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The New Geography of the Automobile Industry: Trends and Challenges in Brazil

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Introduction

Brazil has become one of the core locations of the automobile industry. In 2015, Brazil was among the world's ten largest producers of automobiles and among the largest automobile markets, despite its decline in the last two years due to an internal economic crisis. This discussion paper intends to present an overview of the Brazilian automobile industry, emphasizing national public policies.

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According to the National Association of Vehicle Manufacturers (ANFAVEA) (2016), the automobile industry has currently 65 plants spread across 51 cities in 11 states. It represents more than 20% of industrial gross domestic product (GDP) and 4% of total GDP, with revenues close to US$50 billion.

The importance of the automobile industry is even higher when one notices that it involves a huge supply chain. It includes manufacturers, parts suppliers, raw material producers, dealers, gas stations, insurance companies, repair shops and advertising agencies, among others, which provides direct employment to an impressive number of more than 130,000 employees and 1.5 million employees at the productive chain in Brazil (ANFAVEA 2016).

The Brazilian government has been, and still is, a major partner in the consolidation of the automobile industry in the country. Through tax incentives throughout history and through various programmes, such as Pró-Álcool (National Alcohol Programme) and most recently, the Inovar Auto (Incentive Programme for Technological Innovation and Densification of the Productive Chain of Motor Vehicles), the Brazilian government played, and still does, an important role in this process.

Currently, the automobile industry in Brazil is at a crossroads. In addition to declines in sales due to the national economic crisis, vehicles overcrowd the Brazilian streets, and new challenges facing sustainable urban mobility are emerging in the current scenario.

This chapter is structured as follows: first, an overview of the automobile industry, from the creation and consolidation of its industrial park until the present moment, exploring moments of crisis and growth. Then, it presents a summary of key public policies to encourage the sector in Brazil, especially focusing on the Inovar Auto programme. Finally, an overview of policies regarding innovation in electromobility is presented.

Overview of the Automobile Industry in Brazil

Years 1950–1970: Industry Creation and Consolidation

The development of the Brazilian automobile industry was initiated in the 1950s by President Juscelino Kubitschek of GEIA (Automobile

Industry Executive Group). According to Santos and Burity (1997), GEIA aimed a plan to instal the industry and promote the rapid manufacture of consumer goods (passenger cars) and production of goods (freight vehicles), with priority to the latter.

It also aimed to reduce the impact on the balance of payments due to increased imports of both passenger cars and cargo vehicles and passenger transport. The function of this group was to define the installation standards, production targets and nationalization plans, authorize projects and follow their implementation.

The federal government has produced a series of decrees that inhibit the import and established incentives for foreign exchange and tax. Only projects approved by GEIA have rights to incentives. It also established a quick nationalization programme for parts: already in 1960, trucks and commercial vehicles were at 90% nationalization, and jeeps and passenger cars at 95%.

The auto industry was seen as a priority by the government, and it was considered that the creation of this industry should have foreign capital participation, that is, international automobile manufacturers. It is important to emphasize that the strategy was to bring multinational companies to produce locally instead of investing in local businesses (Arbix et al. 2001, 2002).

However, it would promote a gradual nationalization programme. Hence, from 1967 to 1974, the time of the "economic miracle",[1] the sector was restructured and grew at average rates of 20% per year.

The government had created credit facilities for consumers for the purchase of cars, which caused the explosion of demand. It was then that it could be noticed a change in the production: passenger cars began to grow much faster than trucks and buses did. While the fleet of cars has multiplied by eight times in the span of 17 years (1957–1973), the trucks have increased 2.4 times over the same period. The average annual growth rates of the two fleets were, respectively, 13% and 5% (Santos and Burity 1997) (Table 14.1).

Years 1980–2000: Crisis and Market Opening

The economic crisis in Brazil in the 1980s and early 1990s changed the growth trend of the previous decades. Due to the closed market and

Table 14.1 Sales evolution (1957–1973)

	Units				
Year	Light cars	Light commercials	Trucks	Buses	Total
1957	10,449	1588	16,259	2256	30,552
1958	20,808	9503	26,998	3674	60,983
1959	40,171	16,283	36,657	3003	96,114
1960	70,479	20,875	37,810	3877	133,041
1961	86,437	28,654	26,891	3602	145,584
1962	118,026	33,498	36,174	3496	191,194
1963	121,666	28,495	21,556	2474	174,191
1964	132,157	27,056	21,790	2704	183,707
1965	135,041	25,187	21,828	3131	185,187
1966	157,352	32,204	31,098	3955	224,609
1967	158,362	35,319	27,141	4665	225,487
1968	185,922	46,107	40,642	7044	279,715
1969	258,675	48,777	40,569	5679	353,700
1970	319,574	54,069	38,388	4058	416,089
1971	416,563	56,264	38,868	4393	516,088
1972	482,037	72,194	50,150	5230	609,611
1973	565,221	93,371	64,828	6362	729,782

Source: ANFAVEA (2016)

slowdown of growth, the companies reduced their level of investments, which led to a portfolio of increasingly outdated products and a technologically backward industrial park.

As a response to these problems, the government opened the market to imports and initiated several measures to restore competitiveness in the industry. In 1992 and 1993, the Automotive Sectorial Chamber was established which involved representatives from the companies, unions and the government.

The government reduced taxes and stimulated loans. In turn, it demanded price reductions from the companies and guarantee of a certain employment level in the industry. Special incentives for buyers of small cars with 1.0 L engines were introduced and led to rapid growth of this market segment in the next decade.

In 1995, the Automotive Sectorial Chamber approved the so-called "Automotive Regime" which included a concept of industrial policy for the car sector. The result was rapid market expansion in the late 1990s. New investments led to the production of new models. New players,

such as Peugeot-Citröen (PSA Group) and Renault, Honda, Toyota and Mitsubishi, Chrysler and Mercedes Benz (which until then only manufactured trucks and buses in Brazil), entered the market. During the 1990s, assemblers made investments in Brazil amounting to US$16.6 billion. In comparison, the investments made between 1981 and 1990 amounted to US$5.4 billion (Consoni 2004).

Moreover, from its beginning in the 1950s until the 1990s, the Brazilian automobile production was concentrated in the State of São Paulo (SP), specifically in the ABC region. The ABC region comprises the cities Santo André, São Bernardo dos Campos, and São Caetano, which are located in close proximity to São Paulo.

At that time, Fiat was the sole company to establish a production site outside of the ABC region, that is, in Minas Gerais. However, in the 1990s, the so-called "Fiscal Wars", in which state and municipal governments provided fiscal incentives in order to attract investments made by the automobile industry (Alves 2002), together with the quest for reducing labour costs, caused the production of vehicles to spread to other states such as Rio Grande do Sul (General Motors), Paraná (Renault, Volkswagen), Rio de Janeiro (PSA), Goiás (Mitsubishi) and Bahia (Ford).

The regionalization of the automobile industry in the country has also led to the decentralization of the auto supplier industry, mainly through the creation of industrial parks that integrate suppliers and automakers.

In the 90s there was a reduction of local development activities and processes accompanied by the adoption of the assembled global vehicle production strategy on global platforms, developed at headquarters or European subsidiaries (cases of VW Polo, Ford Fiesta, GM Corsa, Renault Clio and Fiat Palio, for example).

In 1990, the State of São Paulo accounted for 74.8% of the domestic production of vehicles, whereas in 2005, this number dropped to 45.5%. In the ABC region, about 52% of the jobs were cut down in the sector between 1980 and 2002: from 180,1000 employees in 1980 to 88,000 in 2002 (Marx and Mello 2008; Rodrigues et al. 2007).

Although the State of São Paulo has lost some production activity, it has retained most of the technological and engineering activities owing to the availability of qualified professionals, research centres, laboratories, technical schools and the presence of the main auto part manufacturers'

development centres (Salerno et al. 2002; Consoni 2004). Only Renault established its development centre in Curitiba/PR, and PSA recently announced the intention of installing a centre in Rio de Janeiro (RJ).

Following the relocation of production to inner-Brazilian low-cost regions, new production models were introduced in the Brazilian industry, inspired by the concept of lean production and the "Japanese Model". These models included outsourcing activities and new forms of supply chain organization (such as the industrial condominiums), which were brought forward more aggressively than in Europe and the United States, taking advantage of "greenfields" and low resistance on the part of employees.

Salerno et al. (2002) characterized this period as being marked by the adoption of new supply relationships, the relocation of production activities, internal production restructuring and changes in engineering and product design activities. Brazil became a privileged testing ground for the world automobile industry.

The new investments and the following modernization of the Brazilian car industry in the 1990s were accompanied by strong organizational changes in the plants. European, US-American and Japanese companies started to implement "lean production" concepts which included new forms of work organization such as teamwork and reduction of hierarchy levels in the plants.

The relocation of production and the opening of greenfield plants in low-wage regions, like Paranà, Minas Gerais or Bahia, brought the issue of wage differences and wage competition on the top of the trade union's agenda. Besides the wage differences, the companies benefitted from the low degree of organization and the lack of industrial traditions in these regions. Workers coming from agricultural regions were expected to be more "docile" than the strongly organized workers in the ABC region. Yet, nearly a decade after the car companies moved to the low-wage regions in Brazil, a trend towards union organization in these locations has emerged, including the occurrence of strikes.

Years 2000–2014: Market Expansion

In Brazil, a huge transformation in the automobile sector began, as mentioned in the previous subsection, in the 1990s, with the arrival of new

manufacturers such as Chrysler, Mercedes Benz, Renault, PSA, Honda, Toyota and Mitsubishi and investments in new plants or expansion of existing plants, as in the case of General Motors (new plant in Gravataí/RS), Ford (in Camaçari/BA), VW (new factories in Curitiba/PR, São Carlos/SP and remodelling of São Bernardo do Campo/SP factory).

Associated with this wave of new investments, the domestic industry, as well as its headquarters, incorporated new forms of production management, outsourcing activities and new forms of organization of the chain supplies, such as industrial parks.

Moreover, these changes led to an increase in industrial productivity, making it even with the increase in production in recent years, the level of employment in the sector in 2006 is the same as in 1973. Brazil led the process of implementing new forms of organizational supply chain, especially in design and operation management and the use of the configuration of Automaker and Systemist in an Industrial Condominium.

However, the financial crisis in Asia, in addition to energy rationing and the global recession after the attacks of 11/09/2001, interrupted the expected growth of the automobile market after the 1997 vehicle production record. Those numbers were reached again in 2004.

The recovery of the Brazilian automobile sector, in fact, anchored in the domestic market, began in 2004. The main driver of the process was the sustained growth of the economy.

Major automakers returned to show positive results, with first signs of exhaustion of idle capacity appearing in 2007. With macroeconomic stability in Brazil and growth since 2004, the automobile industry experienced a new period of growth of production and sales each year. The years 2007 and 2008 were the best in terms of volume of domestic sales and production in history.

A specificity of the Brazilian market, the use of ethanol as a fuel (which has reduced IPI [industrialized products tax rate]), led local development of flex-fuel engines or "flex fuel", that is, fuelled by alcohol and/or gasoline (Mello et al. 2005).

In 2006, cars and commercial vehicles with engine "flex fuel" accounted for 78% of total sales in the country. Currently, all automobile manufacturers operating in the country offer "flex" versions of their models.

Table 14.2 shows total production over the period of 2002–2014 in Brazil.

Table 14.2 Sales evolution (2002–2014)

	Units				
Year	Light cars	Light commercials	Trucks	Buses	Total
2002	1,376,219	167,767	68,354	21,450	1,633,790
2003	1,428,270	154,181	77,785	24,479	1,684,715
2004	1,777,642	216,735	104,792	25,008	2,124,177
2005	1,929,545	235,340	112,921	29,366	2,307,172
2006	2,027,305	243,666	103,297	29,412	2,403,680
2007	2,360,239	295,738	133,791	35,008	2,824,776
2008	2,498,482	350,190	163,757	38,202	3,050,631
2009	2,568,167	356,837	120,994	30,022	3,076,020
2010	2,682,924	468,747	189,941	40,531	3,382,143
2011	2,630,893	511,918	223,602	49,369	3,415,782
2012	2,763,445	469,480	133,403	36,635	3,402,963
2013	2,954,229	530,901	187,002	40,554	3,712,686
2014	2,502,293	471,191	139,965	32,937	3,146,386

Source: ANFAVEA (2016)

The domestic market has assumed greater importance among international manufacturers in view of the stagnation or reduction of international participation in mature markets like the United States, European Union and Japan. This is in addition to investments in modernization of production processes in restyling models, developing new vehicles and increased productive capacity.

However, the specific characteristics of the Brazilian market—in particular, the law of the "people's car" that granted benefits of IPI (industrialized products tax rate) reduction for vehicles with engine capacity up to 1.0 L—made local adaptations or developed products more successful in the local market than in the corresponding "world" automobiles.

It is important to note that even with the increase of production and the market, R&D investment by automakers was not significant in Brazil. In addition, the exchange hampered exports in the country. In contrast, the increased import of finished parts and vehicles with greater aggregate technology increased.

Figure 14.1 shows the relationship between sales and R&D for the period 2003–2011.

Thus, Brazil has experienced a period of great growth in car sales between 2000 and 2014, when the country was immersed in an economic crisis with great impact on the automobile industry.

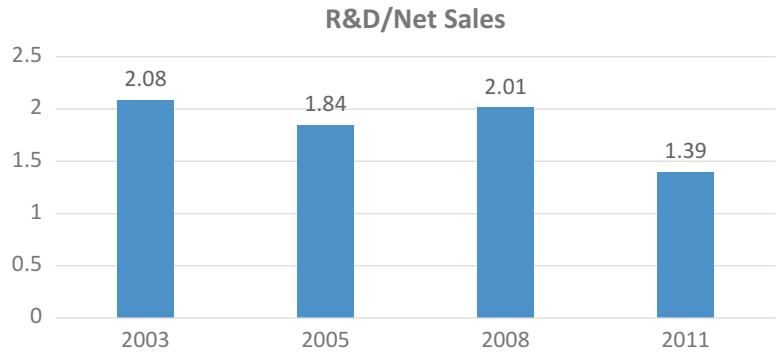

Fig. 14.1 R&D/Net sales from the automobile industry (automakers) in Brazil

Since 2003, with the Workers' Party assuming power at the government and the election of Lula as Brazilian President, unions became part of the government. This has created a privileged position for workers, since former union leaders became Ministers—former ABC Metal Union Luiz Marinho became Minister of Work and Social Security, for example. On the other hand, this situation created a kind of inertia for unions, since their willingness to confront governmental decisions and policies was restricted.

Post 2014: Crisis and Perspectives

After consecutive increases in production and sales in the last 14 years, the automobile industry slowed in 2014. According to ANFAVEA (2016), between 2013 and 2014, there was a decrease of 7.1% in the licensing of cars, light commercial vehicles, trucks and buses (from 3.7 to 3.5 million units) and a decrease of 40% in exports (from 565,000 to 334,000 units).

Among the reasons for the sector's downturn are the significant fall in domestic car sales in 2014, the economic crisis in Argentina (the main destination for Brazilian exports of cars and auto parts), increased rigour

in the granting of credit by banks, worse national macroeconomic scenario and indebtedness of households.

The decrease in production is also reflected in the labour market in the metallurgical sector. Since the crisis began, several automakers made layoffs, announced shutdowns, temporary suspensions, work shifts or production reduction due to technical reasons. In 2017, a new regulation on work relations was approved, weakening the power of unions and reinforcing outsourcing of activities.

According to ANFAVEA (2016), in 2014, there was the steepest drop in occupation since 1999. After the layoffs, automakers ended the year 2015 with 129,776 employees, against 144,508 at the end of 2014.

The layoffs occurred besides the fact that several automakers has joined the Emplyment Protection Programme, as the federal government allowed the reduction of working hours by up to 30% with wage reduction at the same level. Half of the wage loss, however, is compensated by the government with funds from the Worker Support Fund.

Brazil has a lot of internal inequality in relation to vehicle use. While the South and Southeast concentrate almost all vehicles, Midwest, North and Northeast have very low motorization rates. According to ANFAVEA (2016), to reach the index of Argentina, it would take over 30 million cars, which is the equivalent of about ten years of Brazilian annual market.

Unlike other emerging countries, such as China and South Korea, Brazil has no actual national automobile industry: all automakers that produce locally are subsidiaries from foreign multinationals, and most of the first-tier suppliers are foreign companies.

Currently, the country has qualified engineering centres capable of designing a new vehicle from concept definition to product and process validation; but those competencies are still concentrated in the traditional automakers, also called “latecomer companies”. In addition, most of the innovation efforts are driven to adapting global models to local market conditions (Souza and Mello 2014; Salerno et al. 2009).

Public Policies to Support the Automobile Industry

Public Polices: 1950–2010

Automobile Industry Executive Group—GEIA

In order to coordinate the implementation of industry the Automobile Industry Executive Group (GEIA) was created. According to (Santos and Burity 1997), in the 1950s, trucks were responsible for most of the cargo transport in Brazil and were, therefore, priority for GEIA. However, the passenger car was considered emblematic by the government of the time.

The federal government produced a series of decrees that inhibited the import and established incentive and exchange tax. It also established a rapid nationalization programme for parts: already in 1960, commercial trucks and vehicles reached 90% of nationalization, and jeeps and passenger cars reached 95%.

The effort to produce inputs in country led to the need to fund and encourage the auto parts industry by BNDES (Brazilian Development Bank) and establish greater involvement in national manufacturing.

In the first years of GEIA actions, after several government measures, 18 companies submitted projects. Eleven of those implemented the projects. Despite the diversity of products (trucks, utilities, jeeps and passenger cars), market was too small to give efficiency to the plants, especially if we consider that the economic scale (300,000–500,000 per year) was much higher than what it is currently.

National Alcohol Programme—Pró-Álcool

The Pró-Álcool programme was created in 1975 in order to stimulate the production of alcohol in order to meet the needs of domestic market and the needs of automobile fuel policy. The production of ethanol derived from sugarcane, cassava or any other input was encouraged by expanding

the supply of raw materials, with special emphasis on increasing agricultural production, modernization and expansion of existing distilleries and installing new production units and storage units.

The decision to produce ethanol from sugarcane, plus the price of sugar was a political and economic one and it involved additional investments. This decision was taken in 1975 when the federal government decided to encourage the production of ethanol to replace pure gasoline in order to reduce oil imports with a large weight in the external trade balance. At that time, the price of sugar in the international market was declining rapidly, which made it convenient to change sugar to alcohol production.

According to Rico et al. (2010), alcohol production in Brazil in the 1975–1976 period was 600 million litres, in the 1979–1980 period was 3.4 billion and in 1986–1987 was 12.3 billion litres. The programme began to crumble as the international price of oil lowered making the use of alcohol as fuel disadvantageous both for the consumer and the producer.

Successive supply disrutptions, combined with higher ethanol consuption rate and lower gasoline prices, led to general distrust among pro-alcohol consumers and automobile manufacturers to the point that most automakers do not offer more new models running on ethanol (Rico et al. 2010).

In the context of Brazilian pioneer in the ethanol industry, the technology of flex-fuel engines gave new impetus to the domestic consumption of alcohol. The cars could run on petrol, alcohol or a mixture of the two fuels, and this technology was introduced in the country in 2003 and won the consumer quickly.

Today, the choice is already offered for almost all models of the industries, and the demand for flex-fuel vehicles exceeded over the gasoline-powered vehicles for the first time in the internal market (ANFAVEA 2016).

The current price relationship makes the users of flex-fuel models give preference to alcohol, and the rate of consumer acceptance of dual fuel, or flex-fuel, vehicles in the last years was much faster than the auto industry had expected.

Economic Opening

The opening of the Brazilian economy in the 1990s affected deeply the automobile sector. The plan was to modernize the industry, promoting open competition. However, it did not establish any defence mechanism against imports and no preparation was done by national companies.

As a result, the market opening required a complete redesign of strategies in order to adapt to the new market rules. During the period, local production models were implemented creating a huge technological gap.

The restructuring and modernization of Brazilian companies may be considered as defensive and conservative since the main objective was to defend market share, but for this, there was still betting on outdated technology products.

With the economic opening, the automobile industry reformulated its strategy and started to prioritize changes, such as the adoption of new management methods, automating various processes, investing in qualified labour work and in forming partnerships.

However, this restructuring led companies to review the entire supply chain, leaving the small and medium entrepreneurs hurt more than ever. Most of auto parts makers had no capital to modernize their plant, and therefore, forced to close or sell them to foreign capital.

"Popular" Cars

According to Consoni and Quadros (2003), between 1992 and 1994, representatives of the government, trade unions, companies and automakers met to discuss the problems faced by the sector with the economic opening and define specific policies. The end result was an agreement to reduce the rates and prices of Brazilian vehicles to ensure increased production and internal demand for automobile vehicles.

One of the most important actions adopted in this period was the exemption of the IPI (Excise Tax) for vehicles up to 1000 cc, called cars 1.0. This policy gave rise to the concept of "people's car" or "popular cars" that led to the era of simple and popular vehicles.

As a result, there was an explosion in the sale of popular vehicles in Brazil, which led to recovery in automobile production and created a segment in the Brazilian automobile market. Sales of 1.0 vehicles, which represented 4.3% of total sales in 1990, increased to 50% in 1996, the year when new policies were drawn up for the automobile industry, and they continued to grow in response in 2002 to 70% of all cars sold in Brazil (Consoni and Quadros 2003).

It is important to highlight that this process had, however, its dynamics largely determined by the evolution of their own local market, the process of regional integration and the national economic policy. With a particular emphasis in the latter case, the creation of tax incentives for popular cars has played a crucial role in domestic sales in recent years.

Flex Fuel

The Brazilian automobile industry has developed vehicles that are flexible in the type of fuel that they run on. They are popularly known as "flex" in Brazil. The flex-fuel vehicle engine works with any proportion in the mixture of gasoline and alcohol fuel (ethanol), stored in the same tank.

The injection is adjusted according to the blend detected by electronic sensors, which in the case of Brazilian technology, is implemented with automobile software developed in the country, which does not need additional sensors that increase the cost of the vehicle.

The Volkswagen Gol 1.6 Total Flex 2003 model was the first flex-fuel vehicle developed in Brazil capable of operating on any blend of gasoline (E20-E25) and ethanol (E100).

Two months later, the Chevrolet provided the Corsa 1.8 "Flexpower" with an engine developed in partnership with Fiat, called "PowerTrain". In 2005, several automakers producing flex-fuel cars included Chevrolet, Fiat, Ford, Peugeot, Renault, Volkswagen, Honda, Mitsubishi, Toyota and Citroën.

For Amatucci and Spers (2012), flex-fuel technology involved in this mix brings to light a national production system innovation, which can be divided into three phases: phase I increased ethanol production to

meet availability and Pró-Álcool targets: phase II involved adoption of pure ethanol (both by the industry and the market—included resolutions of the distribution problem); and, after the end of phase II, a phase III consisting of the adoption of the flex-fuel technology (each previous stage strongly influenced later):

1. *Phase I—Pró-Álcool programme*: the first phase was characterized by the impulse of historic national dependence on sugarcane and as a form of response to the oil crises of the 1970s, thus being an important part of systemic transformation. The first phase was not really an innovation (at least in regards to improving the mix and quality of ethanol) in both the technological aspect as well as in the social sense.
2. *Phase II—pure ethanol*: the second phase, in turn, presented technological and social innovations involving regulations, private companies and other social entities, such as associations, which were widely adopted by Brazilian consumers. This solution decreased due to fluctuations in the availability and supply breakdowns that severely penalized owners of vehicles powered by pure ethanol.
3. *Phase III and beyond—flex fuel*: the third phase also involved technological innovation and social mobilization in order to bring commercial viability. With the flex-fuel vehicle, the consumer could choose the best fuel from a price perspective and also a sustainable perspective. This flexibility promoted actions to deal with the more smoothly supplied fluctuations. The Brazilian economic growth of the 2000s brought a large proportion of the previously excluded population in the market and has sold a record number of vehicles.

For Amatucci and Spers (2012), all three phases had some common elements. First is the strong perception of a social problem that must be solved urgently, or a belief that things cannot continue as they are. The second is the availability of a technology that, when combined with social logistics solutions, could make for viable social solutions. The third common element was that the social arrangement needed to be catalysed by the action of the private sector and by government incentives.

Government incentives are needed in the early stages of the transition. However, they can be removed when the scale, productivity and consumer confidence levels reach those at the same level as the normal market.

A fourth element common to all the above phases could still be observed for the initial fragility of the situation, which required the customer to circulate paying a higher price at the beginning, in parallel, even tolerating a lower performance, until either technology improved.

Inovar Auto: Increasing Competitiveness

Aiming to increase the competitiveness, technology and security of vehicles produced and sold by the Brazilian Automobile Industry, in 2012, the Brazilian Federal Government established the "Inovar Auto" by executive law. It is an industrial policy that provides tax reduction benefits to assemblers that meet or exceed certain goals.

Overall, the goals involved (Ibusuki et al. 2014) a minimum number of productive activities conducted in the country (mandatory for all companies intending to adhere to the programme), and the improvement in energy efficiency indicators, measured in CO_2 emission/fuel consumption (mandatory for all companies intending to adhere to the programme).

Additionally, each company had to choose two of the following three objectives:

1. A minimum percentage of investment in R&D
2. A minimum percentage of investment in engineering
3. Adherence to the national programme of vehicle labelling related to energy efficiency

The programme was valid for the period 2013–2017 and was to be reviewed at its end. During this period, companies were encouraged to continuously improve the objectives expected to maintain tax reduction benefits over the period.

Before the Inovar Auto Law, the automobile companies had already used the tax incentives from "Lei do Bem" (Law of Goodness), which allows tax deduction for R&D spending. The mechanical and transport

industry represented 24% of the total value declared as tax deduction in 2014, but this number had already doubled by 46% of the total in 2008.

The "Lei do Bem" was emphasized by Brazilian companies as the first significant step that helped to adapt the accounting system for registering R&D expenditures regarding Inovar Auto Law.

Theoretically, Inovar Auto was considered the most comprehensive and well-designed of all previous incentive initiatives established for the sector. Although companies may be considered to be still adjusting their policies in order to meet the programme goals, it should be emphasized that by 2014, about 44 assemblers (which already had operations in Brazil and others that plan to do so) had already joined the programme, aiming to make use of the benefits offered.

Inovar Auto Law is an opportunity for companies to benefit from the government incentives. The vehicle efficiency goal in Brazil was 1.82 MJ/km until 2017. This goal is based on Europe 2015 target for new Light Road Vehicle of 130 gCO_2/km and considering differences in driving cycle, vehicle, fuel and road specifications.

The main opportunity opened the by Inovar Auto Law is the motivation for the automobile industry to internalize international technology decreasing the existing gap in Brazil.

This task is a challenge considering the peculiar characters of the Brazilian market as compared to the assembler headquarters: the road conditions are substantially different from those in developed countries; Brazilian fuel characteristics are also different with a higher blend of ethanol in gasoline; and the main peculiarity is the flex engine.

These conditions require additional developments and investments to adapt the technologies developed outside Brazil to work here. Before the Inovar Auto Law, there was a wide gap regarding technological developments in developed countries.

Companies postponed the internalization of technologies into the Brazilian market because of the costs involved. Regulations and requirements of the Brazilian market did not encourage bridging the gap.

The need to reduce the engine size and weight was also an attractive factor for companies to hire Institutes of Science and Technology (ISTs) for developing new technologies in order to meet the demands of higher energy efficiency.

Overall, statistics do not clearly show these improvements in R&D spending, and it is still early to connect them as a direct result of the Inovar Auto Law. Also, it is still early to talk about sustainable results because the law has been in force for only three years.

In 2014, the Ministry of Science, Technology and Innovation report stated that all assemblers had their R&D spending approved as a result of the uncertainties of R&D classification. Nevertheless, the trend is clear: assemblers sought more partnerships with their suppliers and ISTs to adapt and to absorb the technologies used in developed countries.

Key Initial Impressions of Inovar Auto Results

According to the Ministry of Development, Industry and Commerce, there were a total of 36 companies that qualified for the Inovar Auto programme in April 2015 (including manufacturer and importer qualifications). Considering that each organization would have to opt for two goals from the three existing alternatives, the present frame shows the following:

1. 19 companies opted for attaining the goals in R&D
2. 35 companies for Engineering goals
3. 26 companies for Vehicle Labelling

Traditional companies (latecomers) attained the rates of resource application to engineering and to local content. The investments in R&D were made at different intensities by the assemblers. The smaller the size and the number of development centres of assemblers in the world, the greater was the change in the projects being developed in the country.

The newcomers (Chinese, Japanese, Korean and French) generally had more difficulties with engineering and R&D. For this reason, they sought to study partnerships with Systemists and research institutions to attain the Inovar Auto goals.

Assemblers that were newcomers focused on attaining the minimum rate of investment in R&D and started to establish partnerships with ISTs to develop projects. This was a fast-access path for conducting

research in companies that did not count on installed structure in Brazil but intended to have one in the medium term. Only time will indicate the maturity, sustainability and the effective results of these relationships.

The latecomers' behaviour, in turn, was not even. There were more aggressive companies, others that have done little so far in terms of taking more advantage from and of increasing the quantity and the quality of the R&D initiatives. The most aggressive company introduced the following initiatives:

1. It formalized a specific structure to account for the programme, for the initiatives and procedures bonded to it.
2. Formal procedures were established to record the engineering and R&D activities that may be considered for the effects of the programme, and hence, facilitate and record these hours in the company accounting system.
3. Substantial investments in laboratories and in partnerships with Brazilian universities to develop engineering applications formerly subcontracted abroad or developed in other company offices.

Problems in understanding what can or cannot be considered R&D expenses still remain. These doubts were much greater in the beginning but have largely been reduced with the aid of the Automotive Engineers Association (AEA, which provides technical support and training in the area) and of a private consultancy specializing in fiscal benefits.

This support was repeatedly mentioned as being fundamental to make Inovar Auto clearer and to better guide the companies' actions. Structuring a group with representatives from the government, from AEA, from the consultancy and from the companies to follow-up and to adjust may be considered as a recommendation to make viable future actions with a magnitude similar to that of Inovar Auto.

The cycle considered in the first stage of Inovar Auto (2013–2017) was considered too short. More ambitious and long-term projects eventually did not fit the span of time established for this stage that had no guarantee of continuity.

It would be important for a new version of the legislation to incorporate this modification, with medium- and long-term goals; it would be important for directing the sector efforts.

The smaller-sized auto parts manufacturers are out of the Inovar Auto programme and can be stimulated to contribute by means of invitations/incentives made by the assemblers, besides support from the government and from institutions in the sector.

The existence of public initiatives concerning its role on competitiveness, in general, and in innovation, in particular, is currently very widely recognized. Differently from a couple of years ago, the discussion is now concentrated in what the characteristics and nature of relevant public action would be concerning incentives and subsidies to firms so as to improve—in the long term—competitiveness and innovation.

In the last 12 years, a myriad of public policies were proposed by the federal government, with different tools and oriented to different industries. In many cases, the initial goals were not pursued and the agenda of competitiveness and innovation results was far from being completely achieved. In the case of the Inovar Auto Law, it is possible to point out at least two different characteristics:

1. The focus is on raising energy efficiency; hence, the innovation is oriented to this specific form of product innovation.
2. The type of other investments in R&D that may be considered to give access to subsidies is much more precise if compared to previous initiatives such as the so-called "Innovation Law" (from 2004).

Moreover, the symbolic aspect of the Inovar Auto Law programme is also important; assemblers, in particular, and the automobile chain, in general, started to discuss very specific details, such as what R&D is and what it is not, what the difference is between engineering and R&D.

Electromobility in Brazil

Overview and Initiatives

Yet, if Brazil wants to be a market in which an important part of the automobile industry game is played in the future—not only producing

but also developing products that can be sold worldwide, it is mandatory to develop competencies in electric-powered passenger cars.

The Brazilian government has not yet decided what kind of incentives would be granted to the electric car industry. One of the issues the electrical mobility places in the strategic map of the industry is the possibility of other players, who dominate electricity applications, entering the market, in association with new capitalists.

The automobile industry located in Brazil has been developing very few competencies in this field locally, and there is concern about Brazil becoming a mere importer in this segment, missing an opportunity to consolidate its position as a relevant global developer and producer in the automobile supply chain.

In the quest for environmental and economic sustainable energy sources for mobility, Brazil has the only commercial and technical successful case regarding the use of alternative fuels for internal combustion engines: sugar cane ethanol. Since the 1970s, a complete value chain to produce, distribute and use sugar cane ethanol as an automobile fuel has been developed, showing that it is possible to artificially build a market with institutional support that is sustainable, competitive and profitable.

Only in 2012 did the first hybrid or electric vehicles (EV) start to run in Brazil, some aiming at dissemination, and in other cases, a result of introducing a symbolic number of taxis, as from incentive programmes coordinated by municipal governments, such as that of São Paulo.

Toyota, Renault and Ford, for example, trade hybrid models in Brazil, but due to taxes, the prices reach about US$30,000.00, which makes its large-scale trade unfeasible.

In the urban transportation area, there are older initiatives, timid though, as compared to those occurring in other countries. This is an area in which there would be greater potential for developing and producing national vehicles.

Two hydrogen bus prototypes are under development in Brazil. One of the projects is being developed by the Metropolitan Company of Urban Transport of São Paulo (EMTU-SP) in partnership with the Ministry of Mines and Energy by means of a consortium involving some important energy related companies.

Anyway, except for some outstanding initiatives, the EV scenario in all its variants makes clear that Brazil is far behind USA, Europe and Japan besides China and Korea, for example, regarding technological development or the number and relative importance the EV fleet represents to the country. This scenario must be kept for the coming years.

Prospects for the Future in Electromobility

In order to map and prospect what kind of competencies are being developed concerning electric mobility in Brazil, data on patent applications in Brazil from 2002 to 2011 were researched in the World Intellectual Property Organization database, using the Patentscope search engine. Marx and Mello (2008) searched for all the patents granted in Brazil, regarding EV core technologies, and within the results, for patents whose applicants were Brazilian residents.

The authors also conducted 11 interviews with different actors involved in this field.

The main conclusions that arose from the interviews were the following:

1. Various specific competencies are spread across the country. Initiatives for investing in different areas (batteries, embarked control systems, electric engines, etc.) are not integrated. The initiatives depend on individual interest, and there is a lack of a strong integrator or an actor that can align efforts more effectively to create local EV projects, including the design and/or production of a complete EV;
2. In some cases, niche market products could be developed with a group of companies and institutions with different competencies acting and working together. This may be the most probable outcome (low-volume niche products) if no important entrepreneur takes the initiative to integrate a major programme to develop and/or produce EVs in the country.
3. There seems to be no public interest in investing more heavily in the development of technologies for EVs. According to the interviewees, this lack of interest is the result of the strong influence that the major auto assemblers and Petrobras, the powerful Brazilian public energy company, play in the auto industry.

4. Auto assemblers and traditional auto parts suppliers do not seem to be interested in having local EV development and production; some of them are making investments in their headquarter design centre. A possible exception is Fiat, which supports an EV project developed with electric companies.
5. Petrobras also does not seem to be very interested in EVs, except for some small initiatives. Almost all of its investments are focused on petrol, gas, ethanol or biofuels. On the other hand, in 2011, the Brazilian government created a fund for granting resources to product development projects for EV. After six months, no project was presented for funding, indicating the low level of local development and the poor coordination of the actors so far involved in the sector.
6. There is still no significant societal concern about emission and pollution levels related to the use of vehicles in Brazil, and the electric solution for automobiles is still more expensive than traditional internal combustion engines. These two factors mean that the market for EV is not very attractive for investments, at least in the short term for the major players in the sector.
7. The country would most likely not exhaust its oil resources in the next 30–50 years, given that huge oil reserves have been recently discovered. Thus, the interplay of the presence of petrol resources, the availability of ethanol, the lack of interest from the market and the political interest of Petrobras and the main automakers and traditional auto parts producers might explain the absence of a more integrated set of initiatives (both public and private) towards an investment in EVs design and production in the country.

Final Considerations

The Brazilian automobile industry evolved over the past 60 years through four clearly defined steps:

1. Import of cars, no local assembly, supply chain and development
2. Local assembly of cars from four large major players supplied by local auto part makers and no local development, restricted importations

3. Local assembly of cars by all major global players supplied by global auto parts makers, pushed by liberalization and foreign investment incentive policies, resulting in the participation of local engineering in some global projects, import of cars from specific segments (luxury and newcomers)
4. Same as above, but with rapid increase in the number of factories locally installed (manufacturers aiming at locally producing models that were so far imported, e.g. Toyota, Hyundai or newcomers, e.g. Chinese makers JAC, Chery).

In fact, undergoing these steps has been related to market importance and attractiveness, government influence through regulations and the development of the "global" strategy of the main manufacturers, as confirmed by Salerno et al. (2009).

The automobile industry is one of the most important economic sectors in Brazil not only by quantitative measures but also due to its significant political and social relevance. This industry shows the most developed form of labour union organization and firm-level interest representation in Brazil. Furthermore, the automobile industry originated the introduction of new production models and new forms of work organization spilling over into other sectors (Marx and Mello 2008).

The Inovar Auto initiative was clear in the sense of improving the incentives enforced until then for increasing the capacity building of local assemblers and auto parts manufacturers so as to root design activities, strengthen local research and development, and mainly, focus such initiatives on the quest towards having a more modern fleet, less aggressive to the environment, driver of the most important and necessary incorporations and improvements in new automobile technologies. However, there is no explicit mention or any type of incentive to the use of hybrid and/or electric motoring.

The country could take advantage of this window of opportunity to develop local competencies or even establish a local player in the sector. It became clear that this could occur through the development of local electric mobility.

Thus, unlikely to happen in the short term and in a "leapfrogging" strategy, an evolutionary approach from "locked-in" (or importer) to "local

producer" and "co-developer", could be the best way of inserting the country in future global markets. Yet, this depends on public policies and regulations to enhance market, competencies and infrastructure to develop it.

In its first version (it is expected to be extended and improved in 2018), the programme underwent an understanding and adjustment stage, which lasted almost two years. Only late in 2014 did it actually start to have its actions developed by the companies interested in adhering.

This is a recurrent trend in the Brazilian automobile industry. In periods of crisis, most of the investments yielding results in the medium and long terms undergo cuts or are even frozen independently of the benefit forecast. There are signs that this has already been occurring in several cases in the organizations and in ISTs.

It will only be possible to observe and to comment on the materialization or not of this more pessimistic vision for the future and of innovation in the automobile chain in some months when the effects of the economic crisis on the organizations' investments can be more concretely perceived. In the current scenario of growing competition among subsidiaries and countries, technological uncertainties, economical crises, arrival of new players in the Brazilian market, changes in the workforce social profile and changes in government orientation (Extreme Right won the general elections in 2018), the role of unions and employee representation agenda in order to maintain and create qualified and well-paid jobs in the long term remain a big challenge.

Note

1. The period of the history of Brazil between 1969 and 1973 was marked by strong growth of the economy. At this time, Brazil was a military dictatorship. The term "miracle" is related to a rapid and exceptional economic growth that it has gone through in this period. This period was marked by a growth in GDP between 7% and 13% per annum; significant improvements in the country's infrastructure; increased employment levels provided mainly by investments in infrastructure and industrial sectors and significant industrial development. On the other hand, as the economic development was funded mainly with foreign loans, this debt hindered

the development of Brazil creating a dependence on the creditors and the International Monetary Fund. Although the economy has grown considerably, there was no distribution of income and thus further increased social inequalities in the country with increasing concentration of income in the hands of the wealthiest.

References

Alves, M.A.S. 2002. A Guerra Fiscal e o Setor Automotivo: O custo fiscal dos incentivos. *Revista Dealer-on line*, Edição 34.

Amatucci, M., and E.E. Spers. 2012. Institutional, Technological and Commercial Innovations in the Brazilian Ethanol and Automotive Industries. In *The Greening of Automotive Industry*, ed. G. Calabrese, vol. 1, 164–184. New York: Palgrave Macmillan.

ANFAVEA—Associação Nacional dos Fabricantes de Veículos Automotores. 2016. *Anuário Estatístico Da Indústria Automotiva Brasileira*.

Arbix, G., M.R. Zilbovicius, and R. Abramovay. 2001. Razões e ficções do desenvolvimento. Editora da Unesp/Edusp.

Arbix, G., M. Zilbovicius, R. Abramovay, and A. Comin. 2002. *África do Sul, Índia e China: diálogo entre os que chegaram depois*. México and São Paulo, Brasil: Editora da Unesp/Edusp.

Consoni, F. 2004. *Relatório Setorial, Setor Automóveis*. FINEP, Rede DPP.

Consoni, F., and R. Quadros. 2003. Between Centralisation and Decentralisation of Product Development Competencies: Recent Trajectory Changes in Brazilian Subsidiaries of Car Assemblers. In *11th GERPISA International Colloquium*, Paris.

Ibusuki, U., R.C. Bernardes, and F. Consoni. 2014. New Brazilian Automotive Industrial Policy: Analysis of the Consequences for Local R&D based on New Comer's Strategies. *International Journal of Automotive Technology and Management* 15 (1): 43–62.

Marx, R., and A.M. Mello. 2008. *Automóveis e Comerciais Leves. Relatório Final do Projeto "Uma agenda de competitividade para a indústria paulista"*. IPT.

Mello, A.M., L.H.R. Vasconcellos, and R. Marx. 2005. Estariam as Montadoras Abrindo Mão de Suas Competências Essenciais no Desenvolvimento de Motores? - Um Estudo de Caso do Primeiro Veículo Nacional Bicombustível" In XXIX Encontro da ANPAD, 2005, Brasília. *Anais do XXIX Encontro da ANPAD*.

Rico, J., S. Mercedes, and I. Sauer. 2010. Genesis and Consolidation of the Brazilian Bioethanol: A Review of Policies and Incentive Mechanisms. *Renewable and Sustainable Energy Reviews* 14 (7): 1874–1887.

Rodrigues, I.J., C.C.C. Pontes, J.R. Ramalho, and M.A. Santana. 2007. Velhos e Novos Operários da Indústria Automobilística: O ABC paulista e o Sul Fluminense. In *Trabalho e Sindicato em Antigos e novos territórios produtivos: comparações entre o ABC paulista e o Sul Fluminense*, ed. I.J. Rodrigues and J.R. Ramalho. São Paulo: Ed. Annablume.

Salerno, M.S., R. Marx, and M. Zilbovicius. 2002. A nova configuração da cadeia automotiva brasileira. Relatório de Pesquisa, DEP, EPUSP.

Salerno, M., M. Zilbovicius, R. Marx, and A.V.C. Dias. 2009. The Importance of Locally Commanded Design for the Consolidation of Local Supply Chain: The Concept of Design Headquarters. *International Journal of Manufacturing Technology and Management* 16: 361–376.

Santos, A.M., and P. Burity. 1997. Complexo automotivo. BNDES Setorial, edição Especial.

Souza, I.O.F., and A.M. Mello. 2014. Innovative Developments in the Brazilian Automotive Industry. In *23rd IAMOT Annual Conference*, Washington, DC.