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THE IMPACTS OF MONETARY POLICY ON THE MAIZE AND BEEF SECTORS OF SOUTH AFRICA I: THEORETICAL FOUNDATIONS AND MODEL SPECIFICATION

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Abstract

A general equilibrium simultaneous equations model is specified to analyse the impacts of monetary policy on the maize and beef sectors. Four key macro variables which link monetary policy to agriculture - the interest rate, exchange rate, inflation rate and real income - are studied. The exchange rate, inflation rate and real income are determined endogenously within the model which contains money and foreign exchange markets and a manufacturing sector (macro sector), and the maize and beef sectors (agricultural sector). Macro linkages whereby the impacts of monetary policy are transmitted to the maize and beef sectors are discussed and simulated.

Uittreksel
Die impak van monetêre beleid op die mielie- en beesvleissektore van Suid-Afrika I: Teoretiese onderbou en modelspesifikasie

'n Algemene ewewig gelyktydige-vergelykingsmodel word gespesifiseer om die impak van monetêre beleid op die mielie- en beesvleissektore te ontleed. Vier sleutel makroveranderlikes wat monetêre beleid met die landbou skakel - die rentekoers, wisselkoers, inflasiekoers en reële inkomste - word ondersoek. Die wisselkoers, inflasiekoers en reële inkomste word endogeen bepaal binne die model wat geld- en valuta markte en 'n fabrieksektor (makrosektor) bevat, asook die mielie- en beesvleissektore (landbousektor). Makroskakels in terme waarvan die impak van monetêre beleid op die mielie- en beesvleissektore oorgedra word, word bespreek en gesimuleer.

1. Introduction

Since the early 1970's, South African farmers have been exposed to persistent double digit inflation and fluctuating nominal and real interest rates. More recently, the rand exchange rate has declined against major currencies and real *per capita* incomes have fallen (South African Reserve Bank). Structural changes in South African monetary policy have contributed to instability and uncertainty in the agricultural sector. In January 1979, the South African Reserve Bank (SARB) implemented a managed float system for the rand exchange rate, and in 1980, discount policy and open market operations replaced strict quantitative controls as the main instruments of monetary control. Lack of adequate restraints on the growth of monetary aggregates by the monetary authorities has contributed to general inflation (De Kock Commission, 1988). These developments have created an increased awareness of the need to establish and understand the nature and strength of linkages between the macro sector and agriculture (Groenewald, 1982; 1985; Nieuwoudt, 1986; van Zyl, *et al.*, 1987).

This study partly addresses the above need by specifying a general equilibrium simultaneous equations model to analyse some impacts of monetary policy on the maize and beef sectors in South Africa. The model focuses on four key macrovariables - the interest rate, exchange rate, inflation and real disposable income - identified as linkages between monetary policy and agriculture (Schuh, 1974; Groenewald, 1982; 1985; Devadoss, 1985; Josling,1985; van Zyl, 1986b).

These macrovariables were also studied in a previous analysis by Dushmanitch and Darroch (1990) of the impacts of monetary policy on South African agriculture. The present study differs from that analysis in three ways. Firstly, it gives a more rigorous discussion of the economic theory underlying the specified macrolinkages, highlighting considerable debate about the exchange rate and inflation linkages. Secondly, it estimates model parameters by three-stage least squares (3SLS) rather than two-stage least squares (2SLS). The 3SLS procedure generally produces more efficient (smaller variance) parameter estimates than 2SLS because it takes into account cross-equation correlation (Pindyck and Rubinfeld, 1981:334-338). 3SLS could not be used in the previous model due to insufficient degrees of freedom as the number of exogenous variables exceeded the number of (time series) observations. The present study ensures sufficient degrees of freedom by using only the maize and beef sectors to represent agriculture. The potential gain in efficiency is illustrated by comparing 3SLS and 2SLS parameter estimates for equations specifying these sectors in the model. Thirdly, this study emphasises that monetary policy changes add instability into an already inherently unstable agricultural sector. This inherent instability is due to factors such as price inelastic aggregate food demand, changing weather patterns and rapid technological change (Rausser, 1985).

The first article in this two article series reviews literature on, and discusses the economic theory underlying, the behavioural equations and macrolinkages specified in the model. The second article estimates the model and compares 3SLS and 2SLS parameter estimates for the maize and beef sectors. The implications for these sectors of a simulated expansionary monetary policy are also discussed.

2. Macrolinkages and key macroeconomic variables

Macrolinkages between monetary policy and agriculture associated with the interest rate, exchange rate, inflation and real disposable income are discussed in this section.

2.1 Interest rate (cost and stock effects)

The interest rate, being a cost of capital, has a direct impact on the cost of credit, investment and savings (Du Plessis, 1979). Interest rate cost effects capture the impact on farm supply of changes in production costs associated with changes in the cost of short-term production loans. Agricultural input manufacturers may pass on increased interest charges to farmers by raising input prices.

The farm debt problem has been partly attributed to high nominal interest rates (Louw, 1988). With the level of farm debt approaching 13,6 billion rands (Directorate Agricultural Economic Trends, 1990), continued use of the interest rate as the principal instrument of South African monetary policy has major implications for domestic agriculture. Van Zyl, *et al.* (1987) found both real and nominal agricultural debt to be highly elastic with respect to the interest rate. High nominal interest rates reduce debt repayment capacities and create cash-flow problems.

Stock effects of interest rate changes capture the impact of monetary policy on inventory behaviour. Higher interest rates raise the cost of inventory investment, causing stocks to be run-down. In the livestock sector, slaughterings increase as higher interest rates raise the cost of holding animals on the farm. This is due to higher production costs and increased opportunity costs of herd investment as returns on off-farm interest bearing assets rise (Rausser, 1985).

2.2 Exchange rate (trade effects)

Considerable debate exists in the literature concerning the effects of exchange rate changes on agricultural exports, the role of monetary policy in exchange rate determination, and the choice of an appropriate exchange rate measure.

Some agricultural economists (Schuh, 1974; Chambers, 1979; Chambers and Just, 1981; Rausser, 1985; Devadoss, 1985) support the view that increases in domestic money supply will lower the value of the domestic currency and increase the volume of exports. Under a floating exchange rate regime, domestic currencies are directly influenced by forces in international money markets, the most important being relative changes in domestic and foreign interest rates. Higher relative real interest rates cause capital inflows into a country raising the value of its currency. This causes exports to become less competitive on world markets which reduces export demand (trade effect) and real domestic farm incomes decline.

Schuh (1974) argued that low farm incomes in the United States (U.S.) were directly attributable to the negative impact of an overvalued dollar on the competitive position of U.S. farmers. Chambers and Just (1981) tested this empirically and found that U.S corn, wheat and soya bean exports are sensitive to changes in the exchange rate, inferring that exchange rate fluctuations have significant real impacts on agricultural commodity markets. The adjustment process is complex and each crop adjusts differently to these fluctuations, but in the long term, real export demand for all three crops increases due to a depreciation in the exchange rate.

Several studies have disputed the importance of the exchange rate as a determinant of agricultural exports. Kost (1976) argued that the impact of a change in the exchange rate on agricultural trade would be small, with the major effect being on price rather than quantity due to inelastic demand and supply of farm products. This price change is limited by the percentage change in the exchange rate. Vellianitis-Fidas (1976), using both cross-sectional and time series regression analysis, found that the exchange rate was either not statistically significant or the sign of the coefficient did not comply with theory, indicating that agricultural export variation cannot be explained by fluctuations in the exchange rate. Johnson, *et al.* (1977) examined variables taken from orthodox trade theory - tariffs, export taxes and transport costs - and found that the exchange rate exerted no greater influence on agricultural exports than these variables did.

Other economists (Batten and Belongia, 1984; 1986; Batten and Luttrell, 1982; Childs and Hammig, 1989), acknowledge the link between real exchange rates and agricultural export demand, but argue that monetary policy can only have nominal effects. The lack of any relationship between changes in nominal money supply and changes in the real value of the dollar therefore limits the role of monetary policy in promoting agricultural export volumes in the long-run.

The debate is also complicated by discrepancies in the results obtained using different measures of the exchange rate (Dutton and Grennes, 1987; Batten and Belongia, 1987; Belongia, 1986; Ott, 1987). On theoretical grounds, real rather than nominal, and effective rather than bilateral, exchange rate indices should be used when assessing the effect of exchange rate movements on trade flows. However, difficulties arise regarding the choice of suitable weights and data availability.

In South Africa, the depreciation of the rand since 1984 has impacted positively on nominal gross proceeds of major South African agricultural exports (South African Wool Board, Deciduous Fruit Board, Citrus Board). Conversely, the lower rand exchange rate has serious implications for South African farmers via the demand for imported inputs. A significant percentage of the fuel, fertilisers, chemicals and capital equipment are imported, either as raw materials, or as finished goods (Le Clus, 1979). A depreciated rand causes input prices to rise which impact negatively on agricultural supply.

2.3 Inflation rate (cost effects)

Inflation can be defined as the continuing or persistent rise in the average level of prices for real goods and services (Klinefelter, *et al.*, 1980).

When investigating the causes of inflation, the distinction must be made between real and nominal effects, and relative and nominal price shifts. Failure to make this distinction results in mis-identification of the real causes of inflation (Belongia and Fisher, 1982). Explanations of the causes of inflation in agriculture can be divided into two approaches - the structuralist and the monetarist (Barnett, *et al.*, 1983; Shei and Thompson,1988).

The structuralist approach views inflation as being caused by real shocks such as crop failures and changes in consumption patterns. Money supply adopts a passive role which accommodates price increases in the non-agricultural sector. The agricultural sector is assumed to be perfectly competitive, producing homogenous goods whose prices are completely flexible. The industrial sector is viewed as being oligopolistic, producing heterogeneous goods under increasing returns to scale. Prices are set on a cost-plus basis and lack flexibility.

If all prices were perfectly flexible with the same adjustment rates, the general price level would be unaffected by real shocks, although relative prices would change. Increases in some prices would be exactly offset by declines in others. In the real world however, prices adjust at different rates and tend to be inflexible downwards. Real shocks therefore affect relative prices of agricultural commodities and are viewed as the primary cause of inflation.

The monetarist approach assigns monetary policy an active role in which money supply is controlled directly by the monetary authorities. For monetarists, the equilibrium overall price level is that which induces individuals to hold the exact quantity of money that is available. An excess supply, say from an unanticipated increase in money supply, shifts aggregate demand upwards, causing excess aggregate demand. The general price level thus rises, thereby lowering the real value of nominal money supply. Equilibrium is restored when the stock of real balances again equals the demand for real balances.

Monetarists recognise the existence of real shocks which change relative prices, but see growth in the money supply as the direct cause of inflation because money supply is "the sole known stimulus that can occur continuously without upper bounds on its quantity" (Belongia and Fisher, 1982). All other stimuli, such as wage demands, cannot occur continuously

without monetary accommodation, and therefore inflation - the sustained increase in nominal prices - can occur only under conditions of continued monetary expansion.

A real shock, such as crop failure, raises nominal agricultural prices. Other things being equal, this raises the general price level (reducing the stock of real money balances) and lowers real income (reducing the demand for real balances). If nominal money supply remains the same, individuals must reduce their spending on goods and services to rebuild real balances. Aggregate demand thus shifts downwards, lowering prices in all sectors with upward sloping supply curves. The process continues until the price level has fallen to its original level, where the quantity of money supplied again equals the quantity demanded. Without monetary accommodation, only relative prices - not the general price level - change. Although the two approaches differ as to the causes of inflation, both assign monetary policy a role in its control. They also provide a useful basis from which to investigate the causes of inflation in South African agriculture.

In South Africa, money supply has been assigned a passive role which accommodates increases in nominal prices and wages. Inflation has been attributed to autonomous increases in wages and salaries in excess of increases in labour productivity (Botha, 1986; Moore and Smit, 1986). As the agricultural sector derives a significant percentage of its inputs from the non-agricultural sector, this provides an important pass through for inflation into the agricultural sector.

Several economists have argued that farmers face a cost-price squeeze due to input price increases exceeding agricultural product price increases. Groenewald (1985) contends that South African farmers face cost-push inflation due to their lack of control over input prices. In South Africa, the monopolistic structure and protection of the local input manufacturing industry has contributed to higher agricultural input costs. Le Clus, cited by Groenewald (1982), claims that in 1982 the price of inputs produced by protected industries exceeded the price at which they could be imported by between 34 and 74 percent.

Use of cost-push theory to explain the causes of inflation in agriculture has been criticised (Batten, 1981; Belongia and Fisher, 1982; Belongia, 1985). The cost-push theory of inflation ignores the distinction between "relative price changes" and "inflation". Changes in agricultural prices consist of a relative component caused by shifts in the supply and demand schedules, and a nominal component associated with the trend rate of growth in money supply.

Increases in input prices ahead of product price increases represent a change in relative prices, not inflation. The change is neither sustained, nor is it shared by a wide range of commodities. Inflation only results when nominal price increases of a broad range of goods and services are accommodated by monetary expansion. This is apparent in South Africa where the monetary authorities have been unsuccessful in restraining money supply growth rates. Money supply is passive relative to demand and has accommodated increased prices and wages. Although many factors have contributed to changes in relative prices and added to the agricultural cost-price squeeze, inflation could not have occurred without continued accommodation by monetary authorities.

Failure to distinguish between factors responsible for changes in the relative and nominal components makes it difficult to determine the causes of inflation and the different effects of the two components. Any analysis of inflation must therefore include a relative component (demand and supply shifters) and a monetary component.

2.4 Real income (demand effects)

Real disposable income impacts on agriculture via aggregate demand for agricultural products. As money is neutral in the long run, the impact of monetary policy on agriculture via the real income linkage is a short run phenomenon. The effect of changes in real incomes is commodity specific. As real disposable income increases, demand for highly income elastic commodities increases, e.g. red meat and fruit, and demand for inferior goods, like maize, (Cadiz, 1984; van Zyl, 1986a) falls.

3. Econometric model

A general equilibrium simultaneous equations model is specified using annual data for 1960 to 1987. The model consists of five sectors, two representing agriculture and three representing the macroeconomy. The agricultural sector consists of the maize and beef sectors which were selected as they are the largest contributors to gross crop and livestock production respectively (Directorate Agricultural Economic Trends). The macroeconomy comprises the manufacturing sector and money and foreign exchange markets. The exchange rate, inflation and real disposable income are determined endogenously within the model.

Economic activity in the maize, beef and manufacturing sectors is simulated by the specification of relevant real *per capita* demand, supply, export, import and inventory equations. Interaction between the macroeconomy and the maize and beef sectors is modeled by interest rate, exchange rate, inflation and real income linkages in relevant model equations.

3.1 Money market

The money market is the nucleus of the model from which all monetary shocks originate. It is represented by a nominal money supply identity, real money demand equation and market equilibrium condition.

Money supply, M, is the product of the money multiplier, m, and monetary base, B, such that,

$$M = m.B \qquad (1)$$

Methodology used to specify the money supply function follows that described by Oldham (1978) and Contogiannis (1979). Real money demand is specified as a function of the nominal interest rate, real income and general price level. This reflects the Keynesian specification of real money demand which has two components - the transactions and speculative demand for money (Teigen, 1964). The interest rate and real income represent these two components.

3.2 Foreign exchange market

The foreign exchange market is represented by a balance of payments identity and an exchange rate determination equation. The exchange rate is determined according to the monetarist framework which emphasises the link between money supply and interest rate fluctuations and the exchange rate. This approach maintains that the observed short-run volatility of exchange rates is largely due to monetary policies that are variable and erratic. In the long run, the main factor underlying exchange rate volatility is lack of coordination between the monetary policies of different countries (Humphrey and Keleher, 1982:248).

The exchange rate is estimated as a function of domestic and foreign money supplies, nominal interest rates and real incomes. A country which experiences faster monetary growth, higher nominal interest rates and a lower rate of increase in real income will see its exchange rate depreciate relative to that of the foreign currency.

The exchange rate is defined in terms special drawing rights which gives a better indication of the overall competitive position of the domestic currency and eliminates the need to construct a basket index of exchange rates (Chambers, 1979). A grafted polynomial variable is used to differentiate between three exchange rate regimes during the study period: fixed exchange rates (1960-1971), pegged exchange rates (1972-1978)

and managed floating exchange rates (1979-1987) adopted after implementation of the De Kock Commission recommendations.

The general price level determination equation is specified according to the monetarist interpretation of the quantity equation,

$$MV = PY \quad (2)$$

The line of causation runs from left to right. An increase in the money stock, M, causes the price level, P, to rise given constant velocity of circulation, V, and real income, Y. Rearranging the equation, the price level is derived as,

$$P = MV/Y \quad (3)$$

Therefore the consumer price index (CPI), chosen as a suitable proxy for the general price level, is regressed on the ratio of nominal money supply (M2) to real gross domestic product and lagged CPI to represent inflationary expectations (Devadoss, 1985).

3.3 Manufacturing sector

The manufacturing sector comprises real *per capita* demand and real net import demand equations. South Africa is a net importer of manufactured goods resulting in a net import rather than a net export demand equation. Real *per capita* demand for manufactured goods is a function of the real manufactured goods price and real *per capita* disposable income. Real net import demand for manufactured goods is specified as a function of the real price of imported manufactured goods, exchange rate and real gross domestic product. Real manufactured goods supply is determined from the market equilibrium identity.

3.4 Maize and beef sectors

The maize sector consists of real supply, real *per capita* human demand and real animal demand equations and a market equilibrium identity.

Agricultural supply decisions are based on expectations of future producer and input prices. In the absence of information about future prices, expectations are based on prices of the previous season. Real maize supply is therefore specified as a function of lagged real maize producer price, lagged real input price, lagged real price of major substitutes (wheat, soya beans and oilseed crops), rainfall, area planted and real interest rate. The real interest rate, proxied by the real prime overdraft rate, captures the cost effects of changing short-term debt costs on real maize supply. Inclusion of the real input price simulates the inflation and exchange rate linkages between monetary policy and real maize supply.

A Nerlove lag model was specified to capture the response of maize area planted to lagged area planted and lagged returns or profits per hectare. These variables represent farmers' expectations of future prices, which depend to a limited extent on prices in the previous year (Nerlove, 1956).

The real *per capita* human maize demand equation, like all *per capita* demand equations in the model, is specified according to neoclassical theory. Real *per capita* human maize demand is regressed on the real maize producer price, real price of substitutes (bread, rice and potatoes) and real *per capita* personal disposable income.

Real animal demand for maize is derived from the demand for animal products (Nieuwoudt, 1973). It is therefore estimated as a function of real maize price, real beef price, livestock inventory and lagged real animal maize demand.

South African maize farmers have a small share of the world grain market, making them price takers who face a perfectly elastic export demand curve. They can also be regarded as residual exporters of maize (Nieuwoudt, 1988). Real maize exports and inventories are therefore treated as exogenous variables (independent of price and exchange rates movements) in the model.

The beef sector comprises two behavioural equations representing real supply and real *per capita* demand, and a market equilibrium identity. Real beef supply is specified as a function of the real beef auction price, real input price, real prices of substitutes (mutton, pork and poultry) and herd size, all lagged by one year, and the real prime overdraft rate. A positive sign is hypothesised for the real interest rate coefficient due to the stock effects of real interest rate changes on real beef supply. Real *per capita* beef demand is specified as a function of real beef auction price, real prices of substitutes (mutton, pork and poultry) and real *per capita* personal disposable income.

The need to purchase inputs produced off-farm is reflected by input demand equations for each sector. These equations are specified in their inverted form to capture the effects of inflation and exchange rate changes on input prices (Devadoss, 1985). Input prices in each sector are regressed on the real quantity of inputs purchased, CPI and exchange rate.

A firm's demand for capital depends on the rental cost of capital and the expected level of output (Dornbusch and Fischer, 1981:187). Real agricultural investment is therefore regressed on the real interest rate and real gross farm income. The real interest rate represents the cost of capital and simulates the interest rate linkage. Real gross farm income is derived by summing real income for the maize and beef sectors.

The system is closed by five national accounting identities pertaining to real disposable income, real total personal consumption expenditure, real gross domestic fixed expenditure, real net exports and real gross domestic product.

3.5 Summary of macrolinkage simulations

Endogenous determination of the exchange rate, general price level and real disposable income within the model links changes in monetary policy to the maize and beef sectors. The interest rate is treated exogenously as this variable is under the direct control of the SARB. The macrolinkages are simulated by including these four macrovariables in the relevant agricultural sector equations.

The interest rate linkage is captured by specifying the real interest rate in the real maize supply, real beef supply and real agricultural investment equations. Cost effects of real interest rate changes impact negatively on real maize supply and real investment, while stock effects impact positively on real beef supply. For example, an expansionary monetary policy reduces real interest rates which lowers the cost of short term production loans and hence increases real maize supply. Conversely, lower real interest rates cause real beef supply to fall as the opportunity costs of off-farm investment (e.g. in interest bearing assets) rise and costs of holding animals fall.

The inflation and exchange rate linkages work via the inverted demand equations for off-farm produced inputs. Higher domestic inflation raises input prices due to increased production costs and wage demands. The exchange rate linkage is derived from the significant proportion of agricultural inputs which are imported into South Africa, either as raw materials or as finished goods (Le Clus, 1979). A depreciation in the exchange rate increases the cost of imports and puts upward pressure on input prices. These linkages are simulated by estimating input prices as function of the CPI and exchange rate. Estimated input prices are then included in the real maize and beef supply equations to complete the macrolinkages.

Real personal disposable income is defined as real gross domestic product less real taxes and deductions (Devadoss, 1985). The income linkage is simulated by including real *per capita* personal disposable income in the real *per capita* maize, beef and manufactured goods demand equations.

4. Conclusion

Review of available literature identifies four key macrovariables which link changes in monetary policy to agriculture - the exchange rate, interest rate, inflation and real income. A general equilibrium simultaneous equations model is therefore specified to simulate the macrolinkages associated with these macrovariables through which monetary policy changes are transmitted to the maize and beef sectors in South Africa. The exchange rate, general price level and real income are determined endogenously within the model.

The exogenous interest rate linkage is simulated by including the real interest rate in the real maize supply, real beef supply and real agricultural investment equations. This captures cost and stock effects of interest rate changes on maize and beef supply respectively. The CPI and exchange rate are specified as regressors in inverted demand equations for off-farm inputs to capture inflation and exchange rate cost effects on input prices. Inclusion of these prices in real maize and beef supply equations completes the inflation and exchange rate linkages. The real income linkage is simulated by including *per capita* personal disposable income as a determinant of both real *per capita* human maize demand and real *per capita* beef demand.

The simulated macrolinkages enable the impacts of changes in monetary policy on real maize and beef supply, *per capita* demand, prices and incomes to be analysed. This will give policy makers greater insight into the possible impacts of monetary policy on the maize and beef sectors. The second article provides this insight by reporting model estimation results and simulating the impacts of an expansionary monetary policy on the two sectors. The potential gain in efficiency from parameter estimation by 3SLS rather than 2SLS is also illustrated.

Note

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