Inventory investment in South Africa

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Introduction

Inventory investment makes a significant contribution to short-run changes in gross domestic product. In South Africa relatively little research has gone into a better understanding of inventory changes and their influence on aggregate output and expenditure. The objective of this article is to explore and explain a number of prominent changes in inventory investment in South Africa since the beginning of the 1960s.

Firstly, the role and measurement of inventory investment in the national accounts are described. Secondly, the motives for the holding of inventories are discussed. Then the structural changes that took place in inventory investment in South Africa are analysed, before the relationship between inventory changes and business cycle movements is examined. The article concludes with the specification and estimation of an econometric model of inventory investment.

Inventories in the national accounts

Participants in the processes of production and expenditure can be divided into four sectors, namely business enterprises, general government, households, and non-residents. The basic processes or forms of economic activity are production, consumption, capital formation and transactions with the rest of the world. The transactions relating to each of these processes for the respective sectors are recorded in the different sub-accounts of the national accounts.

Capital formation, or gross domestic investment, represents an increase or decrease in inventories and gross additions to fixed assets. The *change* in inventories and not their *book value* is recorded in the national accounts. Gross domestic product is the value of all final goods and services that are produced during a certain period, e.g. a year, within the boundaries of a country. Existing inventories at the beginning of the period are thus excluded, because they were produced in previous periods. Only the additions to and withdrawals from inventories, in other words the change in inventories during a specific period, form part of the gross domestic product of that period. Inventories consist of raw materials, work in progress and finished products.

Table 1 shows the gross domestic product and expenditure account, in other words the consolidated production account of the economy as a whole. The sum of the expenditure items on the right-hand side of Table 1 is, by definition, equal to the gross domestic product on the left-hand side. The gross domestic product and the different expenditure items are estimated from many different sources of information of which the accuracy and reliability may differ significantly. Because of measurement errors, it is unlikely that the estimate of total production will be exactly equal to the estimate of total expenditure. The difference between these estimates is designated as a residual item and included in the right-hand side of the account. This residual, or balancing item, is seen as part of gross domestic expenditure because the estimated domestic expenditure totals are deemed to be subject to a higher degree of error than the estimates of the gross domestic product and the transactions with the rest of the world.

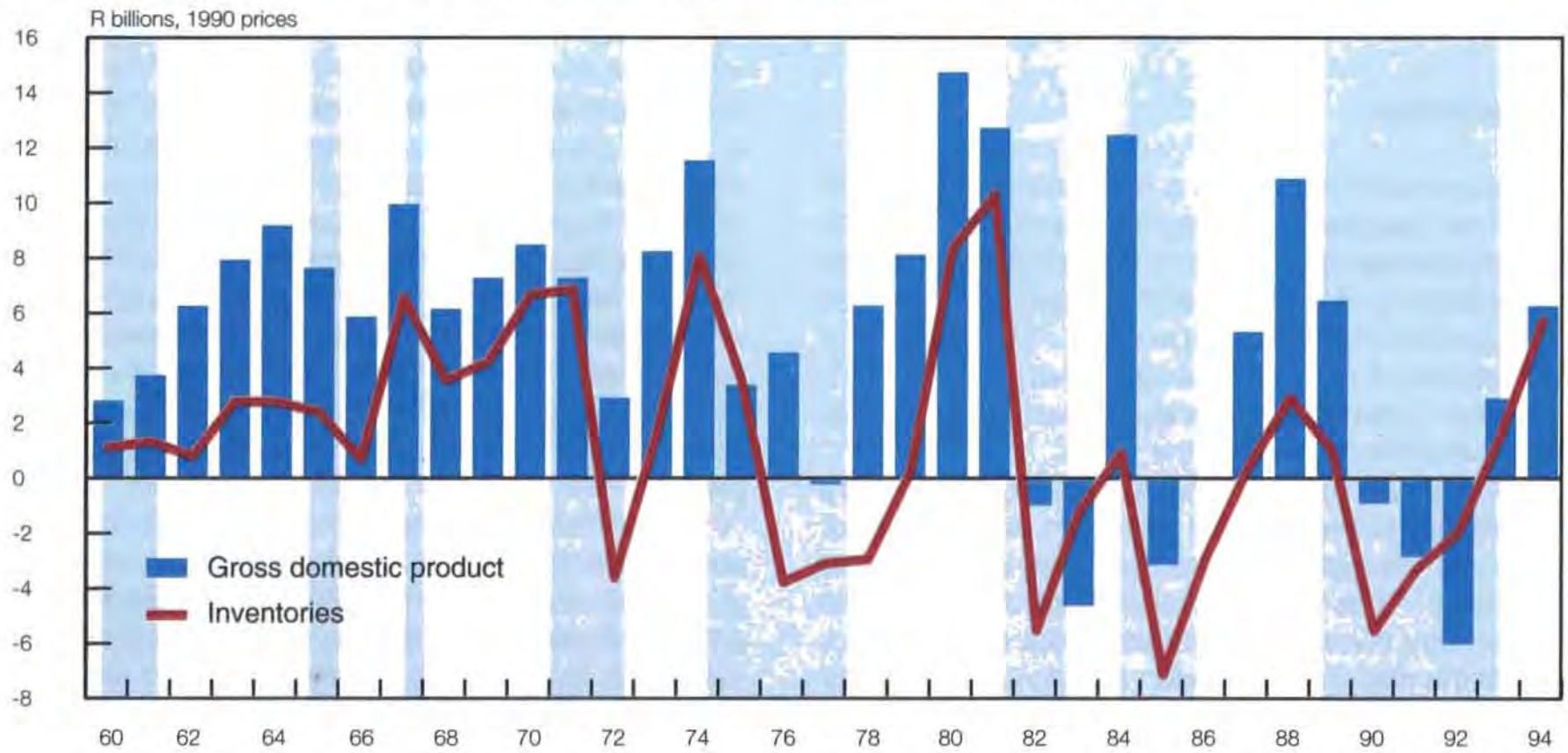
Inventory investment, together with private consumption expenditure, consumption expenditure by the general government and gross domestic fixed investment, forms part of total gross domestic expenditure. Inventory investment therefore contributes,

Table 1. Gross domestic product and expenditure, 1994

R millions

Net domestic product at factor cost (factor income)	323 024	Private consumption expenditure	256 320
Provision for depreciation	59 537	Government consumption expenditure	91 349
Indirect taxes	57 736	Gross domestic fixed investment	68 101
less: Subsidies	7 544	**Change in inventories**	**10 209**
		Residual item	-1 493
		Gross domestic expenditure	424 486
		Exports of goods and non-factor services	102 682
		less: Imports of goods and non-factor services	94 415
Gross domestic product at market prices	**432 753**	**Expenditure on gross domestic product**	**432 753**

Graph 1: Change in real inventories and change in real gross domestic product



Shaded area: Downward phase of the business cycle.

at least in an *ex post*-sense, to the size of the gross domestic product through its direct influence on aggregate demand (see Graph 1).

The change in inventories is also reflected in the consolidated capital finance account for the economy as a whole (see Table 2). It forms part of gross domestic investment on the left-hand side of the account. The right-hand side of the account shows the internal and external financing sources which, lumped together, form the gross saving available to the economy. Inventory investment therefore has a direct influence on the appropriation of investable funds in the economy.

While production and sales are economic processes that adjust continuously depending on supply and demand conditions, they are seldom exactly equal to each other in a specific period. The difference between supply and demand is reflected in a change in inventories. An increase in the level of inventories implies that part of production was not sold. Conversely, when inventory levels decrease, sales exceed production.

Table 2. Gross domestic investment and financing, 1994

R millions

Gross domestic fixed investment	68 101	Net saving	
Change in inventories	**10 209**	Personal saving	9 717
		Corporate saving	24 957
		Government saving	-17 990
		Depreciation	59 537
		Gross domestic saving	76 221
		Net capital inflow from the rest of the world	5 209
		Change in gold and other foreign reserves[1]	-3 120
Gross domestic investment	**78 310**	**Financing of gross domestic investment**	**78 310**

1. Increase -, decrease +.

Changes in inventories can be planned or unplanned. In Keynesian models, unplanned inventory investment often plays a central role in explaining economic expansions and contractions. Empirically, however, the planned and unplanned components of inventory investment are not measured separately.

For national accounts purposes, the change in inventories during a given period should be calculated as the physical change in inventories valued at market prices prevailing during that period. The standard period of accounting in South Africa is a calendar quarter. To obtain the closest feasible approximation of the desired estimate for national accounts purposes, the difference between the physical levels of inventories at the beginning and at the end of a quarter is valued at the price ruling in the quarter. Reported values of inventories at the beginning and end of a quarter, i.e. the current book values of inventories, are revalued to reflect constant price levels. The difference between the revalued inventories at the end and the beginning of the quarter measures the physical change in inventories over the quarter. This physical change in inventories for a quarter is revalued at an average price that prevailed in the quarter. The difference between the revalued physical changes in inventories and the changes in the current book values represents the inventory valuation adjustment, i.e. the change in the value of inventories because of price changes.

As illustrated in Table 3, inventory changes can be calculated from quantity or book value data. Where the actual physical quantities of inventories held by a business enterprise or a sector at the end of each quarter are known, the estimation of inventory investment is straightforward. The change in physical quantity during a quarter is multiplied by the average price of the product concerned for that quarter. This method of calculation is in fact used for livestock and gold inventories.

More often, however, only end-of-quarter book values of inventories are available. Book values may change because of changes in quantities or because of the changes in the prices at which inventories are valued. To obtain the national accounts concept of inventory investment, the change in book values due to price changes should be separated from the total change. To do so, book values are deflated by an appropriate component of the production price index. In this way book values at constant prices are obtained from which the change at constant prices is calculated, i.e. the change in the quantity of inventories. By multiplying the change in quantity with the average price index level for the particular quarter, inventory investment at current prices is obtained.

Quarterly estimates of the book values of inventories at current prices are compiled from information obtained from various sources, such as directly from the Department of Agriculture, from statistical releases and censuses of the Central Statistical Service, and from surveys undertaken by the Reserve Bank for this purpose where information is collected from public corporations, business enterprises of general government and some private business enterprises.

Table 3. The calculation of inventory investment

(a) From quantity data	
Quantity at end of period 0	20 units
Quantity at end of period 1	35 units
Change in quantity	15 units
Average price per unit	R1 000
Inventory investment	R15 000

	Current price book value	Price index (period 0 prices)	Constant price book value
(b) From book value data			
(i) Value at end of period 0	R4 000	100	R4 000
(ii) Value at end of period 1	R5 500	110	R5 000
(iii) Change in book value	R1 500		R1 000
Inventory valuation adjustment:			
(iv) Change in constant price book value (real inventory investment)		R1 000	
(v) Average price index during period 1		105	
(vi) Inventory investment at current prices ((iv) multiplied by (v))		R1 050	
(vii) Inventory valuation adjustment (current price (iii) less (vi))		R450	

A definite pattern of seasonality is descernible in the quarterly estimates of inventory investment. For purposes of inter-quarter comparisons it is necessary to identify those inventory changes that can be attributed to purely seasonal variation. The well-known X-11 Variant of the Census Method II Seasonal Adjustment Programme is used to compute patterns of seasonality in the book value of inventories and the seasonally adjusted book values are then applied to calculate seasonally adjusted inventory changes. In the trade sector of private business enterprises, wholesale, retail, motor trade and agricultural stocks-in-trade are adjusted separately for seasonality. Because of the large seasonal variation in agricultural production, maize inventories are treated as a separate category. The influence of early and late maize crops is taken care of by calculating separate seasonal indices for late and early crops. An early crop is defined as one where 60 per cent of the crop is harvested before 30 June.

Motives for holding inventories

Three motives for holding inventories can be identified:

- Firstly, a so-called *transactions motive* arises to hold inventories when businesses cannot synchronise the receipts of raw materials and components, the processing of the materials and the sale of the finished goods. There are also scale advantages if production, storage, transport and transactions are conducted on a large scale.

- Secondly, a *production smoothing* or buffer-stock motive arises where inventories are held in order to allow for changes in the demand for products. Production can then be carried on relatively smoothly, despite changes in demand. The smooth flow of the production of goods reduces the unit costs of production. Inventories can also be held to provide for any changes in the supply of raw materials, components or finished goods. Inventories decrease the risk of loss of income because of the inability to meet demand. This motive suggests that the inventories of finished goods serve primarily to smooth production levels when sales are variable and the marginal cost of production is rising. A steeply rising marginal cost curve provides a strong motive to smooth production, while high storage costs act as disincentive to such behaviour.

- Thirdly, a *speculation motive* to hold inventories originates from expected price and cost changes. More inventories will be accumulated if a price rise is expected. The speculation motive is usually supported by the gathering and analysis of information.

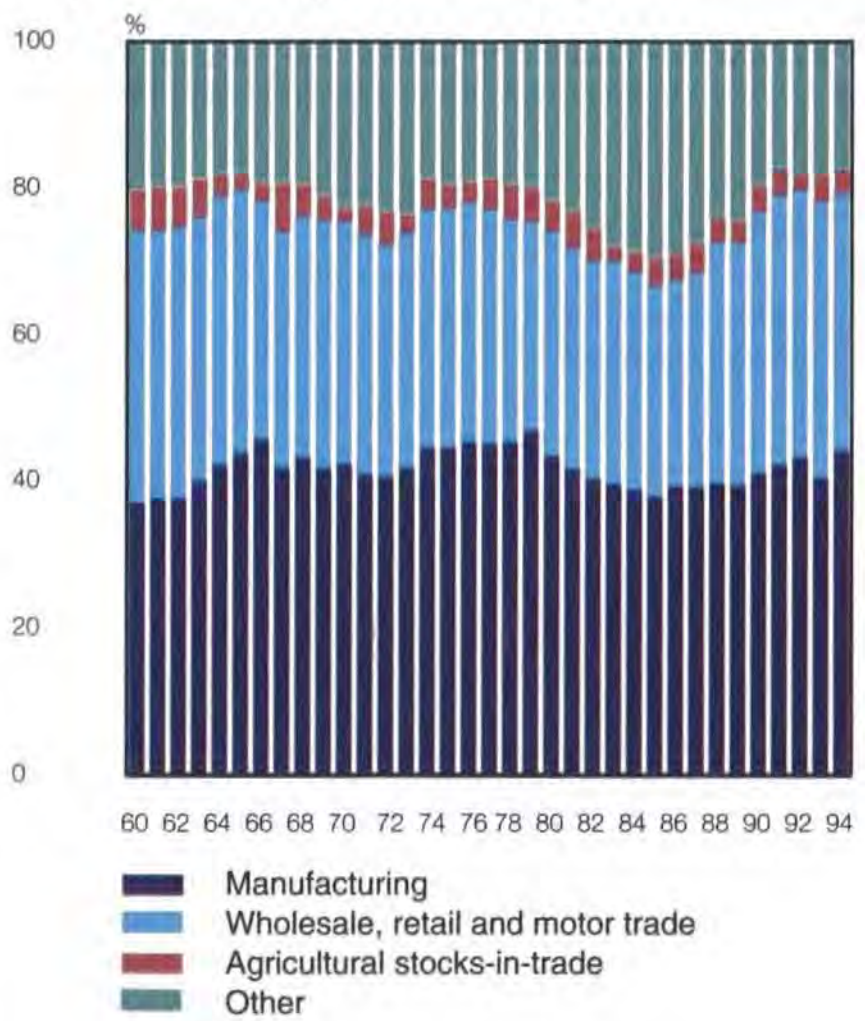
Various models of inventory behaviour have been developed on the basis of these motives. An important development has been to allow for a target of a specific inventory-to-sales ratio. This procedure is followed because it is expensive for businesses if inventories deviate from the desired ratio to actual or expected sales. When a business is attempting to maintain a desired inventory-to-sales ratio, an unanticipated change in sales will inevitably lead to a change in inventories to re-adjust to the desired inventories-to-sales ratio. The accelerator principle may also be at work – the change in sales may lead to a bigger change in production as the business attempts to re-adjust its inventories to the desired inventories-to-sales ratio. Cost shocks can also be introduced into the model to allow for an inventory build-up to occur when production costs are relatively low. Conversely, inventories will be run down when production costs are high. Rather than smoothing the level of production, businesses according to this line of thought smooth the costs of production. It can be argued that cost shocks play at least as important a role as demand shocks in determining the behaviour of inventory investment if production costs are variable.

Structural changes in inventory investment

Changing economic conditions and technological developments have led to structural changes in inventory investment in South Africa. These structural changes in inventory investment are analysed by examining the composition of inventories, the ratio of the level of inventories to gross domestic product and the inventory-to-sales ratio.

An analysis of the composition of total real inventories by type of economic activity shows no major changes in

Graph 2: The composition of inventories



the long run (see Graph 2). It is also clear that industrial and commercial inventories (i.e. inventories in the sectors manufacturing and wholesale, retail and motor trade) form the major part of total inventories. The ratio of manufacturing inventories as a percentage of total inventories remained broadly unchanged during the period 1960 to 1980, and since 1980 has declined only moderately. On the other hand, the ratio of wholesale, retail and motor-trade inventories declined somewhat from 1960 to the middle of the 1980s and increased again from about 1986. The increased importance of other inventories in the periods 1966 to 1975 and 1980 to 1985 can be ascribed to increases in strategic inventories and diamond stocks-in-trade. The graph clearly shows that the ratio of agricultural stocks-in-trade to total inventories is very small and that it did not change much over time. The low level of these inventories can, *inter alia*, be ascribed to the fact that a surplus of agricultural stocks-in-trade is exported, while shortages are usually made good through imports.

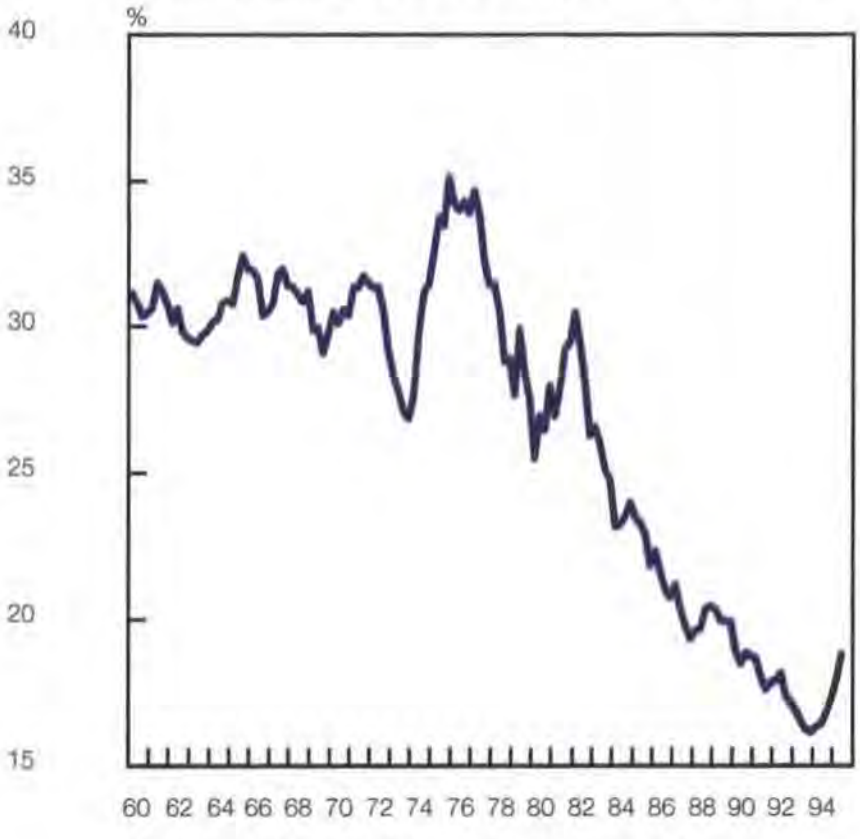
The level of industrial and commercial inventories as a percentage of the non-agricultural gross domestic product for the period from the first quarter of 1960 to the second quarter of 1995 is shown in Graph 3. Two periods can clearly be distinguished in this graph, namely 1960 to 1975 and 1976 onwards. The main feature of the first period is a relatively stable average ratio of industrial and commercial inventories to non-agricultural gross domestic product of about 30 per cent. A high point of 35 per cent was reached in the fourth quarter of 1975. From 1976 onwards this ratio showed a steadily declining long-term tendency. A historical low of 16 per cent was recorded in the fourth quarter of 1993.

Graph 4 shows the industrial and commercial inventory-to-sales ratio for the period from the first quarter of 1966 to the second quarter of 1995. This ratio was calculated by dividing the average inventory level per quarter by the average monthly sales per quarter, obtaining the average number of months it would take to sell off all inventories. From Graph 4 it can be seen that this ratio has displayed a persistently declining long-term trend since the second half of the 1970s. During the period 1966 to 1975 the average ratio was about 2½ months. From 1975 the ratio declined steadily to an average of 2 months in 1980 and 1½ months in 1990. It then fluctuated around the last-mentioned level in the first half of the 1990s.

In Graph 5 the inventory-to-sales ratios of manufacturing, wholesale and retail trade are shown. From this graph it is apparent that the inventory-to-sales ratio of manufacturing has declined sharply since 1981. The sharp drop in the ratio in manufacturing in 1981 was probably caused by the simultaneous occurrence of a depreciation of the rand, an increase in interest rates and higher inflation, that caused a decrease in inventories. Declines in the corresponding ratios in the wholesale and retail trade were not as pronounced as that in manufacturing.

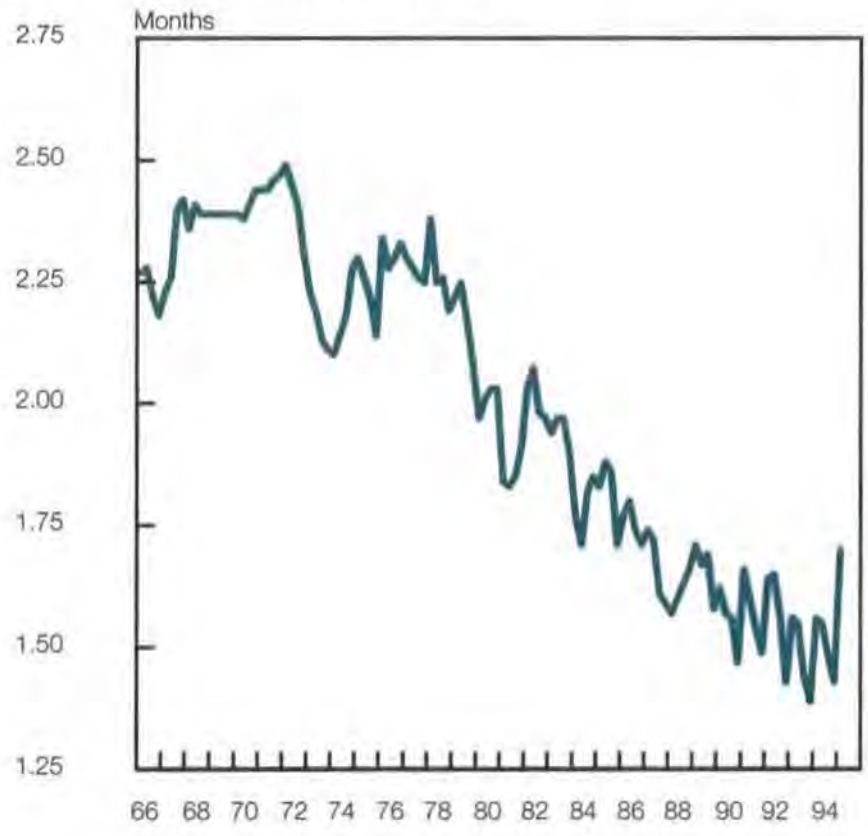
From this analysis it is apparent that a significant structural change occurred in inventory investment in

Graph 3: The ratio of industrial and commercial inventories to gross domestic product



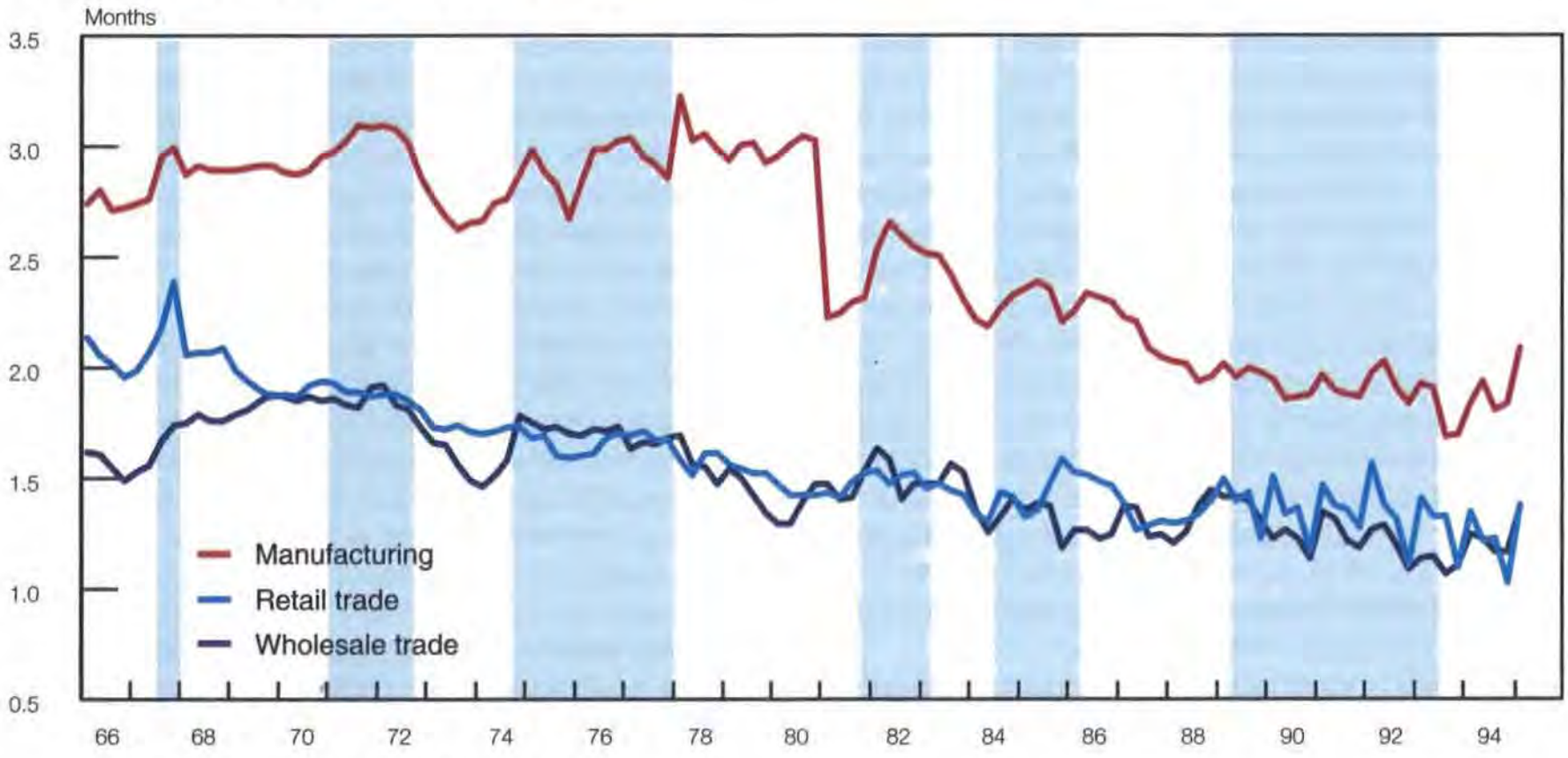
Shaded area: Downward phase of the business cycle.

Graph 4: The ratio of industrial and commercial inventories to sales



Shaded area: Downward phase of the business cycle.

Graph 5: The ratio of inventories to sales



Shaded area: Downward phase of the business cycle.

South Africa from the middle of the 1970s, and that additions to inventories rarely matched increases in aggregate output.

The following reasons for the declining trend in the inventory ratios, as shown in Graphs 3, 4 and 5, can be cited:

- Deteriorating economic growth and an increasingly competitive business environment, necessitating attempts to curtail the costs of holding inventories.

- More effective inventory management techniques made possible by, *inter alia*, advanced computer technology.

- More reliable delivery and transport systems, making it possible to economise on inventory holdings throughout the production and distribution network.

- The shifting of some inventory holdings to informal sector vendors, where it is no longer measured as inventories but as private consumption expenditure.

- Higher interest rates, which caused a rise in the cost of holding inventories. The cost of holding inventories was also affected by the depreciation in the external value of the rand because inventory investment in South Africa has a high import component.

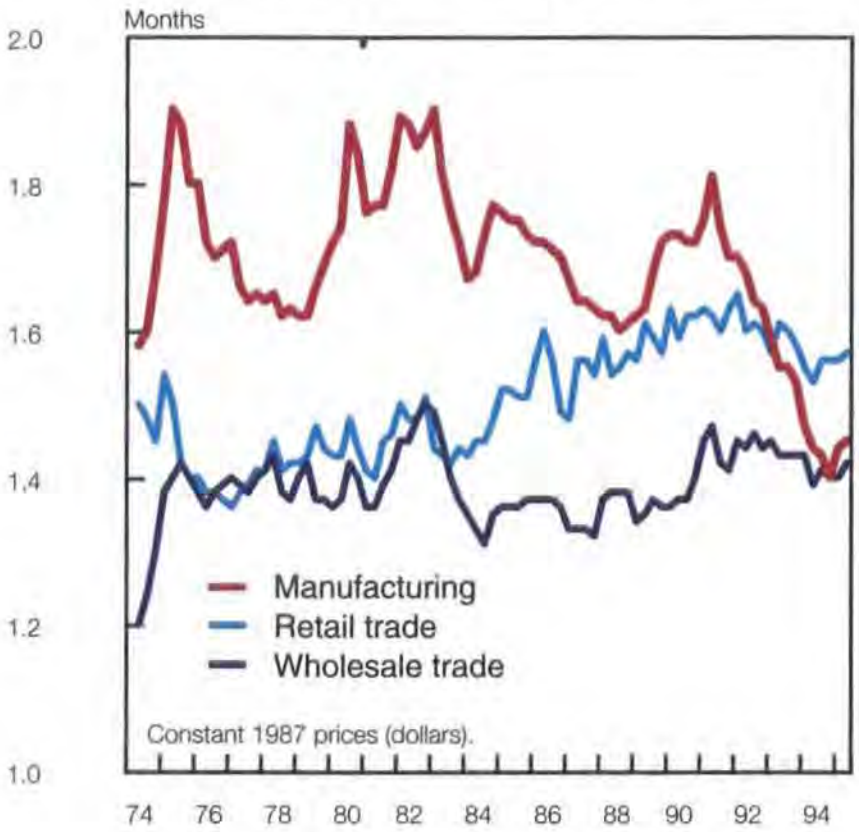
- The growing importance of the financial and general government services sectors in the total gross domestic product and the relatively small inventory holdings of these sectors strengthened the downward drift in the ratio of inventories to gross domestic product.

Inventory developments in other countries broadly followed a pattern similar to that recorded in South Africa. The inventory-to-sales ratios in the major sectors of the economy of the United States of America have fallen since 1982 – modestly for the economy as a whole but more sharply in manufacturing. By contrast, the inventory-to-sales ratio of the wholesale sector remained on more or less the same level, while retail inventories moved slightly upwards, but not enough to offset the decline in the ratio of the manufacturing sector.

During much of the 1960s and 1970s the ratio of inventories to output in the United Kingdom was fairly constant because inventory levels were raised in support of the growing volume of output and demand. During the 1980s, however, there was a strong and uninterrupted decline in the inventories-to-output ratio. This initially reflected a large fall in the level of inventories, but when inventory levels stabilised in 1983 growing output volumes made the major contribution to the declining trend.

Inventory-to-sales ratios in Australia displayed the same trend as that of the United States, viz. a more or less stable ratio for the 1960s and 1970s and a declining trend during the 1980s. A marked decline is particularly

Graph 6: The ratio of inventories to sales in the United States of America



evident in the inventory-to-sales ratio of the manufacturing sector in Australia, while the ratio of the retail sector declined only slightly.

This international comparison confirms that the structural changes in South Africa formed part of similar changes that took place in the rest of the world. The reasons given for the structural changes in the different countries are also broadly similar to those put forward for the declining ratio in South Africa.

Inventory investment and the business cycle

International studies of inventory behaviour over time seem to be in agreement on the importance of inventory investment in the description and explanation of post-war business cycles in industrialised countries. In Table 4 the average contributions of the major expenditure components to the growth in gross domestic product in South Africa are compared over the course of the business cycle. The contribution of each expenditure component to the growth in gross domestic product over the business cycle was obtained by first calculating the change in the constant-price values of that expenditure component over the relevant period. This change was then divided by the accumulated change in gross domestic product over the same period and multiplied by the percentage change of the gross domestic product over that period.

From this table it is apparent that the average contribution of inventory investment during the downswing phases of the business cycle was -3,5 per cent. This negative contribution of inventory investment to the growth in gross domestic product together with that of fixed investment exceeded the positive contributions by the other final demand components. For the upswing phases the average contribution of inventory investment to the growth in gross domestic product was 4,1 per cent, which compared well with those of the other aggregates. If the contribution of investment in industrial and commercial inventories (-2,3 per cent in downswings and 2,6 per cent in upswings) is excluded, the investment in other inventories made a relatively small contribution to changes in gross domestic product (-1,2 per cent in downswings and 1,5 per cent in upswings). The average contribution of inventory investment over the full business cycle was only 0,3 per cent. This means that the negative contribution over the

Table 4. The average contribution of major components of expenditure on gross domestic product to the growth in gross domestic product over the business cycle from 1960 to 1995[1]

Percentages

Average during:	Private consumption expenditure	Consumption expenditure by general government	Gross domestic fixed investment	Final demand	Inventory investment				
					Total	Industrial and commercial			Other
						Manufacturing	Wholesale, retail and motor trade	Total	
Downswings	1,0	1,2	-0,6	1,6	-3,5	-1,5	-0,8	-2,3	-1,2
Upswings	7,2	2,0	3,9	13,1	4,1	1,6	1,0	2,6	1,5
Full cycles	7,1	2,9	2,6	12,6	0,3	0,3	0,2	0,5	-0,2

1. The upswing from June 1993 is not yet complete.

downswing phases and the positive contribution over the upswing phases almost cancelled out over the full business cycle.

The conclusion can therefore be made that inventory investment strengthens the upswing and the downswing phases of the business cycle. The analysis also shows that industrial and commercial inventories are the most important component of inventory investment and that it dominates the long-term movement in inventory investment. If the amplitude of the inventory cycle can be dampened, the variance of the business cycle will accordingly also be smaller.

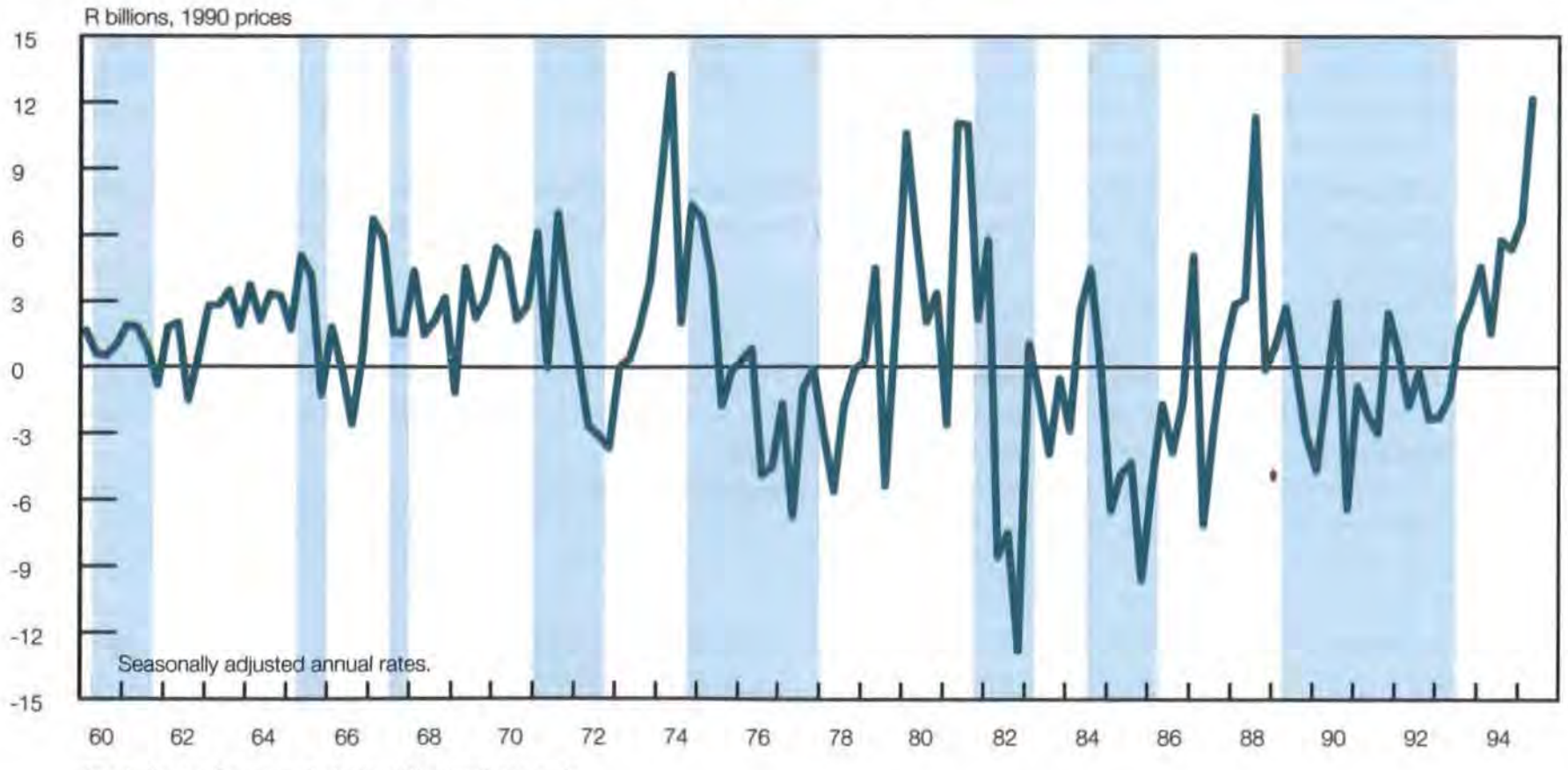
The changes in real industrial and commercial inventories are depicted in Graph 7 together with the business cycle. In general, the inventory cycle and the business cycle are positively correlated. The inventory cycle rises during the upswing phases and decreases during the downswing phases of the business cycle. A more systematic measurement of the timing of turning-points and the correspondence between the inventory cycle for industrial and commercial inventory investment and the business cycle showed that *on average*, the turning-points of the industrial and commercial inventory investment cycle coincided with the business cycle and the lengths of the two cycles were about the same. However, the turning-points of the inventory cycle and the business cycle did not correspond consistently. The inventory cycle led at four peaks and four troughs and lagged at three peaks and three troughs, while it coincided at one peak and one trough. The differences in timing could be attributed to the various lengths of the cycles and the unique circumstances shaping each inventory and business cycle.

Table 5 presents a summary of the timing of turning-points in different measures of the inventory cycle and the correspondence of these cycles with the business cycle. The *level* of inventories lagged behind the business cycle, while inventory *investment* tended to coincide with it. Inventory investment appears to have led the level of inventories by about two to four quarters.

A simple example illustrates why the turning-points of inventory investment lead the turning-points of the level of inventories (see Graph 8). If inventory investment is denoted as ΔN and the level of inventories as N, then $N_t = N_{t-1} + \Delta N$. If ΔN is positive, N rises. If ΔN reaches a maximum positive value and then recedes to a lower but still positive value, ΔN has moved past its upper turning-point. N, however, continues to rise. Only once ΔN has receded to a negative value, will N start to decline, moving past its upper turning-point.

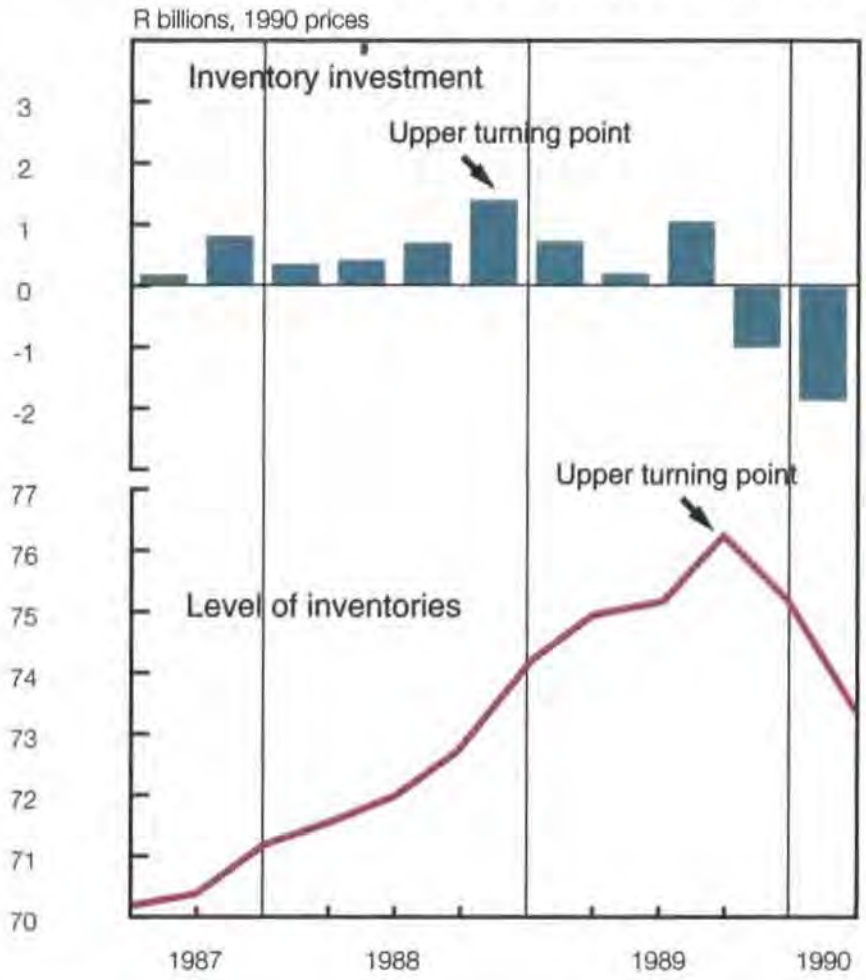
From Table 5 it is clear that the lengths of the cycles of the different inventory series are almost the same and that it is also about the same length as the business cycle. A general conclusion is that the level of real inventories and inventory investment of the different sectors conform positively with the business cycle. On average, total inventory investment lagged the business cycle by one quarter at the peak and coincided at the trough. Industrial and commercial inventory investment coincided with the business cycle at the peak and the

Graph 7: Real industrial and commercial inventory investment



Shaded area: Downward phase of the business cycle.

Graph 8: The relationship between inventory investment and the level of inventories



trough. It is apparent that inventory investment did not initiate the upswing. In the beginning of the upswing phase businesses drew down existing inventories. Only when the surplus inventories were exhausted, an accelerated accumulation of inventories that strengthens the upswing phase took place. Because of its consistent performance as a lagging indicator, the level of industrial and commercial inventories is incorporated in the composite lagging business cycle indicator of the Reserve Bank.

Econometric modelling of inventory investment

Macro-econometric models usually endogenise the main components of final demand and inventory investment in order to analyse systematically the many complex interrelationships in an economy. Economists' understanding of how the economy works is thus assisted by an equation or set of equations summarising the determinants of inventory investment. The construction of a useful quarterly econometric model of inventory investment is quite taxing, given the considerable volatility displayed by this component of aggregate demand. For this reason, the variables used were restricted to those for which time-series data are readily available, in order to enable other researchers to replicate the model and to elaborate on the results obtained here.

The construction of an empirical model in which *total* inventory investment is explained as a single function of a number of macro-economic variables, was frustrated by the strong fluctuations in certain types of inventories that cannot readily be modelled. For example, changes in strategic inventories and inventories of agricultural

Table 5. The average timing and conformity of inventories and the business cycle, 1960-1993

	Timing[1] (quarters)		Length of inventory cycle (quarters)			Number of quarters by which inventory cycle is longer than the business cycle		
	Peak	Trough	Peak	Trough	Full cycle	Peak	Trough	Full cycle
The level of total real inventories.....	3	4	8	9	17	-1	1	0
The level of real industrial and commercial inventories	4	4	9	8	17	0	0	0
The level of other real inventories	4	5	8	8	16	-1	0	-1
Total real inventory investment.....	1	0	9	6	15	0	-2	-2
Real inventory investment in manufacturing.....	0	0	9	8	17	0	0	0
Real inventory investment in wholesale, retail and motor trade .	0	-1	9	7	16	0	-1	-1
Real industrial and commercial inventory investment	0	0	9	8	17	0	0	0
Other real inventory investment.....	1	0	9	6	15	0	-2	-2

1. Lead (-), lag (+) of inventories relative to the business cycle.

products are determined largely by national policy considerations and weather conditions. In a macro-economic modelling framework such changes in inventories are best treated as exogenous. The widest inventory concept which can be modelled meaningfully as a function of other macro-economic variables, is *industrial and commercial inventories*. In the subsequent description, the change in such inventories (at constant 1990 prices) is denoted by ΔI, and its level at the end of the quarter by I; ΔI is the dependent variable in the key equation developed below.

Inventories are normally held to accommodate sales and to minimise the cost of production. Excessive inventories would imply undesired interest and other holding costs; insufficient inventories could result in sales being forfeited. As a first approximation, a certain desired inventories-to-sales ratio may be pre-supposed. If lagged actual sales, S_{t-1}, are equated with expected current sales and Id represents the desired level of inventories, then

$$Id_t = k^*.S_{t-1}\ , \qquad (1)$$

with k^* the desired equilibrium inventories-to-sales ratio.

The desired inventory-to-sales ratio is not constant in the long run. Given the decline in the observed ratio of inventory levels to sales, it seems reasonable to assume that technological advances and cost considerations are pointing to a steady decline in the desired ratio. In the short run, changes in the holding costs of inventories will inevitably exert some influence on the optimal level of inventories that businesses are prepared to carry. Obvious candidates for the explanation of short-run changes in the desired ratio are interest rates and the relative prices of the goods that are held in store. Higher interest rates are likely to reduce the desired ratio, as would higher relative prices of the goods held as stocks-in-trade. Given the high import content of South Africa's industrial and commercial inventories, the real exchange rate can be used as a first approximation for the relative prices of stocks-in-trade. Without imposing any prior restrictions on the functional relationship between k^* and the explanatory variables, the optimal ratio can therefore be written as:

$$k^*_t = k^*(t, Prime, Rex), \qquad (2)$$

where t = time variable to capture the systematic long-run change of k^*,
Prime = interest rate, and
Rex = real exchange rate.

The adjustment of the observed ratio to the desired inventory-to-sales ratio is not instantaneous and can be distributed over more than one calendar quarter. Since sales may vary unpredictably, it is also necessary to provide for unplanned inventory changes by introducing overshooting, undershooting and attempts to return to equilibrium. Using Metzler's approach as a point of departure, the lagged value of the level of inventories was introduced as a further explanatory variable to capture the partial and gradual nature of the adjustment process. Unexpected short-run fluctuations in sales, the empirical equivalent of which can be approached in numerous ways, was also added as an explanatory variable.

By allowing the data to determine the final form of the behavioural equation and after extensive experimentation with numerous alternative specifications, the following equation was estimated as the best approximation of the inventory-accumulation process in the South African economy:

$$\begin{aligned}\Delta I_t = {} & \underset{(1,46)}{1\,632{,}74} + \underset{(4,91)}{0{,}277\ S_{t-1}} \ \underset{(-2,26)}{-0{,}000477\ .\ t\ .\ S_{t-1}} \\ & \underset{(-6,52)}{-0{,}266\ I_{t-2}} \ \underset{(-4,67)}{-0{,}196\ (S_t - \tfrac{1}{4}\sum_{i=1}^{4} S_{t-i})} \\ & \underset{(-3,51)}{-28{,}29\ Prime_{t-1}} \ \underset{(-3,51)}{-42{,}43\ Prime_{t-2}} \\ & \underset{(-3,51)}{-42{,}43\ Prime_{t-3}} \ \underset{(-3,51)}{-28{,}29\ Prime_{t-4}} \\ & \underset{(3,96)}{+9{,}05\ Rex_{t-1}} \ \underset{(3,96)}{+13{,}58\ Rex_{t-2}} \\ & \underset{(3,96)}{+13{,}58\ Rex_{t-3}} \ \underset{(3,96)}{+9{,}05\ Rex_{t-4}} \qquad (3)\end{aligned}$$

$R^2 = 0{,}59$; $\bar{R}^2$ (adjusted for degrees of freedom) = 0,56
F-statistic = 21,82
DW = 1,76
Estimation period = 1971Q1 to 1995Q1.
Estimated by ordinary least squares; t-values in brackets immediately below the estimated coefficients.

The coefficients of lagged values of Prime and Rex were estimated by assuming that these coefficients follow a second-degree polynomial distribution with both endpoints restricted to zero.

The variables involved are listed below. Those marked with * are measured in millions of rand at constant 1990 prices, and are seasonally adjusted.

ΔI = change in industrial and commercial inventories*,
S = aggregate sales* (defined below),
t = time variable, 1960Q1 = 1, 1960Q2 = 2, etc.,
I = quarter-end level of industrial and commercial inventories*,
Prime = quarterly average prime interest rate of the clearing banks, per cent per annum
Rex = quarterly average real effective exchange rate of the rand, 1990 = 100 (rising values signalling an appreciating rand and declining values signalling a depreciating rand).

Aggregate sales encompass gross domestic expenditure, excluding government consumption expenditure (largely services), the services component of private consumption expenditure and industrial and commercial inventory investment, but including exports of manufactured goods:

$$S = GDE - G - Cserv - \Delta I + Xm \qquad (4)$$

where the variables which have not been defined previously are:

GDE = gross domestic expenditure*,
G = government consumption expenditure*,
Cserv = private consumption expenditure on services*, and
Xm = exports of manufactured goods*.

The first three terms on the right-hand side of the estimated equation describe the evolution over time of the long-term desired inventory-to-sales ratio. The negative coefficient of the product term ($t.S_{t-1}$) signals that the optimal inventory ratio declines over time. The linearity of the relationship allows for negative values of the optimal inventory ratio at high values of t. This could cause a problem if the forecast horizon is extended too far into the future, but appears to be a workable assumption when the model is employed over a relatively short forecasting interval. The I_{t-2} variable, with its negative sign, captures the partial adjustment process in which inventory levels that are low relative to the desired level, lead with a time lag to a deliberate rebuilding of inventory levels; the opposite applies if the observed inventory level is high relative to the desired level. The $(S_t - \frac{1}{4}\sum_{i=1}^{4} S_{t-i})$ term allows for unexpectedly high levels of sales in the current quarter to be met from decreases in inventories. Unplanned short-run changes in inventories are captured in this way, also underlining the need for buffer-stocks of inventories. Expected sales equal $\frac{1}{4}\sum_{i=1}^{4} S_{t-i}$; in other words, sales expectations are based on the average sales of the previous four quarters. This seems to be an over-simplification, but experimentation with more complex expectation formation schemes yielded poor results.

The negative coefficient of Prime indicates that high interest rates encourage economising on inventory levels. Whereas a number of previous studies could find little evidence that interest rates have an impact on inventory investment, the estimated coefficient of the interest rate term in this study is well-behaved and statistically significant. The positive sign attached to Rex indicates that when imported goods, and therefore inventories, become less expensive on account of an appreciating currency, inventories are likely to be accumulated. Both Prime and Rex take a number of quarters to exert their full effect.

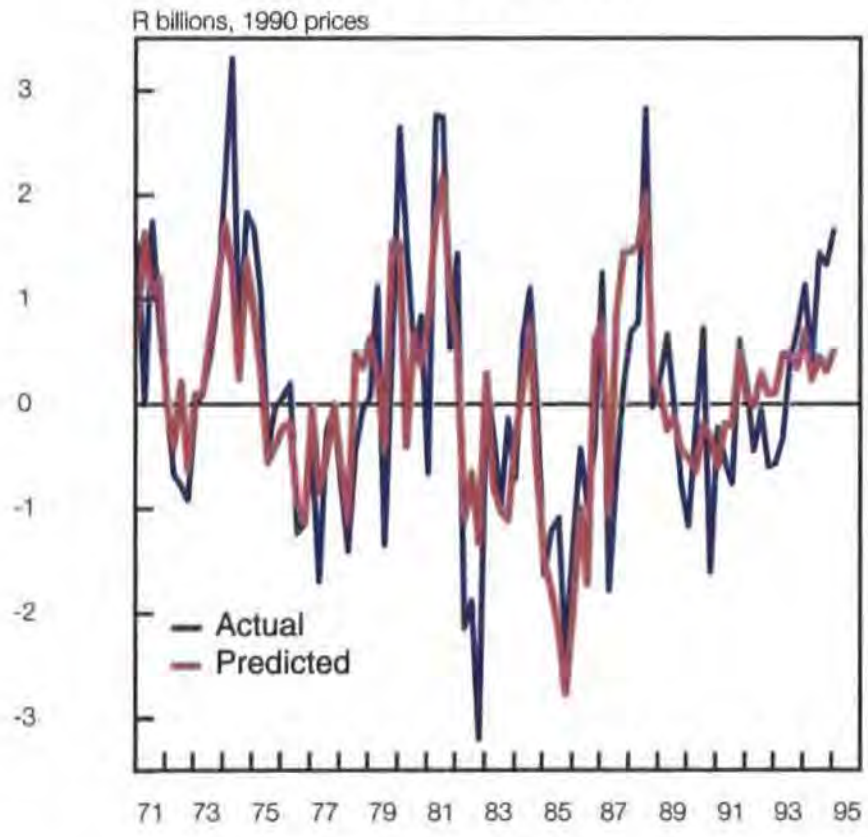
Testing and using the model

A first indication of the model's accuracy is provided by the goodness-of-fit statistics shown above. The signs and t-values of the various estimated coefficients are satisfactory and conform with *a priori* reasoning. The coefficient of determination, R^2, seems reasonably high in the light of the high variance of inventory investment.

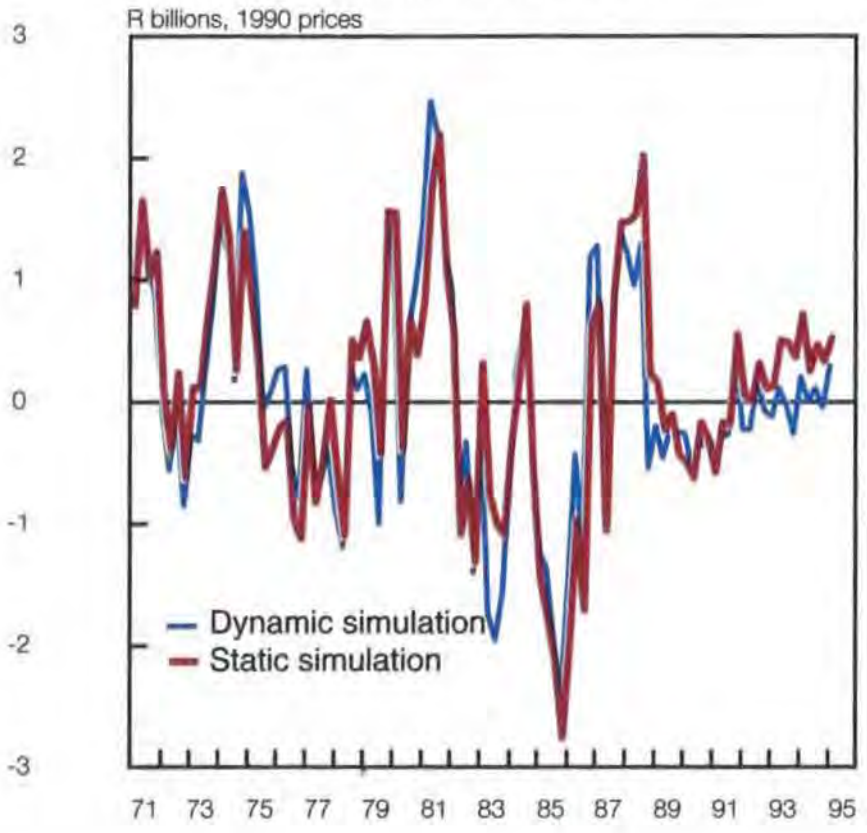
The outcome of an in-sample simulation exercise, obtained by inserting the actual values of all the explanatory variables into the equation and calculating predicted values for inventory investment, is depicted in Graph 9.

Graph 9 shows that observed inventory investment has been much higher than the values predicted by the model from the third quarter of 1994 to the first quarter of 1995. One possible explanation for this is that the more stable monetary policy environment, the withdrawal of sanctions and the more certain business outlook because of the more stable political situation in the country, fostered a willingness to hold more inventories than earlier patterns of behaviour would seem to indicate. Other possible explanations are that the long-term decline in the inventories-to-sales ratio has started to level out, that more inventories are held to contain the effects of expected labour action, or more generally that random forces in the economy produced a number of successive above-expected outcomes of inventory investment. Further investigation is required before this issue can be resolved conclusively.

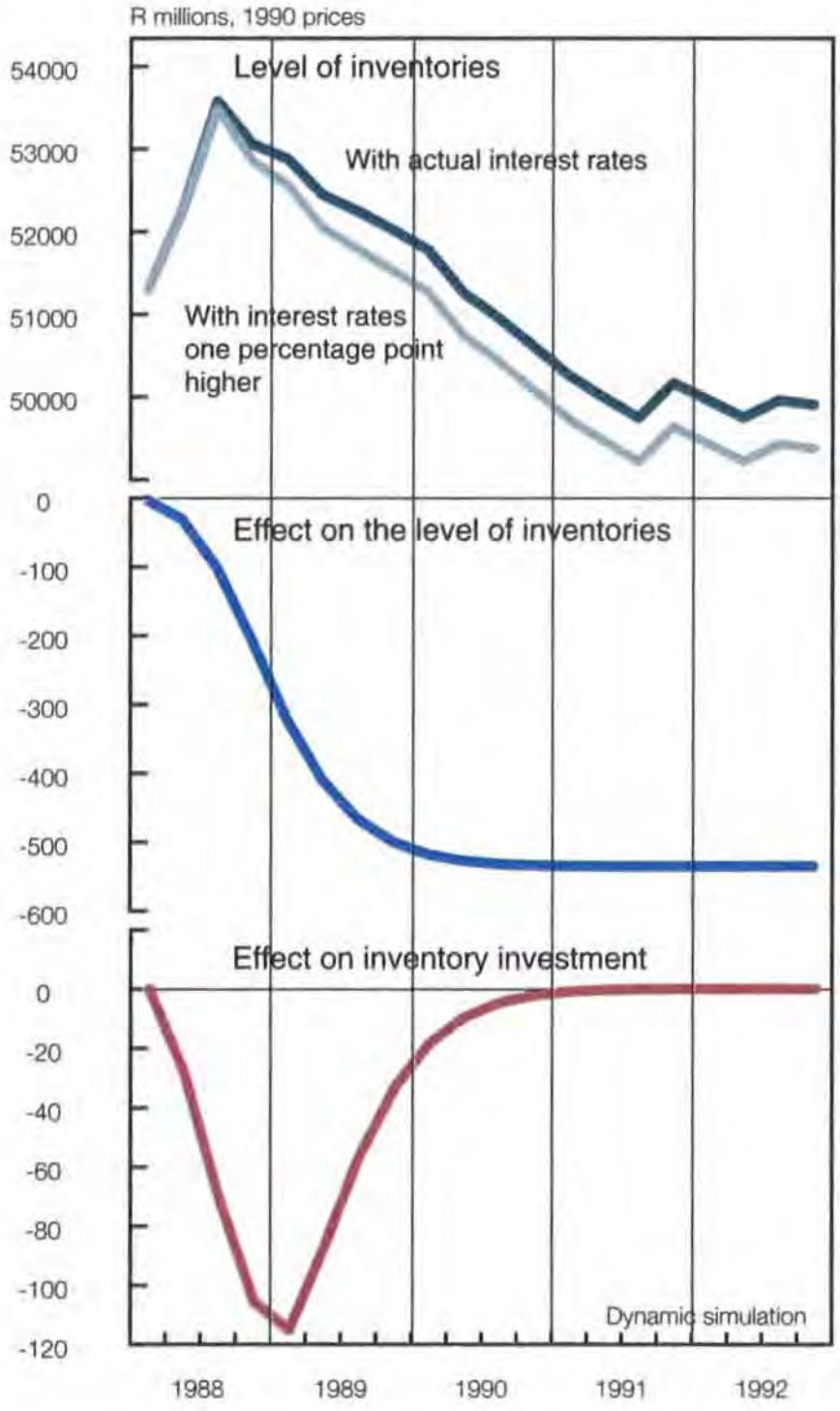
Graph 9: The changes in industrial and commercial inventories: actual and predicted values



Graph 10: Changes in industrial and commercial inventories: predicted values



Graph 11: The effect on industrial and commercial inventories of a sustained increase of one percentage point in the prime overdraft rate



For the purpose of the in-sample simulation, the observed values of past levels of inventories were included as explanatory variables. A further simulation was then prepared by allowing the pre-determined values of the lagged level of inventories to be determined endogenously by the model. The simulated values of the change in inventories were used to calculate the cumulated level of inventories which then appear as an explanatory variable with a two-quarter lag. The results of this (dynamic) simulation are illustrated in Graph 10 along with the outcome of the previous in-sample (static) simulation.

Simulations can also be used to determine the response of inventory investment to changes in the variables exogenous to the model. As an example, the model was solved dynamically from the first quarter of 1971 to the fourth quarter of 1992, using the actual values of the exogenous variables and the endogenously determined values of the level of inventories. The procedure was repeated, but with the interest rate variable Prime increased by one percentage point from the first quarter of 1988 to the fourth quarter of 1992. The results are summarised in Graph 11. A permanent increase in interest rates reduces inventory *investment* for some 13 quarters, and reduces the *level* of inventories permanently. The strongest impact on inventory investment is recorded after four quarters have elapsed.

Summary

Through its direct influence on aggregate demand, inventory investment contributes to the size of gross domestic product. It also has a direct influence on the appropriation of investable funds in the economy. Inventories serve to breach the highly variable gap between aggregate supply and demand.

Economic conditions and changes in technology have brought about a structural decline in the level of inventories relative to the level of output. An international comparison of inventory ratios confirmed that structural changes in South Africa formed part of similar changes that took place in other countries. The reasons put

forward for the structural changes in the different countries are also broadly similar.

Inventory *investment* tends to coincide with the business cycle and does not initiate cyclical changes in the economy, while the *level* of inventories follows the business cycle with a time delay of about three to four quarters. Because of its consistency as a lagging aggregate behind overall economic activity, the level of industrial and commercial inventories forms part of the composite lagging business cycle indicator of the Reserve Bank.

An econometric investigation of quarterly changes in real industrial and commercial inventories has sales, unexpected changes in sales, the lagged level of inventories, interest rates and the real exchange rate as explanatory variables. The model performs reasonably well in *ex post*-forecasting. Of particular significance is that both interest rates and the exchange rate – variables well within the sphere of monetary policy – are shown to have a significant effect on inventory investment.

Bibliography

Abramovitz, M. 1950. *Inventories and business cycles, with special reference to manufacturing inventories.* National Bureau of Economic Research. New York: The Gallery Press.

Blinder, A.S. & Maccini, C.J. 1991. Taking stock: A critical assessment of recent research on inventories. *Journal of economic perspective,* vol. 5, No. 1, 73-96.

Callen, T.S. 1989. Stockbuilding behaviour. Bank of England, Quarterly Bulletin, May, vol. 29, No. 2, 264-270.

Eichenbaum, M. 1988. Some empirical evidence on the production level and production cost smoothing models of inventory investment. *National Bureau of Economic Research, Working paper*, No. 2523.

Etter, R. 1993. *Inventory behaviour of firms at different levels of aggregation.* Lecture presented at the twenty-first CIRET conference.

Evans, M.K. 1969. *Macroeconomic activity: Theory, forecasting, and control.* Harper International.

Flood, D. & Lowe, P. 1993. Inventories and the business cycle. *Reserve Bank of Australia, Research discussion paper,* No. 9306.

Gregory, C.A. 1973. Non-farm inventory investment in Australia 1950-1970. *Committee for economic development of Australia, M series,* No. 36.

Inter-secretariat working group on national accounts. 1993. *System of national accounts 1993.* Eurostat, IMF, OECD, UN and World Bank.

Little, J.S. 1992. Changes in inventory management: Implications for the U.S. recovery. *New England economic review,* Federal Reserve Bank of Boston, November/December 1992, 37-65.

Metzler, L.A. 1941. The nature and stability of inventory cycles. *Review of economic statistics*, vol. 23, No. 3, 113-129.

Pratten, C. 1985. *Destocking in the recession.* Aldershot: Gower publishing company.

Smit, D.J. & Van der Walt, B.E. 1970. Business cycles in South Africa during the post-war period, 1946 to 1968. South African Reserve Bank, *Quarterly Bulletin,* September.

Smit, D.J. & Van der Walt, B.E. 1973. Business cycles in South Africa during the period 1968 to 1972. South African Reserve Bank, *Quarterly Bulletin,* June.

Smit, D.J. & Van der Walt, B.E. 1982. Growth trends and business cycles in the South African economy, 1972 to 1981. South African Reserve Bank, *Quarterly Bulletin*, June.

Smith, H. 1994. *Voorraadinvestering in Suid-Afrika.* Unpublished M.Com dissertation. Pretoria: University of Pretoria.

Stadler, J.J. 1973. *Die nasionale rekeninge van Suid-Afrika.* Cape Town & Pretoria: Haum.

Stanback, T.M. 1962. *Postwar cycles in manufacturing inventories*. National Bureau of Economic Research.

South African Reserve Bank, *Annual Economic Report*, several issues.

South African Reserve Bank, *Quarterly Bulletin,* several issues.

South African Reserve Bank. 1991. South Africa's national accounts, 1946 tot 1990. *Supplement to Quarterly Bulletin,* June.

South African Reserve Bank. 1994. South Africa's national accounts, 1946 tot 1993. *Supplement to Quarterly Bulletin,* June.

Van den Heever, J.P. 1988. *Die kwantifisering van beleidsopsies met betrekking tot die makro-ekonomiese stabilisasievraagstuk in Suid-Afrika*. Unpublished D.Com thesis. Pretoria: University of Pretoria.

Van der Walt, B.E. 1983. Indicators of business cycle changes in South Africa. South African Reserve Bank *Quarterly Bulletin*, March.

UN. 1968. *System of national accounts*. Studies in methods, series F, No. 2, rev. 3, New York: United Nations.

UN. 1986. *Handbook of national accounting, accounting for production: sources and methods*. Studies in methods, series F, No. 39. New York.

U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis, *Survey of Current Business*, several issues.