Impacts of the Agricultural Sector Technological Change on Brazilian Economy

Mariza Marilena T. Luz Barbosa
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Embrapa

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Foreword

Agricultural research traditionally performs a very important role in agribusiness and economic development. In Brazil, there are several examples where the technologies generated by private and public research have been fundamental for the country's progress, especially in the last decades.

For the past 30 years Brazilian society has intensified the investments on agricultural research, as part of an effort to promote the economic development of hinder land, social inclusion, food supply, and the Balance of Payments.

Recent data show that the decision of Brazilian society to increase research investments was correct. The relation between such investments and the growth of the Agricultural Gross National Product of Brazil is very close to that verified in some developed countries like Ireland, Italy, Portugal and Spain. Studies show that this relation has increased more than two times, from 0,8 to 1,7 percent. This rate is even higher than the ones in other developing countries, which are about 0,4%. Other studies also show the positive results of such efforts, considering that the internal rate of return on agricultural research estimated for Brazil is above 25 to 30 percent, which is considered a profitable rate for this sector.

The investments on science and technology for Brazilian agriculture include EMBRAPA (Brazilian Corporation for Agricultural Research, sponsored by the Brazilian Government), research centers, state organizations for agricultural research, universities with programs in agrarian sciences, foundations and private companies, especially the ones related to the seed sector grain sector. Therefore, the impacts of the technological change must be shared by all the institutions that belong to the National System of Agricultural Research. Furthermore, it cannot be forgotten that, on this process of generating agricultural technology, Brazilian Research and Development Institutions have had the support of international partners such as the CGIAR (Consulting Group for International Agricultural Research), and innumerous foreign universities.

It is also important to note that, a major part of the investment in science and technology in Brazil concerning the agricultural sector, corresponds to public resources from the federal government, assigned directly to research institutions like EMBRAPA, or indirectly by the National Council of Scientific and Technological Development (CNPq), the Coordination of Graduate Studies of the Ministry of Education and Culture (CAPES), and the Institute of Study and Project Funding (FINEP), allotted mainly to institutions of high learning. Recently the State Research Foundations have performed an important role in funding agricultural research.

This publication introduces the studies presented at a seminar sponsored by the Ministry of Agriculture and by EMBRAPA, in cooperation with the Ministry of Science and Technology, which aimed to analyze the impacts, on the national economy, of the last 25 years of technological change in the Brazilian agricultural sector.

The first paper evaluates the long term impact of agricultural development on income generation, population growth, and human development in selected geo-economic areas. The main concern is the social inclusion process that accompanies economic and social development in those areas, as well as its interrelation with tax revenues. The basic assumption is that agricultural expansion determines the economic and demographic dynamics, and, consequently, the well being in homogeneous economic areas in Brazil. Indeed, the analysis shows that the hypothesis of the multiplying power of agricultural expansion over other economic activities was confirmed, as well as the impact of agricultural growth on social inclusion.

The second paper analyses the impacts of productivity gains on selected, agricultural sector performance indicators, and emphasizes the implications for the external sector, especially exports. It was verified that productivity shocks effectively increase the competitiveness of national grain and processed food producers, with important effects on the sectoral balance of trade.

The third paper analyzes the effects of Brazilian agricultural research on the consumer, especially where the urban consumer is concerned. It was shown that, for 25 years, the real prices of the food in a significant basket have dropped, on average, 5% per year. Looking at the evolution of grain production and farmed area, is it clear that Brazilian agriculture is increasingly expanding through the incorporation of technology, rather than farmed area. The estimated elasticity values for six of the ten analyzed products are higher than 2.0, that is, every 1% variation in area productivity corresponds to a 2% drop in the real price of these products. It was also verified that development brought up by agricultural research allows production in several soil conditions and climate, distributing more easily the production in time and space, therefore contributing to minimize the supply crisis and its effects, as well as increasing the options for Brazilian consumer.

By launching this publication/work about the impact of technological changes in agriculture, Embrapa hopes to contribute to the development and improvement of public policies in science and technology related to agribusiness, as well as to give a better direction to the institutions that act in this area as a response of the new challenges presented to the sector.

Alberto Duque Portugal
President for EMBRAPA

Contents

1 Long term economic and social impacts of the agricultural expansion in Brazil: invisible revolution and social inclusion

Regis Bonelli [1]

1.1 Introduction

As opposed to urban growth, whose economic and social impacts on the affected populations are more easily perceived by analysts, the outcomes of agricultural development are spread along time and less readily ascertained, because of the territorial dispersion of this economic activity. At the same time, factual evidence points to important changes in the structure and performance of the Brazilian primary sector in various geo-economic areas. Many changes are associated with the introduction of new crops, methods and technologies, and their effect on income generation, jobs and improved living standards are not as easily analyzed and quantified, or even clearly perceived, by the economic agents, including local governments.

Thus, the **objective of the** research is **to evaluate, from the quantitative standpoint, the long term impact of agricultural development on income generation, population growth and human development/living standards in selected geo-economic areas,** focusing, in particular, on known cases of intense structural changes in the rural areas. The geo-economic areas selected for scrutiny, however, include regions developed earlier, as counterpoint to the others. The main concern is the social inclusion process that hopefully accompanies economic and social development in the geo-economic areas undergoing change. Another object of research is the interrelation of this phenomenon with tax revenues and other regular municipal revenues in given territories.

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[1] Associate Researcher at DIMAC/IPEA and consultant to national and international, public and private organizations. Research report to EMBRAPA / Brazilian Agricultural Research Corporation.

The report presents an analysis of some present and past success stories at the municipal level or for a set of continuous or related municipalities. These cases were selected jointly by the researcher and the EMBRAPA team, and are listed in another section of the report.

The **basic assumption of the analysis** is that **agricultural expansion determines the economic** (revenue and employment levels) and **demographic** (migrations and urbanization) **dynamics** and, consequently, the **well being** in homogeneous economic areas in Brazil. This phenomenon, therefore, can be represented by a quality of life or human development indicator, like the United Nations' HDI or other indexes derived therefrom.

For the purpose of this study, therefore, **the intensity of the social inclusion process is identified, together with the magnitude of the changes, using human and social development indexes,** applied along time. This is possible using statistical models that express agricultural growth according to municipality, homogeneous micro-region (HMR), set of municipalities or HMR[2], as well as variables representing the socio-economic processes being analyzed.

The 1975-1996 period was selected for the analysis, because of the availability of statistical information. For the research, a municipal database was specially built on the basis of the needs of the study and the orientation provided by EMBRAPA. The database contains information on the Gross Domestic Product (GDP) for each municipality, HMR or Minimum Comparable Areas (MCA), broken down by economic macro-sector, namely, agriculture, industry and services. It also includes human development indexes (HDI or LSI, Living Standards Index[3])

[2] The issue of dismemberment of municipalities is duly treated in the database, which presents results by comparable area (Minimum Comparable Areas or MCA) and homogeneous micro-region (HMR). Many municipalities have been dismembered in Brazil in the last few years.

[3] Municipal HDIs are available for the 1970, 1980 and 1991 census years. It is possible to associate the results with the statistical database developed for 1975, 1980, 1985, and 1996, without losing generality.

for the population in each selected geographical area[4]; level of municipal urbanization; and tax revenue, when available at the National Treasury Secretariat (from 1985 to 1996/97).

The agricultural GDP was calculated from the revenue standpoint, on the basis of information from the Agricultural Economic Census for 1975, 1980, 1985, and 1996, i.e., the sum total of the production factors (land, labor and capital). This is particularly advantageous for the purpose of this paper, since it represents the revenue effectively generated in the geo-economic area under consideration, which should affect the well-being of the local population, even when the revenue is generated in one region and appropriated in another, as seen in some cases.

The method used in obtaining the database of municipal GDPs and their subdivisions is described in the second section of this report. The third section shows the results obtained at the state level using the methodology proposed for determining revenue. The fourth section, in turn, provides the information necessary to replicate the analysis for selected municipalities. Special emphasis is assigned to the population dynamics during the 1970-2000 period and some of its implications in terms of labor productivity in agriculture. The fifth section complements the previous section by showing the interrelations between agricultural growth and the social inclusion indicators used in this study. The last section sums up the conclusions of the research. An Appendix provides notes on the methodology, as well as support tables.

The municipalities selected for the analysis are listed immediately below. The municipalities and groups of municipalities listed in the same line were analyzed together within each state, since they have similar geo-economic characteristics.

<u>In the North Region</u>

Lábrea, in the State of Amazonas (AM)

Paragominas, in Pará (PA)

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[4] Also without losing generality, the demographic changes will be checked using the population growth from 1970 to 2000, with emphasis on the changes in the urbanization rate, for the two years. This was done to take advantage the census statistics for the latter year, which were made available only recently.

Conceição do Araguaia, Marabá, and Redenção, also in Pará

In the Northeast Region

Barreiras, in Bahia (BA) (the whole micro-region)

Irecê and Luis Eduardo, also in Bahia

Juazeiro (BA)

Balsas and Riachão das Neves, in Maranhão (MA)

Southern Piauí (PI): Bom Jesus, Cristino Castro, Palmeira do Piauí, Ribeiro Gonçalves, Santa Filomena, and Uruçuí

Petrolina, in Pernambuco (PE)

The Açu-Mossoró development cluster: Afonso Bezerra, Alto do Rodrigues, Açú, Baraúna, Carnaubais, Ipanguaçu, Itajá, Mossoró, Pendências, Serra do Mel, and Upanema, in Rio Grande do Norte (RN)

In the Center-West Region

Rio Verde, in Goiás (GO)

Dourados, in Mato Grosso do Sul (MS)

Rondonópolis, in Mato Grosso (MT)

In the Southeast Region

Barretos, Colômbia, Guaíra, Ituverava, and Miguelópolis, in São Paulo (SP)

Paracatu, Patrocínio and Patos de Minas, in Minas Gerais (MG)

Uberlândia and Uberaba, also in MG

Jaíba River Valley: Espinosa, Jaíba, Janaúba, Mato Verde, Monte Azul, Porteirinha, Riacho dos Machados, Rio Pardo de Minas, and São José do Paraíso (MG)

In the South Region

Londrina and Maringá, in Paraná (PR)

São Joaquim and Fraiburgo, in Santa Catarina (SC)

Chapecó, also in SC

Southeast Rio Grande do Sul (RS): Arroio Grande, Jaguarão, Santa Vitória do Palmar, São José do Norte, and Uruguaiana (RS)

Bento Gonçalves, Caxias do Sul, Santana do Livramento and Passo Fundo, also in RS.

1.2 Constructing municipal GDP estimates for the economic macro-sectors, at constant prices, for 1975, 1980, 1985, and 1996[5]

A **two-tier** methodology was used in developing the municipal estimates at constant prices. The purpose of the **first one** is to obtain estimates of **state** GDPs at constant prices for the years being studied. During the second stage, **the state estimates are broken down by municipality**, using existing, current price information[6].

The sectoral division adopted includes the three major sectors of the economy: agriculture (including extractive activities and other non-primary activities not included in farming and animal production), industry (mining, manufacturing, industrial public services, and civil construction) and services (including all other activities and sectors that make up the so-called tertiary sector of the economy).

The starting point of the methodology are the estimates of the Regional Accounts for 1996[7] by State of the Federation (hereinafter referred to as UF) and economic macro-sector. The basic data contain therein refer to the Gross Domestic Product at factor costs (including the imputation of financial services). Consequently, all estimates resulting from the proposed methodology follow the same aggregate.

The four state vectors (referring to agriculture, industry, services, and total GDP) that make up the Considera and Medina

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[5] Readers less interested in methodological procedures can go directly to the following section, without risk of missing any important points in the discussion.

[6] See Thompson de Almeida Andrade and Rodrigo Serra, "Estimativas para o Produto Interno Bruto dos Municipalities Brasileiros: 1975, 1980, 1985 e 1996" (Estimates for the Gross Domestic Product of Brazilian Municipalities: 1975, 1980, 1985, and 1996), IPEA, Projeto NEMESIS [2000].

[7] See C. M. Considera and M. H. Medina, "PIB por Unidade da Federação: Valores Correntes e Constantes" (GDP by Unit of the Federation: Current and Constant Values — 1985-1996). Rio de Janeiro, IPEA, Text for Discussion 610, 1998.

estimates for 1996 were immediately retroacted to 1985 using the specific sectoral indexes shown in Table 6 of the **REGIONAL ACCOUNTS OF BRAZIL 1985-1997**[8]. These indexes refer to the "Evolution of the Value Added Volume at the Basic Price in Large Regions and Units of the Federation, accrued by year, total and economic activity"[9]. Thus are obtained the state value vectors for 1985 at 1996 prices. A more detailed description of the procedure includes the initial calculation of the **state totals** for 1985, followed by the sectoral distribution. The criteria below were used in aggregating the various activities into sectors for 1985.

(i) For agriculture, the published indexes refer exactly to that sector. The difference between the sum of the values for the UFs and the total estimated directly is close to 3%, the sum of the UFs being the lesser value. Since the difference is small, the state results were maintained.

(ii) In the case of industry, the aggregates in Table 6 cover the four industrial sub-sectors: mining, manufacturing, industrial public services, and civil construction. These aggregates were used to weigh the average values for 1985 and 1996 of the respective sub-sectors in Table 9 of the same publication, namely, "Participation of the Economic Activities in the Value Added at Basic Price" for each UF[10]. Since the sum of the estimated state values was approximately 6% lower than the national total, previous estimates were corrected using a 1/0.94 correction factor. Table 1 of the Appendix shows the actual variation indexes of the industrial product estimated using the procedure described (1985-1996).

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[8] See IBGE, Research Directorate, National Accounts Department, National Accounts, Volume 3. Rio de Janeiro, 1999.

[9] Please observe that the Gross Value Added at basic prices differs from the GDP at factor costs. For the Brazil total, the GDP fc is R$ 691.8 billion and the AV at basic prices reached R$ 695 billion in 1996. See IBGE (1999) *op. cit.*, Table 1. Despite the difference, we preferred working with the GDP at factor costs, rather than at market prices, because it is conceptually and empirically closer to the AV at basic prices.

[10] This procedure is clearly a simplification. The correct thing would be to redo the aggregate annual series beginning with the four series of the sub-sectors that make up industry, using their share of the previous year as weigh (the equivalent to a Laspeyres index). Nevertheless, tests for some UFs, using the average weighs, revealed slight differences between the two methods. Obviously, the smaller the structural change within industry, the lesser the difference between the two methods.

(iii) The sectoral values for services were obtained residually, by subtracting the values obtained in (i) and (ii), above, from the state totals. The difference between the sum of the UFs and the prior total obtained directly is close to 1%. Since it is a small difference, the state results were maintained.

The following stage was to estimate the state vectors for the years 1975 through 1980, total and by sector. As opposed to the 1985-96 period, there are no specific indexes available for the actual variation of the state GDPs, much less for the sectoral GDPs for the years prior to 1985. Consequently, we had to resort to approximations.

The procedure adopted involved two steps. Firstly, the GDPs, Brazil total and sectoral totals were retroacted from 1985 to 1980 and 1975. This was done using the National Accounts indexes, at constant prices, relative to the total Brazil GDP and sectoral GDP for the sectors selected (agriculture, industry and services), as well as the Brazil total, for those years. Next, the national and sectoral totals were distributed among the UFs. Several criteria were possible at this point, because of the various possible combinations.

(i) The first criterion is to distribute the national totals (aggregated and by sector) at constant prices by UF according to the GDP Tables at factor costs by UF estimated by the IBGE National Accounts Department for the 1970, 1975, 1980, and 1985 census years[11]. This criterion has the advantage of preserving the original distribution, although the latter is at current prices. But the sectoral totals (horizontal sum) do not total the state GDP obtained using the same process – unless the results for a sector (services, for example) are obtained residually.

(ii) The second criterion uses estimates of the state GDPs at constant prices from an independent source[12] and distributes them by sector (horizontally), starting from the results at current prices mentioned previously[13].

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[11] See, for example, Tables 86.1 through 86.4 in Chapter 86 of the **Anuário Estatístico do Brasil 1991** (Statistical Yearbook for Brazil: 1991), IBGE [1992].

[12] Table 86.7 of the **Anuário Estatístico do Brasil 1991** (IBGE [1992] shows a set of state estimates at constant prices).

[13] Once again, the problem is that the UF totals for each sector do not add to the sectoral GDP for the country, as they should. The difference is particularly remarkable in the case of agriculture: the sum of the states in 1975, for example, greatly exceeds the national total.

(iii) The third criterion, which was adopted in building the tables, is a mixture of the two criteria above. It consists of calculating the state GDPs at constant prices for 1980 and 1975, as in (ii) and then distributing the total of the agricultural and industrial sectors by UF, according to the state GDPs at factors costs at constant prices, as in (i). The services sector is obtained residually.

The state distribution of the GDPs for agriculture and industry in 1975 and 1980 according to this criterion is shown in Table 2 of the Appendix.

Once the state vectors by sector at constant 1996 prices have been obtained for all the years being studied, the distribution by municipality uses the respective shares found in the previously mentioned spreadsheets at current prices[14]. Please note that the municipal GDP is an imperfect indicator of the revenue appropriated in the region, as Andrade and Serra advised in 2000:

"[since] neither the revenue generated by a productive activity in a given geographical area is always entirely owned by the area's residents, nor all revenue appropriated by the residents of an area is generated entirely in that area, it becomes clear that the information on GDP is an imperfect indicator of the total revenue of that locality. This imperfection increases with the level of disaggregation of the geographic units being analyzed. It is also easy to perceive the problem caused by a company's headquarters being in a given state capital and its operations in other municipalities of the state. The entire Product generated by this company would be captured by the national and state GDPs while, at the municipal level, it would be necessary to be careful with the production information, since it will often be recorded according to the location of the company's headquarters, rather than the municipality where the operations are located" (page 4).

[14] The restriction to the years 1975, 1980, 1985, and 1996 is due to the fact that these were precisely the years in T. A. Andrade and R. Serra's landmark paper, without which the estimates in this methodological note – as well as, obviously, in this entire paper – could not have been carried out.

Also according to the authors, the municipal GDP is obtained by prorating the state GDP. For 1975, 1980 and 1985 the prorating was done as follows:

"The share of the municipal GDP in the state GDP for that year (Pj) is estimated to be:

$$Pj = Yj / \Sigma Yj = \{\Sigma [Yi (Xij / \Sigma X ij)]\} / \Sigma Yj$$

Where
Yi is the GDP of sector *i* in the state,
X ij is the value of the reference variable for the activity of sector *i* in municipality *j* and
Yj is the GDP of that municipality."

"For 1996 the municipal GDP estimates were hampered due to the lack of census information, so that the only indication of the municipal share in the sectoral GDP total for the UF is the *People Working* variable, basically (except for the primary sector)" (our emphasis). The underlined phrase clearly indicates that estimates are better precisely for agriculture, which is focused on this report.

1.3 Analysis of the state results

Table 1 shows the practical results of the methodology described above, in terms of the average growth rates of the actual state GDPs (total and by sector) for the 1975-1996 period. These results demonstrate that the methodology apparently generates quite realistic estimates, the only exception being the State of Roraima, where the long-term growth rate is negative. This is due to an apparent methodological change in the way the regional GDP estimates at factor costs were calculated from 1975 to 1985 and the new IBGE methodology used from 1985 through 1997[15]. Please note that Roraima's share in the national agricultural product had already dropped from 1975 to 1980 (as calculated using the first methodology), as seen in table 2 of the Appendix.

[15] More specifically: the share of Roraima in the total agricultural GDP drops abruptly in 1985, when comparing the estimates obtained using the old methodology and the new one for the same year.

An initial exercise to be carried out on the basis of the database developed for the study would be investigating to which extent the agricultural GDP (or agricultural revenue) and that of the other sectors (industry and services) are associated. Or, to be more daring, to what extent the non-agricultural revenue (YÑAGRO) is "determined" by the agricultural revenue (YAGRO). Or, daring even more, to what extent the primary revenue determines the dynamics of the other sectors of the economy in the long term. The non-agricultural GDP, or urban GDP, is rather easily obtained by subtracting the part of the revenue deriving from agriculture from the actual, total state GDP.

Actually, the non-agricultural revenue is closely associated with the agricultural revenue through a process to which we attribute causality, since the economic activities typical of the primary sector antecede urban activities in both time and space. The hypothesis, therefore, is not too bold, since it is supported by the fact that rural investments and economic activities usually precede urban investments, except for extreme cases of government intervention.

The model to be tested is, in logarithmic form, that of the following formula:

$$\ln(\text{YÑAGRO}) = k + \ln(\text{YAGRO})$$

where k is a constant.

Since the total and sectoral GDP results are at constant prices of a same year, it is possible to estimate a regression with the data for all the years (1975, 1980, 1985, and 1996) in order to add robustness to the analysis of the results.

The first results (not shown) of an estimate using minimum squares demonstrate that two UFs systematically fall outside the standard of the other UFs: Rio de Janeiro and Brasília (DF). In both cases, the value adjusted by the formula is always considerably higher than that effectively observed in these UFs. In other words, Rio de Janeiro and the DF have sectoral structures in which the primary sector is characteristically smaller than the national standard: for any given agricultural GDP; the agricultural and total GDPs of RJ and the DF are smaller than those of the other states. Coincidentally, one of these cities is and the other was the nation's capital, where the urban activities associated

Table 1. The average growth rates of the actual states GDPs (total and by sector) at factor cost for the 1975-1996 period.

State	Average annual growth rate 1975-1996			
	Primary	Secondary	Tertiary	Total
BRAZIL	0.0369	0.0246	0.0370	0.0327
North	0.0783	0.0746	0.0701	0.0724
RONDÔNIA	0.1233	0.0669	0.1220	0.1170
ACRE	0.0387	0.1245	0.0812	0.0787
AMAZONAS	0.0440	0.0638	0.0672	0.0635
RORAIMA	-0.0286	0,1650	0.0942	0.0931
PARÁ	0.0787	0.0824	0.0523	0.0632
AMAPÁ	0.0753	0.0697	0.0786	0.0763
TOCANTINS *	0.0395	0.0557	0.0491	0.0427
Northeast	0.0237	0.0388	0.0360	0.0358
MARANHÃO	0.0201	0.0781	0.0381	0.0398
PIAUÍ	0.0364	0.0651	0.0395	0.0419
CEARÁ	0.0235	0.0526	0.0440	0.0438
RIO G. NORTE	0.0178	0.0529	0.0417	0.0424
PARAÍBA	0.0360	0.0091	0.0389	0.0329
PERNAMBUCO	0.0273	0.0033	0.0332	0.0253
ALAGOAS	0.0097	0.0694	0.0349	0.0414
SERGIPE	0.0462	0.0273	0.0511	0.0443
BAHIA	0.0357	0.0464	0.0302	0.0355
Southeast	0.0434	0.0197	0.0360	0.0298
MINAS GERAIS	0.0375	0.0519	0.0269	0.0362
ESPÍRITO SANTO	0.0849	0.0567	0.0393	0.0480
RIO DE JANEIRO	0.0167	0.0132	0.0200	0.0178
	0.0468	0.0149	0.0452	0.0316
South	0.0232	0.0258	0.0264	0.0257
PARANÁ	0.0157	0.0460	0.0222	0.0275
SANTA CATARINA	0.0367	0.0217	0.0435	0.0344
RIO GRANDE DO SUL	0.0261	0.0131	0.0240	0.0210
Center-West	0.0532	0.0773	0.0558	0.0580
MATO GROSSO DO SUL	0.0589	0.0995	0.0495	0.0590
MATO GROSSO	0.1019	0.0459	0.0885	0.0853
GOIÁS	0.0288	0.1395	0.0307	0.0387
BRASÍLIA	0.1228	0.0428	0.0714	0.0678

* 1980-1996

with a numerous public bureaucracy is disproportionatelly high when compared with the agricultural activities.

To a certain extent, the same occurs in São Paulo. Nevertheless, in the case of RJ and the DF the regression residues are particularly high. This suggests the use of a dummy variable for RJ and the DF for the purpose of controlling this phenomenon. The results of the estimate are shown in the chart below, where the regional and state totals are included.

The angular coefficient of the YAGRO variable is, for all purposes, equal to one. **This indicates that for every 1% increase in the agricultural GDP there is a 1% increase in the non-agricultural GDP**. Or, if desired, that a **1% increase in the GDP of the agricultural sector "causes" a 1% increase in the GDP of the other sectors of the economy**. As expected, the dummy variable is positive and significant, which indicates that in the cases of Rio de Janeiro and Brasília the linear coefficient of the formula (intersection) is greater than in the other states. The non-agricultural GDP is typically higher in those cases than in the other UF, for any given agricultural GDP.

Regression Statistics				
R multiple	0.9443			
R-Square	0.8917			
R-Square adjusted	0.8900			
Standard	0.6098			
Notes	131	(Ex. Tocantins 1975)		
	gl	*SQ*	*MQ*	*F*
Regression	2	392.00899	196.0045	527.1551701
Residue	128	47.592392	0.3718156	
Total	130	439.60138		
	Coef.	*Standard*	*Stat t*	*P-value*
Intersection	1.96162	0.2261212	8.6750684	1.60058E-14
ln(YAGRO)	1.00129	0.0312017	32.090783	4.58102E-63
Dummy RJ DF	2.87854	0.2292766	12.55488	4.61721E-24

The previous estimate could be criticized, from the methodological standpoint, for simultaneously incorporating the state observations and respective regional sums. Consequently, the procedure was repeated excluding the regional totals. The new results are shown below.

Regression Statistics			
R multiple	0.922182		
R-Square	0.85042		
R-Square adjusted	0.847544		
Standard	0.613951		
Notes	107		
	gl	*SQ*	*MQ*
Regression	2	222.8750508	111.4375254
Residue	104	39.20131266	0.376935699
Total	106	262.0763635	
	Coefficient	*Standard*	*Stat t*
Intersectio	2.395587	0.268560156	8.920115013
ln(YAGRO)	0.927813	0.039985626	23.20366553
Dummy RJ BSB	2.830631	0.231416319	12.23176993

As expected, excluding the 24 observations pertaining to the regional sums diminishes the quality of the adjustment. The loss, however, is not excessive. The results are still very robust and the adjusted formula is consistent with the data – although the central point of the confidence interval of the angular coefficient has now diminished from 1.001 to 0.9278. Although the 95% probability of it being equal to one cannot be rejected, it seems obvious that it is slightly lower than the previous estimate. This means that every 1% increase in the agricultural revenue corresponds to a slightly less than 1% (0.93%, in fact) increase in the non-agricultural revenue of Brazilian states. Or, to put it more strongly, **a 1% increase in the agricultural revenue causes a 0.93% increase in the revenue generated by the other sectors.**

One of the remaining tasks in the study is to replicate this type of analysis using the data for municipalities and sets of municipalities.

1.4 Analysis by municipality

The main results of the municipal GDP growth estimates at factor costs, by economic sector, are shown in the tables of the first subsection, below, in brief analyzes by state, on the basis of the constant price estimates (in million 1996 constant *reais*). In the subsequent sections, these results are crossed with other economic, demographic and tax information to make up a more complete picture of the long term expansion of the agricultural sector in Brazil and some of the main implications therefrom.

1.4.1 Growth of the Selected Municipalities, 1975-1996

In the State of Amazonas, the municipality selected (Lábrea) had a significant agricultural expansion, with an average annual growth of 5.5% in real terms, during the 1975-96 period[16], which was surpassed by a very high growth of an (incipient) industrial sector (10.4% p.a. during 21 years). Nevertheless, the growth of the agricultural GDP of the municipality exceeded that of the state, which was 4.4% p.a. Estimates of the municipal GDP reveal a curious fact: although the agricultural production grew substantially until 1985, from that date to 1996 it diminished also substantially, as did the state's as a whole [IBGE, Contas Regionais 1985-96 (Regional Accounts), already cited]. A certain amount of caution should be used in applying the results for the period as a whole, since Labrea's agricultural growth for 1985-1996 was apparently sub-estimated.

In the State of Pará, on the other hand, all selected municipalities had exceptional performances. Both the Minimum Comparable Area (MCA) that includes the Conceição do Araguaia, Marabá and Redenção municipalities (13.9% annual growth for the agricultural sector) and the Paragominas area (6.82%) underwent intense agricultural growth from 1975 to 1996. In the latter case, the expressive state total (7.8%) was well outmatched. In Paragominas, industry (sawmills, for example) led the economic growth in the municipality, although agriculture

[16] Just for the sake of having an order of magnitude in comparisons: the actual annual agricultural GDP of Brazil increased 3.45%, on an average, from 1970 to 1999.

had a quite favorable performance in the long term[17]. The state GDP grew at 6.3% p.a., while that of the selected municipalities was 10.3% for the Conceição do Araguaia, Marabá and Redenção area and 7.8% for Paragominas. The two sets of municipalities selected, therefore, had a very good performance.

In Maranhão, the expansion of the municipalities in the Balsas and Riachão region was also quite favorable. The agricultural expansion achieved an expressive 8.5% p.a. during a twenty-one-year period! The total municipal GDP for Balsas and Riachão grew at least 6.6% p.a., well above the state average of almost 4% p.a., as seen in the next table.

State/Municipality	Actual Growth Rate 1975-1996			
	Primary	Secondary	Tertiary	Total
MARANHÃO	**0.0201**	**0.0781**	**0.0381**	**0.0398**
Balsas Riachão p ctes	0.0849	0.1225	0.0521	0.0655

The same phenomenon occurred in the State of Piauí. Agricultural growth in the southern region of the state exceeded 8% p.a., as opposed to the average growth for the whole state, which was 3.6%. The results shown in the following table leave no doubt about the role played by agriculture in the expansion of the GDP of the set of selected municipalities. The subregional

State/Municipality	Actual Growth Rate 1975-1996			
	Primary	Secondary	Tertiary	Total
PIAUÍ	**0.0364**	**0.0651**	**0.0395**	**0.0419**
Cur. prices				
% South Piauí				
South Piauí p ctes	**0.0828**	**0.0280**	**0.0099**	**0.0368**
Sum South Piauí				
BOM JESUS				
CRISTINO CASTRO				
PALMEIRA DO PIAUI				
Ribeiro Gonçalves MCA				
BAIXA GRANDE DO RIBEIRO				
RIBEIRO GONCALVES				
SANTA FILOMENA				
URUCUI				

[17] In fact, the agricultural growth in Paragominas occurred prior to the period being studied.

GDP grew 3.7% p.a., while the state's grew only 4.2% p.a. from 1975 to 1996.

In Rio Grande do Norte, the performance of agriculture at the Açu-Mossoró Cluster greatly exceeded that of the State. In fact, the average long-term growth rates for the sector were 4.8% p.a. in Açu-Mossoró, as against 1.8% for the state total. As regards the GDP, the opposite occurred. The state total grew an average 4.2% p.a. and that of the cluster analyzed was only 2.2 % p.a. This was caused by the negligible growth rate of industry in the Açu-Mossoró region, which did not exceed 0.92% p.a. from 1975 to 1996.

State/Municipality	Actual Growth Rate 1975-1996			
	Primary	Secondary	Tertiary	Total
RIO G. NORTE	0.0178	0.0529	0.0417	0.0424
Cur. prices				
% Açú Mossoró cluster				
Açú Mossoró cluster pctes	0.0475	0.0092	0.0231	0.0220
AFONSO BEZERRA				
ALTO DO RODRIGUES				
AMC Açú				
AÇU				
AREIA BRANCA				
BARAUNA				
CARNAUBAIS				
MOSSORO				
SERRA DO MEL				
IPANGUACU				
PENDENCIAS				
UPANEMA				

In Pernambuco, the Petrolina MCA grew a formidable 13.3% p.a. during a 26-year period! In the same period, agriculture grew only an average 2.7% at the state level.

State/Municipality	Actual Growth Rate 1975-1996			
	Primary	Secondary	Tertiary	Total
PERNAMBUCO	0.0273	0.0033	0.0332	0.0253
PetrolinaMCACur.prices	0.1327	0.0176	0.0550	0.0566
Petrolina MCA				
DORMENTES				
PETROLINA				

The direct result was intense growth of the municipal GDP (5.7% p.a.) in the Petrolina region, led by the agricultural sector[18]. The total state GDP increased only 2.5% p.a. from 1975 to 1996.

One of the municipal records in terms of agricultural growth occurred in Bahia: the municipality of Barreiras had a 20.4% p.a. expansion from 1975 to 1996, well above the state total (3.6% p.a.). Please observe that in another selected municipality, Juazeiro, agricultural performance was also exceptional and contributed substantially to the municipality's sectoral GDP achieving 12.2% p.a. The same occurred in Irecê/Luis Eduardo, where the growth of the agricultural sector was long neglected: 4.5% p.a. for 21 years. These sectoral results had clear impacts on the municipal GDPs, as shown in the table below. The performance of the selected municipalities was always higher than that of the State.

State/Municipality	Actual Growth Rate 1975-1996			
	Primary	Secondary	Tertiary	Total
BAHIA	**0.0357**	**0.0464**	**0.0302**	**0.0355**
Cur. prices				
% Barreiras				
Barreiras c.p.				
BARREIRAS	**0.2041**	**0.1654**	**0.0822**	**0.1235**
% Irecê MCA				
Irecê MCA c.p	**0.0447**	**0.1706**	**0.0362**	**0.0418**
Irecê MCA				
AMERICA DOURADA				
IRECE				
JOAO DOURADO				
LAPAO				
SAO GABRIEL				
% Juazeiro MCA				
Juazeiro MCA c.p.	**0.1218**	**0.1172**	**0.0299**	**0.0648**
Juazeiro MCA				
JUAZEIRO				
SOBRADINHO				

[18] Petrolina and Juazeiro are usually studied together because of the importance of the fruit crops in this development cluster. For an in-depth study, see, for example, "O Cluster da Fruticultura no Pólo Petrolina-Juazeiro" (The Fruit Cluster in the Petrolina-Juazeiro Region) in ***A Competitividade do Agronegócio e o Desenvolvimento Regional no Brasil — Estudos de Clusters*** (The Competitiveness of Agribusiness and Regional Development in Brazil – Studies of Clusters), org. by P. R. Haddad, CNPq/EMBRAPA, Brasília, 1999.

In the State of Minas Gerais, the best agricultural performance among the groups of municipalities selected was that of the Paracatu, Patrocínio and Patos de Minas area, which grew at 6.4% p.a. from 1975 to 1996, as against the GDP for this set of municipalities, whose growth was an appreciable 4.7% p.a. The second highest agricultural growth was that of Uberaba and Uberlândia (5.4% p.a.), with a subregional GDP growth of 4.3% p.a. The set of municipalities located in the Jaíba River Valley, in turn, had a performance below that of the previously mentioned municipalities and the state average: 3.1% p.a. from 1975 to 1996. Please observe that agricultural growth was a modest 3.8% p.a. for the state as a whole. Nevertheless, it was slightly above the average GDP for the state (3.5% p.a.).

State/Municipality	Actual Growth Rate 1975-1996			
	Primary	Secondary	Tertiary	Total
MINAS GERAIS	**0.0375**	**0.0519**	**0.0269**	**0.0362**
Jaíba Valley c.p.	**0.0311**	**0.1048**	**0.0308**	**0.0310**
ESPINOSA				
MAMONAS				
JAIBA				
MANGA				
MATIAS CARDOSO				
MONTE AZUL				
JANAUBA				
MONTEZUMA				
RIO PARDO DE MINAS				
MATO VERDE				
RIACHO DOS MACHADOS				
PORTEIRINHA				
Uberaba+Uberlândia				
UBERABA				
UBERLANDIA	**0.0539**	**0.0762**	**0.0240**	**0.0425**
Paracatu+Patrocínio+Patos				
PARACATU				
PATROCINIO	**0.0638**	**0.0875**	**0.0335**	**0.0473**
PATOS DE MINAS				

In São Paulo, the performance of the selected set of municipalities (Barretos, Colômbia, Guairá, Ituverava, and Miguelópolis) was much higher than the state average, both in the agricultural sector (7.0% as against 4.7% in the state) and the total GDP (4%, compared with the 3.2% for the state).

Actually, the Barretos region, traditionally characterized by extensive cattle ranching, began producing grain using irrigation systems in the 1990s. This technology must have resulted in substantially higher yields and, in particular, agricultural profits.

State/Municipality	Actual Growth Rate 1975-1996			
	Primary	Secondary	Tertiary	Total
SÃO PAULO	**0.0468**	**0.0149**	**0.0452**	**0.0316**
Municipalities c.p.	**0.0703**	**0.0553**	**0.0284**	**0.0404**
BARRETOS				
COLOMBIA				
GUAIRA				
ITUVERAVA				
MIGUELOPOLIS				

The opposite occurred in the State of Paraná. Since Parana's agricultural sector was expanded longer ago than this set of municipalities, the performance of Londrina and Maringá was somehow mediocre. The agricultural GDP in Londrina and Maringá grew only 0.3% p.a. (as opposed to 1.6% for the State), while the total municipal GDP grew at 2.5% p.a., as against 2.8% for the State. The growth rate in Maringá and Londrina during the period was much more closely associated with industry than with agriculture, something easily seen in the next table. It is widely known that the peak of agricultural expansion in this region occurred in the 1950s and early 1960s, when the so-called *terra roxa* was discovered.

State/Municipality	Atual Growth Rate 1975-1996			
	Primary	Secondary	Tertiary	Total
PARANÁ	**0.0157**	**0.0460**	**0.0222**	**0.0275**
Londr + Maringá	**0.0028**	**0.0289**	**0.0162**	**0.0247**
LONDRINA				
MARINGA				

Santa Catarina, on the other hand, is much more of a mosaic. Among the regions selected, the municipalities in the region of Fraiburgo and São Joaquim lead the agricultural expansion (8.7% p.a.), while the Chapecó area grew only 3.8% p.a. from 1975 to 1996, a slightly higher rate than the state's average of 3.7% p.a. The performance of the state GDP, however, reversed this sequence: the leading municipality is now Chapecó (because of its industrial or agroindustrial area)[19], while Fraiburgo and São Joaquim have had lower growth (3.6% p.a.), close to the state total rate of 3 .4% p.a.

State/Municipality	Actual Growth Rate 1975-1996			
	Primary	Secondary	Tertiary	Total
SANTA CATARINA	**0.0367**	**0.0217**	**0.0435**	**0.0344**
Chapecó MCA c.p.	**0.0375**	**0.0629**	**0.0398**	**0.0448**
CHAPECO				
CORDILHEIRA ALTA				
GUATAMBU				
NOVA ITABERABA				
Fraiburgo + SJoaquim	**0.0874**	**-0.0213**	**0.0443**	**0.0371**
FRAIBURGO				
São Joaquim MCA				
SAO JOAQUIM				
URUPEMA				

Some surprises come up in the State of Rio Grande do Sul. The annual growth rate for agriculture in the southeastern region of the state was only 1.9% for a municipal GDP growth of 1.2%. The Passo Fundo region had a better performance during the period: 3.2% for agriculture and 2.2% for the municipal GDP. The best performance was undoubtedly that of the municipalities in the Caxias do Sul, Santana do Livramento and Bento Gonçalves region, where the agricultural activities were already consolidated at the beginning of the period under scrutiny (1975). Nevertheless, the agricultural sector in that region grew at an impressive average annual rate of 4.4% in the long term. Indeed, this performance underpinned the GDP growth rate of this set of municipalities, which was only 1.1% p.a. due to the extremely bad performance

[19] There is a detailed analysis of swine breeding in the western region of Santa Catarina, which includes Chapecó, by J. I. dos Santos Filho; N. A. dos Santos, M. D. Canever, I. S. F. de Souza and L. F. Vieira in "O Cluster Suinícola do Oeste de Santa Catarina" (The Swine Breeding Cluster in Western Santa Catarina), in ***A Competitividade do Agronegócio e o Desenvolvimento Regional no Brasil — Estudos de Clusters***, org. by P. R. Haddad, CNPq/EMBRAPA, Brasília, 1999.

of the industrial sector (-0.8% average annual growth rate from 1975 to 1996). The performance of the state totals was also lusterless: only 2.6% p.a. for agriculture and 2.1% p.a. for total state GDP.

State/Municipality	Actual Growth Rate 1975-1996			
	Primary	Secondary	Tertiary	Total
RIO GRANDE DO SUL	**0.0261**	**0.0131**	**0.0240**	**0.0210**
Sum SE RS	**0.0192**	**0.0137**	**0.0183**	**0.0118**
ARROIO GRANDE				
JAGUARÃO				
SANTA VITÓRIA DO PALMAR				
SÃO JOSÉ DO NORTE				
URUGUAIANA				
Sum SE				
BentoGonçalves CaxiasLivramento	**0.0435**	**-0.0083**	**0.0282**	**0.0106**
Passo Fundo	**-0.0062**	**0.0111**	**0.0200**	**0.0078**

The municipalities of the Dourados region in the State of Mato Grosso do Sul had favorable results. Agriculture grew 4.3% p.a. in the long term and the municipal GDP achieved a 4.2% growth rate. In Mato Grosso do Sul, however, the state totals greatly exceed the totals of the set of municipalities selected. In fact, Mato Grosso do Sul is among the states with the highest growth rates during the 1975-1996 period, as seen in the state growth table in the previous section.

State/Municipality	Actual Growth Rate 1975-1996			
	Primary	Secondary	Tertiary	Total
MATO GROSSO DO SUL	**0.0589**	**0.0995**	**0.0495**	**0.0590**
Sum	**0.0430**	**0.0809**	**0.0305**	**0.0419**
ANGELICA				
DEODAPOLIS				
DOURADINA				
DOURADOS				
FATIMA DO SUL				
GLORIA DE DOURADOS				
VICENTINA				

A similar phenomenon occurred in Mato Grosso. Although the joint growth of the set of selected municipalities (the Rondonópolis region) was very good — average annual rate of

5.5% for agriculture and 6.4% for the total municipal GDP — the state's rates were even better (10.2 and 8.5%, respectively). Indeed, Mato Grosso's was the leading state growth, as seen previously.

State/Municipality	Actual Growth Rate 1975-1996			
	Primary	Secondary	Tertiary	Total
MATO GROSSO	**0.1019**	**0.0459**	**0.0885**	**0.0853**
Sum	**0.0547**	**0.0679**	**0.0706**	**0.0640**
GUIRATINGA				
PEDRA PRETA				
SAO JOSE DO POVO				
RONDONOPOLIS				

Lastly, Goiás is another clear success story in terms of the agricultural performance of the selected municipalities (the Rio Verde region)[20]. Although the industrial growth was very strong (12.7% p.a., a result largely due to the agribusiness subsector, agriculture (6.0% p.a.) accounted for most of the municipal GDP growth (4.1% p.a.).

State/Municipality	Actual Growth Rate 1975-1996			
	Primário	Secundário	Terciário	Total
GOIÁS	**0.0288**	**0.1395**	**0.0307**	**0.0387**
Sum	**0.0597**	**0.1270**	**0.0322**	**0.0405**
CASTELANDIA				
MONTIVIDIU				
RIO VERDE				
SANTO ANTONIO DA BARRA				

1.4.2 Municipal Dynamics from 1970 to 2000

Without losing generality, it is possible to associate the population dynamics from 1970 to 2000 to the economic growth of the period analyzed in this report (1975-1996). Table 2

[20] For an analysis of the region, see F. A. D'Araújo Couto and J. de A. Monteiro's study "O Cluster de Grãos na Região de Rio Verde no Sudoeste de Goiás" (The Grain Cluster in the Rio Verde Region in Southwestern Goiás) in ***A Competitividade do Agronegócio e o Desenvolvimento Regional no Brasil — Estudos de Clusters***, org. by P. R. Haddad, CNPq/EMBRAPA, Brasília, 1999.

Table 2. Total population, urban, rural, urbanization rate in 1970 and 2000.

Municipality	1970 Total Pop.	1970 Urban	1970 Rural	1970 % Urbanization	2000 Total Pop.	2000 Urban	2000 Rural 2000	2000 % Urbanization	Pop. Growth 1970-2000	Urb. Growth 2000-1970
Lábrea	16.737	3.022	13.715	0,181	28.931	19.243	9.688	0,665	0,018	2,684
Conceição Marabá Redenção	45.382	19.653	25.729	0,433	211.326	163.612	47.714	0,774	0,053	0,788
Paragominas	14.697	1.747	12.950	0,119	76.095	58.081	18.014	0,763	0,056	5,421
Balsas + Riachão	37.216	9.362	27.854	0,252	81.129	59.811	21.318	0,737	0,026	1,931
Southern Piauí	43.445	8.633	34.812	0,199	59.113	35.141	23.972	0,594	0,015	1,992
Açú Mossoró cluster	168.830	106.398	62.432	0,630	330.783	273.296	57.487	0,826	0,023	0,311
Petrolina MCA	44.771	37.156	7.615	0,830	218.336	166.113	52.223	0,761	0,054	(0,083)
Barreiras	20.864	9.831	11.033	0,471	131.335	115.331	16.004	0,878	0,063	0,864
Irecê MCA	29.802	10.368	19.434	0,348	57.360	53.073	4.287	0,925	0,022	1,660
Juazeiro MCA	38.663	36.242	2.421	0,937	174.101	132.796	41.305	0,763	0,051	(0,186)
Jaíba Valley	134.333	30.703	103.630	0,229	230.572	136.035	94.537	0,590	0,018	1,581
Uberaba+Uberlândia	239.297	218.548	20.749	0,913	751.254	731.293	19.961	0,973	0,039	0,066
Paracatu+Patrocínio+Patos	134.053	79.454	43.813	0,593	271.930	232.572	39.358	0,855	0,024	0,443
Barretos, etc.	131.128	96.410	34.718	0,735	199.701	186.969	12.732	0,936	0,014	0,273
Londrina + Maringá	235.307	207.931	27.376	0,884	735.314	717.056	18.258	0,975	0,039	0,104
Chapecó MCA	27.934	18.668	9.266	0,668	146.534	134.210	12.324	0,916	0,057	0,371
Fraiburgo + Sjoaquim	20.411	7.818	12.593	0,383	55.617	43.596	12.021	0,784	0,034	1,046
Sum SE RS	131.857	100.142	31.715	0,759	130.125	105.399	24.726	0,810	(0,000)	0,067
Bgonç+Caxias+Livramento	190.613	126.954	13.478	0,666	542.459	499.405	43.054	0,921	0,035	0,382
Passo Fundo	73.750	69.062	4.688	0,936	168.440	163.748	4.692	0,972	0,028	0,038
Dourados MCA	31.528	25.977	5.551	0,824	164.674	149.679	14.995	0,909	0,057	0,103
Rondonópolis	36.933	22.707	14.226	0,615	150.049	141.660	8.389	0,944	0,048	0,536
Rio Verde	42.509	22.339	20.170	0,526	116.559	106.109	10.450	0,910	0,034	0,732

shows data relevant to the analysis: total population, both urban and rural; urbanization rate (the ratio of the urban population who lives in towns and cities to the total population of a municipality or set of municipalities) in 1970 and 2000; and changes (relative variation) in the level of urbanization from 1970 to 2000.

Please observe that the population growth was expressive in most of the 23 sets of municipalities selected for the study[21]. The highest, average annual rate of population growth is that of the Municipality of Barreiras, whose population increased 6.3% p.a. from 1970 to 2000. The second place goes to Chapecó and Dourados, with 5.7% p.a. each during the period, closely followed by Paragominas (5.6%), Petrolina (5.4%) and the Conceição do Araguaia, Marabá and Redenção region (5.3%). The only set of municipalities among those analyzed in this report whose population decreased between the extreme years of the time interval under consideration was southeast Rio Grande do Sul (from 131,900 to 130,100).

Nevertheless, it is remarkable that in some of the high population growth cases mentioned the urbanization rate — defined as the ratio of urban population to total population — increased relatively little during the period under consideration, as follows.

In Barreiras, there was a typical increase of areas undergoing rapid population changes, where the level of urbanization rose from 47% in 1970 to 88% in 2000. Despite the very high increase in the activities associated with urban environments, the long-term agricultural GDP grew at an impressive average annual rate of 20%, while the total municipal GDP grew no less than 12.4% p.a., as seen before. This seems to be a typical case of transformation with enormous productivity gains, since the rural population increased almost 45% in 30 years (or 1.25% p.a.) while the agricultural GDP grew 20% p.a., as seen before.

In the Chapecó MCA, in turn, the rate of urbanization was lower, due perhaps to the relatively high urbanization rate at the

[21] Just for the sake of comparison: the average annual growth of the Brazilian population was 2.02% from 1970 to 2000.

beginning of the period. Actually, the urbanization rate escalated from 67% in 1970 to 92% in 2000. The municipal agricultural rate of growth was 3.8% p.a., while the total annual municipal GDP was 4.5%. This indicates that urban activities and particularly agroindustry drove municipal growth, despite a favorable increase in primary sector activities. The strongest economic activity in the region is animal processing, undoubtedly.

A similar phenomenon occurs in Dourados, where the urbanization rate went from 82% to 91% in the census years considered in this report. In this case, however, the agricultural GDP increased only 4.3% p.a., for a total municipal GDP of 4.2%. The primacy of the activities associated with agriculture over the total growth is undeniable. Notwithstanding, please note that the productivity gains were lower than those of Barreiras, since the rural population grew an average 3.37% p.a.

Paragominas' was among the highest urbanization rates from 1970 to 2000: from 12% to 76%! This is reflected in the difference between the agricultural growth rate (a rather high 6.8% p.a. from 1975 to 1996) and the total municipal GDP (7.8% p.a. during the same period), which indicates a marked growth of urban activities. Actually, the rural population grew 1.11% p.a., suggesting expressive productivity gains in the rural areas.

Petrolina is exactly the opposite case: a demographically mature region, where the level of urbanization changed very little from 1970 to 2000 (in fact, it decreased from 83% to 76%). In absolute terms, however, there was an increase in the number of people employed in agriculture, from 7,600 to 52,200 individuals, which means an average annual rate of 6.63%. Since the GDP growth rate for the primary sector was 13% p.a., the productivity gains have also been expressive.

That was certainly the case of Conceição do Araguaia, Redenção and Marabá — except precisely the opposite of Petrolina. The level of urbanization increased significantly during the three decades, from 43% to 77%. Although urban activities expanded, as seen previously, the agricultural GDP increased an incredible 13.9% p.a. from 1975 to 1996. It is quite remarkable, undoubtedly, since the average growth of the rural population in the municipality was only 2.08 % p.a. from 1970 to 2000.

There are only two cases of decreased urbanization: Petrolina, which was already mentioned and, coincidentally, Juazeiro. In both municipalities urbanization was already intense in 1970 (in Juazeiro the level of urbanization was almost 94% that year). Nevertheless, please note — and this is particularly important — that although the level of urbanization decreased, the rural population increased substantially in both municipalities. In Juazeiro, it went from 2,400 to 41,300 from 1970 to 2000; in Petrolina it expanded from 7,600 to 52,200 during the same period.

Other municipalities with high levels of urbanization in 1970 have distinct characteristics. The level of urbanization of the Uberaba and Uberlândia region, for example, was 91% in 1970 and 97% in 2000. Their rural population was about the same in both dates, making this a case of rather mature development already in 1970.

A similar process occurred in Londrina and Maringá, where the level of urbanization increased from 88% in 1970 to almost 98% in 2000, while the rural population actually diminished during the period, from 27,000 to 18,000. Like cases are Passo Fundo, where the rural population remained stable during the period and the level of urbanization is almost 100%, and the southeast region of the State of Rio Grande do Sul, to a lesser extent, where urbanization increased slightly, but the rural population decreased between the extreme years of the study.

From the point of view of rural population growth, the picture is rather varied, although the rural population has shrunk in the long term, in most cases. The leading example is the Irecê region, where the average annual rate of decrease in 30 years was 4.9% p.a.! The second place belongs to the municipalities in the Barreto region, in the State of São Paulo (- 3.29% p.a.); the Rio Verde region in Goiás (- 2.17%) occupies the third place; Rondonópolis in Mato Grosso (- 1.7%) is in fourth place; Londrina and Maringá in Paraná (- 1.34%) hold the fifth place; southern Piauí (-1,24%) holds the sixth position; and Lábrea in Amazonas (- 1.15%) comes in seventh and last. In several cases, there are rural population decrease rates under 1% p.a.: Balsas and Riachão (-0.89%); southeast Rio Grande do Sul (-0.83%); Paracatu, Patrocínio and Patos de Minas (-0.36%); the Jaíba Valley

(-0.31%); the Açu Mossoró cluster (-0.27%); Fraiburgo and São Joaquim (-0.15%); and Uberaba-Uberlândia (-0.13%).

The nine remaining cases show a positive annual growth rate for the rural population. The leader in this category was the Juazeiro MCA (9.92%), followed by Petrolina (6.63%); Bento Gonçalves, Caxias and Santana do Livramento (3.95%); Dourados (3.37%); Conceição do Araguaia, Marabá and Redenção (2.08%); Barreiras (1.25%); Paragominas (1.11%); Chapecó (0.96%); and Passo Fundo (only 0.0028%. i.e., virtually constant).

1.4.3 Productivity Growth in Agriculture: An Approximation

It is tempting to associate annual relative variations in the rural population of the municipalities (1970-2000 average) with the respective actual growth of agriculture (1975-1996 average), in order to obtain -— even under the guise of an imprecise measurement — an approximation of the productivity gains of the primary sector for the sets of municipalities selected. To that end, it is assumed that the annual average relative variations in employment in agriculture from 1975 to 1996 will follow the average relative variations in the rural population from 1970 to 2000 [22].

If this approximation is accepted, the following results are achieved. Please observe that there were productivity gains for labor in all cases.

(i) The leading outcome was Barreiras' (BA), with an incredible 18.9 % annual productivity gain.

(ii) The second place belongs to the Conceição do Araguaia, Marabá and Redenção region in Pará, with an average annual growth of 11.6%.

(iii) Barretos (SP) comes third, with 10.7%, followed closely by Irecê (BA), with 9.9%; the southern region of Piauí, with 9.6%; Balsas and Riachão (MA), with 9.5% p.a.; Fraiburgo and

[22] Once the differences for the period are left out - less relevant, in fact, than imagined, since we work with annual averages for a long-term period - the approximation adopted implies assuming that the proportion of the rural population employed in agriculture was the same in the extreme years of the time interval. This assumption does not seem completely absurd. It is obvious, however, that the technological changes during the period might have modified the technical coefficients.

São Joaquim (SC), with 8.9%; Rio Verde (GO), with 8.3%; and Rondonópolis (MS), with 7.4% p.a.

(iv) The fourth place is taken by Paracatú, Patrocínio and Patos de Minas (MG), with an average of 6.8%; Lábrea (AM), 6.7%; Petrolina (PE), 6.2%; Paragominas (PA), 5.7% p.a.; Uberaba-Uberlândia (MG), 5.5% p.a.; and the Açu-Mossoró cluster in Rio Grande do Norte, 5%.

(v) A fifth group is made up by Vale do Jaíba (MG), with 3.4% p.a.; Passo Fundo (RS), 3.2% p.a.; southeast Rio Grande do Sul (RS) and Chapecó (SC), both with 2.8% p.a.; Juazeiro (BA), 2.1% p.a.; and Londrina and Maringá (PR), with an average of 1.6% p.a., from 1975 to 1996.

(vi) Trailing behind are Dourados (MS), with 0.9% p.a. and Bento Gonçalves, Caxias and Santana do Livramento (RS), with 0.4% estimated average annual increase in labor productivity from 1975 to 1996.

The important finding is that the regions with the highest productivity gains were those whose agriculture was modernized or whose development occurred more recently, such as Barreiras, Conceição, Marabá and Redenção, Irecê, southern Piauí, Balsa and Riachão, Fraiburgo and São Joaquim, and Rio Verde and Rondonópolis.

It is surprising, however, to find Barretos among the regions with highest productivity gains. Barretos was developed longer ago, and its urbanization rate was already almost 75% at the beginning of the 1970s, having reached 94% in 2000. Barreiras' success is probably due to the development of cattle ranching in the region. It is fantastic, nevertheless, to find an estimated productivity growth of almost 11% p.a. in a region the size of Barretos, whose population was 200,000 in 2000. The strong technological change in the region explains the phenomenon, as previously suggested.

Lagging behind in agricultural productivity growth are the areas developed longer ago, whose urbanization rates increased in recent years, located in the wealthier states. This category includes the southern part of Rio Grande do Sul; Chapecó (SC); Juazeiro; (BA) Londrina and Maringá (PR); Dourados and Bento Gonçalves, Caxias and Santana do Livramento (RS). All these regions had a high level of urbanization in 2000, with the exception of Juazeiro, where this coefficient is 0.76.

What makes Juazeiro different from the other laggards is that the average annual growth rate of the rural population in this region was extremely high from 1970 to 2000, namely, an 9.92%. Furthermore, the agricultural revenue also increased at very high rates: an average of 12.18% p.a. during a 21-year period! This suggests that the adoption of new activities came together with a very large increase in manpower, unprecedented in the regions selected for analysis in this study, representing the use of labor intensive systems.

Not coincidentally, the other case of substantial increase of the rural population was Petrolina (an average of 6.63% p.a.). Like in Juazeiro, the agricultural revenue in Petrolina increased tremendously during the period, namely, an incredible 13.27% p.a. it is not easy to explain, however, why productivity grew so much in Petrolina (more than 6% p.a.) and so relatively little in Juazeiro (2% p.a.).

1.4.4 The Agricultural Income to Economic Growth Relationship or Link Revisited

The objective of this subsection is to analyze the growth of the selected geo-economic areas according to a model similar to that shown in Section 3 in the analysis of the states and using the same implicit dynamics, e.i., the agricultural revenue income growth determines the income growth the other sectors of the economy, as well as the demographic dynamics and well-being of the population, the latter represented by a standard of living index. The following formula sums up the initial results.

Please note that the introduction of dummy variables for a small set of municipalities in selected years reflects some aspects already discussed in previous subsections. In the case of Lábrea and southern Piauí, the variable was introduced because the results of the 1996 estimates for the agricultural revenue of those sets of municipalities seem to overestimate what effectively occurred that year, when compared with the 1975-1985 period. This was confirmed by the statistical analysis.

In the case of Petrolina and Barreiras — regions with huge growth in agricultural income — the opposite happens: the municipal agricultural GDP is consistently higher that the norm for the other municipalities in the end years. Londrina and Maringá share the same characteristic in some years. It could be indication of an average agricultural productivity higher than that of the other municipalities. In essence, however, it means that for a given agricultural income level the non-agricultural income level is consistently higher than the standard prevalent in the other [23].

The most important point of this analysis is that the elasticity of the non-agricultural income with respect to the agricultural income is higher than one. In other words, for every 1% increase in the agricultural revenue there is a 1.07% increase in the non-agricultural revenue — although it is impossible to reject the hypothesis at the 95% level of confidence that the elasticity will equal one. Indeed, the same regression, adjusted without the dummy variables, produces an estimate of one, with a value of the Student-t statistic equal to 14 (highly significant, therefore).

log(YnonAGRO) = f(log[YAGRO, dummies)]

Regression Statistics								
R multiple	0.9000							
R-Square	0.8100							
R-Square adjusted	0.8035							
Stand. Error	0.6956							
Observations	92							
	gl	SQ	MQ	F	Sig. F.			
Regression	3	181.53	60.51	125.06	0.00			
Residue	88	42.58	0.48					
Total	91	224.10						
	Coefficient	Stand. Error	Stat t	value-P	95% infer.	95% sup.	Inf. 95,0%	Sup. 95,0%
Intersectio	0.891	0.268	3.323	0.001	0.358	1.424	0.358	1.424
log(YAGRO)	1.076	0.060	17.976	0.000	0.957	1.195	0.957	1.195
DLabrea So. Piauí 1996	-1.766	0.505	-3.494	0.001	-2.771	-0.761	-2.771	-0.761
DPetrolBarreirasLondrina	1.873	0.245	7.657	0.000	1.387	2.359	1.387	2.359

The results of the analysis at the state level discussed in the previous section are, thus, confirmed: the expansion of agriculture is closely linked to that of the other sectors of the economy. However, we suggest that there is an order of precedence. In this interpretation, the growth of agriculture comes before (and determines) the growth of industry and services — and, therefore, that of the municipal GDP as a whole. Only where

[23] There is another possibility. The method for constructing the municipal GDP estimates by sector could be supplying biased results for 1996, increasing the growth of Barreiras and Petrolina out of proportion. It is generally known that agriculture in Londrina and Maringá has been a well-established and highly productive activity for many years.

state intervention was especially favorable to urban activities is this phenomenon absent.

Following the same pattern, the population dynamics is also determined by the expansion of agriculture. The correlation coefficient between agricultural revenue and urbanization rate is positive (0.43), which indicates that increases in the primary sector revenue are translated into higher productivity and structural change that favor the growth of urban activities and, consequently, into increased urbanization.

Please observe, however, that the association of non-agricultural revenue with the urbanization rate is slightly stronger: 0.49. The natural conclusions are that the expansion of agriculture is associated with the non-agricultural revenue and that both are closely linked to the population dynamics and urbanization processes in the manner of the classical development models. As expected, however, non-agricultural income is much more strongly associated with urbanization than the revenue of the agricultural sector.

Another important aspect in the study is that the strongest statistical relation takes place between the expansion of agriculture and improved living standards for the population, a point discussed in the next section. Before going into that discussion, however, we analyze the impact of the agricultural expansion on tax revenues at the municipal level.

1.4.5 Agricultural Growth and Tax Revenues

One of the most important aspects of economic growth in a given region is, as previously suggested, the multiplier effect of the expansion of the agricultural income on other activities. Our analysis strongly suggests that there is an order of precedence, which is also indicated by the terms characterizing the sectors of the economy: primary, secondary and tertiary. Nevertheless, there are other aspects equally noteworthy in the context of this study. One of them is the expansion of tax revenues that accompanies the development of regions and territories.

In the present case, it is possible to check a relevant hypothesis associating revenue with tax revenues by using information about the current revenues of the municipalities, which include taxes collected at the municipal level as well as state and federal government transfers to the municipalities during the 1985-1996 period[24]. The working hypothesis asserts that the expansion of agricultural activities determines the municipal revenues. This is a strong statement, since it implies a link to the revenues generated in the other sectors of the economy. Or, in other words, there is a sequence such that the growth of the agricultural sector determines the growth of the other sectors of the economy, all of which leads to increased municipal revenues, according to the following regression equation[25]. Please note that the formula was adjusted in logarithmic form. Thus, the interpretation of the angular coefficient is equivalent to an elasticity of the current municipal revenues in relation to the agricultural revenue.

The adjustment can be considered good in this type of analysis since the determination coefficient was 0.57. The estimated elasticity is 0.67: that a 1% increase in the agricultural income "generates" an additional 0.67% revenue for the municipality.

It is a surprising result, to a certain extent, because most of the current revenues of the municipalities come from transfers from the states and the federal government. Since the latter follow prorating criteria that favor proportionally more the poorer municipalities as regards income, it is surprising to find a significant positive association between the current tax revenues and the agricultural income (see regression statistics in next page).

For the same reason, it is even more surprising to find an association stronger than that reported above for the relation between tax revenues and non-agricultural income, which can be associated with the urban revenue, as seen above. The results for the adjusted euqaiton are shown below. Please note that the

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[24] Unfortunately, it was not possible to obtain tax information for previous years.

[25] I would like to thank Fernando Blanco for his kindness in supplying basic information for this part of the analysis. The information supplied was already duly tabulated by municipality, as well as analyzed and deflated using the Getúlio Vargas Foundation's IGP-DI index. The Current Revenue, which is the dependent variable in the formulas, corresponds to the sum of the Tax Revenues and State and Union Transfers to the municipalities.

Current Revenues = f[log (YAGRO)]

Regression Statistics	
R multiple	0.7644
R-Square	0.5843
R-Square adjusted	0.5748
Stand. Error	0.7962
Observations	46

	gl	SQ	MQ	F	Significance F	
Regression	1	39.194	39.194	61.833	0.000	
Residue	44	27.890	0.634			
Total	45	67.084				
	Coefficient	Stand. Error	Stat t	P value	95% inferior	95% superior
Intersection	14.183	0.373	38.065	0.000	13.432	14.934
log (YAGRO)	0.673	0.086	7.863	0.000	0.500	0.845

adjustment is better now than in the previous case, since R-Square equals 0.72. Nevertheless, although the elasticity is more precisely estimated (as seen in the value of the respective t statistic, in comparison to that of the previous formula), it is slightly lower that the result obtained when estimated as a function of agricultural income: 0.62.

Current Revenues = f[log (YÑAGRO)]

Regression Statistics	
R multiple	0.8512
R-Square	0.7245
R-Square adjusted	0.7182
Standard Error	0.6481
Observations	46

	gl	SQ	MQ	F	Significance F	
Regression	1	48.603	48.603	115.708	0.000	
Residue	44	18.482	0.420			
Total	45	67.084				
	Coefficient	Standard Error	Stat t	P-value	95% inferior	95% superior
Intersection	13.608	0.326	41.709	0.000	12.951	14.266
log (YÑAGRO)	0.621	0.058	10.757	0.000	0.505	0.738

The conclusion is that both agricultural and urban income have a positive impact on the municipal revenue. But the statistical association seems to be stronger in the case of non-agricultural income.

1.5 Living standards index (LSI) at the municipal level and agricultural growth

In the last few years the United Nations has been calculating a population development indicator (HDI — Human Development Index) which can be used to represent social inclusion. In 1998 UNDP, IPEA, FJP, and IBGE published a specific research report on Brazil [26] in which a Living Standards Index was introduced, in addition to the traditional HDI indicator, for all municipalities in the country. These indexes – HDI and LSI – were constructed from Demographic and Economic Census data based on economic, demographic and social variables. They are an invaluable source for identifying the level of improvement in the economic and social conditions of the population — and, consequently, social inclusion. The beginning of this section focuses on the methodology and main features of these indexes. The methodological aspects of the various dimensions analyzed by the indexes are shown in the Appendix[27].

1.5.1 Methodological Aspects: HDI and LSI

The **Human Development Index** (HDI) was created by the United Nations in the early 1990s and has been calculated annually for various countries. The HDI served as empirical base for the Human Development Reports monitoring world development in the 1990s. The HDI is usually and regularly calculated for various countries. In the previously mentioned report, the HDI was also calculated for the Units of the Federation (UF). In order to calculate the HDI for the municipalities it was necessary to resort to methodological adaptations, some of which are shown in the Appendix. The HDI is calculated as a simple average of indicators referring to three dimensions of human development, namely, **Income, Education** and **Longevity.**

The **Living Standards Index** (LSI), on the other hand, was developed using the same basic methodology used to build the HDI. The wider scope of the Living Standards Index makes it more appropriate for the purpose of this study. The LSI incorporates more socio-economic performance indicators than

[26] **Desenvolvimento Humano e Condições de Vida: Indicadores Brasileiros.** PNUD/IPEA/FJP/IBGE. Brasília, Setembro de 1998.

[27] The following paragraphs were extracted from the Appendixes of the previously cited report on **Desenvolvimento Humano e Condições de Vida: Indicadores Brasileiros** (Human Development and Living Standards: Brazilian Indicators) and subsequently summed up. Readers not interested in methodological aspects can move on directly to the following section without fearing loss of contents.

the HDI in order to capture the development and social inclusion process in the most comprehensive manner possible. This is achieved by broadening the range of indicators that make up **Income, Education** and **Longevity** and introducing two additional dimensions that picture the status of **Children** and **Housing**.

A three-tier methodology is used to develop both the HDI and the LSI. The first step is to select the indicators and define how they will be divided among the dimensions. The HDI is based on four indicators grouped in three dimensions (Income, Education and Longevity), while the LSI includes 18 indicators distributed among five dimensions (Children and Housing, in addition to those of the HDI).

During the second stage, the various indicators are transformed into indexes whose values vary from **zero** to **one**, the higher values indicating better living standards. In order to obtain an index with these characteristics starting from an indicator, it is necessary (i) to select the worst and best possible values for the indicator (these values can represent either the theoretical limits for the indicator or the interval of variation in which it is expected to fall for all practical effects) and (ii) to obtain the index using the following formula, on the basis of the value observed for the indicator and the established interval limits.

$$\textbf{index} = \frac{\textbf{(value observed for the indicator - worst value)}}{\textbf{(best value - worst value)}}$$

This formula guarantees that the index will always remain between **zero** and **one**, at least while the value observed by the indicator continues within the limits established. Thus, the closer the observed value comes to the limit value the closer the index will be to **one** (best situation). In the opposite situation, when the value observed falls closer to the worst value, the index will come closer to **zero** (worst situation).

The third stage involves the selection of the weigh to be attributed to each indicator. Within each dimension, a weigh is chosen for each indicator in the dimension. On the basis of these weighs, a synthetic index is obtained for each dimension. Next, a weigh is selected for each synthetic index of each dimension and, on the basis of those weighs, the general synthetic index is put together.

1.5.2 Growth of Agriculture and Improved Living Standards: the Social Inclusion Process

As seen before, the non-agricultural income is closely associated with the agricultural income through a process to which we attributed causality by the fact that the economic activities typical of the primary sector precede urban activities in time and space. According to our hypothesis, this dynamics, whose impact on the expansion of the population in selected geo-economic areas was discussed in the previous sections, spreads to the living conditions of the population or, in other words, is reflected in the social inclusion process.

Actually, the simple methodological characterization of the Living Standards Indexes (LSI), above, made clear that these indicators are closely associated not only with improved quality of life for the economically geo-referenced populations, but also with social inclusion. Better education with more years of schooling, higher *per capita* family income, increased life expectancy at birth, improved health and housing standards at the municipal level are each and all of them representatives of important aspects of social inclusion and citizenship rights.

To that end, the statistical model must be sufficiently simple and robust to express the relevant relations. Before introducing the statistical model, however, it would be appropriate to illustrate the comparative magnitudes of the LSIs — or social inclusion indicators — by set of municipalities. The table 3 shows these indicators in 1970 and 1991 for the selected municipalities[28].

I can be immediately noted that the living standards in all the selected regions and municipalities improved substantially. In the United Nations classification, for example, LSI under 0.5 is characterized as low human development/living standards. From 0.5 to 0.8 medium human development prevails. SLI above 0.8 means high human development. According to this criterion, low living standards prevailed in 14 municipalities (or sets of

[28] The non-availability of the LSI for 2000 — soon to be available on the basis of Demographic Census data for that year still being tabulated – forced us to include the results for the period 1991 to 1996 in our analysis. Likewise, the LSI for 1970 is being included into the municipal income data for 1975. At least, the time intervals being considered are equal, namely, 21 years.

municipalities) in 1970, while nine had medium and none had high living standards. In 1991 the picture was completely different: only four municipalities had low living standards, 16 fell in the intermediate category and three had high living standards.

Table 3. Living standards indexes - LSIs 1970 and 1991 for selected municipalities.

State	Municipality	LSI 70	LSI 91
Amazonas	Lábre	0.28	0.41
Pará	Conceição do Araguaia Marabá	0.36	0.57
Pará	Paragomin	0.32	0.52
Maranhão	Balsas +	0.31	0.49
Piauí	Sul do	0.29	0.46
RN	Polo Açu	0.31	0.56
PE	MCA Petrolina	0.43	0.63
Bahia	Barreira	0.39	0.60
Bahia	MCA Irecê	0.39	0.55
Bahia	MCA Juazeiro	0.48	0.58
MG	Jaíba Valley	0.37	0.49
MG	Uberaba+Uberlândia	0.61	0.81
MG	Paracatu+Patrocínio+Patos	0.52	0.74
SP	Barretos	0.57	0.78
Paraná	Londrina + Maringá	0.60	0.80
SC	MCA Chapecó	0.55	0.75
SC	Fraiburgo + São Joaquim	0.50	0.73
RS	Sum Southeast RS	0.43	0.62
RS	Bento Gonçalves Caxias	0.66	0.81
RS	Paaso	0.63	0.78
MS	MCA Dourados	0.45	0.73
MT	Rondonópolis	0.44	0.78
Goiás	Rio Verde	0.50	0.71

The region with the highest LSI in 1970 was Passo Fundo (RS), with a 0.636 index. In 1991 Bento Gonçalves, Caxias do Sul and Santana do Livramento, also in Rio Grande do Sul, had the best index, namely, 0.815 [29]. But several regions had already reached an LSI above 0.6 at that time. Please note that the

[29] It is widely acknowledged that the highest HDI and LSI in Brazil are in Rio Grande do Sul. An exception among large municipalities is Niterói, in Rio de Janeiro, also characterized by very high indexes.

municipalities in the Açu-Mossoró cluster (RN) had the largest relative gains, followed by Rondonópolis (Mato Grosso). Paragominas (PA) and Dourados (MS) make up the second tier, having had LSI gains in excess of 60%. A third group had gains from 50% to 60%. This group is made up by Conceição do Araguaia, Marabá and Redenção (PA), Balsas and Riachão (MA), southern Piauí, and Barreiras (BA). The lowest relative gains obviously occurred in regions where the LSI was already high in 1970, the Rio Grande do Sul mountain region (Bento Gonçalves, etc.) being a true representative of this situation. There are two exceptions, however, the Jaíba Valley in Minas Gerais and Irecê in Bahia, where the low LSIs in 1970 increased relatively little during the period up to 1991.

Another way of examining this issue is through absolute gains in LSI. The leading example, in this case, is Rondonópolis (+0.342), followed by Dourados; the Açu-Mossoró cluster; Fraiburgo and São Joaquim; and Paracatu, Patrocínio and Patos de Minas. The worst performances occurred in Juazeiro, the Jaíba Valley, Irecê, southern Piauí, and the Rio Grande do Sul municipalities. The latter, contrary to the other municipalities, because they already had high living standards in 1970.

In the statistical analysis, the first point worthy of notice is that the association of the agricultural income with the Living Standards Index (LSI) is sufficiently strong for a cross section type of analysis. The regression equation for the living standards index and agricultural income is shown below in semi-logarithmic form. The relation is very robust, as shown by the regression coefficients and adjusted equation statistics.

LSI = f[log(YAGRO)]

Regression Statistics						
R multiple	0.7819					
R-Square	0.6114					
R-Square adjusted	0.6025					
Standard Error	0.0979					
Observations	46					
	gl	SQ	MQ	F	Significance F	
Regression	1	0.66396	0.66396	69.215862	1.40858E-10	
Residue	44	0.4220744	0.00959			
Total	45	1.0860344				
	Coefficient	Stand. Error	Stat t	P-value	95% inferior	95% superior
Intersection	0.1925	0.0458	4.1989	0.0001	0.1001	0.2849
log(YAGRO)	0.0876	0.0105	8.3196	0.0000	0.0664	0.1088

Nevertheless, it is appropriate to question whether the same does not occur with regard to the (revenues of) other sectors, i.e., is the association between income and living standards also true for the other sectors of the economy? Intuition says yes. The answer is found in the following adjusted regression equation, in which the LSI was regressed against the income logarithms of all economic sectors, with the exception of agriculture.

LSI = f(LOGYNAGRO)

Regression Statistics	
R multiple	0.7639
R-Square	0.5835
R-square adjusted	0.5740
Standard Error	0.1014
Observations	46

	gl	SQ	MQ	F	Significance F	
Regression	1	0.633670	0.6336701	61.635035	6.61321E-10	
Residue	44	0.452364	0.010281			
Total	45	1.086034				
	Coefficient	Stand. Error	Stat t	P value	95%	95%
Intersection	0.1712	0.0510	3.3546	0.0016	0.0684	0.2741
log(YNAGRO)	0.0709	0.0090	7.8508	0.0000	0.0527	0.0891

The answer to the previous question is positive, according to the previous equation. In fact, the LSI is equally "explained" by the non-agricultural income. Please note, however, that the adjustment is not quite as good as in the previous case, from the point of view of both the value of the correlation coefficient (0.57, as against 0.60) and the statistic t of the estimated revenue coefficient (7.8, as opposed to 8.3). We conclude that living conditions are positively and significantly affected income generated in both the agricultural and in the non-agricultural sectors.

It is possible to go further in the analysis of the interrelations between social inclusion, growth of the agricultural and non-agricultural income and the demographic variables (level of urbanization, for example) by stating a model in which these variables determine the living standards, as follows:

ICV = f[log(YAGRO), Urbanization]

Regression Statistics	
R multiple	0.8702568
R-Square	0.7573468
R-Square adjusted	0.7460606
Stand. Error	0.0782854
Observations	46

	gl	SQ	MQ	F	Significance F
Regression	2	0.82250	0.41125	67.10383	0.00000
Residue	43	0.26353	0.00613		
Total	45	1.08603			

	Coefficient	Error	Stat t	P-value	95%	95%
Intersection	0.1175	0.0395	2.9751	0.0048	0.0379	0.1971
log(YAGRO)	0.0503	0.0112	4.5048	0.0001	0.0278	0.0728
Urbanization Level	0.3262	0.0641	5.0862	0.0000	0.1968	0.4555

The equation above is more robust than the previous ones. It suggests that both agricultural income and the level of urbanization are important determinants of social inclusion in the geo-economic areas considered in the research.

1.6 Conclusion

In the last three decades Brazilian agriculture underwent profound and significant changes[30]. The adoption of new technologies, products and processes has played an essential role for achieving these outcomes. Ongoing processes have led to successive record performances year after year. As in the other sectors of the economy, however, the performance of the agricultural sector reflects the impacts of the overall economic

[30] In a recent paper for the cropping sector covering the 1975-1996 period, we estimated that labor productivity increased almost 3.6% per year in this sector, while average land productivity grew 2.7% *per annum*. Input (fertilizers, pesticides, etc.) productivity, on the other hand, remained practically unaltered between the extreme years (1975 and 1996), while capital productivity had also remained practically constant from 1976 to 1996, after a substantial drop in 1976. See R. Bonelli and R. Fonseca, "Ganhos de Produtividade e de Eficiência: Novos Resultados para a Economia Brasileira" (Productivity and Efficiency Gains: New Results for the Brazilian Economy), in Pesquisa e Planejamento Econômico, v. 28, n. 2 (August 1998). IPEA, Rio de Janeiro.

policy [31]. In agriculture, as opposed to urban activities, the very diffuse nature of the achievements and outcomes throughout the country makes them less visible and harder to assess by the other economic agents.

To that end, the objective of the research was to evaluate, from the quantitative standpoint, the long-term impact of agricultural development over income generation, population growth, tax revenues, and human development in selected geo-economic areas. The main focus was the social inclusion process that hopefully accompanies the economic and social development associated with agriculture in developing geo-economic areas.

The basic assumption of the analysis — that agricultural expansion determines the economic and demographic dynamics and, consequently, the quality of life in homogeneous economic areas — was confirmed at different points of this extensive study. We associated the intensity of the social inclusion process with the magnitude of changes in indexes representing human and social development through time.

The quantitative analysis was based on a new database especially constructed for the study. Its starting point were pioneering state estimates of the real output growth of the agricultural, industrial and services sectors of the economy. These state estimates enabled the author to obtain a subproduct of immediate interest for the remainder of the study, i.e., the results of the statistical model constructed to explain the level of non-agricultural income as a functión of agricultural income were

[31] S. M. Helfand and G. C. de Rezende examined, in a landmark paper, the impacts of policy reforms on the Brazilian agriculture during the 1990s. The four main aspects focused were (i) the importance of events outside the agricultural sector for the performance of the sector; (ii) policy changes involving much more than the mere opening of the economy (the deregulation of the markets, as well as farm loan and minimum price policies, played a decisive role); (iii) the impacts of the new policies on the input market and on productivity; (iv) the different stamp of the new policies on the sector, affecting regions, products, farm sizes, and sub-periods in a differentiated manner. See the authors' paper entitled "Brazilian Agriculture in the 1990s: Impacts of the Policy Reforms", Text for Discussion n.785, IPEA (April 2001). See also Minister Paulo Haddad's work published in ***A Competitividade do Agronegócio e o Desenvolvimento Regional no Brasil— Estudos de Clusters*** (organized by Paulo R. Haddad), CNPq/EMBRAPA, Brasília, (1999): Chapter 2 "The Impact of Government Plans on the Brazilian Agroindustry" and Chapter 3, "An Analysis of the Impact of Macro-economic Policies on the Brazilian Agroindustry".

quite robust. They imply, at the level of the Units of the Federation and for the 1975-96 period, that the income of the other sectors was closely associated with that of the agricultural sector. Since the latter antecedes the former both conceptually and along time, we concluded that non-agricultural income is determined by the agricultural income in a practically identical relative proportion, i.e., a 1% increase in agricultural income causes an approximately equal variation in the income of the other sectors. It is a strong result, and it guided the remainder of the study.

The next step consisted of exploring the municipal database, including sets of municipalities with similar characteristics, keeping in mind the purpose of the research. The first interesting conclusion was that the 23 municipalities (or sets of municipalities) selected revealed an extremely rich and varied picture, as regards the growth of the economic sectors being studied. As seen, full use was made of the regional diversity.

Indeed, with very few exceptions, the selected areas experienced very marked overall economic and agricultural growth. This was particularly true in the case of areas more recently farmed and developed, albeit not to the exclusion of other areas. The best, actual, agricultural product gains occurred in Barreiras (BA), the Conceição do Araguaia, Marabá and Redenção (PA) group of municipalities and, not coincidentally, Petrolina (PE) and Juazeiro (BA). The only set of municipalities in which the growth of the actual product was relatively disappointing was Londrina and Maringá (PR), which were developed much longer ago and were structurally mature at the beginning of the period being studied.

A close examination of the demographic dynamics, closely associated with urbanization, added new ingredients to the analysis [32]. As expected, new areas underwent intense population growth. The leading, average population growth rate was Barreiras' (BA), where the total population increased at the very high average annual rate of 6.3% from 1970 to 2000, i.e., the population increased more than six-fold during the period. The second highest annual growth rates occurred in Chapecó (SC)

[32] For the population analysis we used the preliminary results of the Demographic Census for 1970 and 2000.

and Dourados (MS) with 5.7%, closely followed by Paragominas (PA, 5.6%); Petrolina (PE, 5.4%) and the region of Conceição do Araguaia, Marabá and Redenção (PA, 5.3%). The only case of diminished population was in the southeastern region of the State of Rio Grande do Sul. Even there, however, it was a small decrease — from 131,900 to 130,100.

From the point of view of rural population growth, the picture is rather varied, although long term population reductions prevail. In Irecê, for example, the average annual decrease rate for 30 years was 4.9%! The second place belongs to the municipalities in the Barretos area, in the State of São Paulo (- 3.29%), followed by the Rio Verde region (-2.17%) in third place, and Rondonópolis (-1.7%) in fourth place. Nine regions had a positive population growth rate, led by Juazeiro (9.92% p.a.), followed by Petrolina (6.63%), Bento Gonçalves, Caxias and Santana do Livramento (3.95%), and Dourados (3.37%).

We also suggested, in the approximate manner that the available data permit, that there were formidable gains in labor productivity in various cases, particularly taking into account the long period studied. The highest estimated productivity gain belongs to Barreiras (BA), with an incredible 18.9 % p.a., followed by Conceição do Araguaia, Marabá and Redenção (PA), whose annual average growth rate was 11.6%. It was also surprising to find the Barretos region (SP) in third place, with approximately 10.7% p.a., closely followed by Irecê (BA) with 9.9%; southern Piauí with 9.6%; Balsas and Riachão (MA) with 9.5% p.a.; Fraiburgo and São Joaquim (SC) with 8.9%; Rio Verde (GO) with 8.3%; and Rondonópolis (MS) with 7.4% p.a.

Next, we analyzed a model in which the agricultural income determines the income of the other sectors of the economy, the demographic dynamics and the well-being of the populations, represented by a quality of life index. The most important point of this analysis is that the elasticity of the non-agricultural income as regards the agricultural income was higher than one. In other words, every 1% increase in the agricultural income corresponded to a 1.07% increase in the non-agricultural income. This impact multiplier, therefore, seems to be higher for the selected regions than that obtained in the state analysis (0.93).

Thus, the hypothesis of the multiplying power of agricultural expansion over other economic activities was confirmed. Our analysis strongly suggested that there is an order of precedence — indicated, in fact, by the expression characterizing the three sectors of the economy, i.e., primary, secondary and tertiary — in which the agricultural income antecedes and causes urban income.

There are other equally remarkable aspects that should be emphasized in the context of the study, including the tax revenues that accompany the development of regions and territories. The results were eloquent in this regard, since not only the agricultural income but also the income of the remaining economic sectors have a significant influence on current municipal revenues. Furthermore, the link with the agricultural income seems to be stronger — albeit not much. This outcome was quite surprising, since it is well known that most of the municipalities' current revenues are made up of transfers from the state and federal governments and these transfers are usually inversely proportional to the municipality's *per capita* income.

In order to represent the social inclusion process, we adopted the LSI (Living Standards Index) measurement for the 1970-1991 period. The tabulations showed that Passo Fundo (RS) had the highest LSI in 1970, namely, 0.636, while in 1991 the region with the best standard of living was Bento Gonçalves, Caxias do Sul and Santana do Livramento, also in Rio Grande do Sul, whose index was 0.815. The largest relative gains from 1970 to 1991 occurred in the municipalities of the Açu-Mossoró cluster (RN), followed by Rondonópolis (Mato Grosso). A second group is constituted by Paragominas (PA) and Dourados (MS), whose LSI gains were in excess of 60%. The third group, which had gains from 50% to 60%, is made up by Conceição do Araguaia, Marabá and Redenção (PA), Balsas and Riachão (MA), Sul do Piauí, and Barreiras (BA). The lowest relative gains were obviously those of the regions with high LSIs already in 1970. The mountain region in Rio Grande do Sul (Bento Gonçalves, etc.) is representative of the latter situation. Nevertheless, there are two exceptions: the Jaíba valley (MG) and Irecê (BA), where the LSIs were low in 1970 and increased relatively little during the period being studied.

As regards the impact of agricultural growth on social inclusion, the results were also positive. We showed that there is a strong association between the level of the agricultural income and the LSI in both years analyzed. As expected, this association also exists with the non-agricultural income, since our hypothesis relates the incomes of both sectors with each other.

A more complete model, in which the Living Standards Index is explained by the municipal agricultural income and the level of urbanization, respectively, showed better and more robust results: three-fourths of the intermunicipal LSI variance can be attributed to the joint influence of these two variables, one representing the economic domain (agricultural income) and the other the demographic domain (level of urbanization).

Appendix

(to Chapter 1)

Table 1. State Value Added Indexes (Actual) at Basic Prices — Industry, 1985-1996.

States	Indexes 1985-96 (1985=1.0)				Mean Weighs 1985-96 (%)				Sum	Index
	Extractive	Transformation	SIUP	Construction	Extractive	Transformation	SIUP	Construction	Industrial Weighs	1996 1985=1.00
RONDÔNIA	1.5479	0.8377	3.011	1.8934	2.97	12.31	0.81	12.96	29.05	1.4419
ACRE	0	2.1156	2.5	1.617	0	8.58	1.23	8.955	18.765	1.9029
AMAZONAS	2.1242	3.7535	2.1228	1.271	3.21	45.445	4.35	6.705	59.71	3.2683
RORAIMA	0	1.7482	3.0154	1.6422	0	2.54	3.62	10.265	16.425	1.9612
PARÁ	3.3275	1.1798	5.454	1.4948	3.75	13.7	1.19	11.56	30.2	1.7355
AMAPÁ	1.0154	1.8513	2.7795	1.705	8.845	4.52	0.935	3.515	17.815	1.4561
TOCANTINS	0	1.8901	2.511	1.0673	0	6.02	0.395	0.0085	6.4235	1.9272
MARANHÃO	0	1.4584	2.9434	1.0239	0	11.76	1.445	5.625	18.83	1.4426
PIAUÍ	0	1.1828	2.2526	1.634	0	11.925	1.815	8.67	22.41	1.4440
CEARÁ	0.6129	1.47	2.0618	2.6113	3.28	17.025	1.66	11.985	33.95	1.8190
RIO G. NORTE	1.7641	1.93	2.5552	1.2753	19.195	13.63	1.71	11.305	45.84	1.7224
PARAÍBA	0	1.72	2.0273	1.4548	0	15.96	1.315	9.56	26.835	1.6406
PERNAMBUCO	2.7382	0.88	1.3247	1.1326	0.08	21.205	1.7	9.685	32.67	0.9826
ALAGOAS	0	1.343	1.5586	1.3564	0	18.825	1.6	8.52	28.945	1.3589
SERGIPE	1.2754	1.2754	1.666	0.9784	14.365	27.07	1.415	7.645	50.495	1.2414
BAHIA	0.7748	1.2223	0.9931	1.1007	3.955	22.505	3.545	8.245	38.25	1.1286
MINAS GERAIS	0.9234	1.2832	1.1871	1.5964	2.98	25.49	3.965	9.505	41.94	1.3195

Continue...

Table 1. Continuation

States	Indexes 1985-96 (1985=1.0)				Mean Weighs 1985-96 (%)				Sum	Index
	Extractive	Transformation	SIUP	Construction	Extractive	Transformation	SIUP	Construction	Industrial Weighs	1996 1985=1.00
ESPÍRITO SANTO	1.0375	1.42	1.6654	1.631	2.425	23.995	1.635	9.425	37.48	1.4590
RIO DE JANEIRO	1.6795	1.005	1.2628	1.153	8.635	18.75	5.27	7.28	39.935	1.2118
SÃO PAULO	1.0835	1.0713	1.7953	1.2868	0.025	38.26	3.02	6.22	47.525	1.1455
PARANÁ	0.3742	1.3686	4.35	1.608	0.06	24.17	3.595	9.48	37.305	1.7151
SANTA CATARINA	0.2051	1.46	1.6934	1.6258	0.73	38.38	1.395	5.33	45.835	1.4664
RIO GRANDE DO SUL	0.7912	1.155	1.5828	1.2436	0.18	32.515	1.87	4.25	38.815	1.1836
MATO GROSSO DO SUL	1.9939	1.754	1.9661	1.2266	0.295	9.62	1.28	8.745	19.94	1.5399
MATO GROSSO	0.6333	2.832	3.2492	1.5748	1.89	9.895	1.96	7.54	21.285	2.2298
GOIÁS	1.3	1.4285	1.9261	1.1784	0.775	13.675	1.655	10.5	26.605	1.3570
BRASÍLIA	1.2751	1.6941	1.8364	1.553	0.035	2.345	0.705	3.495	6.58	1.6322

Table 2. Relative Share of the States in the National Total 1975 and 1980 Agriculture and Industry.

	Agriculture		Industry	
	1975	1980	1975	1980
RONDÔNIA	0.00265	0.00491	0.00049	0.00241
ACRE	0.00237	0.00289	0.00013	0.00067
AMAZONAS	0.01022	0.00937	0.00672	0.01446
RORAIMA	0.00090	0.00077	0.00006	0.00017
PARÁ	0.02006	0.03058	0.00535	0.01313
AMAPÁ	0.00076	0.00108	0.00041	0.00080
TOCANTINS	0.00000	0.00694	0.00000	0.00069
MARANHÃO	0.02617	0.02620	0.00200	0.00447
PIAUÍ	0.00939	0.00839	0.00094	0.00193
CEARÁ	0.02273	0.02312	0.00771	0.01098
RIO G. NORTE	0.01024	0.00779	0.00422	0.00543
PARAÍBA	0.01636	0.01133	0.00448	0.00421
PERNAMBUCO	0.02831	0.02727	0.02220	0.02047
ALAGOAS	0.01442	0.01525	0.00368	0.00368
SERGIPE	0.00586	0.00661	0.00345	0.00274
BAHIA	0.06465	0.06895	0.02592	0.03954
MINAS GERAIS	0.12298	0.16349	0.06601	0.08927
ESPÍRITO SANTO	0.01758	0.02106	0.00673	0.01293
RIO DE JANEIRO	0.02238	0.01980	0.12988	0.11799
SÃO PAULO	0.15790	0.14250	0.55006	0.46971
PARANÁ	0.16901	0.11685	0.03979	0.04881
SANTA CATARINA	0.04984	0.05259	0.03319	0.04002
RIO GRANDE DO SUL	0.14256	0.12562	0.07526	0.07345
MATO GROSSO DO SUL	0.02444	0.04716	0.00211	0.00419
MATO GROSSO	0.00912	0.01421	0.00211	0.00304
GOIÁS	0.04858	0.04453	0.00122	0.01034
BRASÍLIA	0.00054	0.00075	0.00586	0.00451

METHODOLOGICAL APPENDIX[33]. Indicators used in the LSI, organized according to their dimensions: **Income, Education, Children, Housing** and **Longevity.**

Income

The universe includes only family members. It excludes dependents, domestic employees and relatives who live in private homes.

- *Per capita family income*: Ratio between the sum of the personal income of all individuals and the total number of these individuals.
- *Theil Index* – Measures inequality in the distribution of individuals according to the *per capita family income*. Individuals with no per capita income are excluded.
- *Proportion of poor* (P^0) – Proportion of individuals with *per capita family income* under half the minimum wage on 1st September 1991.
- *Mean Income Gap* (P^1) – Mean of the relative income gaps of all individuals, whether or not poor. The relative income gap for one poor individual is defined as the distance between that individual's income (*Y*) and the poverty line (*Z*) – ½ minimum wage – measured as a fraction of the poverty line $(Z-Y)/Z$. For non-poor individuals, the relative income gap is defined as null.
- *Mean Quadratic Income Gap* (P^2) – Mean of the squares of the income gaps of all poor and non-poor individuals. The quadratic income of a poor individual is defined as the square of the distance between that individual's income (*Y*) and the poverty line (*Z*) – ½ minimum wage – measured as a fraction of the poverty line $(Z-Y)/Z$. For non-poor individuals, the relative income gap is defined as null.

[33] Extracted from **Desenvolvimento Humano e Condições de Vida: Indicadores Brasileiros.** (Human Development and Living Standards) PNUD/IPEA/FJP/IBGE. Brasília, September 1998, Appendixes.

Education

Various indicators for the ***Education and Childhood*** dimensions were obtain from the concept of number of years of schooling. For each individual, this concept is defined as the number of school grades completed. It is obtained through the identification of the last grade attended and the school degree successfully obtained.

- *Average number of years of schooling* – ratio of the sum of the number of years of schooling for a population ^{3} 25 years old and the total number of individuals in that age bracket.
- *Percentage of the population with less than four years of schooling* – percentage of individuals ^{3} 25 years old with less than four years of schooling.
- *Percentage of the population with less than eight years of schooling* – percentage of individuals ^{3} 25 years old with less than eight years of schooling.
- *Percentage of the population with more than 11 years of* schooling – percentage of individuals ^{3} 25 years old with more than 11 years of schooling.
- *Rate of illiteracy* – percentage of individuals ^{3} 15 years old unable to read or write a simple note.

Children

In addition to the years of schooling concept, this dimension uses schooling lag. Schooling lag means the difference between the number of years recommended for a child, as a function of her age, and the number of years of schooling actually achieved by the child.

- *Mean schooling lag* – Ratio of the sum of the schooling lag of all children ages 10-14 and the total number of children in that age bracket.

- *Percentage of children with more than one year of schooling lag* – Percentage of children ages 10-14 with have more than one year of schooling lag.

- *Percentage of children not attending school* – Percentage of children ages 7-14 who do not attend school.
- *Percentage of children working* – Percentage of children ages 10-14 engaged in some economic activity in the previous twelve months.

Housing

For all four indicators of the housing standards considered, the research universe includes only the population of permanent private housing, excluding, therefore, individuals living in collective housing and in improvised private housing.

- *Percentage of the population living in housing whose density exceeds two individuals per bedroom*
- *Percentage of the population living in durable housing*
- *Percentage of the population living in housing with adequate water supply*
- *Percentage of the population living in housing with adequate sewage facilities*

Longevity

- *Life expectancy at birth*
- *Infant mortality rate* (IMR) – Probability of a child dying before one year of age, expressed per 1,000 live births.

2 Increases in productivity and exports: an exploratory analysis

Antônio Salazar P. Brandão[1]

2.1 Introduction

The Brazilian economy has undergone structural transformations induced, to a great extent, by the opening of the Brazilian market. The flexible exchange adopted in 1999 initially caused a substantial devaluation of the national currency, the real. Nevertheless, competitive pressures on the tradeable goods sector can be even more marked in the future in the face of a successful macroeconomic adjustment, which could attract large foreign investment capitals and lead to the appreciation of the national currency.

The modernization of the industrial sector in the last few years requires the other sectors producing tradeable goods to be sufficiently competitive to maintain their economic importance. In the case of agriculture, this loss could be expressed as reduced production and exports and increased imports.

The agricultural sector would also feel impacts similar to those noted in the previous paragraph in the event that countries competing with the domestic products in the internal market and with the products exported by Brazil to third markets substantially increased their productivity.

In other words, the Brazilian competitive advantages in the agricultural sector could be compromised were the structural reforms not be accompanied by adequate support in the creation

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of an economic environment favorable to investments in the sector. Because of the new, international trade rules, the government's space for maneuvers is ever more reduced.

One of the most effective public sector actions is supporting research, which is not only approved by the international organizations that oversee trade practices and policies, but also proven to be an investment with a high rate of return.

The impacts of productivity gains on selected, agricultural-sector performance indicators are shown in this paper. The analysis emphasizes the implications for the external sector, especially exports, since many analysts have argued that the currency devaluation of early 1999 did not have the expected impacts on total exports and, in particular, on agricultural exports. The growth of productivity in other sectors of the economy and in the countries that compete with Brazil is another important element of discussion and shall be considered in the following analysis.

The remainder of the document is organized as follows. Section 2 presents some data on the growth of productivity in Brazilian agriculture; section 3 introduces the model used to evaluate the impacts of the productivity gains on the performance of the agricultural sector; section 4 shows the outcomes of applying the model; and section 5 concludes the paper.

2.2 Exports and the growth of productivity

Brazil grew at relatively low rates during the 1980s. The growth rate reduction in agriculture, however, was less than in the economy as a whole. Nevertheless, the long-term growth rate of the agricultural sector GDP was lower than that of the whole GDP, thus reaffirming a characteristic trend of agricultural development throughout the world. The average growth rates are shown in table 1[2].

There is nothing extraordinary about the relatively smaller growth of agriculture. Its main cause is the existence of specific production factors, whose alternative value outside the agricultural

[2] See graphs and tables in the Appendix to this Chapter.

sector is null, maintaining, therefore, the supply of services practically unchanged even in low demand periods.

One of the most remarkable facts in the agricultural development of Brazil in recent years is the expressive growth in productivity observed in most of the main production areas. During most of the 1980s, growth was based on the expansion of the farmed area. Beginning in the late 1980s, productivity became the preponderant growth factor.

Graphs 1 to 3 make these facts self-evident. Graph 1 shows that the harvested area, after achieving a maximum value of almost 52 million hectares, stabilized at approximately 46 million hectares. Graph 2 shows that the average annual rate of growth for the farmed area[3] dropped steadily until the end of the period under issue, reaching 1.13% in the last year of the series.

Graph 3 shows a productivity index for land, which was built by dividing the value of production at 1994 prices by the farmed area[4]. The crops considered in building the index were Cotton, Rice, Cocoa, Coffee, Sugarcane, Beans, Orange, Cassava, Corn, Soybean, and Wheat. The graph shows that:

- until the end of the 1970s, the productivity of land remained below the 1973 level;
- there was a significant rise from 1980 to 1989, albeit with no clear growth trend;
- thereafter, productivity grew systematically, achieving a 176 index (1973 = 100).

Graph 4 shows that the average annual growth rates for the productivity of land[5] remained relatively stable during the whole 1990 decade, at about 2.4% p.a. In addition, the productivity growth rate was higher than the farmed-area growth

[3] It must be noted that these are average growth rates for periods beginning in 1973 and ending in the years shown on the graph.

[4] The production number is used in the numerator because we are adding the amounts of different products. The 1994 prices were selected arbitrarily, albeit trials using the prices for other years did not produce in very different results.

[5] It must be noted that these are average growth rates for periods beginning in 1973 and ending in the years shown on the graph.

rate during the 1990s, which indicates that the former has been the main source of the expansion of the agricultural production.

Graph 5, taken from Brandão (2000), shows the evolution of farmed area, production and yield for the main agricultural products in Brazil, as follows.

Rice. Production increased until 1989 and has dropped ever since. Nevertheless, it is still 30% above the 1973 level. To a great extent, this expansion is explained by the 73% productivity gain during the period[6], since the harvested area decreased by 25%.

Beans. Production growth was similar to that of rice, although the productivity gains were negligible (6.5% from 1973 to 1997). The main reason for the increased production was a 26.5% expansion in the farmed area. It must be noted, however, that yield grew more intensely beginning in the late 1980s. This period coincides with a more generalize use of irrigation in bean farming, irrigation also being responsible for a reduction in the production-per-hectare variability, as shown clearly in the graph.

Soybean. Soybean has had one of the most spectacular performances in Brazilian agriculture in the last decades. Production increased 430%, and both soybean farmed area and yield grew significantly. The most relevant factor was the expansion of the farmed area at an average annual growth rate of almost 5%. The average annual rate of growth for productivity (2.1%) should not be disregarded, since it occurred simultaneously with the expansion of the farmed area[7].

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[6] The average, annual productivity growth rate for the period was 2.3%.

[7] Rice productivity actually grew more than soybean's. Nevertheless, it must be noted that the more marked growth period was simultaneous with the contraction of the farmed area, indicating that the crop was seeking more appropriate soybean-farming regions.

Cassava. This crop's production, farmed area and yield are stagnant. During the period under consideration, these variables remained practically unchanged.

Wheat. The production of wheat had a marked cyclical behavior during the period. Until the beginning of the 1980s, production followed no well-defined trend, despite the occurrence of large variations. From 1984 to 1987 production increased significantly, followed by a downward cycle. During the period as a whole, the average growth rates for wheat production, farmed area and yield were 0.8%, -0.8% and 1.6%, respectively.

Corn. Corn is another success story. Production grew 144%, which corresponds to an average growth rate of 3.8% p.a. Most of the growth results from increased productivity, which grew at an average rate of 2.5% p.a.

Cotton. This crop has become ever less important in Brazil. Its production dropped by 60% and the farmed area, even more (85%). There has been a significant increase in productivity, an average 3.7% p.a. The fact that this growth has come hand-in-hand with a reduction in the farmed area shows the very dynamic nature of the technological changes being introduced in cotton farming. It must be noted, indeed, that the considerable expansion of cotton has been occurring in the center-west region of the country, where the farmed area increased almost three-fold from 1990 to 1998. During the same period, yield rose from approximately 1,500 kg/ha to 1,800 kg/ha.

Orange. This crop also had very significant development during the period at issue. Orange production grew by 366%, as a result of both the expansion of the orange groves and the rise in productivity, 117% and 114%, respectively.

Coffee. Coffee production increased at an average annual rate of 1.2%, mostly due to better yields. It is interesting to note that both production and productivity variability have decreased along the years. Until the late 1980s, data showed a clear cyclic pattern for both variables. Nevertheless, beginning in the 1990s variability diminished. The new pattern is linked to technological and organizational innovations in the sector, namely, the adoption of new coffee varieties, increased crop density and better time intervals in planting.

Cocoa. This traditional crop is produced basically in the State of Bahia. Cocoa plantations expanded by 74% during the period, while production grew 50%. Yield, however, had a different behavior. Until the late 1970s, yield increased by almost 60%, remained at relatively high levels until the mid-1980s, and has dropped sharply ever since. At the end of the period being studied, productivity was 15% lower than that of 1973. The reasons for this steady decrease are the spread of cocoa diseases and reduction of investments in modernization, as a function of the drop in the international prices.

Sugarcane. Production has increased at an average rate of 5.5% p.a., farmed area having grown by 3.9% p.a. and yield by 1.6% p.a. The latter increase occurred steadily along the period.

Graph 6 shows a (partial) index of the amount of agricultural products exported by Brazil. The products considered in this index were cotton, beans, soybean, soybean oil, soybean meal, coffee, orange juice, cocoa, and cocoa products. The unit values of exports (value divided into quantity) for 1994 were used to aggregate exported amount of the various products. In order to facilitate comparison with the productivity index, the 1973 index value is equal to 100. Graph 7 shows the average rates of growth for the index.

The graphs make clear that:

- exports have been growing since 1970 at an average rate of 3.13% p.a.;
- growth became more marked beginning in 1986; and
- the average annual rate of growth became more stable beginning in 1986 and has followed a rising trend since 1992.

During the 1990s, commercial policies in our country and those countries whose exports compete with ours have changed substantially. Nevertheless, the growth of our exports became relative stable after 1992, when there was a significant appreciation of the rate of exchange, as a result of the implementation of the Plano Real.

As seen in Graphs 3 and 6, respectively, the productivity index and the growth of exports are closely associated. It must also be noted that the stabilization of the rate of growth of the export amount index occurred simultaneously with a much more marked increase in productivity than in the expansion of the farmed area. This extremely important association of the two indexes should be taken into account in setting priorities for the agricultural sector and for agricultural research.

2.3 Relation between the productivity index and the export index

Ricardo's international trade theory calls attention to the differences in productivity as the main determinant of the comparative advantages of a country. From that standpoint, it should not be surprising to find a relation between the two indexes considered in our analysis.

Nevertheless, there are other variables that interfere in the structural relation pointed out in Ricardian theory. The recent history of Brazil has been characterized by considerable instability in the rate of exchange and the macro-economic policy as a whole. Both factors are important for our analysis. The first factor refers to the instability of the real rate of exchange, caused by instability in the inflation rate and various failed efforts to achieve macroeconomic stability prior to the *Plano Real*. The second factor is the exchange appreciation observed from the beginning of the *Plano Real* until the adoption of the flexible exchange rate in January 1999.

All of the above make even more relevant this correlation between the two indexes, since these structural relations are not usually as transparent vis-a-vis intense, short-term macroeconomic oscillations.

For example, we estimated a regression having the export index (logarithm) as dependent variable and the productivity index (logarithm) as independent variable. A binary variable with null values until 1993 was introduced to take into account the reduction of inflation and of its variability after the *Plano Real*. Please note that the data series closes in 1997, without including the exchange flexibility period.

The main results are shown below:

$$\underset{}{\text{export index}} = \underset{(1{,}66)}{1.07} + \underset{(5{,}73)}{0.77^{*}} \text{ productivity index} + \underset{(1{,}52)}{0.12^{*}} \text{ binary variation}$$

The values in parenthesis are the respective t statistics. The R^2 of the regression is 0.74 and the statistic F is 32.27.

It is important to emphasize that the productivity index is significant at 1%, while the binary variable is only marginally significant (15%). When the regression is estimated without the binary variable, there is no change in the quality of the adjustment and both the value and the level of significance of the coefficient of the productivity index increase.

2.4 The analysis model

An analysis of the impact of the research findings on economic activities should take into account inter-sectoral relations in the factor and product markets.

The magnitude of the productivity increases sometimes causes significant variations in the prices and in the use of the factors in the agroindustrial sector, which affect the whole economic system and result in variations in the revenues and well-being of all sectors. Even when agriculture is a relatively small part of the economy, the effects can be considerable.

It is also necessary to consider the fact that productivity increases often occur in the other sectors of the economy, which can mitigate some of the evident effects of specific technological innovations in the sector.

Likewise, innovations in other countries can reduce or cancel out the effects of the research efforts of the domestic institutions. This happens because the producers of export goods that compete with the imports will not be able to maintain their costs at the same level as those obtainable by countries where productivity has increased.

In order to have a comprehensive view of the effects of productivity increases it is necessary to use a model that contemplates the various aspects of the problem. This is done by using a world model of international trade developed by Hertel *et al.*[8] at Purdue University. The model is called the *General Trade Analysis Package* (GTAP). It is described in summary form in the following pages (readers interested in a more complete explanation, please see Hertel, 1997).

The main characteristics of the GTAP are the following:

- it is a world model. In the version used for the simulations 24 regions and 37 goods are considered, to which ten goods and eight regions were added;

- as usual in this type of model, there are two types of formulas: identities that guarantee the consistency of the solution and behavioral relations derived from maximization of profit and utility;

- the technology is simple, using constant substitution elasticity. Imported inputs are combined with domestic

[8] Various research institutes and international organizations collaborated in the research. Under the leadership of Prof. Hertel, the following institutions are contributing or contributed to the research: USDA, The World Bank, UNCTAD, World Trade Organization, Monash University (Australia), Australian Bureau of Agricultural Research (ABARE), Agriculture Canada, and others.

inputs to produce each of the ten goods considered in the analysis;

- imported inputs are differentiated by origin, and each region selects the composition of its imports so as to minimize costs;

- consumption is made up of domestically produced goods and imported goods. The demand is obtained from the maximization of the utility to consumers;

- the revenue generated in each region has the following destination: private consumption, government consumption and savings;

- capital and labor are completely mobile among the sectors within each region; and

- land is only used in the agricultural sector.

The sectors created for this application, together with their composition are described below.

- Natural resources: forest resources, fisheries, coal, oil, gas, ores, and timber.

- Natural-resource intensive manufactured goods: textiles, clothes, leather goods, paper, petroleum, non-metallic ores, ferrous metals, non-ferrous metals, and metallic goods.

- Manufactured goods and capital goods: chemical rubbers, plastics, transportation, and other manufactured goods.

- Other mechanical equipment: machinery and equipment.

- Grains: whole rice, wheat, corn, and cotton.

- Other agricultural products: produce, fruits, vegetables, soybean, and soybean products, miscellaneous.

- Animal products: wool, meat, live animals, and other animal husbandry products

- Processed foods: processed rice, coffee, sugar, cocoa, other beverages, tobacco, and other processed products.

- Dairy products

- Services: electricity, water, gas, civil construction, commerce, and transportation, other private services, other governmental services.

The model offers distinct possibilities as regards the macroeconomic scenario. For this application, it is important to mention the choices made:

- full employment. This hypothesis highlights inter-sectoral labor allocation problems in the experiments;

- the investment return rate is not altered as a result of the experiments. Consequently, the external capital flows and the current account of the balance of payment remain approximately constant[9].

2.5 Main Results

Various scenarios will be analyzed in order to evaluate the impacts of productivity increases. In addition to considering the results on exports and the trade balance (exports minus imports), other variables of interest will be included in the analyses below,

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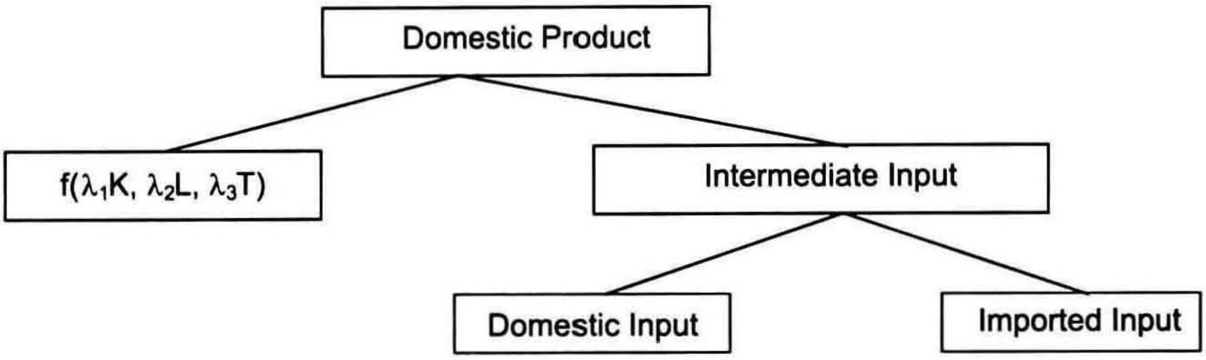
[9] Of course we could adopt an alternative hypothesis, namely, that the rate of return on investments changes and, thus, the foreign capital flows also change. Nevertheless, the hypothesis of an approximately constant current account is useful to show the inter-sectoral impact of productivity gains. It must also be observed that if the alternative hypothesis were adopted the productivity gains would cause increases in investment profits, increasing the net capital inflow and, consequently, the deficit in the current account of the balance of payments.

such as the consumer price index, terms of exchange, price of factors, equivalent variation[10], and the use of the factors, among others.

The production functions specified in the model, as regards the added value, contain coefficients reflecting factor augmenting technical progress, the technical advances that *increase the factors*[11]. In all scenarios the yield increases refer to increments in these coefficients[12].

The figure below is a schematic representation of the structure of the productive sector:



The intermediate input results from a minimization of the cost of domestic and imported inputs. Imported inputs are the result of minimizing the importation costs from the various regions in the model. The added value, represented by f(K,L,T), is obtained through a production function of constant substitution elasticity and production is the result of the combination of the added value with the intermediate input through a Leontieff-type production function.

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[10] This measurement shows the revenue variation, which is equivalent to the impact on the utility to consumers of a productivity increase or a policy change. It uses current prices for comparison purposes.

[11] The English expression is *factor augmenting*.

[12] Brandão and Tsigas (1994) analyzed the impacts of productivity yields occurring together with trade liberalization in an *ex-ante* evaluation of the impacts of the Uruguay round of GATT.

The scenarios presented below consider 10% increases in the λ_1, λ_2 and λ_3 coefficients. In order to simplify the technology, we refer to these coefficients as _productivity increases_[13].

2.5.1 Scenario 1: Productivity increases in the grain sector.

This experiment consists of a10% increase in the productivity of land, labor and capital in the grain sector.

The third column of Table 2 contains the results of the selected macro-economic variable. The impact on the balance of trade is relatively small, as expected from the macro-economic closing used. As regards the other variables, it must be noted that:

- the equivalent variation of approximately US$ 800 million reflects the gross monetary value[14] of this productivity gain to the economy;
- the impacts on most of the macro-economic variables are relatively small, since the share of this sector in the GDP is also small;
- there is a significant reduction in the real price of land. This reduction follows the increase in land productivity as well as the fact that this factor is used only in the agricultural sector. Table 8 shows a reduction in the use of land by the grain sector and resulting increment in the other rural sectors;
- the increase in the prices of labor and capital occurs as a function of their inter-sectoral mobility. In order to continue attracting these factors, the other sectors must remunerate them according to the increased productivity now obtained in the grain sector;

[13] It is not the most adequate terminology because, the production function being concave, a 10% increase in the coefficient causes less than a 10% increase in productivity.

[14] Since research costs were not considered, this is actually not the gain in well-being.

- the variations in the GDP implicit deflator and the consumer price index are small. Nevertheless, it is important to note that the implicit deflator increases and the consumer price index diminishes. This behavior results from the different weighing systems used.

Table 3 shows the trade balance variation by sector in the model. There is a significant increase in the three agricultural sectors (grain, other agricultural products and animal production), as well as in processed foods. This increment follows the increased competitiveness of the domestic products of course. The other products have a smaller share in the trade balance, since their sectors will have to pay prices reflecting the higher yields obtained by labor and capital and will have not had any gains in competitiveness. These sectors will also pay higher prices for the raw materials derived from other urban-sector products.

A significant drop in the relative price of grain can be seen in Table 4, together with reductions in the other agricultural sector products. Processed foods also have their relative prices reduced. The variations in production (Table 5) are compatible with the variations in prices, and there is an expressive increase in the grain and processed foods sectors.

The percentage variations in the value of sectoral exports are shown in Table 6. There are relatively important increments in grain and processed foods. It must be noted, however, that the percentage variations in this case are not very significant, in view of the low level of grain exports. It must also be emphasized that the higher percentage reductions in the value of imports take place in precisely those sectors (Table 7).

Thus, productivity shocks effectively increase the competitiveness of national grain and processed food producers, with important effects on the sectoral balance of trade.

Tables 8, 9 and 10 show the percentage variations in the use of the production factors in the agricultural sector. The use of land in the grain sector decreases by approximately 4%. Since the land is only used in agriculture, this reduction is evened out by 1.5% and 1.3% increases in the other products of the agricultural sector and animal production, respectively.

The decreased observed in the price of land, despite its productivity increase, is due to fact that its use value outside the agricultural sector is null. The increase of the demand for this factor, which is caused by its higher productivity, leads to an increase in grain supply and a substantial reduction in the relative price of this product. Furthermore, the relative prices of the other agricultural sector products decrease, while production increases[15].

In addition, there is less use of manpower (8.4%) and capital (8.3%) in this sector. The increase in labor and capital use in other agricultural sector products is not enough to counterbalance this extremely high variation. It must be emphasized that the reduction in the use of manpower in the agricultural sector (approximately 1.3%) signifies migrations to the urban sector.

2.5.2 Scenario 2: Productivity increases in the sector of other agricultural products

This experiment consists in increasing the productivity of land, labor and capital in the production of other agricultural products. Selected results are shown in tables 2 to 10.

It must be initially noted that the macro-economic impacts are similar to those of the previous scenario, from the qualitative standpoint. Nevertheless, the following aspects are worth noting (Table 2, column 4):

- the equivalent variation is significantly higher than that obtained in the previous scenario;

[15] The percentage price and amount variations in these sectors are sufficiently below those of grain.

- the reduction in the real price of land is smaller and the increases in real labor and capital prices are higher than in the case of grains; and

- the effect on the balance of trade is equivalent to that of the previous experiment.

A close examination of Table 3 leads to the conclusion that the impact of this productivity increase on the balance of trade of the other agricultural products sector is high. The value of sectoral exports increases by 19% (Table 6) and the value of the imports decreases by 12.5% (Table 7)[16]. It must also be noted that there is a significant reduction in the relative prices of the products in this sector (Table 4) and a substantial production increase (Table 5).

In this experiment, grain production increases significantly (Table 5) and the relative prices of grains and animal products have a small increase (Table 4). These facts help explain the lesser reduction in the real price of land, when compared with both the previous and the following case.

It is also worth emphasizing the high negative impact of this productivity increase on the use of labor and capital. As in the previous case, there will be significant migration to the urban sector.

2.5.3 Scenario 3: Productivity increases in animal production

This experiment consists in increasing the productivity of land, labor and capital in animal production. Selected results are shown in tables 2 to 10.

The results have qualitative similarities with those analyzed in the previous experiments. It necessary to highlight, however, the negative and rather high impacts on the use of labor and capital in the sector.

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[16] This sector accounts for only 5% of the total exports of the country.

2.5.4 Conclusions of the previous analyses

The three previous experiments show relatively small macro-economic effects, with the exception of the reduction in the relative price of land, which can be as high as 3%. This is due to the fact that land has no alternative use outside the agricultural sector and to the reduction of the relative prices of agricultural sector products.

In all cases, there are significant increments in the exports of the respective sectors. These increases are more relevant in the case of other agricultural products and animal production, whose exports are already relatively high[17].

Also in all cases, there is a reduction in the use of labor and capital in the agricultural sector. One of the consequences is increased supply of labor for the non-agricultural sectors.

In all cases, the equivalent variation is significant, which indicates expressive social gain.

It should also be emphasized that the reduction in the relative prices of animal products observed in these experiments represents gains for low-income consumers, since they spend most of their income in food. In addition, there is a significant reduction in the relative price of processed foods (Scenario 1) and dairy products (Scenario 3).

2.5.5 Scenario 4: Productivity increases in processed foods and dairy products

This experiment includes the food processing and dairy products sectors. There are two main reasons for their relevance:

- the existence of several centers linked to agricultural research which focus on food technology and processing and

[17] This is not true for grain.

- the existence of economic links between the various elements of the productive chains which transmit the effects of the productivity increases to the part of the industrial sector that has primary sector inputs (grain, other agricultural products and animal products).

The experiment consists in increasing the productivity of the labor and capital factors in food processing and dairy product sectors. The results are shown in tables 11 to 19.

Observing the macro-economic impacts (Table 11) we note the following:

- as in the previous results, most of the percentage variations are not very significant;

- the equivalent variation is approximately the same as that in the experiments, where the increase in productivity occurs in the primary sector;

- the prices of all production factors increase. The most significant increment occurs in the remuneration of land, since this factor has no inter-sectoral mobility and, therefore, the demand of all agricultural sub-sectors that use land increases.

There is a rather significant increase in the trade balance of the processed food sector (Table 12). Exports (Table 15) of processed foods grow by approximately 9%, while imports (Table 16) decrease by 3%. These results are significant in view of the fact that Brazil exports and imports expressive amounts of processed foods.

In the dairy product sector, the 5% increase in exports is much less significant since Brazil imports a very small amount of dairy products. The main reason for the increase in the trade balance of this sector is the 3% reduction in imports.

It is necessary to note that all primary sector exports diminish as a function of the productivity increase in the industrial sector. This reduction means that Brazil no longer exports raw products and, instead, sells value-added products abroad. Imports of primary sector products also increase.

The relative prices of processed foods and dairy products drop substantially (Table 13), while the amounts produced by both sectors increase (Table 14).

The grain sector has strong links with the food-processing sector. The increase in productivity expands production by 2.5% (Table 14) and increases prices by 1.2% (Table 13). The food industry is the final beneficiary of almost all the production expansion in the grain sector.

Consistently with the observation in the previous paragraph, the use of land, labor and capital in the grain sector increases by 1.4%, 3.6% and 3.6%, respectively. In addition, there are increases in use of labor and capital in other agricultural products and animal products.

This experiment shows the importance of the agroindustrial sector in reducing migrations from rural to urban areas in Brazil. The effects of technological improvements in the agricultural sector increase the demand for primary sector products, leading to increased demand for manpower.

2.5.6 Scenario 5: Increased land productivity

This experiment consists of increasing land productivity by 10% in the grain, other agricultural products and animal production sectors. The results are shown in tables 20 to 28.

The macro-economic impacts (Table 20) are small. Nevertheless, the following results are worth noting:

- the US$ 1,116 million equivalent variation is equivalent to that of the previous experiments and

- the price of land decreases by 7% as a result of its lack of inter-sectoral mobility and the variations in the relative prices of the primary sector products.

The trade balance (Table 21) of the primary and processed food sectors increases by approximately US$ 850 million, confirming the observations made in section 2 of the paper.

Because of the hypothesis adopted in the other experiments, there are substantial reductions in the trade balance of the other sectors. Nevertheless, this experiment shows that land yield increases have significant impacts on the competitiveness of Brazilian agriculture and of those sectors using agricultural products as raw material.

The relative prices (Table 22) of raw and processed agricultural products have very significant reductions: 4.3% for grain; 3.7% for other agricultural products; 2.8% for animal products; 0.93% for processed foods; and 1.4% for dairy products. The production (Table 23) of these sectors also grows significantly.

Tables 24 and 25 show that these sectors will significantly expand their exports and reduce their imports. In addition, it underlines the importance of increasing the productivity of land in order to increase the competitiveness of domestic producers, both in the domestic market (competing with imports) and in foreign markets (competing with exports from other countries).

Tables 26, 27 and 28 show the impact on the use of the production factors. It should be observed that:

- land use increases for other agricultural products and animal production;

- there is a 1.9% reduction in the use of labor in grains and 1.8%, in animal production. The use of manpower increases by 0.22% in other agricultural products, but this increase is not sufficient to make up the reduction in demand in the other two sectors. The net balance is an approximately 1% decrease in the use of manpower in the sector; and

- the use of capital in the grain and animal production sectors diminishes by approximately 2%, with a small increase in other agricultural products.

2.5.7 Scenario 6: Increased labor productivity

This experiment consists in raising labor productivity by 10% in the grain, other agricultural products and animal production sectors. The results are shown in tables 20 to 28. Some observations arising from these tables are listed below:

- without exception, the macro-economic impacts are very small (Table 20);
- there are positive effects on the trade balance of the sector, albeit less significant than those seen in the previous scenario (Table 21);
- the relative prices of the products in the agroindustrial chain diminish (Table 22);
- the amounts produced in the sectors linked to the agroindustrial chain increase (Table 23), as exports grow (Table 24) and imports diminish (Table 25) in these sectors; and
- the use of manpower decreases by 4.5%, 3.9% and 3.6% (Table 27) in the grain, other agricultural products and animal production sectors, respectively.

2.5.8 Scenario 7: Increased capital productivity

This experiment consists in raising the productivity of capital by 10% in the grain, other agricultural products and animal production sectors. The results are shown in tables 20 to 28. Since the results in this case are similar to those obtained in scenario 6, we shall not go into details.

2.5.9 Scenario 8: Productivity increases in the non-agricultural sector

The purpose of this experiment is to demonstrate that in order to maintain the competitiveness of the agricultural sector it is necessary that the sector's productivity growth be equivalent to that of the other sectors of the economy. For this experiment, the sectors selected were natural resources and natural resource-intensive manufacture goods.

The experiment consists in increasing the productivity of labor and capital by 10% in the two above-mentioned sectors. Selected results are shown in tables 29, 30 and 31. Close examination of these tables shows that:

- since these sectors account for a high share of the GDP, the macro-economic impacts are more substantial;
- the real remuneration of land, labor and capital increased by 1.25%, 2.25% and 1.82%, respectively. These increases are induced by the fact that the other sectors continue to attract capital and manpower (mobile factors) and will have to remunerate them according to their higher productivity in those two sectors. In the case of land (fixed factor), the increase is mainly induced by the rise in the relative price of agricultural products;
- there was an increase in relative prices in the sectors in which there were no productivity increases, which is a natural result of the higher costs, as well as of the high impact on income and, therefore, on the aggregate demand;
- the production of the grain and other agricultural products sectors, as well as the use of the land, labor and capital factors, decreased;

- animal production underwent a small expansion, accompanied by increased use of land and capital and decreased use of labor;

- there was a small drop (0.2%) in the production of processed foods and a slightly more significant increase (0.8%) in the production of dairy products;

- exports diminished in all sector of the economy, with the exception of those in which productivity increased. The largest reductions occurred exactly in grain, other agricultural products, animal production, processed foods, and dairy products[18]; and

- the largest import increases occurred in the sectors in which exports decreased more markedly.

From an analysis of this scenario the fact stands out that productivity increases in the non-agricultural sector will reduce substantially the competitiveness of the agricultural sector. This calls attention to the fact that for agricultural research to prove its importance to society at large it is necessary that productivity gains be compatible with those occurring in other sectors of the economy.

This observation suggests the need for agricultural research institutions to be effective and able to show this clearly to society. It is necessary for them to achieve a level of efficiency equal to or higher than those attained by research institutions working in other sectors of the economy.

2.5.10 Scenario 9: Productivity increases in the European Union

The purpose of this experiment is to demonstrate that in order to maintain the country's competitiveness productivity must

[18] In the case of dairy products, this decrease is not very significant, since dairy exports are very small.

grow at the same pace as in other regions of the world. The European Union was selected in order to illustrate the nature of the adverse effects of productivity increases, since this is an important trade partner of Brazil as regards agroindustrial products.

The experiment consists in increasing the productivity of land, labor and capital by 10% in the grain, other agricultural products and animal production sectors in the European Union. The selected results referring to Brazil, shown in tables 32, 33 and 34, elicit the following comments:

- the macro-economic impacts are small, but the balance of trade shows a drop in its balance and a negative equivalent variation;

- the real price of land diminishes, as a result of a drop in production in the agricultural sector;

- agricultural exports decrease and imports increase;

- the higher imported amounts of grain, other agricultural products and processed food, however, are accompanied by a lessened value of the imports, because the prices paid for the imports decrease as a function of an increase in the world supply resulting from higher productivity in the European Union;

- these price reductions have an inverse effect as regards exports, where the reductions in value are higher than the reductions in amount;

- there are small reduction in the production of the agroindustrial sectors;

- the relatively high prices of products fall, and the slightly more significant reductions affect the products of the agroindustrial sector; and

- there is a reduction in the use of labor and capital in the agroindustrial sectors.

2.6 Summary and conclusions

This paper presents an analysis of the impact of increases in productivity in agriculture, trying the highlight those associated with the competitiveness of the agricultural sector. The data indicate that the Brazilian agricultural sector has had expressive gains in the productivity of land and equally substantial gains in exports. The fact that this association comes through clearly in the Brazilian data is noteworthy, since the economic instability during a good part of the period under issue caused instability in the real rate of exchange.

A simple estimate of the relation between the productivity index and the export index resulted in an elasticity of 0.77, indicating that a 10% increase in the productivity of land can increase exports by 7.7%. This value may seem low, but it is compatible with the fact that the domestic production accounts for a very small share of exports.

Gains in productivity have effects that go beyond the frontiers of the agricultural sector and even national frontiers. In order to take into account these impacts, the GTAP applied general equilibrium model overall balance model was used. The scenarios analyzed aimed at illustrating the following aspects:

- effects of productivity increases in the agricultural sector itself;
- effects of productivity increases for each of the production factors;
- effects of productivity increases in the food processing sector;

- the importance of bringing about productivity increases in agriculture that are compatible with those taking place in other sectors of the economy; and

- the importance of achieving productivity increases that are compatible with those taking place in agriculture in other countries.

The main conclusions are summed up in the following propositions:

- the macro-economic impacts of productivity increases in agriculture and the food processing industry are relatively small;

- there are reductions, some times considerable reductions, in the price of land as a functions of the productivity increases in the agricultural sector. This phenomenon is largely induced by a reduction in the relative prices of agricultural products;

- price reductions in agricultural products are more beneficial to low-income families, who spend a larger share of their budgets buying food;

- productivity gains increase significantly the competitiveness of the agricultural sector, generating substantial increases in exports and considerable decreases in imports;

- productivity increases in the agroindustrial sector significantly enhance social well-being;

- productivity increases in agriculture cause increased migration from rural to urban areas;

- productivity increases in the processing sector (processed foods and dairy products) have positive impacts on the production of the primary sector, particularly on the grain and animal production sub-sectors; and

- consequently, the use of manpower in the primary sector increases and brings about a decrease in the migration from rural to urban areas;

- productivity increases outside the agroindustrial sector cause reduction in the production of the sectors linked to agriculture (grain, other agricultural products and processed foods);

- in this case, there is a small expansion of animal production and dairy products, driven by increases in the demand;

- productivity increases outside the agroindustrial sector reduce exports and increase imports of the whole agroindustrial complex; and

- in the experiment showing productivity increases in the European Union, there are reductions in production and exports, as well as increases in agroindustrial sector imports.

Productivity increases in agroindustry result from investments made by the sector's research institutions and businesses. Evidence in Brazil shows that this effort has met with successful. The results of the simulations confirm the importance of this fact. They also call to attention, however, the need to take into account the behavior of productivity in other sectors and countries when deciding how much public and private money should be invested in the agricultural sector.

The OECD countries, some of which are substantial competitors of our products, earmark a significant part of their budgets to agricultural research. The substantial protection accorded to their agroindustrial sector contributes to increasing the investment capability of the private sector and, consequently, its productivity gains. The natural corollary is that in order to maintain the competitiveness of Brazilian agriculture it is necessary to keep up the research effort[18].

2.7 References

Brandão, Antônio Salazar P. *Evolução da Agricultura e o Papel da Tecnologia*, em Paterniani, Ernesto (editor) A Tecnologia na Agricultura Brasileira. No prelo, EMBRAPA, 2000.

Brandão, Antônio Salazar P.; Marinos Tsigas; Ian Goldin and Dominique van der Mensbrugghe *Trade Liberalisation and Technical Change*, cap. 9. In Goldin, Ian; Odin Knudsen; and Dominique van der Mensbrugghe Trade Liberalisation: Global Economic Implications, OECE and Banco Mundial, Paris and Washington DC, (1993).

Brandão, Antônio Salazar P. and Lia Valls Pereira (organizadores) MERCOSUL: Perspectivas da Integração, Editora da Fundação Getulio Vargas, Rio de Janeiro, 1996.

Castro, J. Ramalho de and G. Edward Schuh *An Empirical Test of an Economic Model for Establishing Research Priorities: A Brazil Case Study.* In Arndt, T., D. Darlymple and V. Ruttan (editores) Resource Allocation and Productivity in National and International Agricultural Research. University of Minnesota Press, Minneapolis, 1977.

Frisvold, George B. *Multimarket effects of agricultural research with technological spillovers*. In Hertel, Thomas W. (editor) *Global Trade Analysis: Modeling and Applications*, Cambridge University Press, Cambridge, 1997.

Hertel, Thomas W. (editor) *Global Trade Analysis: Modeling and Applications*, Cambridge University Press, Cambridge, 1997.

[18] Obviously in addition to continuing pressing these countries to reduce their protection of the agricultural sector.

Martin, Will and J. Alston *A Dual Approach to Evaluating Research Benefits in the Presence of Trade Distortions.* American Journal of Agricultural Economics, vol 74, p. 26-35, 1994.

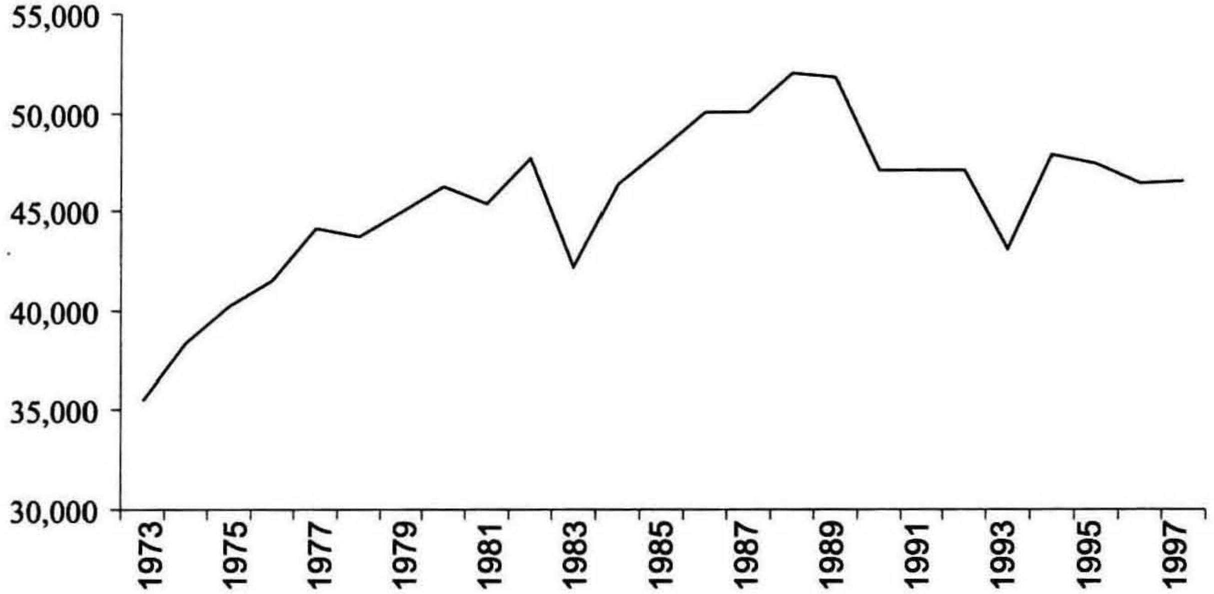
Scobie, G. and R. Posada *The Impact of Technical Change on Income Distribution: The Case of Rice in Colombia.* American Journal of Agricultural Economics, vol. 60, p. 85-91, 1978.

Appendix

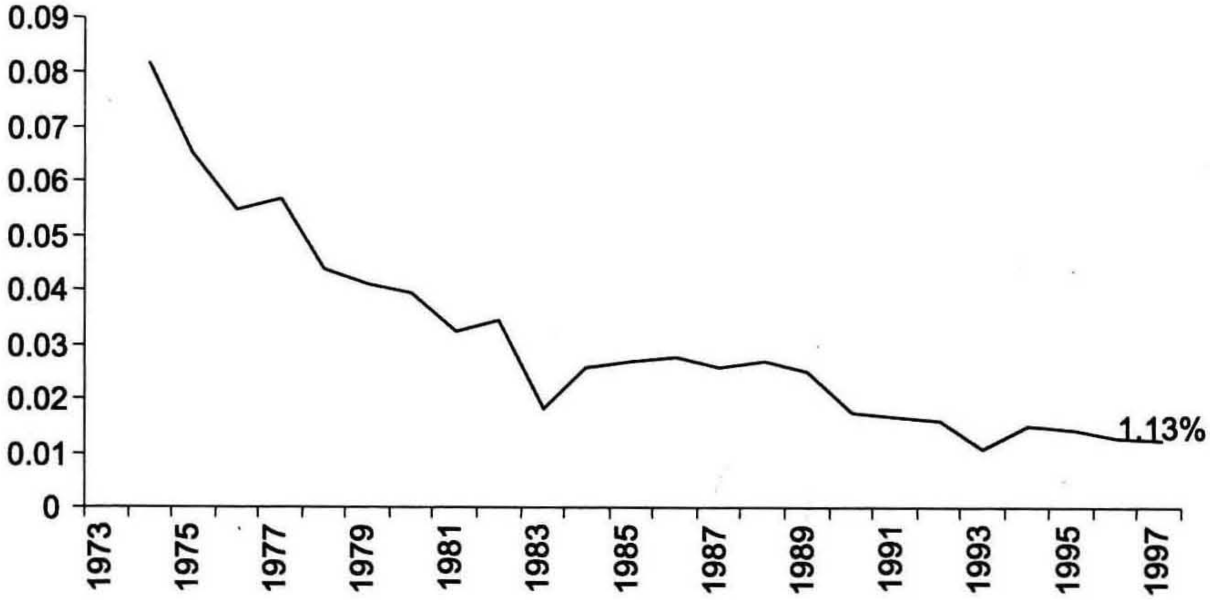
(to Chapter 2)

Graphs and tables

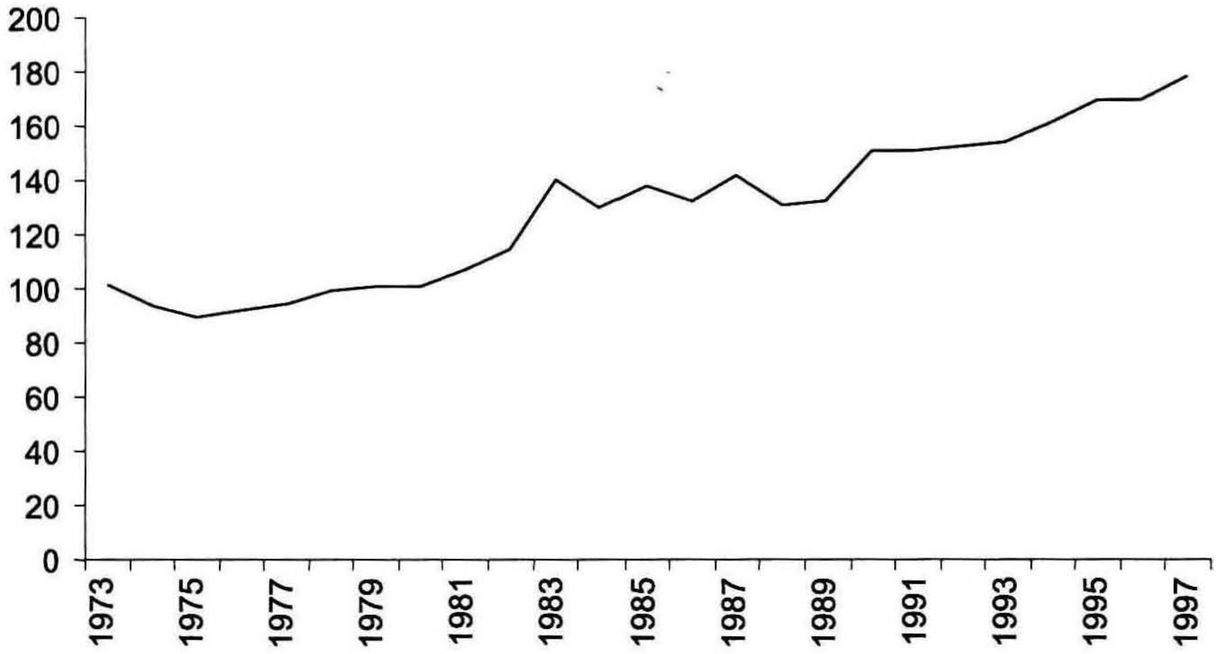
Graph 1. Area (1000 ha)



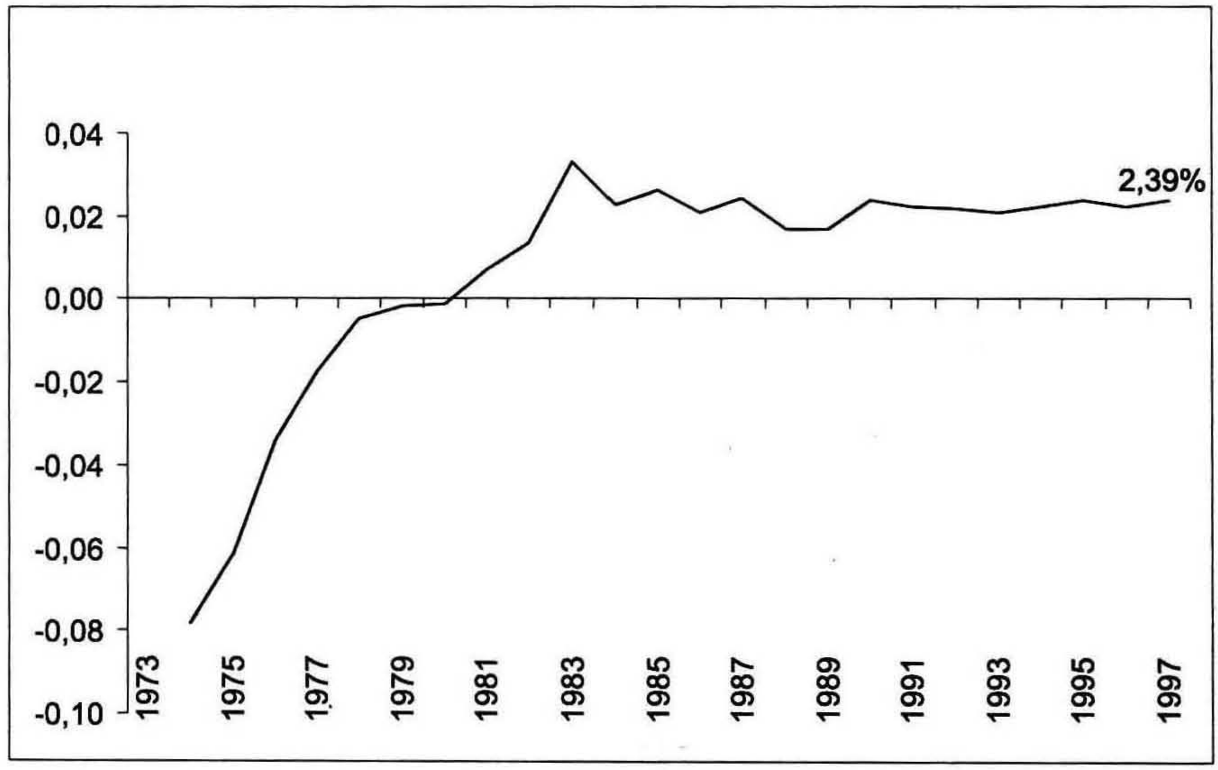
Graph 2. Average growth rate of farmed area



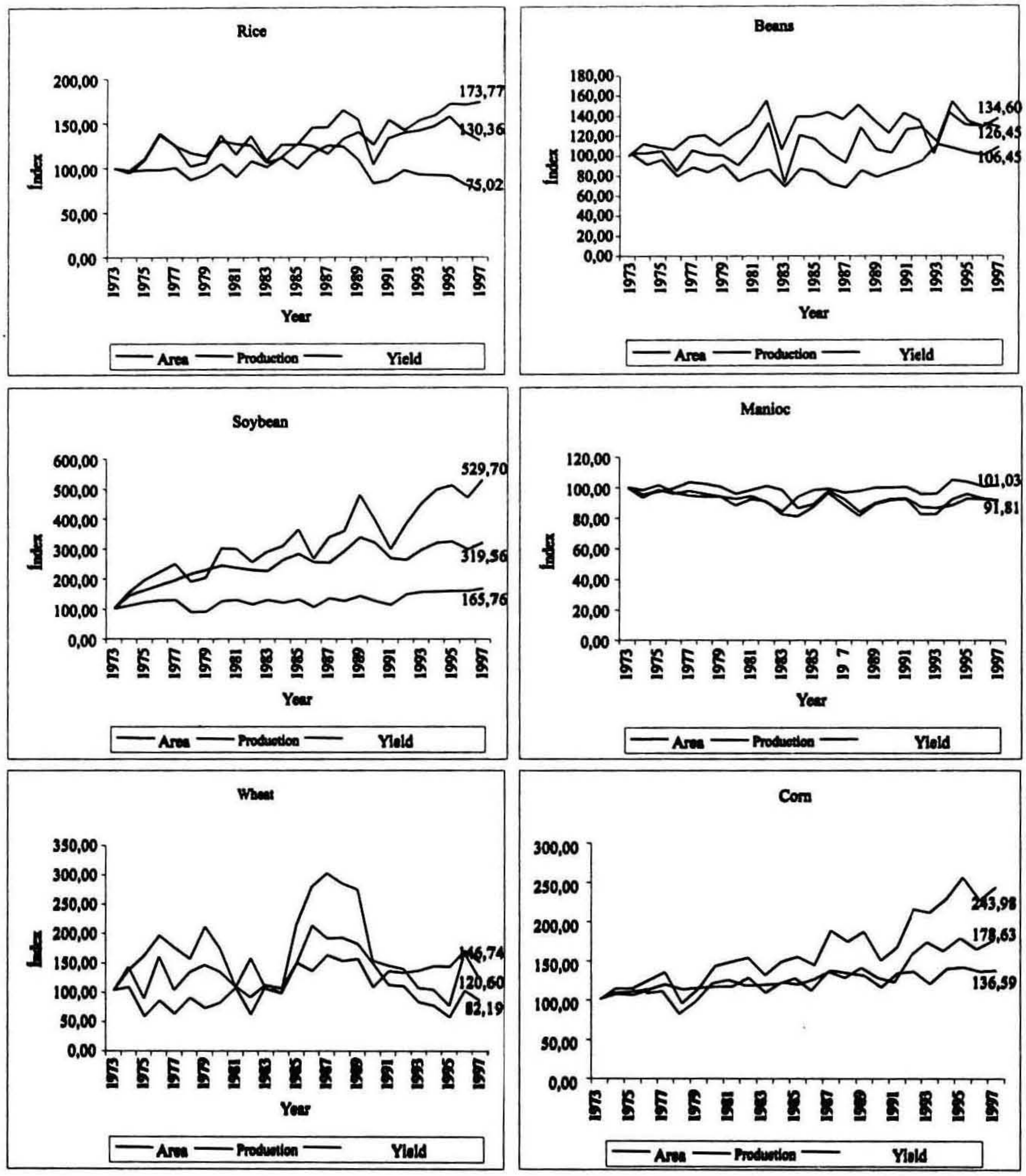
Graph 3. Agricultural yield index



Graph 4. Average growth rate of yield

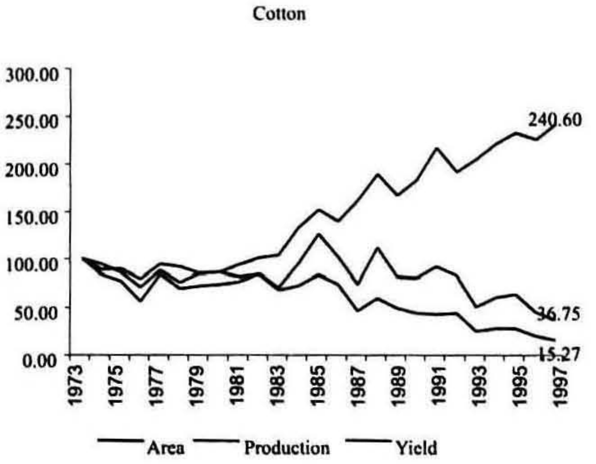


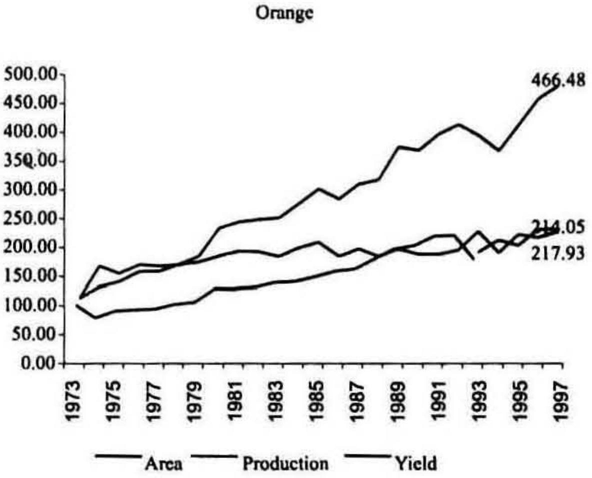
Graph 5. Evolution of farmed area, production and yield for the main agricultural products in Brazil

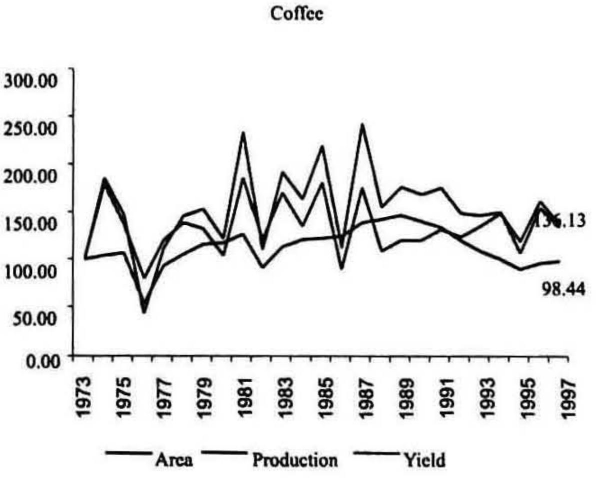


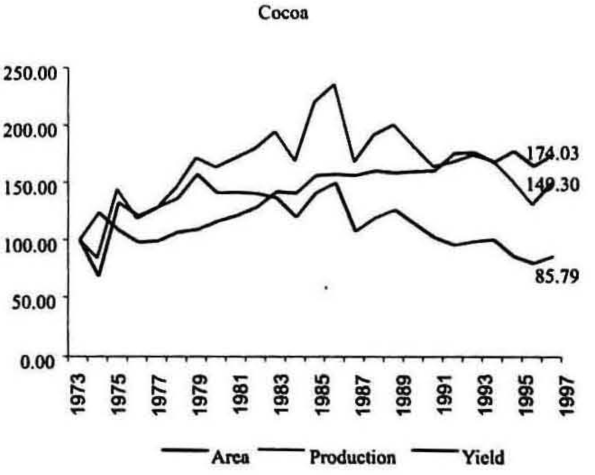
Continues...

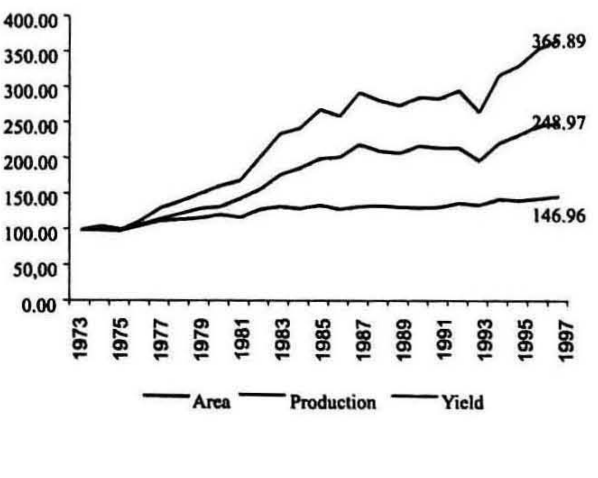
Graph 5. continuation



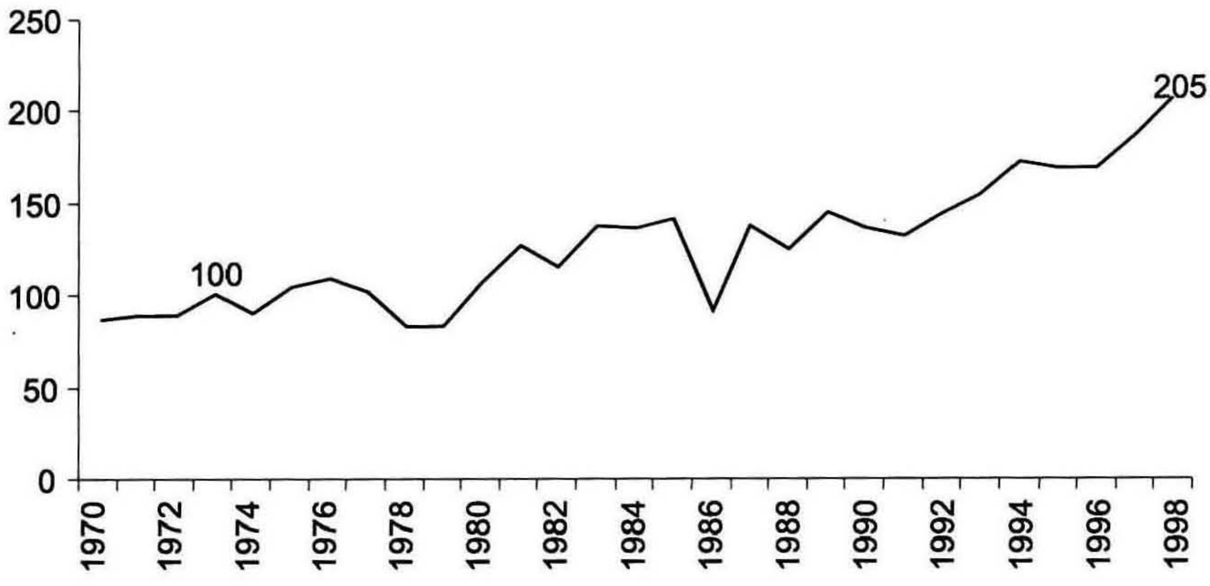








Graph 6. Export index (1973 = 100)



Graph 7. Rate of growth of the export index

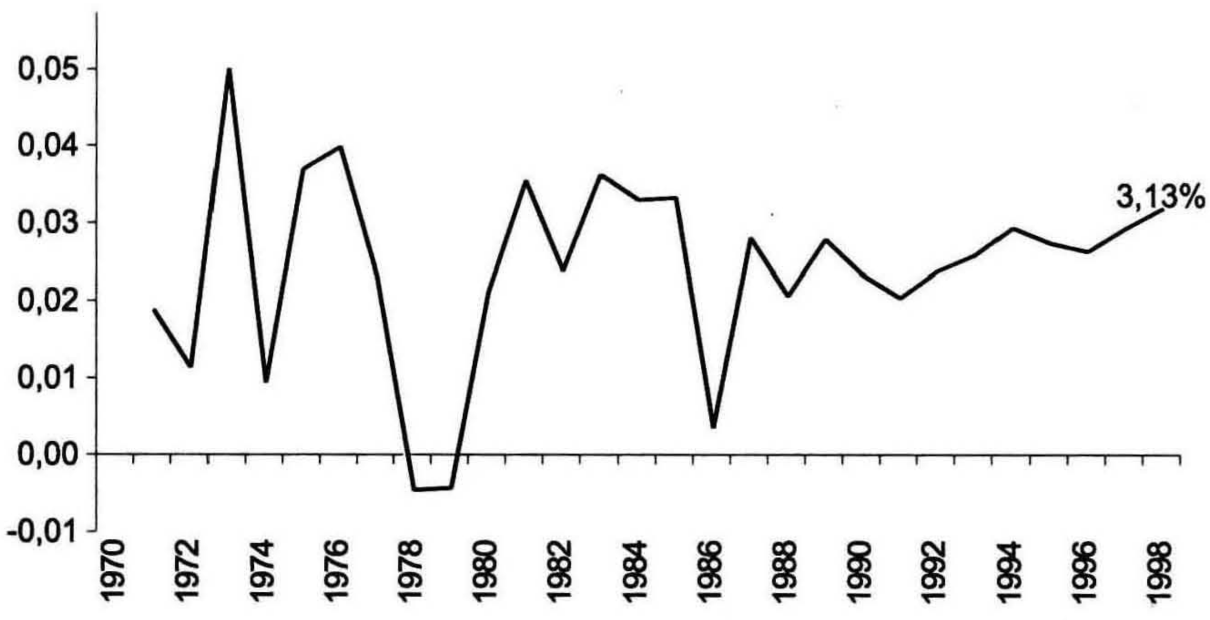


Table 1. The average growth rates of whole GDP and agricultural sector GDP - 1971 - 1995

Period	**Average growth rate**	
	Agriculture	**Total**
1971/1980	3.72%	7.46%
1981/1990	1.66%	2.02%
1991/1995	3.78%	2.60%
1981/1995	2.55%	2.24%

Source: IBGE, Author's calculations.

Table 2. Macroeconomic impacts

	Unit	Experiments		
		Yield increase in the grain sector: 10%	Yield increase in other agricultural products: 10%	Yield increase in animal products: 10%
Balance of Trade	US$ million	50.71	53.22	83.02
Equivalent Variation	US$ million	794.87	1027.33	1390.53
Implicit Deflator	%	0.03	0.08	-0.23
Consumer price index	%	-0.03	0.03	-0.33
Real GDP real	%	0.21	0.29	0.39
Terms of exchange	%	-0.03	-0.25	-0.16
GDP (value)	%	0.23	0.37	0.16
Real price of land	%	-3.05	-1.56	-3.36
Real price of labor	%	0.33	0.48	0.68
Real price of capital	%	0.27	0.44	0.54
Nominal price of land	%	-3.07	-1.54	-3.68
Nominal price of labor	%	0.30	0.49	0.35
Nominal price of capital	%	0.24	0.46	0.21

Table 3. Balance of Trade Variation by sector (US$ million)

Sectors	Experiments		
	Yield increase in the grain sector: 10%	Yield increase for other agricultural products: 10%	Yield increase in animal products: 10%
Natural resources	-55.86	-102.63	-67.29
Natural resource-intensive man. goods	-134.15	-197.72	-105.31
Manufactured goods and capital goods	-118.76	-208.00	-133.23
Other mechanical equipment	-82.50	-136.03	-90.02
Grain	141.24	-14.35	2.86
Other agricultural products	22.90	658.22	31.99
Animal products	16.12	-7.23	462.17
Processed foodstuff	308.61	143.72	9.69
Dairy products	0.10	-1.94	22.31
Services	-47.69	-80.81	-50.16
Total	50.01	53.23	83.01

Table 4. Percentage variation in relative domestic prices

Sectors	Experiments		
	Yield increase in the grain sector: 10%	Yield increase for other agricultural products: 10%	Yield increase in animal products: 10%
Natural resources	0.22	0.34	0.53
Natural resource-intensive man. goods	0.21	0.25	0.47
Manufactured goods and capital goods	0.19	0.26	0.49
Other mechanical equipment	0.22	0.29	0.51
Grain	-8.04	0.13	-0.13
Other agricultural products	-0.32	-6.88	-0.09
Animal products	-0.27	.05	-6.56
Processed foodstuff	-1.28	-0.69	0.24
Dairy products	-0.11	0.10	-3.36
Services	-0.17	0.33	0.52

* Percentage variation of price minus the percentage variation in the consumer price index

Table 5. Percentage variation in the amounts produced

Sectors	Experiments		
	Yield increase in the grain sector: 10%	Yield increase for other agricultural products: 10%	Yield increase in animal products: 10%
Natural resources	-0.12	-0.32	0.03
Natural resource-intensive man. goods	0.00	-0.05	0.21
Manufactured goods and capital goods	-0.03	-0.10	0.19
Other mechanical equipment	-0.25	-0.50	-0.13
Grain	2.52	1.05	0.70
Other agricultural products	0.81	6.49	0.69
Animal products	0.33	0.22	4.05
Processed foodstuff	1.68	1.18	0.63
Dairy products	0.29	0.33	1.51
Services	0.12	0.14	0.24

Table 6. Percentage variation inthe value of exports

Sectors	Experiments		
	Yield increase in the grain sector: 10%	Yield increase for other agricultural products: 10%	Yield increase in animal products: 10%
Natural resources	-0.71	-1.35	-0.72
Natural resource-intensive man. goods	-0.77	-1.15	-0.55
Manufactured goods and capital goods	-0.69	-1.25	-0.65
Other mechanical equipment	-0.74	-1.25	-0.70
Grain	28.07	-0.60	1.30
Other agricultural products	0.82	18.95	1.01
Animal products	0.86	-0.33	24.37
Processed foodstuff	4.44	2.11	0.27
Dairy products	0.33	-0.44	11.74
Services	-0.43	-0.77	-0.38

* fob prices

Table 7. Percentage variation in the value of imports

Sectors	Experiments		
	Yield increase in the grain sector: 10%	Yield increase for other agricultural products: 10%	Yield increase in animal products: 10%
Natural resources	0.40	0.70	0.61
Natural resource-intensive man. goods	0.52	0.69	0.57
Manufactured goods and capital goods	0.39	0.65	0.56
Other mechanical equipment	0.33	0.51	0.43
Grain	-14.51	1.48	-0.29
Other agricultural products	0.02	-12.49	-0.37
Animal products	-0.45	0.43	-14.14
Processed foodstuff	-1.52	-0.59	0.28
Dairy products	-0.01	0.61	-6.58
Services	0.50	0.83	0.59

* cif prices

Table 8. Percentage variation in the use of land in the agricultural sector

Sectors	Experiments		
	Yield increase in the grain sector: 10%	Yield increase for other agricultural products: 10%	Yield increase in animal products: 10%
Grain	-4.28	1.31	1.55
Other agricultural products	1.49	-1.85	1.57
Animal products	1.32	0.80	-2.44

Table 9. Percentage variation in the use of labor in the agricultural sector

Sectors	Experiments		
	Yield increase in the grain sector: 10%	Yield increase for other agricultural products: 10%	Yield increase in animal products: 10%
Grain	-8.36	0.88	0.11
Other agricultural products	0.39	-3.98	0.13
Animal products	-0.14	-0.06	-6.75

Table 10. Percentage variation in the use of capital in the agricultural sector

Sectors	Experiments		
	Yield increase in the grain sector: 10%	Yield increase for other agricultural products: 10%	Yield increase in animal products: 10%
Grain	-8.33	0.90	0.18
Other agricultural products	0.42	-3.96	0.21
Animal products	-0.10	-0.03	-6.67

Table 11. Yield increase in the food processing and dairy products sectors: macroeconomic impacts

	Unit	Yield increase of labor and capital: 10%
Balance of Trade	US$ million	47.28
Equivalent Variation	US$ million	1,106.56
Implicit Deflator	%	-0.04
Consumer price index	%	-0.12
Real GDP real	%	0.30
Terms of exchange	%	-0.14
GDP (value)	%	0.26
Real price of land	%	2.83
Real price of labor	%	0.42
Real price of capital	%	0.34
Nominal price of land	%	2.72
Nominal price of labor	%	0.31
Nominal price of capital	%	0.23

Table 12. Yield increase in the food processing and dairy products sectors: variation in the balance of trade by sector (US$ million)

Sectors	Yield increase of labor and capital: 10%
Natural resources	-55.10
Natural resource-intensive man. goods	-136.20
Manufactured goods and capital goods	-120.81
Other mechanical equipment	-86.53
Grain	-51.43
Other agricultural products	-68.93
Animal products	-26.40
Processed foodstuff	631.55
Dairy products	9.76
Services	-48.63
Total	47.28

Table 13. Yield increase in the food processing and dairy products sectors: percentage variation in relative domestic prices *

Sectors	Yield increase of labor and capital: 10%
Natural resources	0.29
Natural resource-intensive man. goods	0.30
Manufactured goods and capital goods	0.27
Other mechanical equipment	0.30
Grain	1.21
Other agricultural products	0.73
Animal products	0.54
Processed foodstuff	-2.47
Dairy products	-1.53
Services	0.30

* Percentage variation of prices minus the percentage variation in the consume price index

Table 14. Yield increase in the food processing and dairy products sectors: percentage variation in the amount produced

Sectors	Yield increase of labor and capital: 10%
Natural resources	0.01
Natural resource-intensive man. goods	0.12
Manufactured goods and capital goods	0.08
Other mechanical equipment	-0.15
Grain	2.73
Other agricultural products	0.52
Animal products	0.13
Processed foodstuff	3.21
Dairy products	0.82
Services	0.21

Table 15. Yield increase in the food processing and dairy products sectors: percentage variation in the value* of exports

Sectors	Yield increase of labor and capital: 10%
Natural resources	-0.62
Natural resource-intensive man. goods	-0.75
Manufactured goods and capital goods	-0.63
Other mechanical equipment	-0.72
Grain	-3.22
Other agricultural products	-1.57
Animal products	-1.30
Processed foodstuff	9.06
Dairy products	5.06
Services	-0.39

* fob prices

Table 16. Yield increase in the food processing and dairy products sectors: percentage variation in the value* of imports

Sectors	Yield increase of labor and capital: 10%
Natural resources	0.47
Natural resource-intensive man. goods	0.61
Manufactured goods and capital goods	0.47
Other mechanical equipment	0.38
Grain	5.31
Other agricultural products	2.49
Animal products	1.19
Processed foodstuff	-3.19
Dairy products	-2.88
Services	0.56

* cif prices

Table 17. Yield increase in the food processing and dairy products sectors: percentage variation inthe use of land in the agricultural sector

Sectors	Yield increase of labor and capital: 10%
Grain	1.40
Other agricultural products	-0.24
Animal products	-0.69

Table 18. Yield increase in the food processing and dairy products sectors: percentage variation in the use of labor in the agricultural sector

Sectors	Yield increase of labor and capital: 10%
Grain	3.56
Other agricultural products	0.96
Animal products	0.47

Table 19. Yield increase in the food processing and dairy products sectors: percentage variation in the use of capital in the agricultural sector

Sectors	Yield increase of labor and capital: 10%
Grain	3.61
Other agricultural products	1.00
Animal products	0.53

Table 20. Macroeconomic impacts

	Unit	Experiments		
		Yield increase of land: 10%	Yield increase of labor: 10%	Yield increase of capital: 10%
Balance of Trade	US$ million	54.88	43.95	87.39
Equivalent Variation	US$ million	1,116.83	721.42	1412.61
Implicit Deflator	%	-0.02	-0.05	-0.08
Consumer price index	%	-0.12	-0.08	-0.16
Real GDP real	%	0.31	0.20	0.39
Terms of exchange	%	-0.17	-0.08	-0.16
GDP (value)	%	0.29	0.15	0.31
Real price of land	%	-7.00	-0.34	-0.80
Real price of labor	%	0.67	0.20	0.64
Real price of capital	%	0.62	0.30	0.34
Nominal price of land	%	-7.12	-0.43	-0.96
Nominal price of labor	%	0.55	0.11	0.48
Nominal price of capital	%	0.50	0.22	0.18

Table 21. Variation in the balance of trade by sector (US$ million)

Sectors	Experiments		
	Yield increase of land: 10%	Yield increase of labor: 10%	Yield increase of capital: 10%
Natural resources	-110.83	-42.06	-71.50
Natural resource-intensive man. goods	-224.52	-71.28	-134.80
Manufactured goods and capital goods	-225.11	-79.43	-151.10
Other mechanical equipment	-149.63	-49.74	-107.36
Grain	71.06	20.70	44.35
Other agricultural products	349.31	127.21	220.71
Animal products	183.69	85.32	184.83
Processed foodstuff	236.90	78.40	157.02
Dairy products	8.43	4.12	8.78
Services	-84.42	-29.29	-63.54
Total	54.88	43.95	87.39

Table 22. Percentage variation in relative domestic prices

Sectors	Experiments		
	Yield increase of land: 10%	Yield increase of labor: 10%	Yield increase of capital: 10%
Natural resources	0.52	0.22	0.38
Natural resource-intensive man. goods	0.44	0.17	0.34
Manufactured goods and capital goods	0.44	0.18	0.34
Other mechanical equipment	0.47	0.18	0.39
Grain	-4.26	-1.26	-2.67
Other agricultural products	-3.71	-1.36	-2.32
Animal products	-2.84	-1.32	-2.80
Processed foodstuff	-0.93	-0.28	-0.55
Dairy products	-1.40	-0.66	-1.41
Services	0.51	0.19	0.41

* Percentage variation of the price minus the percentage variation in the consumer price index

Table 23. Percentage variation in the amount produced

Sectors	Experiments		
	Yield increase of land: 10%	Yield increase of labor: 10%	Yield increase of capital: 10%
Natural resources	-0.33	-0.04	-0.02
Natural resource-intensive man. goods	-0.06	0.07	0.16
Manufactured goods and capital goods	-0.11	0.06	0.13
Other mechanical equipment	-0.54	-0.10	-0.23
Grain	2.05	0.75	1.52
Other agricultural products	3.80	1.40	2.52
Animal products	1.80	0.84	1.80
Processed foodstuff	1.65	0.63	1.26
Dairy products	0.87	0.42	0.87
Services	0.12	0.13	0.25

Table 24. Percentage variation in the value of exports

Sectors	Experiments		
	Yield increase of land: 10%	Yield increase of labor: 10%	Yield increase of capital: 10%
Natural resources	-1.45	-0.49	-0.81
Natural resource-intensive man. goods	-1.30	-0.39	-0.73
Manufactured goods and capital goods	-1.35	-0.42	-0.79
Other mechanical equipment	-1.37	-0.40	-0.89
Grain	13.99	4.03	8.77
Other agricultural products	10.05	3.64	6.35
Animal products	9.58	4.43	9.64
Processed foodstuff	3.46	1.16	2.33
Dairy products	4.55	2.20	4.73
Services	-0.82	-0.23	-0.52

* fob prices

Table 25. Percentage variation in the value of imports

Sectors	Experiments		
	Yield increase of land: 10%	Yield increase of labor: 10%	Yield increase of capital: 10%
Natural resources	0.76	0.34	0.61
Natural resource-intensive man. goods	0.80	0.33	0.64
Manufactured goods and capital goods	0.70	0.30	0.58
Other mechanical equipment	0.57	0.22	0.47
Grain	-7.30	-2.13	-4.56
Other agricultural products	-6.64	-2.49	-4.19
Animal products	-6.06	-2.90	-6.09
Processed foodstuff	-1.03	-0.29	-0.58
Dairy products	-2.48	-1.21	-2.58
Services	0.85	0.34	0.72

* cif prices

Table 26. Percentage variation in the use of land: in the agricultural sector

Sectors	Experiments		
	Yield increase of land: 10%	Yield increase of labor: 10%	Yield increase of capital: 10%
Grain	-1.07	-0.07	-0.18
Other agricultural products	0.30	0.29	0.63
Animal products	0.41	-0.22	-0.45

Table 27. Percentage variation in the use of labor in the agricultural sector

Sectors	Experiments		
	Yield increase of land: 10%	Yield increase of labor: 10%	Yield increase of capital: 10%
Grain	-1.90	-4.50	-1.08
Other agricultural products	0.22	-3.96	0.17
Animal products	-1.79	-3.64	-1.74

Table 28. Percentage variation in the use of capital in the agricultural sector

Sectors	Experiments		
	Yield increase of land: 10%	Yield increase of labor: 10%	Yield increase of capital: 10%
Grain	-1.88	-0.46	-4.98
Other agricultural products	0.24	0.09	-3.78
Animal products	-1.76	-0.81	-4.42

Table 29. Yield increase in Natural Resources and Natural-Resource-Intensive Manufactured Goods

	Unit	Variation
Balance of Trade	US$ million	656.01
Equivalent Variation	US$ million	6873.34
Implicit Deflator	%	0.90
Consumer price index	%	0.81
Real GDP real	%	1.81
Terms of exchange	%	-0.51
GDP (value)	%	2.73
Real price of land	%	1.25
Real price of labor	%	2.25
Real price of capital	%	1.82
Nominal price of land	%	2.08
Nominal price of labor	%	3.08
Nominal price of capital	%	2.65

Table 30. Yield increase in Natural Resources and Natural Resource-Intensive Man. Goods

Sectors	Exports (%)		Imports (%)	
	Quantum	Value (fob)	Quantum	Value (cif)
Natural resources	18.27	13.98	-3.14	-3.16
Natural resource-intensive man. goods	16.64	13.14	-4.37	-4.39
Manufactured goods and capital goods	-3.94	-3.20	2.91	2.92
Other mechanical equipment	-3.68	-2.95	2.15	2.14
Grain	-7.42	-5.58	3.81	3.91
Other agricultural products	-6.31	-4.54	4.26	4.30
Animal products	-7.97	-6.09	5.61	5.64
Processed foodstuff	-6.66	-5.16	3.30	3.35
Dairy products	-6.97	-5.24	5.02	5.03
Services	-5.26	-3.59	5.08	5.07

Table 31. Yield increase in Natural Resources and Natural Resource-Intensive Manufactured goods –Percentage Variations

Sectors	Production	Price to the farmer	Use of Factors		
			Land	Labor	Capital
Natural resources	7.13	-3.62	0.00	-2.90	-2.47
Natural resource-intensive man. goods	4.65	-3.00	0.00	-5.15	-4.64
Manufactured goods and capital goods	0.72	0.77	0.00	0.42	0.96
Other mechanical equipment	0.02	0.76	0.00	-0.19	0.34
Grain	-0.25	1.98	-0.01	-0.57	-0.33
Other agricultural products	-0.81	1.88	-0.42	-1.19	-0.96
Animal products	0.23	2.05	0.38	-0.04	0.26
Processed foodstuff	-0.20	1.60	0.00	-0.51	-0.04
Dairy products	0.81	1.86	0.00	0.57	1.05
Services	1.34	1.76	0.00	1.10	1.70

Table 32. Yield increase in the European Union

	Unit	Variation
Balance of Trade	US$ million	-22.16
Equivalent Variation	US$ million	-53.59
Implicit Deflator	%	-0.17
Consumer price index	%	-0.17
Real GDP real	%	0.00
Terms of exchange	%	-0.07
GDP (value)	%	-0.16
Real price of land	%	-1.12
Real price of labor	%	0.05
Real price of capital	%	0.03
Nominal price of land	%	-1.29
Nominal price of labor	%	-0.13
Nominal price of capital	%	-0.15

Table 33. Yield increase in the European Union

Sectors	Exports (%)		Imports (%)	
	Quantum	Value (fob)	Quantum	Value (cif)
Natural resources	0.62	0.49	-0.08	-0.11
Natural resource-intensive man. goods	0.60	0.47	-0.02	-0.09
Manufactured goods and capital goods	0.51	0.38	-0.08	-0.12
Other mechanical equipment	0.53	0.42	-0.13	-0.12
Grain	-3.47	-3.85	0.11	-0.37
Other agricultural products	-3.17	-3.64	0.37	-0.32
Animal products	-6.28	-6.66	5.14	2.46
Processed foodstuff	-0.28	-0.52	0.17	-0.18
Dairy products	-2.23	-2.52	0.99	0.21
Services	0.48	0.35	-0.20	-0.22

Table 34. Yield increase in the European Union

Sectors	Production	Price to the farmer	Use of Factors		
			Land	Labor	Capital
Natural resources	0.19	-0.13	0.00	0.18	0.20
Natural resource-intensive man. goods	0.13	-0.14	0.00	0.11	0.14
Manufactured goods and capital goods	0.14	-0.12	0.00	0.12	0.15
Other mechanical equipment	0.25	-0.11	0.00	0.24	0.26
Grain	-0.08	-0.39	0.24	-0.29	-0.28
Other agricultural products	-0.61	-0.48	-0.15	-0.88	-0.87
Animal products	-0.57	-0.41	-0.02	-0.83	-0.82
Processed foodstuff	-0.08	-0.24	0.00	-0.09	-0.07
Dairy products	-0.05	-0.29	0.00	-0.06	-0.04
Services	0.01	-0.14	0.00	0.00	0.02

3

Effects of agricultural research on the consumer

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3.1 Evolution of agricultural consumer prices

Agricultural research affects consumers in at least three ways: causing a drop in the real price of food, diminishing the supply crises and, consequently, price variability and, finally, improving the quality of the food ingested.

Indeed, research also affects consumers in a more indirect manner, since the price and quality of natural fibers and other raw materials for non-food industries must also be considered. Despite their importance, the report will concentrate on food for two reasons: in low-income populations food is by far the most important item of the family budget and, since natural fibers are mixed with synthetic fibers, it would be necessary to undertake a study of the whole textile industry, which would mean going beyond the scope and methodology used herein.

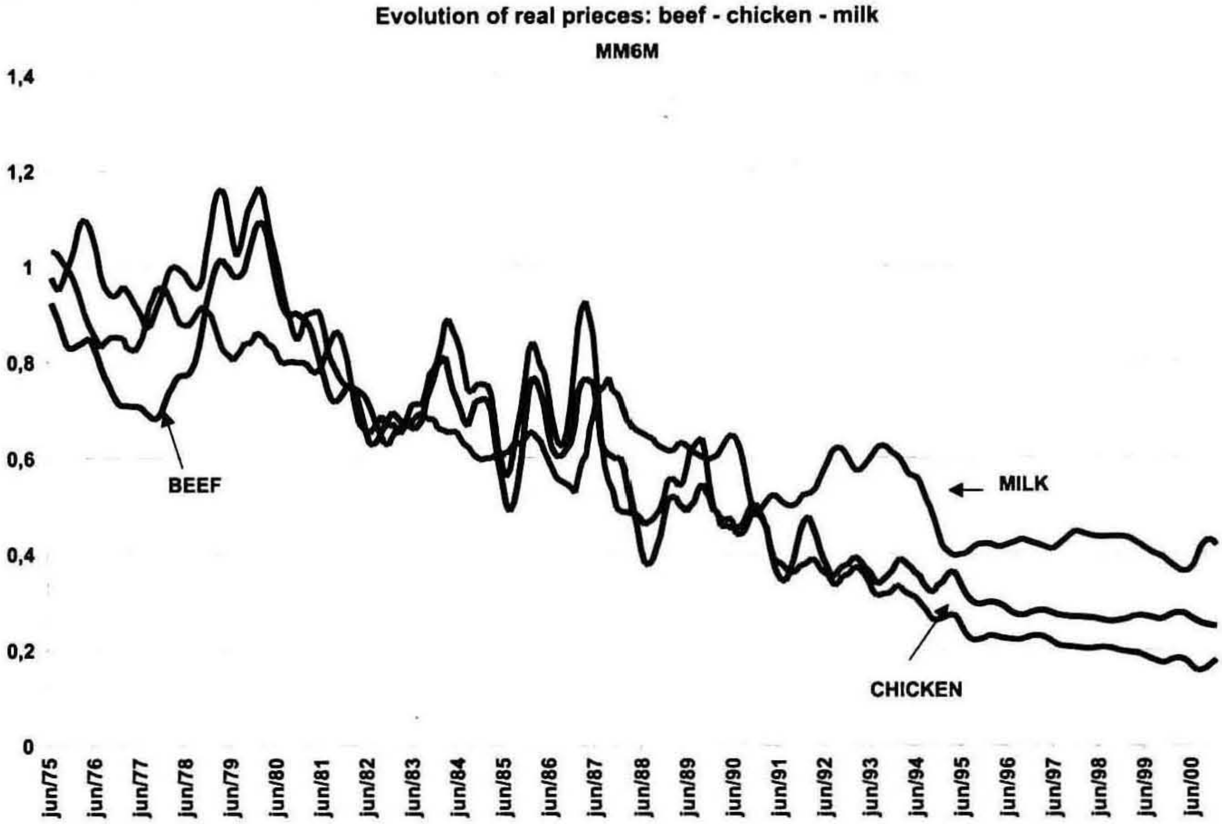
Agricultural research also affects the environment and, thus, the consumer. Without disagreeing with this positive effect, we believe that it is the farmers and rural workers that benefit more directly. Nevertheless, to the extent that research contributes to, for example, reducing the presence of chemical residues in the products, this effect will be considered in the third item mentioned above, namely improvement in product quality.

In this report, we present the results pertaining to the issue of food prices. A drop in food prices can be attributed to three main elements. Firstly, food prices can decrease as a result of persistent rises in productivity, which increase production (keeping all else constant) and, through the market competition mechanism, cause a drop in prices at end of the chain. This classical mechanism for transferring productivity gains to consumers is well known in agricultural economics. On the other hand, prices also tend to diminish along time through a decrease in the margin between the farmers' prices and those to consumers, which we shall call the processing and commercialization margin. Lastly, price reductions can result from occasional reductions in the tax load.

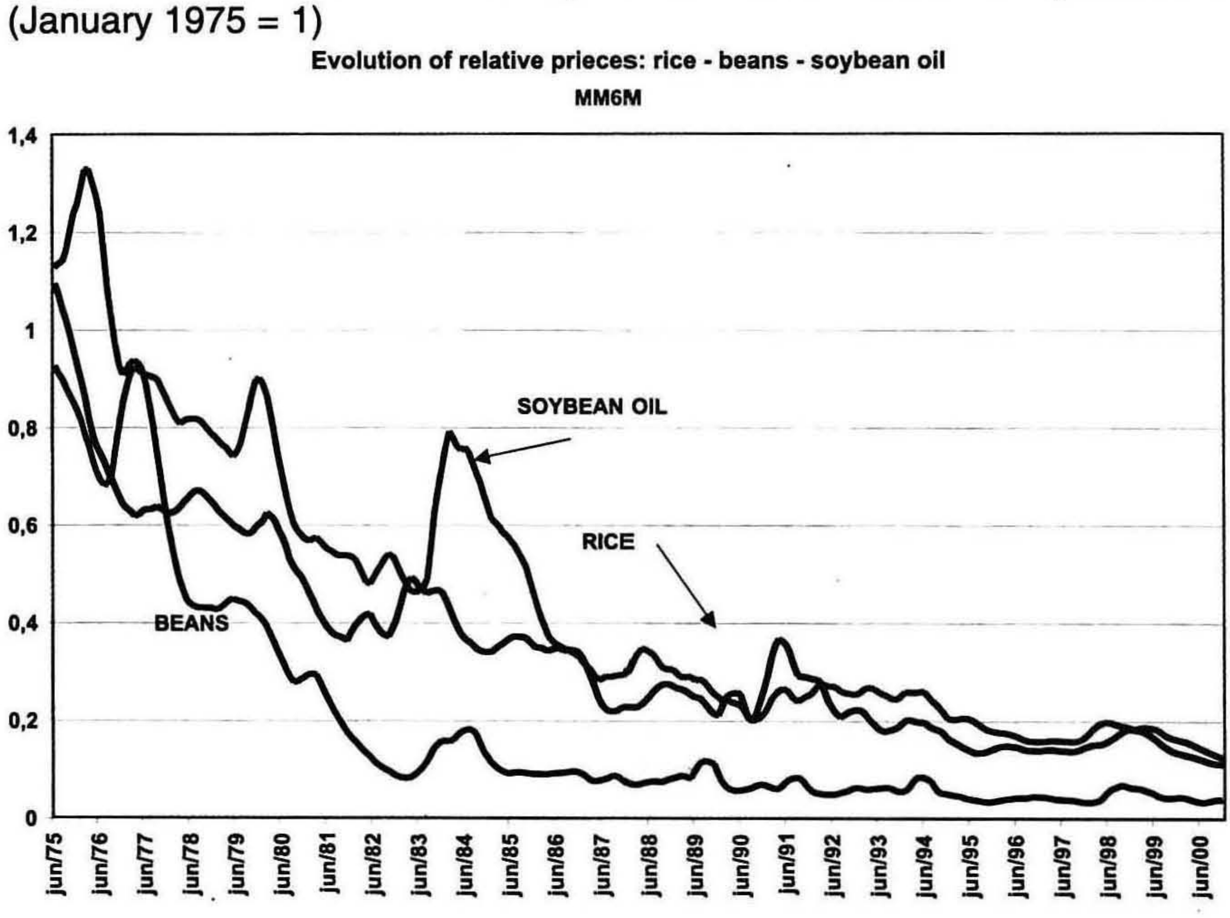
Before discussing causes, however, it is necessary to verify the behavior of retail prices. We worked with monthly data from the FIPE's Consumer Price Index for the city of São Paulo, for the period from January 1975 to December 2000. There are some advantages in working with the FIPE index, particularly the systematic review of family budgets and the fact that it is the only index whose prices are collected every week. Our product basket is made up of milk, beef, chicken, rice, beans, oranges, tomatoes, onions, potatoes, bananas, sugar, lettuce, coffee, carrots, papaya, eggs, and soybean oil. It is a very representative set of the food item.

Graphs 1 to 6 show the evolution of real prices (in relation to the IGP (General Price Index) of the Getúlio Vargas Foundation) of the products listed above. ***Graph 7*** shows the average index, calculated using the weighs of each product in the CPI (Consumer Price Index) –FIPE.

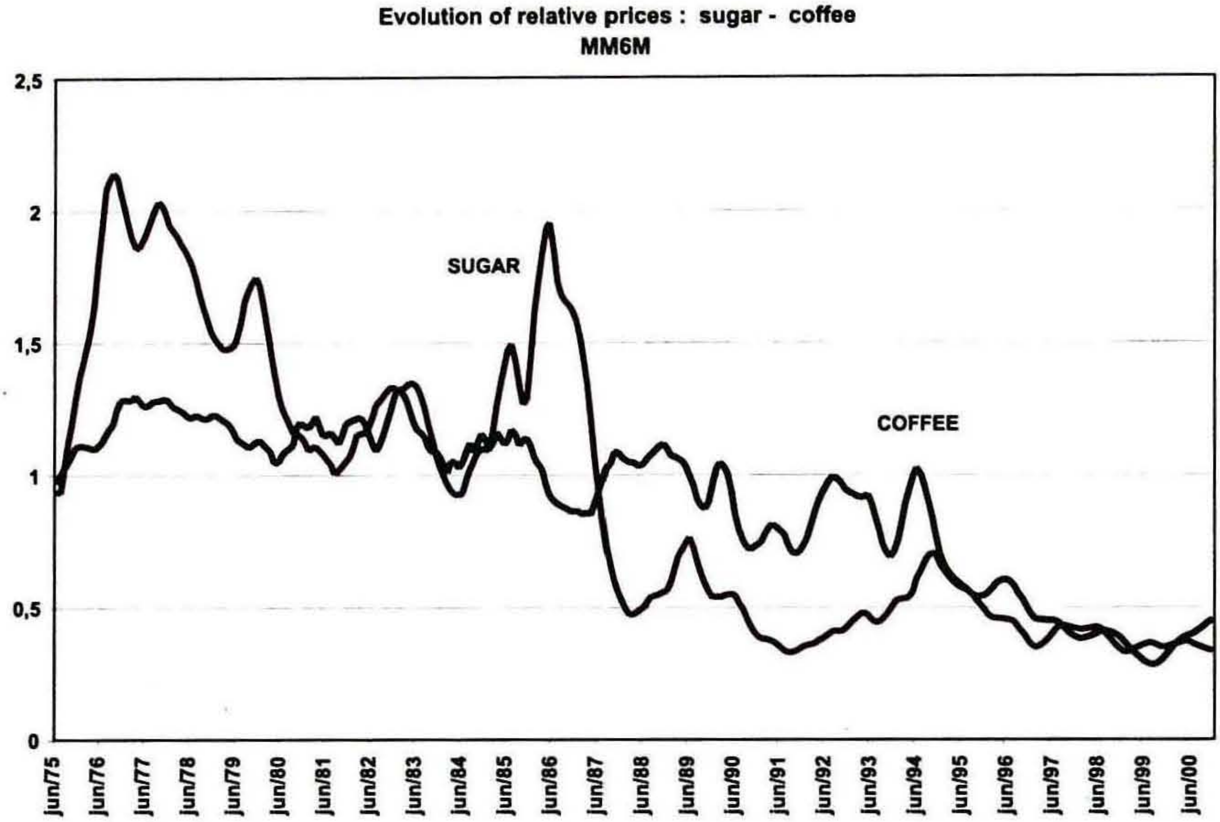
Graph 1 – Evolution of the real prices of beef, chicken and milk. (January 1975 = 1)



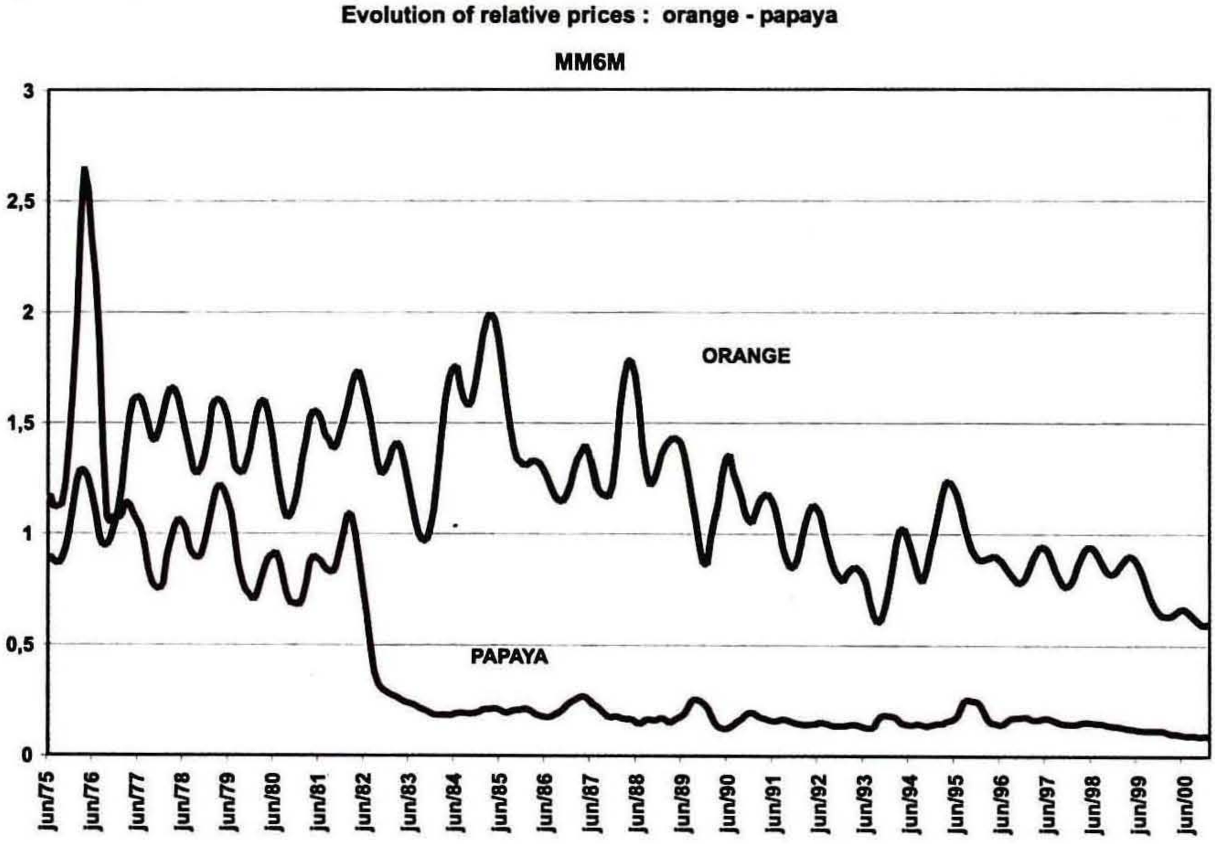
Graph 2 – Evolution of the real prices of rice, beans and soybean oil. (January 1975 = 1)



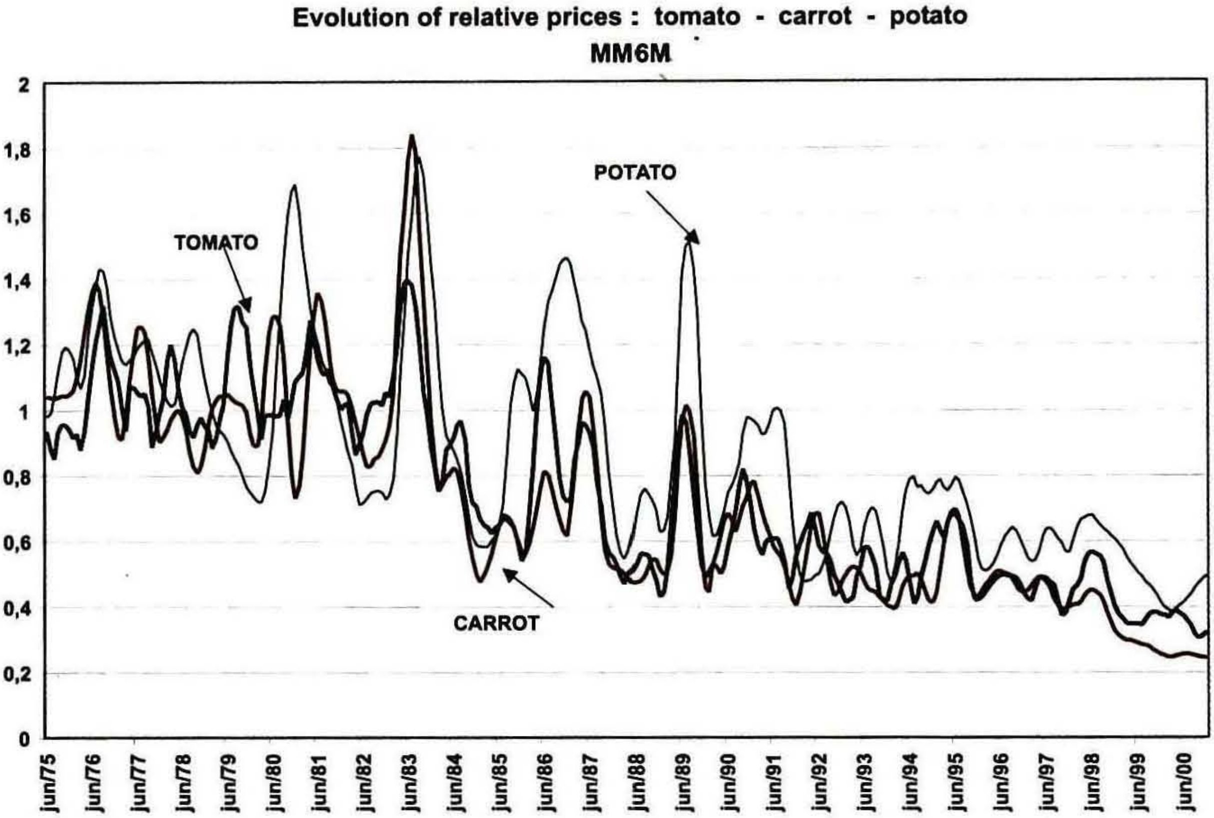
Graph 3 – Evolution of the real prices of sugar and coffee. (January 1975 = 1)



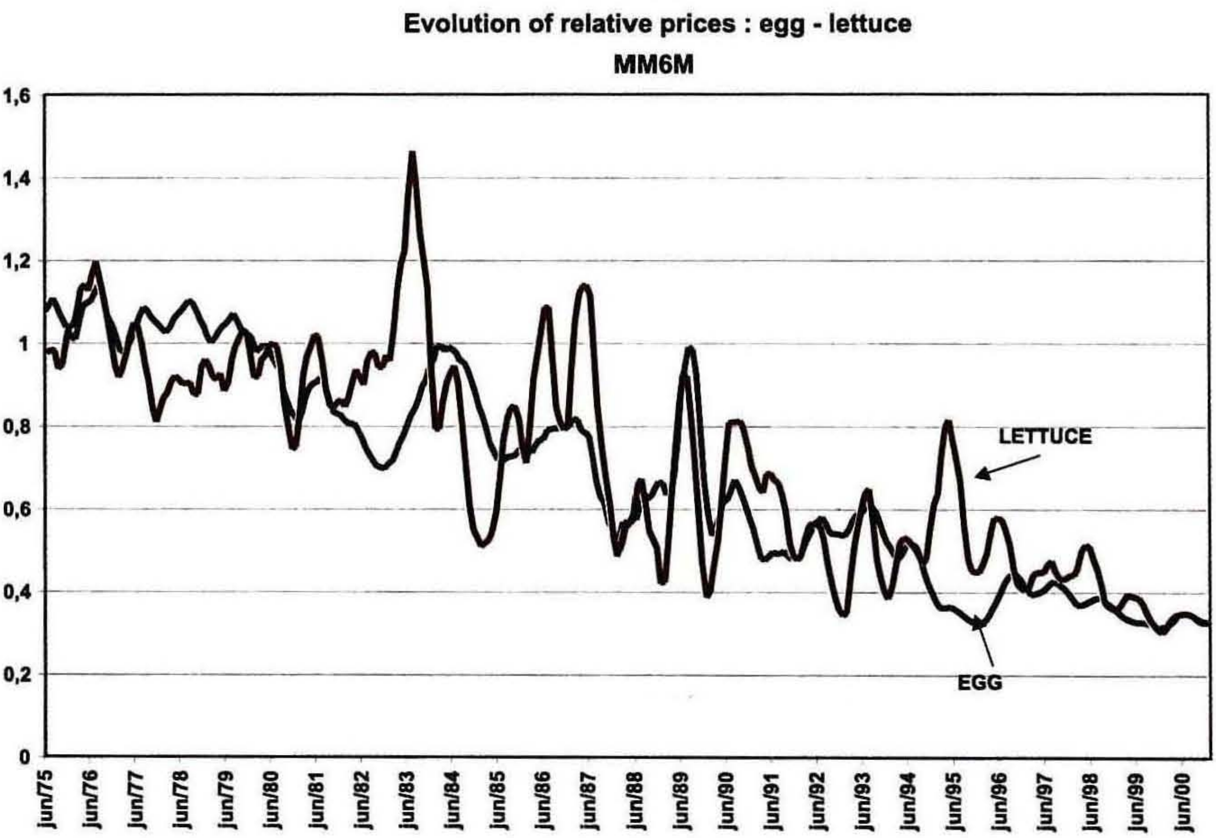
Graph 4 – Evolution of the real prices of oranges and papaya. (January 1975 = 1)



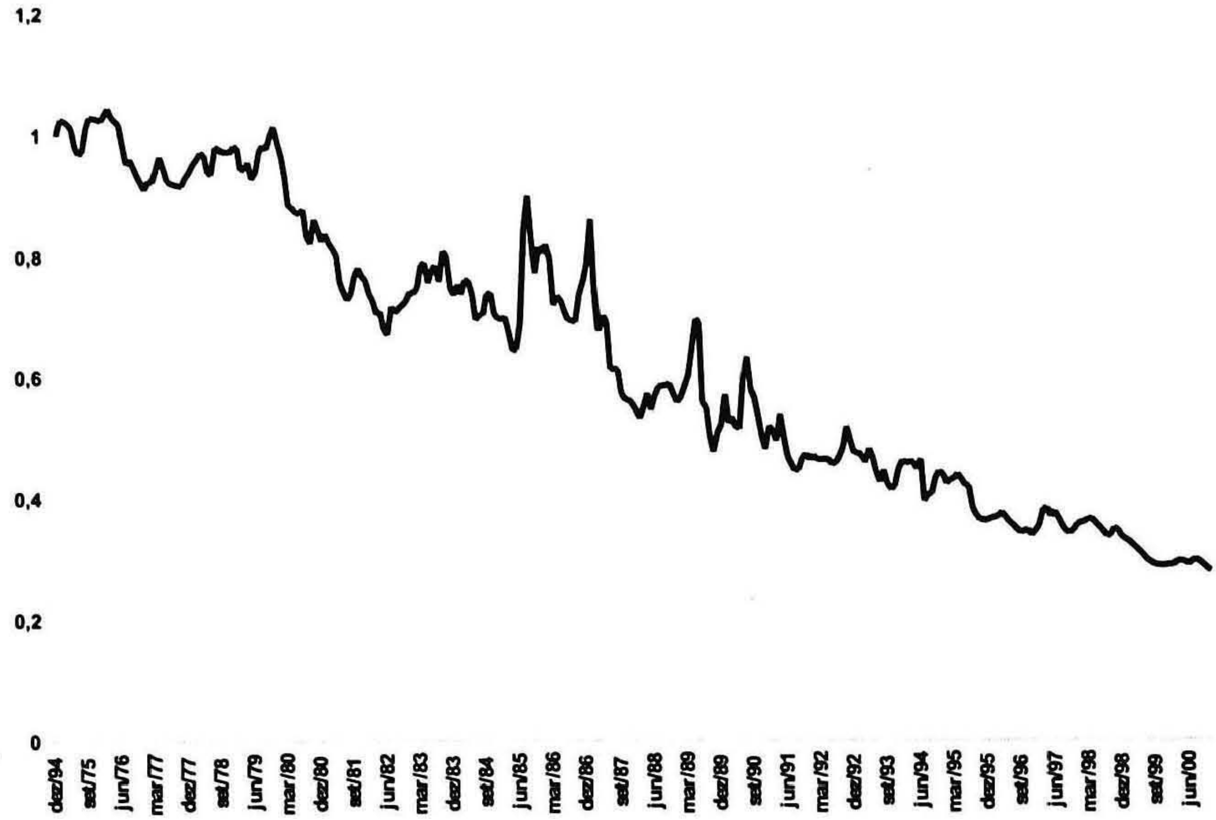
Graph 5 – Evolution of the real prices of tomatoes, carrots and potatoes. (January 1975 = 1)



Graph 6 – Evolution of the real prices of eggs and lettuce. (January 1975 = 1)



Graph 7 – Price index for food basket. (December 1994 = 1)



In all cases, there is a significant drop in real prices. ***Table 1,*** below, shows the annual rates for each product.

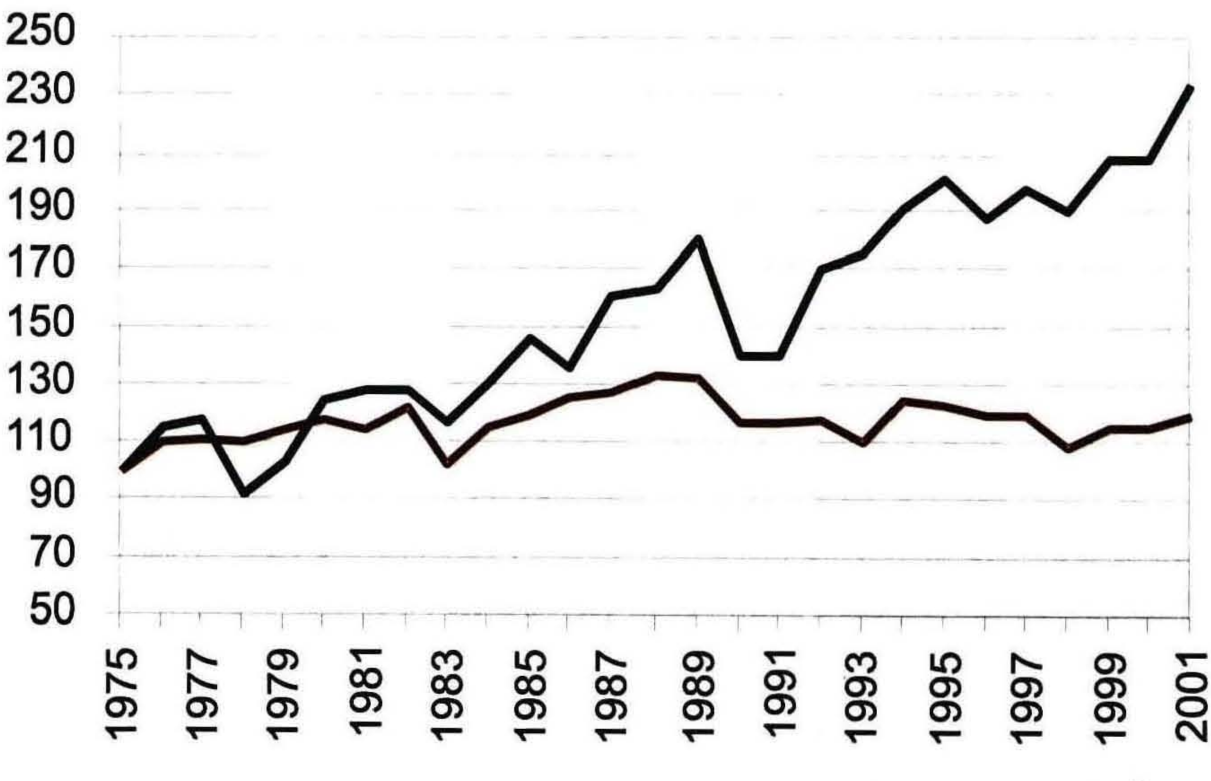
Table 1 – Real Prices – Average Annual Variation 1975-2000.

	%		%
BANANA	-3.07	MILK	-3.58
BEANS	-13.39	ORANGE	-2.65
BEEF	-5.82	PAPAYA	-4.41
CARROTS	-5.51	POTATOES	-3.51
CHICKEN	-8.22	RICE	-7.77
COFFEE	-7.38	SOYBEAN OIL	-8.06
EGG	-5.17	SUGAR	-4.77
LETTUCE	-4.52	TOMATOES	-4.7
	OVERALL	-5.25	

As shown above, the results are truly remarkable. For 25 years, the real prices of the food in a significant basket have dropped, on average, 5% per year! It is true that such a price reduction resulted from a series of factors. Nevertheless, without a strong rise in productivity, the obvious effect of research, it would be impossible for farmers to absorb such price reductions without an interruption in the supply. In fact, the period under issue was accompanied by a constant expansion of food supply, both in the domestic and export markets.

Graph 8 shows the evolution of grain production and farmed area, in which the former is used as an approximation of overall agricultural supply. It is clear that Brazilian agriculture is increasingly expanding through the incorporation of technology, rather than farmed area.

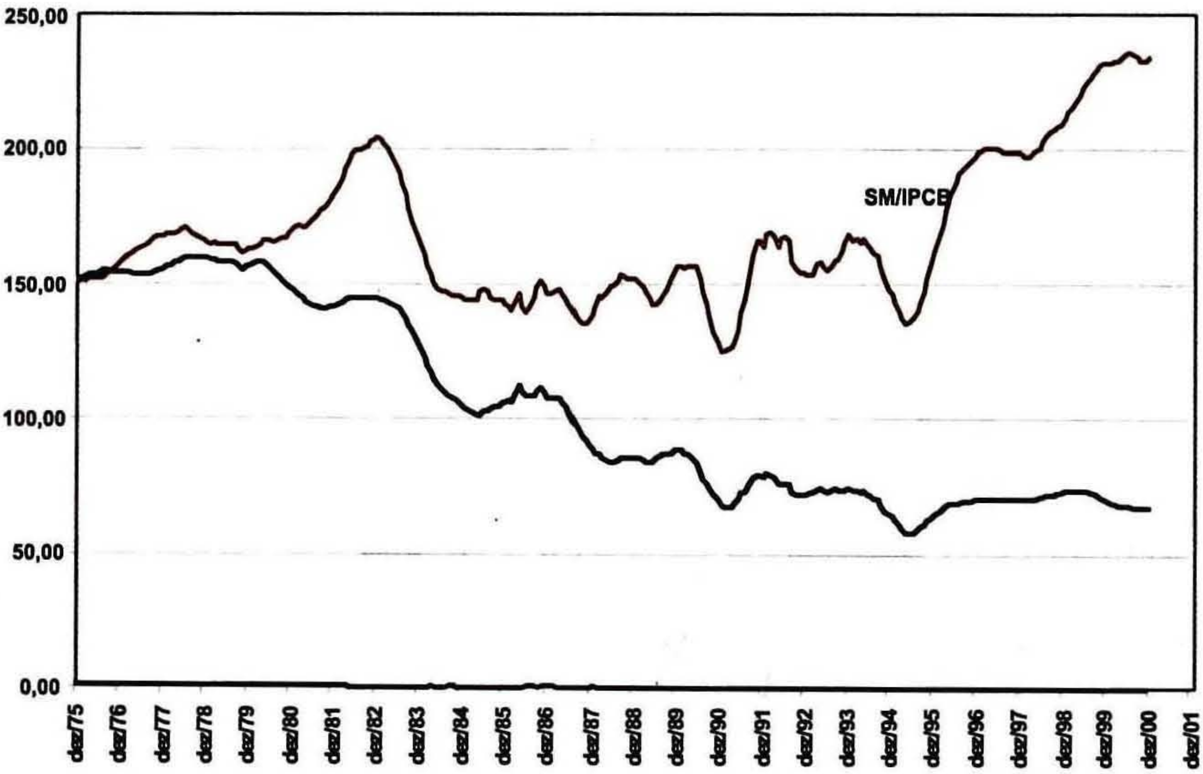
Graph 8 – Index of the evolution of the grain farmed area and production in Brazil, 1975 – 2000. (1975 = 100)



The major implication of food price reductions is the rise in the purchasing power of salaries. Two exercises were carried out in **Graph 9**, namely, the value of the minimum wage deflated using the General Price Index of the Getúlio Vargas Foundation and, alternatively, using the food price index based on our own basic basket. The clarity of the results is impressive: the rise in the purchasing power after 1995 suggests that, in addition to the effects of research, the stabilization of inflation helps explain the improvement of the whole picture. An important point to be discussed later.

Nevertheless, it could be argued that, although relevant for many people, the minimum wage is a value determined by the government. For this reason, we carried out another exercise considering the wage of masons or bricklayers, also a monthly calculation by FIPE, beginning in the early 1970s[1]. The amazing

Graph 9 – Value of the minimum wage deflated using the IGP-FGV and the Food Price Index. (December 1975 = 1)



[1] This procedure was first adopted by Dias, G.L.S. and Amaral, C.M. (2000) "Mudanças estruturais na agricultura brasileira, 1980-1998". In: Baumann, R. (org) Brasil: Uma Década de Transição. Ed. Campus, São Paulo, 332 pp.

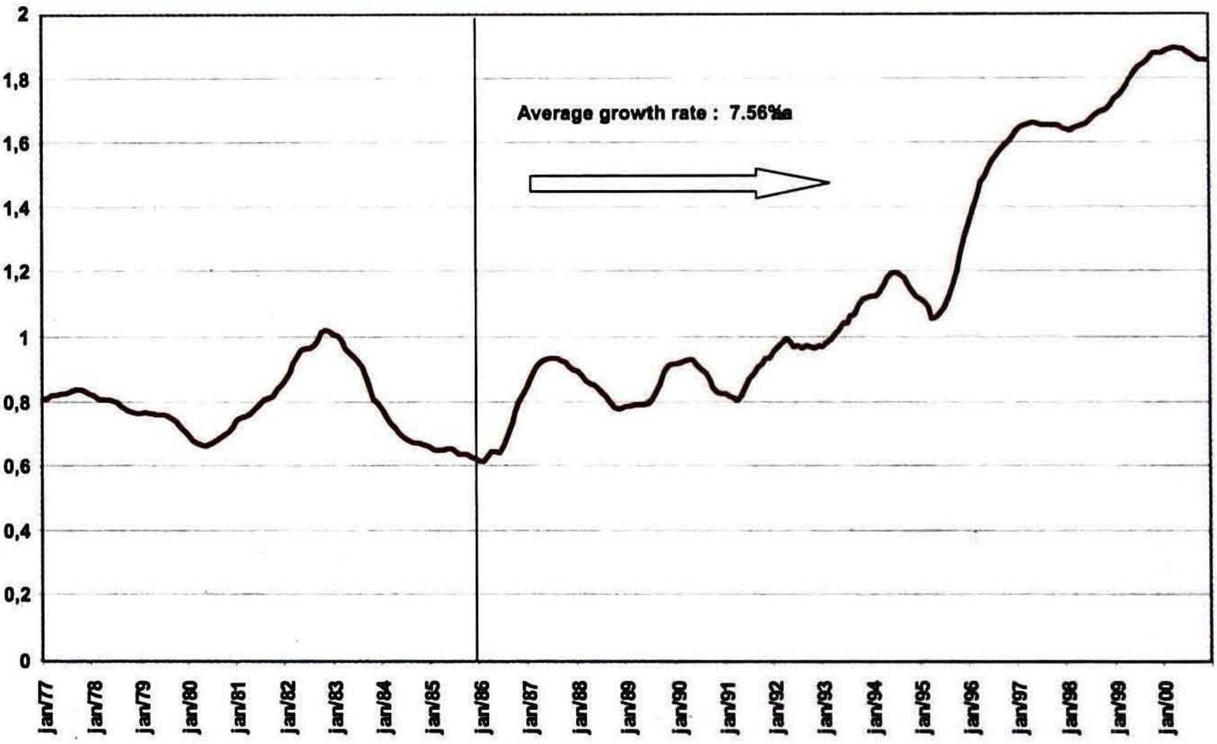
results are shown in **Graph 10.** From **1986** to **2000** the salary of masons increased geometrically at 7.5% p.a.

In summary, there is no doubt that the strong food-cost reductions benefited consumers.

As previously noted, the reduction in food costs may result from at least three causes: productivity gains, reduction of the gap between farm and retail prices and reduction in the tax load. To a certain extent, the stabilization of the economy also played a role.

Graphs 11 to **20** and **Table 2** show the evolution of the productivity of the various crops under analysis. With the exception of bananas, the gains are truly expressive.

Graph 10 – Evolution of the purchasing power of the average mason wage measured at basic basket prices – city of São Paulo. (December 1976 = 1)



Graphs 11 to 20 – Index of the evolution of productivity in rice, banana, coffee, onions, beans, orange, tomatoes, corn, soybean, and potatoes. (1975 = 100)

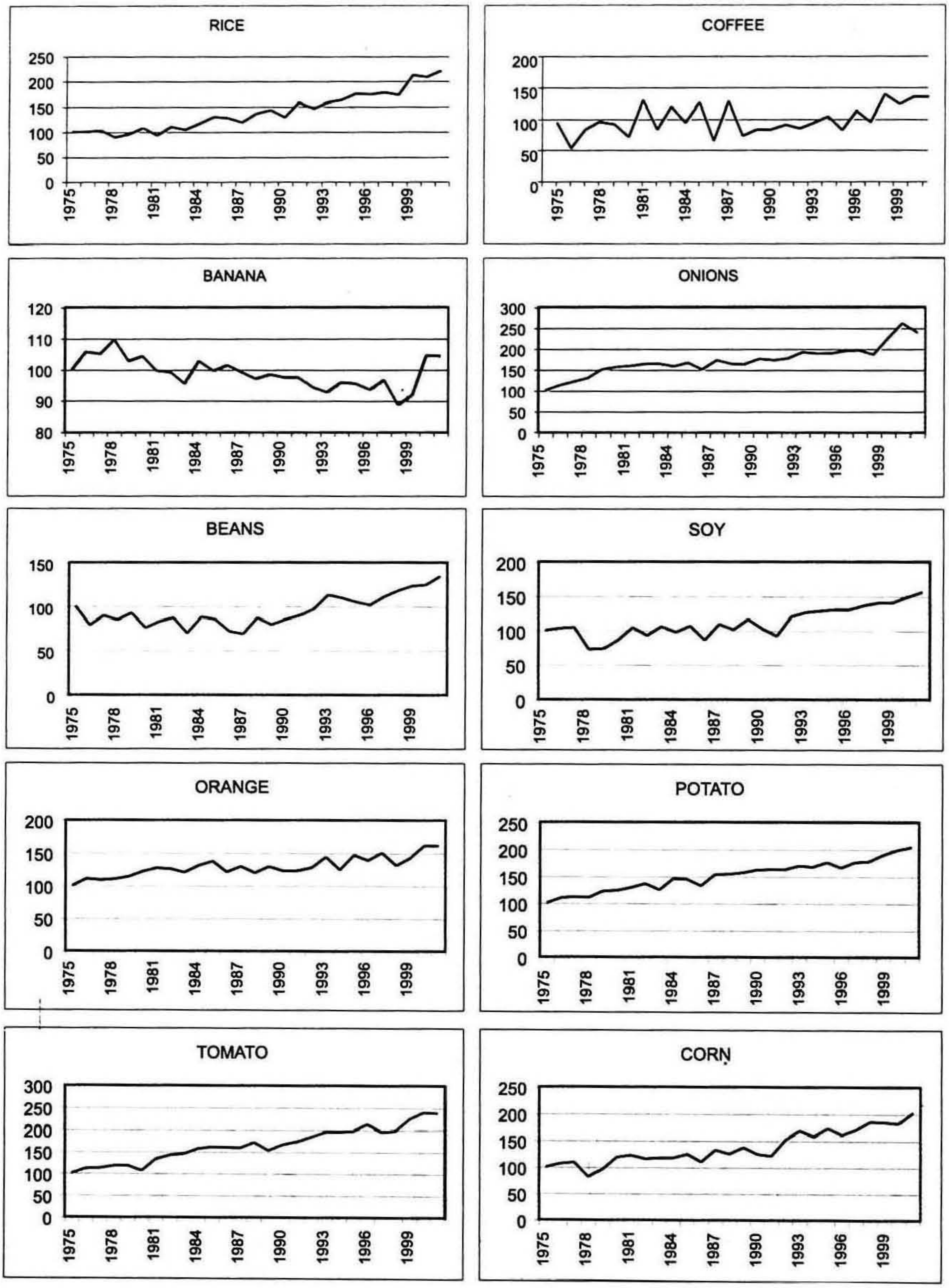
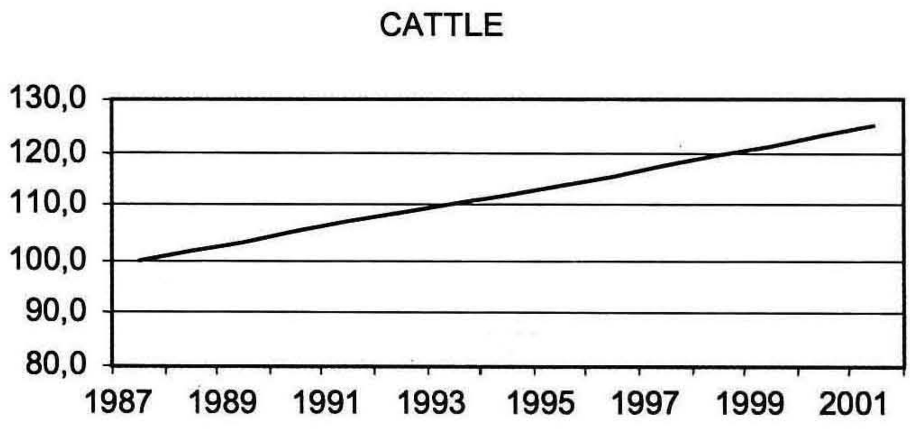


Table 2 – Variation of the Average Productivity per hectare, 1975 to 2000.

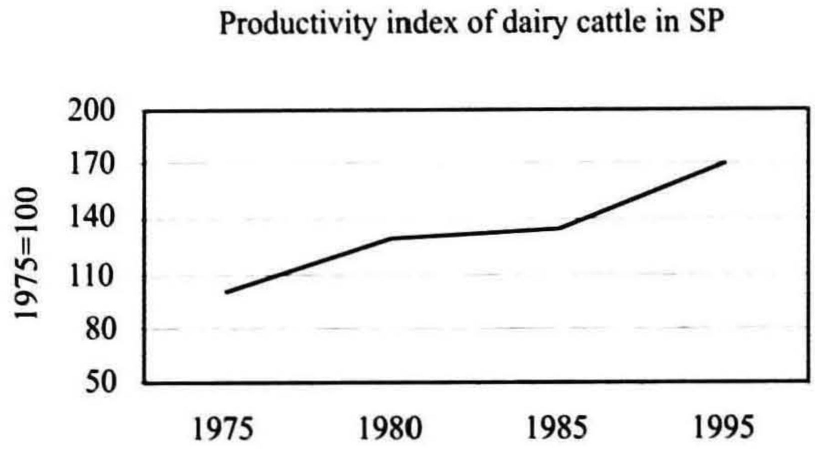
Product	Percentage
Rice	107%
Banana	5%
Coffee	40%
Onions	160%
Beans	24%
Orange	61%
Tomatoes	139%
Potatoes	98%
Soybean	48%
Sugarcane	43%
Corn	81%

Animal products also showed a pattern of substantial productivity increments. ***Graphs 21*** and ***22*** and ***Table 3*** show the cattle productivity outcomes. The primary data used in the construction of the indexes came from agricultural censuses. It is possible to observe that, as in the case of crops, there was a significant increase in cattle productivity during the period. Please observe that milk production per cow increased by 70% from 1975 to 1995 and that the slaughter rate varied approximately 25% from 1987 to 2000.

Graph 21 – Index of the evolution of productivity in beef cattle production.



Graph 22 – Index of the evolution of productivity in dairy cattle production.



Source: Agricultural Censuses

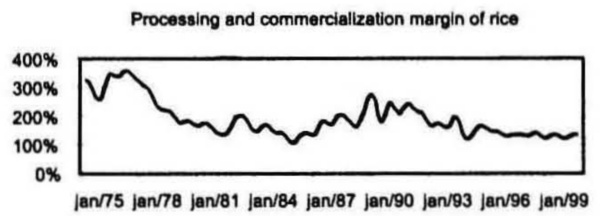
Poultry production also made important progress. From 1970 to 2000 the average age at slaughter diminished from 49 to 41 days, while the food conversion rate moved from 1.7 to 1.4.

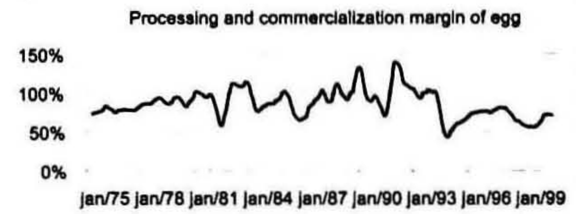
In addition to analyzing productivity performance, it is essential to assess the behavior of the industrialization and commercialization margins. A reduction of said margins can influence the food-price reduction pattern. **Graphs 23** to **31** reveal the evolution of the industrialization and commercialization margins of the food selected for the study during the 1975-2000 period. Except for rice and beans, the margins are similar or greater than those at the beginning of the period, which makes the contribution of productivity even more relevant in explaining the drop in the final prices of food.

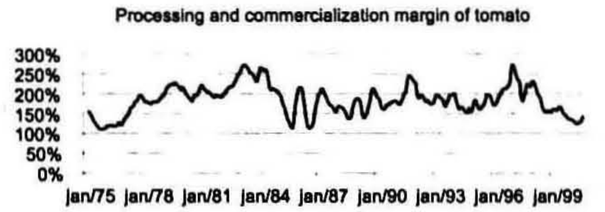
As previously argued, consumer prices can vary as a result of productivity, processing and industrialization margins and, lastly, tax load variations. With regard to the last item, it was impossible to design a consistent index due to the acknowledged complexity of the ICMS[2] legislation. Indeed, each state treats the matter differently, with variations along time. It can be said, however, that taxes on food were reduced during the 1990s in the State of São Paulo, particularly after 1995; the same seems to hold true for other regions.

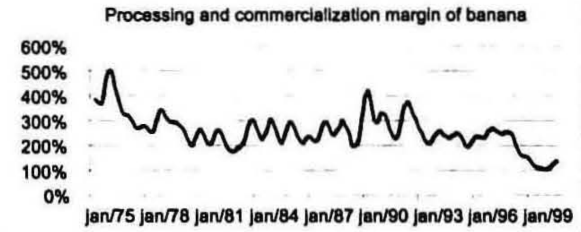
[2] Translator's Note: The acronym stands for Tax on Circulation of Merchandise and Services.

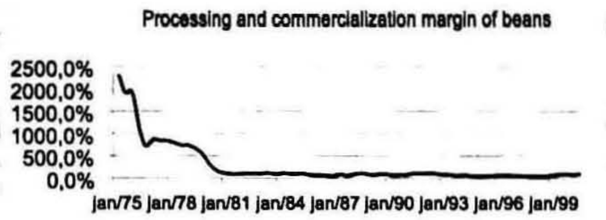
Graphs 23 to 31 – Processing and commercialization margins for rice, tomatoes, beans, onions, coffee, eggs, bananas, milk, and potatoes from 1975 to 2000.

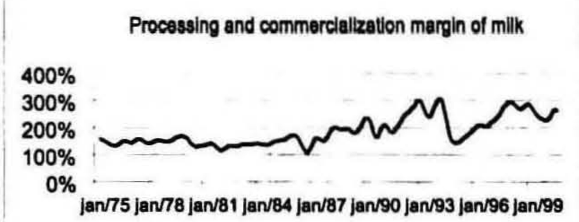


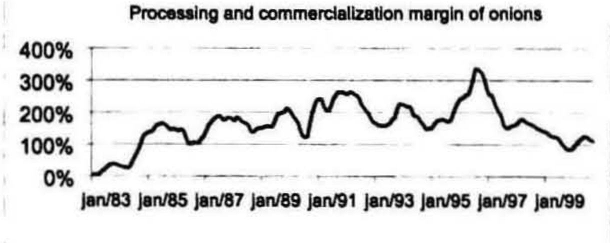


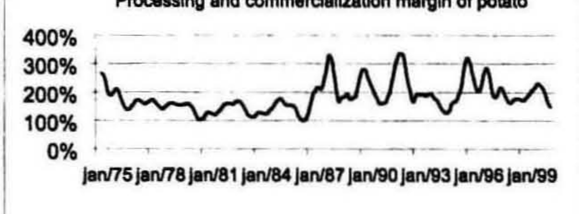


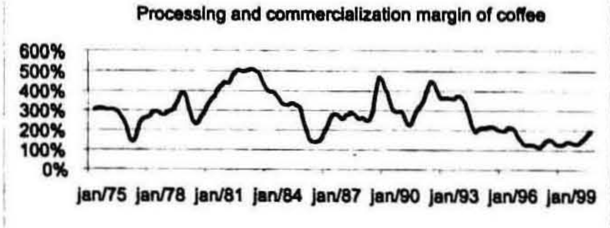












An examination of the evolution of real salaries, as shown in **Graph 10**, highlights a phenomenon that has occurred since 1995, when there was a rise in the growth rate of the purchasing power of salaries. The fact that there was no change in the trend of productivity during that period, however, leads us to believe that something new was at work. In our opinion, the tax load reduction mentioned above, as well as the reduction in the inflation tax resulting from the stabilization of inflation, is probably part of the overall explanation.

In conclusion, there was an important, sustained drop in the real prices of food during the last 25 years. This drop resulted in a rise in real salaries, especially for low-income groups. Furthermore, it seems clear that the main cause of this behavior was a persistent rise in the incorporation of technology by the agricultural sector of the economy. And the technology, in turn, derived essentially from research on the use of so-called modern inputs. The social gains arising from agricultural research cannot be more patent, particularly in a country with admittedly bad income distribution. In this case, there is probably no distributive policy more efficient than lowering food costs for the poor.

3.2 Supply and seasonal variations in agricultural prices

On the basis of the premise that agricultural research develops crop varieties adapted to prevailing soil, climate, pests, and management conditions, it is reasonable to suppose that production can be more easily distributed along time and space. Such distribution would contribute to minimizing supply crises during the period of sharp variations in supply, whether due, or not, to between-harvest periods. Consequently, the purpose of this section of the report is to check to what extent a possible reduction in the magnitude of the seasonal variations could reflect increased regularity in food supply, contributing to lessen price volatility along the year and among the regions. This test was performed using two distinct methodologies: i) the X-11 method (ARIMA) included in the Eviews econometric package and ii) the structural decomposition of the components in the time series being studied.

3.2.1 Calculation of the Season Pattern of Agricultural Prices – X-11 Method (ARIMA)

The X-11 method is a statistical package built into Eviews, with some limitations to be noted, namely, all series must cover at least five years and no more than 20 years of monthly data. The X-11 method calculates the evolution of seasonal prices along years and months, and reports on the tests on the statistical significance of the seasonal pattern between and within years. The results of these tests are shown in **Table 4**, below.

The data reveal that all products, except coffee, have a seasonal pattern along the year, which is perhaps reasonable, since coffee is an international commodity whose market is stabilized by buffer stocks. Between years, no variations can be seen in the seasonal patterns of lettuce and carrots. Between months, however, there are fantastic variations in the prices of oranges, lettuce and carrots, since, among other reasons, these products cannot be stocked.

Table 4 – F Test on seasonal stability

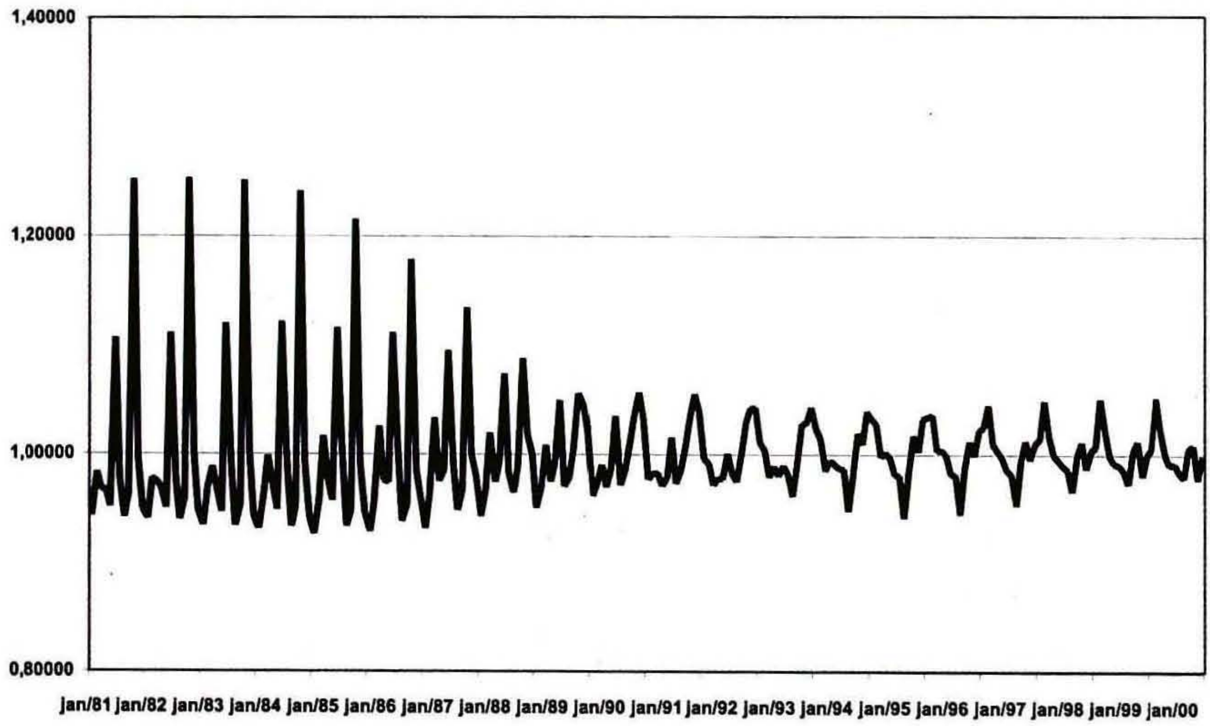
F test on seasonal stability 1981/2000

Product	Month	Year	Product	Month	Year
SUGAR	3.56	3.52	CARROT	9.31	1.54 *
LETTUCE	10.17	1.45 *	BEANS	1.91	1.87
RICE	3.32	3.47	CHICKEN	2.43	4.82
BANANA	7.54	2.86	ORANGE	20.3	2.39
POTATO	4.43	2.01	MILK	4.71	4.38
ONIONS	4.35	2.26	PAPAYA	4.16	2.31
COFFEE	1.53 *	2.26	SOY OIL	2.17	3.69
BEEF	4.77	5.67	EGG	3.45	4.71
			TOMATO	3.30	1.89

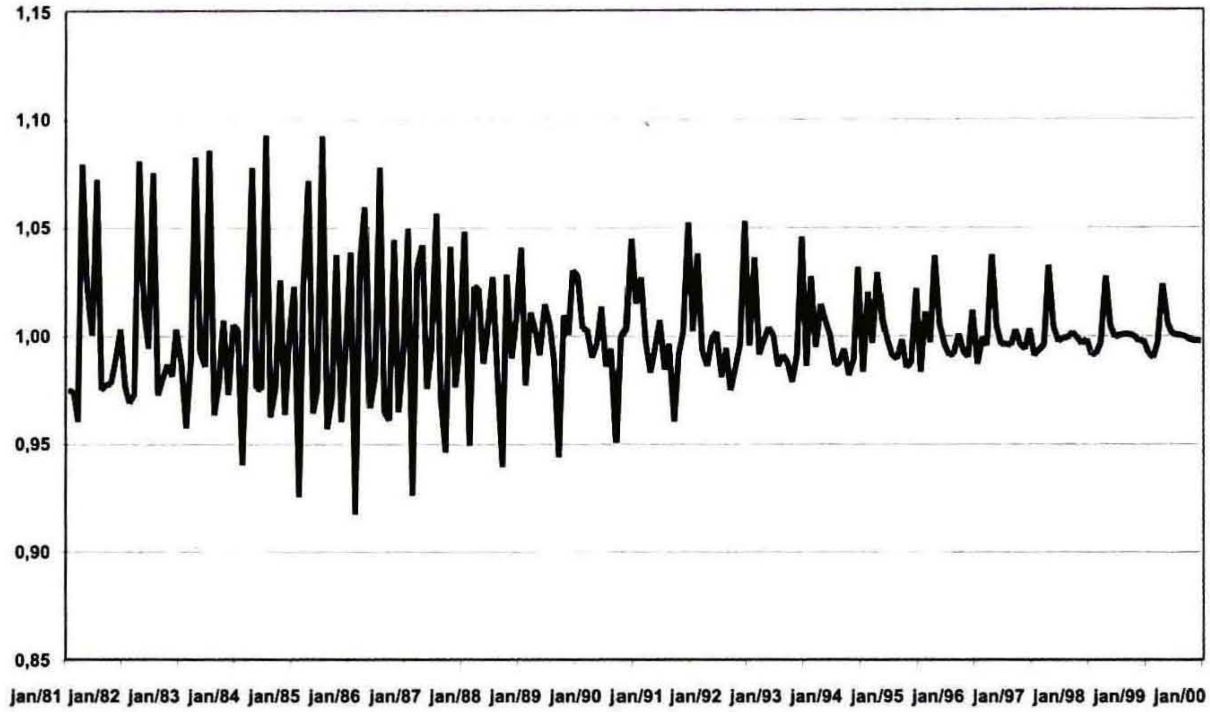
(*) not significant

Graphs 32 to 48, below, show the seasonal behavior of prices by product, there being a reduction in the dispersion between years that probably lessen supply crises for products such as sugar, milk, chicken, beef, rice, and onions. Dispersion indeed increases during periods with high inflation rates, thereby hiding the benefits of increased technology input in agriculture. On the other hand, the diminished price fluctuations arising from stability and technical progress are highlighted.

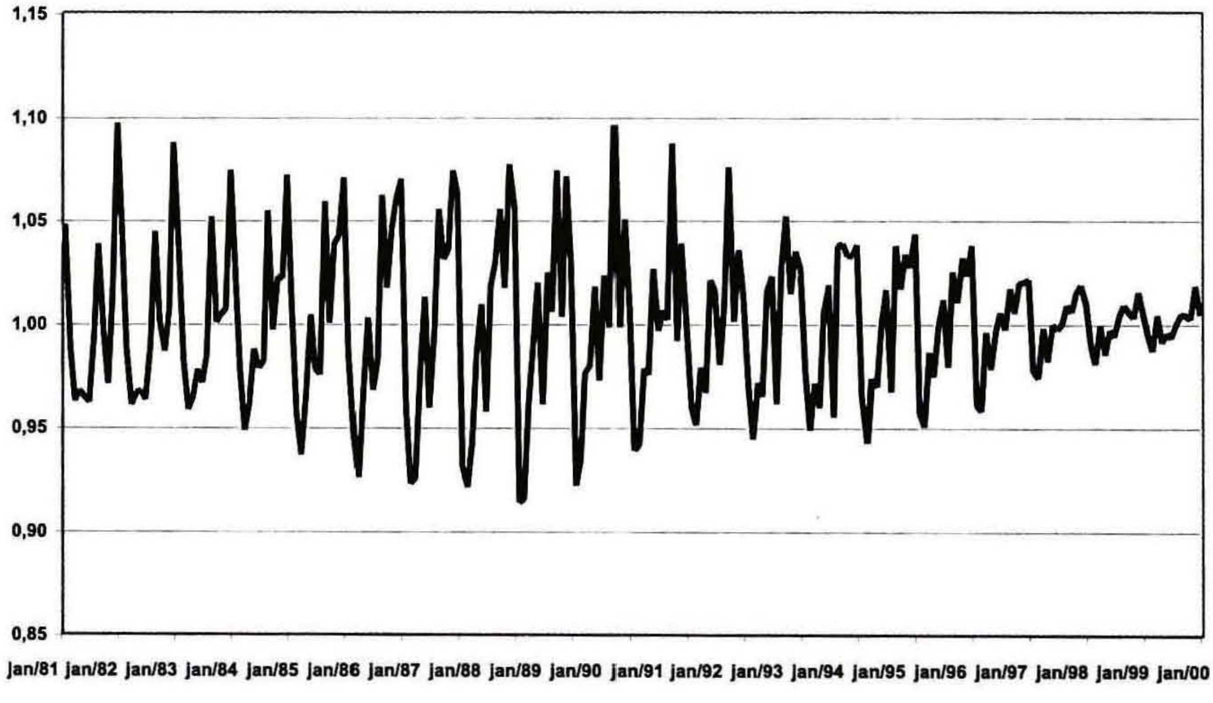
Graph 32. Seasonal pattern: sugar



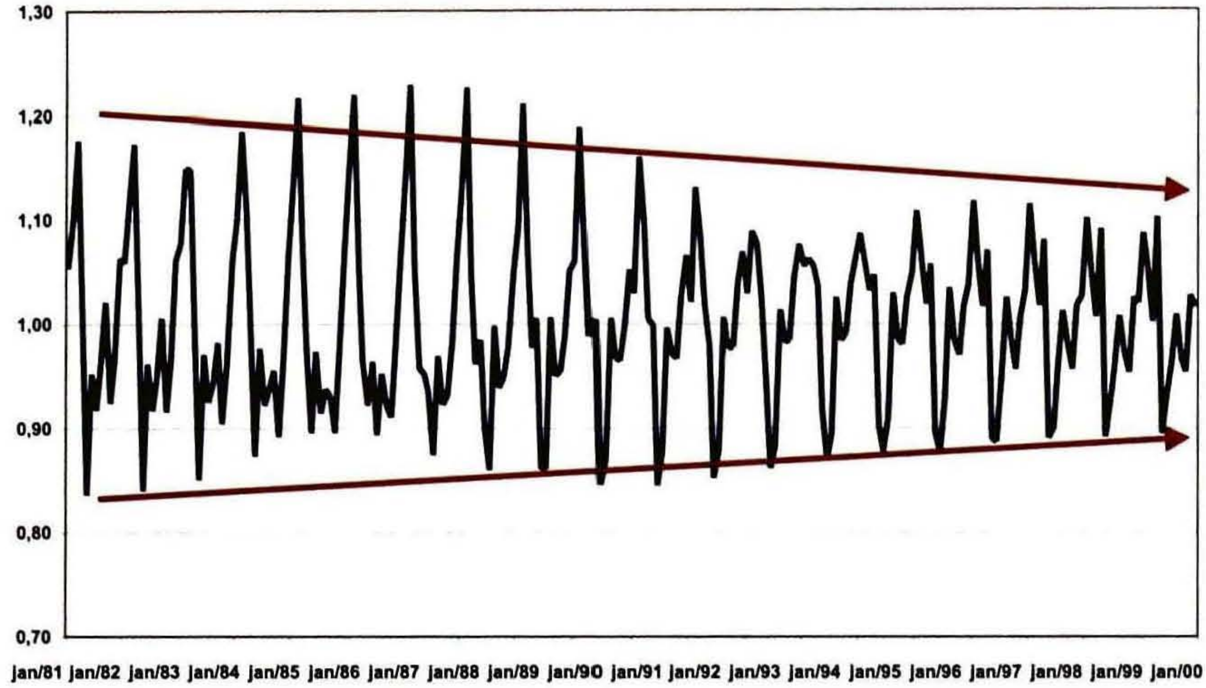
Graph 33. Seasonal pattern: milk



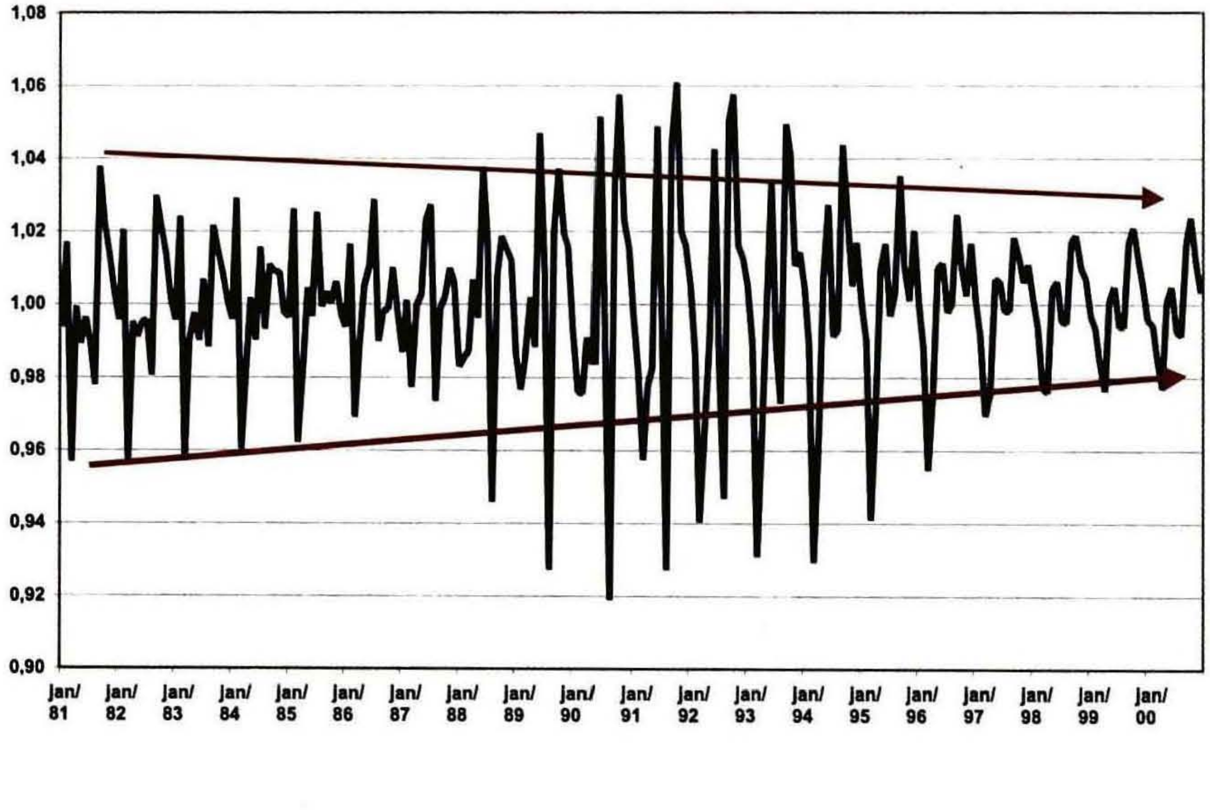
Graph 34. Seasonal pattern: chicken



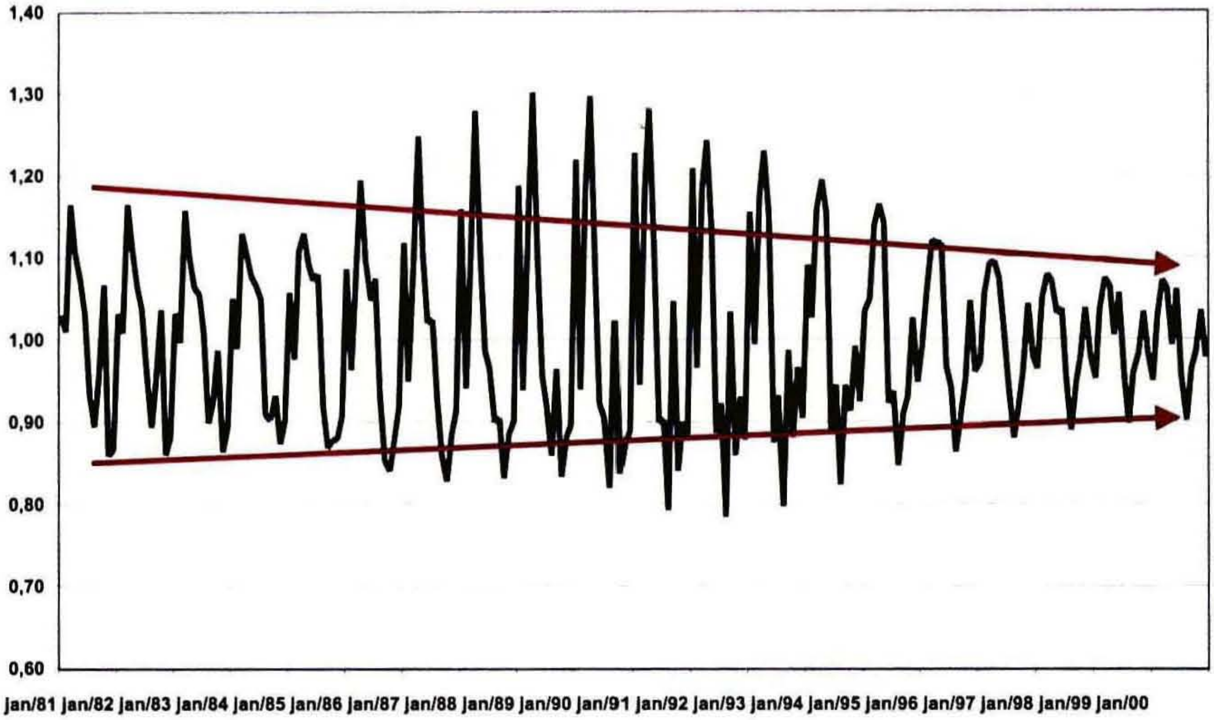
Graph 35. Seasonal pattern: beef



Graph 36. Seasonal pattern: rice

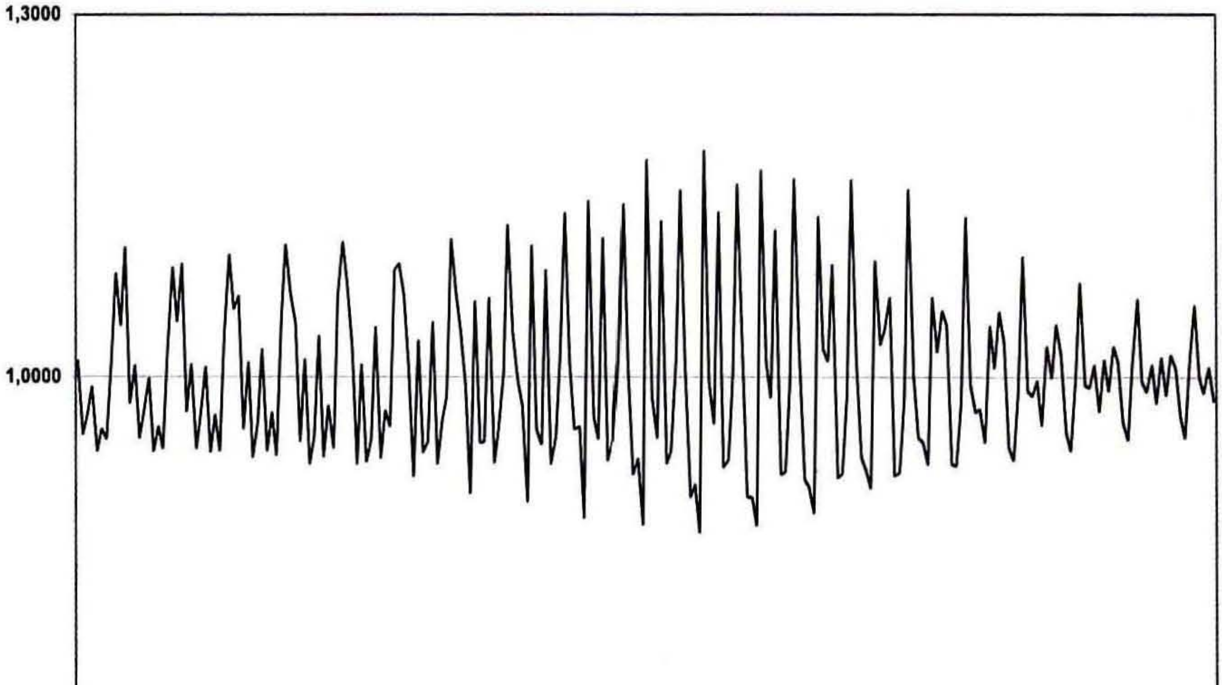


Graph 37. Seasonal pattern: onions

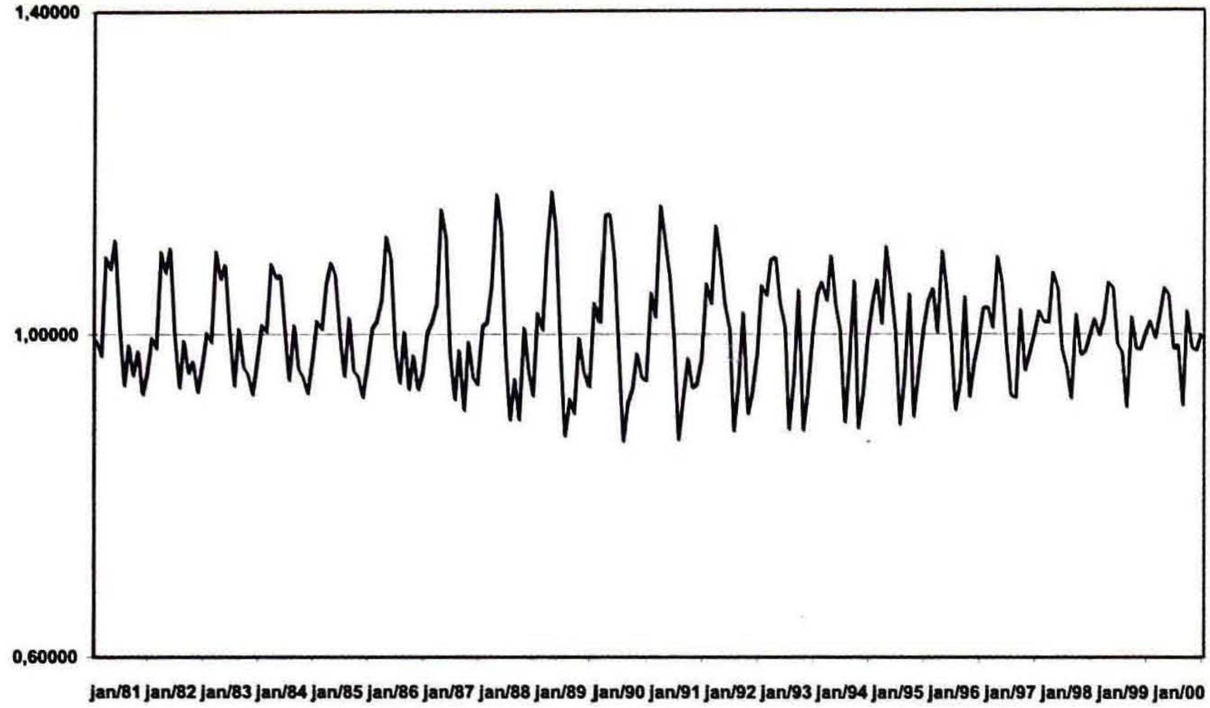


For the other products the behavior of the seasonality standard between years does not show a definite trend.

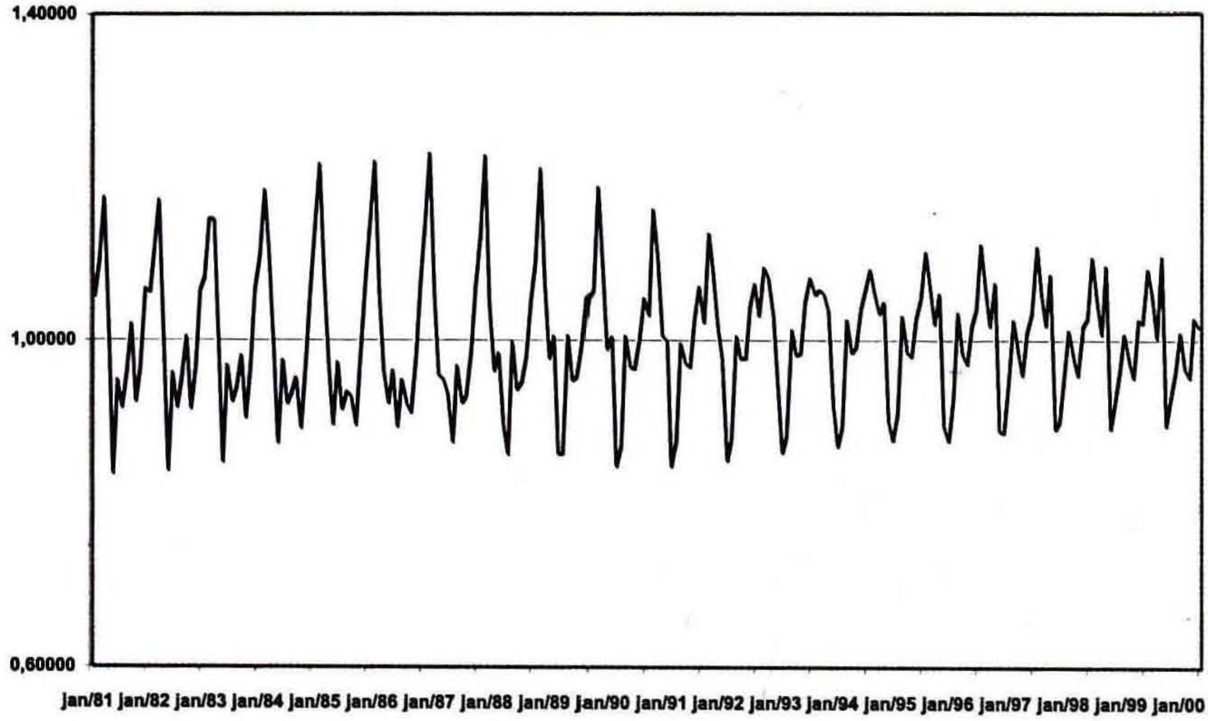
Graph 38. Seasonal pattern: banana



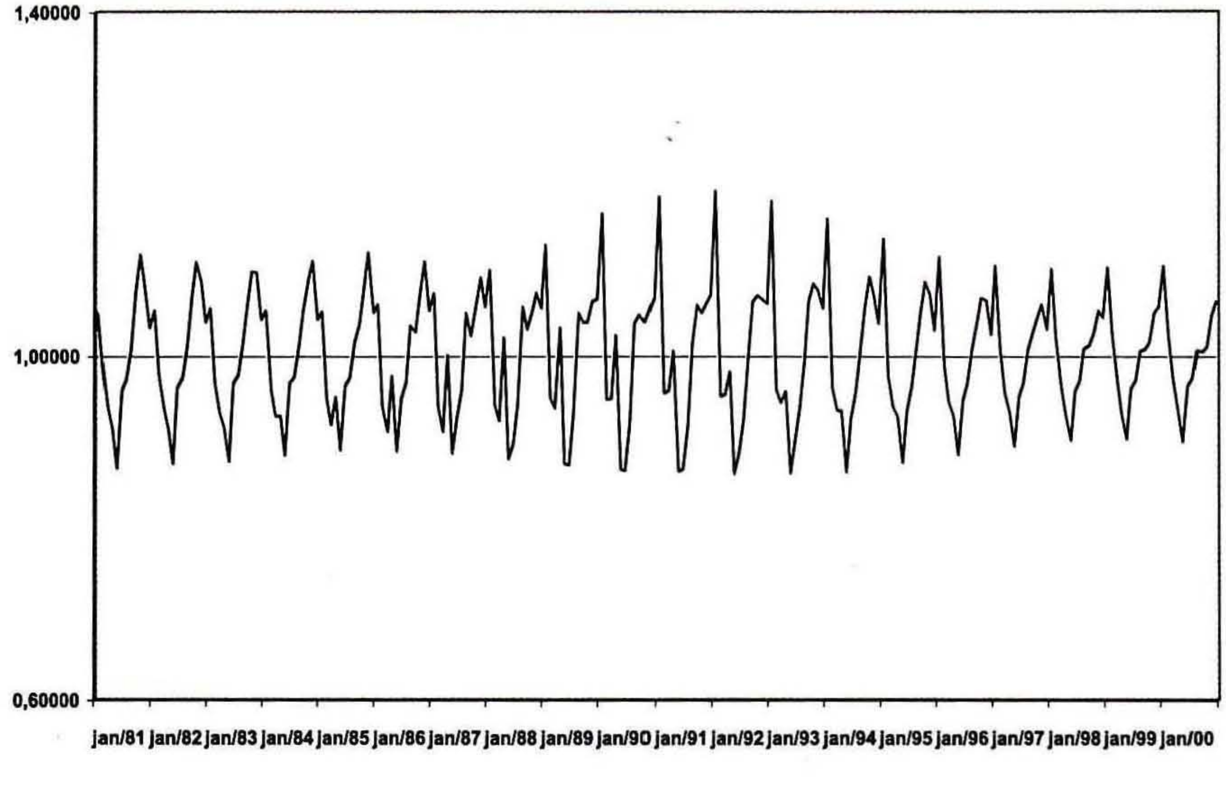
Graph 39. Seasonal pattern: potato



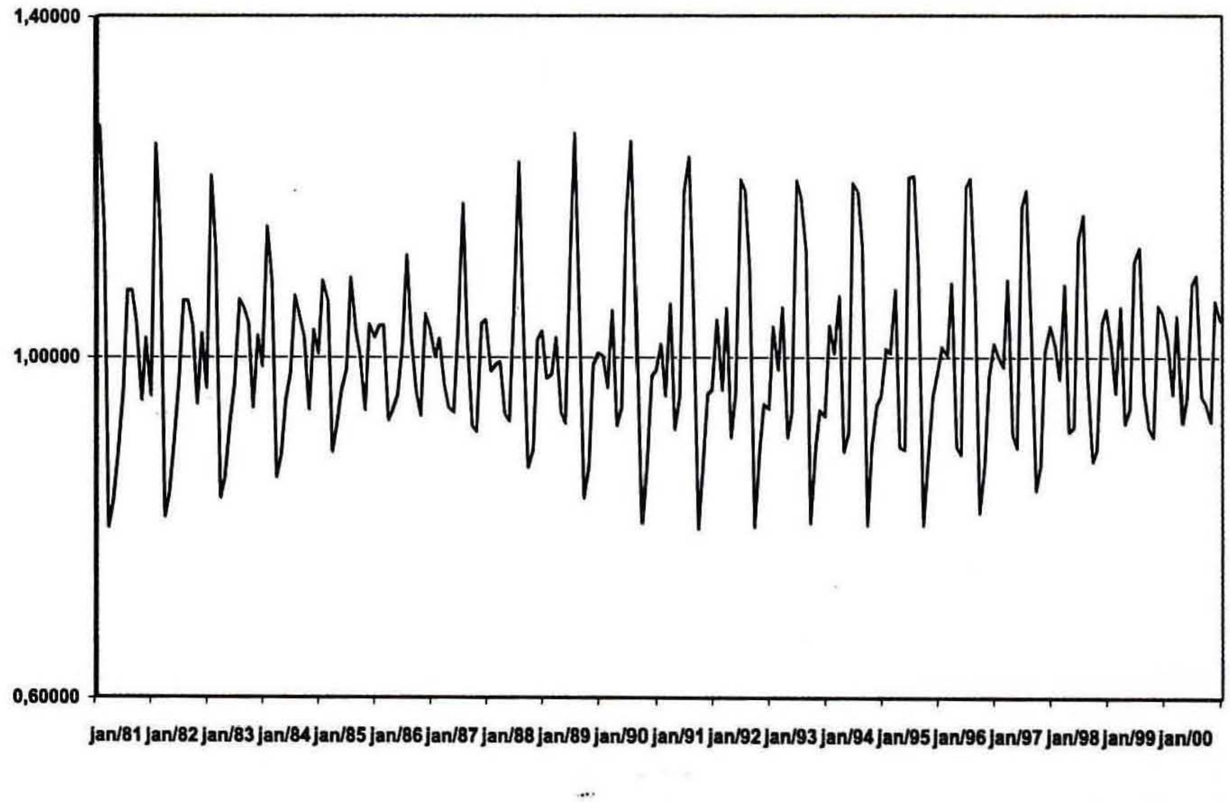
Graph 40. Seasonal pattern: carrots



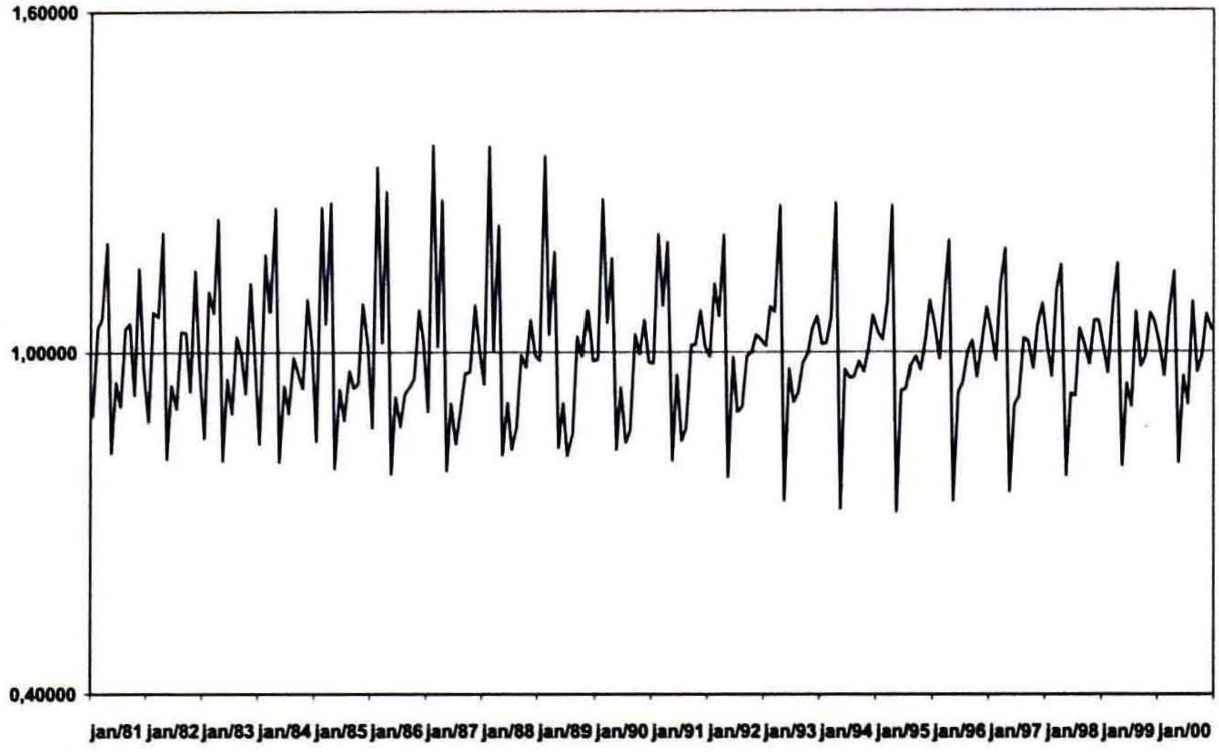
Graph 41. Seasonal pattern: orange



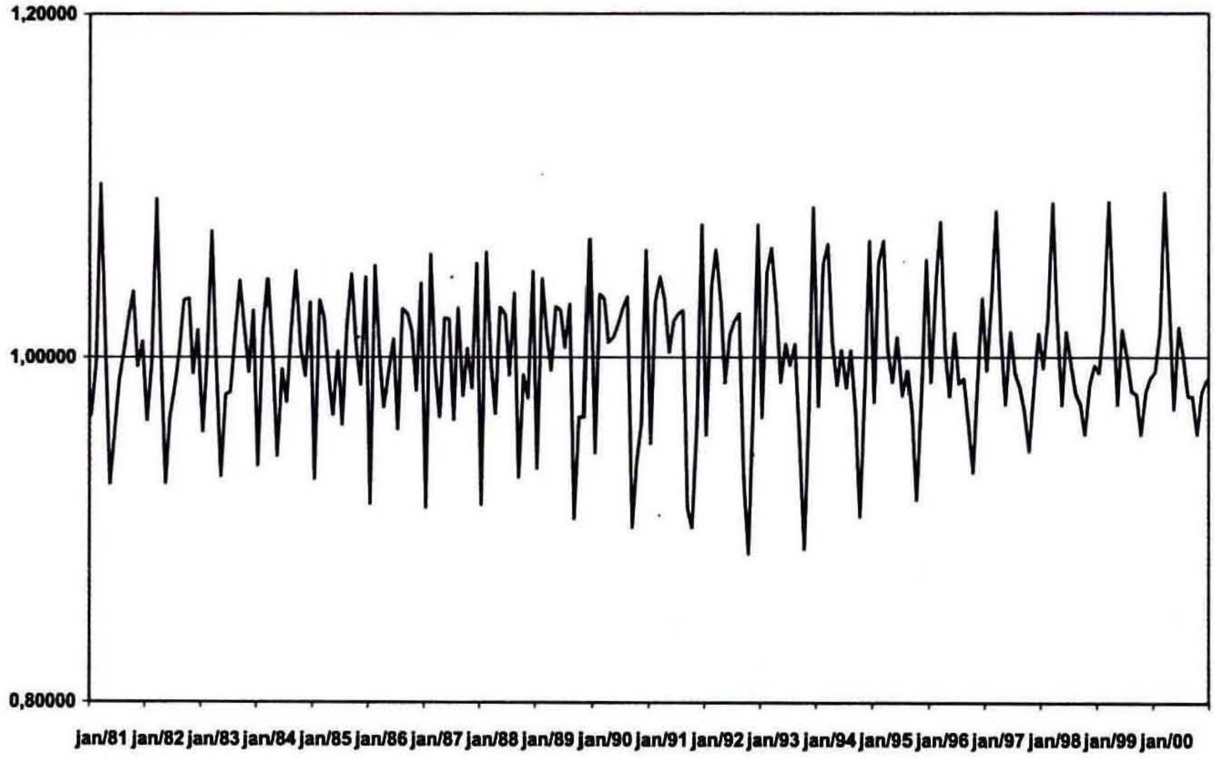
Graph 42. Seasonal pattern: papaya



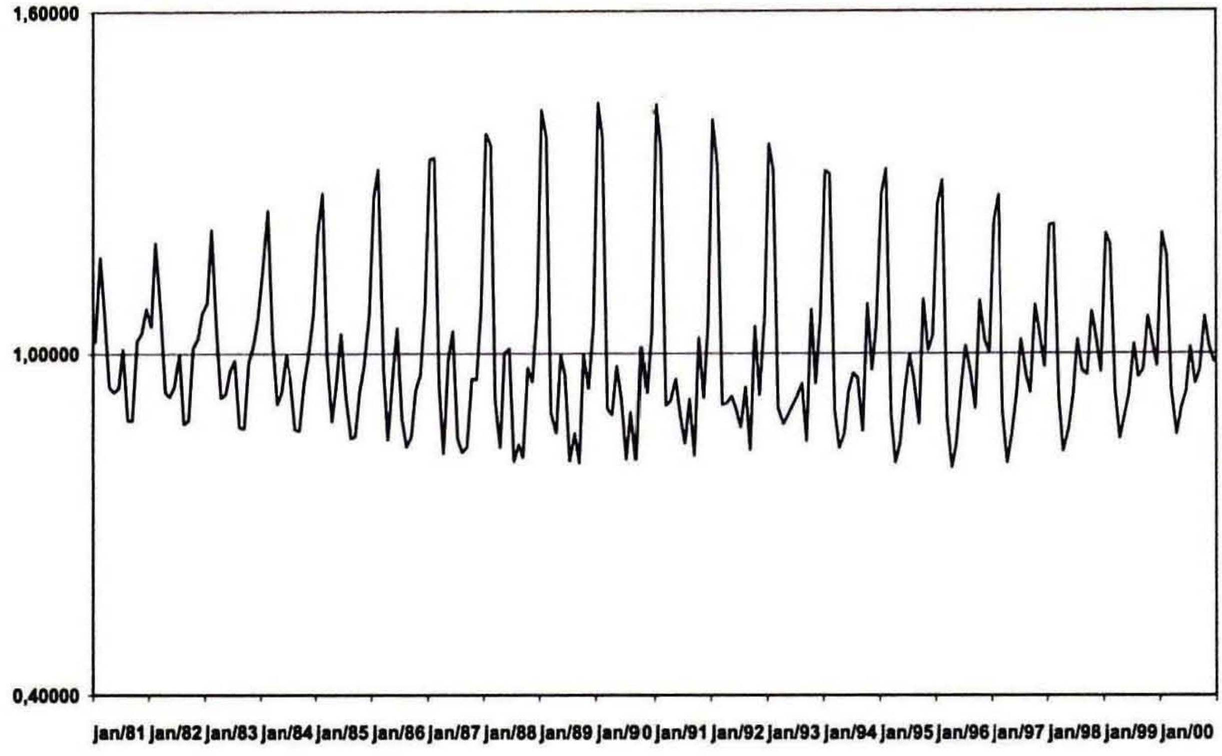
Graph 43. Seasonal pattern: tomato



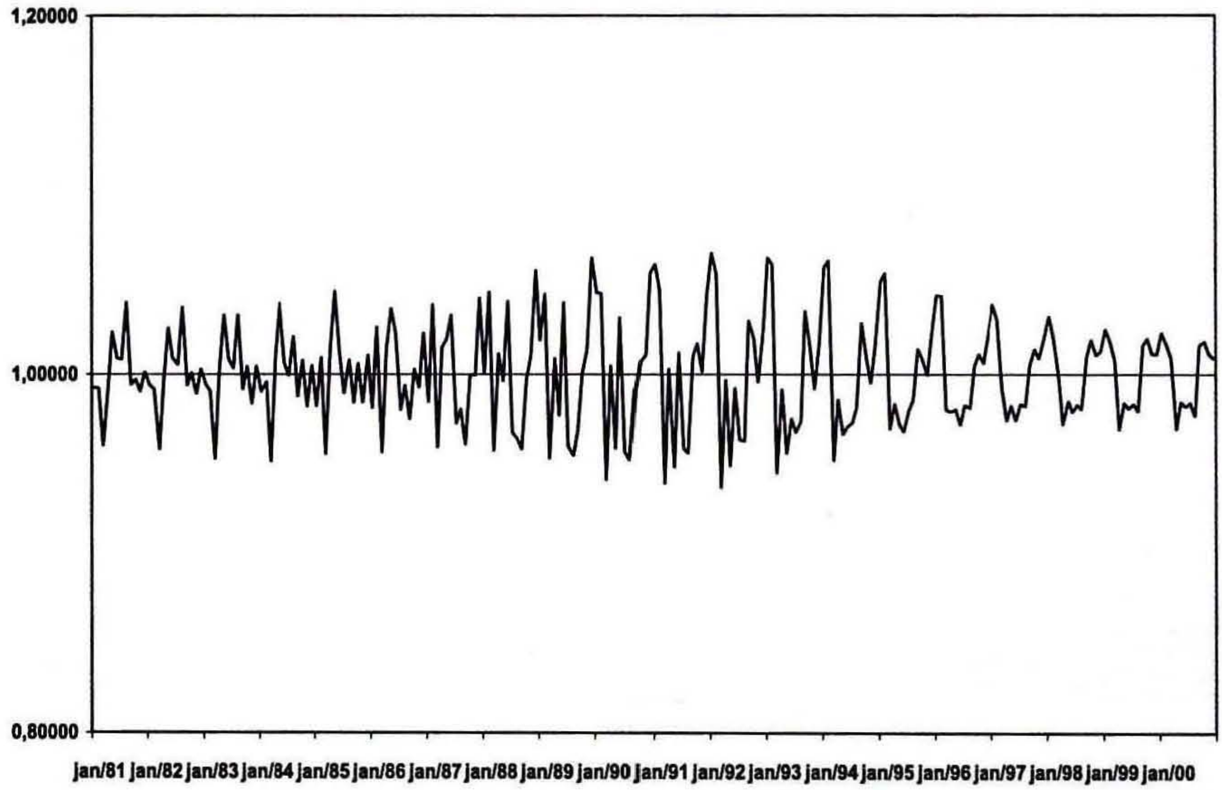
Graph 44. Seasonal pattern: egg



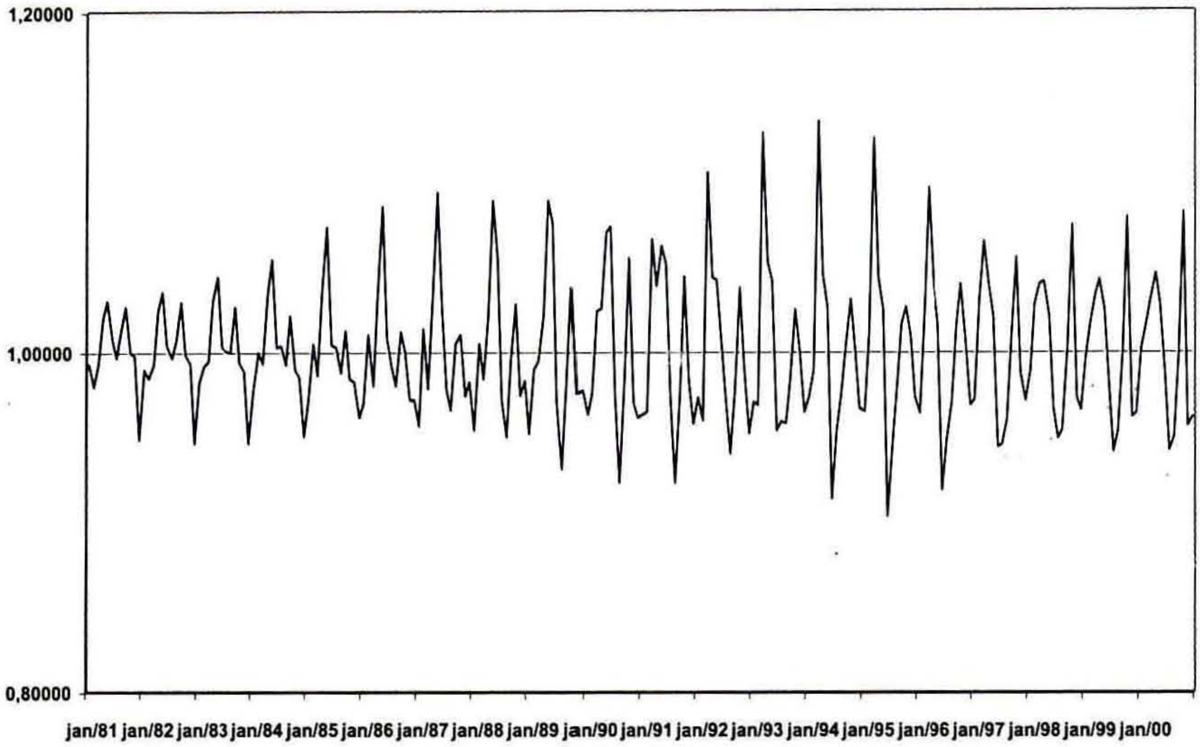
Graph 45. Seasonal pattern: lettuce



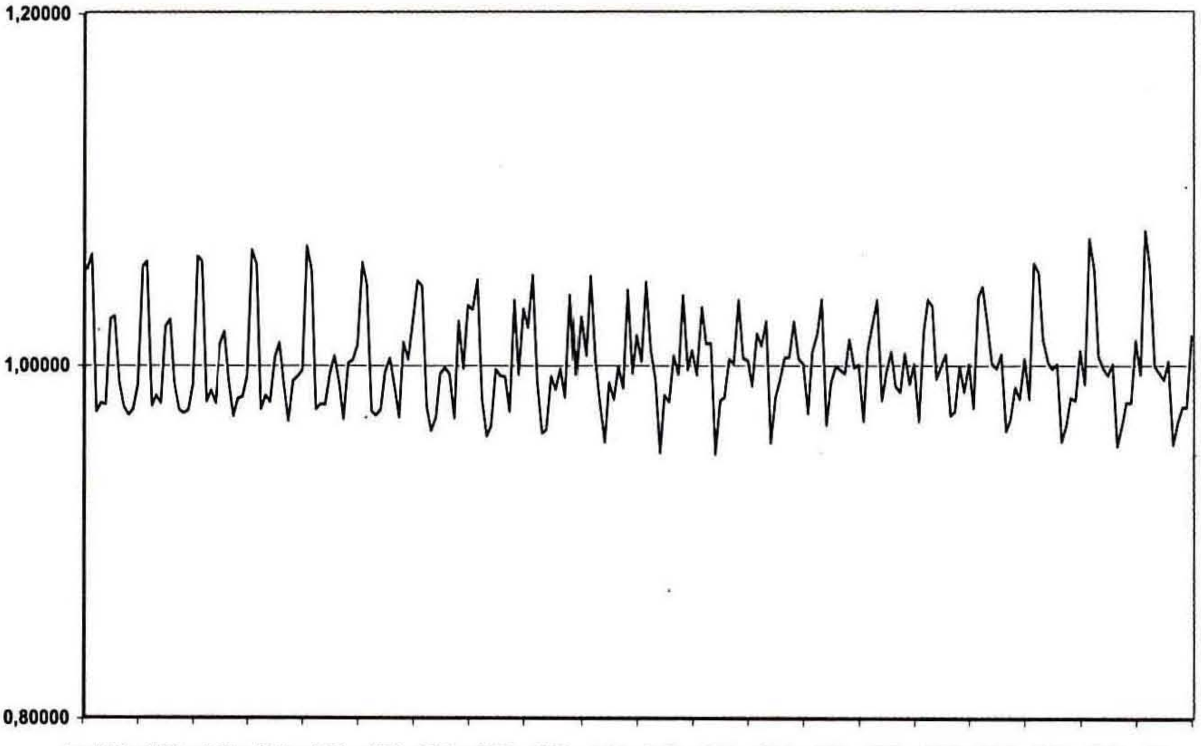
Graph 46. Seasonal pattern: soybean oil



Graph 47. Seasonal pattern: beans



Graph 48. Seasonal pattern: coffee



Shown below are the statistical results on the behavior of the series. These results were calculated using the more appropriate structural method to break down the components of each price series into trend, seasonality, cycle, and irregular. It should be mentioned, however, that the X-11 model constructs and tests only the seasonal pattern for 11 months, while the structural method enables finding the most adequate periodicity, which has varied from 6 to 8 months. This is done through spectral frequency analysis.

There may initially appear a higher price variability within the year, albeit a lower range of variation.

3.2.2 – Structural Decomposition of the Agricultural Price Series

The statistical approach used in this study is the structural decomposition of temporal series. The basic underlying idea is rather intuitive, i.e., the trajectory values of a price series can be expressed in terms of the basic components representing different regularity forms or standards found in the data themselves. In order to understand the result, it is necessary to understand the role played by each component. These components may be thought of as defined by regularities present in different time sequences. A fundamental component in economic series is the long-term trend, which expresses the evolution of the behavior of the values of the series along several years, ignoring the effects of fluctuations that occur in higher temporal frequencies, within such periods. These fluctuations, in turn, may be represented by patterns with shorter periods. When the frequency is only a few years and can even be observed within the sample used, the estimated pattern is called cycle. When fluctuations occur evenly, within each year in the sample, the resulting patterns give rise to the seasonal component. These are the trend, cycle and seasonality components, which capture, in different ways, what can be considered the "systematic" behavior of the series being analyzed. The last component in the structural model is called the irregular component, which represents the value that makes up the difference between what the systematic part of the model predicted for each period and what was effectively observed. In this context, when the model is correctly specified, the irregular component does not show any behavior pattern, being, therefore, purely random or unpredictable. When observing the values in an economic series, the realizations of the irregular component are interpreted in an interesting manner when we are able to relate them to different "shocks" or unexpected and/or unpredictable events that significantly influenced the economic environment in which the generated data were observed. These shocks are a normal part of the economic life and can be negative or positive. Harvest losses with consequent decrease in the supply of a given agricultural product in a given market, for example, represent a positive, short-term shock on the price of that product, while the availability of a fertilizer capable of increasing yield could be represented as a negative, long-term shock on the price, if we assume the result to be a significant increase in supply.

A properly specified model will produce an irregular component without a perceptible pattern, albeit with an observable dynamics of adjustment to the various shocks having occurred. In order to guarantee this essential behavior of the estimated irregular component, some of the series analyzed also included displacements of the variable being analyzed using the structural model. The purpose of this strategy is to prevent the systematic component from showing any serial correlation, incorporating into the self-regressive dynamics in the structural part of the model.

Each of the previously mentioned components can be significant, or not, for modeling a given series of data. Even when they are significant, they can be significant in different ways. Basically, a distinction is made between components with random dynamic behavior (within a known probabilistic structure) and deterministic dynamic behavior. For each of the series, the more general model was always estimated, before considering any statistics of the fundamental estimated parameters in order to derive inferences appropriately from the statistical standpoint. When the estimated standard deviation of a particular component was zero, we considered that component to have a potential deterministic effect on the series, while an estimated standard deviation significantly different from zero led us to assume that the effect of the component on the series was potentially random.

The difference between these two types of effect lies precisely in the relative unpredictability of the future values of the series, which is lower in the case of deterministic effects, when compared with the case of random effects.

The second step was testing the statistical significance of the coefficients and parameters in the model. The results reported are always those for the model whose specifications were considered most adequate, in terms of both the choice of components of the structural formulation and the number of displacements of the variable at issue used to ensure an adequate behavior of the estimated irregular component.

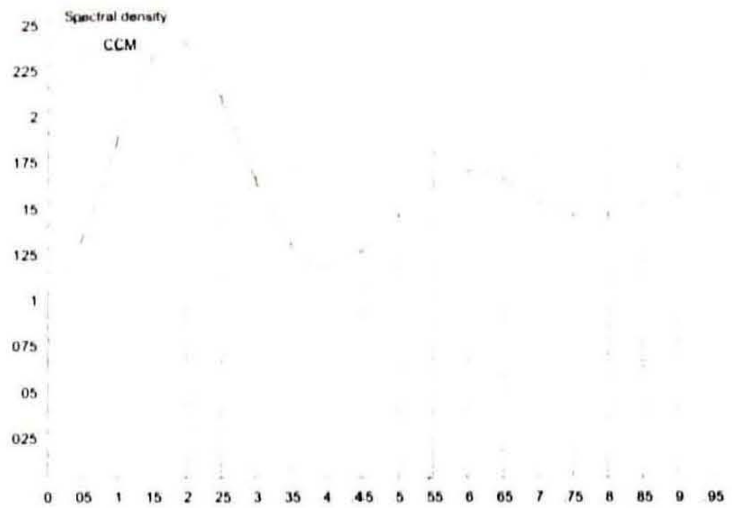
The results reveal some interesting patterns in the series, in terms of both of the long-term trend and the seasonal and random behavior.

The first step in the analysis was to estimate periodogram of the rates of variation of each series. These results reveal the relative contribution of each time frequency to the total observed variation in the series along the whole sample. The overall result is that none of the series showed significant long-term cycles and practically all series showed significant seasonal components. Each of the results is individually commented below.

(1) CCM - beef

As previously mentioned, the graph 49 represents the periodogram of the series analyzed, which is an estimate of the spectral density. In order to interpret it, as well as those of the other series analyzed, we must concentrate on the points in which the estimated curve shows a spectral density value relatively higher than the others, as measured in the ordinate or vertical axis. Along the abscissa or horizontal axis are the points representing the various temporal frequency values in the series. In the case of monthly frequencies, as in our data, the values must be calculated dividing into two the corresponding number along the abscissa, which is an artificial frequency scale measured from zero to Pi.

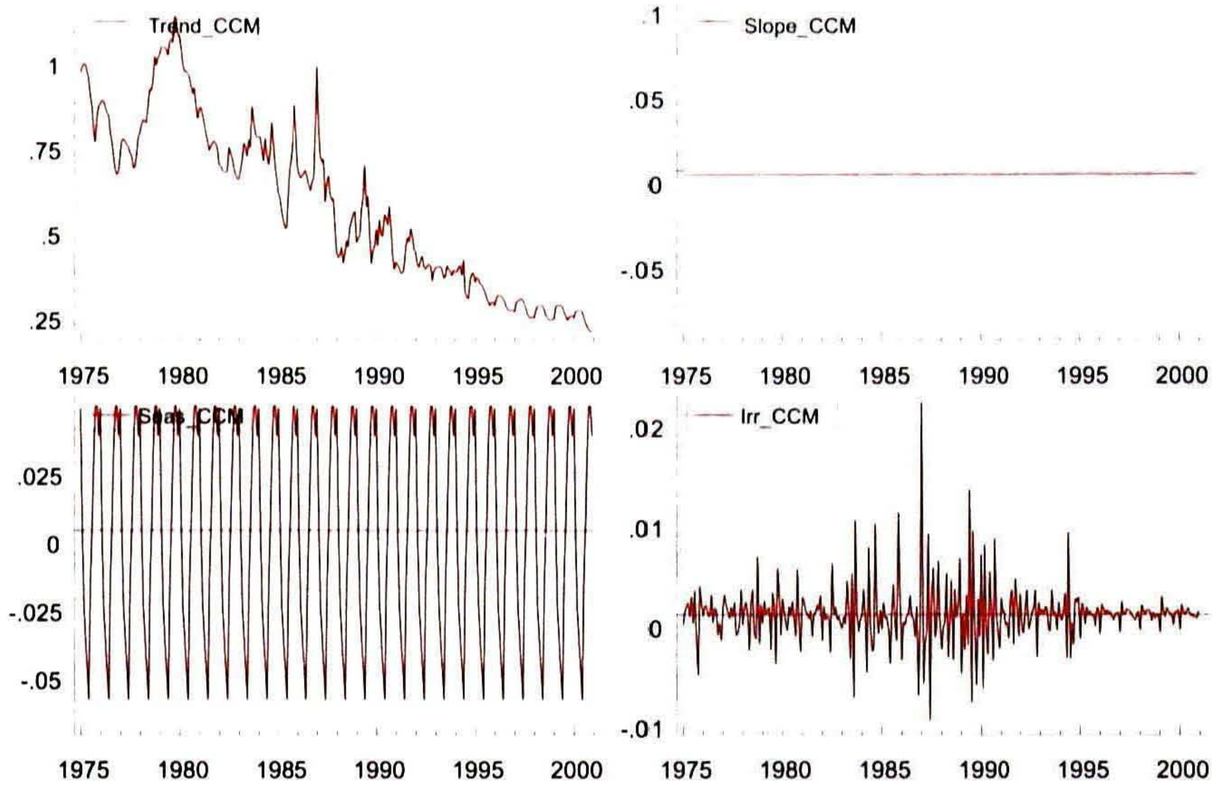
Graph 49. Periodogram - beef



Dividing 2 into 0.18, for example, we get approximately 12, which indicates a 12-month frequency for the regularities in the series. This is the point with the highest spectral density, indicating that the highest contribution to the total variation observed in the series comes from the 12-month variations. Selecting the other point of maximum estimated spectral density, we have 2 divided into 0.6, which represents approximately 3 months, indicating that this frequency is potentially important in estimating the seasonal component. We can observe in this series, as in all the other series analyzed herein, that the longer frequencies do not play a relevant role in the total variation of the series, which means there are no well-defined, medium-term cycles.

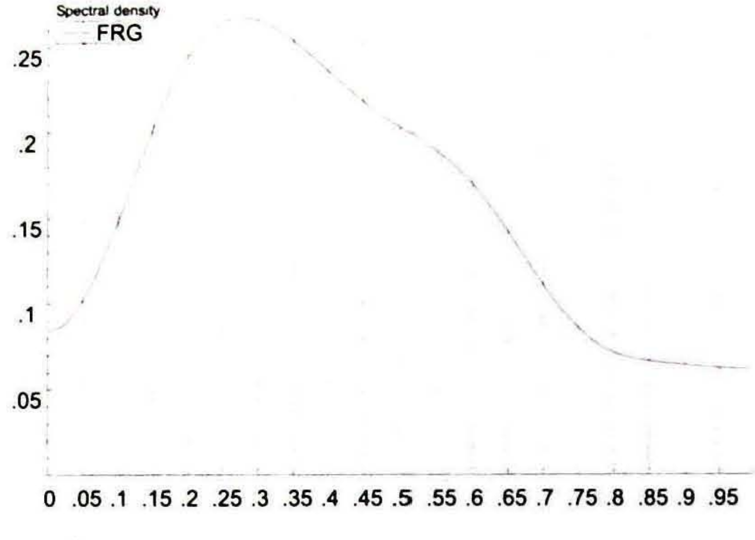
The model selected following the methodology previously outlined provides a break down of the series that can be more easily perceived by observing the graphs with the estimated values of the component in the sample (graph 50).

Graph 50. Estimated values of the component - beef

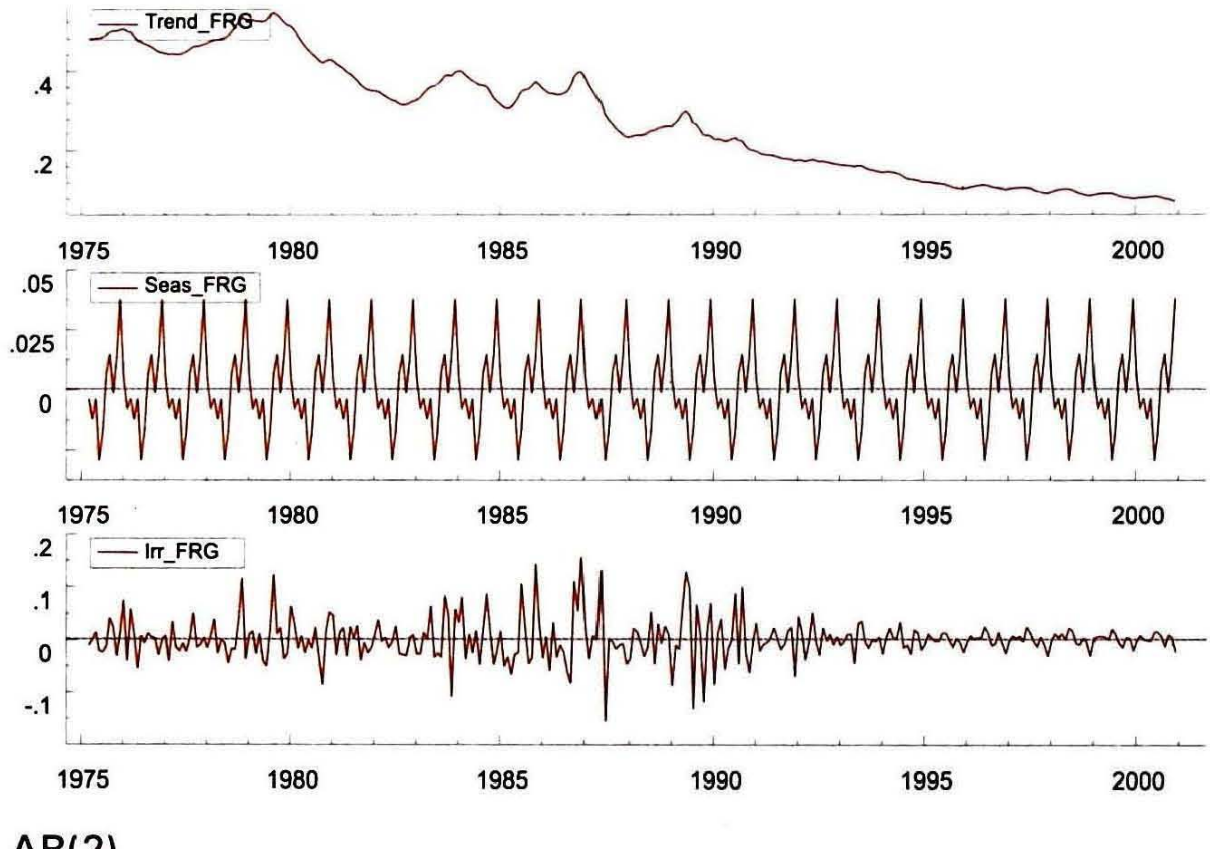


The trajectory of each of the estimated components is shown in a separate graph. At the top left there is a clear declining random trend. At the top right, the trend inclination component proved to be deterministic and negative, which explains the drop in the values of the trend in a monotonic form along time. In the graph at the bottom left, a significant deterministic seasonality can be observed, with periods of about 12 (more intense) and 4 months, as expected from the estimated spectral density results. In the graph at the bottom right, we can find the estimates for the irregular component, which reveal major random shocks along the 1980s and in 1994.

Graph 51. Chicken

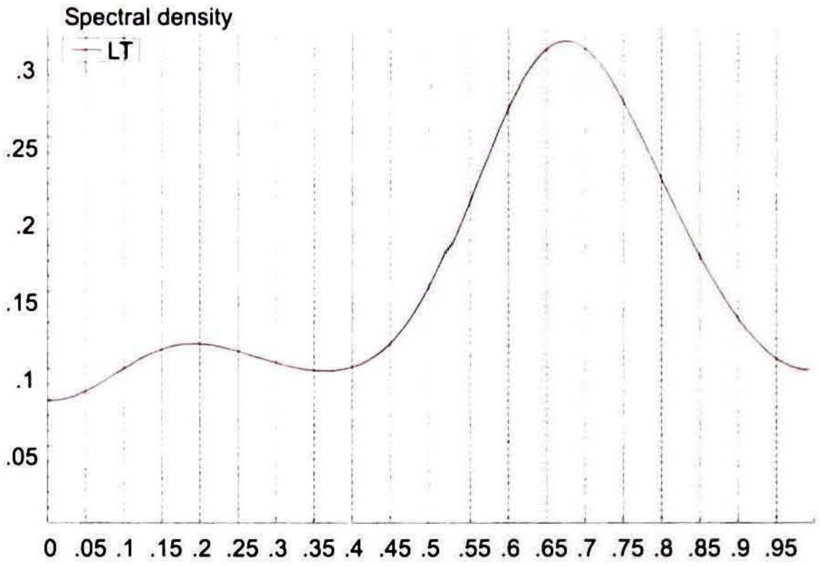


Frequency with the highest relative importance: 8 months.

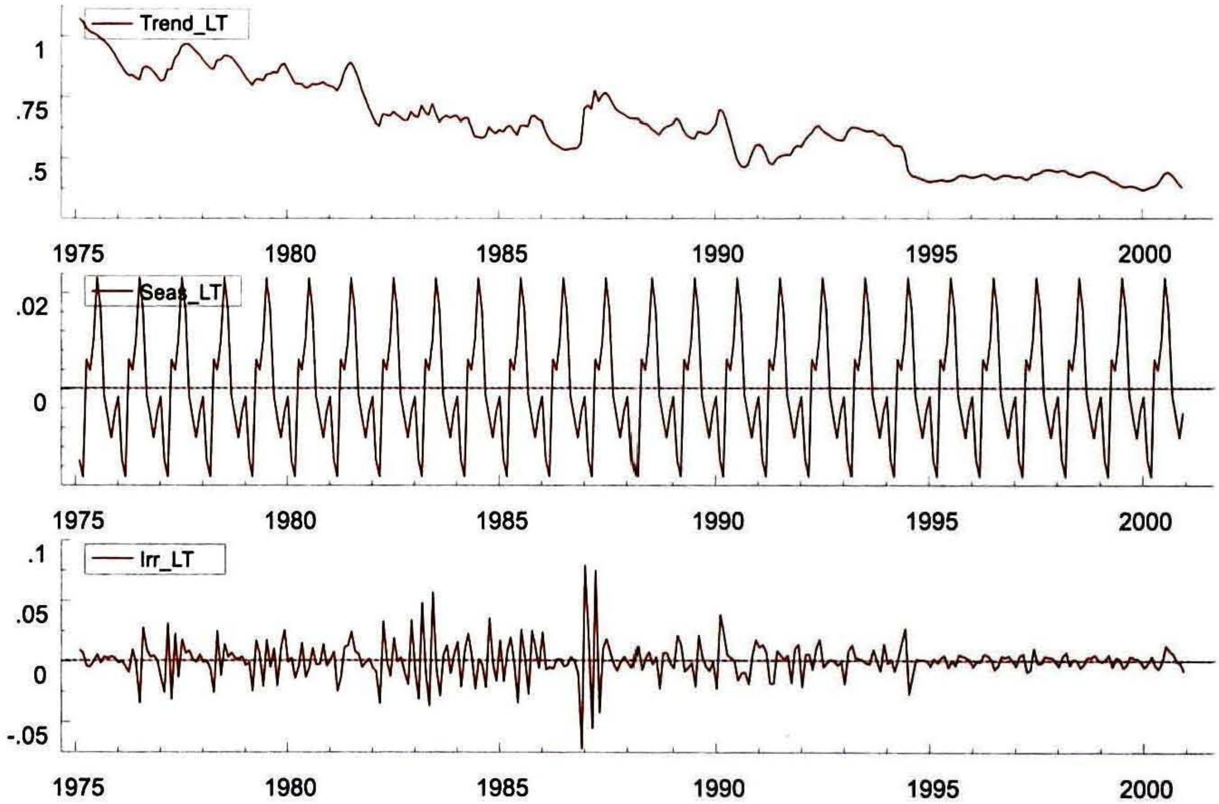


AR(2)
Declining random trend
Non-significant slope
Significant deterministic seasonality
Major random shocks in 1986 and 1989

Graph 52. Milk

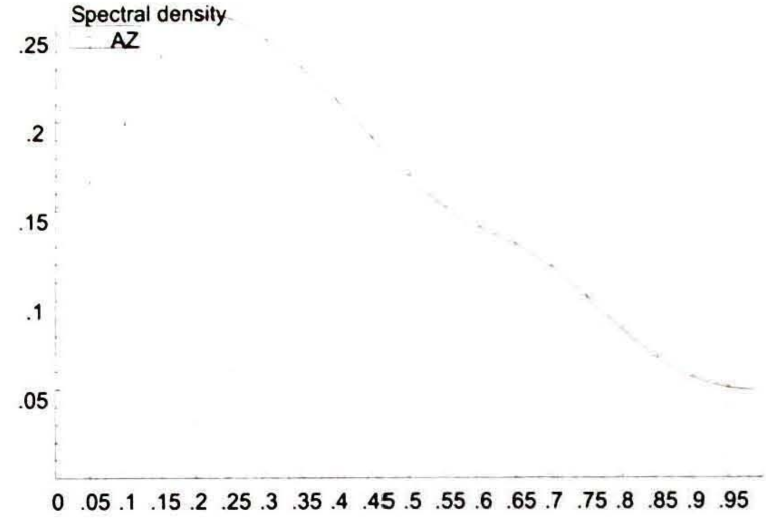


Frequency with the highest relative importance: 4 months.

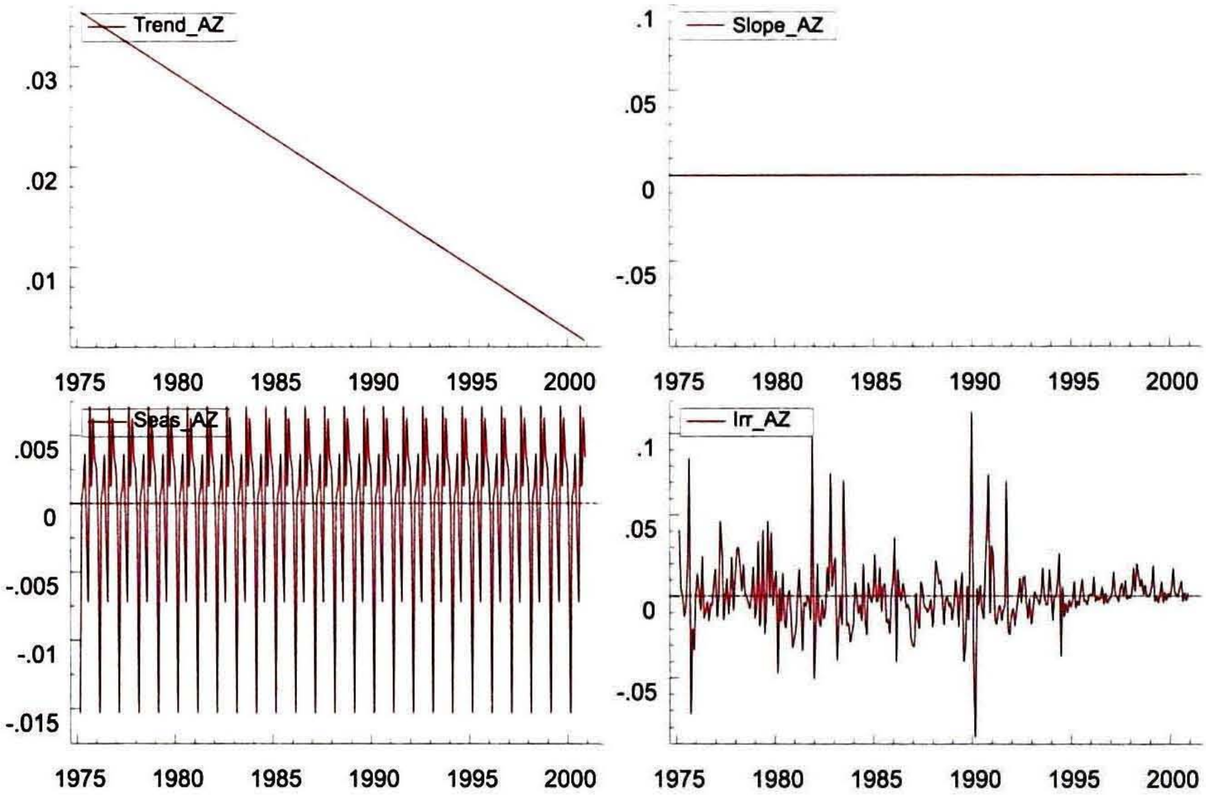


Declining random trend
Non-significant slope
Significant deterministic seasonality
Major random shocks in 1987/88

Graph 53. Rice

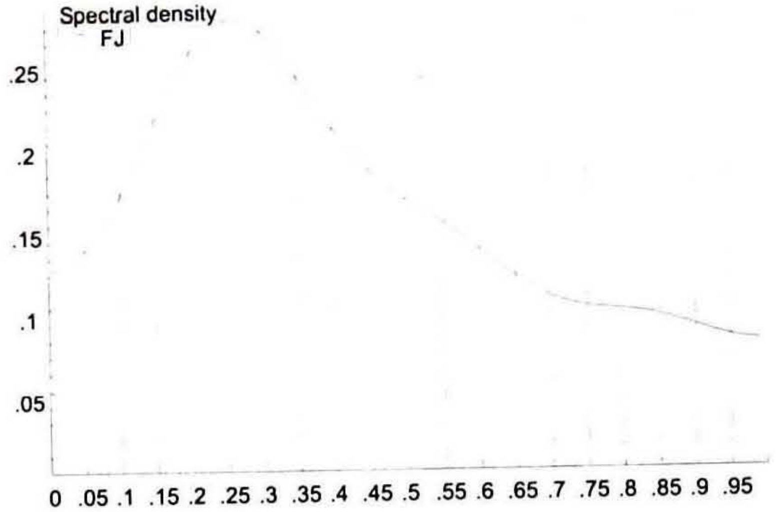


Frequency with the highest relative importance: 8 months.

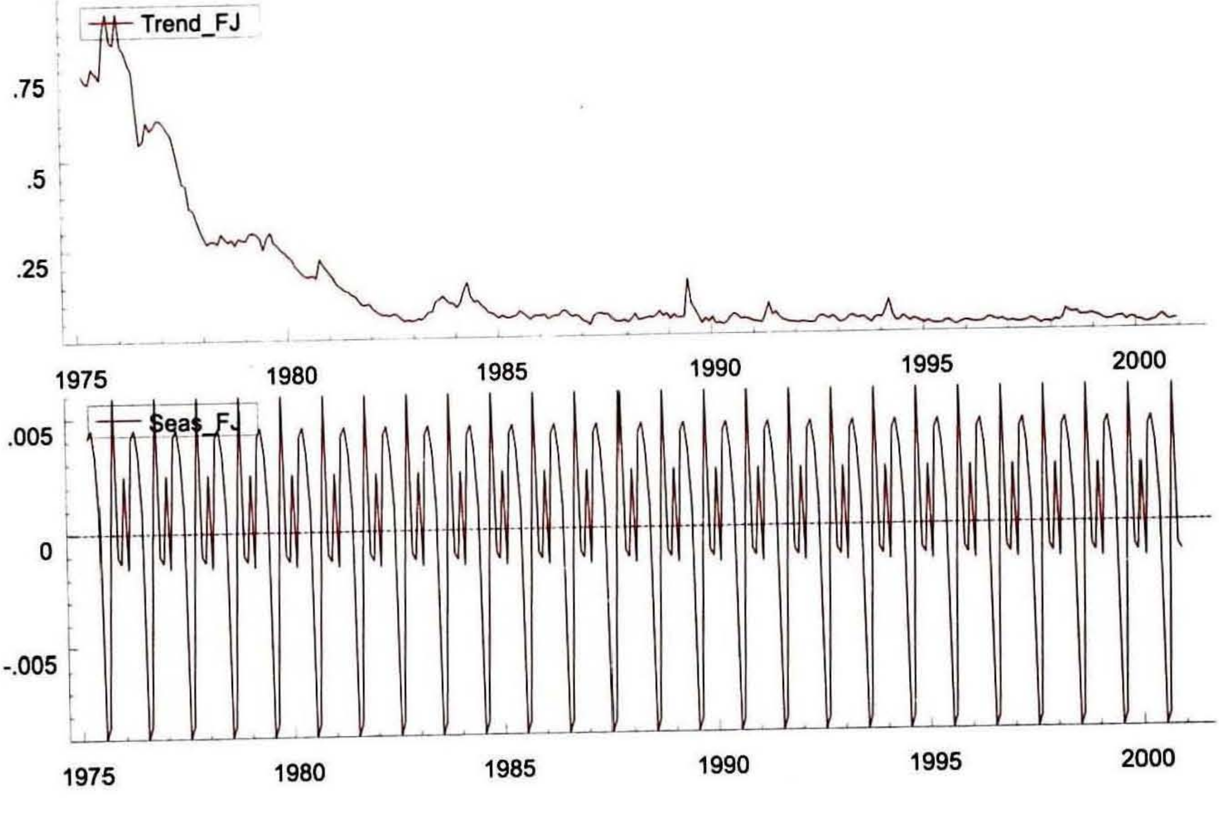


AR(2)
Declining deterministic trend
Non-significant slope
Significant deterministic seasonality
Major random shocks in 1983 and 1990

Graph 54. Beans

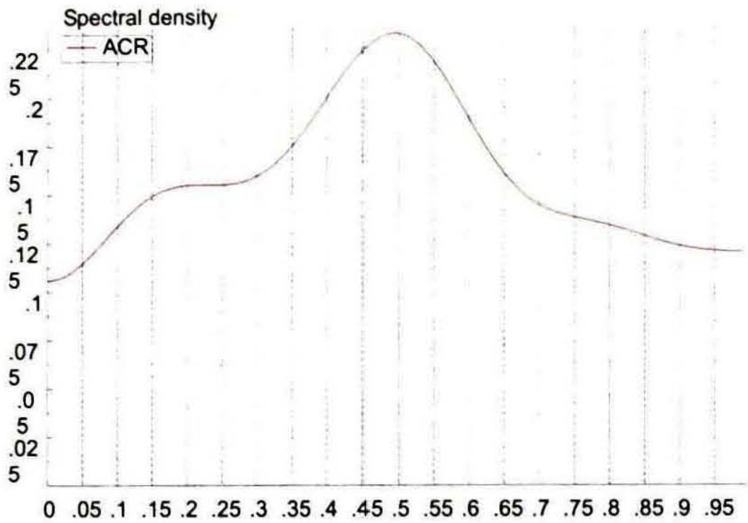


Frequency with the highest relative importance: 8 months.

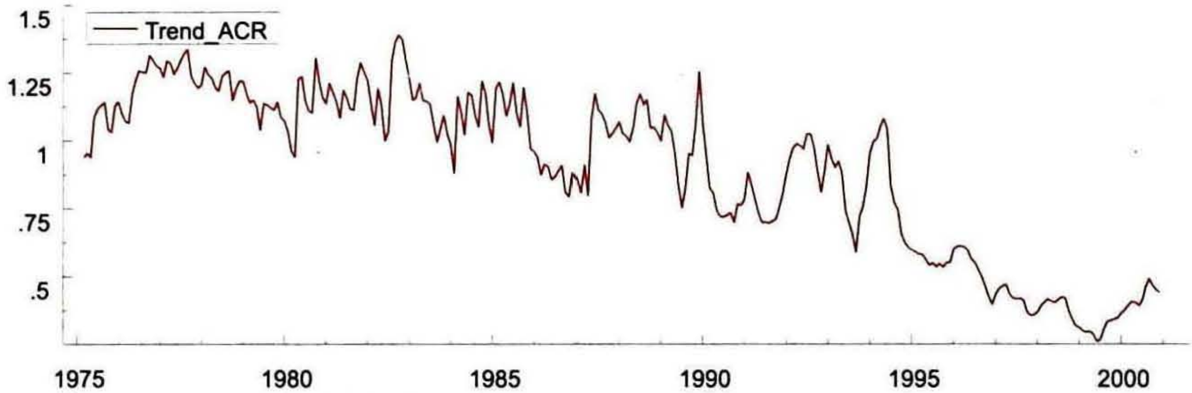


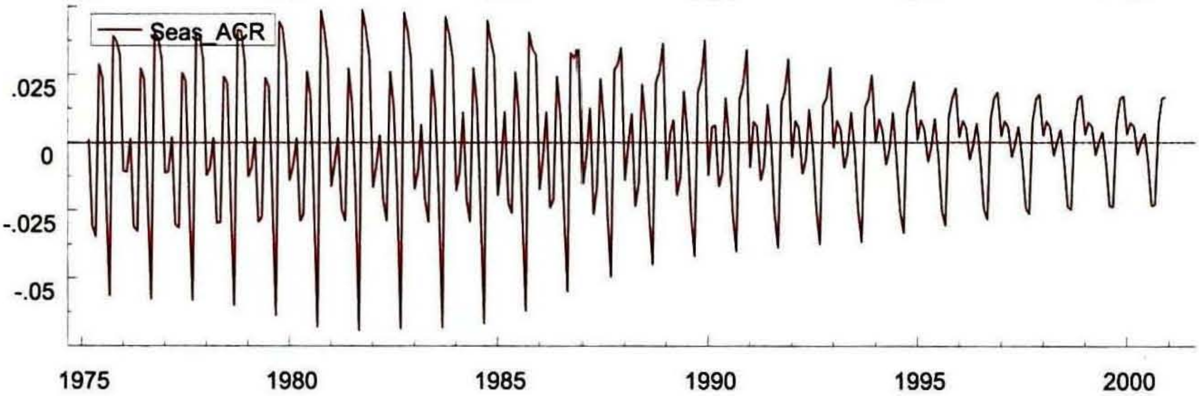
AR(2)
Declining random trend
Non-significant slope
Not very significant deterministic seasonality
Non-significant random shocks

Graph 55. Sugar



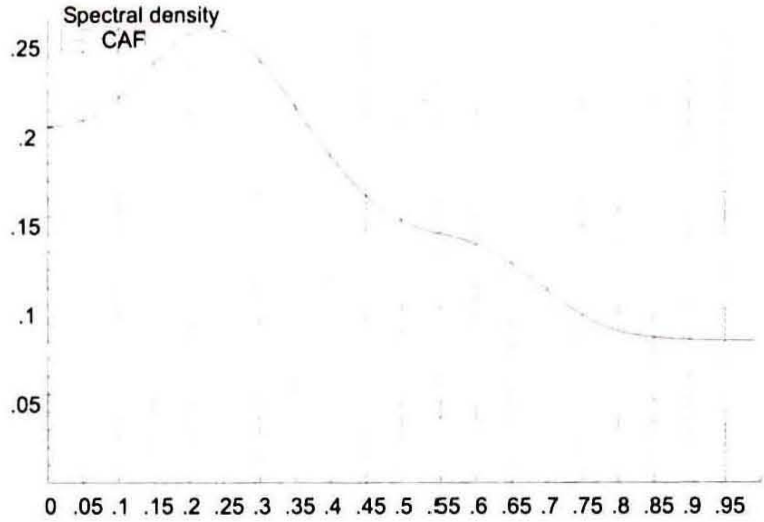
Frequency with the highest relative importance: 4 months.



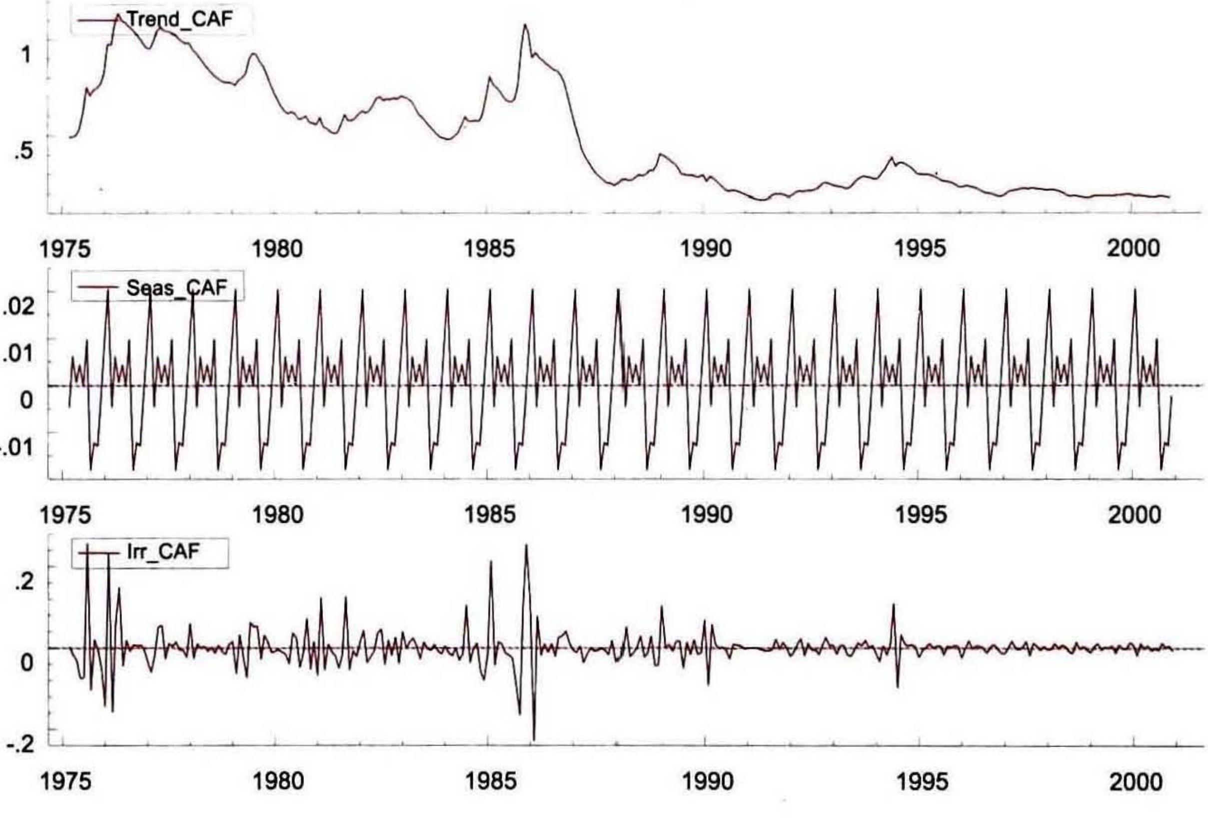


Declining random trend after 1985, with major shocks
Non-significant slope
Significant declining random seasonality

Graph 56. Coffee

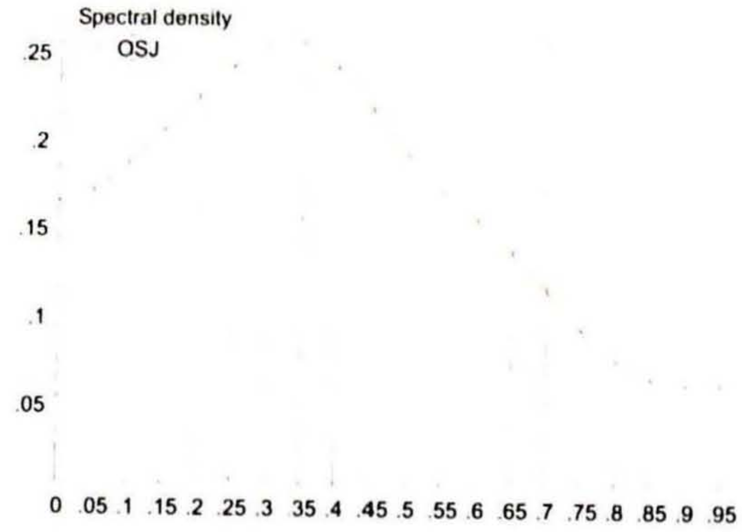


Frequency with the highest relative importance: 8 months.

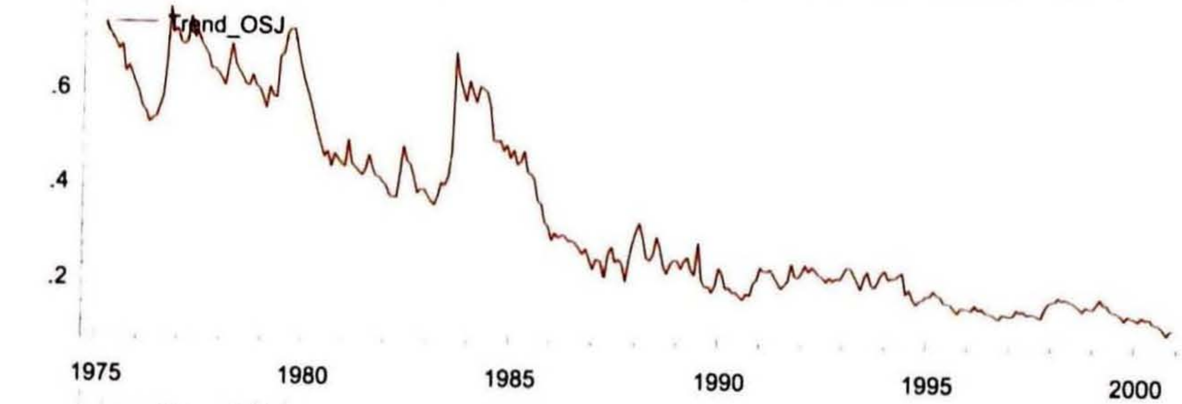


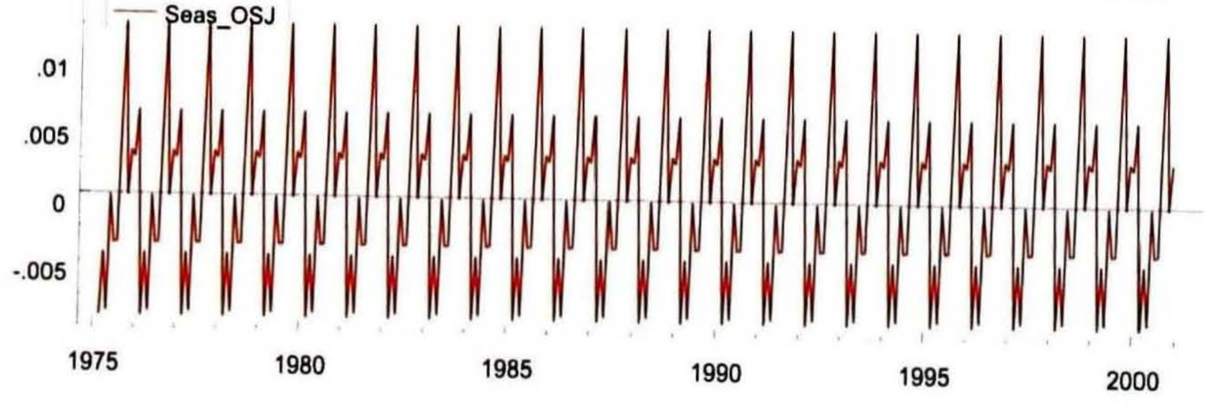
AR(2)
Random trend with two levels, one before 1986 and a lower one after 1986
Non-significant slope
Not very significant, deterministic seasonality
Major random shocks in 1976 and 1986

Graph 57. Soybean oil



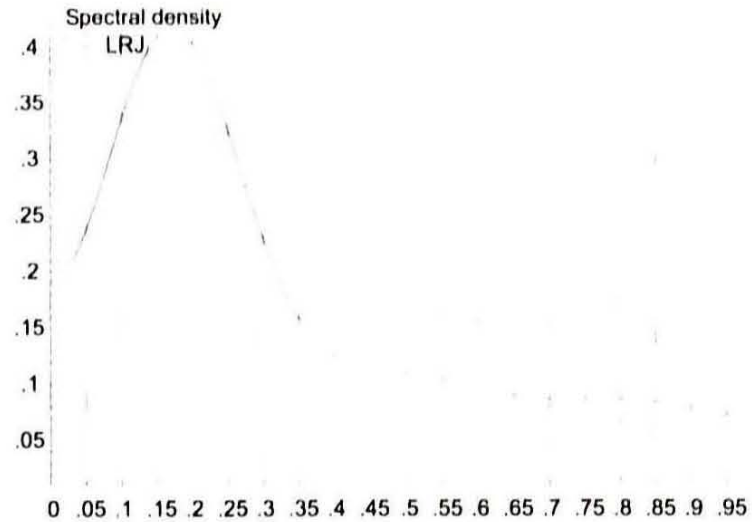
Frequency with the highest relative importance: 6 months.



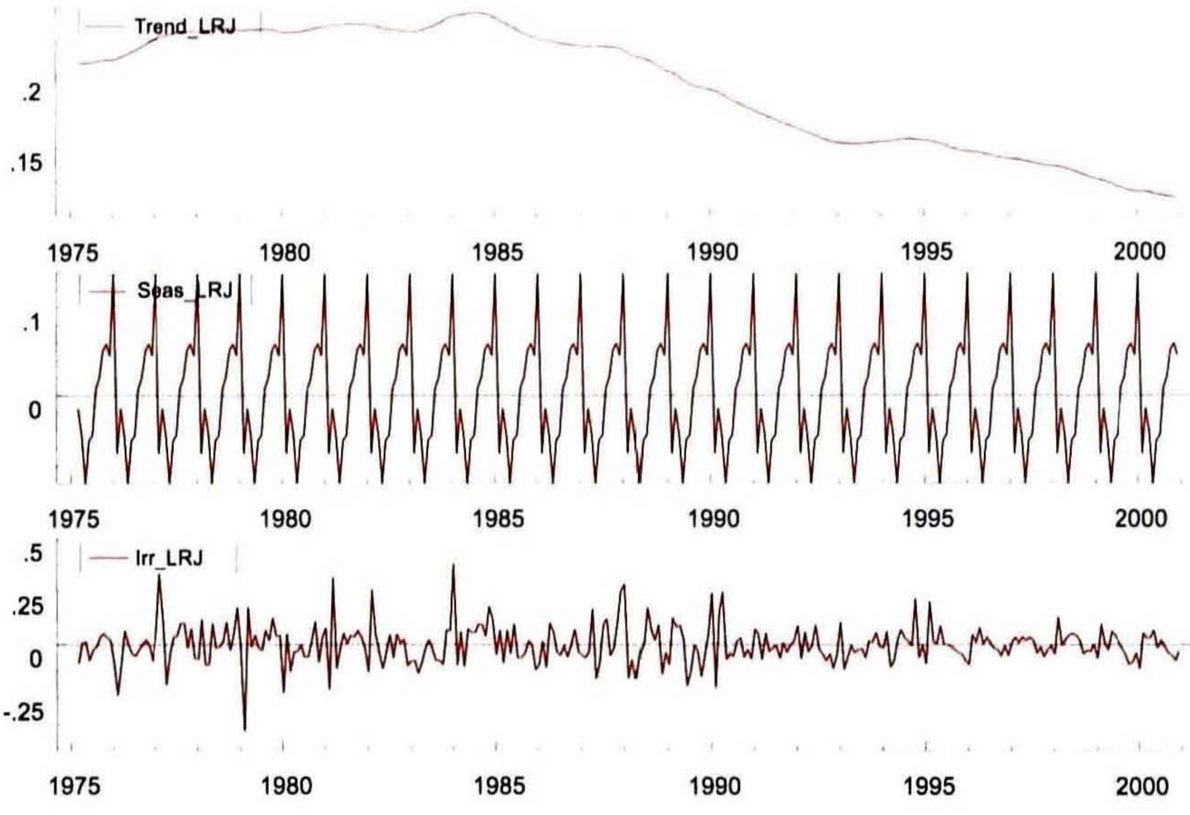


AR(2)
Declining random trend, with a rise in 1985 and relative stabilization after 1990
Non-significant slope
Significant deterministic seasonality
Relatively insignificant random shocks

Graph 58. Orange

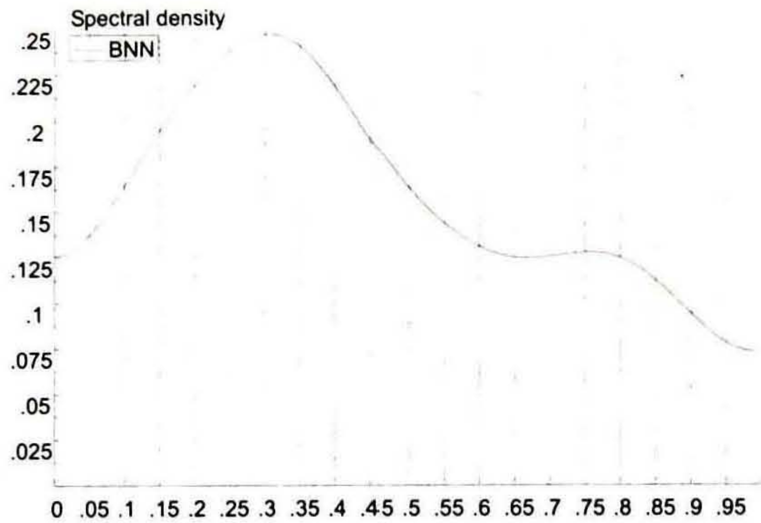


Frequency with the highest relative importance: 12 months.

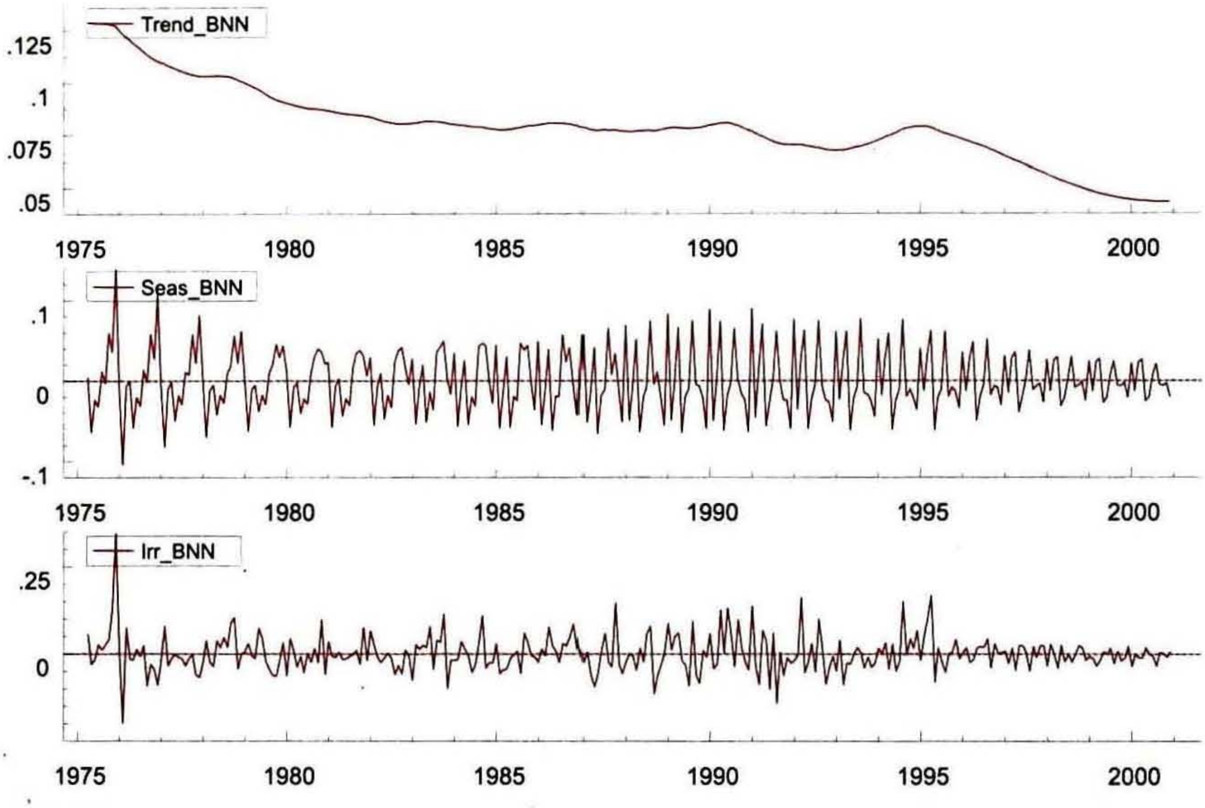


AR(2)
Constant random trend from 1975 to 1985, and significantly declining thereafter
Non-significant slope
Highly significant, deterministic seasonality
Major random shocks in 1977 and 1979

Graph 59. Banana



Frequency with the highest relative importance: 6 months.



AR(3)

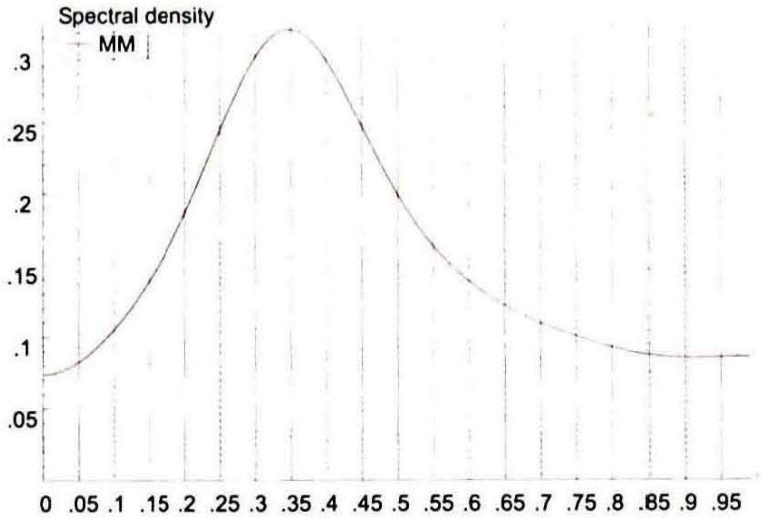
Declining random trend, more intense beginning in 1995

Non-significant slope

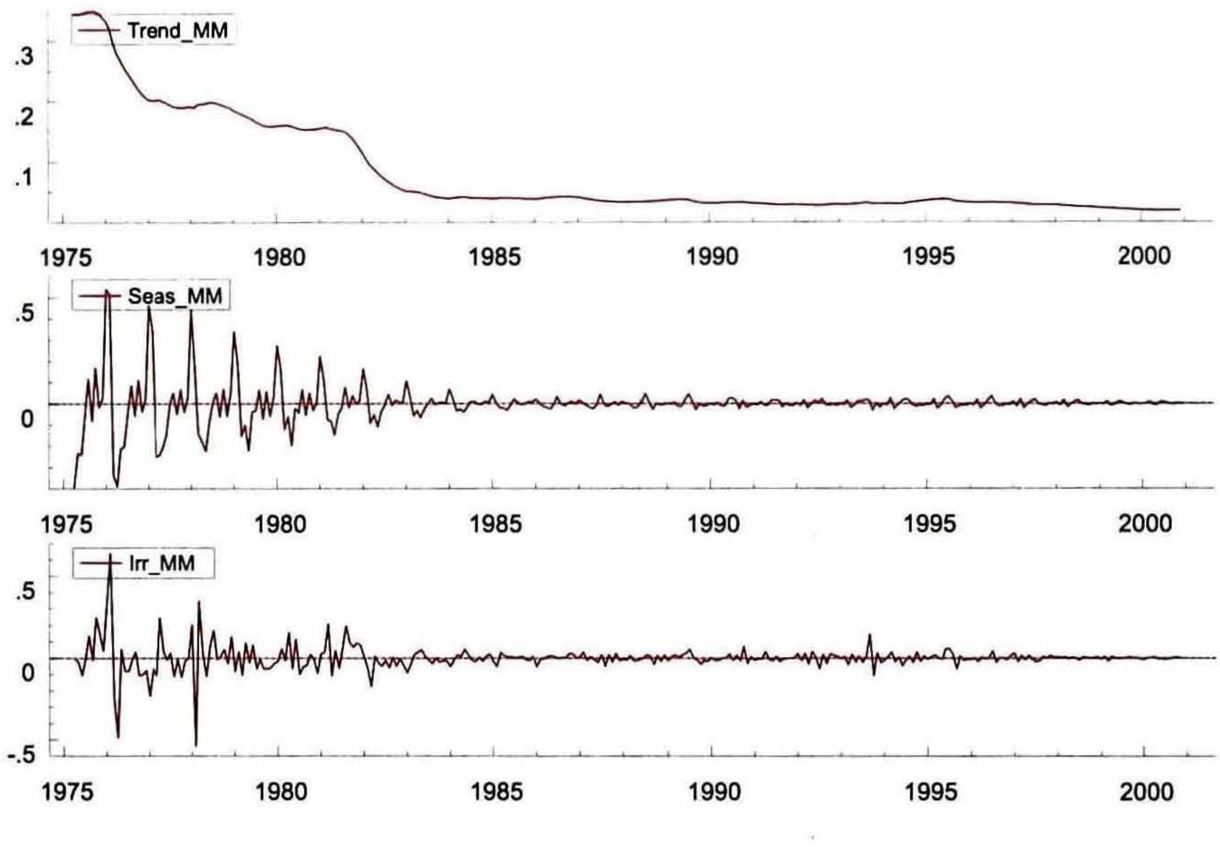
Significant random seasonality, with a change in pattern and a drop after 1995

Major random shocks in 1976 and 1991

Graph 60. Papaya

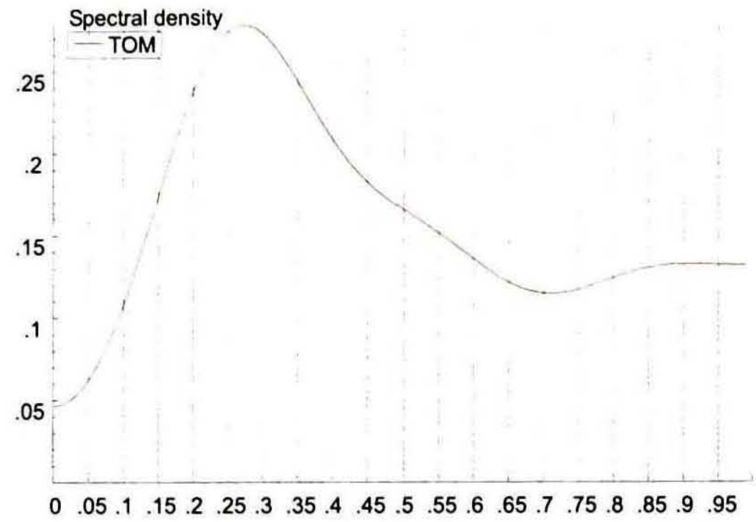


Frequency with the highest relative importance: 6 months.

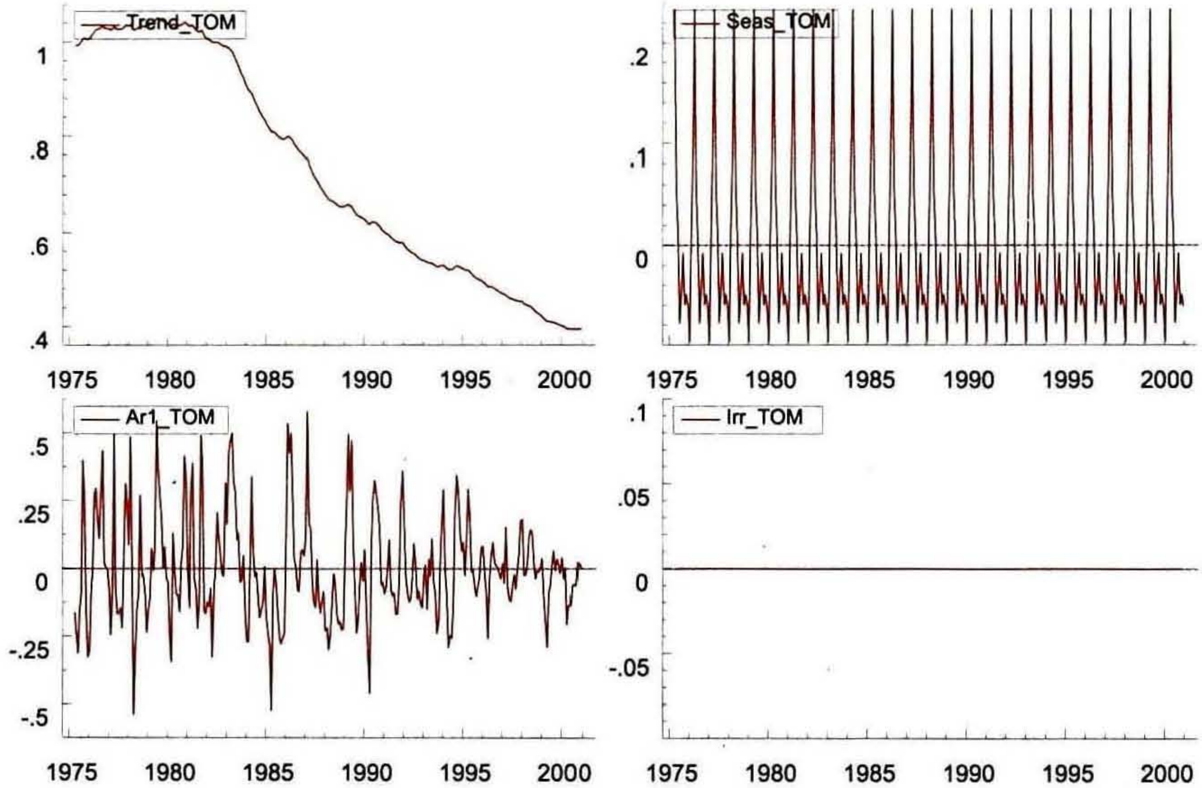


AR(3)
Declining random trend until 1983, with later stabilization
Non-significant slope
Significant random seasonality, with a change in pattern and a drop after 1995
Major random shocks in 1976 and 1991

Graph 61. Tomatoes

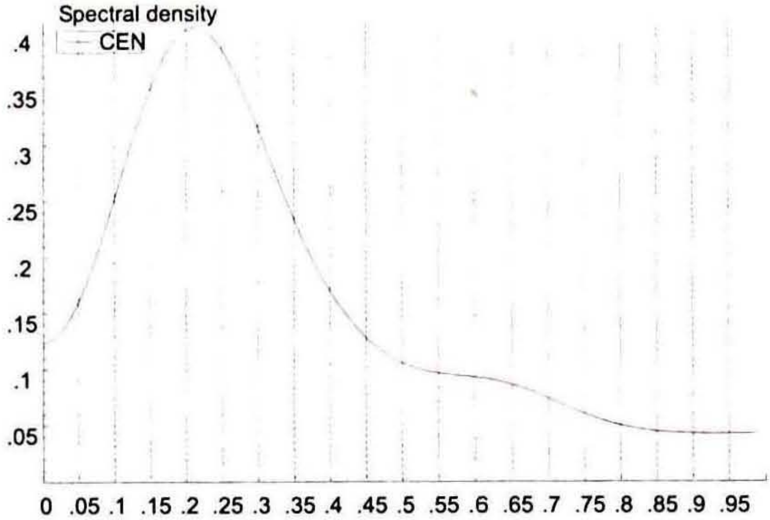


Frequency with the highest relative importance: 6 months.

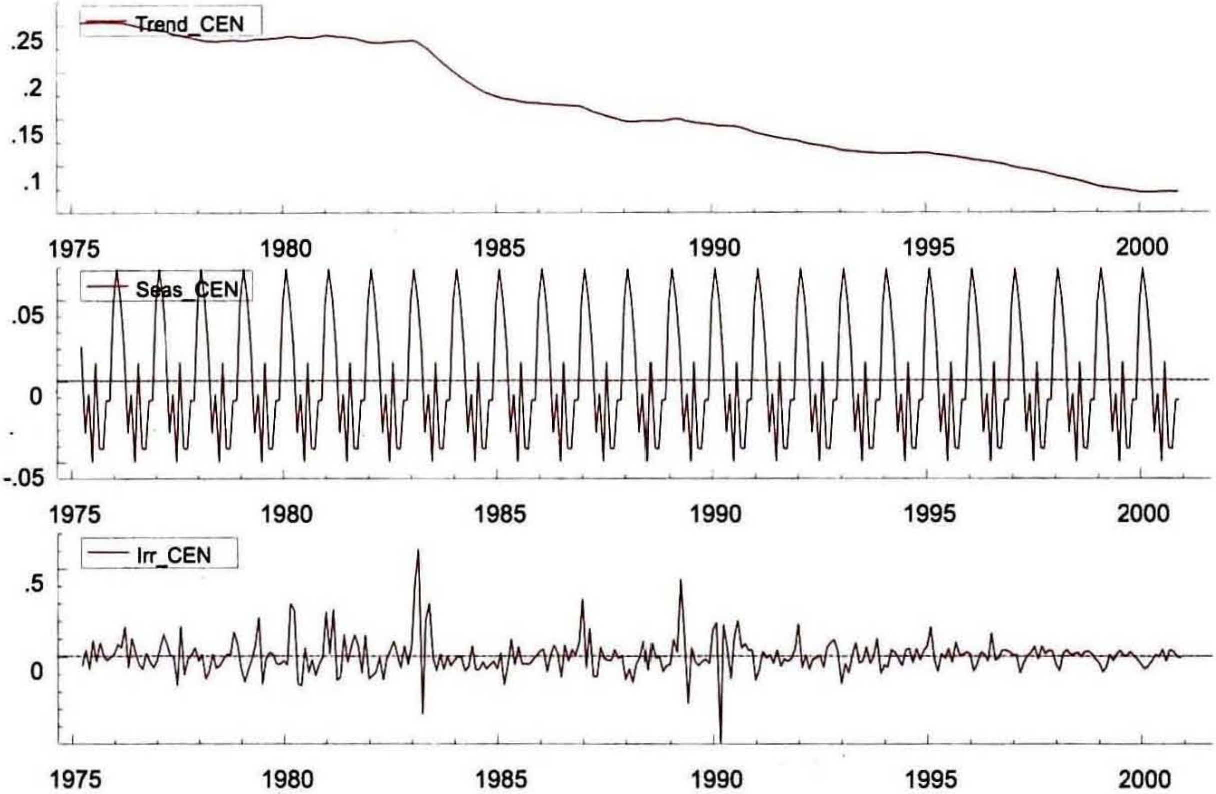


Random trend with a major drop beginning in 1983
Constant significant deterministic seasonality
Random shocks with a self-regressive pattern, declining beginning in 1995

Graph 62. Carrots

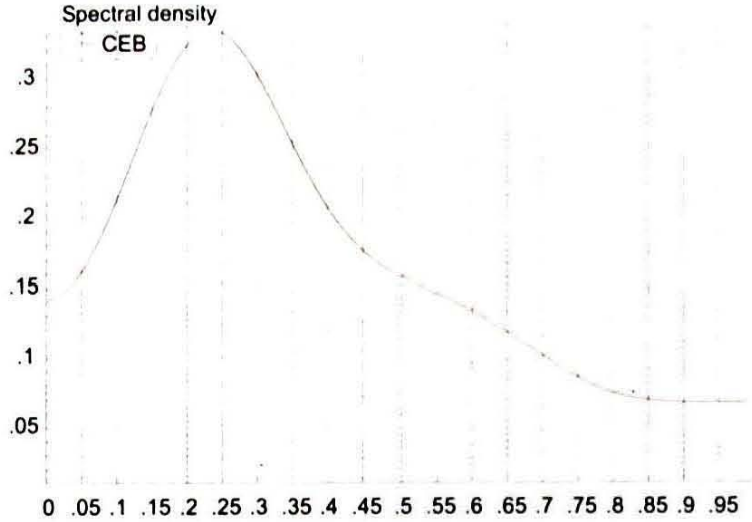


Frequency with the highest relative importance: 8 months.

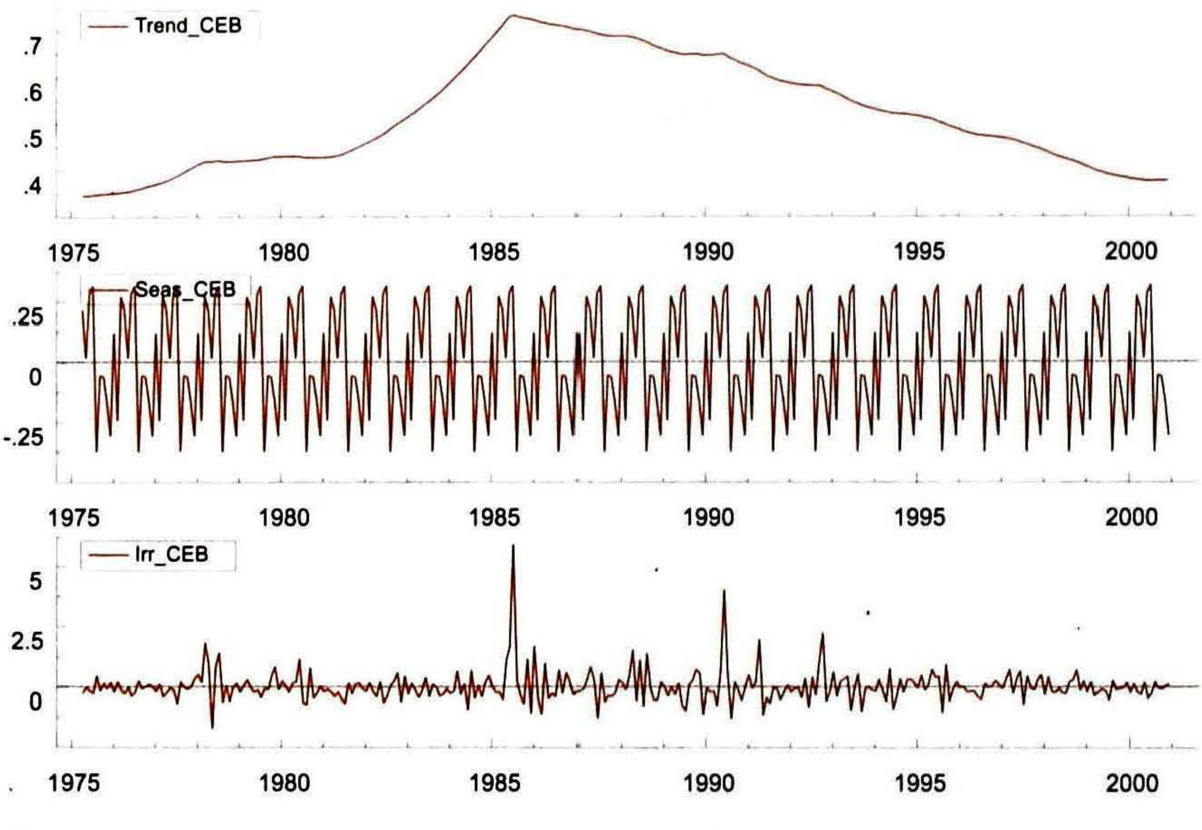


AR(3)
Stable random trend until 1983, with a declining pattern thereafter
Significant deterministic seasonality
Major random shocks in 1983 and 1990.

Graph 63. Onions

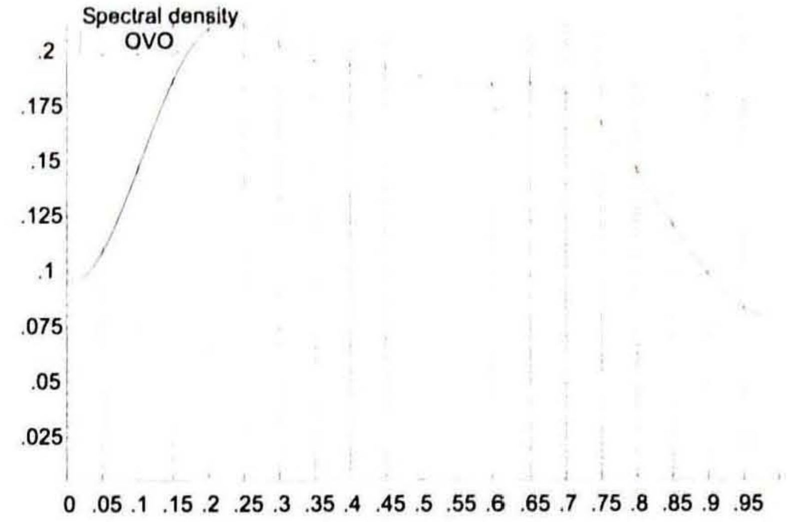


Frequency with the highest relative importance: 8 months.

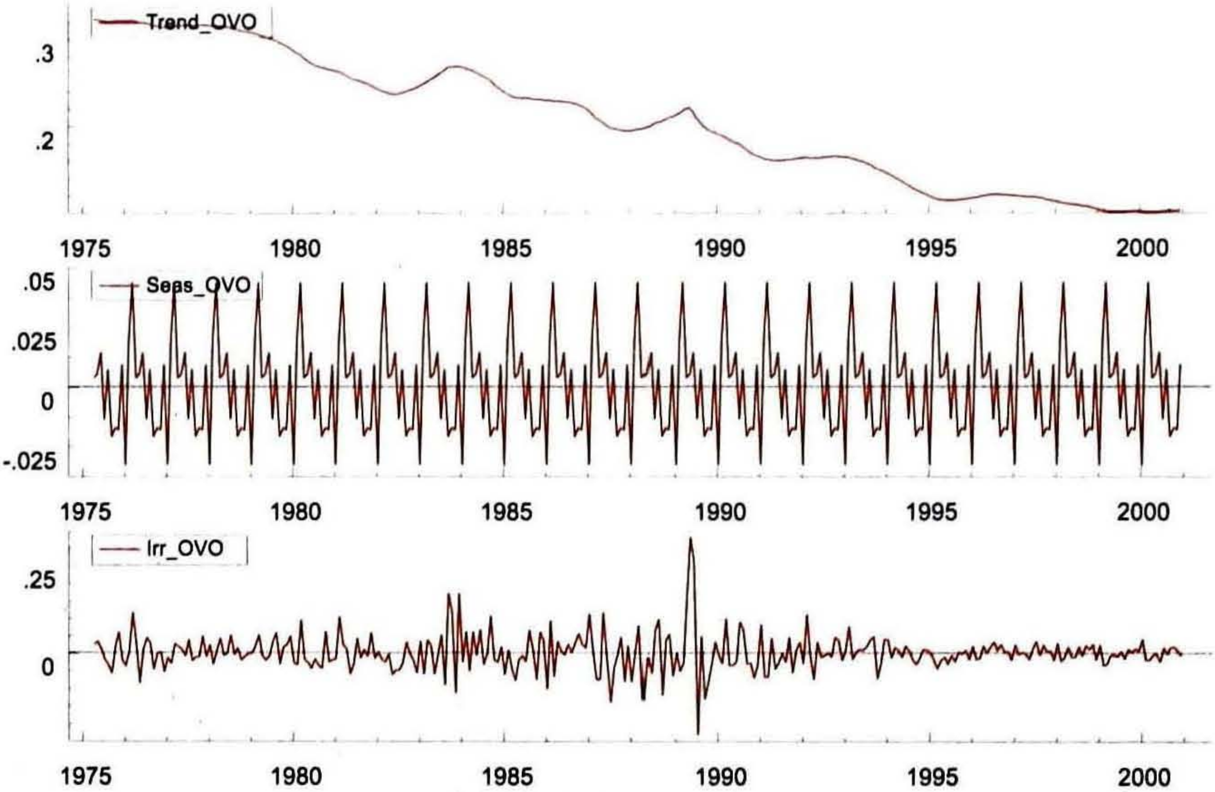


AR(3)
Growing random trend from 1975 to 1985, declining thereafter
Significant deterministic seasonality
Major random shocks in 1985 and 1990

Graph 64. Eggs

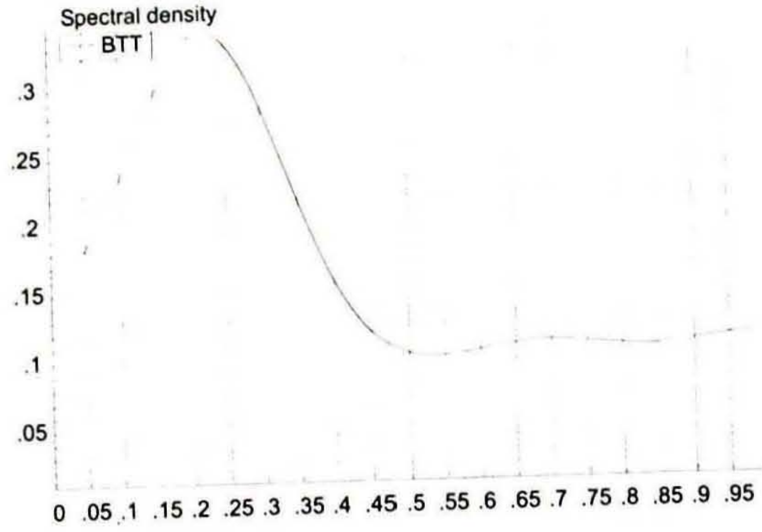


Frequency with the highest relative importance: 12 and 3 months.

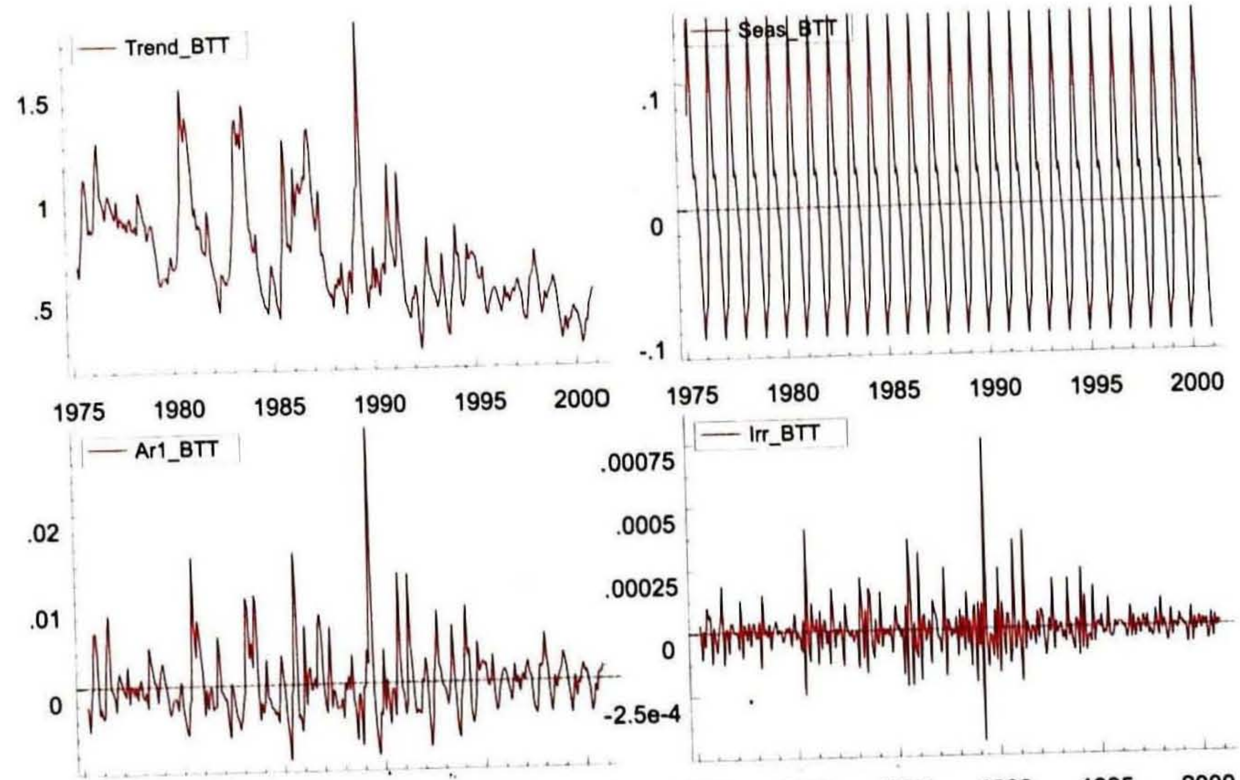


AR(2)
Declining random trend
Stable significant seasonality
Major random shock in 1988

Graph 65. Potatoes

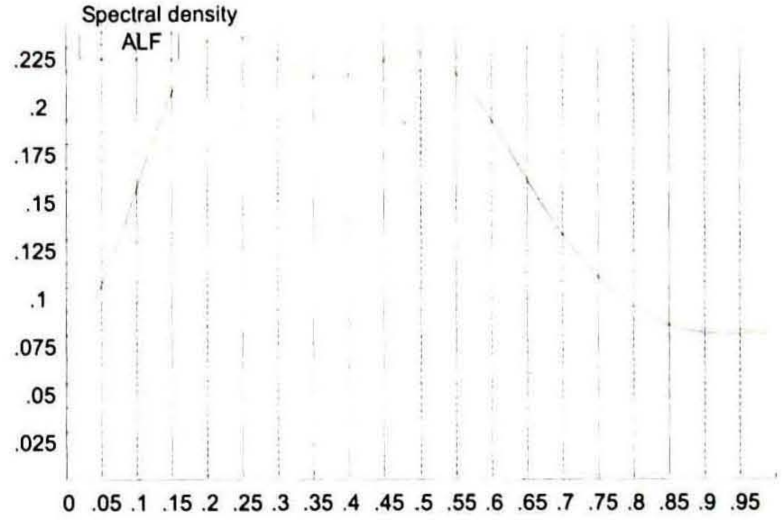


Frequency with the highest relative importance: 8 months.

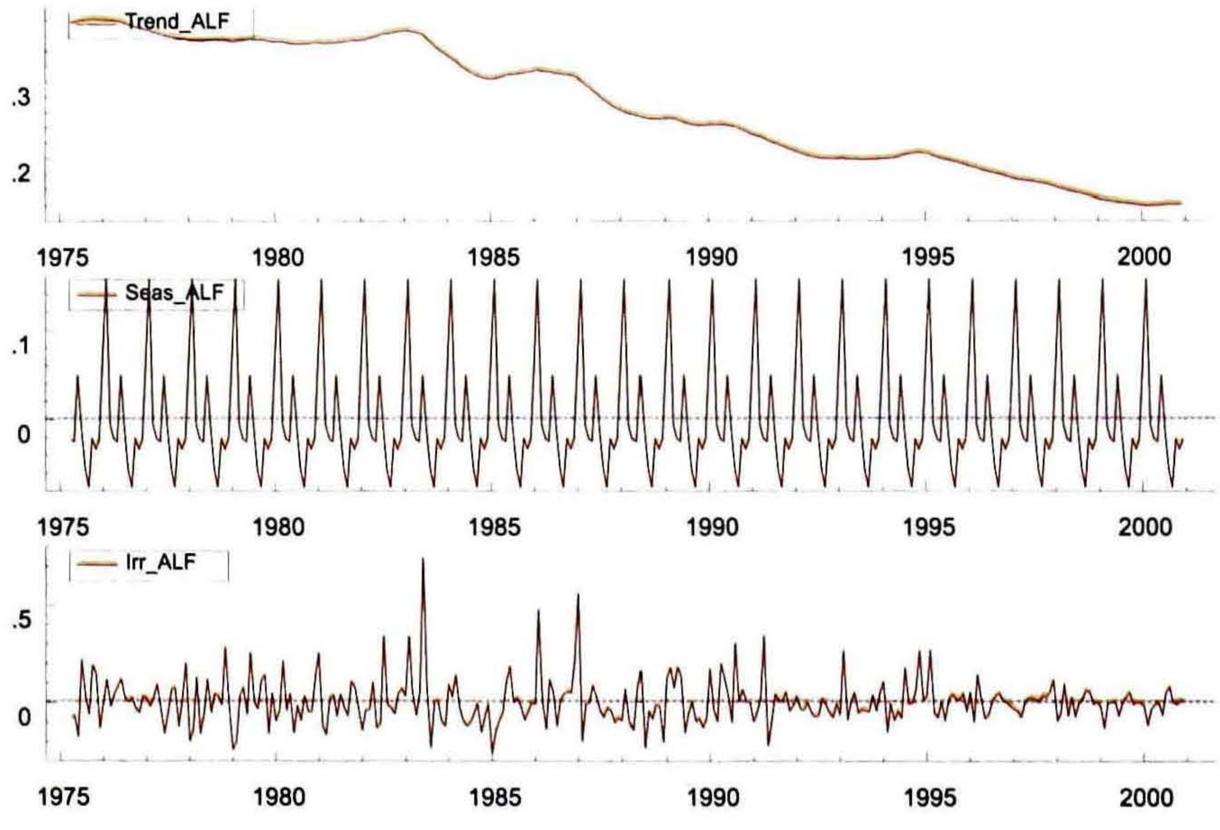


AR(1)
Declining random trend, with large oscillations
Stable significant seasonality
Significant random self-regressive component
Major random shock in 1988

Graph 66. Lettuce



Frequency with the highest relative importance: 12 and 4 months.



AR(2)
Stable random trend from 1975 to 1884, with sharp decline thereafter
Stable significant seasonality
Major random shocks in 1984 and 1987

3.3 References

BONELLI, R.; FONSECA, R. Ganhos de produtividade e de eficiência: novos resultados para a economia brasileira. **Pesquisa e Planejamento Econômico**, Rio de Janeiro, v. 28, n. 2, agosto 1998.

BRANDÃO, A. S. P. Evolução da agricultura e o papel da tecnologia. In: PATERNIANI, E. (Ed.). **A tecnologia na agricultura brasileira**. Brasília: Embrapa, 2000

BRANDÃO, A. S. P.; PEREIRA, L. V. (Org.). **Mercosul**: perspectivas da integração. Rio de Janeiro: Fundação Getúlio Vargas, 1996.

BRANDÃO, A. S. P.; TSIGAS, M.; GOLDIN, I.; MENSBRUGGHE, D. van der. Trade liberalization and technical change. In: GOLDIN, I.; KNUDSEN, O.; MENSBRUGGHE, D. van der. **Trade liberalization**: global economic implications. Paris: OECE / Banco Mundial, 1993. Cap. 9.

CASTRO, J. R.; SCHUH, G. E. An empirical test of an economic model for establishing research priorities: a Brazil case study. In: ARNDT, T.; DARLYMPLE, D; RUTTAN, V. (Ed.). **Resource allocation and productivity in national and international agricultural research.** Minneapolis: Minnesota University Press, 1977.

CONSIDERA, C. M.; MEDINA, M. H. **PIB por unidade da Federação**: valores correntes e constantes – 1985-1996. Rio de Janeiro: IPEA, 1998. (Textos para Discussão, 610).

COUTO, F. A. D'A.; MONTEIRO, J. de A. O Cluster de grãos na região de Rio Verde no sudoeste de Goiás. In: HADDAD, P. R. (Org.). **A competitividade do agronegócio e o desenvolvimento regional no Brasil – Estudos de Clusters**. Brasília: CNPq / Embrapa, 1999.

DESENVOLVIMENTO humano e condições de vida: indicadores brasileiros. Brasília: PNUD/IPEA/FJP/IBGE, 1998. Apêndices.

FRISVOLD, G. B. Multimarket effects of agricultural research with technological spillovers. In: HERTEL, T. W. (Ed.). **Global trade analysis**: modeling and applications. Cambridge: Cambridge University Press, 1997.

HADDAD, P. R. (Org.). **A competitividade do agronegócio e o desenvolvimento regional no Brasil – Estudos de Clusters.** Brasília: CNPq/ Embrapa, 1999.

HERTEL, T. W. (Ed.). **Global trade analysis**: modeling and applications. Cambridge: Cambridge University Press, 1997.

MARTIN, W.; ALSTON, J. A dual approach to evaluating research benefits in the presence of trade distortions. **American Journal of Agricultural Economics**, v. 74, p. 26-35, 1994.

SANTOS FILHO, J. I. dos; SANTOS, N. A. dos; CANEVER, M. D.; SOUZA, I. S. F. de; VIEIRA, L. F. O Cluster suinícola do oeste de Santa Catarina. In: HADDAD, P. R. (Org.). **A competitividade do agronegócio e o desenvolvimento regional no Brasil – Estudos de Clusters.** Brasília: CNPq/Embrapa, 1999.

SCOBIE, G.; POSADA, R. The impact of technical change on income distributions: the case of the rice in Colombia. **American Journal of Agricultural Economics**, v. 60, p. 81-95, 1978.

Appendix

(to Chapter 3)

Correlation between productivity gains per area and real consumer prices: a theoretical and empirical approach

The purpose of this part of the study is to set forth the theoretical bases of the relation between productivity gains and the evolution of real food prices, whose behavior was been presented in the first part of this report.

A.1 – Introduction

Economic literature suggests that the price of any good or service is determined by the interaction between the factors that determine demand and supply in each market. It could not be any different for the food contemplated in this study. Thus, it is possible to describe the average rate of price variation for a given food j as ensuing from the difference between the variation of demand and the variation of supply:

$$DP_j/P_j = DQ_{d,j}/Q_{d,j} - DQ_{s,j}/Q_{s,j} \qquad (1)$$

The expansion of demand derives from the growth of income per capita multiplied by the income elasticity of the product demand, invariably inelastic, plus the population growth rate. In this competitive agricultural sector, the supply growth rate depends on the rate of accumulation of the inputs used in the production process, plus the gains in productivity of the respective production factors. Technological innovations generate productivity gains, which are usually appropriated by the producers, consumers, or government, depending on the conditions of competition of each participant. Since the purpose of this part of the study is to show the empirical relation between the behavior of real consumer prices and productivity gains per area, it would be appropriate to make some theoretical considerations, since these two variables are only indirectly related to each other.

Firstly, it is necessary to recall that foodstuff begin in agriculture, go through an industrial processing and reach the consumer through distributors, with different characteristics, most of the time as a similar product. For example, soybean and soybean oil, ground or whole grain coffee or, then, the product is only selected, processes and packaged, as in the case of rice, beans or tomatoes. As a rule, throughout the whole processing and distribution chain, a part parcel of values added up until compared with the limit of consumers use value to make up the market value.

For theoretical purposes, let us suppose that the supply of product j, presented to consumer $Q_{s,j,t}$, is the result of the following production chain process:

$$Q_{s,j,t} = e^{(i+c).t} Q_{j,t} \qquad (2)$$

where : $Q_{j,t}$ = production of product j in agriculture
(i + c) = coefficients of innovation to the agricultural product by industry (processing) and commercial distribution (logistics, marketing, packaging).

On the other hand, the agricultural production function can be described as follows:

$$Q_{j,t} = e^{a.t} f(A;F;V;L;M;S) \qquad (3)$$

Where $e^{a.t}$ corresponds to technological innovations, or variation in the overall productivity of the factors, which are made of A = farmed area, F = fertilizers, V = plant varieties, L = labor, M = mecanization, and S = available social infrastructure. In order to facilitate the issue, the set of factors can be represented by a single vector T = (F,V,L,M,S), except for area A, which will be kept isolated. That is, the biological (F,V,S) or mechanical technologies (L,M,S) are combined per unit area on the same available social infrastructure. Thus, formula (3) can be rewritten as follows:

$$Q_{j,t} = e^{a.t} . f(A,T) \qquad (4)$$

Such a function, if homogeneous of degree one and of the power-type, can be expressed as:

$$Q_{j,t} / A = e^{a.t} (T/A)^{b} \ ; \text{ for } b<1 \qquad (5)$$

Figure A1 shows the graphic representation of this formula, where area productivity "w" is given by the dominant technology "f" and the accumulation of factors per area $(T/A)_{0}$.

Figure A.1

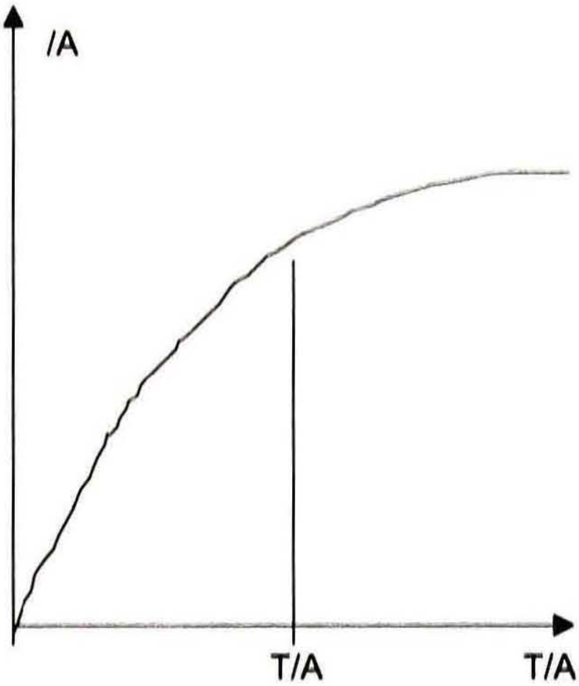
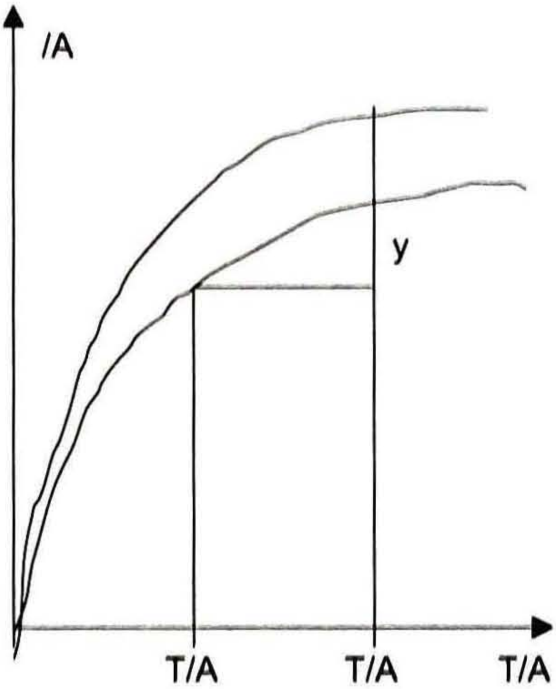


Figure A.2



On the other hand, the variation rate of productivity per area (xz) is determined by the total productivity gains of the factors (yz), plus the growth rate of the accumulation factors per unit area (xy), i.e., by the formula:

$$D(Q_{j,t} / A) / (Q_{s,t} / A) = a + b\, D(T/A)/(T/A) \qquad (6)$$

Once again, for the sake of simplification, it is presumed that the accumulation of the factors has the following function: $(T/A)_{j,t} = (T/A)_{j,0}\, e^{f.t}$, where f is equivalent to the growth rate during the period of accumulation of the factors per area. So that substituting this function in (6) we have:

$$D(Q_{j,t} / A) / (Q_{a,t} / A) = a + b . f \qquad (7)$$

Figure 2 shows diminishing returns to factor productivity per area Q/A can be broken down into the two components of the model: the first due to the total productivity gain of the factors "a"; and the second due to the rate of accumulation of the factors "f", weighed by the factors/product elasticity per area "b". The value of the latter parameter must be lower than one, because formula (5) shows decreasing productivity values for the factors.

Lastly, it is possible to transform the agricultural food supply into the food supply perceived by the consumer, as described in formula (2), which ultimately is the supply linked to the prices faced by consumers and used in this study. Thus, formula (2) can be rewritten as follows:

$$Q_{a,j,t} / A = e^{(i+c).t} (Q_{j,t}/A) = e^{(a+f.b+i+c)} (T/A)_{j,o} \qquad (8)$$

The variation rate of this equation is given by:

$$D(Q_{a,j,t} / A)/(Q_{a,j,t} / A) = a+f.b+i+c \qquad (9)$$

This rate includes all the factors that contribute to an increase in food supply, i.e., originates in the gains initiated in the gross agricultural production, goes through innovations in the industrial processing of such products and reaches the consumer through the changes in distribution logistics and the strategic marketing of commercialization.

But what could be the purpose of all this deducting?

Everything started with the need to find a theoretical basis to justify the empirical correlation between the historical series on productivity gain per area with the real prices of the foodstuff selected for the study. Since these variables are not appropriate for a direct correlation, i.e., they only interact in an indirect manner, it was be desirable not only to set forth the theoretical bases that support such relation, but also to open the way for making considerations on the magnitude of the estimated coefficient of correlation between the two variables.

The econometric model that makes it possible to estimate the degree of association of productivity per area with the real price for each product was the following:

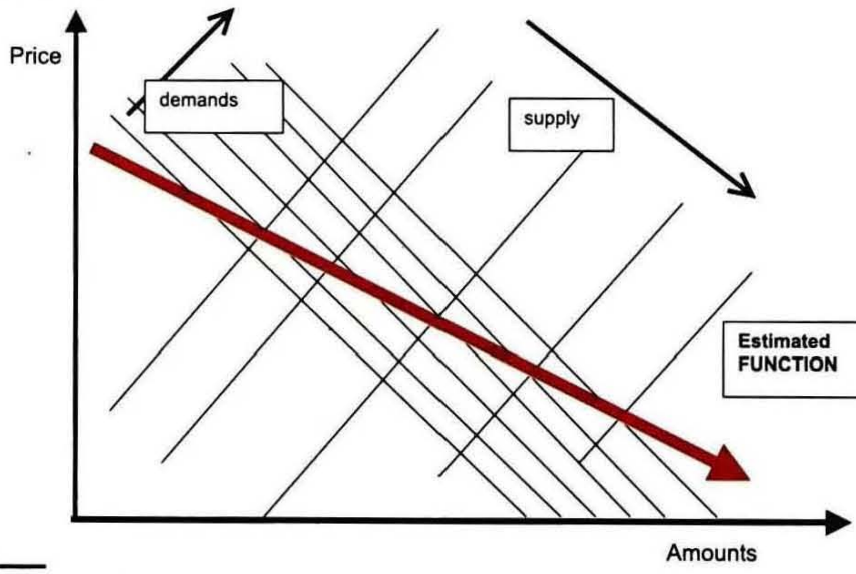
$$(Q_{j,t} \,/\, A) = K.\ P^{\theta}_{j,t} \qquad (10)$$

The estimated parameter "θ" corresponds to an elasticity measurement, i.e., it measures the percentage variation rate of consumer prices as a response to the percentage variation of the productivity gains per area:

$$\theta = [(DQ_{j,t}/A)/(Q_{j,t})/A)] \,/\, [DP_{j,t}/P_{j,t}] \qquad (11)$$

It becomes clear that "θ" is over estimated, since the gains of agriculture, as well as industry and commerce, are incorporated, after deducting the demand growth rate. This is equivalent to saying that the effect of productivity on the real prices is over estimated[3]; although it does have an appreciable effect, since it helps reduce prices along time. In econometric terms, it is said that were the supply displacements to be higher than the demand displacements, the estimated relation would make $\theta < 0$, because it is the long-term demand that is being identified, as seen in Figure A.3, below.

Figure A.3



[3] Nevertheless, as shown in Chapter I, the contribution of the commercialization and industrialization margins to explaining price reductions seems to have been small. In other words, the over estimation mentioned in the text may not be very large in the concrete case analyzed.

A.2 - Empirical Results

The values for the estimated "θ" elasticities of the products studied are shown in Table A.1.

Table A1 – Productivity Gains and Drop in Real Prices, 1975 – 2000.

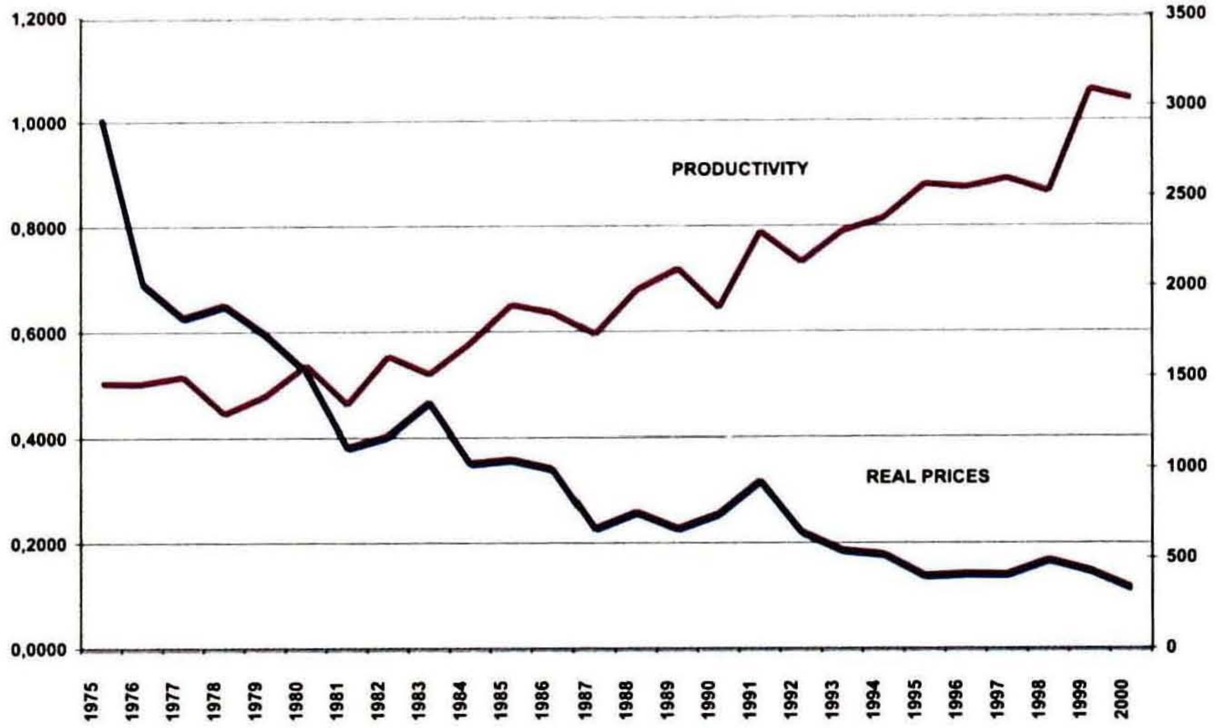
Product	Elasticity "θ"	T-student	R2
Banana	0.09	2.3	18%
Beans	-2.47	2.15	16%
Coffee	-0.99	1.95	14%
Onions	-2.07	4.44	57%
Orange	-2.01	2.97	37%
Potatoes	-1.46	6.77	66%
Rice	-2.1	10.72	83%
Soybean Oil/soybean	-2.46	5.83	59%
Sugarcane	-2.54	4.21	43%
Tomatoes	-1.41	10.17	81%

Please observe that the estimated elasticity values for rice, beans, sugar, soybean oil, onions, and orange are higher than 2.0, that is, every 1% variation in area productivity corresponds to a 2% drop in the real price of these products. Banana has a strange behavior, since the decrease in the real price has nothing to do with the decrease in productivity. Nevertheless, as explained previously, this value is certainly over estimated, because, in addition to the effect of productivity itself, it includes the effects of the other components that affect consumer prices. Another way of thinking about the relative gains in productivity is to observe the order of the regression coefficients (R2). High regression coefficients show increased consistency between the two variables, which is not a spurious correlation at all, but reveals an enhanced effect of productivity on the real price of each product. Rice and tomatoes are good examples of this type of effect; coffee and beans, on the other hand, are further away, due perhaps to their respective impacts having occurred before the second half of the 1970 decade.

Graphs A1 to A10, below, show the relation between productivity per area and the evolution of real prices, case by case.

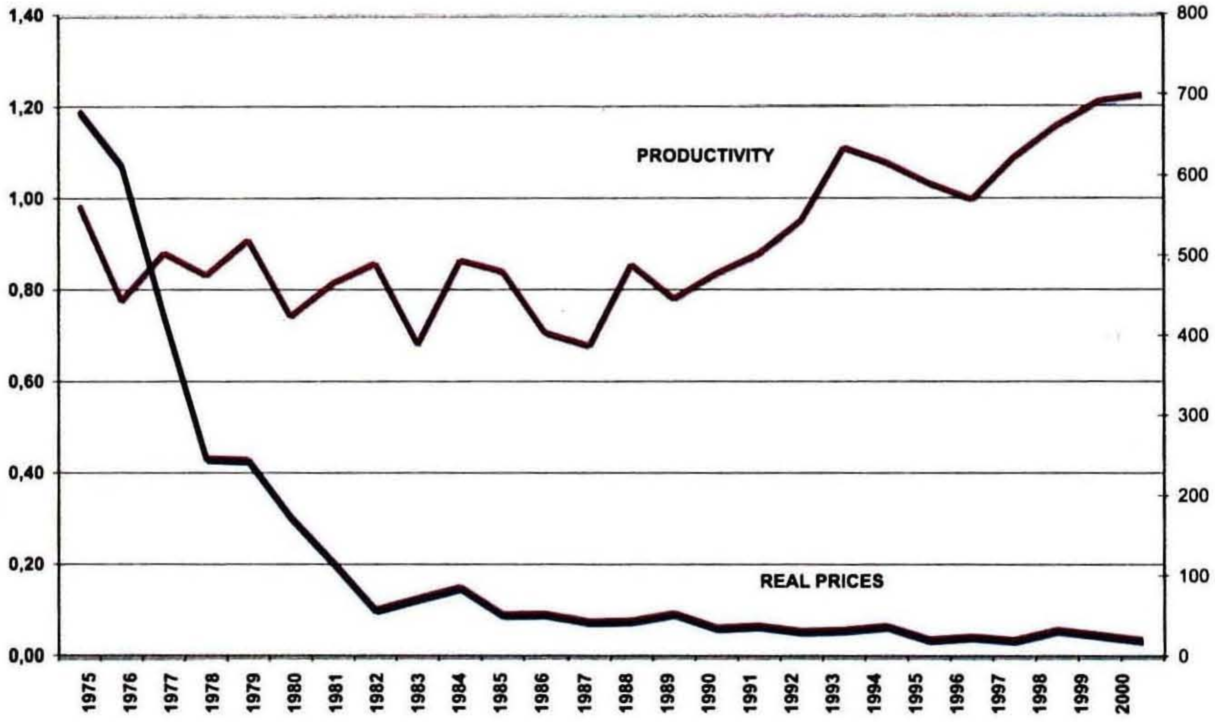
A1

RICE

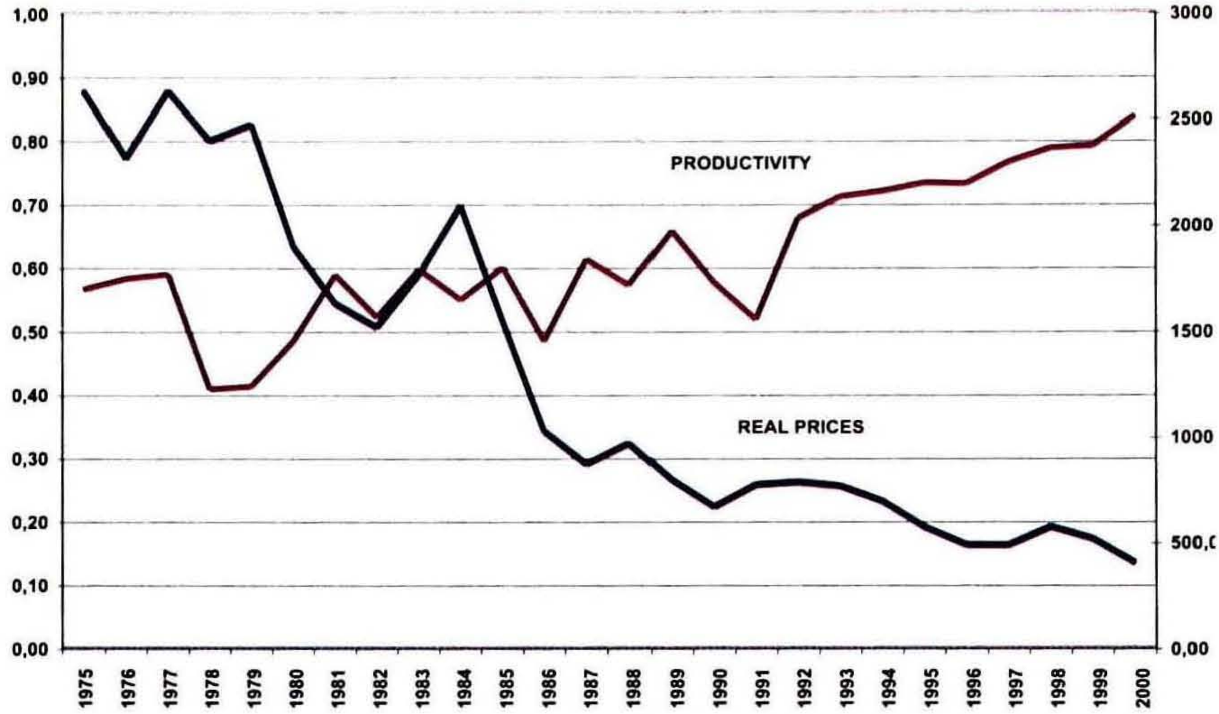


A2

BEANS



A3 SOYBEAN & SOYBEAN OIL



A4 SUGAR AND SUGARCANE