HUMAN CAPITAL AND AGRICULTURAL DEVELOPMENT IN SÃO PAULO, BRAZIL

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V. TECHNOLOGICAL CHANGES IN AGRICULTURE AND AGribusiness
VI. FINAL COMMENTS

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I. HUMAN CAPITAL AND ECONOMIC DEVELOPMENT THEORY

• Solow (1957) \( Y = F(K, L, t) \) \( t := \text{technological change} / \text{"Solow residual"} \) \( \text{"technical progress"} \)

• Johnston and Mellor (1961) define the role of agriculture in economic development in five propositions:
  1. Provide increased food supplies
  2. Enlarge agricultural exports
  3. Transfer of manpower from agriculture to nonagricultural sectors
  4. Agriculture's contributions to capital formation
  5. Increase rural net cash income to stimulate industrialization
I. HUMAN CAPITAL AND ECONOMIC DEVELOPMENT THEORY

- **Kuznets (1964)** summarizes the role of agriculture through three types of contributions: *in product, in market* and *in labor force*

- **Becker (1964)** argues that continuous growth is not explained only by the use of capital (K/L) and land (D/L) per worker in agriculture. The *law of decreasing returns* would stop the growth process.

- Education is undervalued by rural population in a subsistence agriculture context. However, in an environment of instability and modernization, farmers will attribute priority and high value to education. They are *in front of a growth process of agribusiness.*
I. HUMAN CAPITAL AND ECONOMIC DEVELOPMENT THEORY

ECONOMIC AND SOCIAL RATES OF RETURN:

• Griliches (1964).
  • In US, the internal rate of return to agricultural research investment equals to 13 US$ per US$ unit.

• Evenson, Pray and Rosegrant (1999).
  • Estimated the return on investment in public and private agricultural research in India: 5 rupees per unit invested

• Araújo, Schuh, Mendonça de Barros, Shirotta and Nicolella (2003)
  • Estimated return on investment in agricultural research in the State of SP was R$ 10 per monetary unit invested

• Figueiredo, Mendonça de Barros, Peres and Conceição (2012) - For every R$ 1.00 invested in citrus research; there is an increase of R$13 on the production value of orange in the state of São Paulo.
II. HUMAN CAPITAL FOR THE STATE OF SÃO PAULO AND BRAZIL IN NUMBERS

• Human Capital for Agriculture / Agribusiness in São Paulo - 2012 (USP, UNICAMP, UNESP and UFSCAR)

• Faculty

<table>
<thead>
<tr>
<th>Agribusiness</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.387</td>
<td>12.585</td>
<td>11%</td>
</tr>
</tbody>
</table>

• Degrees Awarded

<table>
<thead>
<tr>
<th>Undergraduate</th>
<th>Agribusiness</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Universities</td>
<td>32.553</td>
</tr>
<tr>
<td>ESALQ/USP</td>
<td>12.922</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Graduate</th>
<th>MS</th>
<th>Phd</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Universities</td>
<td>5.526</td>
<td>3.451</td>
</tr>
<tr>
<td>ESALQ/USP</td>
<td>4.996</td>
<td>2.625</td>
</tr>
<tr>
<td>Total</td>
<td>10.522</td>
<td>6.076</td>
</tr>
</tbody>
</table>

• Agronomy, Agricultural Engineering, Economics, Food Engineering, Food Sciences, Forestry, Veterinary, Zootechnics, ...
II. HUMAN CAPITAL FOR THE STATE OF SÃO PAULO AND BRAZIL IN NAMES

- Frederich Gustav Brieger (Genetics)
- Sylvio Moreira (Citrus)
- Alcides Carvalho (Coffee)
- Ruy Miller Paiva (Agricultural Economics)
- Veridiana Victoria Rossetti (Phytopathology / citrus)
- Marcilio Dias (Genetics / vegetables)
- Eurípedes Malavolta (Chemistry / Fertilizers)
- Ernesto Paterniani (Maize)

- Shiro Miyasaka (Soybean)
- João Lúcio de Azevedo (Genetics)
- Romeu Kiihl (Soybean)
- Henrique Viana de Amorim (Ethanol from sugarcane)
- Klaus Reichardt (Physics of environment)
- José Roberto Postali Parra (Entomology)
- Rodolfo Hoffmann (Econometrics / Income distribution)
- Nilson Augusto Vilanova (Agrometeorology / sugarcane)
III. RECENT FIGURES OF THE BRAZILIAN ECONOMY

- GDP, 2013
  - Brazil: 2.171 US$ bi
- Growth rate, 2013
  - Brazil: 2.3%
- Share of Agriculture, 2013
  - Brazil: 7%
- Share of Agribusiness
  - Brazil: 22%
- Total Population (2010)
  - Brazil: 190 M
- Rural Population
  - Brazil: 15%
- GDP per capita
  - Brazil: 11.340 US$
- HDI
  - Brazil: 0.73

- São Paulo
  - GDP, 2013
    - São Paulo: 680 US$ bi
  - Growth rate, 2013
    - São Paulo: 1.7%
  - Share of Agriculture, 2013
    - São Paulo: 2%
  - Share of Agribusiness
    - São Paulo: 19% (2008)
  - Total Population (2010)
    - São Paulo: 41 M
  - Rural Population
    - São Paulo: 4%
  - GDP per capita
    - São Paulo: 17.780 US$
  - HDI
    - São Paulo: 0.783
IV. AGRICULTURE AND AGRIBUSINESS IN BRAZIL AND SÃO PAULO

Brazilian share in world production and exports (2012)

<table>
<thead>
<tr>
<th>Product</th>
<th>Production</th>
<th>Ranking</th>
<th>Exports</th>
<th>Ranking</th>
<th>Main market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar</td>
<td>22%</td>
<td>1</td>
<td>45%</td>
<td>1</td>
<td>Russia</td>
</tr>
<tr>
<td>Ethanol</td>
<td>29%</td>
<td>2</td>
<td>55%</td>
<td>1</td>
<td>USA</td>
</tr>
<tr>
<td>Soybean</td>
<td>31%</td>
<td>2</td>
<td>42%</td>
<td>1</td>
<td>China</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>15%</td>
<td>4</td>
<td>23%</td>
<td>2</td>
<td>Europe</td>
</tr>
<tr>
<td>Corn</td>
<td>9%</td>
<td>3</td>
<td>26%</td>
<td>3</td>
<td>Japan</td>
</tr>
<tr>
<td>Rice</td>
<td>2%</td>
<td>9</td>
<td>2%</td>
<td>9</td>
<td>Nigeria</td>
</tr>
<tr>
<td>Orange Juice</td>
<td>53%</td>
<td>1</td>
<td>80%</td>
<td>1</td>
<td>Europe</td>
</tr>
<tr>
<td>Coffee</td>
<td>40%</td>
<td>1</td>
<td>32%</td>
<td>1</td>
<td>USA</td>
</tr>
<tr>
<td>Cotton</td>
<td>5%</td>
<td>5</td>
<td>9%</td>
<td>4</td>
<td>China</td>
</tr>
<tr>
<td>Swine</td>
<td>3%</td>
<td>4</td>
<td>9%</td>
<td>4</td>
<td>Ukraine</td>
</tr>
<tr>
<td>Poultry</td>
<td>15%</td>
<td>3</td>
<td>35%</td>
<td>1</td>
<td>Saudi Arabia</td>
</tr>
<tr>
<td>Beef</td>
<td>16%</td>
<td>2</td>
<td>19%</td>
<td>1</td>
<td>Russia</td>
</tr>
</tbody>
</table>

Definition of Agribusiness

- It is the sum of four segments:
  - i. agricultural and livestock production;
  - ii. inputs for agriculture;
  - iii. agroindustry / processing; and,
  - iv. distribution services

• (CEPEA / ESALQ, USP)
IV. AGRICULTURE AND AGribusiness in Brazil and São Paulo

BRAZIL

Source: CEPEA-USP/CNA, Prepared by: MB Agro
# IV. AGRICULTURE AND AGRIBUSINESS IN BRAZIL AND SÃO PAULO

## Production in Brazil and São Paulo (000 tonnes)

<table>
<thead>
<tr>
<th>Product</th>
<th>Brazil</th>
<th>São Paulo</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange</td>
<td>18.013</td>
<td>13.366</td>
<td>74%</td>
</tr>
<tr>
<td>Others Fruits</td>
<td>20.995</td>
<td>3.793</td>
<td>18%</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>721.077</td>
<td>406.153</td>
<td>56%</td>
</tr>
<tr>
<td>Coffee (Arabic)</td>
<td>2.279</td>
<td>275</td>
<td>12%</td>
</tr>
<tr>
<td>Cereals and oilseeds</td>
<td>163.646</td>
<td>6.945</td>
<td>4%</td>
</tr>
<tr>
<td>Horticultural</td>
<td>32.756</td>
<td>3.195</td>
<td>10%</td>
</tr>
</tbody>
</table>

*Source: IBGE*

## Exports from Brazil and São Paulo (000 US$)

<table>
<thead>
<tr>
<th>Product</th>
<th>Brazil</th>
<th>São Paulo</th>
<th>Share SP/BR</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>242.178.649</td>
<td>56.317.626</td>
<td>23%</td>
</tr>
<tr>
<td>AGROBUSINESS</td>
<td>99.967.784</td>
<td>20.775.068</td>
<td>21%</td>
</tr>
<tr>
<td>JUICES</td>
<td>2.460.180</td>
<td>2.163.035</td>
<td>88%</td>
</tr>
<tr>
<td>DAIRY</td>
<td>117.728</td>
<td>95.641</td>
<td>81%</td>
</tr>
<tr>
<td>OTHER FOOD PRODUCTS</td>
<td>545.950</td>
<td>374.573</td>
<td>69%</td>
</tr>
<tr>
<td>SUGAR AND ALCOHOL</td>
<td>13.717.911</td>
<td>9.217.414</td>
<td>67%</td>
</tr>
<tr>
<td>LIVE TREES AND OTHER PLANTS</td>
<td>23.925</td>
<td>15.741</td>
<td>66%</td>
</tr>
<tr>
<td>OTHER ANIMAL PRODUCTS</td>
<td>679.546</td>
<td>338.107</td>
<td>50%</td>
</tr>
<tr>
<td>OTHER PLANT PRODUCTS</td>
<td>928.520</td>
<td>459.265</td>
<td>49%</td>
</tr>
<tr>
<td>OLEAGINOUS PRODUCTS (EXCLUDING SOY)</td>
<td>309.959</td>
<td>151.250</td>
<td>49%</td>
</tr>
<tr>
<td>FEEDING ANIMALS</td>
<td>217.215</td>
<td>74.182</td>
<td>34%</td>
</tr>
<tr>
<td>BEE PRODUCTS</td>
<td>61.434</td>
<td>18.743</td>
<td>31%</td>
</tr>
<tr>
<td>VEGETABLES, PULSES, ROOTS AND TUBERS</td>
<td>81.229</td>
<td>16.841</td>
<td>21%</td>
</tr>
<tr>
<td>LEATHER, LEATHER PRODUCTS</td>
<td>3.026.777</td>
<td>612.479</td>
<td>20%</td>
</tr>
<tr>
<td>FOREST PRODUCTS</td>
<td>9.634.768</td>
<td>1.829.950</td>
<td>19%</td>
</tr>
<tr>
<td>BEVERAGES</td>
<td>459.544</td>
<td>82.378</td>
<td>18%</td>
</tr>
<tr>
<td>MEAT</td>
<td>16.802.628</td>
<td>2.624.860</td>
<td>16%</td>
</tr>
<tr>
<td>COCOA AND ITS PRODUCTS</td>
<td>307.027</td>
<td>47.713</td>
<td>16%</td>
</tr>
<tr>
<td>COFFEE</td>
<td>5.275.719</td>
<td>724.051</td>
<td>14%</td>
</tr>
<tr>
<td>FRUIT (INCLUDES NUTS AND CHESTNUT)</td>
<td>877.606</td>
<td>112.039</td>
<td>13%</td>
</tr>
<tr>
<td>LIVE ANIMALS (OTHER THAN FISH)</td>
<td>782.598</td>
<td>44.896</td>
<td>6%</td>
</tr>
<tr>
<td>FIBER AND TEXTILE PRODUCTS</td>
<td>1.591.836</td>
<td>89.668</td>
<td>6%</td>
</tr>
<tr>
<td>SOY COMPLEX</td>
<td>30.961.266</td>
<td>1.396.624</td>
<td>5%</td>
</tr>
<tr>
<td>CEREALS, FLOUR AND PREPARATIONS</td>
<td>7.252.065</td>
<td>271.665</td>
<td>4%</td>
</tr>
<tr>
<td>TEA, MATE AND SPICES</td>
<td>362.613</td>
<td>8.724</td>
<td>2%</td>
</tr>
<tr>
<td>FISH</td>
<td>218.000</td>
<td>5.228</td>
<td>2%</td>
</tr>
</tbody>
</table>

*Source: Secex*
V. TECHNOLOGICAL CHANGES IN AGRICULTURE AND AGRIBUSINESS

• MAIN FEATURES:

• 1. Abundance of water and land, and low cost of natural resources, mainly in Northern, Northwest and Tropical savanna (cerrado) regions;

• 2. Technological innovation in agriculture and agribusiness;

• 3. Returns to scale in agricultural production;

• 4. Sophisticated agribusiness system: efficient management and high profitability

• (MB Agro)
V. TECHNOLOGICAL CHANGES IN AGRICULTURE AND AGribusiness

- Occupation of tropical savanna

- Adaptation of soybean and corn crops to new agricultural regions of the country.

“Cerrado and Campos Gerais”: new areas

(MB Agro)
V. TECHNOLOGICAL CHANGES IN AGRICULTURE AND AGRIBUSINESS

• No tillage and double crop system

• Returns to scale in agriculture

• Efficient and profitable changes

(MB Agro)
V. TECHNOLOGICAL CHANGES IN AGRICULTURE AND AGRIBUSINESS: Agriculture-Cattle Raising Integration

The new production system is evolving toward an integration of animal, forestry and agriculture.
V. TECHNOLOGICAL CHANGES IN AGRICULTURE AND AGRIBUSINESS: the history of soybeans in Brazil

- Early crops in Agricultural Station of Campinas (IAC)
- Soybeans are introduced in the Rio Grande do Sul State
- Pig and poultry production generates demand for soybean meal
- Increased use of inputs and mechanization.
- Soybeans reaches the wheat importance in South region
- Embrapa Soybean program
- Integrated pest management
- Embrapa launches Soybean rust resistant
- Biosecurity Law
- Agricultural and climatic zoning
- Baculovirus biological insecticide
- Massification of zero tillage
- Seed quality
- First transgenic soybean variety
- Brazil reaches the USA, largest producer
- Expansion to the Northeast
- Soils Correction technology in Cerrado
- Varieties adapted to low latitudes
- Biosecurity Law
- Update
- Increased use of inputs and mechanization.
- Expansion to the Cerrado
- Expansion to the Northeast

Source: IBGE. Elaboration: MB Agro.
V. TECHNOLOGICAL CHANGES IN AGRICULTURE AND AGRIBUSINESS: HDI between 1990 and 2000, and the Soybean crop

Municipalities with Soybean production:
Average HDI 2000 = 0.752

Municipalities without Soybean production:
Average HDI 2000 = 0.678

Source: PNUD.
Average Variation in Municipal Human Development Index by State of Brazil, 1991 to 2000

With soybean
- Mato Grosso: 0.660 (IDH 91), 0.750 (IDH 00)
- Bahia: 0.500 (IDH 91), 0.577 (IDH 00)
- Rio Grande do Sul: 0.504 (IDH 91), 0.634 (IDH 00)
- Paraná: 0.510 (IDH 91), 0.626 (IDH 00)

Without Soy
- Mato Grosso: 0.660 (IDH 91), 0.639 (IDH 00)
- Bahia: 0.500 (IDH 91), 0.577 (IDH 00)
- Rio Grande do Sul: 0.504 (IDH 91), 0.634 (IDH 00)
- Paraná: 0.510 (IDH 91), 0.626 (IDH 00)

Source: PNUD
V. TECHNOLOGICAL CHANGES IN AGRICULTURE AND AGRIBUSINESS: Sugar cane crop in São Paulo

Reasons:


**Production of Sugar cane at 1973**

**Production of sugar cane at 2007**

a) Slope of sugar cane area: major problem for mechanical harvesting

b) Higher prices of land with urbanization in original crop regions
V. TECHNOLOGICAL CHANGES IN AGRICULTURE AND AGRIBUSINESS: Highlights on Brazilian Ethanol from Sugarcane

• Brazilian National Ethanol Program – PROALCOOL – was launched in 1975
• We produce and use sugarcane ethanol as fuel in large scale (since 2003: flex fuel cars)
• Brazil has the lowest production cost of ethanol (US$ 0.25 / liter)
  • Result of investments in technology made in sugarcane, ethanol and sugar production: new sugarcane varieties; better agronomic controls; better fermentation processes; use of vinasse as fertilizer; greater industrial automation
• Electric power co-generation from bagasse: ethanol mills invested in electric power co-generation from sugarcane bagasse, in order to trade electric power in markets
• Mills self-sufficient in energy
VI. Final Comments

• Brazil and the State of São Paulo have benefited with human capital investments in agriculture and agribusiness, especially those developed through public research institutes and universities in São Paulo, and more recently by EMPRAPA. Also, private institutions have increased their agribusiness activities, as well as investments in human capital.

• The agroindustrial executive decisions on production and investments facilitate the integration of urban areas, rural activities and international markets. In such a context, decisions on agricultural production will tend will be based on scientific knowledge and technological inovation. Also, high rates of TFP growth in agriculture will be dependent or strongly influenced by the so called agroindustrial farming.
BIBLIOGRAPHY

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• CEPEA – Centro de Estudos Avançados em Economia Aplicada – ESALQ – USP. PIB do Agronegócio.
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• JOHNSTON, Bruce F.; MELLOR, John W. The Role of Agriculture in Economic Development. The American Economic Review, V=v. 51, n.4, p.566-593, 1961..

• MORAES, Márcia Azanha Ferraz Dias, ZILBERMAN, David. Production of Ethanol from Sugarcane in Brazil. Springer, 2014.


APPENDICES
The consequence of mechanization in traditional tropical conditions was the loss of soil by erosion.

Source: MB Agro
Agricultural Trade Balance Deficits and Surpluses (billion US$, WTO data)

Source: WTO.
Brazilian Trade Balance (US$ million)

Source: AgroStat Brasil/SECEX/MDIC
Elaboration: MBAgro
Port of Santos – State of São Paulo – Total Exports (000 tonnes)
Agribusiness Products Exports - by Port of Santos (SP) - from States of Origin, (%)

- Sao Paulo: 39%
- Mato Grosso: 33%
- Goias: 11%
- Minas Gerais: 10%
- Mato Grosso do Sul: 5%
- Bahia: 1%
- Parana: 1%
- Others States: 0%
### Position of São Paulo in World Exports

(million tonnes)

<table>
<thead>
<tr>
<th>Product</th>
<th>São Paulo</th>
<th>SP/Brazil</th>
<th>Global exports</th>
<th>SP/Global exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange Juice</td>
<td>1.8</td>
<td>94%</td>
<td>2.3</td>
<td>78%</td>
</tr>
<tr>
<td>Sugar</td>
<td>14.3</td>
<td>59%</td>
<td>55.1</td>
<td>26%</td>
</tr>
<tr>
<td>Beef</td>
<td>0.3</td>
<td>32%</td>
<td>8.1</td>
<td>4%</td>
</tr>
<tr>
<td>Coffee</td>
<td>0.2</td>
<td>11%</td>
<td>6.9</td>
<td>3%</td>
</tr>
<tr>
<td>Poultry</td>
<td>0.3</td>
<td>7%</td>
<td>10.1</td>
<td>3%</td>
</tr>
<tr>
<td>Pulp</td>
<td>1.1</td>
<td>12%</td>
<td>47.0</td>
<td>2%</td>
</tr>
<tr>
<td>Soybean</td>
<td>1.4</td>
<td>4%</td>
<td>99.6</td>
<td>1%</td>
</tr>
<tr>
<td>Soybean Meal</td>
<td>0.4</td>
<td>3%</td>
<td>57.5</td>
<td>1%</td>
</tr>
<tr>
<td>Corn</td>
<td>0.6</td>
<td>3%</td>
<td>94.5</td>
<td>1%</td>
</tr>
</tbody>
</table>

Source: Secex/USDA
Position of Port of Santos in World Exports

<table>
<thead>
<tr>
<th></th>
<th>Port of Santos</th>
<th>Port of Santos/Brazil</th>
<th>Global exports</th>
<th>SP/Global exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange Juice</td>
<td>1,8</td>
<td>96%</td>
<td>2,3</td>
<td>79%</td>
</tr>
<tr>
<td>Sugar</td>
<td>16,7</td>
<td>68%</td>
<td>55,1</td>
<td>30%</td>
</tr>
<tr>
<td>Beef</td>
<td>0,7</td>
<td>71%</td>
<td>8,1</td>
<td>9%</td>
</tr>
<tr>
<td>Coffee</td>
<td>1,2</td>
<td>75%</td>
<td>6,9</td>
<td>17%</td>
</tr>
<tr>
<td>Poultry</td>
<td>0,4</td>
<td>11%</td>
<td>10,1</td>
<td>4%</td>
</tr>
<tr>
<td>Pulp</td>
<td>2,0</td>
<td>22%</td>
<td>47,0</td>
<td>4%</td>
</tr>
<tr>
<td>Soybean</td>
<td>10,4</td>
<td>32%</td>
<td>99,6</td>
<td>10%</td>
</tr>
<tr>
<td>Soybean Meal</td>
<td>3,8</td>
<td>26%</td>
<td>57,5</td>
<td>7%</td>
</tr>
<tr>
<td>Corn</td>
<td>9,1</td>
<td>46%</td>
<td>94,5</td>
<td>10%</td>
</tr>
</tbody>
</table>

Source: Secex/USDA
CURRENT & FUTURE PRODUCTS FROM SUGAR CANE

Source: UNICA
Productivity Gains

Center-South Region

Source: UNICA
Eletric Power Co-Generation from Bagasse

- Mills invested in electric power co-generation from sugarcane bagasse, in order to trade electric power in the market
- Experience and know how
  - Units are self-sufficient in energy

Main Benefits:
- Renewable and clean energy
  - Low environmental impact
  - Provide carbon credits
- Synergy with hydro production pattern
  - Bioelectricity is produced during the dry season
- Strengthen the national equipment industry and create jobs

Source: PSR, Cogen, UNICA, Elaboration: UNICA

Source: UNICA
Mitigating Global Warming: Reducing Greenhouse Gases

Estimative based on life cycle analysis shows that sugarcane ethanol reduces GHG emissions by 90% compared with gasoline.

**Average GHG Balance on a life-cycle basis**

Emissions avoided with ethanol replacing gasoline

- Ethanol from grains (US/EU)
- Ethanol from sugar beet (EU)
- Ethanol from sugarcane (Brazil)

**Note:** Reductions in well-to-wheel CO₂-equivalent GHG emissions per km, from bioethanol compared to gasoline, calculated on a life-cycle basis.


**Data compiled:** by Icône and Unica.
Energy Balance

Sugarcane provides the best energy balance in production of ethanol.

Energy contained in ethanol/Fossil fuel used to provide it.

**Energy Balance**

Data represent the amount of energy contained in ethanol per unit of fossil fuel input.

Note: estimated data


Data compiled by Icone and Unica.
Ethanol Yields

Sources: IEA – International Energy Agency (2005) e MTEC.
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