OECD DEVELOPMENT CENTRE

Working Paper No. 15
(Formerly Technical Paper No. 15)

AGRICULTURE AND THE ECONOMIC CYCLE: AN ECONOMIC AND ECONOMETRIC ANALYSIS WITH SPECIAL REFERENCE TO BRAZIL

by

Florence Contré and Ian Goldin

Research programme on:
Developing Country Agriculture and International Economic Trends

June 1990

OECD OCDE

TABLE OF CONTENTS

SUMMARY 9

PREFACE 11

INTRODUCTION 13

PART ONE
ECONOMIC THEORY 15

PART TWO
QUANTITATIVE ANALYSIS 19

A. Proportions and growth rates 19

Comparative growth rate ratios 20
Conclusion 20

B. Econometric evidence: Standard Deviations and Elasticities, Stationarity and Cointegration 21

Method 22
Estimations and their interpretation 23
Result 25

PART THREE
REFLECTIONS 27

Stability and Growth 27
Growth and Adjustment 27
Food versus Export Crops 28
Conclusion: Agriculture, Adjustment and Stability 29

NOTES 30

APPENDIX ONE 33

APPENDIX TWO 36

BIBLIOGRAPHICAL REFERENCES 37

TABLES AND FIGURES 43

SUMMARY

This study provides an economic and econometric analysis of agriculture in the economic cycle, with special reference to the recent experience of Brazil. Part One of the paper discusses the economic theory and points to the relevance of classical texts for analysis of agriculture's role in the economic crisis facing developing countries. Part Two of the paper tests the hypothesis that agriculture exercises a stabilising role in the economic cycle using statistical and econometric procedures. It offers a novel application of tests of cointegration and stationarity and concludes on this basis that agriculture does indeed exercise a stabilising role in the economic cycle.

The study was concluded under the Development Centre's programme "Developing Country Agriculture and International Economic Trends", directed by Ian Goldin.

RÉSUMÉ

L'analyse économique et économétrique de l'agriculture dans l'ensemble du cycle économique, objet de cette étude, fait spécialement appel à l'expérience récente du Brésil. La première partie traite de la théorie économique et signale l'adéquation des textes classiques pour l'analyse du rôle de l'agriculture dans la crise économique des pays en développement. La deuxième partie évalue, à l'aide de statistiques et d'opérations économétriques, l'hypothèse selon laquelle l'agriculture a une fonction stabilisatrice dans le cycle économique. Il s'agit d'une application originale de tests de cointégration et de stationnarité qui conclut, sur ces bases, au rôle stabilisateur de l'agriculture dans le cycle économique.

Cette étude entre dans le cadre du programme du Centre de Développement "Agriculture des pays en développement et évolution de l'économie internationale", dirigé par Ian Goldin.

PREFACE

The decade of the 1980s was characterised by a deep recession in many developing countries. Nevertheless, the overall stagnation, or, in many cases, decline in economic activity, concealed a highly significant phenomenon: agriculture appeared relatively unaffected by the crisis. Its strength exercised a cushioning effect on the decline in economic activity, moderating declines in incomes and providing a pole for employment and growth.

This paper provides an economic explanation and undertakes econometric testing of the role of agriculture in the economic cycle. It breaks new ground in applying the insights of classical economic texts and of economic theory to the understanding of agriculture's position in the cycle. Equally innovative is the application of recently developed econometric tests which offer a powerful new tool for the analysis of dynamic economic relations, affording an opportunity for examining relationships which hitherto have remained elusive.

The analysis provides original insights which will be of interest to both theoretical and applied economists. Its interest is, however, by no means confined to academics: the development of an appropriate appreciation of agriculture's contribution to growth is a prerequsite for policy makers interested in sustainable development.

Louis Emmerij
President, OECD Development Centre
June 1990

AGRICULTURE AND THE ECONOMIC CYCLE:

AN ECONOMIC AND ECONOMETRIC ANALYSIS WITH SPECIAL REFERENCE TO BRAZIL*

INTRODUCTION

Agriculture's resilience

In Brazil, record harvests in 1987, 1988 and 1989 have popularised the notion that agriculture has become immune to the worsening of the economic situation, and that it is capable of cushioning the fall in the level of economic activity. In fact, agricultural production since the beginning of the 1980s appears to have performed a stabilising function, limiting the collapse of the Brazilian economy.

The relative strength of agricultural performance in this period bears repeating. For example, in the period 1981-83, when industrial output contracted by 15 per cent, agricultural output rose seven per cent. Figure 1 shows, furthermore, that successively better harvests in the period 1987-89 reflected the continuation of the growth trend interrupted in 1986. Normalising for the impact of the 1985 climatic disaster, we observe an annual geometric average growth rate of agriculture of 3.1 per cent between 1980 and 1988, which compares to 1.2 per cent for industry; in the period 1970-80, these growth rates were 4.7 per cent and 9.3 per cent respectively.

Comparative perspectives

The apparent immunity of agricultural production to the economic crisis of the 1980s appears to be a phenomenon which extends beyond the borders of Brazil. While the dearth of comparative studies of inter-sectoral growth trends makes generalisation hazardous, our preliminary comparison of agricultural and industrial growth trends indicates that Brazil's experience may well be typical.

Comparative analysis of the inter-sectoral growth rates in Latin America (de Janvry, 1988) provide preliminary support for the findings of our Brazilian case study. Support for the hypothesis that agriculture has provided a cushion for the fall in GDP also is provided by the data assembled by the World Bank (World Development Report, 1989). It shows that in both developing and OECD countries, agricultural growth tended to fall less rapidly than industry and GDP in the period 1980-86. In the period 1965-80 the corollary was also true; agriculture grew less rapidly than industry and GDP.

Exceptions to this apparent trend in inter-sectoral relations are evident. Further research will reveal whether these exceptions may be explained with reference to

distortionary phenomena, such as oil finds, (for example, "Dutch Disease" in Cameroon), civil war (for example, in Ethiopia, Mozambique or El Salvador), or climatic disaster (as in Sudan) or whether they invalidate the hypothesis that agriculture acts as a stabilising force in the economic cycle.

Here, we present our initial results, offering original insights both with respect to the economic explanation and the quantitative analysis. In Part One, the apparent stability of agriculture is explored with reference to economic analysis of the business cycle and the classical agricultural texts. In Part Two, the Brazilian evidence is subjected to econometric tests. The confirmation of the hypothesis is then extended to other Latin American countries. Finally, in Part Three, we consider the Brazilian experience in the light of the econometric results and offer conclusions as to the wider applicability of the research findings.

PART ONE

ECONOMIC THEORY

A reading of the economic literature on business and trade cycles reveals the dearth of substantive analysis of agriculture and the cycle. The classic texts of Hayek (1931), Kalecki (1935), Keynes (1936), Haberler (1937), Schumpeter (1939) and Kaldor (1940) illustrate the extent to which concerns about agriculture or inter-sectoral relationships even during the 1930s remained outside the main-stream of economic analysis of business cycles. Following the further development of mutliplier-accelerator theories in the 1950s, the cyclical focus, and its distinctly Keynesian flavour, in the 1960s gave way to monetarist concerns and the static prejudice of equilibrium analysis. While the development of rational expectations models of the business cycle has been a central issue on the macroeconomic research agenda since the influential work of Lucas (1972), neither the monetarist business cycle models, such as those of Lucas and Barro (1976), nor the real business cycle models, such as those of Kydland and Prescott (1982) and Long and Plosser (1983), attach analytical significance to inter-sectoral relationships or to agriculture.

The role of agriculture in the cycle is not examined in much of the growth cycle literature. However, a wider review of the classical literature has provided important comparative insights. In particular, work by Kirk (1933), Galbraith and Black (1938) and Schultz (1945) which considers agricultural performance during the Great Depression has proved relevant. These authors highlight the relatively robust performance of agriculture during the Great Depression, explaining this in terms of the peculiarities of agriculture *vis-à-vis* industry.

Among the key explanatory variables for the varying performance of agriculture and industry in the business cycle is the view that the price-elasticity of agricultural supply is close to zero in the short run, and that this leads, in a recession, to a fall in the relative prices of agricultural goods, even though the decline in demand for industrial goods is greater. This is based on the observation that agricultural production is less easily adjustable than industrial processes. Once agricultural production cycles have been initiated, the reversion of the production process and their adjustment to changes in demand incurs higher costs than changes to the industrial production process, which in the Great Depression was observed to be more easily adjusted. In addition, whereas industrial products are in general storable, the perishability of agricultural products makes storage relatively expensive, and, due to the instability of the agricultural markets, is highly risky for private investors.

Differences in the market structure of agricultural and industrial products also contributes to changes in the agricultural-industrial sectors' relative growth rates over the trade cycle. The differing market structure apparently explains the phenomenon that industrial prices are generally determined on a "cost-plus" basis, whereas in the case of agriculture, individual producers are less able to prevent prices declining when supply outpaces demand, irrespective of whether this in the short-run covers the production costs. Agricultural prices thus suffer a relatively greater decline in prices when demand contracts than that experienced by industrial goods. The ironic implication is, in the face of inelastic demand for food, that a generalised reduction of supply -- even if this implies the destruction of stocks and crops -- can raise the total revenue accruing to producers (as evident in the 1930s burning by Brazil of its coffee stocks).

Although not examined in the context of longer term relations, the differentiation between the short term behaviour of agricultural and industrial prices has been studied by Kalecki (1971), Hicks (1974), Kaldor (1976) and others and has also attracted attention in Brazil, most notably, from Sayad (1984). This post-War literature does not however appear to consider the question of medium term responses; unlike the pre-War analysis of Kirk, Galbraith and Schultz, the recent literature does not examine the production response of agriculture to changing prices, and how this changes over the cycle. The recent literature thus is virtually silent on the important question of how agricultural terms of trade change through the course of a business cycle and how one can expect agriculture's relative performance to behave during a recession.

The analysis of agricultural terms of trade depends, of course, on the aggregate price elasticity of agricultural supply in the medium term. If agricultural supply in the medium run (after responding to the initial price changes) is relatively insensitive to the initial fall in prices, it may be concluded that terms of trade will throughout the recessive period remain inferior to those prevailing before the recession started.

Hansen (1932), Harrod (1936), Galbraith and Black (1938), Schultz (1945) and Johnson (1950) have suggested that the medium term price elasticity of agricultural supply is indeed very low. Among the most important of the explanatory factors are the flexibility of the prices of the primary factors of production (land and labour) and the maximising behaviour at the farm level, which in the context of the competitive structure of agriculture, leads to full utilisation of capital stock.

In the case of a recession, Goldin and Rezende (1990) confirmed, factor price flexibility meant that wages and rents declined faster in the agricultural sector than the industrial sector [1]. In Brazil, as elsewhere, the explanation for this is to be found in the analysis of the supply price (cost) of labour. This price is closely determined by the alternative income that the rural labour force can earn outside agriculture. Analysis of rural labour markets in the United States during the Great Depression suggests that the opportunity cost (alternative income) falls drastically during a recession, especially if the higher search costs, resulting from the fact that increased unemployment reduces the

probability of finding an urban job, are taken into account. In the Great Depression, this process apparently went so far as to lead to a decline in net migration to the cities and an increase in employment in agriculture.

The recent evidence from Brazil suggests a similar rural labour response to recession. In developing countries, such as Brazil, in which agricultural sector production is based on the co-existence of wage labour systems and family labour systems Goldin and Rezende (1990) suggest a further dimension to the response of agricultural factors of production to recession. In particular, family farming units appear on the basis of labour costs to be relatively more competitive during a recession; firstly, because the (imputed) wage for family labour may be expected to fall more sharply than for hired labour, whose wages -- at least for some categories of workers -- are related to those in the urban sector, and secondly, because whereas the cost of hired labour has to be fully covered, this variable cost does not constitute the same type of risk in family production, as it is the residual income.

The rental value of land, when considering agriculture as a whole, may also be considered as a residue. This means that during an agricultural recession it will generally accompany agricultural prices in their fall. To the extent that agricultural land has no alternative use outside agriculture, its price elasticity of supply is zero (the supply curve is vertical), implying that as long as the rent is positive, all available land will be supplied and utilised. Of course, the selling price of land, being the capitalised rent accruing today and in the future, may not fall, if the decreased rents are perceived by land investors as a temporary phenomenon and, therefore, are not projected into the future.

The same argument that may be used to explain continued land use during a recession may be applied to previously accumulated capital goods, such as tractors, irrigation channels, buildings and working animals, developed pastures, established forests and other capital assets. As is the case with land, the competitive structure of agriculture suggests that as long as the additional income obtained from their utilisation covers at least part of the fixed cost (maintenance expenses, interest on capital invested etc.), thereby minimising losses, the assets will continue to be fully utilised during a recession. In industry, by contrast, oligopolistic prices which are designed to recover full costs in the face of reduced demand lead to lower capacity utilisation.

Whereas the agricultural sector utilisation of accumulated capital goods need not fall during a recession, the demand for new capital goods -- investment -- will fall. This is the case with respect to investment in new land frontiers and private investment in agricultural infrastructure as well as to investment in current inputs. Investments in industrial outputs, such as chemical fertilisers, are particularly vulnerable during a recession because they become more expensive both in terms of the agricultural output and in terms of the primary factors, land and labour.

The extent to which the rate of new investment will fall during a recession depends on the cost and availability of new capital, that is, on the levels of interest rates and liquidity within the agricultural sector. Lower farm incomes reduce farmers' own savings and potential for new investment, so that the need for external finance for new investments and the financing of current inputs may be expected to increase during a recession. These credit considerations also affect the level of utilisation of previously accumulated capital, because their fixed costs include the interest on previous debt and influence calculations regarding the amortisation of this debt. Tight monetary and credit policies in many countries, including Brazil, have been closely associated with, if not blamed for, recession. In recessionary times, farmers may therefore be expected to be faced by tighter credit conditions, which reinforce the decline in new investment in agriculture.

Declines in agricultural income, brought about by lower agricultural prices, the Brazilian evidence suggests, did not lead to a lower utilisation of the two main factors of production, land and labour, or of the capital stock. Lower levels of farm income may be expected to lead to sharp reductions in agricultural investment. To the extent that this is associated with reductions in the use of current inputs -- such as fertilisers -- it may be associated with a decline in yields and fall in output. However, factor substitutability in agriculture means that output need not fall; for example, it is possible that increases in labour use more than compensate for declines in chemical application, and that even if declines in yields are recorded, output is maintained through increased land use.

The empirical evidence regarding the behaviour of factor prices and factor use during the recent economic cycle in Brazil in general accords with the economic perspectives presented above. While producer prices declined markedly during the recession of the 1980s, the flexibility of land and labour costs together with continued utilisation of capital stock meant that output growth remained strong, and, despite the deterioration of the economy, in recent years has reached record levels. In one respect, however, the Brazilian experience did not accord with the theory; the severe rationing of credit (especially after 1984, when real interest rates became positive and credit fell to half of its 1982 level) resulted in no obvious liquidity crisis in the agricultural sector and on the basis of input indicators was associated with increased, rather than lower levels of short-term investment. The most likely explanation for this unanticipated result is that the relative profitability of the agricultural sector convinced farmers as well as some individuals and institutions in other sectors to finance agricultural investment, and especially investment yielding short-term (less than a year) returns.

PART TWO

QUANTITATIVE ANALYSIS

Statistical approach

Having in Part One provided a number of economic explanations for the apparent stability of Brazilian agriculture in the period of crisis, we in Part Two of the paper subject the hypothesis to statistical and econometric analysis, in order to explore more fully the relationship between agriculture and economic crisis in Brazil. The aim is to prove two hypotheses : the relatively constant behaviour of the agricultural sector in the long run, and its stabilising role in economic activity as a whole.

This analysis is voluntarily restricted to the study of agriculture and industry. We have chosen their respective output at constant market prices of 1980 for calculations and assume their sum to be the total output that is, GDP[1].

A. Proportions and growth rates

Consistent time series data is available for the period 1965 to 1987. During this period, the sharp decrease of the agricultural share in GDP was observed mainly between 1965 and 1973, falling from 20% to 11%, but after this date its proportion stayed constant around 10 and 11% of GDP, even during the crisis (1980-1987) (see Table 1a). Thus, the explanation for changes in agricultural output should not be sought in the fluctuations of its proportion to GDP.

By contrast, the share of industrial production in GDP fluctuated widely. Its contribution to total output rose constantly from 1965 to 1980, going from 32 to 37% of GDP, with eight years of a stagnant share at 37%. Since 1980, and the onset of the economic crisis, this proportion has been eroded, fluctuating between 33 and 35%. Industrial production appears, therefore, to be more sensitive to the economic health of the country, with this sensitivity accounting for much of the changes in GDP.

A simple analysis of growth rates provides interesting results. Figure 3 illustrates the relation between agricultural, industrial and GDP growth rates. Although industry accounts for much of the fluctuation in GDP, increases or decreases in industrial output are not the sole factors affecting the variation of GDP. The agricultural sector reduces GDP fluctuations due to the absence of complementarity between the growth rate of the two sectors (agriculture & industry), and to their respective independence despite their close correlation. For example, in 1977 agricultural production recorded a very positive growth (12%) while industrial output had a sharp decrease of its growth rate (1976=12% and 1977=3%), which led to a lower decline in GDP growth.

During the period of growth (1965-73), GDP increases typically were greater than agricultural ones, but as far back as 1973-75 - the beginning of the economic recession - the trends in industry and agriculture diverged, sometimes leaving industry with negative growth rates while agriculture kept its positive tendency. 1986 was not a typical year, as it followed the severe drought; in that year industrial growth rose 12% and agricultural change declined by 8%. The two years when agriculture evolved counter-cyclically were 1986 and 1987. In those years, as appears to be the case for 1988 and 1989, the economic crisis did not affect agriculture as much as industry, so that fluctuations in GDP were mainly accounted for by industry and the economic cycle was stabilised by agriculture.

The changing share of the different sectors in GDP has been isolated from the annual variation in the levels of total output. Although the global tendency is for agriculture to decrease, because its share in GDP is falling, the variation in industry's share is much greater. Keeping a constant share to GDP, agriculture is able to grow while industry is affected because of its dependancy on conjunctural trends (see Table 1a). Agriculture is a more stable sector compared with industry, both in terms of the changes in its annual growth rates and in terms of the changes in its share of GDP.

Comparative growth rate ratios

Growth rate ratios calculated in Table 2 illustrate the dynamism of agriculture and industry with regard to GDP.

Two ratios are calculated: agricultural growth over GDP growth and industrial growth over GDP growth. Their signs reveal whether either sector is more dynamic than GDP as a whole[2] . Except for a few years, when a third sector rose to prominence, this "superiority" seems not to be exclusively attributed to industry but to both sectors alternately. During the periods of economic growth, industry led activity, but after 1974, leadership was sometime taken by agriculture, allowing for continued GDP growth. The stabilising role of agriculture is evident in the crisis period.

Conclusion

This first step of the statistical examination leads to three conclusions : the first is that agriculture maintains its position, principally during the crisis period. Secondly, that industrial output is continuously subjected to fluctuations despite its dominance with regard to agriculture. Finally, the resilience of agricultural growth with regard to GDP growth indicates that it performs a stabilising role.

The same calculations have been made for all Latin America and have provided similar conclusions (See Table 1b). Agricultural structures differ from one country to another and their contribution to GDP is sometimes higher than for Brazil. Moreover, the agricultural sector is subjected to greater fluctuations in some countries than is the case for Brazil, where it is relatively stable.

On average, in Latin America, agriculture's share of GDP is 12-13%, and the share of industry is about 31-32%. These proportions have been relatively stable since the mid 1970's which imply that the movement of both sectors is not the result of the variations of their weights, as was the case in Brazil. It is noteworthy that during the crisis period, agricultural performance was higher elsewhere in Latin America than in Brazil (growth rate ratios are all superior to 1 for agriculture) (see Table 2 and Figure 4), but the alternation of signs is much less frequent than that observed for Brazil, implying that in other countries, foreign balances or services have a bigger influence in the economic activity.

B. Econometric evidence: Standard Deviations and Elasticities, Stationarity and Cointegration

This section uses more advanced techniques to improve the relationships found statistically that is, (i) the real domination of the industrial sector in the determination of the GDP growth rate (with a strong correlation between the two growth rates of these aggregates); (ii) the non-negligible influence of agriculture (despite its low share in GDP), ensuing from the great independence of this sector with regard to the level of general economic activity. This independence is exacerbated in crisis periods because of the limited reaction of agriculture when global economic activity is fluctuating or is subjected to shocks, whereas industry is really dependent on conjuncture.

Within the cycles existing for each variable used, if the decrease of industry brings on a decrease in GDP, the upholding of agricultural growth prevents GDP from falling below a certain level of activity corresponding to the dynamism of the sector.

These observations can be explained by an econometrical estimate.

(i) Standard deviations[3]

Standard deviations and elasticities have been calculated for Brazil and a large panel of Latin American countries (see Table 3).

Standard deviations imply that agriculture is a stable and moderating sector if two conditions are met. First, whatever period is considered, the standard deviation of agriculture must always be lower than that of GDP or industry. Second, the sector assumed to be stable must record nearly the same standard deviation in growth (1965-76) as well as in recession (1976-87) periods. These two conditions are verified for Brazil

and all Latin America, showing that whatever the economic situation, the agricultural sector does not diverge from its trend. By contrast, variances observed for industry are very different according to the period. Between 1965 and 1975, the standard deviation for Brazilian agriculture was 0.12 and for industry 0.35, and between 1975 and 1987 was 0.14 for agriculture and 0.11 for industry. It can be observed that the range of the fluctuations is greater during a growth period for industry and that the slowdown of economic activity narrows the range. Once again, this points to the dominance of industry over agriculture in economic growth and the more dynamic evolution of agriculture in times of recession. For all other countries, agriculture seems more volatile than for Brazil but remains less volatile than industry. The standard deviation in all countries is less for agriculture than for industry.

The fact that the standard deviation for agriculture is small and always less than for industry, proves the stability of the agricultural sector and, for many countries, including Brazil, its regulating role can be shown to be independent of the general well-being of economic activity.

(ii) Elasticities

The calculation of elasticities indicates the near-perfect inelasticity of agriculture with regard to GDP when industry is following GDP; this holds for all the countries registered (see Table 3). In the Brazilian case, the elasticity of agriculture compared that of industry is 0.05 and industry over GDP is 1.37, indicating that agriculture follows a constant evolution in the long run[4].

(iii) Econometric Tests: Stationarity and Cointegration

Method

More advanced techniques which use econometric estimates of cycles and tendencies, by the examination of stationarity and cointegration tests, offer a means for further verification of the hypotheses.

In contemporary econometrics, the determination of cycles and tendencies is a preliminary condition of modeling. Our concern is with accounting variables and not behaviour variables, and here we do not build a model.

Economic theory informs us that certain pairs of economic variables should not diverge from each other to a great extent, at least in the long run. Such variables may drift apart in the short run or according to seasonal factors, but, if they continue to be too far apart in the long run, then economic forces, such as market mechanisms or goverment intervention, will begin to bring them together again. Economic theory involving equilibrium concepts suggests close relationships in the long run, possibly with the addition of yet further variables. These beliefs regarding long term relationships may be

empirically validated. The idea underlying cointegration applied to a pair of variables is to capture part of the phenomena of relative stability. It is thus aposite to an investigation of the hypothesis of agriculture's stability, as noted above.

Cointegration lends itself to the examination of dynamic systems. Time series do not tend to show stationarity but are more specifically integrated series. The existence of stationarity has strong effects on statistical inference. If a time series is stationary[5]. (See Appendix 1) that is, if it verifies all properties of stationarity, then there is a long run equilibrium relation which does not vary with time. This series has a mean and has a tendency to return to this mean, fluctuating around the mean, crossing that value frequently with rare extensive excursions. Its memory is finite, that is to say that an innovation to the process (or a shock) does not occur. By contrast, a non-stationary series has a tendency which has an indefinitely long memory, and its fluctuations rarely return to the mean.

If two series are cointegrated[6] (See Appendix 2), there is a special long run relationship between the two variables; they grow in the same direction and a causality exists between them. The absence of cointegration does not mean that the independent variable has no deterministic economic role, but it means that their evolution does not have the same spectrum.

Estimations and their interpretation

Consider the three economic aggregates: GDP, Agriculture and Industry. They are denoted as following: GDP is Y, Agriculture is Ya and Industry is Yi. They are first submitted to the stationarity test (considering two alternative hypotheses)[7]:

a) GDP or Y for the period 1966-1987:

$$\Delta \ln Y_t = \alpha . \ln Y_{(t-1)} + ß_t + c + e_t \qquad (1)$$

After regressing :

$$\Delta \ln Y_t = - 0.046 \ln Y_{(t-1)} + 0.0002.t + 1.078$$

The Student Statistic T is 0.53 and the Dickey Fuller critical value at 5% of confidence is 4.11 T<4.11, Ho is decided, thus non-stationarity, implying that GDP has

a tendency and an infinite variance. The same result is found using the more rigorous test of ADF (Augmented Dickey Fuller Regression), which calculates the following equation :

$$\Delta \ln Y_t = \Sigma \alpha i . \ln Y_{t-i} + ßt + c + e_t \qquad (2)$$

The second step is to test the integration of first order, d=1 :

$$\Delta^2 \ln Y_t = \alpha . \Delta \ln Y_{t-1} + ßt + c + e_t \qquad (3)$$

In absolute value, T= |-3.56| < 4.11 (Dickey Fuller tabulation), then the series is not integrated of order one implying another differenciation of GDP as following:

$$\Delta^3 \ln Y_t = \alpha . \Delta^2 \ln Y(t-1) + ßt + c + e_t \qquad (4)$$

GDP follows an I(2) and has a long memory process e.g. with tendency. All shocks imposed to this variable have a permanent effect with time.

b) Industry, Yi, for the period 1966-1987:

The same tests have been made for Industry with an identical mathematical construction; the first conclusion is supported, the series is non-stationary. It is also integrated of second order, deviations depending from shocks and changes of economic activity.

c) Agriculture, Ya for the period 1966-1987:

Results for this sector are completly different and allow the economic interpretation. Tests prove that in the long run, agriculture shows all caracteristics of stationnarity :

$$\Delta \ln Ya_t = \alpha . \ln Ya_{t-1} + ßt + c + e_t \qquad (5)$$

T = -6.45 > 4.11 in absolute value (DF), so the agricultural series is stationary or I(0).

The Brazilian agricultural sector does not move in the long run and has no tendency. All fluctuations are restrained around an equal mean. The series looks like a constant, insensitive to exogenous shocks. Agriculture does not have an autoregressive process and is a stable sector of the economy.

The tests on stationarity have shown that agriculture is a sector which has all the characteristics of stability. When subjected to exogenous shock, or macroeconomic fluctuations, it rapidly returns back to its initial rhythm. This phenomenon is stronger

during the crisis period when industrial activity is seriously affected and agricultural activity is not. (It would be interesting to seek the causes of this phenomenon by introducing prices or exchange rates to see their effect on agriculture and industry.)

Cointegration tests are close to stationarity ones but the demonstration is based on errors (e_t). Two by two, variables with the same order of integration are tested. If the order is not respected, first difference of an I(1) or second difference of an I(2) becomes an I(0). As GDP and Industry are I(2), we can use the simple OLS estimation as:

$$\ln Y_t = 0.718.\ln Yi_t + 0.018.t + 6.97$$

Respective T are 39.43, 14.8, 18.2, and $R^2 = 0.99$ and DW = 1.31

CRDW test is made on two alternative hypotheses of cointegration and non-cointegration construction[8].

GDP and Industry appear to be cointegrated, but this test is not sufficient; the complete estimation needs the examination of errors by extracting them from the previous equation and by submitting them to the test:

$$U_t = \ln Y_t - \alpha.\ln Y_{it} - ßt - c \qquad (6)$$

$$\Delta U_t = \alpha.U_{t-1} + ßt + c + e_t \qquad (7)$$

T = |-4.98| > 4.11 critical value DF.

GDP and Industry are cointegrated. There is a special long term relationship between them and their respective growth have the same direction. Identical conclusions are reached between GDP and agriculture after the differenciation of the former.

Result

Given the stationarity process followed by the agricultural sector in the long run and the order two of integration of the other two variables, a logical conclusion, which is contrary to the mathematical definition of GDP however, would confirm that agriculture is not a determining factor in the evolution of economic activity and would not go inside the long run relation defined above. However, despite the low and constant weight of agriculture in total production, it should not be excluded, as it performs a central role in the economic cycle. In the analysis, agriculture's role is evident through the differentiation of the other variable.

Industry and GDP follow the same tendency; this phenomenon is exacerbated by the simple fact that the industrial sector represents around 35% of GDP. The stabilising force of agriculture lies in the absence of tendency of its growth and its stable contribution

to GDP. In crisis periods, constraints tending to restrain economic activity do not affect the agricultural sector, which tends to attract the positive forces that help to maintain it at a high level. It is the transfer of these forces which limits the decline in GDP; thus, the adjusment can be lightened in the face of cyclical variations (sometimes important) of industry thanks to the strong correlation existing between agriculture and GDP.

PART THREE

REFLECTIONS

Stability and Growth

The evidence supports the view that it is necessary to distinguish between forces which led to *stability of output* (as noted by Schultz or Galbraith) and forces that led to *output growth*. Flexibility of land and labour costs, as well as continued utilisation of capital stock, provided the basis for stability of output, but not necessarily output growth; the latter implies capital accumulation. That is, that the rate of return on agricultural investment was attractive *vis-à-vis* other alternatives (real as well as financial). Economic policy played important roles in providing incentives to this capital accumulation in agriculture both intentionally (for example, minimum price policy; credit policy in the period 1979-82; and exchange rate devaluations) and unintentionally (for example, as evident in 1986 when the deindexation of financial assets led land prices to soar prompting a sharp improvement in agricultural sentiment; or as evident in lower input and freight costs associated with the fall in petroleum prices since 1985).

Growth and Adjustment

The deepening of the Brazilian economic crisis from 1979 was associated with the official "prioritisation" of the agricultural sector. The public objective of regularising domestic food supplies through increased output reflected the determination of the government to ensure that food demand was not satisfied either by increased imports or a restriction of exports. With the "prioritisation" of agriculture, the intent was to reduce imports and increase exports; the underlying target of the prioritisation was the improvement in the balance of payments.

It is difficult to assess the extent to which the official prioritisation of agriculture can be responsible for the improvement in the relative performance of the agricultural sector in the 1980s. Total government spending on agriculture declined from an estimated $3.8 billion in 1980 to $1.1 billion in 1983, but then recovered to late 1970s levels. Within the agricultural budget, resources were reallocated away from rural credit and research and extension to the minimum price, proalcool and wheat programmes. It would appear that the "prioritisation" therefore reallocated resources within the agricultural sector, rather than signifying a greater direct commitment from the government to the agricultural sector.

Changes in macroeconomic policies which affected the agricultural sector indirectly also led to changes in intra-agricultural allocation of resources, but did not reflect a deepening of the overall commitment of government to agriculture. Trade policies which increased the incentives for processed agricultural exports simultaneously discriminated against unprocessed agricultural exports. Similarly, while the depreciation of the

exchange rate in the 1980s benefited agricultural exports, it also benefited manufactured exports.

The analysis of direct and indirect policies affecting agriculture showed that the "prioritisation" of agriculture in practice translated into an overwhelming concern with balance of trade issues. The prioritisation failed to increase the transfer to the agriculture sector, or, more accurately, to reduce the net transfer from the agricultural sector. The negative protection rates for the 1980s reveal no significant overall decline in the drain of resources from the agricultural sector. However, important intra-agricultural changes are evident. In particular, the minimum price policy appears to have led to reductions in negative protection for a number of the crops covered, while the wheat policy has led to substantial positive protection for that crop.

Food versus Export Crops

A comparison of the (negative) protection rates for food and export crops reveals that discrimination against food crops was gradually reduced during the 1970s. Brazilian commentators in the early 1980s expected this trend to be reversed by the balance of payments crisis, and what was widely viewed as the prioritisation of exports. The evidence suggests however that the crop production destined for domestic consumption grew faster in the period 1979-88 than in the 1973-79 period. Between 1979 and 1988, increases in the rates of growth of rice, corn and wheat were recorded, while beans and manioc production held stable. Of the non-food crops, only cotton recorded a sharp output growth. Sugar-cane, supported by the Proalcool programme, maintained its earlier growth levels, while soybean, citrus, cocoa and coffee growth decelerated sharply.

These empirical findings cast doubt on assumptions regarding the negative impact of macroeconomic adjustments on domestic market agriculture. Recession, together with exchange rate devaluation, did, as expected, lead to a fall in the relative prices (in terms of export products) of agricultural goods produced for the domestic market. In order to assess its impact on performance, the change in relative product prices needs, however, to be analysed in association with factor prices or costs. In the case of Brazil, the response of changes in factor prices was differentiated according to type of production process and agricultural activity.

In the absence of detailed evidence regarding the production process, it cannot be predicted in advance what the final effect of the recession will be on the relative profitabilities of domestic market and export crops. Equally, further research may show that, contrary to the received wisdom, exchange rate devaluation has been relatively beneficial to domestic crops; due to the substitution effect, exchange rate devaluation raises the real price of non-traded agricultural goods (through, for example, a substitution of corn for soymeal) and in developing countries such as Brazil may also be expected to raise their relative price in terms of non-traded goods in the rest of the economy. Furthermore, exchange rate devaluation by increasing the price of imported agricultural

products, stimulates the production of import-substituting production. Where imports are a significant part of domestic food consumption, devaluation may be expected to benefit the whole agricultural sector, and not just export agriculture. Thus in major food importers, such as Mexico, Venezuela, Brazil or Peru, the whole agricultural sector may be expected to benefit from devaluation, whereas this import-substituting explanation for agricultural improvement would be less relevant in self-sufficient countries, such as Argentina. In Brazil it was estimated that in late 1970s wheat accounted for around a quarter of total protein intake. Over 70 per cent of total consumption was imported, so that exchange rate devaluation benefited not only domestic wheat production, but also, by forcing up the domestic price of wheat, stimulated production of protein substitutes such as rice, edible beans, manioc, corn and animal products.

Conclusion: Agriculture, Adjustment and Stability

We have shown that the resilience of agriculture to the economic crisis and its strong growth in the 1980s is partly attributable to the reduced penalties imposed upon this sector. Under the weight of debt and pressures for adjustment, policies of import substitution industrialisation gave way to the promotion of agricultural export promotion. Domestic crop production remained remarkably robust, however, for reasons which are attributable both to the linkages between import and export crops and to the fundamental economic factors underlying agriculture's strength and stability.

This stability, which in times of economic crisis is revealed as a strength, in Part Two was confirmed by means of statistical and econometric tests. The constant trend of Brazilian agriculture whatever the economic situation, shown by its lower elasticity and variance is confirmed by the test of stationnarity. The fact that this sector is cointegrated with GDP confirms its stabilising role, while the industrial sector follows an erratic movement. Simple statistical tests suggest similar inter-sectoral relationships elsewhere in Latin America. Our examination has provided an initial, and we believe original, examination of agriculture's role, and offers a novel application of cointegration. We trust that this will be of interest to economists and econometricians and stimulate comment and further analysis.

NOTES

1. Services are voluntarily omitted even though they are becoming more and more important in the determination of GDP.

2. Consider Y being GDP, Ya agriculture output and, Yi industry output. The ratios are: $\Delta Ya/\Delta Y$ and $\Delta Yi/\Delta Y$.
   If $\Delta Ya>\Delta Y$ and $\Delta Yi>\Delta Y$ the sign stay positive or >1
   If $\Delta Ya<\Delta Y$ and $\Delta Yi<\Delta Y$ the sign is negative or <1
   The following cases are observed:
   1) $\Delta Ya>\Delta Y$ and $\Delta Yi>\Delta Y$ is the case where agriculture growth and industry growth overtake GDP growth. This case is very rare as Table 2 shows. 1980 and 1985 are two years where the dynamism of industry and agriculture is greater than GDP (which is reduced by services).
   2) $\Delta Ya<\Delta Y$ and $\Delta Yi<\Delta Y$ is symetric to the previous case and leads to similar conclusions. Three years where industry and agriculture have a velocity growth lower than GDP, are registered: 1974 (first oil shock), 1979 (second oil shock) and 1982 (devaluation).
   3) This third case is the most interesting for interpretation because it tells which of the two sectors is more dynamic with regard to GDP. Two results are observed: $\Delta Ya<\Delta Y$ and $\Delta Yi>\Delta Y$ or $\Delta Ya>\Delta Y$.
      From 1967 to 1973 the dynamism of industry is evident (ratio>1 for industry), but after 1973 we note an alternance of signs, showing the stronger performance of the agricultural sector (ratio>1 for agriculture).

3. Standard deviations are calculated as following:

$$\sigma_x^2=\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^2$$

4. We have estimated elasticities on the basis of a regression of log agriculture over log GDP and log industry over log GDP, over the whole time period. The coefficient provides an elasticity indicator.

5. Definitions and properties of stationarity: See Appendix 1

6. Definition and properties of cointegration: see Appendix 2.

7. For the tabulated values refer to Table 4.

8. CRDW : Cointegrating Durbin Watson. See Table 4.

ACKNOWLEDGEMENTS

(*) The analysis and data draws on Ian Goldin and Gervasio Castro de Rezende, *Agriculture and Economic Crisis: Lessons from Brazil* (OECD, Paris, 1990) and the economic analysis owes much to the insights of Gervasio Castro de Rezende. The authors are also grateful to François Delorme, Armelle le Clec'h and Alain de Janvry for their comments and assistance.

APPENDIX ONE

Consider a simple time series X_t at equal intervals of time, mechanisms generated must verify all the usual statistical properties of linearity or at very least the conditional mean, variance and temporal autocorrelation.

The equilibrium relation which could exist in the series is defined by a stationnary point, from which all forces tend to push the economy under this equilibrium whatever the moment.

If X_t is the vector, equilibrium is achieved when the specifical linear constraint is $\alpha'.X_t = 0$.

Throughout the period, Xt will not be at the equilibrium and the unvariante quantity $Z_t = \alpha.X_t$ will be called equilibrium error. A series is said to be stationary when linearity properties exist, and are unvariante with time: the series has a spectrum which is finite but non-zero at all frequencies. Such a series is called "integrated of order zero", denoted I(0).

Some series need to be differentiated to achieve properties of linearity. They are integrated of order d when they are differentiated d times, denoted $X_t \sim I(d)$ but are not stationnary and follow a random walk $\Delta X_t = e_t$ with a drift $\Delta X_t = \mu + et$ and they admit an unit root.

Sometimes, the series need to be integrated to become I(0); often, it is not necessary to exceed the order 2 of integration. A simple example of a stationary series I(0) is a AR(1) series generated by $X_t = \alpha.X_{t-1} + et$, where $|\alpha| < 1$ and et is a white noise with zero mean.

There are many substantial differencies between I(0) and I(1) or I (2) series. An I(0) series has a mean and there is a tendency for the series to return to the mean, so that it tends to fluctuate around the mean, crossing that value frequently and with rare extensive excursions. Autocorrelation declines rapidly as the lag increases and the process gives low weight to events in the medium to distant past, and thus has a finite memory.

An I(1) or I (2) will be relatively smooth, will wander widely and will only rarely return to an earlier value.

In fact, for a random walk, for a fixed arbitrary value the expected time until the process again passes through this value is infinite. This does not mean that returns do not occur, but the time to return is very long-tailed. Autocorrelation {ρk} are all near one in magnitude even for large k; an shock to the process affects all the later values and so the process has indefinitely long memory.

APPENDIX TWO

Definition and properties of cointegration :

This concept improves stationarity tests applied to a pair of series X_t and Y_t.

One of the objects of building an economic adjustment model is to explain the fluctuations of dependant variable by those of explaining variables leaving few unexplained variations in the perturbator term et.

Consider a vector Xt of variables, this vector is said cointegrated if :

a) each element is I(d) d > 1

b) there exist a vector α (called cointegrating parameter) such as $\alpha'.X_t$ is I(d-b) where $\alpha = 0$ and $d > b > 0$.

The usual case $d = b = 1$, where $\alpha'.X_t$ is I(0).

The stationnarity is one condition to cointegration. Thus, if the dependant variable is I(1), beyond the explaining variables, there must be one variable I(1) at least. A bad specification of the model would be verified if all the independant variables were I(1) and this would be reflected in the error which would be I(1) instead of being I(0). The perturbation would not be stationnary or I(1) if the dependant variable were I(0). In fact, all this is a question of calculation of the integration and thus of the growth. The right and left side of the equation must be of the same order of integration or must have the same tendency. To explain the growth of a series, at least one beyond explaining variables must also grow so that this growth could be explained. Other variables simply express the deviations around the general growth.

If two variables are cointegrated there is a special long run relation. Here the definition of the long run does not accord with the conventional economic uses. For example, variables which are I(0) non-integrated can have an important role in the long run relationship. The formalisation and tabulation have been built on the work of Granger (1986), Engle and Granger (1987), Engle and Yoo (1986) and Dickey and Fuller .

BIBLIOGRAPHICAL REFERENCES

BARRO, R. (1976)
"Rational Expectations and the Role of Monetary Policy", *Journal of Monetary Economics*, 2, pp. 1-32.

BELLAMY, M. and B. GREENSHIELDS, (eds.)
Agriculture and Economic Instability, London, Gower, 1987.

CALEGAR, G. and G. SCHUH (1988)
"The Brazilian Wheat Policy", *International Food Policy Research Report*, No. 66, Washington, May.

CARNEIRO, D. (1987)
Stabilisation and Adjustment Policies and Programmes: Brazil, Helsinki, WIDER.

CENTRAL BANK OF BRAZIL (1988-89)
Boletim Mensal, Vols. 24-25, Brasilia, Central Bank.

CEPAL (1987)
Cepal Review, No. 33, (Special issue on Structural Adjustment and Agriculture in Latin America).

DIAS, G. (1988)
"Ajustamento Macroeconomica e a Contribuicao da Agricultura", mimeo, Sao Paulo.

ENGLE, R. and B. YOO
(1987) "Forecasting and Testing in Co-integrated Systems", *Journal of Econometrics*, 35, pp. 143-159.

FONSECA, M. and J. GUILHOTO (1987)
"Uma Analise dos Efeitos Economicos de Estrategias Setoriais", *Revista Brasileira de Economia*, 41:1, pp. 81-98.

FUNDACAO GETULIO VARGAS (1989)
Conjuntura Economica, 1985-June 1989, Rio de Janeiro, FGV.

FUNDACAO GETULIO VARGAS (1987-88)
Instituto Brasileiro de Economia, *Agroanalysis*, Rio de Janeiro, FGV.

FURTADO, D. (1958)
Perspectivas da Economia Brasileira, Rio de Janeiro, ISEB.

GALBRAITH, J. and J. BLACK (1938)
"The Maintenance of Agricultural Production during Depression: The Explanations Reviewed", *Journal of Political Economy,* 46:3, pp. 305-323.

GASQUES, J. and A. PAIVA (1987)
"Salarios Rurais e Precos de Terras no Brasil", *IPEA Dados Conjuntirais da Agropecuaria*, No. 147, Brasilia, IPEA, 1987.

GASQUES, J. *et al.* (1988)
"Gastos Publicos na Agricultura", *IPEA Dados Conjunturais da Agropecuaria no Brasil*, No. 153, Brasilia, June.
GOLDIN, I. and G.C. de REZENDE (1990)
Agriculture and Economic Crisis: Lessons from Brazil, Paris, OECD.
GRAHAM, D. *et al.* (1987)
"Thirty Years of Agricultural Growth in Brazil", *Economic* Development and *Cultural Change*, 36, pp. 1-34.
GRANGER, C. (1986)
"Developments in the Study of Cointegrated Economic Variables", *Oxford Bulletin of Economics and Statistics*, 48, pp. 213-228.
HENDRY, D. (1986)
"Econometric Modelling with Cointegrated Variables: An Overview", *Oxford Bulletin of Economics and Statistics*, 48, pp. 201-212.
HANSEN, A. (1932)
"The Business Cycle and its Relation to Agriculture", *Journal of Farm Economics,* 14, pp. 59-68.
HABERLER, G. (1937)
Prosperity and Depression, Geneva, League of Nations.
HARROD, R. (1936)
The Trade Cycle, Oxford, Clarendon Press.
HATHAWAY, D. (1959)
"Agriculture in an Unstable Economy Revisited", *Journal of Farm Economics*, XLI, pp. 487-499.
HAYEK, F. (1931)
Prices and Production, London, Routledge.
HENSHALL, J. and R. MOMSEN (1973)
"Regional Disparities and Economic Growth in Brazil", *La Revista Geografica*, 79, pp. 167-176.
HICKS, J. (1950)
A Contribution to the Theory of the Trade Cycle, Oxford, Claredon Press.
HICKS, J. (1974)
The Crisis in Keynesian Economics, New York, Basic Books.
HOMEM DE MELO, F.
(1985), *Prioridade Agricola: Sucesso ou Fracasso?*, Sao Paulo, FIPE.
HOMEM DE MELO, F.
(1986) *Estabilizacao de Precos: Exportaveis vs. Domesticos,* Sao Paulo, USP.
HOMEM DE MELO, F. (1987a)
"Export-Orientated Agricultural Growth: The Case of Brazil", *World Employment Programme Research Working Papers,* Geneva, September.

HOMEM DE MELO, F. (1987b)
"The External Crisis, Adjustment Policies and Agricultural Development in Brazil", *CEPAL Review*, 33, pp. 83-90.
de JANVRY, A. *et al.* (1988)
"Rural Development in Latin America: An Evaluation and a Proposal", Paper presented to Seminario Internacional la Agricultura Latinoamericana: Crisis, Tranformaciones y Perspectivas, Chile, September.
JOHNSON, D. (1950)
"The Nature of the Supply Function for Agricultural Products" *American Economic Review*, 40, pp. 539-564.
JORGENSON, D. (1969)
"The Role of Agriculture in Economic Development", in C. Wharton (ed.), *Subsistence Agriculture and Economic Development,* Chicago, Aldine.
KALDOR, N. (1940)
"A Model of the Trade Cycle", *Economic Journal*, 50, pp. 78-92.
KALDOR, N. (1976)
"Inflation and Recession in the World Economy", *Economic Journal*, 86:12, pp. 703-714.
KALECKI, M. (1935)
"A Macrodynamic Theory of Business Cycles", *Econometrica,* 3, pp. 327-44.
KALECKI, M. (1971)
Selected Essays on the Dynamics of the Capitalist Economy, Cambridge, CUP.
KEYNES, J. (1936)
The General Theory of Employment, Interest and Money, London, MacMillan.
KIRK, J. (1933), *Agriculture and the Trade Cycle*, London, King and Son.
KNIGHT, P. (1971)
Brazilian Agricultural Technology and Trade, New York, Praeger.
KRUEGER, A. *et al.* (1988)
"Agricultural Incentives in Developing Countries: Measuring the Effect of Sectoral and Economywide Effects", *World Bank Economic Review*, 2:3, pp. 255-271.
KUZNETS, S. (1971)
Economic Growth of Nations: Total Output and Production Structure, Cambridge Mass., Harvard University Press.
KYDLAND, F. and E. PRESCOTT (1982)
"Time to Build and Aggregate Fluctuations", *Econometrica*, 50, pp. 1345-70.
LECAILLON, J. *et al.* (1987)
Economic Policies and Agricultural Performance of Low-Income Countries, Paris, OECD.
LEWIS, W. (1954)
"Economic Development with Unlimited Supplies of Labour", *Manchester School of Economic and Social Studies*, 22, pp. 139-191.

LIEBHARDT, M. (1988)
"Adjustamento do Setor Agricola as Mudancas no Credito Rural", CFP *Colecao Analise e Pesquisa*, Vol. 35, Brasilia, October.
LIMA, J. and I. da COSTA (1985)
Estatisticas Basicas do Setor Agricola no Brasil, IPE, USP, Sao Paulo.
LITTLE, I. *et al.* (1970)
Industry and Trade in Developing Countries: A Comparative Study, Paris and London, OECD and OUP.
LONG, J. and C. PLOSSER (1983)
"Real Business Cycles", *Journal of Political Economy*, 91, pp. 39-69.
LOPES, M. and G. SCHUH (1979)
"A Mobilizacao de Recursos da Agricultura", *CFP* Colecao Analise e Pesquisa, Vol. 8, Brasilia.
LOPES, M. (1986)
"A Intervencao do Goveno nos Mercados Agricolas no Brasil", *CFP Colecao Analise e Pesquia*, Vol. 33, Brasilia.
LUCAS, R. (1972)
"Expectations and the Neutrality of Money", *Journal of Economic Theory*, 4, pp. 103-24.
LUCAS, R. (1977)
"Understanding Business Cycles", in K. Brunner and A. Meltzer (eds.) *Stabilisation of the Domestic and International Economy*, Amsterdam, North Holland.
MARTONE. C. (1987)
"Macroeconomic Policies, Debt Accumulation, and Adjustment in Brazil, 1965-84", *World Bank Discussion Papers*, No. 8, Washington D.C.
MAUREL, F. (1989)
"Modèle à Correction d'Erreur: l'Apport de la Théorie de la Co-intégration", *Economie et Prévision*, 88.
de OLIVEIRA, C. (1983)
"Resource Transfers from Agriculture in Brazil", *Fundacao Universidade de Brasilia*, *Working Paper 98*, Brasilia, June.
PAARLBERG, P. and R. CHAMBERS (eds.) (1988)
Macroeconomics, Agriculture and Exchange Rates, London, Westview Press.
PREBISCH, R. (1963)
Towards a Dynamic Development Policy for Latin America, New York, United Nations.
RANIS, G. and J. FEI (1961)
"A Theory of Economic Development", *American Economic Review*, 51, pp. 533-565.
REZENDE, G.C. (1987)
"Food Production, Income Distribution and Prices: Brazil 1960-80", *World Employment Programme Research Working Papers*, Geneva, November.

REZENDE, G.C. (1988a)
"Ajuste Externo e Agricultura no Brasil, 1981-86", *Revista Brasileira de Economia*, Vol. 42, No. 2, pp. 101-137.
REZENDE, G.C. (1988b)
"A Agricultura de Graos no Centro-Oeste", mimeo.
SAHOTA, G. (1981)
"Process of Production and Income Distribution in Brazilian Agriculture", *Economic Development and Cultural Change*, 29, pp. 683-722.
dos SANTOS, R. (1988)
"Processo de Modernizacao da Agricultura Brasileira, *Revista da Economia Politica*, 8, pp. 131-148.
SARGAN, J. and A. BHARGAVA (1983)
"Testing Residuals from Least Squares Regression for Being Generated by the Gaussian Random Walk", *Econometrica*, 51, pp. 153-174.
SAYAD, J. (1984)
Credito Rural no Brasil, Sao Paulo, FIPE-USP.
SCHERR, S. (1989)
"Agriculture in an Export Boom Economy", *World Development*, 17:4, pp. 543-560.
SCHUH, G. (1970)
The Agricultural Development of Brazil, New York, Praeger.
SCHULTZ, T. (1945)
Agriculture in an Unstable Economy, New York, McGraw-Hill.
SCHUMPETER, J. (1939)
Business Cycles, New York, McGraw Hill.
de SILVA, J. (1984)
"Capitalist Modernisation and Employment in Brazilian Agriculture, 1960-75", *Latin American Perspectives*, 11:1, pp. 117-136.
SINGER, P. (1961)
Revista Brasileira de Estudos Politicos, October.
SMITH, G. (1969)
"Brazilian Agricultural Policy: 1950-67", in H. Ellis (ed.), *Essays on the Economy of Brazil*, University of California Press.
THERY, H. (1990)
"Atouts et Problèmes de l'agriculture Brésilienne", *Problemes Economiques*, No.2. 169, avril.
THIESENHUSEN, W. and J. MELMED-SANJAK, (1990)
"Brazil's Agrarian Structure: Changes from 1970 through 1980, *World Development*, XVIII:3, pp.393-415.
TWOMEY, M. (1989)
"La Crisis de la Deuda y la Agricultura Latinoamericana", mimeo.

VALDES, A. (1986)
"Impact of Trade and Macroeconomic Policies on Agricultural Growth: The South American Experience", in IADB, *Economic and Social Progress in Latin America: 1986 Report*, Washinghton D.C.
WEISSKOFF, R. (1979)
"Trade Protection and Import Elasticities for Brazil", *The Review of Economics and Statistics*, LXI:1, pp. 58-66.
WELLS, J. (1989)
"On the Agricultural Performance of Developing Countries, 1950-85", *Food Research Institute Studies*, XXI:2, pp. 165-n192.
WORLD BANK (1989)
World Development Report 1989, Oxford, OUP

Table 1a : PROPORTIONS AND GROWTH RATES. BRAZIL

	Ya/Y (%)	Yi/Y (%)	Annual Growth Rates (%) : GDP	Agriculture	Industry	Comparative weight & Growth : (a)*(d)=(f)	(b)*(e)=(g)
	(a)	(b)	(c)	(d)	(e)		
1965	20.08	32.46					
1966	16.45	34.40	4.15	-14.65	10.40	0.14	0.38
1967	17.07	33.71	4.91	8.88	2.79	0.19	0.35
1968	16.08	34.35	11.41	4.89	13.53	0.17	0.39
1969	15.18	35.04	9.75	3.63	11.94	0.16	0.39
1970	14.10	35.08	8.77	1.00	8.89	0.14	0.38
1971	13.95	35.25	11.30	10.16	11.84	0.15	0.39
1972	12.94	35.97	12.05	3.97	14.34	0.13	0.41
1973	11.36	36.96	13.98	0.03	17.13	0.11	0.43
1974	10.52	36.73	9.04	0.99	8.35	0.11	0.40
1975	10.72	36.58	5.21	7.21	4.78	0.11	0.38
1976	10.00	37.22	9.79	2.44	11.71	0.10	0.42
1977	10.72	36.69	4.61	12.13	3.11	0.12	0.38
1978	9.93	37.23	4.82	-2.95	6.37	0.10	0.40
1979	9.72	37.02	7.21	4.92	6.61	0.10	0.39
1980	9.76	37.05	9.13	9.59	9.21	0.11	0.40
1981	10.90	34.74	-3.13	8.20	-9.18	0.12	0.32
1982	10.74	34.34	1.08	-0.37	-0.08	0.11	0.34
1983	11.01	33.09	-2.83	-0.37	-6.37	0.11	0.31
1984	10.73	33.33	5.67	2.98	6.43	0.11	0.35
1985	10.91	33.51	8.38	10.13	8.97	0.12	0.37
1986	9.28	34.70	8.04	-8.05	11.87	0.09	0.39
1987	10.11	33.92	2.98	12.16	0.68	0.11	0.34

Notes : - (a) and (b) are respective agricultural share and industrial share to GDP
- The calculation of (f) and (g) are based on the index numbers of precedent columns.

Source: World Bank Tables.

Table 1b : PROPORTIONS AND GROWTH RATES. LATIN AMERICA

	Ya/Y (%)	Yi/Y (%)	Annual Growth Rates (%) : GDP	Agriculture	Industry	Comparative weight & Growth :	
	(a)	(b)	(c)	(d)	(e)	(a)*(d)=(f)	(b)*(e)=(g)
1965	15.90	30.82					
1966	15.38	31.23	6.93	3.46	8.36	0.16	0.34
1967	15.13	31.48	5.07	3.33	5.91	0.16	0.33
1968	14.81	31.58	6.41	4.19	6.73	0.15	0.34
1969	14.17	31.87	5.40	0.82	6.36	0.14	0.34
1970	13.92	32.24	6.23	4.33	7.47	0.15	0.35
1971	13.58	31.99	5.33	2.75	4.52	0.14	0.33
1972	13.09	32.24	6.26	2.44	7.09	0.13	0.35
1973	12.66	33.02	6.09	2.59	8.64	0.13	0.36
1974	12.82	32.88	5.09	6.46	4.67	0.14	0.34
1975	13.11	31.56	2.17	4.44	-1.96	0.14	0.31
1976	12.73	31.72	4.75	1.73	5.30	0.13	0.33
1977	12.86	31.22	4.87	5.97	3.21	0.14	0.32
1978	12.52	31.23	8.03	5.13	8.06	0.13	0.34
1979	11.88	31.50	7.89	2.41	8.81	0.12	0.34
1980	11.66	32.13	7.23	5.22	9.39	0.12	0.35
1981	11.56	32.12	6.49	5.60	6.43	0.12	0.34
1982	11.68	31.51	-2.22	-1.27	-4.07	0.12	0.30
1983	12.04	30.78	-2.59	0.47	-4.84	0.12	0.29
1984	12.04	31.13	3.71	3.66	4.89	0.12	0.33
1985	12.14	31.63	2.73	3.61	4.38	0.13	0.33
1986	12.14	31.63	-0.03	0.01	-0.02	0.12	0.32
1987	12.27	31.45	2.67	3.78	2.09	0.13	0.32

Notes : - (a) and (b) are respective agricultural share and industrial share to GDP
- The calculation of (f) and (g) are based on the index numbers of the precedent columns.

Source: World Bank Tables.

Table 2: GROWTH RATE RATIOS

	Latin America		Brazil	
	Agri. Growth /GDP growth	Ind. Growth /GDP Growth	Agri. Growth /GDP growth	Ind. Growth /GDP growth
1965				
1966	0.97	1.01	0.82	1.06
1967	0.98	1.01	1.04	0.98
1968	0.98	1.00	0.94	1.02
1969	0.96	1.01	0.94	1.02
1970	0.98	1.01	0.93	1.00
1971	0.98	0.99	0.99	1.00
1972	0.96	1.01	0.93	1.02
1973	0.97	1.02	0.88	1.03
1974	1.01	1.00	0.93	0.99
1975	1.02	0.96	1.02	1.00
1976	0.97	1.01	0.93	1.02
1977	1.01	0.98	1.07	0.99
1978	0.97	1.00	0.93	1.01
1979	0.95	1.01	0.98	0.99
1980	0.98	1.02	1.00	1.00
1981	0.99	1.00	1.12	0.94
1982	1.01	0.98	0.99	0.99
1983	1.03	0.98	1.03	0.96
1984	1.00	1.01	0.97	1.01
1985	1.01	1.02	1.02	1.01
1986	1.00	1.00	0.85	1.04
1987	1.01	0.99	1.09	0.98

Source: World Bank Tables.

Table 3 : ELASTICITIES AND STANDARD DEVIATIONS

	ELASTICITIES:		STANDART DEVIATIONS:								
			Whole Period (1960-87)			Relative Growth Period (1965-75)			Deceleration & Recession (1976-87)		
	(a) Agri./GDP	(b) Ind./GDP	Y	Yi	Ya	Y	Yi	Ya	Y	Yi	Ya
Latin America	0.32	1.13	0.32	0.31	0.23	0.18	0.20	0.11	0.14	0.15	0.12
Argentina	0.05	1.50	0.22	0.23	0.14	0.21	0.24	0.08	0.04	0.08	0.06
Bolivia	0.26	1.70	0.28	0.25	0.26	0.23	0.26	0.17	0.06	0.19	0.09
Brazil	0.05	1.37	0.46	0.47	0.26	0.31	0.35	0.12	0.14	0.11	0.14
Chile	0.13	1.16	0.21	0.18	0.20	0.16	0.16	0.12	0.14	0.14	0.12
Colombia	0.54	1.02	0.40	0.41	0.30	0.26	0.30	0.18	0.14	0.16	0.11
Costa Rica	0.76	1.59	0.41	0.56	0.31	0.30	0.43	0.26	0.1	0.11	0.08
Dominican Rep.	0.59	1.82	0.44	0.60	0.30	0.30	0.46	0.19	0.11	0.09	0.11
Ecuador	0.08	2.01	0.45	0.67	0.21	0.29	0.53	0.13	0.14	0.16	0.12
Mexico	0.33	1.41	0.36	0.40	0.20	0.22	0.26	0.10	0.15	0.16	0.11
Paraguay	0.72	1.56	0.46	0.60	0.34	0.21	0.26	0.14	0.18	0.22	0.13
Peru	0.33	1.08	0.27	0.29	0.13	0.23	0.23	0.12	0.08	0.09	0.08
Venezuela	0.51	0.92	0.25	0.13	0.31	0.20	0.14	0.23	0.05	0.06	0.11

Notes : - (a) and (b) are respective elasticities of agriculture output with regard to GDP and industrial output with regard to GDP.
- For Peru, the period begins in 1961
For Paraguay, the period begins in 1962
For Latin America, Ecuador and Mexico the period begins in 1965
- Y is GDP, Yi is Industrial output, Ya is Agricultural output

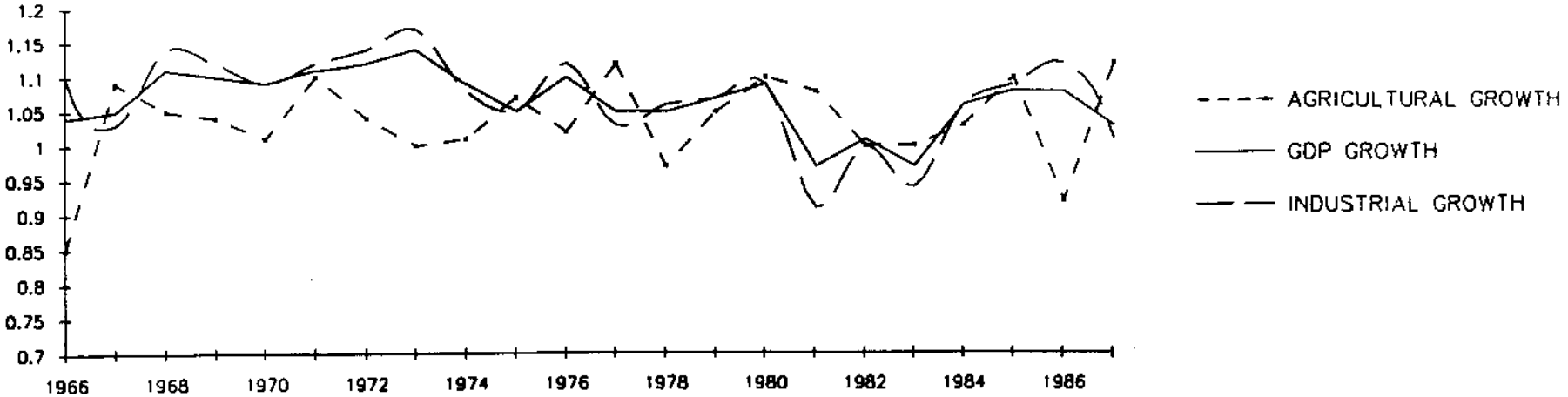
Sources: World Bank Tables.

Table 4: STATIONARITY AND COINTEGRATION : ECONOMETRICAL RESULTS FOR BRAZIL

REGRESSIONS	RESULTS				CONCLUSIONS
STATIONARITY TESTS :					
GDP or Y:1) DlnYt = f(lnY(t-1), t, C)	Coef.	-0.046	0.0002	1.078	
	(T stat.)	(-0.53)			GDP non stationary
2) D2lnYt = f(DlnY(t-1), t, C)	Coef.	-0.79	-0.004	0.1	
	(T stat.)	(-3.56)			GDP not integrated of order one
3) D3lnYt = f(D2lnY(t-1), t, C)	Coef.	-1.34	6.9.10-5	-0.004	
	(T stat.)	(-5.83)			GDP integrated of order 2
IND or Yi:1) DlnYit = f(lnYi(t-1), t, C)	Coef.	-0.078	0.001	0.102	
	(T stat.)	(-0.90)			Industry non stationary
2) D2lnYit = f(DlnYi(t-1), t, C)	Coef.	-0.87	-0.005	0.13	
	(T stat.)	(-3.86)			Industry not integrated of order one
3) D3lnYit = f(D2lnYi(t-1), t, C)	Coef.	-1.46	8.7.10-5	-0.005	
	(T stat.)	(-6.57)			Industry integrated of order 2 or I(2)
AGR or Ya: DlnYat = f(lnYa(t-1), t, C)	Coef.	-1.114	0.044	64.8	
	(T stat.)	(-6.44)			Agriculture stationary
COINTEGRATION TESTS :					
GDP and INDUSTRY:					
a) lnYt = f(lnYit, t, C)	Coef.	0.718	0.018	6.97	
	(T stat.)	(39.43)	(14.8)	(18.2)	
	DW	1.31			GDP & Industry cointegrated by CRDW test
b) DUt = f(U(t-1), t, C)	Coef.	-0.47	0.001	0.004	
	(T stat.)	(-4.98)	(0.06)	(0.51)	GDP & Industry cointegrated by test on errors
GDP and AGRICULTURE:					
a) D2lnYt = f(lnYat, t, C)	Coef.	-0.27	0.01	5.55	
	(T stat.)	(-0.93)	(0.85)	(0.93)	
	DW	2.45			GDP & Agriculture cointegrated by CRDW test
b) DU1t = f(U1(t-1), t, C)	Coef.	-1.34	-0.013	-7.07	
	(T stat.)	(-5.83)	(-4.46)	(-5.85)	GDP & Agriculture cointegrated by test on errors

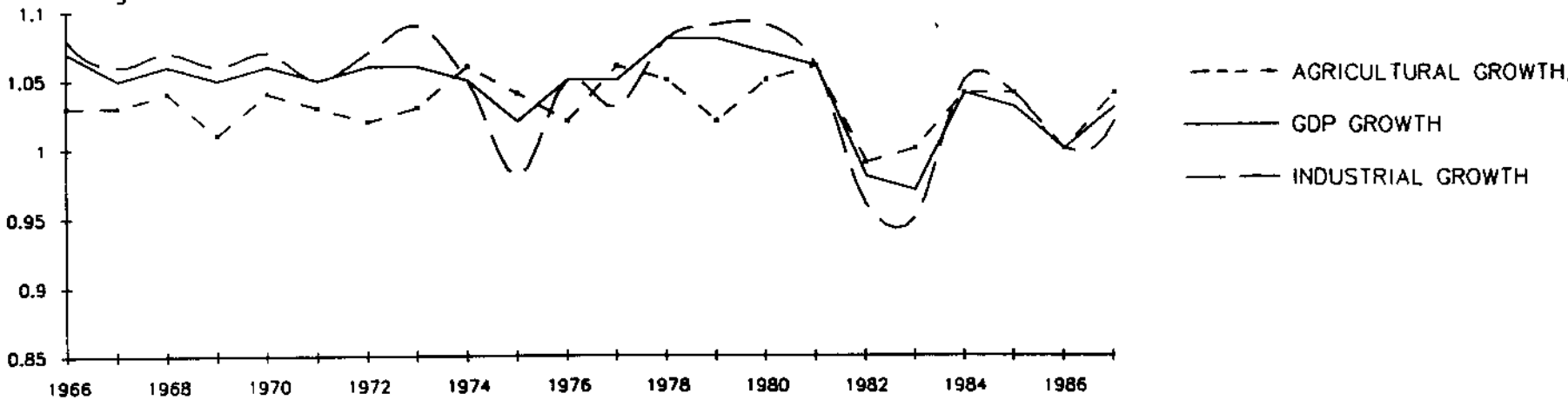
Notes: - Alternative hypotheses of stationarity test :
Ho : T (T stat.) < critical value = non stationary (Dickey Fuller)
H1 : T (T stat.) > critical value = stationary of order d (Dickey Fuller)
- Alternative hypotheses of cointegration test :
Two equations are estimated : a) Simple OLS regression with a test on Durbin Watson stat. (CRDW)
b) OLS applied on errors : Ho : T < critical value (Dickey Fuller) = Non cointegrated
H1 : T > critical value (DF) = cointegrated
- DlnYt is the fist difference of the function, t is the trend, C is the constante and Ut the error.

Figure 3 : COMPARATIVE GROWTH INDICES POINTS FOR BRAZIL



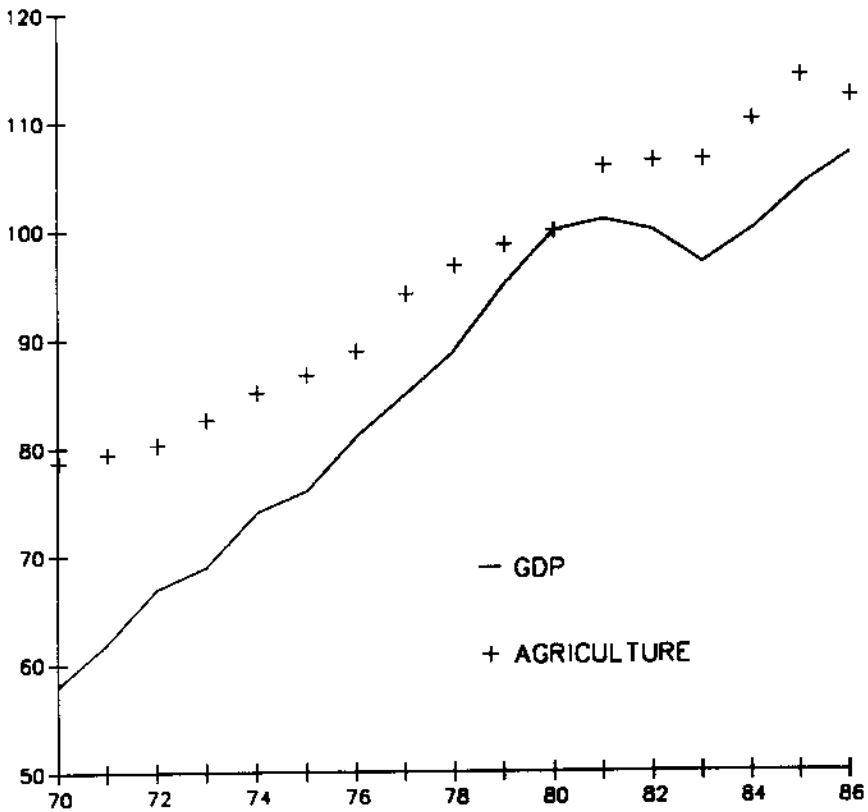
Source: World Bank Tables

Figure 4 : COMPARARTIVE GROWTH INDICES POINTS FOR LATIN AMERICA



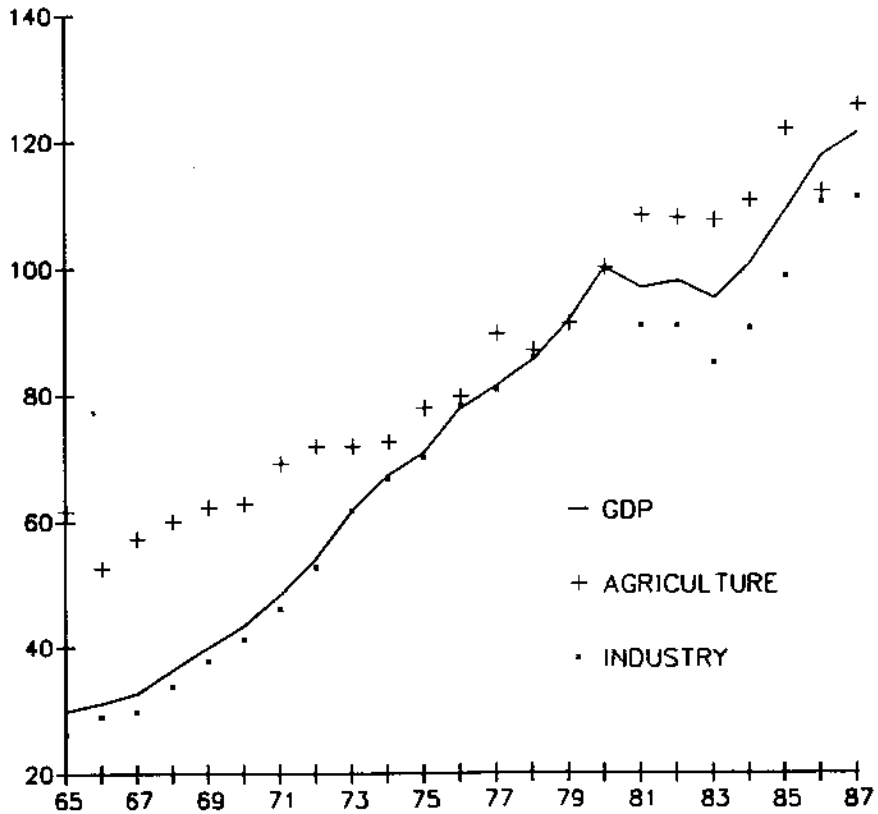
Source: World Bank Tables

FIGURE 1
GDP AND AGRICULTURE IN LATIN AMERICA
(Index Numbers 1980=100)



Source : Goldin and Rezende (1990), Table 1.2.

FIGURE 2
GDP, AGRICULTURE AND INDUSTRY IN BRAZIL
(Index Numbers 1980=100)



Source : Goldin and Rezende (1990) Table 1.3a.