Temporal homogeneity between financial stress and the economic cycle

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Abstract

This paper analyses the homogeneity of temporal variations between the economic and financial cycles in South Africa. This is achieved by identifying the similarity of cyclical and volatility regime changes between the indicator of financial stress and the economic cycle. The results show that periods of moderate growth in financial stress coincide with periods of similar growth in the economic cycle whereas the periods of high growth in financial stress coincide with periods of low growth in the economic cycle. The results further show that the periods of low volatility of financial stress coincide with periods of similar volatility of the economic cycle and that the periods of high volatility of financial stress coincide with periods of similar volatility of the economic cycle with the exception of the period following the US war on terror where the volatility of the economic cycle remained low despite high volatility of financial stress. Although the results show that the cyclical regime shifts of financial stress occur earlier than those of the economic cycle, they do not conclusively show whether or not the volatility regime changes of financial stress occur earlier or later than those of the economic cycle perhaps on data frequency.

JEL Classification: C13, E32, G12
Keywords: Economic cycle, Financial stress, Change point analysis

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Introduction

The dynamic relationship between the economic variables is a subject of great interest among economists and policy makers. This is particularly the case with the economic and financial variables whose temporal structure has become increasingly important since the global financial crisis. The renewed interest is because the severity of the recent financial crises have highlighted the importance of financial variables in macroeconomic fluctuations. According to BCBS (2010) and Taylor (2013), economic and financial variables are related and hence the misalighnments in credit, money, house prices, equity prices, market rates and exchange rates have important implications for economic conditions in real markets. Since the recent global financial crisis, there is a notable resurgence in the literature on the role of asset price misalignments in macroeconomic fluctuations. Notable contributions to the empirical literature on the interaction between the economic and financial cycles during different phases of the business cycles include Claessens et al. (2012), Borio et al. (2012), Borio (2014) and Hiebert et al. (2015). The other strand of literature, that include Borio et al. (2012), Drehmann and Tsatsaronis (2000) and Hiebert et al. (2015) studies the dynamic relationship between several economic and financial variables, while similar studies in South Africa include Raputsoane (2015a) and Bernstein et al. (2016).

The recent financial crisis has highlighted the need to develop economic models to analyse financial markets and real economy within a unified framework. Consequently, the existing literature has identified a number of stylised facts on the temporal structure of economic and financial cycles. For instance, Stock and Watson (1999)) suggests that the business cycle normally last between 6 to 32 months. Among the other stylised features of the economic and financial cycles, BCBS (2010) and Borio et al. (2012) argue that the fluctuations in output growth has a higher frequency than the occurrences of the distressed economic conditions that are associated with serious financial crises hence the episodes of financial distress are rare and reflect longer and larger cycles in credit and asset prices. However, according to Claessens et al. (2012), the empirical knowledge about the interactions between real and financial sectors during the different phases of business and financial cycles is still rather limited. This is particularly the case with the composite indicator of financial stress that takes into account asset prices, such as currency and equity markets variables, contrary to the financial cycle, that Drehmann et al. (2011) and Drehmann and Tsatsaronis (2000) argue, is more parsimoniously described is in terms of credit and property prices that are mostly dominated by their low frequency components.

This paper analyses the homogeneity of temporal variations between financial stress and the economic cycle in South Africa. This is achieved by identifying the similarity of cyclical and volatility regime changes between the indicator of financial stress and the economic cycle. The indicator of financial stress is approximated as a composite index that aggregates the financial market variables that include the money and equity markets as well as the commodity and foreign exchange markets. According to Borio et al. (2012), the economic environment that has prevailed in recent decades necessitate a rethink of the modelling strategies and hence important adjustments to macroeconomic policies. Claessens and Kose (2013) further argue that the financial crises often require immediate and comprehensive policy responses and necessitate major coordination of financial, monetary and fiscal policies. Thus studying the homogeneity of temporal variations between financial stress and the economic cycle is important because it will facilitate the proper understanding of the dynamic interaction of financial variables and the economic variables. This will help policy makers to design informed policies to avert future financial crises and the associated economic recessions ensuring macroeconomic stability.

The paper is organised as follows. The next section describes the data, in particular, the economic cycle and the indicator of financial stress. This is followed by the methodology which outlines the analysis of homogeneity of the temporal variations in the variables. Then its the discussion of the empirical results and the associated findings and last is the conclusion.

Data

Monthly data spanning the period January 2000 to December 2016 is used in the paper. The data is sourced from the South African Reserve Bank. The coincident business cycle indicator, denoted economic cycle, is a proxy of the Gross Domestic Product (GDP) gap. The economic cycle is constructed as the deviation of the coincident business cycle index from its Hodrick and Prescott (1997) trend. 12 months are forecasted at the end of the coincident business cycle index data series to correct the end point problem following Ravn and Uhlig (2002) and Mise et al. (2005). Financial stress is the composite indicator of variables that cover the main segments of the South African financial market. Financial stress is not directly observable and is assumed to be reflected in the fluctuations of the financial market variables. The indicator of financial stress is constructed as a composite index that cover the main segments of the South African financial market that include the money and equity markets as well as the commodity and foreign exchange markets. The financial stress indicator variables comprise a set of 15 variables and these are described in Table 1. The selection of the variables that are used in the construction of the indicator of financial stress relied on the existing literature as well as on the relevance of such variables in capturing the distress in financial markets as ell as the availability of data.

Table 1: Financial stress indicator variables

Variable	Description
Interbank spread	Spread between the 3 month JIBAR rates and the 3 month Treasury bill rate
Future spread	Spread between the 3 month FRAs and the 3 month treasury bill rate
Government bond spread	Spread between the yield on 3 year government bond and the yield on 10 year government bond
A rated bond spread	Spread between the yield on A rated Eskom bond and the yield on 10 year government bond
Corporate bond spread	Spread between the FTSE/JSE All Bond yield and the yield on 10 year government bond
Stock market return	Annual change in the FTSE/JSE All Share stock market index
Financial sector return	Annual change in the FTSE/JSE Financials stock market index
Banking sector return	Annual change in the FTSE/JSE Banks stock market index
Financial sector beta	CAPM beta of the one year rolling window of the annual FTSE/JSE Financials stock market index returns
Banking sector beta	CAPM beta of the one year rolling window of the annual FTSE/JSE Banks stock market index returns
Nominal eff. exchange rate return	Annual change in nominal effective exchange rate
Credit extension growth	Annual change in total private credit extension
Property market return	Annual change in the average price of all houses compiled by the ABSA bank
Commodity market return	Annual change in the Economist's commodity price index
Oil market return	Annual change in the Brent crude oil price
VIX S&P500	Chicago Board's implied volatility of the S&P 500 index

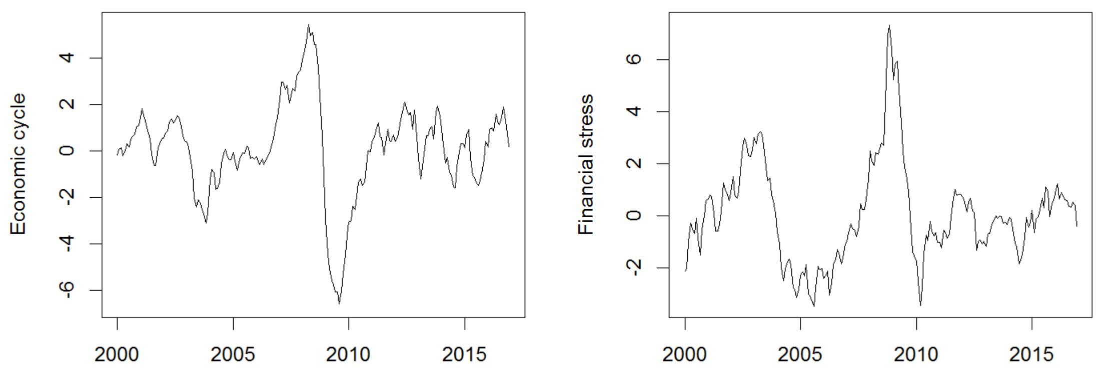
Notes: Own calculations with data from the South African Reserve Bank. JIBAR rate is the Johannesburg Interbank Agreed Rate, FRAs are the Forward Rate Agreements, Eskom is a state owned entity for electricity generation, FTSE/JSE is the Johannesburg Stock Exchange Limited and the Financial Times Stock Exchange Group, CAPM is the Capital Asset Pricing Model, ABSA is a commercial bank and S&P is Standard & Poor's.

The financial stress indicator variables were standardised and then aggregated using the principal components analysis weighting scheme. The standardisation involved demeaning the variables by subtracting their respective means and then dividing them by their respective standard deviations. As such, a value of 1 in each one of these variables represents a 1 standard deviation difference from their mean value over the sample period. The implied weights of the first component from the Principal components analysis were used to aggregate the financial stress variables. Principal components is a dimension reduction method of extracting the factors that are responsible for ensuring the comovement of a group of variables. It used to reduce a set of the financial stress indicator variables to an index that contains most of the information in these variables. Financial stress differs from the financial cycle that is proposed by Claessens et al. (2012), Borio et al. (2012), Borio (2014) that is identified with the aggregation of the medium term component of the fluctuations of credit extension and property prices. In contrast, financial stress is identified with the aggregation of the short term component of the fluctuations of the money and equity markets as well as the commodity and foreign exchange markets variables.

Financial stress captures the interruption of the normal functioning of the financial markets. This interruption is characterised by increased uncertainty about the fundamental values of financial assets, increased information asymmetry and heightened aversion from holding illiquid and risky assets that result in liquidity shortages as well as significant shifts in asset prices. Similar indicators of financial stress have been constructed by Illing and Liu (2006), Balakrishnan et al. (2011), Cardarelli et al. (2011), Hakkio and Keeton (2009), Cevik et al. (2013) as well as Raputsoane (2014, 2015b), among others while Kliesen et al. (2012) further provides a survey of the similar the indicators of financial stress. The indicators of financial stress are also constructed and issued by different institutions that include the Federal Reserve Systems of Kansas City, Saint Louis, Chicago and Cleveland as well as Bank of Canada and the European central bank, the Organisation for Economic Co-operation and Development and the International Monetary fund. Kliesen et al. (2012) survey the literature on the indicators of financial stress by comparing their datasets and find that, although they are different in their construction, the correlation between them is high given that each of the indicators measure the same thing in principle.

Figure 1 depicts the evolution of the main variables. Financial stress exhibits two distinct peaks in middle of 2003 that coincides with the war on terror following the 9/11 attacks as well as in late 2008 following the build up of financially stressed financial markets that culminated into the the global financial crisis. The indicator increased steadily from the beginning of 2000 reaching a peak in middle of 2003 where it then decreased notably reaching a low in the middle of 2004. Financial stress then remained range bound to early 2006 where it increased markedly reaching an all time high towards the end of 2008. The indicator then fell sharply reaching an all time low in early 2010, due to onset of the financial crisis, where it increased again reaching its long term average in late 2010. The indicator then experienced range bound volatility to the end of 2016 with notable increase in early 2012 as a decline in the middle of 2014. The movements in the economic cycle largely mirror those of financial stress where the indicator increased steadily reaching an all time high in the second half of 2008. It dropped dramatically reaching an all time low towards the end of 2009 following some range bound volatility from the beginning of the sample to early 2003 as well as from late 2010 to the end of the sample. The economic cycle exhibits two distinct troughs in late 2003 as well as in late 2009 contrary to financial stress.

Figure 1: Plots of the main variables



Notes: Own calculations with data from the South African Reserve Bank. Economic cycle is the deviation of the coincident business cycle indicator from its long term trend and is measured in percentage points. Financial stress is a composite index of financial market variables that include the money and equity markets as well as the commodity and currency markets and is measured in standard deviations from the mean value of the variable.

Methodology

The homogeneity of temporal variations between financial stress and the economic cycle in South Africa is identified using the change point analysis method. The change point analysis method was suggested by Eckley et al. (2010) and Eckley et al. (2012) and is described in detail by Eckley and Killick (2014). In particular, the change point analysis method is implemented for the change in mean and variance settings hence it will help identify the similarity of the cyclical and volatility regime changes between financial stress and the economic cycle. According to Beaulieu et al. (2012) and Eckley and Killick (2014), a change point is an instance where the statistical properties of an economic data series differ before and after any particular point in time. Thus the challenge of the change point analysis method is the detection of change points to identify their optimal number and location in a data series. Eckley and Killick (2014) further argue that the change point analysis method provides a choice of search algorithms for multiple change point detection in addition to a variety of test statistics. In this instance, the change point analysis method that will be used to detect the regime changes in financial stress and the economic cycle time series variables is the Pruned Exact Linear Time (PELT) algorithm.

The change point analysis model is specified following Eckley and Killick (2014) where an ordered sequence of data, $y_t = (y_1, ..., y_n)$, where n is the sample size, is assumed. A change point is said to occur within this data set when there exists a time, τ, such that the statistical properties of $(y_1, ..., y_\tau)$ and $(y_{\tau+1}, ..., y_n)$ are different where the preceding is an example of a single change point. The detection of a single change point can be posed as a hypothesis test where the null hypothesis, H_0, corresponds to no change point $(m = 0)$ and the alternative hypothesis, H_1, is a single change point $(m = 1)$. The general likelihood ratio based approach is used to test the hypothesis. A test statistic can be constructed which we will use to decide whether a change has occurred. The likelihood ratio method requires the calculation of the maximum log likelihood under both null and alternative hypotheses. The null hypothesis the maximum log-likelihood function

$$\log p\left(y_t \mid \hat{\theta}\right) \tag{1}$$

is the probability density function, $p(\cdot)$, associated with the distribution of the data and $\hat{\theta}$ is the maximum likelihood estimate of the parameters. Under the alternative hypothesis, the maximum log likelihood for a given change point at time τ is

$$ML(\tau) = \log p\left(y_t \mid \hat{\theta_1}\right) + \log p\left(y_{t+1} \mid \hat{\theta_2}\right) \tag{2}$$

The maximum log-likelihood value under the alternative is $\max_\tau ML(\tau)$, given the discrete nature of the change point location, where the maximum is taken over all possible change point locations. The test statistic is

$$\lambda = 2\left[\max_{\tau} ML(\tau) - \log p\left(y_t \mid \hat{\theta}\right)\right] \tag{3}$$

The test involves choosing a threshold, c, such that the null hypothesis is rejected if $\lambda > c$. If we reject the null hypothesis, i.e. detect a change point, then its position is estimated as $\hat{\tau}$ the value of τ that maximises $ML(\tau)$. However, as argue Lavielle (2005) as well as Birge and Massart (2007), the appropriate value for the parameter c is still an open research question and typically depends on many factors including the size of the change points as well as the length of segments between the change points, both of which are unknown prior to analysis.

In a multiple change point setting, or a generalised setting, denote the number of change points, m, and their positions, $\tau_t = (\tau_1, ..., \tau_n)$. Each change point position is an integer between 1 and $n - 1$ inclusive so that the m change points will split the data into $m + 1$ segments with with the i^{th} segment containing data $y_{\tau_{i-1}+1}$. The parameters associated with the i^{th} segment is denoted θ_i, ϕ_i, where ϕ_i are nuisance parameters and θ_i is the set of parameters that contain the change points. The number of the needed segments to represent the data, i.e. how many change points are present and estimate the values of the parameters associated with each segment, are tested. The likelihood test statistic can be extended to multiple changes by summing the likelihood for each of the m segments. According to Eckley and Killick (2014), the common approach to identify multiple change points is to minimise

$$\sum_{i=1}^{m+1} \left[C(y_{\tau_{i-1}+1}) \right] + \beta f(m) \tag{4}$$

where C is the cost function for a segment and $\beta f(m)$ is a penalty to guard against over fitting. The change point search algorithms that minimise Equation (2) are the segment neibourhood (SN) algorithm proposed by Auger and Lawrence (1989) and Bai and Perron (1998) as well as the Pruned Exact Linear Time (PELT) algorithm proposed by Eckley et al. (2012).

The segment neibourhood (SN) algorithm minimises algorithm minimizes the expression given by Equation (4) exactly using a dynamic programming to obtain the optimal segmentation for $m + 1$ change points reusing the information that was calculated for m change points. This reduces the computational complexity from $\delta(2^n)$ for a naive search to $\delta(\sigma n^2)$ where σ is the maximum number of change points to identify. Whilst this algorithm is exact, the computational complexity is considerably higher. The Pruned Exact Linear Time (PELT) algorithm is similar to the Segment Neibourhood (SN) algorithm. This algorithm is more computationally efficient due to its use of dynamic programming and pruning which can result in an $\delta(n)$ search algorithm. The algorithm reduces computational time by assuming that the number of change points increases linearly as the data set grows, i.e. change points are spread throughout the data rather than confined to one portion. As discussed, the change point analysis method is implemented for the change in mean and variance settings hence it will help identify the similarity of cyclical and volatility regime changes between the indicator of financial stress and the economic cycle. The cyclical regime shifts are characterised by the low growth, or trough phase, moderate growth, or the medium phase, and the high growth, or peak phase, of financial stress and the economic cycle. The volatility regime changes are characterised by the periods of low volatility, medium volatility as well as high volatility of financial stress and the economic cycle.

Results

The homogeneity of temporal variations between financial stress and the economic cycle in South Africa is identified using the change point analysis method. In particular, the Pruned Exact Linear Time (PELT) change points search algorithm proposed by Eckley et al. (2012) is implemented for multiple change point detection in the selected variables. The change point analysis model requires the specification of the test statistic, or the assumed distribution for data, the maximum number of change points to search for, the minimum segment length between change points as well as the penalty value, or the cost function for identification of the segments, among others. According to Eckley and Killick (2014), there several standard penalty functions within change point analysis that include the Schwarz information criteria, the Bayesian information criteria, the Akaike information criteria and the Hannan Quinn information criteria. Lavielle (2005) and Birge and Massart (2007), among others, argue that the choice of the appropriate penalty is an open question and typically depends on many factors including the size of the changes and the length of segments, both of which are unknown prior to analysis. Consequently, the Pruned Exact Linear Time (PELT) algorithm allows a manual penalty function to be set pending the plausibility of the results. As discussed, the change point analysis method is implemented for the change in mean and variance settings hence it will help identify the similarity of cyclical and volatility regime changes between financial stress and the economic cycle.

Table 2 shows the results of the change point analysis for the changes in mean. The cyclical regime shifts in financial stress and the economic cycle are characterised by low growth, which is the trough phase, moderate growth, which is the medium phase, and high growth, which is peak phase. The cyclical regime shifts are realised by splitting the variables into quartiles. The variables are split such that their values below 1^{st} quartile characterise low growth, values between 1^{st} quartile and 3^{rd} quartile characterise moderate growth while values above 3^{rd} percentile characterise the high growth. The 1^{st} quartile of the economic cycle is -0.674930 such that the values below is number represent low growth, the 3^{rd} quartile of the economic cycle is 1.109630 such that the values above is number represent high growth while the values of financial stress that fall between the 1^{st} quartile and the 3^{rd} quartile characterise moderate, or trend, growth of the economic cycle. The 1^{st} quartile of financial stress is -1.086800 such that the values below is number represent low growth, the 3^{rd} quartile of financial stress is 0.818250 such that the values above is number represent high growth while the values of financial stress that fall between the 1^{st} quartile and the 3^{rd} quartile characterise moderate, or trend, growth of financial stress.

Table 2: Results for the changes in mean

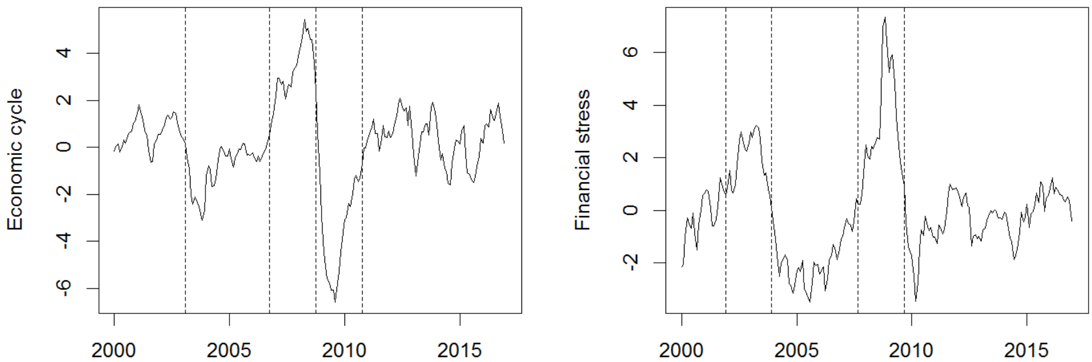
Economic cycle			Financial cycle		
Period	Value	Mean	Period	Value	Mean
2000-01	-0,16928	0.60690	2000-01	-2,13067	-0.40830
2003-03	-0,43947	-1.88952	2001-08	0,17694	1.77644
2004-06	-1,33359	-0.12243	2003-12	0,09702	-1.97594
2006-12	1,45882	3.38243	2007-06	-0,80318	1.36945
2008-11	0,63524	-4.35227	2008-06	2,57518	4.86908
2010-04	-2,50496	0.29574	2009-06	2,47806	-0.25630
-2*LogLik		560.131	-2*LogLik		566.670
-2*LogLik+pen		679.789	-2*LogLik+pen		686.328

Notes: Own calculations with data from the South African Reserve Bank. Period are change point locations, or a specific point in time that a change point occurs. Value is observation of the variable at a specific point in time at which a change point occurs. Mean is average value of the segment at a specific period in time between any two change points for the economic cycle and Financial cycle, respectively, -2*LogLik is the log likelihood of occurrence of the change points for the fitted data and -2*LogLik+pen is the log likelihood with the penalty.

The change point search algorithm for the changes in mean is set up as follows: The search algorithm is the Pruned Exact Linear Time (PELT). The test statistic, or the assumed distribution for data is the normal distribution. The maximum number of change points to search for is set at 10. The minimum segment length, or the number of observations between change points, is set at 12 months, or a year. The penalty value, or a cost function which determines the sensitivity of the change point analysis method in identifying the change point segments, is manual and is set at $4.5 * \log(\mathrm{n})$ where n is the number of observations in the economic cycle and the indicator of financial stress. The results of the likelihood statistics show that the change points search algorithm has a marginally higher likelihood of identifying the change points of financial stress at 566.670 and 686.328 for the log likelihood and the log likelihood coupled with the penalty, respectively, compared to 560.131 and 679.789 for the log likelihood and the log likelihood coupled with the penalty, respectively. This means that the Pruned Exact Linear Time (PELT) change points search algorithm has a higher probability of locating the change in mean, or cyclical regime shifts, in financial stress while it has a lower probability of locating the change in mean, or cyclical regime shifts, in the economic cycle over the sample period.

The results show that the change points search algorithm has identified 5 change points, or cyclical regime shifts, in both the economic cycle and financial stress. Recall that the cyclical regime shifts in financial stress and the economic cycle are characterised by low growth, which is trough phase, moderate growth, which is the medium phase, and high growth, which is peak phase. The economic cycle realised low growth in the periods between March 2003 and June 2004 as well as between November 2008 and April 2010 while high growth was recorded between December 2006 and November 2008 whereas the indicator realised moderate growth in the other periods. Financial stress realised low growth in the period between December 2003 and June 2007 while high growth was recorded between August 2001 and December 2003 as well as between June 2007 and April 2010 whereas the indicator realised moderate growth in the other periods. Thus the results show that the periods of moderate growth in financial stress coincide with periods of moderate growth in the economic cycle whereas the periods of high growth in financial stress coincide with periods of low growth in the economic cycle. The results further show that the change points, or cyclical regime shifts, of financial stress occur somewhat earlier than of economic cycle. Figure 2 is the pictorial depiction of the results of the change points analysis using the Pruned Exact Linear Time (PELT) search algorithm for the changes in mean.

Figure 2: Plots of the changes in mean



Notes: Own calculations with data from the South African Reserve Bank. Economic cycle is the deviation of the coincident business cycle indicator from its long term trend. Financial stress is a composite index that aggregates the financial market variables that include the money and equity markets as well as the commodity and currency markets. Vertical broken lines mark the change points locations in financial stress and the economic cycle.

Table 3 shows the change point analysis results for the changes in variance using the Pruned Exact Linear Time (PELT) algorithm. The volatility regime changes are characterised by the periods of low volatility, medium volatility as well as high volatility of financial stress and the economic cycle. The volatility regime changes are realised by splitting the variables into squared series of their standard deviations. The variables are split such that their values below 1^{st} power of the standard deviation characterise low volatility, values between 1^{st} and 3^{rd} powers of the standard deviation characterise moderate volatility while values above 3^{rd} power of the standard deviation characterise the high volatility. The 1^{st} power of the standard deviation of the economic cycle is 2.039966 such that the values below is number represent low volatility, the 3^{rd} power of the standard deviation of the economic cycle is 4.161461 such that the values above is number represent high volatility while the values of the economic cycle that fall in the middle characterise moderate volatility. The 1^{st} power of the standard deviation of financial stress is 1.935110 such that the values below is number represent low volatility, the 3^{rd} power of the standard deviation of financial stress is 3.744650 such that the values above is number represent high volatility while the values of financial stress that fall in the middle of the 1^{st} and the 3^{rd} of the power of the standard deviation characterise moderate, or trend, volatility.

Table 3: Results for the changes in variance

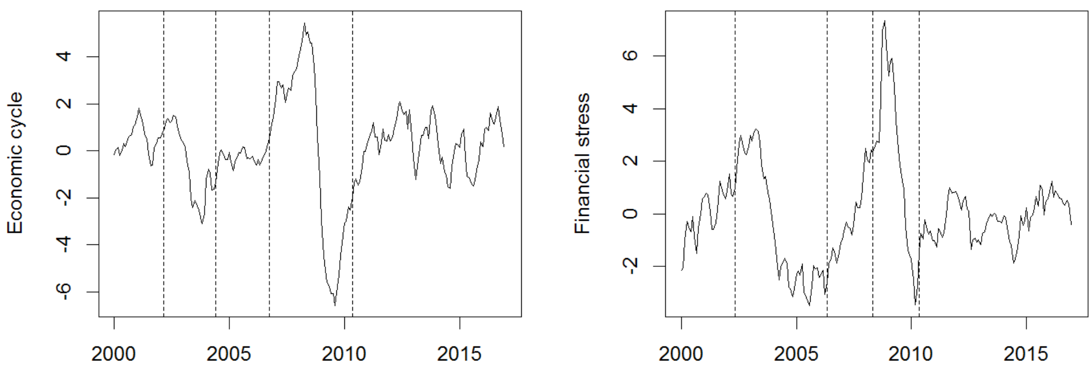
Economic cycle			Financial cycle		
Period	Value	Variance	Period	Value	Variance
2000-01	-0,16928	0.42935	2000-01	-2,13067	0.86728
2003-04	-0,90220	0.48448	2002-05	0,95361	4.98871
2004-06	-1,33359	0.08428	2006-11	-1,64138	0.29975
2006-10	0,51583	15.47165	2007-11	0,61114	8.73121
2010-05	-1,96909	0.98799	2010-05	-1,45722	0.53322
-2*LogLik		657.453	-2*LogLik		689.958
-2*LogLik+pen		699.998	-2*LogLik+pen		732.503

Notes: Own calculations with data from the South African Reserve Bank. Period are change point locations, or a specific point in time that a change point occurs. Value is observation of the variable at a specific point in time at which a change point occurs. Mean is average value of the segment at a specific period in time between any two change points for the economic cycle and Financial cycle, respectively, -2*LogLik is the log likelihood of occurrence of the change points for the fitted data and -2*LogLik+pen is the log likelihood with the penalty.

The change points search algorithm for the changes in variance is set up as follows: The test statistic, or the assumed distribution for data is the normal distribution. The maximum number of change points to search for is set at 10. The minimum segment length, or the number of observations between change points, is set at 12 months, or a year. The penalty value, or a cost function which determines the sensitivity of the change point analysis method in identifying the change point segments, is manual and is set at $2.0 * \log(n)$ where n is the number of observations in the economic cycle and financial stress. The results of the likelihood statistics show that the change points search algorithm has a somewhat higher likelihood of identifying the change points of financial stress at 689.958 and 732.503 for the log likelihood and the log likelihood coupled with the penalty, respectively compared to 657.453 and 699.998 for the log likelihood and the log likelihood coupled with the penalty, respectively. Thus the Pruned Exact Linear Time (PELT) change points search algorithm has a higher probability of locating the change in variance, or volatility regime changes, in the indicator of financial stress while it has a lower probability of locating the change in variance, or volatility regime changes, in the economic cycle during the sample period in contrast to the change point analysis results of the changes in mean.

The the results show that the change points search algorithm has identified 5 change points, or volatility regime changes, in both the economic cycle and financial stress. Recall that the volatility regime changes are characterised by the periods of low volatility, medium volatility as well as high volatility of financial stress and the economic cycle. The economic cycle realised low volatility in the periods between January 2000 and October 2006 as well as between May 2010 and December 2016 while high volatility was recorded between October 2006 and May 2010. Financial stress realised low volatility between January 2000 and May 2002, November 2006 and November 2007 as well as between May 2010 and December 2016. High volatility was recorded between May 2002 and November 2006 as well as between November 2007 and may 2010. Thus the periods of low volatility of financial stress coincide with similar periods of the economic cycle similar to the periods of high volatility of financial stress which also coincide with similar periods of the economic cycle. The exception is the period following the US war on terror where the volatility of the economic cycle remained low despite high volatility of financial stress. The results do not show conclusively whether or not the volatility regime changes of financial stress occur earlier or later than that of economic cycle perhaps due to the frequency of the data. Figure 3 is the pictorial depiction of the results of the change points analysis using the Pruned Exact Linear Time (PELT) search algorithm for the changes in variance.

Figure 3: Plots of the changes in variance



Notes: Own calculations with data from the South African Reserve Bank. Economic cycle is the deviation of the coincident business cycle indicator from its long term trend. Financial stress is a composite index that aggregates the financial market variables that include the money and equity markets as well as the commodity and currency markets. Vertical broken lines mark the change points locations in financial stress and the economic cycle.

In summary, the Pruned Exact Linear Time (PELT) change points search algorithm has a higher probability of locating the change in mean, or cyclical regime shifts, as well as the change in variance, or volatility regime changes, in financial stress while it has a marginally lower probability of locating the change in mean, or cyclical regime shifts, in the economic cycle. The periods of moderate growth in financial stress coincide with periods of moderate growth in the economic cycle whereas the periods of high growth in financial stress coincide with periods of low growth in the economic cycle. The results further show that the change points, or cyclical regime shifts, of financial stress occur somewhat earlier than of economic cycle. The results also show that the periods of low volatility of financial stress coincide with periods of low volatility of the economic cycle whereas the periods of high volatility of financial stress coincide with periods of high volatility of the economic cycle. The exception is between May 2002 and November 2006 where the volatility of the economic cycle remained low despite high volatility of financial stress. The results do not conclusively show whether or not the change points, or volatility regime changes, of financial stress occur earlier or later than than those of economic cycle.

Conclusion

This paper analysed the homogeneity of temporal variations between the economic and financial cycles in South Africa. This was achieved by identifying the similarity of cyclical and volatility regime changes between the indicator of financial stress and the economic cycle. The results show that the periods of moderate growth in financial stress coincide with periods of moderate growth in the economic cycle whereas the periods of high growth in financial stress coincide with periods of low growth in the economic cycle. The results further show that the periods of low volatility of financial stress coincide with periods of low volatility of the economic cycle whereas the periods of high volatility of financial stress coincide with periods of high volatility of the economic cycle. The exception is in the period following the US war on terror where the volatility of the economic cycle remained low despite high volatility of financial stress. The results also show that the cyclical regime shifts of the indicator of financial stress occur earlier than those of economic cycle while they do not show conclusively whether or not the volatility regime changes of financial stress occur earlier or later than than those of the economic cycle.

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