Is the South African Business Cycle Time Dependent?

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ABSTRACT

This study is concerned with the South African business cycle and makes use of the hazard function to determine the importance of duration for its analysis. This function gives the conditional probability that a state sustained through a previous period will end in the current one. The study estimates this probability for both economic downturn and expansion. At the 95 per cent confidence level, there is no statistical underpinning found for conventional ideas about the likelihood of an upturn or downturn in the economy over time. The duration of a business cycle does not help predict the turning point.

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INTRODUCTION

Thirteen times in the past fifty-three years, South African business has passed through a crisis. The list of crisis years [1947, 1950, 1953, 1956, 1959, 1961, 1965, 1967, 1972, 1977, 1983, 1986, 1993] (SARB, 1999) shows that the periods between successive crises have varied considerably in length. Further, no two crises have been precisely alike and the differences between some crises have been more conspicuous than their similarities. It is not surprising then, that business long thought of crises as abnormal events brought on by some foolish blunder made by the public or the government (Mitchell, 1923). Longer experience, wider knowledge of business in other countries and better statistical data have gradually discredited the view that the crises are abnormal events, each due to a special cause. The modern view is that crises are but one aspect of recurrent business cycles.

Business cycles refer to short-run fluctuations in general prices which are characterized by business prosperity, recession, depression and recovery (James, 1958). Statistically the term means two things (Schumpeter, 1935):

- that fluctuations of values of economic quantities in historic time, do not display haphazard increase or decrease, but rather recurrence of either these values themselves or values related to them, and

- that these fluctuations do not occur independently in every such time series, but always display their immediate or lagged association with each other.

OBJECTIVE OF THE STUDY

This study seeks to answer the question as to whether the termination probabilities of a business expansion or contraction increase with age. Market views such as "since the economy is bad this year, it will probably be better next year", tacitly imply that duration is a factor in judging the likely course of the economy. This paper investigates whether the assumption is valid for South Africa.

The concept of duration dependence may be illustrated quite simply. Consider first a lottery: A person purchases a lottery ticket every month but has never won the first prize. Is it more likely that he will do so next time, since he has been unlucky for so long? That is, does the probability he will get the first prize increase the longer he has been unlucky? Obviously not, since each lottery is an independent event and the probability of winning the first prize is the same across the number of players (assuming one ticket per player), even though some may be first-time buyers and others regular players. Thus the chances of winning at the lottery show no duration dependence.

Now consider a bingo game: There are 75 balls in a box. Each ball bears a number, from 1 to 75. One ball is drawn every minute. After 25 balls have been drawn, ball number five is required for a call of "bingo". The probability that ball number five is drawn in the 26^{th} draw, given that it has not appeared in the last 25 trials (minutes) is two per cent. The probability of a change in a players state – from being unable to call "bingo" to winning in the 26^{th} trial after 25 minutes is similarly two per cent. In the same way, the probability that ball number five is drawn in the 36^{th} trial, given that it has not appeared in the last 35 trials, rises to 2.5 per cent. This probability rises to 3.33 per cent in the 46^{th} trial, given it has not appeared in the last 45 trials. In this example, the probability that ball number five will be drawn increases the longer it fails to come up. This is an example of an event with positive duration dependence.

Several authors have recently modelled the business cycle as the outcome of a Mitchell process that switches between two discrete states, with one of the states representing expansions and the other representing recessions. However, very different specifications have been adopted for the transition probability governing the movement of the economy between these two states. For example, Neftci (1982) assumed that the transition probabilities were duration dependent; in particular, he contended that the longer the economy remained in one state, the more likely it was to change to the other. In contrast Hamilton (1989) assumed that the state transition probabilities were duration independent so that, for example, after a long expansion (*i.e.*, a long time in the expansion state), the economy was no more likely to switch to the recession state than after a short expansion. This is also the finding of Diebold and Rudebusch (1989).

To resolve the question of duration dependence of expansions and contractions in South Africa, this study investigates the nature of the probability process that generates their length. Of interest, of course, is the significance of the tendency of business fluctuations to maintain a fixed cyclical length. Early on, Irving Fisher (1925) argued that business cycles had no such tendency, but rather resembled "Monte Carlo cycles", the phantom cycles of luck perceived by gamblers at a casino. Similarly, to a casual observer of a repeated coin toss, runs of consecutive heads or tails may appear more likely to end as they grow longer, but the termination probability of a run actually remains constant. As Fisher (1925) would argue, "one may tabulate the number of consecutive heads in repeated trials and may find the average length of these runs, but there is no intrinsic clustering of run lengths or periodicity, in the process". It is precisely this interpretation of weak business cycle periodicity that this study tests as its hypothesis.

HOW BUSINESS CYCLES ARE IDENTIFIED

The South African Reserve Bank has identified the turning points of South Africa's business cycle since 1946. These upper and lower turning points (or peaks and troughs) have generally been regarded as the reference turning points in the South African business cycle.

Pretorius *et al.* (1999) describe the combination of methods used in determining reference turning points:

- First, the composite leading and lagging indicators are calculated (*cf.* Burns & Mitchell, 1946). The composite leading indicator is calculated as a weighted average of a selected number of individual economic indicators that have historically anteceded changes in general economic activity. Similarly, the coincident indicator combines a selected number of economic indicators that have historically coincided with the business cycle (see Table 1).
- Second, a comprehensive composite index [called the current diffusion index] (*cf.* Broida, 1955) is compiled from the actual month to month percentage changes in each of 251 seasonally adjusted economic time series. These series cover economic processes such as production, demand, employment and income in different industries or sectors of the economy. The sectoral contributions are weighted according to their respective

contributions to aggregate value added. As these weights may change over time, the weight assigned to a particular sector is determined as the average of the relative contribution that sector makes to the total value of production for different sub-periods.

- Third, the same 251 series are used in calculating a historical difussion index, defined as a measure of dispersion of the changes in a number of time series during any period (Smit & Van der Walt, 1970). The sectoral weighting scheme is identical to the weighting structure of the current diffusion index. The turning point of the cyclical component of each series is determined. The value of the historical diffusion index is obtained by expressing the number of series which increase during any particular period as a percentage of the total number of series considered.
- Fourth, use is made of both survey techniques and a production function. In practice it has been found that surveys of business confidence in trade, manufacturing and mining; order volume in manufacturing; as well as of stocks in relation to demand in manufacturing and trade, produce series that lead the cycle (Boyd & Blatt, 1988). A production function tests the utilization of productive capacity in manufacturing and this has been found to produce coincident series (Christiano, 1981).
- Finally, as the identification of a turning point is never a purely mechanical exercise, important economic events and developments occurring near a possible turning point are appraised to determine its exact date.

Gabisch and Lorenz (1989) provide a comprehensive summary of methods used internationally.

Table 1 Composite Business Cycle Indicators

Leading Business Cycle Indicators	**Coincident Business Cycle Indicators**
- Overtime hours as a percentage of ordinary hours worked in manufacturing. - Physical volume of gold ore mined. - Opinion survey of business confidence: manufacturing, construction and trade. - Physical volume of mining production, excluding gold. - Opinion survey of volume of orders in maufacturing. - Number of new motorcars sold - International business cycle indicator: industrial production. - Value of merchandise exports, excluding gold and agriculture. - Number of residential building plans passed. - Net number of new companies registered. - Number of real estate transactions. - Opinion surveys of stocks in relation to demand: manufacturing and trade. - Prices of all classes of shares. - London gold price in Rand. - Company profits, after tax. - Commodity prices: percentage change over twelve months. - Ratio of output prices to unit labour costs in manufacturing. - Real M1 money supply: percentage change over twelve months. - Net gold and other foreign reserves. - Consumer credit at constant prices. - Tender treasury bill discount rate.	- Employment in manufacturing, mining and the construction sector. - Gross domestic product at constant prices, excluding agriculture. - Physical volume of manufacturing production: non-durable goods. - Physical volume of manufacturing production: durable goods. - Utilization of production capacity in manufacturing. - Value of wholesale, retail and motorcar sales at constant prices. - Value of imports at constant prices, excluding mineral products. **Lagging Business Cycle Indicators** - Employment in non-agricultural sectors. - Total number of hours worked by production workers in the construction industry. - Physical volume of mining production of building materials. - Value of unfilled orders as percentage of sales in manufacturing. - Value of fixed investment in machinery and equipment. - Value of non-residential buildings completed. - Value of industrial and commercial inventories at constant prices. - Labour costs per unit of physical volume of manufacturing production.

Source: Van der Walt and Pretorius (1994)

METHOD

A large statistical and econometric literature has addressed the interpretation of duration data, with unemployment spell length receiving much of that focus (Devine & Kiefer, 1987). The papers by Lancaster (1979) and Nickell (1979) use the hazard function to develop behavioural models based on job search arguments. Being reduced form results, they can serve to rule out a few potential scenarios but cannot distinguish between others, and hence there is dissent (Atkinson & Micklewright, 1985). More recently Sichel (1991) used the technique to analyze post war US business cycles while Diebold *et al.* (1994) focused on pre-war data. The central concept in these methods is not the unconditional probability of an individual becoming unemployed, but rather its conditional probability. That is, the probability of an individual leaving unemployment in the tenth week, having been unemployed for nine. Of course, conditional and unconditional probabilities are related, making the mathematical description the same in either case (Kiefer, 1988). It is the conceptual difference rather, that is of importance in the business modelling of duration data.

The special methods of duration analysis are useful and convenient ways of organizing, summarizing and interpreting data for which representation in terms of conditional probabilities is appealing (Cox & Oakes, 1985). The functions $\lambda(t)$ are hazard functions for random variables such as contraction or expansion in the business cycle, conveniently presenting a continuous-time version of a sequence of conditional probabilities. Simply, $\lambda(t)$ is the rate at which spells will be completed at duration t, given that they last until t.

A simple generalization of the exponential distribution, obtained by setting $\alpha = 1$, results in a two parameter distribution ($\gamma > 0$, $\alpha > 0$) with a hazard function, called the Weibull Hazard:

$$\lambda(t) = \gamma \alpha t^{\alpha - 1}. \qquad (1)$$

Matsuoka (1998), due to a limited number of observation points, made use of this approach in discussing sequential probability recursion of Japanese business cycle data. The Weibull can be conceptualized as an exponential distribution on a rescaled time axis. It provides a transformation of duration that is both exponentially distributed but dependent on more than just the value of γ. The function is increasing in duration if $\alpha > 1$, decreasing if $\alpha < 1$ and constant if $\alpha = 1$. Alpha thus shows whether business cycles exhibit positive duration on time, with gamma being the starting value of the hazard function at time 1 for any given series.

The lengths of expansions and contractions are as designated by the Reserve Bank business cycle turning dates. These durations (in months) are given in Table 2 and provide the raw data for analysis. The table shows that on average expansions have lasted longer than downturns, but not markedly so. The difference in duration is only 1.4 fold compared with 2.1 fold for Japan and 3.6 fold for the United States (Matsuoka, 1999). The asterisked duration is ongoing to July 1999. The average duration excluded this observation.

Table 2 Turning points and durations of business cycles in South Africa

Trough	Peak	Trough	Expansion	Downturn
	07/46	04/47		9
04/47	11/48	02/50	19	15
02/50	12/51	03/53	22	15
03/53	04/55	09/56	25	17
09/56	01/58	03/59	16	14
03/59	04/60	08/61	13	16
08/61	04/65	12/65	44	8
12/65	05/67	12/67	17	7
12/67	12/70	08/72	36	20
08/72	08/74	12/77	24	40
12/77	08/81	03/83	44	19
03/83	06/84	03/86	15	21
03/86	02/89	05/93	35	51
05/93	11/96	?	42	32*
Average Duration			27	19

Adapted from SARB (1999)

In the Weibull hazard, the density of a duration of length t may be written as $f(t,\theta)$. If an observation pool of n completed spells is available and each individual's spell is independent of the others, the likelihood function is:

$$L^{*}(\theta) = \prod_{i=1}^{n} f(t_i, \theta) \qquad (2)$$

as usual. Simply stated, the likelihood function is the joint probability distribution of the sample as a function of parameter θ. When a spell is censored, at duration t_j for example, the only information available is that the duration was at least t_j. Thus the contribution to likelihood from that observation is the value of the survivor function, $S(t_j, \theta)$, the probability that the duration is longer than t_k. Let $d_k = 1$ if the k^{th} spell is uncensored, $d_k = 0$ if censored. Then the likelihood function $L(\theta) = \ln L^*(\theta)$ is:

$$L(\theta) = \sum_{i=1}^{n} d_i \ln f(t_i, \theta) + \sum_{i=1}^{n} (1-d_i) \ln S(t_i, \theta) \qquad (3)$$

which has completed spells contributing to the density term $f(t_i, \theta)$. Using the fact that the density function is the product of the hazard and the survivor function, $f(t, \theta) = \lambda(t, \theta)\, S(t,\theta)$, and the fact that the log of the survivor function is minus the integrated hazard $\ln S(t, \theta) = -\ (t, \theta)$, t h e log-likelihood function can now be expressed as in terms of the hazard function:

$$L(\theta) = \sum_{i=1}^{n} d_i \ln \lambda(t_i,\theta) - \sum_{i=1}^{n} \wedge (t_i, \theta) \qquad (4)$$

In practice it is usual to estimate the parameters by maximum likelihood. When the Weibull hazard function expressed above is substituted in this equation, then the log-likelihood function for expansions in South Africa (all spells complete) can be obtained using:

$$L^e(\gamma,\alpha) = \sum_{i=1}^{n} \ln\gamma + \sum_{i=1}^{n} \ln\alpha + (\alpha-1) \sum_{i=1}^{n} \ln t_i - \gamma \sum_{i=1}^{n} t_i^{\alpha} \qquad (5)$$

The downturn since November 1996 in South Africa is considered an incomplete spell (censored observation) hence its contribution to likelihood is the survivor and not the density function. The log likelihood function for downturns can be written as:

$$L^d(\gamma, \alpha) = \sum_{i=1}^{n-1} \ln\gamma + \sum_{i=1}^{n-1} \ln\alpha + (\alpha-1) \sum_{i=1}^{n-1} \ln t_i - \gamma \sum_{i=1}^{n} t_i^{\alpha} \qquad (6)$$

For South Africa, n=13 for post war expansion and n=14 for contraction. The parameters α and γ may be obtained through grid search. The negative inverses of the second derivatives of the log-likelihood function can be used as the asymptotic variances of α and γ. For downturns we get:

$$\frac{\partial L}{\partial \alpha} = \frac{n-1}{\alpha} + \sum^{n-1} \ln d_i - \gamma \sum^{n} [\ln d_i\, (d_i^{\alpha})] \qquad (7)$$

$$\frac{\partial^2 L^d}{\partial \alpha^2} = - \frac{n-1}{\alpha^2} - \gamma \sum^{n} [(\ln d_i)^2 d_i^{\alpha}] \quad (8)$$

$$\text{Var}(\alpha\hat{}) = - \{\partial^2 L^d / \partial \alpha^2 \, I \alpha\hat{}\gamma\hat{}\}^{-1} \quad (9)$$

$$\text{Var}(\gamma\hat{}) = - \{\partial^2 L^d / \partial \gamma^2 \, I \, \alpha\hat{}\gamma\hat{}\}^{-1} \quad (10)$$

where α^ and γ^ are the maximum likelihood estimates of α and γ. In case of expansions in which we do not have censored observations (all durations are complete), the terms involving n-1 are replaced with n.

ANALYSIS AND DISCUSSION

Table 3 summarizes results of the Weibull hazard estimates obtained from maximum likelihood for both expansions and contractions. The most important parameter in the table is alpha, the slope of the hazard.

For South Africa's expansion, α is 1.2701 (with a standard error of 0.2292). The 95 per cent confidence interval ranges between 0.821 and 1.715. Because this range includes 1, the likelihood of $\alpha > 1$ and $\alpha < 1$ can both be rejected. On this basis the probability of an expansion ending in South Africa does not rise the longer the expansion lasts.

Similarly for downturns the likelihood of $\alpha > 1$ or $\alpha < 1$ can also be rejected. At the 95 per cent confidence level, alpha ranges between 0.714 and 1.554 and thus still includes 1. This suggests that in South Africa, the probability of a recession ending does not rise the longer the recession lasts.

Table 3 Estimated parameters in Weibull function

	Alpha		Gamma	
	Expansion	**Downturn**	**Expansion**	**Downturn**
Maximum Likelihood	1.2701	1.1338	0.02908	0.04341
Standard Error	0.2292	0.2143	0.0081	0.0120

Table 4 summarizes a series of hazard function values for different month durations, that is, the conditional probability that a turning point has arrived this month given it had not arrived by the previous month.

Table 4 Hazard function conditional probabilities

Months	10	20	30	40	50	60	70	80	90	100
Expand Prob.	0.069	0.083	0.093	0.1	0.106	0.112	0.116	0.121	0.125	0.128
Contract Prob.	0.067	0.073	0.078	0.081	0.083	0.085	0.087	0.088	0.090	0.091

Manipulating the table above by interpolation shows that the hazard function for upturns in the 27th month is nine per cent, although this has been the historic average duration. Comparing this to the hazard function for, say, the 50th month shows that there is only a 1.3 percentage difference or hardly any change in probability, this as $\alpha = 1.2701$ is extremely close to 1. While the table does suggest that the hazard rises slowly to the right with time, as the confidence interval is extremely wide, it is not possible to conclude that $\alpha > 1$.

Similarly, the hazard function for contractions in the 19th month results in a probability of only 6.7 per cent, although this has also been the historic average duration. Comparing this to the hazard function for the 50th month shows only a 1.6 percentage difference, being an extremely small change in probability over a rather considerable change in duration. Again the hazard function does slope gradually to the right but this is not statistically significant.

IMPLICATIONS FOR FURTHER RESEARCH

If it is postulated that government and the Reserve Bank have the power of counter-cyclical macroeconomic policy, which aims at smoothing out business fluctuations, the result of this intervention should be longer periods of expansion and shorter periods of recession. If such a policy was effective the alpha for expansion would be smaller and that for recession larger, meaning that expansions lengthen in time. The hazard function would show greater time independence (posting results closer to $\alpha = 1$). Similarly as recessions would end in a shorter time, the hazard function should show an increasingly positive duration dependence ($\alpha > 1$). In South Africa a greater alpha value for expansions rather than contractions suggests that this has not been the case.

George (1998) described the two purposes of central banks, monetary and financial stability, as being "inextricably bound up with each other". Is it possible that the unexpected hazard function values arrived at, point to a more structural weakness on the part of the Reserve Bank, such as its historic preoccupation with defending the currency at the expense of sustainable growth? Further research into this question would be welcome.

REFERENCES

1 ATKINSON, A.B. & MICKLEWRIGHT, J. (1985) *Unemployment Benefits and Unemployment Duration: A Study of Men in the United Kingdom in the 1970s,* London School of Economics and Political Science: Suntory-Toyota International Centre for Economics and Related Disciplines.

2 BOYD, I., & BLATT, J.M. (1988) *Investment Confidence and Business Cycles,* New York: Springer.

3 BROIDA, A.L. (1955) "Diffusion Indexes", *The American Statistician,* 9: 7-16.

4 BURNS, A.F. & MITCHELL, W.C. (1946) *Measuring Business Cycles,* National Bureau of Economic Research: Studies in Business Cycles No 2. Cambridge, Mass.: NBER.

5 CHRISTIANO, L.J. (1981) *A Survey of Measures of Capacity Utilization,* IMF Staff Papers, 28: 144-98.

6 COX, D.R. & OAKES, D. (1985) *Analysis of Survival Data,* London & New York: Chapman & Hall.

7 DEVINE, T.J. and KIEFER, N.M. (1987) *Empirical Labor Economics in the Search Framework,* Manuscript, Cornell: Cornell University.

8 DIEBOLD, F.X. & RUDEBUSCH, G.D. (1989) "Scoring the Leading Indicators", *Journal of Business,* 62: 369-91.

9 DIEBOLD, F.X., GLENN, D. & SICHEL, D.E. (1994) "Further Evidence on Business-Cycle Duration Dependence in Stock", J.H. & Watson, M.W. (eds.) *Business Cycles, Indicators and Forecasting,* Chicago: University of Chicago Press.

10 FISHER, I. (1925) "Our Unstable Dollar and the So-Called Business Cycle", *Journal of the American Statistical Association,* 20: 179-202.

11 GABISCH G. and LORENZ, H.W. (1989) *Business Cycle Theory: A Survey of Methods and Concepts* (2nd ed.), Berlin: Springer-Verlag.

12 GEORGE, E.A.J. (1998) "Maintaining Financial Stability", *South African Journal of Economic and Management Sciences,* 1: 192-203.

13 HAMILTON, J.D. (1989) "A New Approach to the Economic Analysis of Non-Stationary Time Series and the Business Cycle", *Econometrica,* 57: 357-84.

14 JAMES, C.L. (1958) *Principles of Economics,* New York: Barnes & Noble.

15 KIEFER, N. M. (1988) "Economic Duration Data and Hazard Function" *Journal of Economic Literature,* 26: 646-79.

16 LANCASTER, T. (1979) "Econometric Methods for the Duration of Unemployment", *Econometrica,* 47: 939-56.
17 MATSUOKA, M. (1998) "Prediction of Business Cycle Turning Points: An Application of Sequential Probability Recursion", *Simulation,* 13: 3-13.
18 MATSUOKA, M. (1999) *Time Alone Won't Heal the Economy,* Economics Research, Japan, Tokyo: Jardine Fleming.
19 MITCHELL, W.C. (1923) *Business Cycles and Unemployment,* Cambridge, MA.: National Bureau of Economic Research.
20 NEFTCI, S.N. (1982) "Optimal Prediction of Cyclical Downturns", *Journal of Economic Dynamics and Control,* 4: 225-41.
21 Nickell, S.J. (1979) "Estimating the Probability of Leaving Unemployment", *Econometrica,* 47: 1249-66.
22 PRETORIUS, W.S., VENTER, J.C. & WEIDERMAN, P.J. (1999) "Business Cycles in South Africa during the Period 1993-1997", *Quarterly Bulletin, March,* South African Reserve Bank: Pretoria.
23 SARB [South African Reserve Bank] (1999) *Business Cycle Data,* Pretoria: SARB.
24 SCHUMPETER, J.A. (1935) "The Analysis of Economic Change", *The Review of Economic Statistics,* 17: 2-10.
25 SICHEL, D.E. (1991) "Business Cycle Duration Dependence: A Parametric Approach", *Review of Economics and Statistics,* 71: 254-60.
26 SMIT, D.J. and VAN DER WALT, B.E. (1970) "Business Cycles in South Africa During the Post-War Period, 1946 to 1968", *Quarterly Bulletin, September,* South African Reserve Bank: Pretoria.
27 VAN DER WALT, B.E. and PRETORIUS, W.S. (1994) "Notes on the Revision of the Composite Business Cycle Indicators", *Quarterly Bulletin, September,* South African Reserve Bank: Pretoria.