

# ANIMAL RAISING AND THE MEAT INDUSTRY: IMPORTANCE FOR THE BRAZILIAN ECONOMY

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## ABSTRACT

In this work we analyzed the importance of the meat sector – cattle, poultry and other animals raising, slaughter and processing – for the other Brazilian economic sectors. We used the input-output model, mainly the following analyzes Rasmussen-Hirschman multipliers and linkage indices, and pure inter-industrial linkage indices. And we used the Brazilian input-output matrix of 1995. The results indicate that: a) the cattle and poultry slaughter and process industries can be considered key-sectors for the Brazilian economy; b) changes in the final demand of the cattle and poultry slaughter and process industries, will result in a significant impacts on the total production, salary and imports of the Brazilian economy; and changes in the final demand of the animals raising sectors and animal slaughter and process industry, except beef and poultry, will not be significant; c) the beef and poultry industries are strongly dependent of the other economic sectors, and those sectors are more connected to final demand; d) changes in the production process of the animal-raising sectors and meat process industries do not affect its share in the Brazilian economy, and do not affect the share of other Brazilian economic sectors in the national economy.

**Key words:** Brazilian Economy, Animal-Raising, Meat Processing.

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## 1 Introduction

The main productive chains of the Brazilian meat sector are the beef chain, the poultry chain, and the pork chain. The animal slaughter/process industries are very important to the Brazilian economy because:

a) The cattle are raised in almost all the Brazilian municipality, and the Brazilian herd is distributed as following: 34.0% in the Middle West region, 23.0% Southeast, 16.5% South, 14.5% Northeast and 12.0% in the North region; cattle-raising's share in the Brazilian Gross Domestic Product (GDP) is above 3.0% (Números..., 1994); beef is sold in more than 1.8 million commercial establishments; and the beef chain employs around 8 million people (Dbo Rural, 1995);

b) The Brazilian poultry sector has a significant participation in the Brazilian meat production and consumption. The poultry production is concentrated in the South region, 45.0%, and 55.0% are distributed as following: 29.0% in the Southeast region, 15.0% in the Northeast, 6.0% in the Middle West and 5.0% in the North region. The poultry slaughter and processing industries are also concentrated in the South and Southeast. Through the poultry chain flow about US\$ 6 billion yearly (Coutinho & Ferraz, 1993; Martins, 1996);

c) The pork are raised on at least 2.7 million rural properties and through this chain flow about US\$ 920 million yearly in farm production alone; the pork chain employs about 2.5 million people in the South and South-East region of the country and consumes a significant part of Brazilian production of corn and soy oil byproducts (ANUALPEC, 1996 and 1997). Around 35.0% of the Brazilian pork are raised in the South region (close to the largest part of the slaughter and pork process industry), 17.0% are located in the Southeast, 10% in the Middle West (where there are good perspectives of expansion, following the increase of corn and soybean productions); 13.0% in the North and 25.0% in the Northeast regions, and are used for the subsistence.

In the economic literature there are some papers that analyze the

Brazilian productive structure. Nevertheless, usually the economic sectors are aggregated, with a view to possibility to compare each economic sector with the rest of the Brazilian economy. In general, the different segments of the meat sector (animal-raising sectors and animal slaughter sectors) are aggregated in the sectors “Cattle-raising” and “Animal slaughter” respectively. And sometimes those sectors are incorporated in the sectors “Agriculture” and “Food industry” respectively.

The Brazilian meat sector is very important to the Brazilian economy, especially to the Brazilian agriculture and food industry, therefore the main objective of this work is to consider those sectors separately, and to analyze the importance of each segment of the meat sector to the other sectors of the national economy. The specific objectives are: a) to analyze the importance of the cattle, poultry and other animal-raising sectors and beef, poultry and other animal slaughter/process industries, mainly the impact of changes in their final demand on the rest of the economy, and the linkage power in the Brazilian economy; b) to analyze the effects of changes in the productive process in those sectors on their own share in the national economy, and on the share of the other economic sectors.

## **2 Methods**

Inter-industries flows in a specific economy are determined by technological and economic factors, and these flows can be described by a system of simultaneous equations represented by:

$$X = A X + Y \quad (1)$$

where:  $X$  is a vector ( $n \times 1$ ) and it contains the value of total production by sector;  $Y$  is also a vector ( $n \times 1$ ) and it contains the final demand values; and  $A$  is a ( $n \times n$ ) matrix which contains the production technical coefficient (Leontief, 1951, in Guilhoto et al., 1994; Guilhoto, 1995;

Guilhoto & Picerno, (1995); e Miller & Blair, 1985).

In the model above, the final demand vector is usually considered exogenous to the system; thus, the total production vector is determined only by the final demand vector, that is:

$$X = B Y \quad (2) \quad \text{and} \quad B = (I - A)^{-1} \quad (3)$$

where  $B$  is a  $(n \times n)$  matrix which contains the Leontief inverse matrix.

Starting from equation (1), we can evaluate the impact of different changes in the final demand on the total production, import volumes and total salaries. Thus,

$$\Delta X = B \Delta Y \quad , \quad \Delta M = m \Delta X \quad \text{and} \quad \Delta S = s \Delta X$$

where  $\Delta Y$ ,  $\Delta X$ ,  $\Delta M$  and  $\Delta S$  are  $(n \times 1)$  vectors which show respectively the final demand increase, and the impacts on the total production volume, on the import values and on the salary totals;  $m$  and  $s$  are diagonal  $(n \times n)$  matrices in which the diagonal elements are the import and salary coefficients.

Starting from equation (3), and following Rasmussen (1956) and Hirschman (1958), we can determine which sectors present high linkage power in a specific economy. Those authors defined the backward and forward linkage indices as following: a) **backward linkage index**: this index indicate how much a specific sector demand inputs from the other sectors; values above 1 indicate a sector very dependent of the rest of the economy; b) **forward linkage index**: this index indicate how much the other economic sectors demand inputs from a specific sector; values above 1 indicate a sector which products are very demand by the rest of the economy.

The key-sectors for the growing of the national economy are those which show Rasmussen/Hirschman backward and forward linkage indices

above 1. Values above 1 indicate sectors above the average (restrict concept). But we can consider a less restrict concept: the key-sector is that one that shows Rasmussen/Hirschman backward and/or forward linkage indices above 1.

Starting from equation (3),  $b_{ij}$  can be defined as an element of the inverse Leontief matrix  $B$ ;  $B^*$  as the average of all elements of  $B$ ; and  $B^*_j$  and  $B^*_i$  as the sum of a characteristic column and line of  $B$ , respectively. The indices will be<sup>1</sup>:

$$\text{Backward linkage index: } U_j = [ B^*_j / n ] / B^* \quad (4)$$

$$\text{Forward linkage index: } U_i = [ B^*_i / n ] / B^* \quad (5)$$

The input-output model permit us to obtain the Rasmussen-Hirschman multipliers, that can be used to determine the impact of changes in the final demand on the total production volume, on the import values and on the salary totals. The alteration in the final demand can be induced by the intervention of the public sector in the national economy. That is, the Rasmussen-Hirschman multipliers analyses permit us to determine the impact of different Government politics on the total production, imports, salaries and income distribution. The governmental interventions that affect sector that present high multipliers will result in significant impacts on the economy. This work uses the Leontief multipliers, or multipliers Type I. These multipliers do not consider the endogenous demand that is generated into productive process, after a determined impact on the exogenous demand. This situation, in general, results in Rasmussen-Hirschman multipliers sub-estimated.

To separate the impacts of a certain sector from the other economic sectors we can use the pure inter-industrial linkage index. This proceeding can also be used to separate the impacts of the certain region from the rest of the economy, or still to separate the impacts of certain country from

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<sup>1</sup> Those indices were completed whit the dispersion indices (Bulmer-Thomas, 1982): the dispersion of the backward linkage indices indicate how much a sectorial impact is distributed to the other sectors, and the dispersion of the forward linkage indices indicate how much a determined sector is demanded by the other sectors.

the economic block in which it is inserted (Guilhoto, Sonis, Hewings, 1996; Guilhoto, Hewings, Sonis, 1997). This index is an improvement of the Cella-Clements approach.

The basic idea is to isolate certain sectors  $j$  from the rest of the economy and to define the effect of the total linkages of the sector  $j$  in the economy. That is, the difference between the total production of the economy and the production in the economy if the sector  $j$  does not buy inputs from the rest of the economy and it does not sell its production to the rest of the economy. This situation is equivalent to an elimination of a given industrial sector.

We can isolate determined sectors  $j$  from the rest of the economy considering an input-output system with two regions, which can be represented by the following direct Leontief coefficients (Guilhoto, Hewings, Sonis, 1997):

$$A = \begin{pmatrix} A_{jj} & A_{jr} \\ A_{rj} & A_{rr} \end{pmatrix} \quad (6)$$

where  $A_{jj}$  and  $A_{rr}$  are the quadrate matrices of direct inputs within the first and second regions and  $A_{jr}$  and  $A_{rj}$  are the rectangular matrices showing the direct inputs purchased by the second region and vice versa.

From (6), we can generate the following expression:

$$B = (I - A)^{-1} = \begin{pmatrix} B_{jj} & B_{jr} \\ B_{rj} & B_{rr} \end{pmatrix} = \begin{pmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{pmatrix} \begin{pmatrix} \Delta_j & 0 \\ 0 & \Delta_r \end{pmatrix} \begin{pmatrix} I & A_{jr} \Delta_r \\ A_{rj} \Delta_j & I \end{pmatrix} \quad (7)$$

Where:  $\Delta_j = (I - A_{jj})^{-1}$  (8)  $\Delta_r = (I - A_{rr})^{-1}$  (9)

$$\Delta_{jj} = \left( I - \Delta_j A_{jr} \Delta_r A_{rj} \right)^{-1} \quad (10)$$

$$\Delta_{rr} = \left( I - \Delta_r A_{rj} \Delta_j A_{jr} \right)^{-1} \quad (11)$$

Through the equation (7) we can reveal the process of production in an economy as well as derive a set of multipliers/linkages.

In the matrix

$$\begin{pmatrix} I & A_{jr} \Delta_r \\ A_{rj} \Delta_j & I \end{pmatrix} \quad (12)$$

the first row separates the final demand by its origin; that is, it distinguishes between the final demand that comes from inside the region (I) from the one that comes from outside the region ( $A_{jr} \Delta_r$ ). From the Leontief:

$$X = \left( I - A \right)^{-1} Y \quad (13)$$

And using the equation (7) to (12), we can derive a set of indices that can be used to rank the regions in terms of their importance in the economy and to see how the production process occurs in the economy, the pure inter-industrial indices:

$$PBL = \Delta_r A_{rj} \Delta_j Y_j \quad \text{and} \quad PFL = \Delta_j A_{jr} \Delta_r Y_r \quad (14)$$

The **PBL** will give us the pure impact on the rest of the economy of the value of the total production in region  $j$ , ( $\Delta_r Y_j$ ). This impact is free from: a) the demand inputs that region  $j$  makes from region  $j$ , and b) the feedback from the rest of the economy to region  $j$  and vice-versa. The **PFL** will give us the pure impact on region  $j$  of the total production in the

rest of the economy ( $\Delta_r Y_r$ ). Then, we can obtain the total pure inter-industrial index, **PTL**, if we add PBL and PFL.

The structure of the Leontief model compel us to assume that: a) there is useless capacity in the economy, and an increase in the demand level result in an increase in the production level; b) the technical coefficients are fix (there are not technological changes during the period analyzed); c) the imports to be used in the productive process are not restrict.

This work uses the Brazilian input-output matrix of 1995 (MIP-IBGE, 1997). Some sectors of the production and input tables, "Agricultural" and "Animal slaughter", were desegregated into different segments to permit the study of the cattle, poultry and other animal-raising sectors and the beef, poultry and other animal process industries. Then we made a final balance to redistribute the internal values of these matrices into row and column totals, RAS Method (Bacharach, 1970). We considered the objectives of this work and the information available, and then we aggregated some other sectors of the economy. In the total we obtained 32 sectors.

The effects of changes in the productive process of the animal-raising sectors and meat process industries on the Brazilian economy are also analyzed using the input-output model. In this work we simulated changes in the technical production coefficient of the Brazilian animal-raising and animal slaughter/meat industry sector. We considerate that the meat sectors can improve its production process in the next 5 years, and that the other productive sectors would not have changes in their respective technical production coefficients. We changed the production coefficient of the sectors 2-Cattle-raising ( $a_{22}$ ), 3-Poultry-raising ( $a_{33}$ ), 4-Other animal-raising ( $a_{44}$ ), 20-Beef slaughter/processes industry ( $a_{2020}$ ), 21-Poultry slaughter/process industry ( $a_{2121}$ ) and 22-Other animal slaughter/process industry ( $a_{2222}$ ). The coefficient was reduced in the same proportion in which the increases in the production efficiency of the 16-Meat industry are expected.



The simulations realized are represented in the Table 1. To estimate changes in the production technical coefficient we considered preliminary studies, just as Bliska *et al.* (1998) and Coutinho & Ferraz (1993), statistics on the meat sectors (ANUALPEC 1996/1998), and results of studies on the technological demand, that are still not published, and that are being conducted in the Agricultural Secretary of the São Paulo State.

Table 1. Changes in the production process in the cattle, poultry and other Brazilian animal-raising sectors, and beef, poultry and other Brazilian meat process industries.

Sector	Coefficient changed in the Matrix A	% of changes in the coefficients of Matrix A			
		Simulations			
		1 <sup>st</sup> -	2 <sup>nd</sup> -	3 <sup>rd</sup> -	4 <sup>th</sup> -
2-Cattle-raising	$a_{22}$	5	5	10	20
3-Poultry-raising	$a_{33}$	2	2	5	20
4-Other animals-raising	$a_{44}$	2	11	11	20
20-Cattle slaughter / industry	$a_{2020}$	5	10	10	20
21-Poultry slaughter / industry	$a_{2121}$	5	5	10	20
22-Other animals slaughter	$a_{2222}$	5	10	15	20

### 3 Results

The type I multipliers and the Rasmussen-Hirschman backward and forward linkage indices are represented in the Table 2. The Type 1 multipliers indicate that changes in the final demands of the cattle slaughter industry and poultry slaughter industry (respectively sectors 20 and 21) can result in significant impacts on the Brazilian economic production. Those sectors present, respectively, the highest multiplier and the third highest multiplier. The multipliers of the animal production sectors indicate

that changes in their final demands probably do not generate significant impacts on the Brazilian economy.

The sector 22-Other animals slaughter presents the second smallest multiplier. Then the effect of changes in the final demand of this sector on the Brazilian economy will be smaller than the effect of changes in the final demand of the beef and poultry slaughter/process industry. But the sector 4-Other animals-raising presents multiplier bigger than the cattle and poultry-raising multipliers.

Sectors 2-Cattle-raising, 3-Poultry-raising and 4-Other animals-raising presents the 13<sup>th</sup>-, 14<sup>th</sup>- and 25<sup>th</sup>- forward linkage indices, respectively. And sectors 20-Beef slaughter/process industry, 21-Poultry slaughter/process industry and 22-Other animals slaughter/process industry presents the 18<sup>th</sup>-, 32<sup>nd</sup>- and 30<sup>th</sup>- forward linkage indices.

These results confirm that sectors 2-Cattle-raising and 3-poultry-raising are demanded by the other economic sectors, and that the poultry slaughter and industrial sector presents the smallest forward linkages index into Brazilian economy, therefore this is sector more connected with the final demand.

Table 2. Type 1 (Leontief) Multipliers and Rasmussen/Hirschman backward and forward linkage indices.

Sectors	Multipliers	Order	Rasmussen/Hirschman linkage indices			
			Backward		Forward	
			Index	Order	Index	Order
1-Corn	1,6238	25	1,0060	11	0,8109	25
2-Cattle-raising	1,5625	29	0,9009	13	0,7803	30
3-Poultry-raising	2,0746	15	0,8188	14	1,0360	15
4-Other animals-raising	2,1585	12	0,6333	25	1,0779	12
5-Other farm products	1,5695	28	2,7366	2	0,7837	29
6-Mining	1,9552	19	1,1166	7	0,9764	19
7-Steel industry	2,3387	7	1,6713	5	1,1679	7
8-Machinery / vehicles	2,0361	16	1,0927	8	1,0167	16
9-Electric / electronic	1,9342	21	0,6608	22	0,9659	21
10-Wood / furnishings	2,0022	17	0,6536	23	0,9998	17
11-Paper / graphics	2,1552	13	0,9779	12	1,0763	13
12-Rubber industry	2,1526	14	0,8022	15	1,0749	14
13-Chemistry	1,9209	22	2,7639	1	0,9592	22
14-Pharmacy / veterinary	1,8384	23	0,5429	31	0,9181	23
15-Plastic goods	1,9584	18	0,7502	17	0,9780	18
16-Textile industry / clothing	2,2227	9	1,0318	10	1,1099	9

Table 2. Type 1 (Leontief) Multipliers and Rasmussen/Hirschman backward and forward linkage indices.(continuation)

Sectors	Multipliers	Order	Rasmussen/Hirschman linkage indices			
			Backward		Forward	
			Index	Order	Index	Order
17-Shoes industry	2,2038	10	0,6123	27	1,1005	10
18-Coffee industry	2,3726	6	0,6762	20	1,1848	6
19-Vegetable products processing	2,1967	11	0,6906	19	1,0970	11
20-Cattle slaughter / industry	2,5524	1	0,6920	18	1,2746	1
21-Poultry slaughter / industry	2,4566	3	0,5045	32	1,2268	3
22-Other animals slaughter	1,5165	31	0,5474	30	0,7573	31
23-Milk industry	2,4154	5	0,6372	24	1,2062	5
24-Sugar industry	2,4421	4	0,6731	21	1,2195	4
25-Vegetable oils industry	2,5043	2	0,7758	16	1,2505	2
26-Other food products	2,3070	8	1,0375	9	1,1520	8
27-Other industries	1,9432	20	0,6016	28	0,9704	20
28-Public usefulness	1,5990	27	1,1328	6	0,7985	27
29-Building	1,6257	24	0,5939	29	0,8118	24
30-Commerce / transport	1,6171	26	2,0746	3	0,8076	26
31-Communication	1,2533	32	0,6230	26	0,6258	32
32-Services	1,5718	30	1,9680	4	0,7849	28

Since 80 years, the poultry slaughters house are increasing the production of products with high added value, to supply the retail market, mainly poultry parts, boned or not, marinated, batter and breaded products, hamburger and meat balls. And the major part of cattle slaughter houses have as final product the half carcass, that are divided in the supermarkets and butchers (the boned are been implanted in the slaughters house and processing industries, but it is not significant when we consider the total volume of cattle hearted in the country). Over that, just 15.0% of the Brazilian beef are destined to the processing industries, while 85.0% are consumed *in nature*. The Federal Edict that regulates the Brazilian meat market, restricting the half-carcass commerce, is not totally implanted (Bliska, 1997a; Bliska, 1997b; Bliska, 1998; Bliska *et al*, 1998). The sector 4-Other animals-raising and the sector 22-Other animals slaughter/processing industries present forward linkage indices very small, that is, these sectors are not strongly demanded by the other economic sectors.

At least, the animal raising sectors and animals slaughter/process industries do not present forward linkage indices above 1. That is, these sectors are not strongly demanded by the other economic sectors. The forward dispersion indices of sectors 21-Poultry slaughter/process industries and 22-Other animals slaughter/process industries indicate that these sectors are demanded by a few economic sectors. The forward dispersion indices of sectors 2-Cattle-raising and 3-Poultry-raising indicate that these sectors are homogeneously demanded by the other sectors. These results are similar to those obtained by Guilhoto & Picerno (1996): sectors with the highest forward linkage indices present the smallest dispersion indices and vice-versa; that is, important sectors as input suppliers have impacts better distributed into other economic sectors.

The cattle and poultry slaughter and industrial sectors also present the highest and the third highest backward linkages and the small forward linkages index, indicating that those sectors demand products from the other several sectors, but they are not demanded by other sectors since most of their sales are to final demand. Both present backward linkage

indices above 1, that is, these sectors are strongly dependents of the rest of the economy. The value of the backward linkage indices of the food industry are among the highest indices into Brazilian economy, and the backward linkage indices of the animals raising sectors show small values. The animals slaughter/process industries present small values of backward dispersion indices, that is, the impact of changes in the production level of these sectors will stimulate the other economic sectors uniformly. The dispersion indices of the animals raising sectors indicate that the effects resulted from changes on the cattle production, sector 2-Cattle-raising, will be concentrated in a small number of sectors, in relation to poultry and other animals raising. These last sectors will stimulate the other economic sectors uniformly. The sector that presents high backward linkage indices, also presents small dispersion indices and vice-versa.

The analyzes show us that sectors 4-Other animal-raising and 22-Other animals slaughter/process industries are not strongly demanded by the other economic sectors. Above that, the sector 4-Other animals-raising presents the highest backward linkage index among the animals raising sectors (this is the animal raising sector that demand more inputs from the rest of the economy). And the sector 22-Other animal slaughter/process industries presents the smallest backward linkage index among the animals slaughter/process industries (the animal process sector that presents smaller dependence from the other economic sectors). The other animals raising sector also presents the highest type I multiplier, among the animals raising sectors; and the smallest type I multiplier, among the animals slaughter/process industries. If we consider that around 85.0% of the pig are used in the industrial processing, and 15.0% are consumed in nature (Bliska, 1997b), and considering that around 28.0% of the pork raising are used to subsistence, those results can show a strong informal slaughter, to subsistence, or at least an informal market bigger than in the beef and poultry markets.

With relation to the sectors with the highest linkage indices in the Brazilian economy, this work obtained results similar to those one obtained

by other authors, such as Bliska & Guilhoto (1996), Guilhoto (1992), Guilhoto, Conceição & Crocomo (1996) e Guilhoto & Picerno (1995). But these other studies analyzed other periods of time and an aggregated meat sector.

Finally, if we consider that key-sectors are those which display Rasmussen/Hirschman backward and forward linkage indices above 1 (restrict concept), animal-raising sectors and animal slaughter/process industries can not be considered key-sectors to the Brazilian economy. But if we consider that key-sectors are those that display Rasmussen/Hirschman backward and/or forward linkage indices above 1, a less restrictive concept, sectors 20-Beef slaughter/process industries and 21-Poultry slaughter/process industries can be considered key-sectors. These sectors present backward linkage indices above 1, and present respectively the highest and the 3<sup>rd</sup>- highest backward linkage indices. This result is similar to the multipliers analyzes (beef and poultry slaughter/process industries present the highest and the 3<sup>rd</sup>- highest type I multiplier).

The pure forward, backward and total inter-industrial indices are represented in the Table 3, and measure monetary impacts (R\$) of each sector on the other economic sectors. The results indicate that the disappearance of the animal raising sectors – 2-Cattle-raising, 3-Poultry-raising and 4-Other animals-raising – and 22-Other animals slaughter/process industry should not cause significant impacts on the Brazilian economy. And the disappearance of sectors 20-Cattle and 21-Poultry slaughter and industrial sectors should result in significant impacts on the economy. The pure indices confirm the results obtained in the Rasmussen/Hirschman on the importance of the cattle and poultry slaughter and industrial sectors for the economy.

We analyzed the changes in the production processes of the meat industry, and we verified that those changes do not affect their share in the Brazilian economy. First, we analyzed Rasmussen/Hirschman backward and forward linkage indices and pure backward, forward and total linkage indices. Second, we simulated changes in the technical

coefficients and calculate those indices again. Then, we compare the order of those indices before and after the changes in the production process. We can see, in Tables 4 and 5 (results of the 4<sup>th</sup>- simulation), that there are small changes in the indices analyzed, but there are not significant changes in the hierarchy of those indices, although we had considered changes of 20.0% in the animal raising sectors and animal slaughter and process industries. The significant changes occurred in the hierarchy of the first four sectors with highest type I multipliers, and the first four sectors with highest Rasmussen/Hirschman backward linkage indices.

Moreover, although all the Brazilian meat sectors can still increase its production and improve its technological process, changes in the production processes of the meat sector do not affect its share in the regional and national economies, and will not affect the share of the other economic sectors.

Changes in the production processes of the animal raising sectors and animal slaughter /process industries do not affect the Brazilian economy directly, but we have to consider the impacts on the economy when certain economic sector uses old technologies, and the economic damage that can not be detected by the input-output model. The absence of technological changes can increase the external competition.



Table 3. Pure inter-industrial linkage indices (R\$-billions): Pure Forward Linkage - (PFL), Pure Backward Linkage (PBL) and Pure Total Linkage (PTL).

Sectors	Pure Indices					
	PFL		PBL		PTL	
	Index	Order	Index	Order	Index	Order
1-Corn	3,564	22	0,058	32	3,620	30
2-Cattle-raising	5,173	16	1,720	25	6,890	22
3-Poultry-raising	2,633	23	1,474	27	4,110	29
4-Other animals-raising	1,976	25	1,646	26	3,620	31
5-Other farm products	34,655	4	9,846	9	44,500	5
6-Mining	19,730	6	2,882	22	22,610	9
7-Steel industry	34,785	3	6,128	13	40,910	7
8-Machinery / vehicles	15,752	8	27,376	4	43,130	6
9-Electric / electronic	5,317	15	15,462	6	20,780	10
10-Wood / furnishings	4,023	19	5,700	15	9,720	17
11-Paper / graphics	13,231	9	3,635	20	16,870	13
12-Rubber industry	5,463	14	0,589	31	6,050	24
13-Chemistry	49,544	2	5,595	16	55,140	3
14-Pharmacy / veterinary	0,980	28	7,337	11	8,320	18
15-Plastic goods	6,482	11	1,094	29	7,580	19
16-Textile industry / clothing	4,968	17	8,154	10	13,120	14

Table 3. Pure inter-industrial linkage indices (R\$-billions): Pure Forward Linkage - (PFL), Pure Backward Linkage (PBL) and Pure Total Linkage (PTL).(continuation)

Sectors	Pure Indices					
	PFL		PBL		PTL	
	Index	Order	Index	Order	Index	Order
17-Shoes industry	0,383	31	4,230	18	4,610	27
18-Coffee industry	0,603	30	3,651	19	4,250	28
19-Vegetable products processing	4,245	18	14,702	7	18,950	11
20-Cattle slaughter / industry	1,947	26	9,984	8	11,930	15
21-Poultry slaughter / industry	0,296	32	5,522	17	5,820	25
22-Other animals slaughter	0,657	29	0,852	30	1,510	32
23-Milk industry	1,082	27	6,056	14	7,140	20
24-Sugar industry	1,985	24	3,156	21	5,140	26
25-Vegetable oils industry	3,764	20	7,232	12	11,000	16
26-Other food products	7,058	10	19,564	5	26,620	8
27-Other industries	3,586	21	2,526	23	6,110	23
28-Public usefulness	15,856	7	2,322	24	18,180	12
29-Building	5,521	13	48,012	2	53,530	4
30-Commerce / transport	44,232	1	35,540	3	79,770	2
31-Communication	5,832	12	1,195	28	7,030	21
32-Services	34,082	5	78,002	1	112,080	1

Table 4. Type 1 (Leontief) Multipliers and Rasmussen/Hirschman backward and forward linkage indices after the 4<sup>th</sup>- simulation of change in the production process of the cattle, poultry and other animal-raising sectors, and beef, poultry and other meat process industries.

Sectors	Multipliers	Order	Rasmussen/Hirschman linkage indices			
			Backward		Forward	
			Index	Order	Index	Order
1-Corn	1,6238	25	0,8130	25	1,0052	11
2-Cattle-raising	1,5469	30	0,7745	30	0,8859	13
3-Poultry-raising	2,0406	15	1,0218	15	0,8076	14
4-Other animals-raising	2,1539	14	1,0785	13	0,6314	25
5-Other farm products	1,5691	29	0,7857	28	2,7403	2
6-Mining	1,9550	19	0,9789	19	1,1189	7
7-Steel industry	2,3385	7	1,1709	7	1,6749	5
8-Machinery / vehicles	2,0359	16	1,0194	16	1,0950	8
9-Electric / electronic	1,9340	21	0,9684	21	0,6625	22
10-Wood / furnishings	2,0020	17	1,0024	17	0,6553	23
11-Paper / graphics	2,1550	12	1,0790	12	0,9801	12
12-Rubber industry	2,1524	13	1,0777	14	0,8042	15
13-Chemistry	1,9207	22	0,9617	22	2,7672	1
14-Pharmacy / veterinary	1,8380	23	0,9203	23	0,5439	31
15-Plastic goods	1,9583	18	0,9805	18	0,7519	17
16-Textile industry / clothing	2,2225	9	1,1128	9	1,0343	10

Table 4. Type 1 (Leontief) Multipliers and Rasmussen/Hirschman backward and forward linkage indices after the 4<sup>th</sup>- simulation of change in the production process of the cattle, poultry and other animal-raising sectors, and beef, poultry and other meat process industries.(continuation)

Sectors	Multipliers	Order	Rasmussen/Hirschman linkage indices			
			Backward		Forward	
			Index	Order	Index	Order
17-Shoes industry	2,1979	10	1,1005	10	0,6138	27
18-Coffee industry	2,3725	6	1,1879	6	0,6780	19
19-Vegetable products processing	2,1963	11	1,0997	11	0,6917	18
20-Cattle slaughter / industry	2,4823	2	1,2429	2	0,6769	20
21-Poultry slaughter / industry	2,4390	4	1,2212	4	0,5056	32
22-Other animals slaughter	1,5010	31	0,7515	31	0,5455	30
23-Milk industry	2,4151	5	1,2093	5	0,6389	24
24-Sugar industry	2,4418	3	1,2226	3	0,6747	21
25-Vegetable oils industry	2,5033	1	1,2534	1	0,7774	16
26-Other food products	2,3061	8	1,1547	8	1,0349	9
27-Other industries	1,9429	20	0,9728	20	0,6031	28
28-Public usefulness	1,5989	27	0,8006	27	1,1350	6
29-Building	1,6256	24	0,8140	24	0,5954	29
30-Commerce / transport	1,6160	26	0,8091	26	2,0759	3
31-Communication	1,2532	32	0,6275	32	0,6244	26
32-Services	1,5710	28	0,7866	29	1,9703	4

Table 5. Pure inter-industrial linkage indices (R\$-billions): Pure Forward Linkage - (PFL), Pure Backward Linkage (PBL) and Pure Total Linkage (PTL) after the 4<sup>th</sup>- simulation of change in the production process of the cattle, poultry and other animal-raising sectors, and beef, poultry and other meat process industries.

Sectors	Pure Indices					
	PFL		PBL		PTL	
	Index	Order	Index	Order	Index	Order
1-Corn	3,564	22	0,058	32	3,620	30
2-Cattle-raising	5,122	16	1,744	25	6,870	22
3-Poultry-raising	2,590	23	1,513	27	4,100	29
4-Other animals-raising	1,973	25	1,648	26	3,620	31
5-Other farm products	34,655	5	9,841	9	44,50	5
6-Mining	19,73	6	2,882	22	22,610	9
7-Steel industry	34,785	4	6,127	13	40,910	7
8-Machinery / vehicles	15,752	8	27,375	4	43,130	6
9-Electric / electronic	5,317	15	15,461	6	20,780	10
10-Wood / furnishings	4,023	19	5,699	15	9,720	17
11-Paper / graphics	13,231	9	3,635	20	16,870	13
12-Rubber industry	5,463	14	0,589	31	6,050	24
13-Chemistry	49,544	1	5,595	16	55,140	3
14-Pharmacy / veterinary	0,980	28	7,334	11	8,310	18
15-Plastic goods	6,482	11	1,094	29	7,580	19
16-Textile industry / clothing	4,968	17	8,153	10	13,120	14

Table 5. Pure inter-industrial linkage indices (R\$-billions): Pure Forward Linkage - (PFL), Pure Backward Linkage (PBL) and Pure Total Linkage (PTL) after the 4<sup>th</sup>- simulation of change in the production process of the cattle, poultry and other animal-raising sectors, and beef, poultry and other meat process industries.(continuation)

Sectors	Pure Indices					
	PFL		PBL		PTL	
	Index	Order	Index	Order	Index	Order
17-Shoes industry	0,383	31	4,206	18	4,590	27
18-Coffee industry	0,603	30	3,650	19	4,250	28
19-Vegetable products processing	4,245	18	14,699	7	18,940	11
20-Cattle slaughter / industry	1,901	26	9,980	8	11,880	15
21-Poultry slaughter / industry	0,296	32	5,460	17	5,760	25
22-Other animals slaughter	0,653	29	0,840	30	1,490	32
23-Milk industry	1,082	27	6,055	14	7,140	20
24-Sugar industry	1,985	24	3,156	21	5,140	26
25-Vegetable oils industry	3,764	20	7,228	12	10,990	16
26-Other food products	7,059	10	19,540	5	26,610	8
27-Other industries	3,586	21	2,526	23	6,110	23
28-Public usefulness	15,856	7	2,322	24	18,180	12
29-Building	5,521	13	48,010	2	53,530	4
30-Commerce / transport	44,233	2	35,537	3	79,770	2
31-Communication	5,832	12	1,195	28	7,030	21
32-Services	34,084	3	77,934	1	112,020	1

## **4 Conclusions**

The main conclusions are: a) changes in the final demand of the beef and poultry process industries will result in a significant impact on the Brazilian economy, while changes in the final demands of the other Brazilian economic sectors will not affect the national economy significantly; b) the beef and poultry process industries can be considered key-sectors to the Brazilian economy – we are considering that key-sectors are those which display Rasmussen/Hirschman backward or forward linkage indices above 1 – but the animal-raising sectors can not be considered key-sectors; c) the pure inter-industrial linkage indices show that the disappearance of the meat industry sector will result in a significant impact on the Brazilian economy, but the effects of the disappearance of the animal-raising sectors will not be significant; d) the animal-raising sectors and the meat industry are very demanded by the other Brazilian economic sectors; e) the beef and poultry industries are strongly dependent of the other economic sectors, and those sectors are more connected to final demand; f) changes in the production process of the animal-raising sectors and meat process industries do not affect its share in the Brazilian economy, and do not affect the share of other Brazilian economic sectors in the national economy.

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