CHAPTER EIGHT

EMPIRICAL EVALUATION TECHNIQUES

8.1 INTRODUCTION

The purpose of this chapter is to use normal estimation techniques to empirically evaluate the challenge of orthodox or neo-liberal theory by structuralists, regarding the efficacy of monetary policy in stimulating economic growth of a small and open economy, using South Africa as a case study, that is to test the argument presented in the previous chapters. Also presented will be the specification of the single-equation models used to test the structuralist view, that monetary policy in a small and open economy is not effective in promoting economic growth. According to structuralist theory, monetary transmission is inoperative in such economies, since changes in money supply, pursuant to either contractionary or expansionary policies are ineffective. For instance, it has already been stated that if monetary authorities opt for an expansionary policy, by increasing money supply, to lower interest rates, as the interest rates drop so does net foreign assets (NFA). Consequently, the drop in NFA reduces the money supply, which is the opposite of the intended monetary objective. In contrast, if the objective is to raise interest rates by following a contractionary monetary policy, the resultant increase in interest rates attracts NFA, in turn increasing money supply. Thus, again the opposite effect to that intended is said to be the result. At the heart of the structuralist argument is thus the uncontrollability of money supply. This argument is refuted by neo-liberal theory, which considers the interest-rate elasticity of NFA movements to be too low, for it to dampen and reverse monetary policy objectives, consequently rendering monetary policy effective in controlling money stock.

Cognate to the above argument, structuralists reject both postulates of neo-liberal theory, that is the ability of the monetary authorities of a small and open economy to control the money stock and the ability of money supply changes to influence economic growth (GDP) via the interest rates (r), since the opposite of the expected results of the pursued monetary policy objectives occur. Accordingly, changes by increasing or decreasing the money stock to reduce or increase interest rates respectively are said to achieve, ultimately, the opposite effects on interest rates. Furthermore, structuralists by arguing that money stock changes do not influence interest rates, also imply in-operability of the monetary transmission mechanism, since it is via interest rates that investment is changed, which in turn has an impact on economic growth.

Structuralists further challenge the impact of inflation on economic growth. They reject the orthodox view that inflation is primarily a monetary phenomenon. Instead, inflation is said to be structural and imported from big developed countries with which the small and open countries trade. Export-oriented economic policies to stimulate growth are also rejected; import-substitution policies are promoted instead, since exports are said to have nothing to do with money supply changes via inflation and foreign exchange. Rather, structuralists would argue that exports depend on the level of economic growth (GDP) of the big and developed countries with which small and open countries trade.

Consequently, the techniques discussed in this chapter are those that were be used to empirically evaluate the structuralist argument that monetary policy cannot stimulate economic growth in a small and open country, in this case South Africa. The techniques that were be used are: the ordinary least squares (OLS) regression analysis technique, which is conventionally used, and cointegration, to determine the long-run equilibrium positions, after testing the time series used for stationarity. Error correction model (ECM) is only described and not used, because it is not essential for this study. "ECM is a popular macroeconomic specification which integrates the long-run equilibrium analysis and short-run dynamic adjustment by including in the short-term dynamic model a measure of how much out of equilibrium or target the variables are in the last period, as in Pagan and Wickens (1989). It relates changes in y_t, to last period's error, $y^*_{t-1} - y_{t-1}$, where y^*_t denotes the target or equilibrium value" (Intriligator, Bodkin, & Hsigo 1996:414). In fact, "many economic time-series tend to behave as random walks. This has led to the development of cointegration analysis which seeks to investigate long-run relations between economic variables without falling prey to spurious correlations. Furthermore, error-correction models (for a recent and comprehensive reference, see, for example, Banerjee et al 1993) seek to incorporate short-run disequilibrium behaviour along with long-run tendencies in econometric modelling." (Mukherjee, White & Wuyts 1998:41).

8.2 OVERVIEW OF EMPIRICAL EVALUATION

Conventionally, an empirical study, to test economic theory, follows the following five consecutive basic steps:

(1) Formulating a model;
(2) Gathering the data;
(3) Estimating the model;
(4) Subjecting the model to hypothesis testing; and
(5) Interpreting the results.

In economics, as in physical science, the model formulated is set up in the form of equations, which describe the behaviour of economic and related variables. The model formulated might consist of a single equation, or a system involving a set of several simultaneous equations. The single equation model was used in this study. In single equation specification, the variable explained is referred to as the dependent variable or regress and those variables that influence it are called independent variables or exogenous variables or explanatory variables or regressors. After formulating the model, the next step is to gather reliable data that are suited to the economic theory being tested. Time series data that give measurements at different points in time are used in this study. The third step is the estimation of the model, that is obtaining estimates of the unknown parameters of the model. The postulated hypotheses are then tested by subjecting the model to diagnostic tests to make sure that the underlying assumptions and estimation methods are appropriate. Finally, the results are interpreted, to draw conclusions that might support or contradict the postulated economic theory (Ramanathan 1995). If the time series are non-stationary, they are transformed by differencing to determine whether or not they are co-integrated, concurrently establishing the long-run equilibrium. With the time series rendered stationary, spurious and non-sensical results are avoided.

Schematically the flowchart of steps taken to conduct this study's empirical evaluation of the hypotheses underlying the economic debate between structuralists and neo-liberalists on whether or not monetary policy, via controlled or deliberate changes in the money supply, can stimulate the economic growth of a small and open country, in this case the Republic of South Africa, is presented by figure 10 on the following page.

In line with the cointegration approach, collected data used were be tested for stationarity and the determination of the level of integration. If the time series are stationary, then the classical assumptions of OLS regression analysis technique are satisfied. However, if the time series are found to be non-stationary, they are transformed. Cointegration is used to establish long-term relationships between the variables. Then after the long-run equilibrium has been determined, to establish its dynamic nature or the short-run relationship, the cointegration regression results that have been obtained are used to estimate the ECM. This gives the dynamic relationship between the variables in the model, important from a forecasting perspective (Engle & Granger 1987:251-76). As stated above, the ECM is not used in this study. Since OLS regression analysis technique is well known, only cointegration and ECM will be briefly discussed in turn.

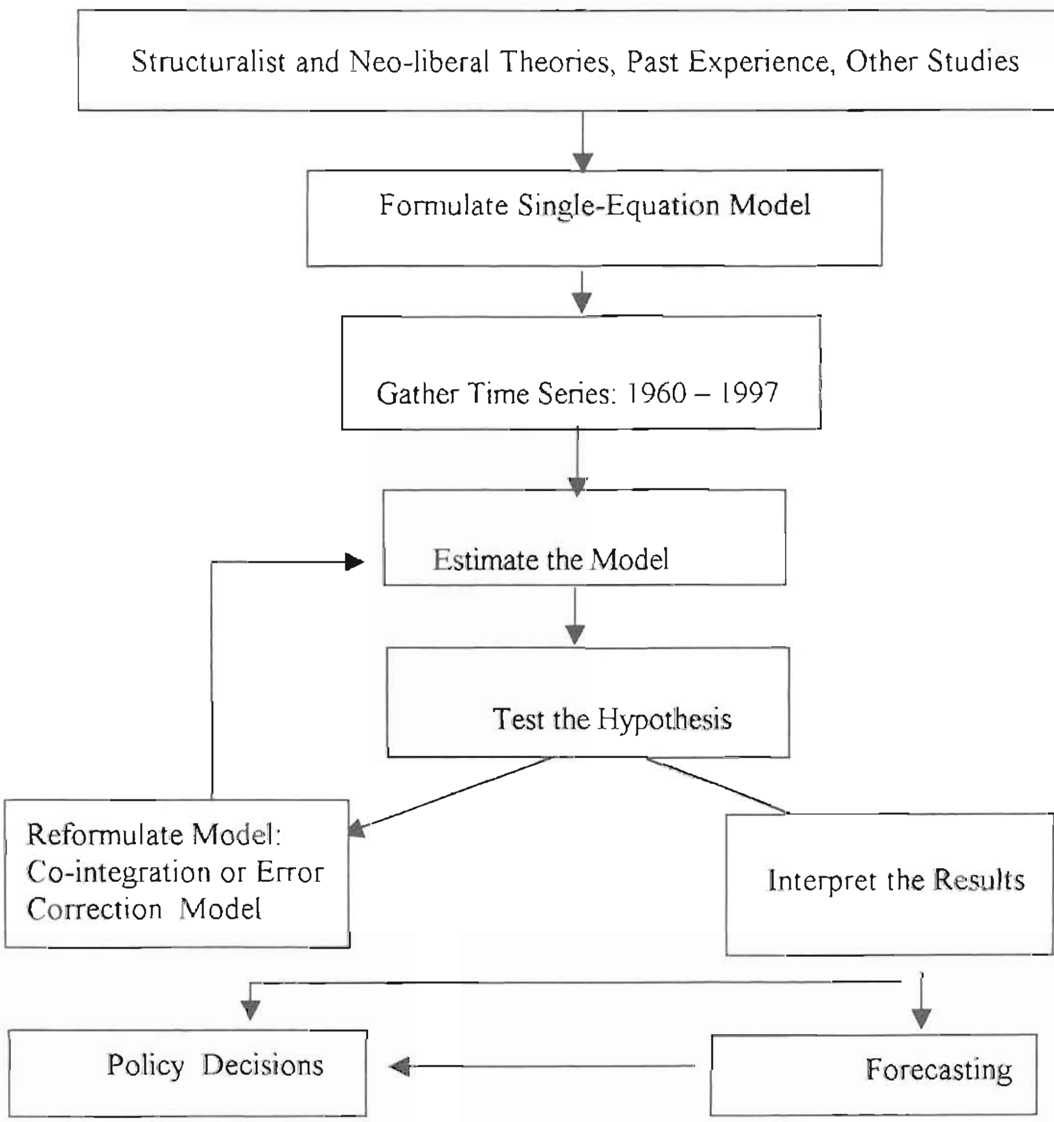
8.3 COINTEGRATION AND ERROR CORRECTION APPROACH

8.3.1 Overview

This section briefly covers co-integrated series and the augmented Dickey-Fuller (ADF) test used to test time series for co-integration, to avoid spurious correlations that persist even when the sample gets larger. Thus, co-integration distinguishes between stationary and non-stationary variables, the source of spurious regression, to obtain meaningful causal relationships rather than contemporaneous ones. The economic interpretation of cointegration is "that if two (or more) series are linked to form an equilibrium relationship spanning the long-run, then even though the series themselves may contain stochastic trends (i.e. be non-stationary) they will nevertheless move closely together over time and the difference between them will be stable (i.e. stationary)" (Harris 1995: 6).

When the variables are co-integrated, moving closely together over time and with the difference between them stable, the long-run relationships between economic variables are separated from their short-run responses by estimating an error correction model (ECM), which is of importance from a *forecasting perspective* (Harris, 1995:23). Although ECM

FIGURE 10: ADAPTED FLOWCHART OF STEPS IN EMPIRICAL STUDY: MONETARY POLICY AND ECONOMIC GROWTH IN SOUTH AFRICA



SOURCE: Ramanathan, 1995:6.

is not used for the reasons stated above, it will be briefly described for he sake of completeness. For the existence of long-run equilibrium, the variables that enter the relationship must be cointegrated, that is all variables of the same order are integrated and there is a linear combination of these variables, with a lower order of integration (Engle & Granger 1987:251-276). For instance, if two variables are both integrated of order 1, that is I(1), that means there is a linear combination of these variables which are integrated of order one, that is I(Z) implying stationarity. Thus, an I(Z) error implies that the dis-equilibrium error will seldom move too far from zero and will often cross the zero line, meaning the occasional occurrence of equilibrium (Engle and Granger 1987:253).

8.3.2 Testing for cointegration

Tests for co-integration start with visual inspection of the first-order and second-order moments that can be employed. Even if more formal tests such as the Dickey-Fuller (DF) and augmented Dickey Fuller (ADF) tests are more objective, visual inspection of the first-order and second-order moments remains valuable. Test of co-integration rely on *weak stationarity* or *second-order stationarity* or *covariance stationarity*, when the mean, variance or covariance are independent of time. Non-stationarity of a variable is determined by existence of a *unit root*. Unit root tests are firstly used to determine the order of integration of the variables in the co-integrating equation. Then a test for co-integration, to determine whether the residual of this cointegrating equation is integrated of a lower order than that of the variables of the cointegration equation is made. Beyond the visual or informal inspection of the *plot of the error term* and *correlogram of the error term*, formal tests such as DF, ADF and Phillips-Perron (PP), with the cointegrating regression Durbin-Watson (CRDW) are used.(Harris 1995:34-57).

The difference between the DF and ADF tests, is that DF assumes that the variable considered follows a first-order auto-regression and that the residual of the DF-regression is independently and identically distributed, while ADF drops this assumption. Further, the ADF-test extends the DF-test by allowing for inclusion of lagged values of the dependent variable, the intercept and a deterministic trend Lagging the dependent variable ensures that the process of the ADF model is white noise. The number of lags to be included to produce white noise is determined by performing tests for serial correlations, heteroskedasticity and the normality on the residuals of the ADF model and selection of the number of lags that minuses the Aike's Information Criterion (AIC) (Engle & Yoo 1987). Consideration is also given to the reduction of lags until the last lag is significant or until the model does not contain any lags. The testing for co-integration between variables also imply testing for the presence or absence of a long-term equilibrium relationship between these variables. If variables are found to be co-integrated, the Error Correction Model (ECM), which is discussed in the following section, is estimated (Engle & Yoo 1987:143-159).

8.3.3 Error correction models (ECMs)

A valid error correction model of data exists when a set of variables are integrated of the same order (Cuthbertson, Hall & Taylor, 1992:140-141). ECM gives the dynamic relationship between variables, that is dependent variable fluctuations around its long-term trend are explained by fluctuations in the explanatory variables around their long-term trend. This means, disequilibrium in one period is corrected in the next period (Engle & Granger 1987:253). The long-term effects are also included, , through the error term of the long-term co-integrating relationship in the ECM (Harris 1995).

The specification of the ECM is as follows:

(1) All variables are transformed to stationary variables by differencing; for example, an I(2) variable will be differenced twice to generate an I(Z).

(2) The stationary form of the dependent variable is regressed on the other stationary variables.

(3). Lagged dependent and independent variables are included in the ECM.

(4) The error term of co-integrating regression (lagged one period) is included in the ECM.

(5). With all variables in ECM being stationary, the classical regression assumption is are fulfilled and the conventional diagnostic tests can be applied, to determine which variables should be included in the final specification of the ECM.

While the strength of cointegration and the ECM approach is to help avoid spurious economic causal relationships, by giving long-term and dynamic economic relationships, there are a few weaknesses. Under certain circumstances ADF is not powerful, giving consistent estimated coefficients which are not fully efficient. Also, the coefficients cannot be used for hypothesis testing since they are generally non-normal. These weaknesses are overcome by a third step proposed by Engle and Yoo (1987:143-159).

The analytical tools that were be used in conducting this study's empirical analysis on the whether or not monetary policy via controlling the money supply can stimulate the economic growth (GDP) of a small and open country, having been described, the next section specifies the model that was be used.

8.4 SPECIFICATION OF THE MODEL

Since this is not an econometric study, the purpose is not to formulate a rigorous econometric macro-economic growth model. The main aim is to empirically test the tenability of structuralist theory, or lack thereof, on whether monetary policy is effective in stimulating the economic growth of a small and open economy, namely, whether or not GDP is significantly impacted by changes in M3 and CPI. Accordingly, a single-equation model was be used. As stated in the previous chapters, structuralists in opposing orthodox or neo-liberal theory, mainly argue that GDP is not significantly changed by M3 and CPI because monetary authorities in pursuing either an expansionary or a contractionary policy of increasing or reducing money stock (M3) of a small and open economy cannot be successful, since they achieve the opposite of their desired aim. Intended increases of M3 to reduce interest rates, are said to cause outflows of net foreign assets, NFA, which as a component of M3, ends up reducing M3, while intended decreases in M3 to increase interest rates also achieve the opposite of the desired effect, that is increased interest rate attracts inflows of NFA, which instead increases M3. Instead, domestic economic growth, GDP, is said to be determined by the levels of GDP of big trading partners, namely the GDP of South Africa is determined by those of the United States, the United Kingdom, France, Germany and Japan.

However, according to orthodox theory, changes in NFA as a result of the impact of changes in M3 on the interest rate (r) are smaller than the changes in M3, that is the interest-elasticity of NFA is small. Thus, monetary authorities can control changes in the money stock, thereby influencing interest-rates, which in turn impacts on domestic investment, which ultimately brings about changes in economic growth, GDP, via this *monetary transmission mechanism*. Accordingly, controllability of the money supply by monetary authorities, namely, keeping it within set targets, becomes a minor premise of the major argument on whether or not GDP is affected by M3 and CPI. Controllability also implies absence of external influence. Thus, M3 will also be considered in terms of foreign influences, using the United States dollar exchange rate, FOREX, as a proxy, and the REPO as the domestic monetary policy tool.

Structuralists further argue, as opposed to orthodox or neo-liberal theory, that the economic growth of open and small countries is not affected by inflation, which is considered a non-monetary phenomenon, but imported. Thus, structuralists, as opposed to neo-liberalists do not regard inflation as primarily a monetary phenomenon, influenced mainly by changes in money supply, as argued by Friedman (1970) for instance. For simplicity of exposition, the single-equation model was used, to test the opposed arguments advanced by structuralists and orthodox or neo-liberal economists. These, for *controllability of money supply*, will be formulated as the null and alternative hypotheses, as follows:

1.) Null hypothesis (structuralist) : $M3_t \neq f(M3_{t-1})$;
Alternative hypothesis (orthodox): $M3_t = f(M3_{t-1})$;

2.) Null hypothesis (structuralist) : $GDP \neq f(M3, CPI)$
Alternative hypothesis (orthodox): $GDP = f(M3, CPI)$;

3.) Null hypothesis (structuralist) : Incontrollability of money supply

Alternative hypothesis (orthodox): Money supply is controllable.

Thus, to reject the null hypothesis, formulated to represent the a particular argument, means we must "accept" the alternative hypothesis, formulated to represent the opposite argument, and *vice versa*, namely, if we fail to reject the null hypothesis, then we must "accept" it and reject the alternative orthodox hypothesis.

Put differently, if we reject the orthodox null hypothesis (1) above, namely, that there is a relationship between the current level of money supply, M3, in current period, t, and the level in the previous period, t – 1, the alternative hypothesis that such relationship exists must be "accepted", and *vice versa;* also, to reject orthodox null hypothesis (2) above, that changes in money supply, M3, and inflation , CPI, do affect economic growth, GDP, is to "accept" the alternative hypothesis that M3 and CPI do not affect GDP, and *vice versa*; and to reject the structuralist null hypothesis (3) above, that money supply cannot be controlled by monetary policy, is to "accept" the alternate hypothesis that such controllability exist.

The structuralist argument is that monetary policy cannot stimulate economic growth by changing the money supply, based on the argument that monetary authorities cannot influence the current period money stock by manipulating that of the previous period:

$$M3 = f(M3_{t-1}) \qquad (69)$$

If it is not possible to reject the structuralist null hypothesis that there is no correlation between M3 and $M3_{t-1}$, that is the correlation coefficient between them is zero, applying the classical regression analysis assumptions stated above, then the structuralist argument would be affirmed, and the alternative hypothesis, that is the correlation co-efficient between M3 and $M3_{t-1}$ is non-zero, which represents the orthodox theory, would be rejected. Consequently, there would be no need for further testing of whether monetary policy, in changing money supply levels, can stimulate the economic growth of a small and open economy, as well as whether inflation has any impact on it. However, if the null hypothesis, representing the structuralist theory, is rejected, the next step is to test the impact of changes in money supply, (M3), and inflation, consumer price index (CPI), on real economic growth, (GDP). This will be estimated by the following equation:

$$GDP = f(M3, CPI) \qquad (70)$$

Again, the argument of no relationship will be represented by the null hypothesis, that is zero correlation coefficients between GDP and M3, and GDP and CPI. If be are unable to reject the null hypothesis, then the alternative hypothesis, of non-zero correlation coefficients, representing the orthodox or neo-liberal theory, must be accepted, and *vice-versa*.

To avoid a spurious conclusion on the causal relationships represented by the tested hypothesis, further testing for cointegration was be conducted. However, even if this is not an econometric study, but an economic one, even if a single-equation model was used, care was be taken to observe the principles of model specification and selection. Also, in testing for stationarity of time series to avoid non-sensical or spurious conclusions the more popular and objective augmented Dickey Fuller (ADF) test were be used to test for the presence of unit roots.

8.5 CONCLUSION

In this chapter the steps, techniques and the tools that were used to empirically test the hypotheses postulated by both structuralists and neo-liberals on the role of monetary policy on economic growth of a small and open economy, South Africa in this case, are briefly discussed. These steps outline the research methodology used, from literature survey; formulation of the type of model used; the scope of the study; the estimation of the model and testing of the hypothesis; and how to ensure that the results obtained are not spurious for policy decisions. The techniques and tools used are OLS regression analysis and co-integration, to test for stationarity of the time-series. For this study, only co-integration is essential, to avoid spurious conclusions. The next chapter describes the empirical evaluation.