates to the bonds having the same anticipated return which means a bond investor will not have a preferred bond of one maturity over another (Mishkin and Eakins, 1998).

The expectations theory provides an explanation for the finding that interest rates on bonds with differing maturities movement correlates to one another overtime (Mishkin, 2004). This is attributed to the fact that long term rate equate to the average of the anticipated upcoming short term rate. Thus (Howells and Bain, 1998) confirmed short term rates increases leads to rates being higher in succeeding periods.

The Segmented Markets Theory

Investors are usually interested in different characteristics of the securities and are not entirely and solely attracted by yields. As underlined by Mishkin and Eakins (1998) the hypothesis of market segmentation of term structure takes an assumption that make differing bond maturities solely separated and segmented. Bonds with non-identical maturities are not substitutes of each other this assumption of the theory of segmented markets is identified as the most vital. Howells and Bain (1998) assert that this theory holds due to some portion of investors preferences are being controlled by the aspects of their liabilities.

The regular habit of the yield curve to generally be upward sloping is explained by the segmented markets theory. This phenomenon is demonstrated through the investor's preference towards lower risk association hence predominantly in bonds with short-lived maturities. Thus implying long-lived securities usually experience greater returns to stimulate their low demand.

The Liquidity Premium Theory

This hypothesis asserts the rate on a long term bond equates to a median of the short term rate for duration of the long term bond with an attached premium serving as a compensation for opting for a longer term maturity security (Howells and Bain, 2002). Explained simply by Van Zyl, Botha and Skeritt (2002), investors will require an extra return in a form of a premium for the increased risk exposure for investing in long term financial instruments. The liquidity premium hypothesis assumes bonds with differing terms to maturity are replacements to one another however definitely cannot be absolute replacements to one another.

2.3. The Term Structure and Economic Activity Theory

Moneta (2003) observes the term structure and economic activity exerts a positive relation. There are theoretical explanations of this relationship the term structure and upcoming changes in economic activity exerts. An upward sloped yield curve relates to economic growth and the converse holds true (Estrella and Trubin, 2006).

Moneta (2003) identified foundational rationale describing the term structure and economic activity relation. These can be summed into the following: What the markets expects regarding anticipated upcoming rates, monetary policy and investor hedging. The three identified categories are further discussed next. The following categories are equally important literature for the study mainly for developing countries which do implement monetary policy furthermore this where the paper is located from a theoretical framework view.

What the Markets Expect about Future Interest Rates

The market expectations theory stems from the expectations theory explored above as a component of the composition of the core hypothesis of term structure. It assumes that the long term rates represents the mean of anticipated upcoming short term rates hence the reason why the long term rates are considered to carry expectations about future economic activity (Moolman, 2002).

When there is a period of economic downturn, markets expects the short term interest rates to decrease. This market expectation is driven by the anticipation of a counter cyclical monetary policy whose goal will be to fuel the economy (Moneta, 2003). Given what markets expects is accurate, long term rates should decline due to the expected lower short term rate, which will lead to the yield curve sloping downward. Similarly for an economic expansion, the general market expectation is that short term rates will increase due to expectation of a contractionary monetary policy implementation which will cause the yield curve to be upward sloping.

Effects of Monetary Policy

According to Gowland (1991) there is a significant role the monetary policy plays in impacting the term structure and thus affecting the economic output. Considering that a large portion of activities in the economy are influenced by long term rates the effect of monetary policy on aggregate demand is resultant from short term rates changes impacts yield curve on its long end (Gowland, 1991).

It is evident that the central bank can use the term structure to control economic activity. Therefore the term structure can be viewed to have a role of being a key transmission tool for the central bank.

Moolman (2002) argues that increases of short term rates lead to spread between the short and long term rates decreasing, causing markets to anticipate inflation to decrease in the near future as well as short term rates. Contractionary monetary policy can trigger a decline in spending and leads to an economic activity slowdown. Action taken by the central bank can create an expectation of economic downturn amongst investors causing the term structure to invert, similarly the converse is true.

Investor Hedging

The hedging behaviour of consumers is the third reason which explains the term structure and economic activity relation (Moneta, 2003). Moneta (2003) opined that consumer preferred great stability with regards to their income compared to a volatile one. For an example, a steady level of income over the entire business cycle is preferred rather than receiving extremely greater earnings during economic growth periods similarly extremely small earnings during periods of economic contractions. Thus the aim to hedge against the irregular income movement during the high and low in order to maintain consistence stability is important.

When there is an anticipation of economic expansion, the expectation is for short term rates to increase, investors shifts their funds to short-lived bonds from long-lived bonds through the sale of the long term securities. When an economic contraction is anticipated the expectation is for short term rates to decrease thus the funds are now moving from short-lived bonds to long-lived bonds through the sale of short-lived securities. Investors will always gravitate towards bonds providing the better returns to shield against possible loss of not taking advantage of the higher yields. Moneta (2003), states that the shifting from short-lived bonds to long-lived bonds throughout contractionary economic activities and expansionary economic activities results in prices and yields of bond changes in turn leads to the yield curve slope changing.

2.4. Term Structure and Economic Activity empirical evidence

There exists empirical evidence which exemplify the relationship of the term structure and upcoming economic activity. As illustrated by Estrella and Hardouvelis (1991) the term structure slope gauges growing gradual changes in output for lengthy horizons typically four to eight quarters in advanced. They demonstrated the abovementioned phenomenon utilising US 1955 to 1988 data range. Estrella and Hardouvelis (1991) regressed Gross National Product (GNP) on the yield curve. In their paper the yield curve represents the spread between yields computed as 10 years government bond minus the 3 months treasury bill. Their research showed flattening yield curve signals slow paced expansion of economic activity but steeper yield curve signals fast paced expansion in the upcoming periods. Estrella and Hardouvelis (1991) study also displayed in comparison to supplemental measures, the role of the yield curve in forecasting real output expansion produces better estimation results.

Haubirch and Dombrosky (1996) utilises an econometric technique to predict the United States real Gross Domestic Product (GDP) growth three months ahead making use of the yield curve. The data range: 1961, quarter one to 1995, quarter three. Their quantitative assessment conveyed real GDP growth and yield curve exerts a positive relation. Declining GDP growth generally related to declining yield spread similarly the yield spread narrowing normally shows decreasing real GDP growth. Again simple regression was used and the variables interchanged to be lagged dependent variables. Their study concluded by confirming that a downward sloping yield curve signals recessions.

Karunaratne (1999) findings indicated the yield curve's role is to predict future economic output in Australia. The yield curve according to Karunaratne (1999) is defined as the 10 year bond minus 90 days bank bill rate. Karunaratne (1999) shows the forecast strength of the yield curve is greater and performs better when the probit model has lagged dependent variables. Thus he asserts that the dynamic probit model produces superior forecast results than the static probit model. Static probit model does not have capability to include dynamic formation feature of the lagged dependent variable. Therefore incorporating dependent variables which are lagged, betters the competency of the probit model thus correspondingly achieves the correcting for any serial correlations.

Bronser-Neal and Morley (1997) paper examined yield curve being a real economic activity estimator for regions not in the US but still considered developed. Their assessment was on the capability of the yield curve being a forecaster of real economic activity in Austria, Canada, France, Germany, Italy, Japan, Netherlands, Sweden, Switzerland and UK. Their paper evaluated variations of real GDP growth on the yield spread, the sample estimation produced utilising the data sourced in 1971 ending 1996. Findings by Bronser-Neal and Morley (1997) demonstrated the yield spread as a vital predictor of economic activity for all the countries examined using one, two and three years period and carries evidence of term structure forecast power for regions not in the US.

Harvey (1997) explored the relation of the term structure and economic growth in Canada. His study used the 10 year government bond and 3 month treasury bill. The set of data starts at 1958, first quarter to 1995, fourth quarter. The evidence produced by his paper shows, in Canada the term structure and economic growth has a stable link. Harvey makes use of Consumption Capital Asset Pricing Model (CCAPM) as an explanation why the bond yields can carry relevant information on the real economic output in the future. He performs the necessary econometric checks on his model, such as, stability, heteroscedascity, out of sample to name a few to ensure accuracy and improvement of results.

Mishkin (1990) conducted research the term structure and economic activity connection using the United States data. The empirical analysis looked at monthly data for inflation rates and interest rates where the range starts at 1953 ending at 1987; 3 month and 5 year bond rates. Due to the drastic relationship of the interest rate and inflation shift driven by the change in the monetary regime in October 1979, study had a before October 1979 and after October 1979. The results presented in the paper shows, the slope of the yield curve does have strong forecasting capabilities for the future variations in inflation. Furthermore he highlights the term structure also has a role of assessing pressures driven by inflation. The yield curve becomes steeper, signals future increase in inflation and when the slope becomes flatter it indicates a decrease in the inflation rate.

A study carried out by Nel (1996) researches the relation in South Africa of the term structure and real economic output growth. The set of information used by Nel (1996) is from 1974 to 1993. He measured economic activity using GDP and for the term structure, had the 10 years government bond minus 3 months treasury bill was used. Nel (2006) makes use of co-integration econometric techniques. His findings were that the upward sloping yield curve relates to growth in real economic activity.

Other papers, alongside with all the ones reviewed in this research report illustrates the relation of the term structure and real economic activity is found not only to hold true only in the United States. Most studies have represented the term structure, as the subtraction of the 3 months or 1 year treasury bill (short term rate gauge) from the 10 year government bond (long term rate gauge). With regards to economic activity which is normally the dependent variable, bulk of the papers measures it as variations of real GDP, real GNP, CPI alternatively unemployment rate as in the case for Bernanke (1990). This paper is particularly built upon the market expects about future interest rates given the effects of monetary policy.

Some empirical evidence of the term structure and economic activity relationship included but not limited to: Dotsey (1998), Haurich and Dowbrosky (1996), Estrella and Hardouvelis (1991), Mishkin (1999), Stojanovic and Vaughan (1997) in the US. Bonser and Morley (1997) and Moneta (2003) in Europe found validation of the relation. In Australia Karunaratne (1999), Fisher and Felmingham (1998) and Lowe (1992) confirmed the link. Artus and Kaabi (1993) for France, Brunetti and Torricelli (2009) in Italy and Cozier and Tkacz (1994) in France showed favourable results. Plosser and Rouwenhorst (1994) conducted a cross countries for Germany, UK and US Bernard and Gerlach

(1996) looked at Belgium, Canada, France, Germany, Japan, Netherlands, UK which provided evidence of the existence of the relationship. Estrella and Mishkin (1997) also provide evidence of the relationship for the following counties: France, Germany, Italy, UK, US.

Selective Summary of Studies Assessing the Role of the Term Structure in the Real Economy (where only GDP was used as the economic activity measure).

Study	Country	EAM	Forecast Horizon	Spread (l,s)	Additional Variable	Outcome
1. Harvey (1997)	Canada 1960 - 1995	GDP	-	l = 10 year s = 3 month	-	Favourable
2. Alles (2001)	Australia 1976 - 1993	GDP	-	l = 10 year s = 6 month	-	Favourable
3. Nel (1996)	South Africa 1974 - 1993	GDP	-	l = 10 year s = 3 month	-	Favourable
4. Kim and Limpaphayom (1997)	Japan 1975 - 1991	GDP	5 quarters	l = 10 year s = 3 month	-	Favourable
5. Peel and Loannidis (2002)	US & Canada 1975 - 1991	GDP	5 quarters	l = 10 years s = 3 months	-	Favourable
6. Haurich and Dombrosky (1996)	US 1961 - 1995	GDP	4 quarters	l = 10 year s = 3 month	yt-i	Favourable
7. Harvery (1991b)	France 1966 - 1989	GDP	4 quarters	l = government bond term s = call money rate term	-	Favourable
8. Clinton (1994)	Canada 1962 - 1993	GDP	1 to 20 quarters	l = 10 year s = 3 month	∏t, ΔM	Favourable for 20 quarters
9. McMillan (2002)	UK 1963 - 1996	GDP	1 to 16 quarters	l = 10 year s = 3 month	yt-i, ΔSI	Favourable for 8 quarters
10. Alonso et al. (2001)	Spain 1978 - 1997	GDP	1, 4,8 and 12 quarters	l = 1 and 3 year s = 1 month	yt-i	Unfavourable
11. Davis and Henry (1994)	UK and Germany 1969 - 1990	GDP	1 quarter	l = 10 year s = 3 month	-	Favourable

12. Moersch (1996a)	US, UK, Germany, Canada & Japan various - 1994	GDP	1 quarter	l = Long term as per IFS s = 3 month	yt-i, rt, & ΔM	Unfavourable for Japan
13. Estrella and Mishkin (1997)	US, UK, Germany, France & Italy 1973 - 1994	GDP	1 to 20 quarters	l = 10 year s = 3 month	∏t, yt-i, rt, & ΔM	Unfavourable for UK & Italy

Key:

GDP = Gross Domestic Product; EAM = Economic Activity Measure; ∏t = real short term rate; rt = nominal short term rate; l and s = long and short term rates respectively; yt-i = lags of dependent variables; ΔSI = growth rate of a stock market index; ΔM = growth rate of a money supply and IFS = International Financial Statistics.

3. Methodology

3.1. Introduction

The chapter covers three econometric models utilised in this research to examine the term structure and real economic activity relation and to also analyse the term structure forecast strength which is the main objective of this paper. The three econometric methods used are the simple (linear) probit model, modified (non-linear) probit model and the general method of moments (GMM). The chapter will present an overview of each model employed and highlight the arguments for the usage. The major aim of applying all three is to determine which of the models specified produces the best results in terms of forecasting output, given how important it is from a policy standpoint to be able to accurately calculate this outcome.

3.2. Model Specification and Estimation Method

3.2.1. The Simple Probit Model

There exist two commonly used methods for analysing the relation of term structure and real economic output. These methods also used to test the term structure's predictive strength. The first way is to estimate the future levels of GDP by regressing running previous GDP growth rates, previous superior economic indicators growth rates, yield spread using a multi-variable technique (Filardo, 1999). This is the simple probit model, where the binary dummy variable is defined as the variable determined by the model. Estrella and Hardouvelis (1991) suggested term structure as binary variable Z_t forecaster demonstrating good chance of an economic downturn occurring given Z_t = 1 and given Z_t = 0 a likelihood an economic downturn not materialising. Limitation with this model is the presence of the large sample size which can result to large predicting errors. Thus cannot be considered as a reliable forecasting instrument (Khomo and Aziakponno, 2007). The linear regression is as follows:

$$Z\_t = \psi + \phi X\_(t-q) + \varepsilon\_t \quad \dots\dots\dots (1)$$

Z_t is the variable determined by the model and not observed providing good chance indication of an economic downturn at t. X_{t-q} equals term structure slope of the lagged at t-q, where q equals required lag span to ensure term structure slope forecasts economic downturn. ψ, ϕ are the model coefficients to be computed and ε_t equals normally distributed error term.

Generally accepted identification of a recession (GDP decline in two successive quarters) is utilised to assign each economic downturn to Z_t = 1 and economic expansion to Z_t = 0. The 10 year government bond will serve be the long term rate proxy while the 3 month treasury bill will be used to measure short term rate. The interest rates classifications are also consistent with what previous literature has employed such as, Kim and Limpaphayom (1997), Hu (1993), Campbell and Hamao (1991), Estrella and Hardouvelis (1991).

Thus we define simple probit model as:

$$Pr\,(Z_t = 1) = F\left(\psi + \phi X_{t-q}\right) \;\dots\dots\dots (2)$$

Pr (Z_t = 1) represents the probability of economic downturn occurring conditional on the independent variable X which is observed with a lag of q periods in advance. F, ψ, ϕ = cumulative distribution function estimated and variables by maximising the likelihood function (Khomo and Aziakpono, 2007 and Atta Mensah and Thacz, 1998).

3.2.2. The Modified Probit Model

Second estimation approach Estrella and Hardouvelis (1991) developed. The development of this estimation technique stems from the assumption frequently applied by the simple probit model, residuals are distributed evenly, independent plus have exerts a mean equating to zero (Dueker, 1997). The above assumed doesn't hold true in a series of values of a variable at successive times data due to possible existence of high correlation between error terms. Given the shortcomings identified with the simple probit model, the modified probit model has been developed as an enhancement of the simple probit model. It is worth mentioning the drawbacks for the simple probit model is witnessed to be for developed countries. However this paper seeks to confirm if the very same limitations will prevail for developing countries. This proposed and improved methodology targets to eliminate any autocorrelation present between residuals through the addition of lagged dependent variable to the simple probit model. The addition of a dependent variable which is lagged improves correctness assumed residuals exert a zero mean (Nyberg, 2010). Adoption of the modified probit model which forecast the probability of an economic downturn occurring using the yield spread was also used as an econometric method in most academic research such as Chinn and Kucko (2009), Khomo and Aziakpono (2007), Estrella and Trubin (2006), Nyberg (2003), Moolman (2002), Karunratne (1999), Dueker (1997), Estrella and Mishkin (1997), Bernard and Gerlach (1996), Estrella and Mishkin (1996).

Thus modified probit model is stated as:

$$Pr\,(Z_t\ =\ 1)\ =\ F\,(\psi\ +\phi_1\,X_{t-q} + \phi_2 Z_{t-q})\quad \ldots\ldots\ldots.(3)$$

Z_{t-q} = lagged dependent variable

For non-linear models assessing the goodness of fit, the adjusted R^2 and R^2 become insufficient measures. An alternative measure is employed in this paper which Estrella (1995) developed and was also utilised by Moneta (2003), Estrella and Mishkin (1998), Bernard and Gerlach (1997). The measurement identified to be the pseudo R^2 and is calculated as follows:

$$Pseudo\,R^2\ =\ 1\ -\ \left(\frac{Lu}{Lc}\right) - (\tfrac{2}{N})\,L_c\quad \ldots\ldots\ldots.(4)$$

L_u equals the log likelihood value for computed model, L_c equals restricted model value only holding the constant and N represents number of observations.

The pseudo is utilised as well as t-statistic sourced using regressions computed with aim of generating lags producing optimal match for all variables. Predictive accuracy measurement is completed through the root mean square error (RMSE). The technique is also employed in Dotsey (1998) and Alessandro (2000) studies amongst others. It demonstrates how the predicting strength during the period of estimation can differ.

3.2.3. The Generalised Method of Moments

Research conducted on the term structure and real economic activity predominantly utilises the OLS which similarly generally employs Newey-West (1987) to rectify autocorrelation plus heteroskedasticity as reviewed in the previous section. As mentioned the third method applied by this study is the generalised method of moments (GMM). The GMM technique calculates parameter estimates which according to Hanse (1982) are asymptotically better than OLS estimates. The explanation behind this feature is the disturbance term having a possibility of serial correlation with regards to time series application.

The GMM estimator employed applies the quadratic spectral kernel to state an acceptable weighting matrix (Andrew, 1991). χ^2 statistic is also calculated to test the orthogonality of the instruments from the error term. χ^2 possess n-m degrees of freedom, n equals orthogonality conditions summed quantity inside GMM model similarly m equals total parameters summation. Accroding to (Hanse and Singleton, 1982), given χ^2 is insignificant it means model constraints specified well

The paper makes use of equation (5) below which is in agreement with Kim and Limpaphayom (1997) analyses relation of the term structure and real economic activity. It also evaluates predictive strength of the term structure.

$$\Delta GDP_{t+k} = \alpha + \theta_1 TERM_t + \varepsilon_{t+k} \quad \dots\dots\dots (5)$$

Where $\Delta GDP_{t+k} = (400/k)*(\log GDP_{t+k} - \log GDP_t)$, is the per quarter GDP growth, k equals quarters in advance. Similarly Estrella and Hardouvelis (1991) adopted the above thus also in line with their paper. α equals intercept, $\theta_1$represents coefficient which carries information in forecasting the course of a future change in output, $TERM_t$ equals the long term rate minus the short term and ε_{t+k} equals the error term.

This estimation technique requires the time series data to be stationary. Most term structure research makes use of the OLS regression applies certain techniques for the rectifications of any autocorrelation and heteroskedasticity. The paper exerts the GMM technique (along-side the simple and modified probit models) since GMM has distinct advantages compared to various estimation techniques. According to Kim and Limpaphayom (1997) the GMM is considered a powerful predictor since it requires no data of exact and approximate distribution of disturbances. According to Hansen

(1982) and Kim and Limpaphayom (1997) GMM estimates are known to be superiorly efficient asymptotically compared to the OLS ones. GMM estimates are known for being asymptotically more efficient because their disturbance term may be serially correlated from a time series analysis perspective. Also in comparison with other regression practices for instance the OLS spherical disturbance, the GMM needs less stern deducing for measuring the residuals. Similarly GMM estimates simply become robust to autocorrelation by adjusting the covariance matrix of the explanatory variables

One of the challenges of the use the Generalised Method of Moments as an estimation technique is there exist no found theory to decide how to choose the instrumental variables. The selection process is usually at the researcher's discretion. The instruments are often determined by improvised rationalisation or by availability which could lead possibly to enfeeble instruments.

Instruments selected is required not correlated with residuals plus describe a portion where endogenous regressor exerts variability, which means instruments are unable impact the dependent variable directly. The instruments number must ensure parsimonious due to efficiency asymmetric which is enhanced if extra instruments carry additional knowledge.

Noted by Kim and Limpaphayon (1997) is the GMM asymptotic distributions are dependent on regularity conditions which can affect finite sample performance unfavourably under moment conditions which are enfeeble. GMM estimates are not consistent but converge weakly to a non-degenerate limit distribution.

This paper selects instrumental variables using the lags of the variables in the model which is consistent with Kim and Limpaphayon (1997). To be in line with Kim and Limpaphayom (1997) the study measure of economic activity using GDP. 10 year government bond serves as long term rate proxy while 3 month treasury bill will be used as short term rate. Interest rates classifications consistent with what previous literature has employed such as, Kim and Limpaphayom (1997), Hu (1993), Estrella and Hardouvelis (1991), Campbell and Hamao (1991).

4. Estimation and Results

4.2. Data and source

The below tables indicates the different statistical databases, the OECD Databank and the IMF Data - International Financial where the data was sourced from and the dates the data was available for.

Data Table			
Countries	GDP	Long Term Interest Rate	Short Term Interest Rate
1. South Africa (ZAF)*	1960 Q2 - 2015 Q4	1960 Q1 - 2015 Q4	1960 Q1 - 2015 Q4
2. China (CHN)*	1987 Q1 - 2015 Q4	1995 Q1 - 2015 Q4	1990 Q1 - 2015 Q4
3. Brazil (BRA)**	1996 Q2 - 2015 Q4	1997 Q1 - 2015 Q4	1990 Q1 - 2015 Q4
4. Chile (CHL)*	1995 Q2 - 2015 Q4	2000 Q1 - 2015 Q4	1997 Q3 - 2015 Q4
5. Poland (POL)*	1990 Q1 - 2015 Q4	1996 Q1 - 2015 Q4	1993 Q3 - 2015 Q4
*10 year government bond and 3 month treasury bill sourced from OECD Databank ** 10 year government bond and 3 month treasury bill sourced from IMF Data - International Financial Statistics			

4.2. Introduction

Priori expectation, increasing term structure decreases probability of a downturn occurs meanwhile term structure converse increases likelihood of a downswing occurrence. Similarly given the yield spread relation with the business cycle, there will exists an inverse relation between the likelihood of a downswing and the yield spread (Aziakpono and Khomo, 2007).

4.3. Estimation and Results

The results from the simple probit estimated assessing forecast strength of the term structure are presented in Table 1 to Table 5 for South Africa, Poland, China, Chile and Brazil respectively. The tables provide the coefficient correlating with independent variable for each lag span. Significance is sourced from z-statistics and probability-values. Lag length which produces the best forecast period has highest pseudo R2. RMSE and Variance Proportion (VP) utilised for generating the best forecast evaluation.

4.3.1. The Simple Probit Model

From the analysis captured in Table 1 to Table 5 the results presented shows that the lag lengths for all coefficients are negative, which signals that the term structure and economic activity are inversely related conforming expectations. The probability-values and z-statistics for the coefficient computed show term structure is significant for most of the countries reaching 15 lags. The exception is Brazil who only exhibit significance specifically in lags 1, 15 and 18 only. The findings furthermore displayed that each country experience varying lag lengths for their optimal fit assessed using the greatest pseudo R^2 as a measurement. Correspondingly for the best forecast evaluation utilising the lowest RSME and VP, the different countries produce varying results.

The optimal fit sourced utilising the highest pseudo R^2 and the best forecast evaluation making use the lowest RSME and VP shared the same the lags. That is, for all the countries with an exception of South Africa, the highest pseudo R^2 and lowest RSME and VP shared the same lag. The next section captures the estimated equation of the simple probit with term structure with their different optimal lag lengths for all the countries. For South Africa, the estimated equation of the simple probit with term structure having a 3 lag length is:

$$Pr\,(Zt + 3 = 1) \ = \ F\,(0.218342 - 24.91516Xt) \ \dots\dots\dots.(6)$$

The predicted likelihoods in the simple probit, 3 lags can be compared with the actual economic activity downturn to assess the model precision. Figure 1 gives a graphical representation of the occurrence of economic activity. It is evident that the simple probit model utilising term structure is able correctly to forecast variations in economic output using the 3 lags period. Poland's estimated equation of the simple probit model using the term structure at one lag is given by:

$$Pr\,(Zt + 1 = 1) \ = \ F\,(0.192491 - 56.11155Xt) \ \dots\dots\dots.(7)$$

Similarly the estimated probabilities from this simple probit model at 1 lag can be compared with the economic output downturn to evaluate the accuracy of the technique. Given Figure 2, it is demonstrated that the simple probit model using the term structure has the ability to predict variations of economic activity using one lag. China has the following equation of the simple probit making use of term structure within the lag span of 5 is:

$$Pr\,(Zt + 5 = 1) = \ F\,(0.276514 - 15.81526Xt) \dots\dots\dots\ (8)$$

The estimated probability using simple probit, 5 lags gauged against the observed economic activity downturn to test the accuracy of the model. The graphical illustration, figure 3, shows the simple probit model using the term structure can correctly forecast discrepancies in economic activity 5 lags. Chile's optimal estimated equation of the simple probit model using the term structure at 4 lags is given by:

$$Pr\,(Zt + 4 = 1) \ = \ F\,(0.238593 - 37.76047Xt) \ \dots\ (9)$$

The equation of the simple probit model using the term structure at 1 lag estimated for Brazil is given by:

$$Pr\,(Zt + 1 = 1) \ = \ F\,(0.877884 - 1.919432Xt) \ \dots\ (10)$$

This forecast analysis proposes that the term structure is still a reliable estimation tool for economic activity. Additionally the benchmarked against the graphical representations completed for each country shows vividly that the simple probit model utilising the term structure was able to accurately predict variations in economic output using the selected optimal lags identified.

4.3.2. The Modified Probit Model

Dueker (1997) highlights one challenge of the simple probit model as an estimation technique is the residuals to be identically distributed having zero mean assumption and independent. The assumed may be mot feasible especially for a series of values of a quantity obtained at successive times due to possible existent of high correlation between error terms. Modified probit thus calculated with an aim to eliminate any serial correlation which may be present among residuals simply by including dependent variable which is lagged as an explanatory variable to the simple probit equation (Dueker, 1997).

Term structure utilised as independent variable along-side an added lagged dependent variable which predicts the probability of an economic activity downswing. Results are presented in Table 6 to Table 10 for South Africa, Poland, China, Chile and Brazil respectively. All lags independent variable and added dependent variable which is lagged have correlating computed coefficients, probability-values and z-statistics and show statistical significance. Pseudo R^2, RMSE and VP are also documented.

The analysis documented in Table 6 to Table 10 the results provide illustrate that the lag lengths for each coefficients are negative, which signals that the term structure and economic activity are inversely related conforming expectations. One of the distinct differences in this analysis between the simple and modified probit model, is that the probability-values and z-statistics captured for the coefficients computed show that the level of significances of the term structure increases for most of the countries. Furthermore in most cases the dependent variables which are lagged, their coefficients are positive and significant as far as 9 months thereafter become negative.

The optimal fit sourced utilising the highest pseudo $R^2$and the best forecast evaluation making use the lowest RSME and VP shared the same the lags. In this scenario, most countries experienced that the lower RMSE and VP in the shorter lags. Correspondingly this was observed from a optimal fit perspective. That is, highest Pseudo R^2 exerted in short lag lengths. The next section captures the estimated equation of the simple probit with term structure with their different optimal lag lengths for all the countries.

Predicted equation for modified probit using the term structure at 1 lag for South Africa is given by:

$$Pr\ (Zt + 1 = 1)\ =\ F\ (-1.347534 - 12.89843Xt + 2.9944412Zt)\ \ldots\ (11)$$

Poland's estimated equation of the modified probit model using the term structure at 1 lag is given by:

$$Pr\ (Zt + 1 = 1)\ =\ F\ (-1.346774 - 18.57533Xt + 2.814722Zt)\ \ldots\ (12)$$

The modified probit model using the term structure at 1 lag for China is documented as:

$$Pr\ (Zt + 1 = 1)\ =\ F\ (-1.335333 - 8.479983Xt + 3.029718Zt)\ \ldots\ (13)$$

Chile's Computed equation for modified probit using the term structure at 1 lag is given by:

$$Pr\ (Zt + 1 = 1)\ =\ F\ (-1.096757 - 11.8912Xt + 2.368316Zt)\ \ldots\ (14)$$

The modified probit equation for Brazil using the term structure at 1 lag is captured as the following:

$$Pr\ (Zt + 1 = 1)\ =\ F(-1.347534 - 12.89843Xt + 2.9944412Zt)\ \ldots\ (15)$$

The prediction assessment conducted for the modified probit model illustrates that the term structure could still be used as a predictor (among other robust economic indicators) of economic activity. Additionally the simple probit model predictive rates were far more accurate in comparison to its counterpart, the simple probit model for all the countries. For example in South for the year 2009 using 3 lags, the simple probit model predicted 84% chance of economic activity downturn which was correct versus the prediction of a 96% chance for the exact same year and lag using the modified probit model.

4.3.3. The Generalised Method of Moments

The estimated bivariate models are reported in appendix B from Table 11 to Table 28. The bivariate GMM in all the selected periods were assessed. The aim was a selection of an optimal specified model. For the forecast horizons, chi squared statistic (d.f. =4) are statistically insignificant illustrating models specified well (Kim and Limpaphayom, 2007). Term structure coefficient significance produces some knowledge with regards to how useful equation is in predicting economic activity's direction. This paper selects instrumental variables using the lags of the variables in the model which is consistent with Kim and Limpaphayon (1997). Similarly to be in line with Kim and Limpaphayom (1997) the study measure of economic activity using GDP. 10 year government bond is used as long term rate proxy and the 3 month treasury bill is used as short term rate.

The estimated bivariate models are reported in appendix B from Table 11 to Table 25. The bivariate GMM in all the selected periods were assessed. The aim was a selection of an optimal specified model. For the forecast horizons, chi squared statistic (d.f. =4) are statistically insignificant illustrating models specified well (Kim and Limpaphayom, 2007). Term structure coefficient significance produces some knowledge with regards to how useful equation is in predicting economic activity's direction. Given the distinct set of results in GMM technique the analysis is presented using the three periods.

Whole Period Analysis

South Africa's term structure coefficient is significance statistically only for lag 1 under the whole period (1960 - 2015) documented in table 11. As captured by the probability-value being zero means coefficient marked to be very significance with a 99% confidence interval. The positive sign of the term variable conforms expectations and has an adjusted R^2 of 0.095888. For Poland, the term structure variable coefficients are statistical significant up to and including lags 3 under the whole period (1960 - 2015) captured in table 12. As witnessed in the p-value, the coefficient is significance at 2% level. Similarly as with the case in South Africa results, the positive sign of the term variable conforming expectations and the adjusted R^2 of 0.19577 highest at the best fit which is, 3 lags. The MSE is also lowest at 3 lag. Table 13 captures China's findings, which indicates no coefficient is statistically significant. The term variables all have positive signs, conforming a priori expectations and the adjusted R^2 is 0.006535. The MSE is also lowest at the highest R^2 lag, which is, 3 lags. Table 14 reporting Chile's results presented show there is no coefficient that is statistically significant. The term variables which have positive signs which are in line with a priori expectations are lags 3 - 4 and 6 - 8. The highest adjusted R^2 is 0.286363 at lags 3. Table 15 documents Brazil's entire period, the results reported show there is no coefficient that is statistically significant. The term variables which have positive signs which are in line with a priori expectations are only lags 2 and 3.

First Sub Period Analysis

In the first sub period (1960 – 2007) presented in table 16 for South Africa, the optimal model specified has obtained the correct sign for the term structure. The p-value is zero suggesting the coefficient of the term structure marked to be significant with a 99% confidence interval. The adjusted R^2 of 0.887674 implying the forecast strength of the term structure has increased. Polands presents a different view, that is, the term structure variable coefficients significance as far as and including lags 6 for the first sub period captured in table 17. The optimal specified model which is reported under lag 1 has a correct sign for the term structure. The p-value is zero suggesting the term structure coefficient is significant with a 99% confidence interval. Adjusted R^2 is 0.592039 implying the forecast strength of the term structure has increased compared to the whole period. Table 18 illustrates China's set of results for its first period. The correct signs for the term structure are obtained. The p-values propose that all the term structure coefficients are not statistically significant. The highest adjusted R^2 is 0.009004 sitting at 3 lags. In Chile's case, viewing Table 19 shows all coefficients obtain correct signs for the term structure are obtained except lag 7. The p-values propose that only the lags 1 - 3 term structure coefficients are significance with the significance percentage being 1% and 2% respectively. Highest adjusted R^2 is 0.468861 sitting at 3 lags. Brazil's presents a contrary set of results in table 20. The findings demonstrate incorrect signs for the term structure for all the lags. The p-values suggest term structure coefficients are statistically significant except for lags 7 and 8. The highest adjusted R^2 is 0.468861 sitting at 3 lags.

Second Sub Period Analysis

In the second sub period (2008 – 2015) reported in table 21 for South Africa, the right sign for the term structure was attained. Similarly the zero probability-value suggests that the term structure is significance with a 99% confidence interval. Adjusted R^2 of 0.436248 was relatively lower than the first sub period but higher than the whole period. One would expect smaller descriptive predictive strength for term structure with regards to economic activity for whole duration due to the sample of the entire period encapsulates different economic environments. The results are in agreement with Kim and Limpaphayom (1997). In table 22, Poland's the second sub period analysis shows that the right sign for the term structure was obtained for only lags 3 to 8. The term structure is not statistically significant at any of the lags. Adjusted R^2 is highest at lag 3. China's set of results for this particular period shows that the right sign for the term structure wasn't acquired. The p-value of zero proposes the term structure is only statistically significant with 99% confidence interval under 3 lags. Similarly the adjusted R^2 of 0.384844 is highest at 3 lags. Analysis for Chile provided in table 24, the right sign for the term structure obtained excluding lags 1 and 2. The p-values indicate the term structure is statistically insignificant at all lags. Brazil presents a case dissimilar to all the countries, however is in line with its first sub period results in table 25. The term structure renders the wrong sign obtained for all the lags. Correspondingly the p-values indicate the term structure is statistically insignificant at all lags.

4.3.4. Forecast Evaluation of the Models

For forecast evaluation analysis the technique applied by Clark and West (2007) the mean squared error (MSE) for assessing the precision of the model was used then regressed against a constant. The MSE is computed by subtracting the fitted value (y_{ft}) from the actual value (y_{at}) and is denoted as ε_t , after calculating ε_t the final step is to square the ε_t to get ε_t^2. As illustrated below and is calculated for each model and documented in Table 1:

$$\varepsilon_t = y_{at} - y_{ft} \; \dots \dots (17)$$

$$\varepsilon_2^2 = (y_{at} - y_{ft})^2 \; \dots \dots (18)$$

Table 1 : Estimation Results for MSE

	ε_{tm1}^2	ε_{tm2}^2	ε_{tm3}^2
South Africa	0.44984	0.46035	0.12994
Poland	0.44145	0.42744	0.04069
China	0.47661	0.46695	0.03923
Chile	0.46802	0.46799	0.02512
Brazil	0.49054	0.48393	0.3635

ε_{tm1}^2 = MSE for model 1 (simple probit model), ε_{tm2}^2= MSE for model 2 (modified probit model) and ε_{tm1}^2 = MSE for model 3 (generalised method of moments)

Given the calculated MSE for each model per country as indicated in the above Table 1, the next step is to generate $\varepsilon_{tm1m2}^2 = \varepsilon_{tm1}^2 - \varepsilon_{tm2}^2$ for each country to be able to apply the Clarke and West (2007) forecast technique. Once generate the final step is to regress ε_{tm1m2}^2 against a constant (c), that is $\varepsilon_{tm1m2}{}^2 = c$ and then evaluate the prediction strength of each model by analysing the constant results produced by the regression. That is,

$$\varepsilon_{tm1m2}{}^2 = c \quad \dots\dots (19)$$

The results are documented in Table 2 below. The variable of interest is the constant as Clarke and West (2007) ascertained if c is greater than zero in equation 19 then model 1 is outperformed by model 2 as it means the model 1 exerts higher error terms than model 2, the converse is true.

Table 2: Estimation Results for Constant

South Africa	ε_{tm1m2}	ε_{tm1m3}	ε_{tm2m3}
Constant	-0.010*	0.185*	0.195*
Standard Error	3E+15	5E+15	6E+15
Poland	ε_{tm1m2}	ε_{tm1m3}	ε_{tm2m3}
Constant	0.012*	0.193*	0.181*
Standard Error	7E+15	1E+15	1E+15
China	ε_{tm1m2}	ε_{tm1m3}	ε_{tm2m3}
Constant	0.009*	0.226*	0.217*
Standard Error	1E+16	1E+15	1E+16
Chile	ε_{tm1m2}	ε_{tm1m3}	ε_{tm2m3}
Constant	0.000*	0.218*	0.218*
Standard Error	2E+16	4E+16	4E+16
Brazil	ε_{tm1m2}	ε_{tm1m3}	ε_{tm2m3}
Constant	0.006*	0.108*	0.102*
Standard Error	1E+16	3E+15	6E+15

*Mean significant at 1%

The results from Table 2 were as follows, for South Africa the paper found that the first model (which is the simple probit model) outperformed the second model (modified probit model) and the third model (generalised method of moments) outperforms both the SPM and MPM in terms of the forecast precision. The constant coefficient is statistically significant at 1% level of significance for all the countries. The findings for Poland, China, Chile and Brazil similarly indicate that the simple probit model is outperformed by modified probit model. However as with the case for South Africa, generalised method of moments outperforms both the simple probit model and modified probit model for all the countries. Thus it is evident that the generalised method of moments technique definitely provides a better forecast results in terms of the accuracy. This is in line with Clarke and West (2007) whose paper found that the parsimonious model (in this paper, the generalised method of moments) tends to have smaller MSE than that of its alternatives larger models (in this paper, the simple probit model and modified probit model). Clarke and West (2007) also found that the larger model initiate noise into its estimation by forecasting parameters whose population values are zero. Hence asserted that this where the expectation of smaller MSE for the parsimonious model stems from this element.

5. Conclusion

The paper assessed the term structure predictive strength on real economic output, utilising three different estimation techniques with data computed quarterly starting off at year 1960 ending at year 2015. Correspondingly the assessment was conducted looking at non-identical economic environments and dissimilar regulatory set ups (where applicable) to truly encapsulates the term structure predictor power, the study period was ordered into two sub periods under the GMM estimation technique. The outcome under this technique illustrates the significance of reviewing in existence monetary policy regimes as well as any government involvement before piloting any of the applied research done on the term structure. This conclusive insight is sourced from the various economic terrains experienced in the different sub periods. That is, the first sub period captures the pre global financial crisis versus the second sub period that is in the post pre global financial crisis.

The modified probit model generates higher likelihood of the economic activity (downswing in the case of this paper) when compared to the simple probit model and also as demonstrated in the forecast evaluation table, the modified probit model produces better forecast precisions. Thus given these findings it is possible to draw the conclusion that the term structure can still be considered satisfactory predictor for economic activity in developing countries. Furthermore for improved forecast performance, the modified probit model must be utilised because of its ability to rectify for any possible autocorrelation. The GMM comes out as a top performer as it manages to consistently attain the lowest MSE for all the countries when compared to both the simple and modified probit models.

The results of the study illustrates that the term structure for South Africa, Poland, China, Chile and Brazil carries valuable information in forecasting economic activity. The term structure and the growth in real economic activity are positively related as captured in this study focused on developing countries. Therefore the term structure can be cautiously used as a predictor of economic activity in developing countries. The research further concord with Kim and Limpaphayom (1997), in that it indicates that the term structure stages diversely as the prediction instrument of real economic activity under unlike economic and financial conditions.

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Appendix A: The Simple and Modified Model Tables and Figures

Table 1: Simple Probit Results for South Africa

Variables (X_{t-q})	q=1	**q=3**	q=4	q=5	q=6	q=9	q=12	q=15	q=18	q=21	q=24
Beta	-23.17	**-24.92**	-24.33	-23.08	-21.89	-17.49	-14.12	-9.02	-4.77	-1.53	1.94
Z-Statistic	-8.14	**-8.54**	-8.40	-8.10	-7.80	-6.57	-5.46	-3.61	-1.95	-0.63	0.80
Probability	0.00*	**0.00***	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.05*	0.53*	0.43*
Pseudo R^2	0.13	**0.15**	0.14	0.13	0.12	0.08	0.06	0.02	0.01	0.00	0.00
RMSE	0.455	**0.450**	0.452	0.456	0.459	0.472	0.481	0.491	0.496	0.498	0.498
VP	0.42	**0.40**	0.40	0.42	0.43	0.50	0.57	0.69	0.82	0.94	0.92

Table 2: Simple Probit Results for Poland

Variables (X_{t-q})	**q=1**	q=3	q=4	q=5	q=6	q=9	q=12	q=15	q=18	q=21	q=24
Beta	**-56.11**	-50.37	-44.80	-40.37	-36.30	-24.19	-19.21	-10.82	-3.11	6.36	26.25
Z-Statistic	**-5.27**	-4.98	-4.67	-4.40	-4.16	-3.37	-2.93	-1.86	-0.57	1.17	3.17
Probability	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.06*	0.57*	0.24*	0.00*
Pseudo R^2	**0.18**	0.16	0.14	0.12	0.11	0.06	0.04	0.02	0.00	0.01	0.06
RMSE	**0.441**	0.450	0.457	0.462	0.467	0.479	0.483	0.489	0.492	0.488	0.470
VP	**0.37**	0.39	0.41	0.43	0.45	0.55	0.60	0.73	0.91	0.84	0.56

Table 3: Simple Probit Results for China											
Variables (X_{t-q})	q=1	q=3	q=4	**q=5**	q=6	q=9	q=12	q=15	q=18	q=21	q=24
Beta	-12.96	-15.28	-15.73	**-15.82**	-15.28	-14.24	-9.23	-7.60	-7.78	-6.86	-3.50
Z-Statistic	-3.21	-3.73	-3.82	**-3.83**	-3.70	-3.45	-2.27	-1.85	-1.87	-1.62	-0.82
Probability	0.00*	0.00*	0.00*	**0.00***	0.00*	0.00*	0.02*	0.06*	0.06*	0.10*	0.41*
Pseudo R^2	0.03	0.05	0.05	**0.05**	0.05	0.04	0.02	0.01	0.01	0.01	0.00
RMSE	0.485	0.479	0.477	**0.477**	0.477	0.478	0.487	0.489	0.490	0.489	0.490
VP	0.65	0.60	0.60	**0.60**	0.61	0.63	0.74	0.78	0.77	0.79	0.89

Table 4: Simple Probit Results for Chile											
Variables (X_{t-q})	q=1	q=3	**q=4**	q=5	q=6	q=9	q=12	q=15	q=18	q=21	q=24
Beta	-13.98	-36.14	**-37.76**	-35.89	-33.57	-25.59	-27.15	-18.92	-8.51	-11.79	-6.27
Z-Statistic	-2.46	-4.03	**-4.15**	-4.04	-3.89	-3.41	-3.55	-2.93	-1.53	-1.94	-1.10
Probability	0.01*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.13*	0.05*	0.27*
Pseudo R^2	0.03	0.10	**0.10**	0.10	0.09	0.06	0.07	0.04	0.01	0.02	0.01
RMSE	0.489	0.471	**0.468**	0.470	0.473	0.480	0.478	0.485	0.496	0.494	0.498
VP	0.71	0.49	**0.47**	0.48	0.50	0.56	0.54	0.62	0.79	0.72	0.83

Table 5: Simple Probit Results for Brazil											
Variables (X_{t-q})	**q=1**	q=3	q=4	q=5	q=6	q=9	q=12	q=15	q=18	q=21	q=24
Beta	**-1.92**	-1.03	0.70	0.39	0.10	-0.35	-1.22	-1.81	-1.77	-1.33	-1.00
Z-Statistic	**-2.29**	-1.25	0.85	0.48	0.13	-0.43	-1.47	-2.09	-1.99	-1.49	-1.10
Probability	**0.02***	0.21*	0.39*	0.63*	0.90*	0.67*	0.14*	0.04*	0.05*	0.14*	0.27*
Pseudo R^2	**0.02**	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.00
RMSE	**0.491**	0.495	0.496	0.497	0.498	0.498	0.495	0.491	0.491	0.492	0.492
VP	**0.73**	0.85	0.89	0.94	0.98	0.94	0.82	0.75	0.76	0.81	0.86

Table 6: Modifed Probit Results for South Africa											
Variables	**q=1**	q=3	**q=4**	q=5	q=6	q=9	q=12	q=15	q=18	q=21	q=24
X_{t-q}											
Beta	**-12.90**	-17.05	-17.32	-17.37	-17.98	-18.78	-17.76	-11.25	-7.85	-5.77	-2.86
Z-Statistic	**-2.92**	-5.09	-5.48	-5.69	-5.99	-6.34	-6.03	-4.02	-2.86	-2.11	-1.04
Probability	**0.00***	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.03*	0.30*
Z_{t-q}											
Beta	**2.99**	1.63	1.20	0.85	0.52	-0.15	-0.40	-0.26	-0.37	-0.52	-0.59
Z-Statistic	**15.25**	10.93	8.35	6.03	3.71	-1.03	-2.79	-1.86	-2.66	-3.67	-4.13
Probability	**0.00***	0.00*	0.00*	0.00*	0.00*	0.30*	0.01*	0.06*	0.01*	0.00*	0.00*
Pseudo R^2	**0.69**	0.37	0.27	0.20	0.14	0.08	0.07	0.03	0.02	0.03	0.03
RMSE	0.56	0.46	**0.46**	0.46	0.46	0.47	0.48	0.49	0.49	0.49	0.50
VP	**0.03**	0.25	0.34	0.41	0.44	0.49	0.51	0.64	0.74	0.80	0.85

Table 7: Modified Probit Results for Poland

Variables	**q=1**	q=3	q=4	q=5	q=6	**q=9**	q=12	q=15	q=18	q=21	q=24
X_{t-q}											
Beta	**-18.58**	-24.38	-24.26	-21.85	-20.90	-18.59	-25.53	-27.19	-20.58	-7.69	10.92
Z-Statistic	**-1.35**	-2.27	-2.47	-2.38	-2.40	-2.46	-3.28	-3.59	-2.96	-1.21	1.31
Probability	**0.02***	0.02*	0.01*	0.02*	0.02*	0.01*	0.00*	0.00*	0.00*	0.23*	0.19*
Z_{t-q}											
Beta	**2.81**	1.66	1.26	1.16	0.97	0.38	-0.42	-1.15	-1.36	-1.23	-1.08
Z-Statistic	**9.28**	6.95	5.55	5.13	4.36	1.77	-1.87	-4.75	-5.48	-5.07	-4.48
Probability	0.00*	0.00*	0.00*	0.00*	0.00*	0.08*	0.06*	0.00*	0.00*	0.00*	0.00*
Pseudo R^2	**0.65**	0.37	0.27	0.23	0.19	0.08	0.06	0.12	0.15	0.14	0.17
RMSE	0.54	0.47	0.47	0.47	0.47	**0.43**	0.48	0.47	0.48	0.49	0.49
VP	**0.10**	0.33	0.40	0.44	0.47	0.55	0.57	0.61	0.69	0.76	0.51

Table 8: Modified Probit Results for China

Variables	**q=1**	**q=3**	q=4	q=5	q=6	q=9	q=12	q=15	q=18	q=21	q=24
X_{t-q}											
Beta	**-8.48**	-11.11	-11.80	-12.25	-12.30	-13.84	-11.44	-10.59	-10.20	-8.35	-4.91
Z-Statistic	**-1.36**	-2.34	-2.62	-2.80	-2.87	-3.26	-2.68	-2.43	-2.32	-1.90	-1.12
Probability	**0.02***	0.02*	0.01*	0.01*	0.00*	0.00*	0.01*	0.02*	0.02*	0.06*	0.26*
Z_{t-q}											
Beta	**3.03**	1.75	1.35	1.04	0.75	0.08	-0.40	-0.54	-0.43	-0.30	-0.33
Z-Statistic	**11.24**	8.64	7.01	5.56	4.10	0.42	-2.12	-2.84	-2.26	-1.60	-1.75
Probability	0.00*	0.00*	0.00*	0.00*	0.00*	0.67*	0.03*	0.00*	0.02*	0.11*	0.08*
Pseudo R^2	**0.66**	0.33	0.23	0.16	0.11	0.04	0.03	0.04	0.03	0.02	0.01
RMSE	0.48	**0.47**	0.47	0.47	0.47	0.48	0.49	0.49	0.49	0.49	0.49
VP	**0.08**	0.39	0.48	0.53	0.58	0.63	0.70	0.70	0.71	0.75	0.83

Table 9: Modified Probit Results for Chile											
Variables	**q=1**	q=3	**q=4**	q=5	q=6	q=9	q=12	q=15	q=18	q=21	q=24
X_{t-q}											
Beta	**-11.89**	-31.30	-35.90	-36.48	-35.70	-27.08	-28.79	-17.88	-7.78	-14.95	-7.88
Z-Statistic	**-1.72**	-3.48	-3.88	-4.00	-3.97	-3.42	-3.56	-2.73	-1.37	-2.27	-1.31
Probability	**0.09***	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.01*	0.17*	0.02*	0.19*
Z_{t-q}											
Beta	**2.37**	0.70	0.21	-0.06	-0.21	-0.16	-0.16	0.15	0.17	-0.45	-0.26
Z-Statistic	**9.60**	3.48	1.08	-0.30	-1.02	-0.77	-0.77	0.74	0.85	-2.13	-1.23
Probability	0.00*	0.00*	0.28*	0.76*	0.31*	0.44*	0.44*	0.46*	0.39*	0.03*	0.22*
Pseudo R^2	**0.49**	0.15	0.11	0.10	0.09	0.07	0.07	0.05	0.01	0.04	0.01
RMSE	0.48	0.47	**0.47**	0.47	0.47	0.48	0.48	0.49	0.49	0.49	0.50
VP	**0.32**	0.45	0.47	0.49	0.50	0.55	0.53	0.62	0.79	0.68	0.81

Table 10: Modified Probit Results for Brazil											
Variables	**q=1**	q=3	q=4	q=5	q=6	q=9	q=12	q=15	**q=18**	q=21	q=24
X_{t-q}											
Beta	**-0.06**	-0.32	-0.42	-0.48	-0.45	-0.09	-0.43	-0.89	-0.96	-0.41	-0.29
Z-Statistic	**-0.05**	-0.35	-0.47	-0.55	-0.53	-0.11	-0.50	-0.99	-1.02	-0.43	-0.30
Probability	**0.10***	0.07*	0.06*	0.06*	0.06*	0.91*	0.62*	0.32*	0.31*	0.67*	0.77*
Z_{t-q}											
Beta	**2.76**	1.50	1.19	0.90	0.57	-0.26	-0.76	-0.84	-0.75	-0.68	-0.43
Z-Statistic	**11.20**	7.81	6.40	4.95	3.19	-1.46	-4.07	-4.38	-3.95	-3.51	-2.16
Probability	0.00*	0.00*	0.00*	0.00*	0.00*	0.14*	0.00*	0.00*	0.00*	0.00*	0.03*
Pseudo R^2	**0.58**	0.22	0.14	0.08	0.03	0.01	0.07	0.08	0.07	0.05	0.02
RMSE	0.56	0.50	0.50	0.50	0.50	0.50	0.50	0.49	**0.48**	0.48	0.49
VP	**0.74**	0.82	0.82	0.84	0.87	0.97	0.87	0.82	0.83	0.85	0.89

Figure 1: Simple Probit Model forecasted probabilities of an Economic Activity downswing occurring at 3 lags compared to actual Economic Activity downswing for South Africa

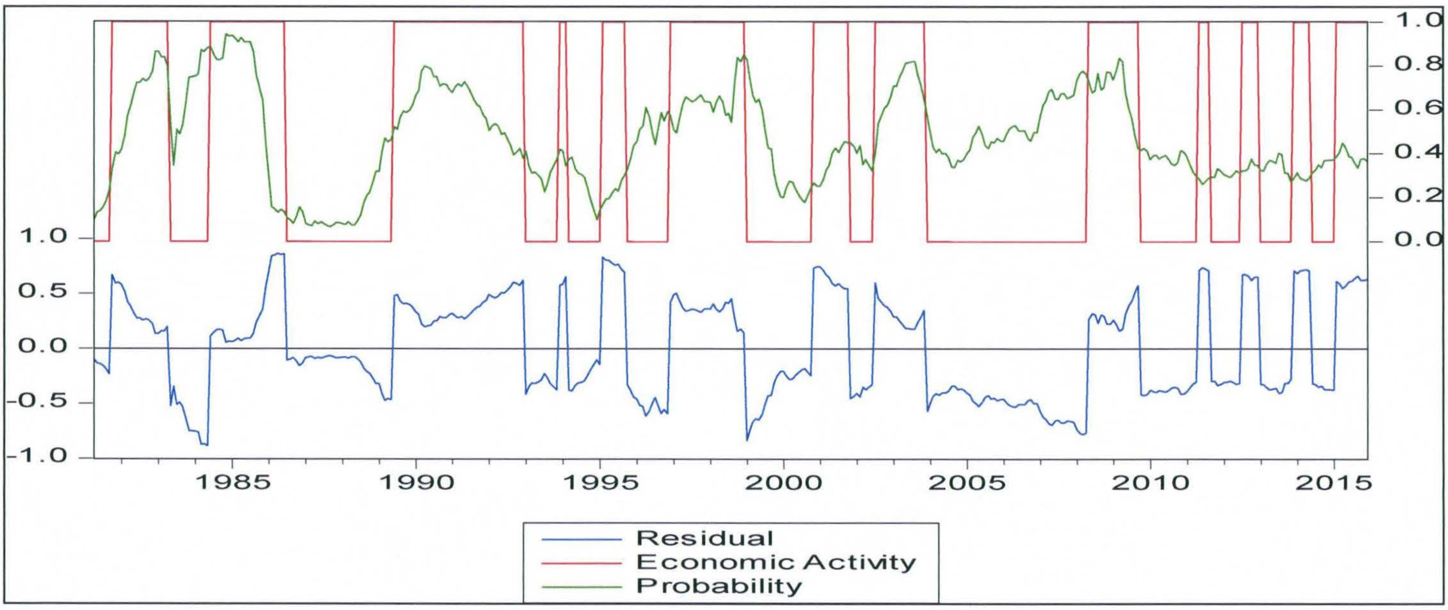


Figure 2: Simple Probit Model forecasted probabilities of an Economic Activity downswing occurring at 1 lag compared to actual Economic Activity downswing for Poland

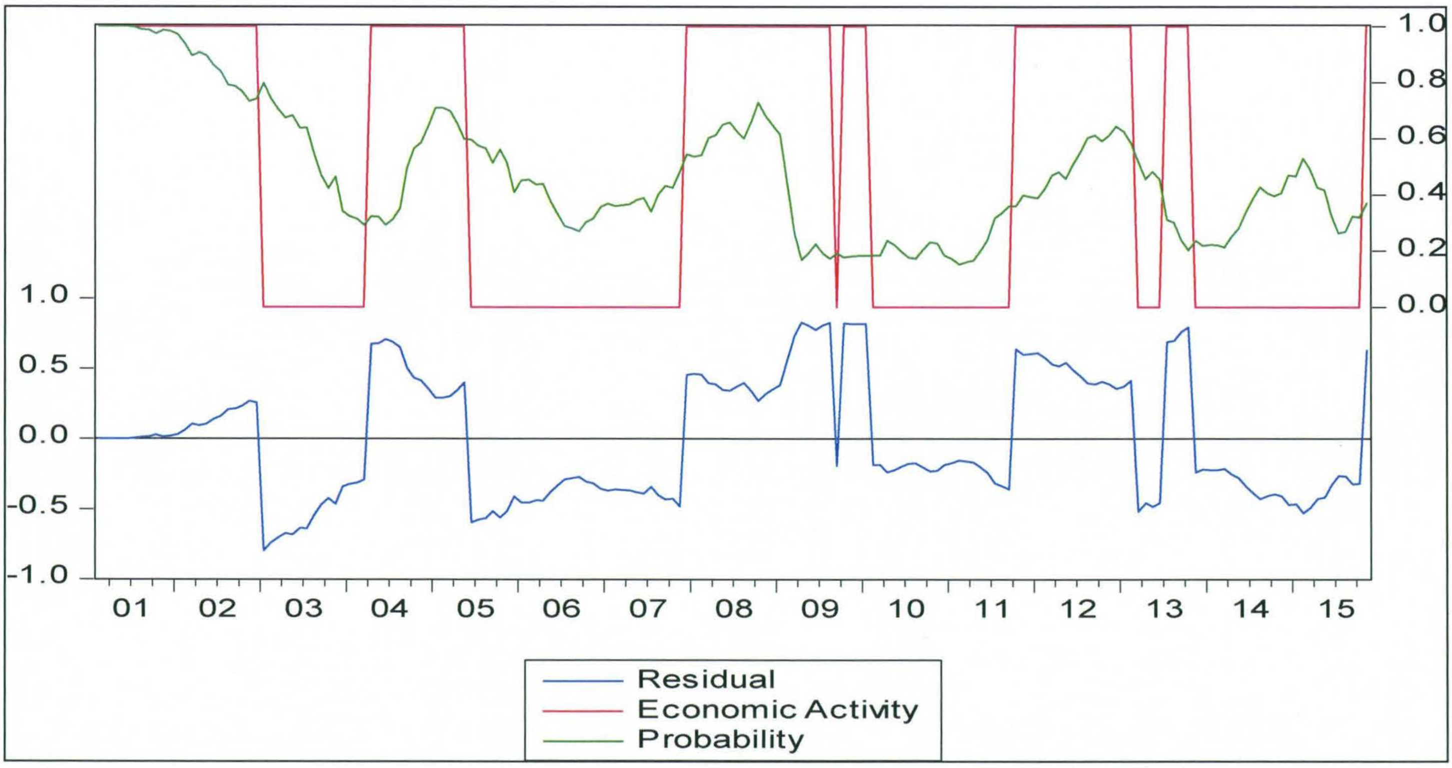


Figure 3: Simple Probit Model forecasted probabilities of an Economic Activity downswing occurring at 5 lags compared to actual Economic Activity downswing for China

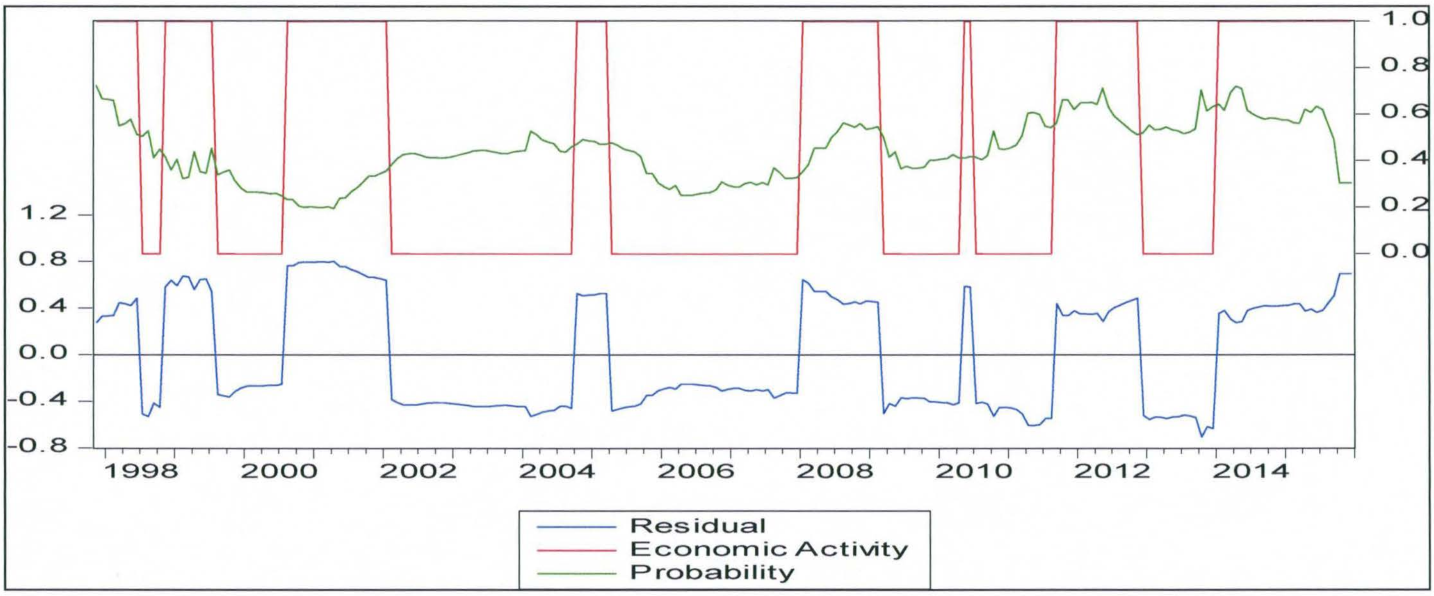


Figure 4: Simple Probit Model forecasted probabilities of an Economic Activity downswing occurring at 4 lags compared to actual Economic Activity downswing for Chile

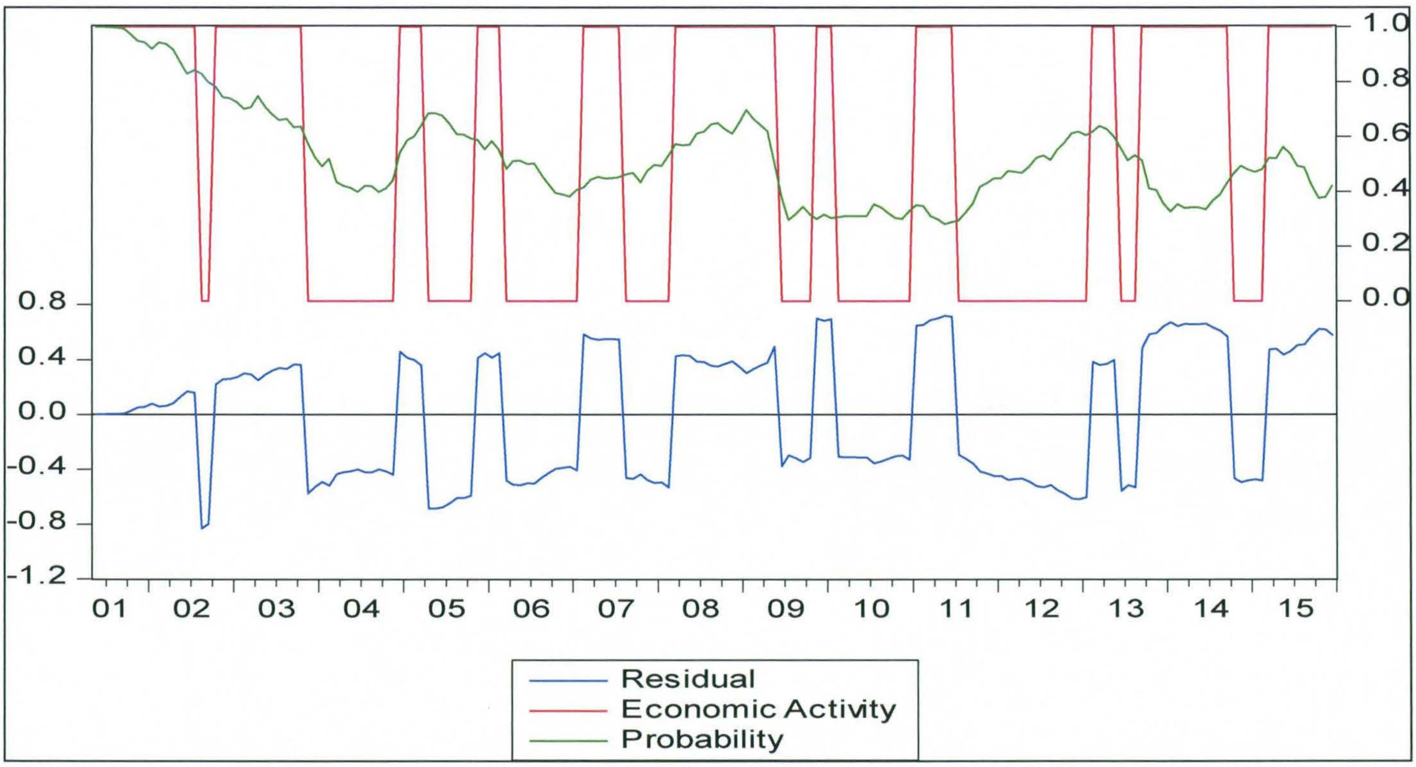


Figure 5: Simple Probit Model forecasted probabilities of an Economic Activity downswing occurring at 1 lag compared to actual Economic Activity downswing for Brazil

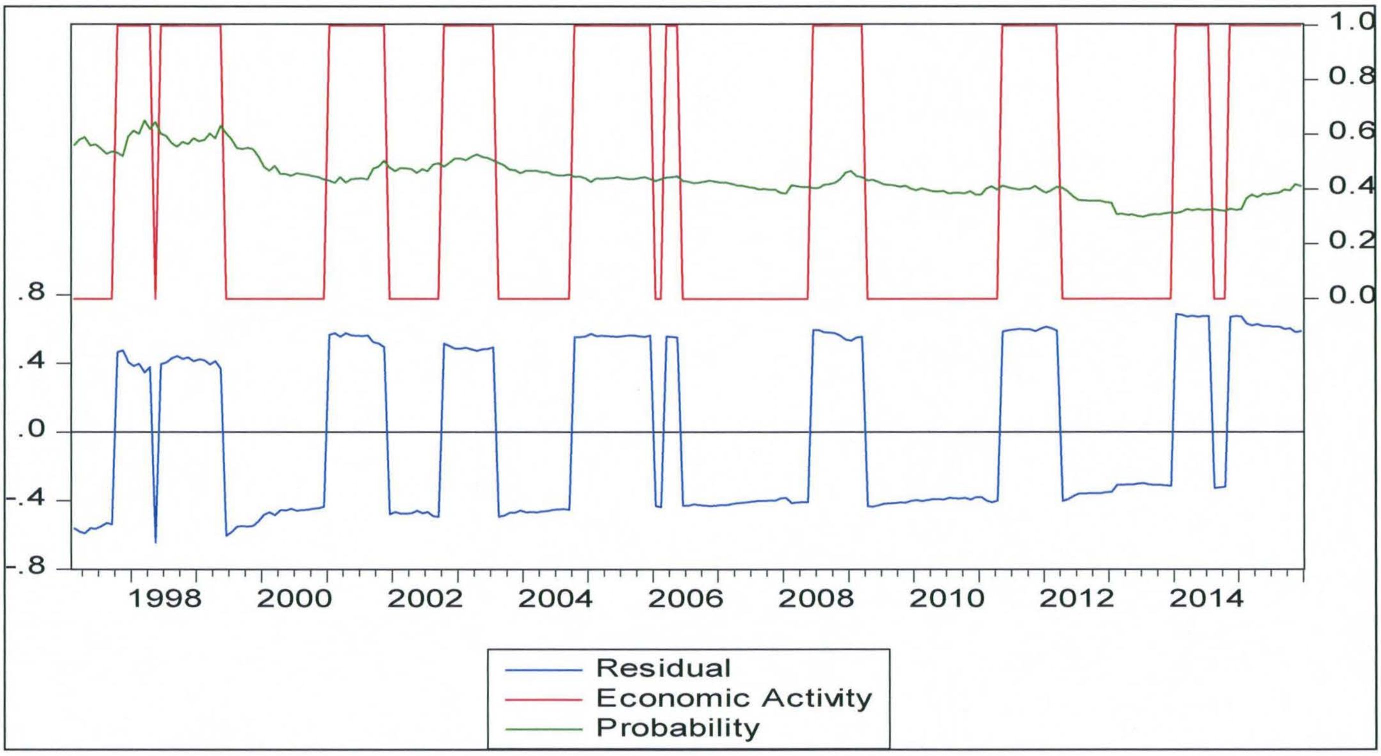


Figure 6: Modified Probit Model forecasted probabilities of an Economic Activity downswing occurring at 1 lag compared to actual Economic Activity downswing for South Africa

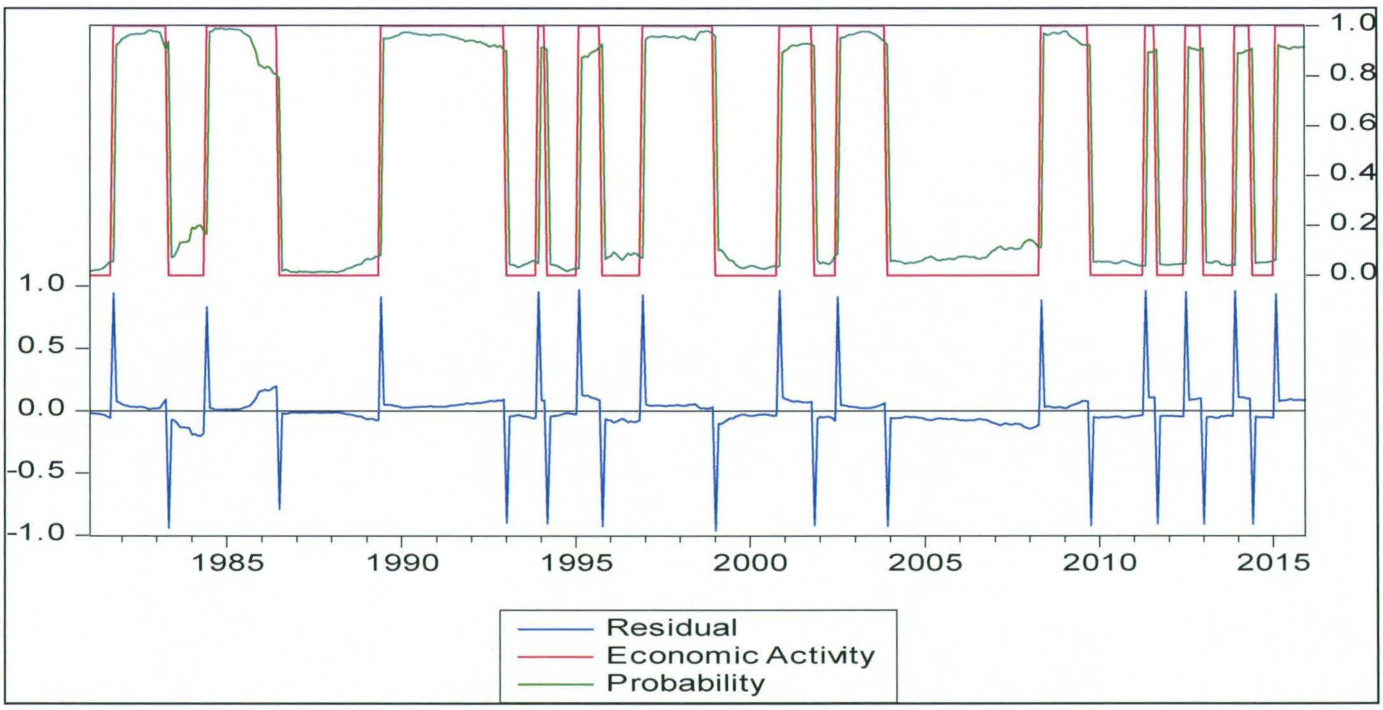


Figure 7: Modified Probit Model forecasted probabilities of an Economic Activity downswing occurring at 1 lag compared to actual Economic Activity downswing for Poland

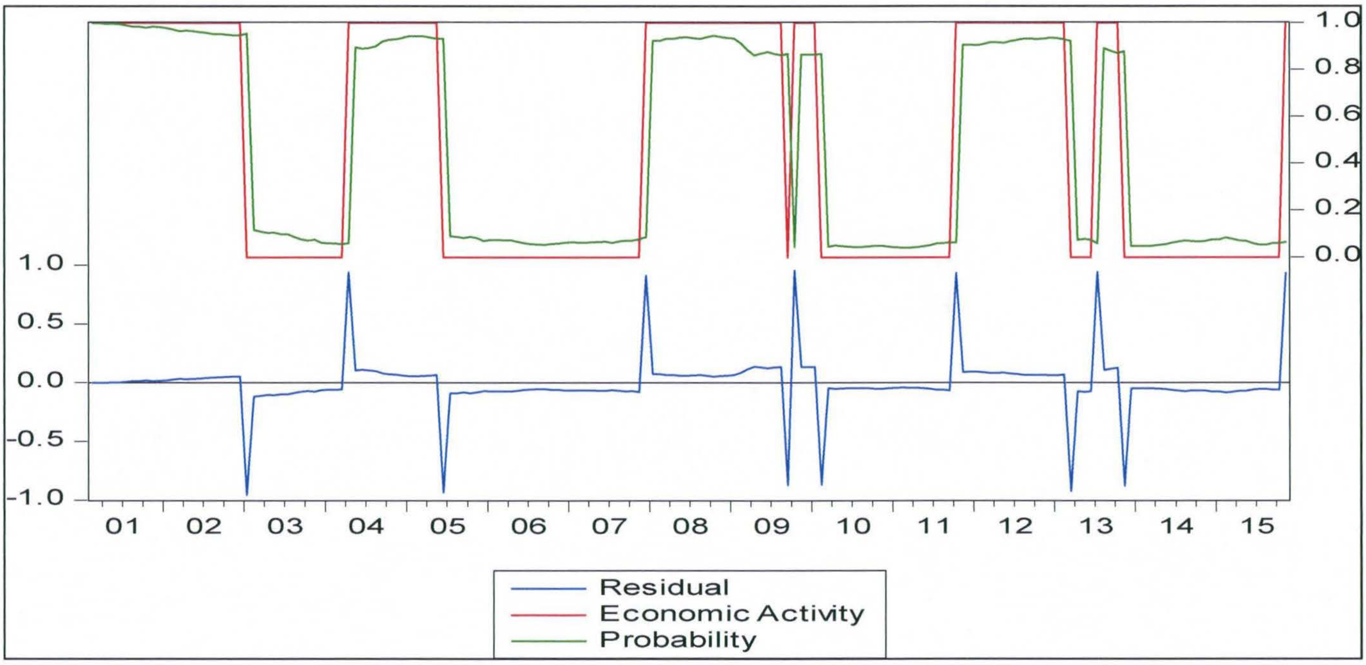


Figure 8: Modified Probit Model forecasted probabilities of an Economic Activity downswing occurring at 1 lag compared to actual Economic Activity downswing for China

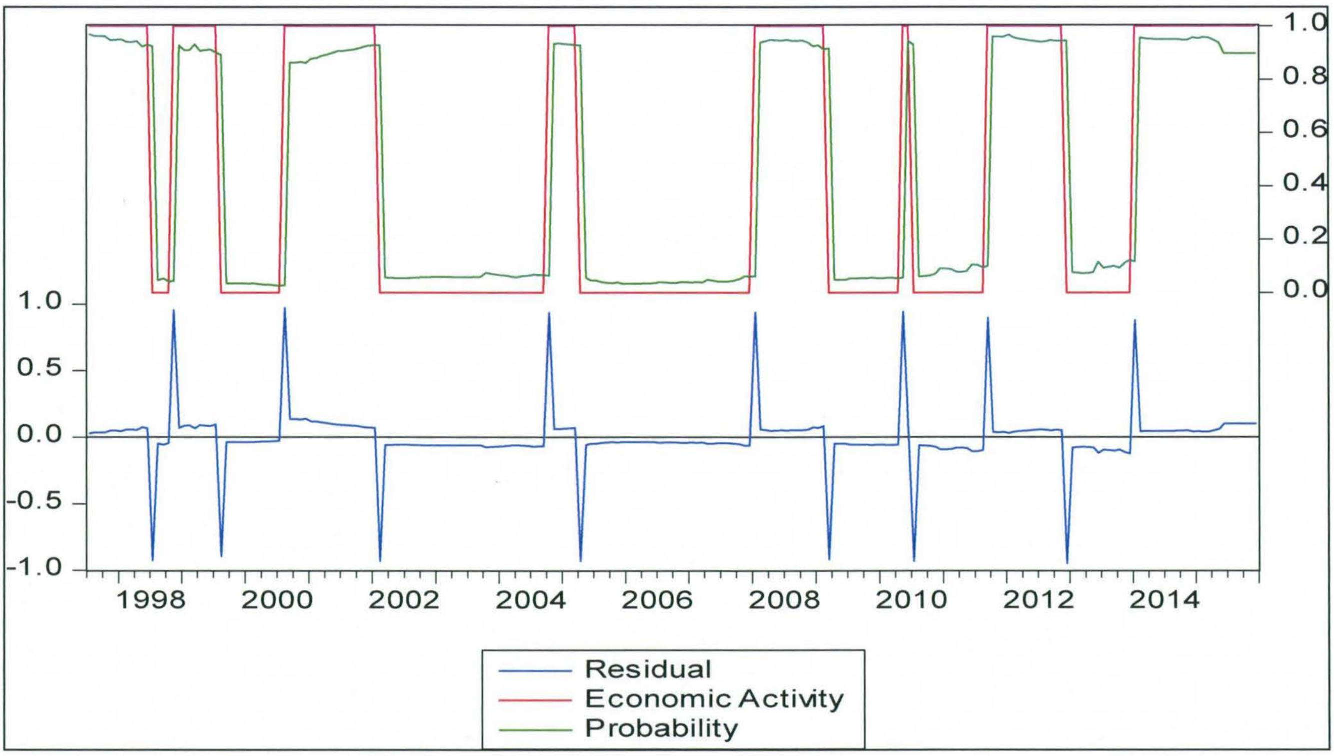


Figure 9: Modified Probit Model forecasted probabilities of an Economic Activity downswing occurring at 1 lag compared to actual Economic Activity downswing for Chile

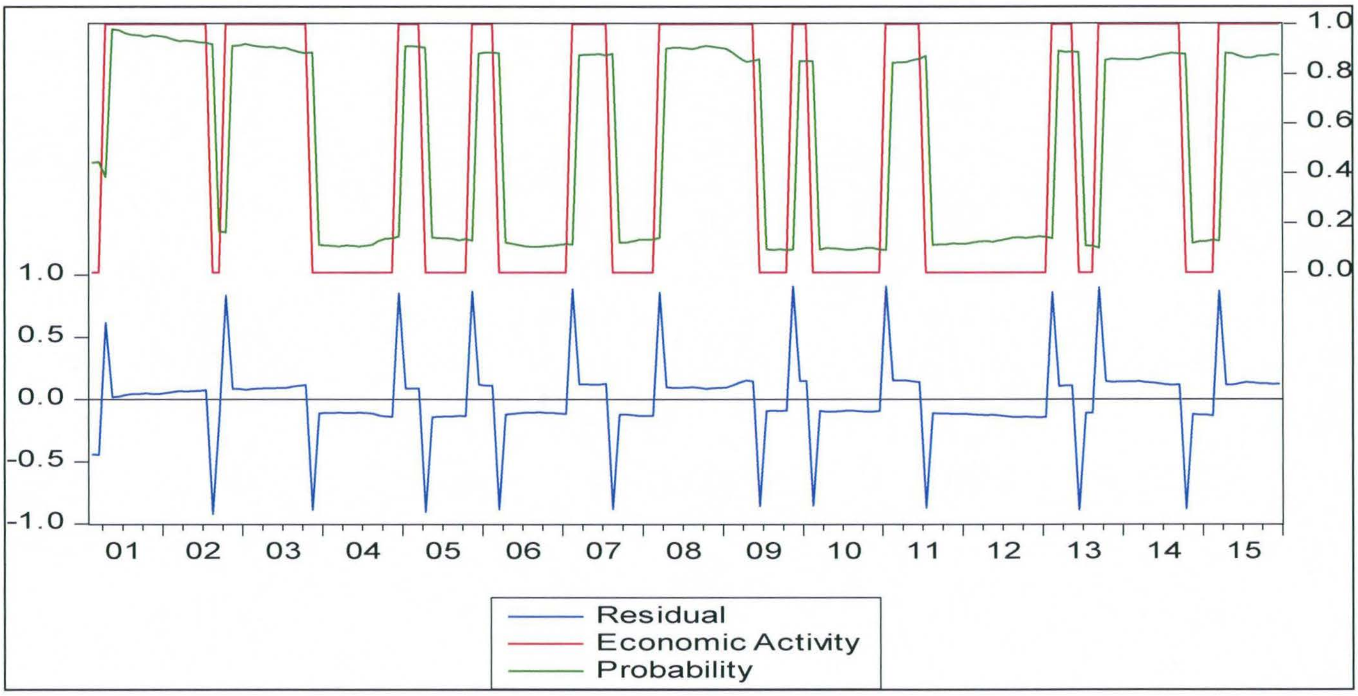
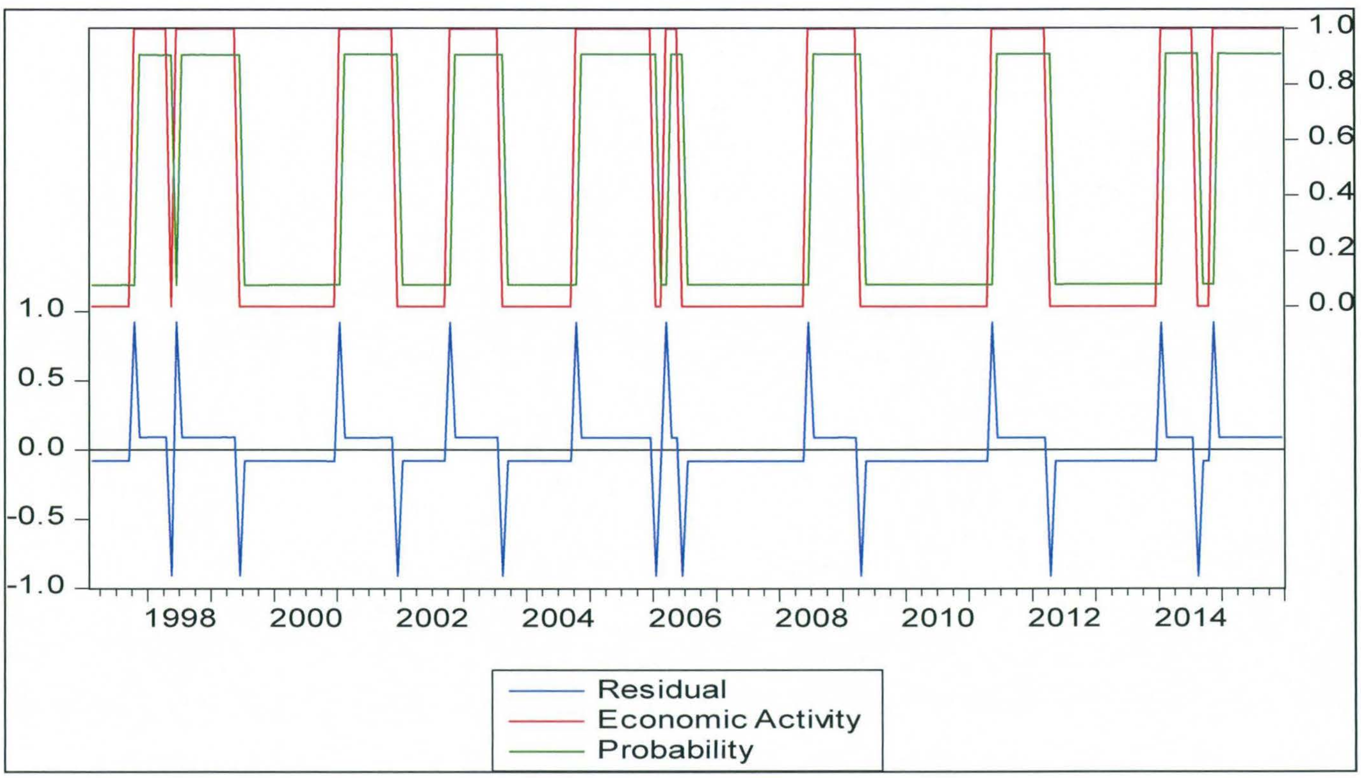


Figure 10: Modified Probit Model forecasted probabilities of an Economic Activity downswing occurring at 1 lag compared to actual Economic Activity downswing for Brazil



Appendix B: The Generalised Method of Moments Tables and Figures

Table 11: Generalised Method of Moments Results for South Africa: Whole Period

Number of Lags	ψ	θ_1	χ^2	R^2
1	-0.19 (0,001)	3.66 (0,000)	0.00	0.10
2	-0.39 (0,0708)	6.71 (0,0394)	0.00	-5.09
3	-2.47 (0,6966)	38.42 (0,6841)	0.00	-231.11
4	0.76 (0,1043)	-10.80 (0,1333)	0.00	-16.43
5	1.06 (0,1564)	-15.29 (0,196)	0.00	-34.98
6	1.74 (0,2791)	-26.65 (0,3205)	0.00	-94.84
7	5.87 (0,6183)	-95.52 (0,6337)	0.00	-1,047.97
8	-4.45 (0,3612)	77.27 (0,3238)	0.00	-556.78

Table 12: Generalised Method of Moments Results for Poland: Whole Period

Number of Lags	ψ	Θ_1	χ^2	R^2
1	0.03	0.45	0.00	0.18
	(0,000)	(0,0153)		
2	0.04	0.46	0.00	0.19
	(0,000)	(0,031)		
3	0.04	0.52	0.00	0.20
	(0,000)	(0,0286)		
4	0.04	0.47	0.00	0.06
	(0,000)	(0,1983)		
5	0.04	0.38	0.00	-0.03
	(0,000)	(0,4727)		
6	0.04	0.34	0.00	-0.08
	(0,000)	(0,6577)		
7	0.04	0.15	0.00	-0.07
	(0,000)	(0,8652)		
8	0.04	-0.07	0.00	-0.00
	(0,000)	(0,9505)		

Table 13: Generalised Method of Moments Results for China: Whole Period

Number of Lags	ψ	θ_1	χ^2	R^2
1	0.02 (0,7224)	0.31 (0,819)	0.00	-0.00
2	0.01 (0,829)	0.47 (0,7559)	0.00	0.00
3	0.01 (0,8369)	0.50 (0,7213)	0.00	0.01
4	0.01 (0,8618)	0.52 (0,7436)	0.00	-0.00
5	0.01 (0,9266)	0.63 (0,7495)	0.00	-0.02
6	0.00 (0,9803)	0.75 (0,7407)	0.00	-0.05
7	0.00 (0,9721)	0.74 (0,7062)	0.00	-0.06
8	0.01 (0,9201)	0.62 (0,7386)	0.00	-0.05

Table 14: Generalised Method of Moments Results for Chile: Whole Period

Number of Lags	ψ	Θ_1	χ^2	R^2
1	0.05 (0,0001)	-0.47 (0,4605)	0.00	-0.32
2	0.06 (0,2091)	-1.33 (0,7182)	0.00	-1.86
3	0.03 (0,6309)	0.77 (0,878)	0.00	0.29
4	0.02 (0,5052)	0.88 (0,7136)	0.00	0.11
5	0.64 (0,939)	-34.80 (0,9425)	0.00	-249.59
6	-0.02 (0,5505)	2.92 (0,1402)	0.00	-0.43
7	-0.03 (0,5653)	4.22 (0,279)	0.00	-2.39
8	-0.07 (0,6302)	6.05 (0,5289)	0.00	-9.95

Table 15: Generalised Method of Moments Results for Brazil: Whole Period

Number of Lags	ψ	θ_1	χ^2	R^2
1	0.02 (0,1596)	-0.00 (0,9789)	0.00	-0.02
2	0.02 (0,2175)	0.00 (0,9049)	0.00	-0.01
3	0.02 (0,2449)	0.01 (0,8525)	0.00	-0.00
4	0.03 (0,1732)	-0.01 (0,8096)	0.00	-0.05
5	0.03 (0,1942)	-0.02 (0,7416)	0.00	-0.07
6	0.03 (0,2731)	-0.02 (0,7841)	0.00	-0.07
7	0.03 (0,3127)	-0.02 (0,8025)	0.00	-0.07
8	0.03 (0,3241)	-0.02 (0,8119)	0.00	-0.07

Table 16: Generalised Method of Moments Results for South Africa: Sub Period 1

Number of Lags	ψ	θ_1	χ^2	R^2
1	-0.11 (0,000)	2.38 (0,000)	0.00	0.89
2	-0.09 (0,000)	2.08 (0,000)	0.00	0.68
3	-0.07 (0,0087)	1.75 (0,0001)	0.00	0.48
4	-0.06 (0,0871)	1.49 (0,0067)	0.00	0.34
5	-0.05 (0,1912)	1.33 (0,025)	0.00	0.27
6	-0.04 (0,3041)	1.18 (0,0513)	0.00	0.21
7	-0.03 (0,451)	1.01 (0,0929)	0.00	0.16
8	-0.02 (0,6323)	0.85 (0,1542)	0.00	0.11

Table 17: Generalised Method of Moments Results for Poland: Sub Period 1

Number of Lags	ψ	Θ_1	χ^2	R^2
1	0.05 (0,000)	0.83 (0,0013)	0.00	0.59
2	0.05 (0,000)	0.89 (0,0005)	0.00	0.55
3	0.05 (0,000)	0.97 (0,0002)	0.00	0.55
4	0.05 (0,000)	0.98 (0,0051)	0.00	0.24
5	0.05 (0,000)	0.98 (0,0272)	0.00	-0.10
6	0.06 (0,000)	1.07 (0,0516)	0.00	-0.38
7	0.06 (0,000)	1.03 (0,1176)	0.00	-0.72
8	0.06 (0,000)	1.04 (0,2556)	0.00	-1.44

Table 18: Generalised Method of Moments Results for China: Sub Period 1

Number of Lags	ψ	Θ_1	χ^2	R^2
1	-0.11 (0,6846)	4.29 (0,1286)	0.00	0.12
2	-0.17 (0,6884)	6.02 (0,1214)	0.00	-0.14
3	-0.15 (0,6841)	5.34 (0,1111)	0.00	0.01
4	-0.21 (0,689)	7.21 (0,1238)	0.00	-0.64
5	-0.47 (0,6757)	14.54 (0,0988)	0.00	-5.24
6	-1.18 (0,574)	35.25 (0,0377)	0.00	-38.31
7	-0.35 (0,5611)	11.26 (0,028)	0.00	-3.70
8	-0.29 (0,5309)	9.46 (0,0109)	0.00	-2.56

Table 19: Generalised Method of Moments Results for Chile: Sub Period 1

Number of Lags	ψ	Θ_1	χ^2	R^2
1	0.04 (0,000)	0.77 (0,0027)	0.00	0.41
2	0.05 (0,000)	0.41 (0,0114)	0.00	0.37
3	0.05 (0,000)	0.36 (0,0247)	0.00	0.47
4	0.05 (0,000)	0.17 (0,2974)	0.00	0.16
5	0.05 (0,0001)	0.13 (0,5302)	0.00	-0.04
6	0.05 (0,0015)	0.20 (0,4806)	0.00	0.05
7	0.05 (0,0217)	-0.04 (0,939)	0.00	-0.26
8	-0.15 (0,9524)	6.68 (0,9367)	0.00	-105.12

Table 20: Generalised Method of Moments Results for Brazil: Sub Period 1

Number of Lags	ψ	θ_1	χ^2	R^2
1	0.10 (0,000)	-0.15 (0,0004)	0.00	0.25
2	0.11 (0,000)	-0.19 (0,0002)	0.00	0.07
3	0.12 (0,000)	-0.20 (0,0008)	0.00	-0.34
4	0.14 (0,000)	-0.24 (0,0003)	0.00	-0.56
5	0.16 (0,0008)	-0.30 (0,0035)	0.00	-0.30
6	0.26 (0,0584)	-0.54 (0,0921)	0.00	-3.35
7	0.36 (0,1712)	-0.76 (0,2099)	0.00	-7.06
8	0.34 (0,1783)	-0.70 (0,2214)	0.00	-5.91

Table 21: Generalised Method of Moments Results for South Africa: Sub Period 2

Number of Lags	ψ	θ_1	χ^2	R^2
1	-0.04 (0,2341)	1.71 (0,000)	0.00	0.44
2	0.03 (0,6458)	0.86 (0,0145)	0.00	0.09
3	0.10 (0,2008)	0.06 (0,8982)	0.00	-0.03
4	0.17 (0,0809)	-0.98 (0,1534)	0.00	0.08
5	0.16 (0,0867)	-0.87 (0,2223)	0.00	0.04
6	0.14 (0,1091)	-0.65 (0,3568)	0.00	-0.00
7	0.12 (0,1673)	-0.24 (0,6978)	0.00	-0.03
8	0.10 (0,2706)	0.12 (0,6819)	0.00	-0.03

Table 22: Generalised Method of Moments Results for Poland: Sub Period 2

Number of Lags	ψ	θ_1	χ^2	R^2
1	0.03 (0,0033)	-0.78 (0,3817)	0.00	-0.20
2	0.04 (0,0482)	-1.85 (0,4836)	0.00	-1.14
3	0.01 (0,8092)	3.35 (0,5012)	0.00	0.05
4	0.02 (0,0018)	1.06 (0,4162)	0.00	0.05
5	0.02 (0,0022)	0.89 (0,4291)	0.00	-0.06
6	0.02 (0,0135)	0.90 (0,4485)	0.00	-0.19
7	0.02 (0,1269)	1.12 (0,4696)	0.00	-0.43
8	0.01 (0,6058)	1.70 (0,5079)	0.00	-0.02

Table 23: Generalised Method of Moments Results for China: Sub Period 2

Number of Lags	ψ	Θ_1	χ^2	R^2
1	3.15 (0,8295)	-64.43 (0,8304)	0.00	-19.78
2	1.70 (0,6382)	-34.93 (0,6416)	0.00	-7.37
3	0.27 (0,000)	-5.28 (0,000)	0.00	-0.38
4	0.38 (0,0265)	-7.60 (0,0393)	0.00	-0.87
5	1.89 (0,7369)	-39.65 (0,7395)	0.00	-21.81
6	2.19 (0,6669)	-46.59 (0,6708)	0.00	-27.34
7	0.55 (0,0603)	-11.50 (0,0783)	0.00	-2.77
8	0.38 (0,0271)	-7.96 (0,0429)	0.00	-1.57

Table 24: Generalised Method of Moments Results for Chile: Sub Period 2

Number of Lags	ψ	θ_1	χ^2	R^2
1	0.03	-0.97	0.00	-0.78
	(0,0554)	(0,2064)		
2	0.04	-3.56	0.00	-7.58
	(0,3359)	(0,773)		
3	0.02	0.62	0.00	-0.02
	(0,0155)	(0,6638)		
4	0.02	0.75	0.00	-0.17
	(0,2482)	(0,6672)		
5	-0.06	8.04	0.00	-4.26
	(0,2741)	(0,273)		
6	-0.01	2.71	0.00	-0.37
	(0,7192)	(0,3147)		
7	-0.03	5.84	0.00	-3.36
	(0,6565)	(0,4906)		
8	-0.26	24.48	0.00	-187.95
	(0,8941)	(0,8909)		

Table 25: Generalised Method of Moments Results for Brazil: Sub Period 2

Number of Lags	ψ	Θ_1	χ^2	R^2
1	0.04 (0,1243)	-0.12 (0,3134)	0.00	-0.04
2	0.05 (0,1797)	-0.14 (0,3443)	0.00	-0.16
3	0.06 (0,269)	-0.17 (0,3986)	0.00	-0.38
4	0.08 (0,3988)	-0.26 (0,4762)	0.00	-0.87
5	0.12 (0,5269)	-0.41 (0,5663)	0.00	-1.63
6	0.18 (0,6251)	-0.61 (0,6467)	0.00	-2.82
7	0.27 (0,6966)	-0.90 (0,7098)	0.00	-5.12
8	0.40 (0,75)	-1.31 (0,759)	0.00	-8.98

Figure 11: South Africa Real GDP Growth (DLRGP) and Term Structure (TERM1)

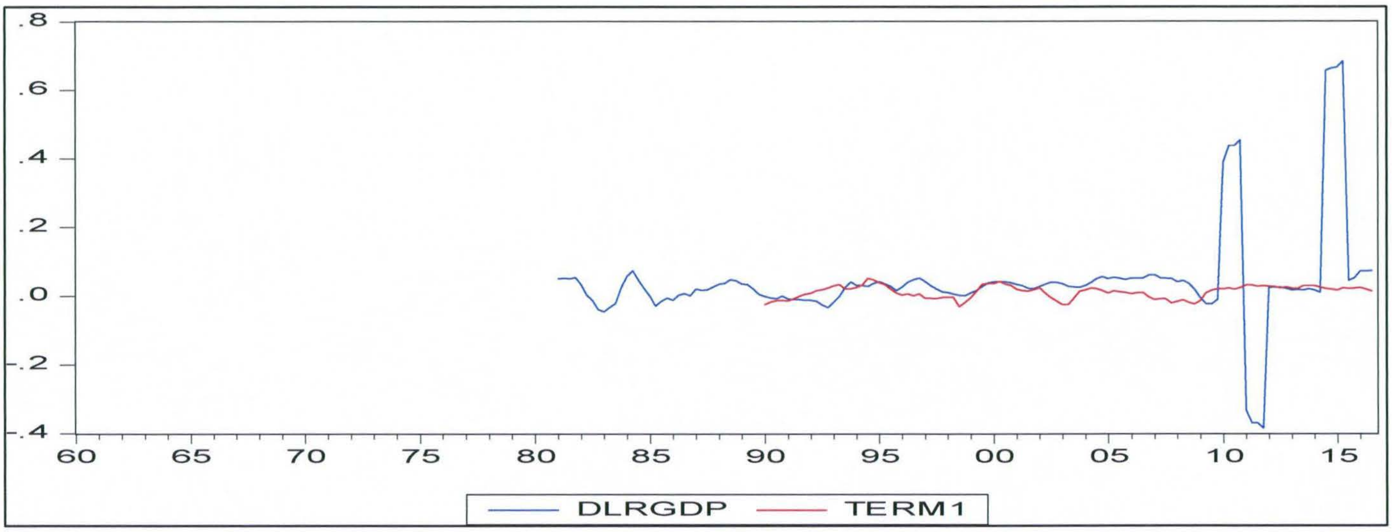


Figure 12: Poland Real GDP Growth (DLRGP) and Term Structure (TERM1)

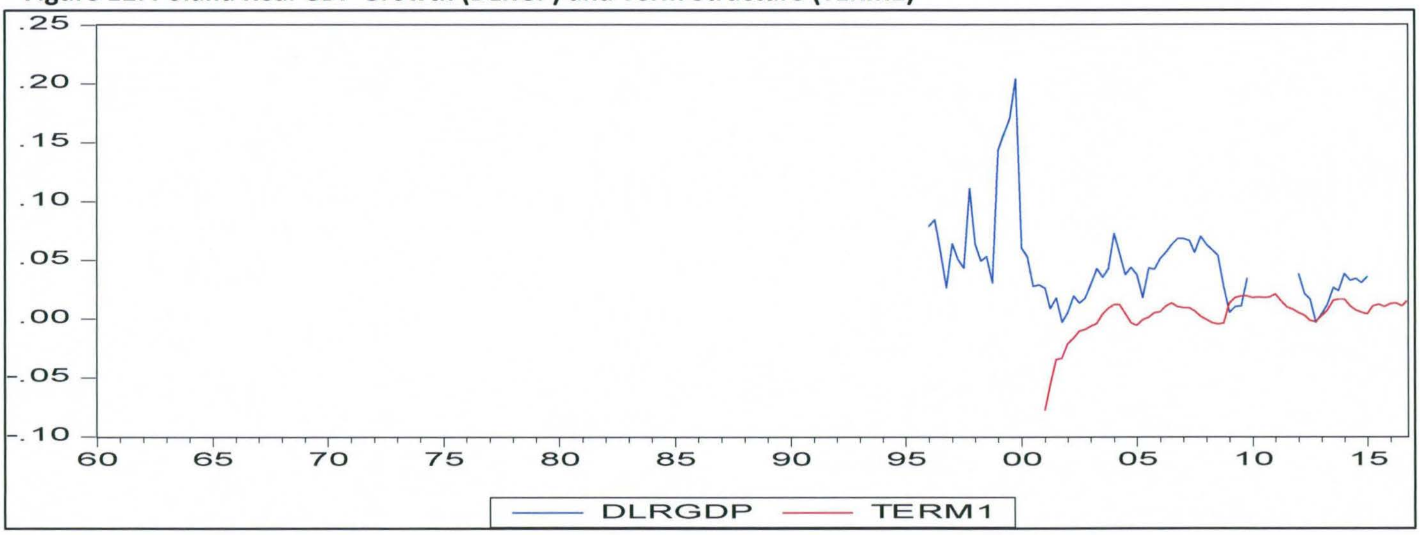


Figure 13: China Real GDP Growth (DLRGP) and Term Structure (TERM1)

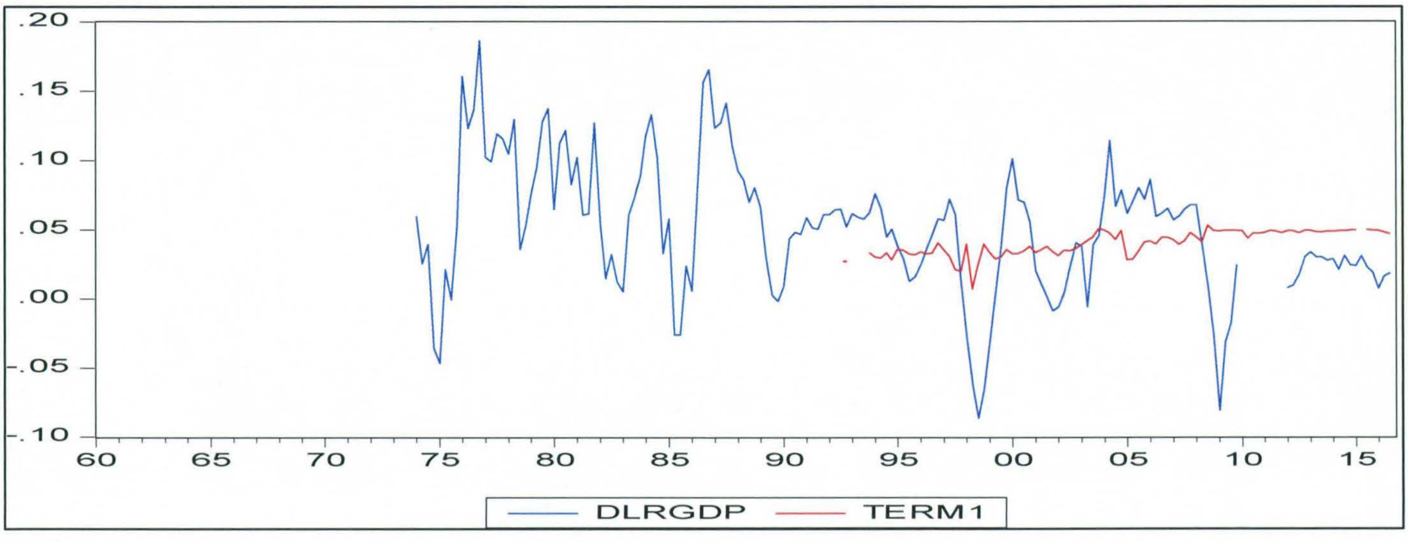


Figure 14: Chile Real GDP Growth (DLRGP) and Term Structure (TERM1)

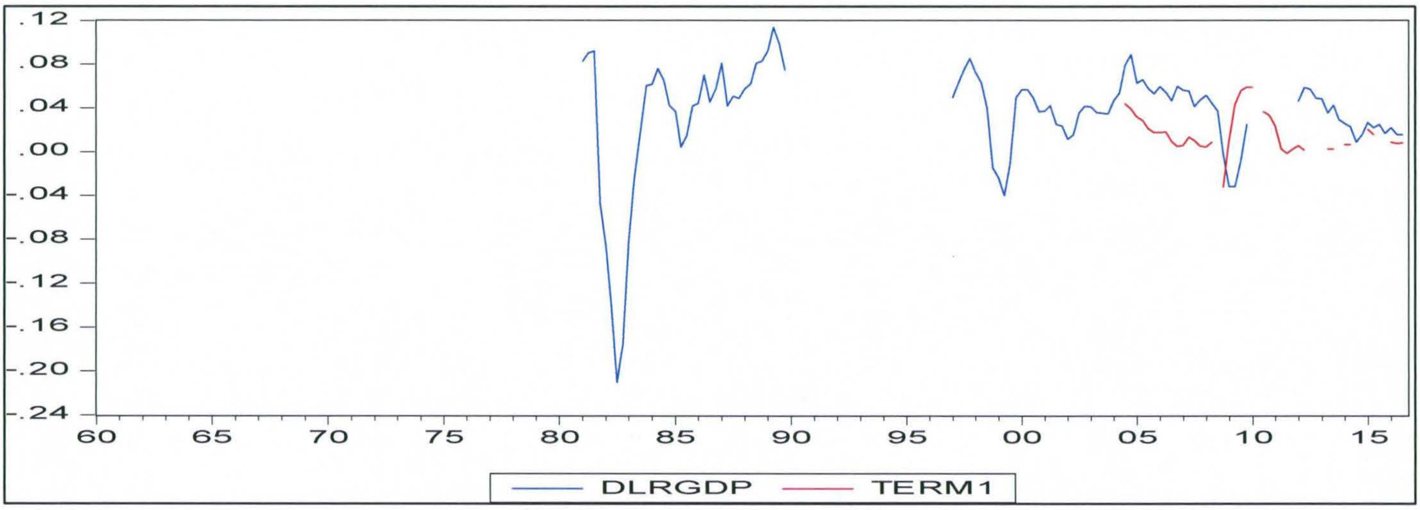


Figure 15: Brazil Real GDP Growth (DLRGP) and Term Structure (TERM1)