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A macro sectorial study of semiconductor production

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Abstract. The increasing demand of electronic components has expanded business and investment in research. Noteworthy is the development of materials, specifically semiconductors. This study analyzes the macro sector of semiconductor production and the cyclical growth prospects of international trade and investment in this sector. Through a quantitative exploratory study it was possible to identify in the cyclical context the recent insertion of Brazil in the semiconductor production scenario with a growing view in the industry.

Keywords: Production of Semiconductors, Electronic Components, International Trade.

1 Introduction

The conjunctural issues in the semiconductor manufacturing industry can give the companies opportunities of being more competitive. To be competitive, the company requires planning, research, development of new manufacturing processes, primarily in technology, skilled labor, efficiency, profitability, and investment. In Brazil, new production models, macroeconomic policies and the growth of technologies are making the electronic industries more specialized, thus increasing the value added to the product and/or process. The increase in these processes and projects that are improved, well-defined and strategically productive can provide a higher competitive advantage to the country.

Global economies are leading the productive semiconductor industry with significant production, sales and employment generation. These economies have previously defined strategies for all production processes, making them more competitive.

2 Methodology

The approach will be the quantitative exploratory research with cyclical and macro sectorial analysis of import, export, production and national and international investments in the semiconductor industry.

3 Theoretical Framework

3.1 Processes of semiconductor production

The semiconductor fabrication begins with the production of wafers, namely a thin, round slice of a semiconductor material ranging in size from 152.4 mm to 304.8 mm in diameter. The finished wafer is approximately 15mm thick. After the production of wafers, integrated circuits that generate microprocessors and chips are assembled [1; 14].

3.2 Semiconductor production in Brazil

Brazilian Company of Semiconductors - CBS was supported by the government through the Program of Technological Development Support for the Semiconductor Industry - PADIS. The unit installed in Minas Gerais was formed with capital from German companies and Brazilian Bank for Economic and Social Development - BNDES. The company will manufacture electronic integrated circuits assembled, unassembled or in the form of discs (wafers) that have not been cut into chips yet. Incentives for semiconductor plants are a priority of the new industrial policy of the country. Upon qualification, CBS will produce circuits with tax exemptions, and incentives will expire in 2022 [2].

Brazilian government's strategic option for a sustainable development model focused on industry competitiveness was consolidated through the Greater Brazil Plan - PBM. Such plan encourages the productive sector in its efforts to technological development and innovation, including mechanisms to support business expenditure on research and development. The support includes financial, tax and regulatory instruments to encourage investments [3].

In 2005 the activity in the chip design center was started at the National Center for Advanced Electronic Technology - CEITEC, with the announcement of CI-Brazil program to support the design of commercial chips in the country. In 2008, federal authorization for the institutionalization of a public company in semiconductors, named CEITEC, was conferred by Federal Law Nº 11759/2008, and such company was operated judicially in the year 2009 in order to encompass the previous operations of the Center Design of CEITEC [4].

CEITEC is a public company linked to the Ministry of Science, Technology and Innovation - MCTI that operates in the semiconductor industry by developing solutions for automatic identification (Radio Frequency Identification and smartcards) and specific applications [5]. As an extension of the PBM, law Nº 11484 was approved in 2007, granting incentives to industries of digital TV equipment and semiconductor electronic components and rules on the intellectual property protection of topographies of integrated circuits, thus instituting PADIS, whose purpose is to support technology development for the semiconductor industry in Brazil [6].

Also in this context, the Federal Revenue of Brazil – RFB, by Normative Instruction Nº 852, dated June 13, 2008, established procedures to authorize the Program of

Technological Development Support for the Semiconductor Industry in the country (PADIS) [7].

3.3 Brazilian foreign trade

According to Foundation for Research Support of the State of Sao Paulo - FAPESP magazine, the country exports metallurgical silicon at US$ 2/kg. After purified abroad, the silicon is transformed into sheets used in the manufacture of semiconductors or photovoltaic cells, and the cost in that stage ranges between US$ 50 and US$ 1,000, depending on the purity and crystallinity [8].

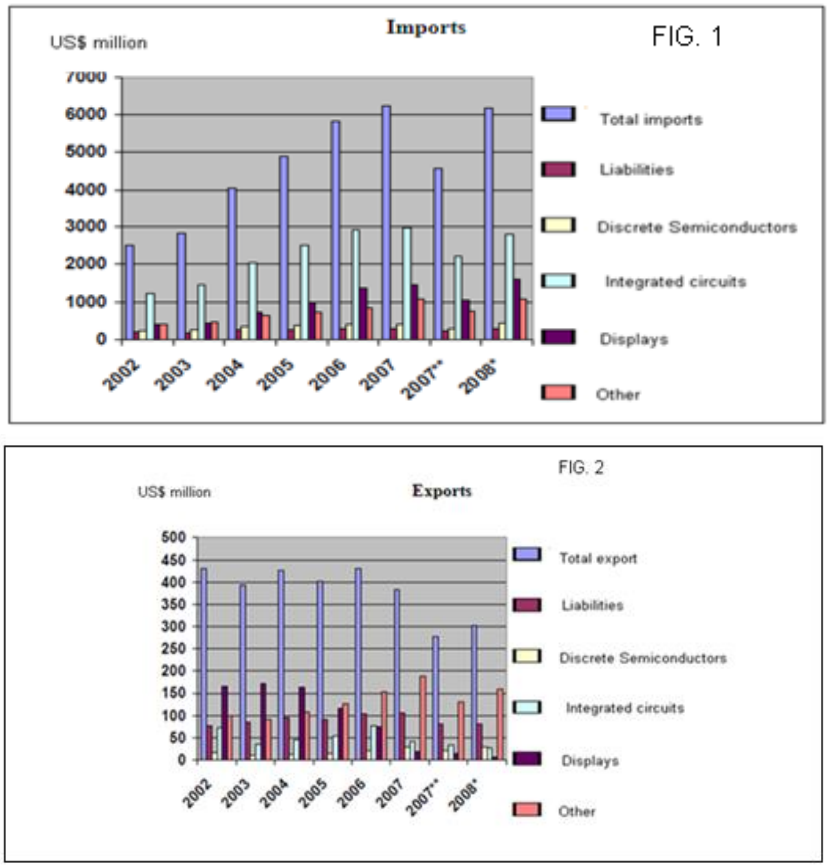
According to Brazilian Association of Electrical and Electronics Industry - ABINEE, the trade balance of the appliances and electronics sector in the period from January to November 2013 showed the following results: exports of US$ 6.69 billion and imports of US$ 40.48 billion, thus generating a deficit of US$ 33.79 billion in the trade balance of electronics products. This result was 11% higher than the occurred in the same period in 2012 (US$ 30.35 billion) [9].

3.3.1 Imports and Exports

For CBS the rate of import duty levied on imported goods was reduced to zero for products such as machinery, apparatus, tools, equipment, computer tools - software for incorporation into their fixed assets, intended for tunneling activities and testing of electronic semiconductor devices [2].

Imports of electrical and electronic components totaled US$ 2.0 billion, being 14.7% higher than those occurring in November 2012, highlighting the components for telecommunications and semiconductors, which together totaled almost US$ 1 billion [10]. The three most imported items in such industry were: components for telecommunications (US$ 6.2 billion); semiconductors (US$ 4.9 billion) and computer components (US$ 3.0 billion) [10].

The Trade Balance of the components segment for the period 2002-2008 (Figures 1 and 2) had a small participation in the import and export of semiconductors and, in accordance with the BNDES, imports of discrete semiconductors (diodes, transistors, photodetectors and photoemitters) reached US$ 423.1 million and exports totaled US$ 29.6 million data is from September 2008 [4].



* until September 2008 ** until September 2007

Fig. 1 and Fig. 2 Adapted from Trade Balance of Components Segment Secex Aggregation BNDES [4]

3.3.2 International trade

The Semiconductor Industry Association - SIA, representing U.S. leadership in semiconductor manufacture and design, announced that worldwide semiconductor sales in 2013 reached $ 305.6 billion, the highest annual total ever in the industry, and an increase of 4.8% in relation to the 2012 total of $ 291.6 billion. Global sales in December 2013 totaled $ 26.6 billion, marking the strongest amount recorded in December, while December sales in the Americas increased 17.3% compared to the same period of the previous year [11; 12].

A research conducted by KPMG U.S. indicated that, worldwide, the semiconductor market is extremely relevant, reaching a turnover of US$ 295 billion in 2010, against US$ 220 billion in 2009, and that the segment generates 200,000 jobs, according to the SIA [13]. Worldwide, some companies lead the semiconductor production as presented in (Table 1) in the biennium 2007/2008.

Table 1. Ranking of the top three semiconductor companies

Ranking 2007/08	Companies	Sales 2007 (US$ Bi)	Sales 2008 (US$ Bi)
1	INTEL	33.9	34.1
2	SAMSUNG	19.7	17.9
3	TEXAS INSTRUMENTS	12.3	11.5

Source: Adapted from BNDES - iSuppli, 2008 [4].

In Figure 3, BNDES presents a more updated scenario that shows a reduction of global semiconductor production between 2008 and 2011. With respect to investments in the semiconductor industry in the period of 2008-2011 (Figure 4), it is presented a sharp decline with signs of recovery in 2011.

Fig. 3 World Market for Semiconductors (Adapted from BNDES *apud* SAI) [15]

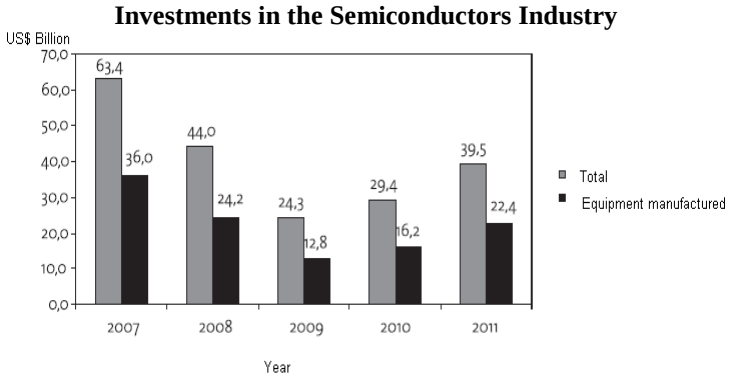


Fig. 4 Investments in the sector (Adapted from BNDES *apud* Gamerd; Fabtech) [15]

4 Results and Discussion

In Brazil, implementation processes for semiconductor production occurred in 2005, with the creation of CEITEC and, subsequently, various legal and tax incentives were adopted for the development of semiconductor and hence the creation of new businesses. On the national scenario of companies in the electronics industry subsystem, imports of semiconductors in 2013 grew 10% compared to 2012 with increasing trend.

There was a significant deficit in the trade balance of Brazil in the field of appliances and electronics, which includes semiconductors. Even so, discreetly, Brazil entered the international scenario of semiconductors export. The research shows the importance of the development of semiconductors with an increasing demand in many countries of the world and that, in 2013, the highest sales of semiconductors was recorded, in the order of 4.8%, according to ABINEE [10]. Semiconductors are among the most imported products in Brazil, with a variation of 10% in the period of 2012/2013. In 2007/2008, the sector had an important sales scenario, where in (Table 1) it is possible to see that the ranking of the three largest companies in US$ billions is positive for the leader.

Despite of the growing sales trend, it is observed that the development of the sector in Brazil needs more technical/commercial diversification to add value to the primary product, which is a relevant question to make the national semiconductor industry more competitive.

In Brazil, the use of semiconductors is growing proportionally to the production of appliances and electronics, and the country is an exporter of primary raw material (silicon) for the production of semiconductors. According to the macro sectorial scenario, it is observed that with R&D investment the domestic industry will add value to the input manufacture process, making it more competitive and less dependent on imports. In the context of technological innovation, it is important to highlight the need of research and development of alternative materials for the production of semiconductor, such as niobium, since Brazil is the largest global producer, with a share of 96% of the market [16]. Brazil exports silicon, which is the main component for the production of semiconductors, which after purification and processing abroad return to the country as finished product, with a much higher aggregate cost, making obvious the need for investments in the sector. However, such export does not bring great benefits to the country because the added value is low, with the trading of product at US$ 2.0/Kg, while after processing abroad it can cost around US$ 1000, depending on the degree of purity, thus obtaining an expressive and attractive market value.

Although speculatively, it is necessary to mention that researches on the quantum computer are growing worldwide. If feasible, the conversion of physical principles into technological equipment with properties where the transistors are not used will have a strong impact on the semiconductor industry, reason why the participants of the semiconductor chain must pay attention to the evolution of the quantum computer research.

5 Conclusion

As noted in the article, it is a sector in full development. Additionally to investments in technology, the issue of qualification of the workforce should be considered in a broader and strategic project for the country.

Upon the growing demand, companies in the electronics sector have been seeking for new technologies and new processes in order to meet their productive and economic needs. Strategies should be defined for optimized production processes and public/private investments, thus generating greater competitiveness. National companies will be more competitive if they start using well-defined strategies developed by the R&D sector of the government and organizations that facilitate investment to meet the demand.

It is observed that there is a structured and measured design over the years for such process, allowing for a guaranteed repeatability, thus favoring the industry. In the macro sectorial environment, the semiconductor industry is booming with a strong tendency to adjust alternative materials.

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