


Twenty years performance of Volkswagen's Truck and Bus modular consortium

Vinte anos de desempenho do consórcio modular Volkswagen Caminhões e Ônibus

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Abstract: This article analyzes the performance of the modular consortium installed in the truck and bus factory of Volkswagen in the city of Resende, Rio de Janeiro, in its first 20 years of operation. For that purpose we formulated a multidimensional performance analysis model, composed of indicators of the various aspects of the company and the main economic and market factors, covering the period 1990-2014. The model was based on aspects of the Balanced Scorecard (BSC) and Political, Economic, Sociocultural, Technological, Environmental and Legal (PESTEL) models. While the BSC guided the choice of the internal performance indicators, the PESTEL oriented the selection of the economic factors that affected the company's performance. The main characteristics of modular consortiums, taken from the scientific literature, were used to analyze the arrangement's performance, along with on-site observation at the plant. The results were obtained by examining the company's indicators during the period studied, taking into consideration the influence of historical factors and the main aspects of modular consortiums. The Volkswagen modular consortium was in general resilient to the economic variations in the period, and facilitated expansion of the company's product portfolio, contributing to leadership in the truck market.

Keywords: Modular Consortium; Performance Analysis; Multidimensional Performance Analysis Model (MPAM); Volkswagen Trucks and Buses; MAN Latin America.

Resumo: Este artigo analisa o desempenho do consórcio modular instalado na fábrica de caminhões e ônibus da Volkswagen em Resende-RJ, ao longo dos seus primeiros vinte anos de operação. Para tal, é proposto um modelo multidimensional de análise de desempenho, o qual é composto por indicadores das diversas perspectivas da empresa e pelos principais fatores econômicos e mercadológicos do período 1990-2014. A formulação do modelo multidimensional se sustenta em aspectos dos modelos BSC (*Balanced Scorecard*) e PESTEL (*Political, Economic, Sociocultural, Technological, Environmental, and Legal*). Enquanto o BSC orientou a escolha dos indicadores internos de desempenho, o PESTEL norteou a seleção dos fatores econômicos que interferiram no desempenho da empresa. As principais características dos consórcios modulares, retirados da literatura científica, são utilizadas na análise de desempenho deste caso específico construído a partir de documentos e de estudo de caso com imersão na

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planta. Os resultados desse trabalho foram obtidos a partir da análise dos indicadores da empresa ao longo do tempo, levando em conta a influência dos fatores históricos e dos principais aspectos dos consórcios modulares. A partir das análises, pode-se dizer que o consórcio modular Volkswagen apresentou resiliência às variações da economia no período, além de agilizar a expansão de portfólio, suportando que empresa se tornasse líder no mercado de caminhões.

Palavras-chave: Consórcio modular; Análise de desempenho; Modelo Multidimensional de Análise de Desempenho (MMAD); Volkswagen Caminhões e Ônibus; MAN Latin America.

1 Introduction

Brazil's economic opening in the 1990s exposed the nation's industry to global competition from companies having higher quality and productivity levels. In response to these challenges, the players in the automotive sector sought new productive configurations to increase their efficiency (Harvey, 2005; Salerno et al., 1998). Two concepts supported these new productive configurations: the industrial condominium and modular consortium (MC) (Pires, 1998; Pires & Sacomano, 2010). Both aim to establish tighter relations between assemblers and suppliers and closer physical proximity of their productive units as well.

The industrial condominium is characterized by the location of the suppliers within or nearby the factory installations of the vehicle maker, while the MC is characterized by installation of the main suppliers' productive units along the production line itself (Marx et al., 1997). Various companies in Brazil, such as Fiat (Betim, MG), Ford (São Bernardo do Campo, SP), Renault (São José dos Pinhais, PR), General Motors (São Caetano do Sul, SP) and Volkswagen (São Bernardo do Campo, SP) chose the industrial condominium model, while Volkswagen Trucks and Busses (VWTB), in Resende, RJ, and later Ford, in Camaçari, BA, chose the MC (Sacomano & Iemma, 2009).

At VWTB, the main suppliers add their components directly on the final assembly line, with VW being responsible for marketing, sales, product development and quality control (Sako, 1996). VWTB's choice of the MC model was also the result of the end of Autolatina in 1994, a joint venture between VW and Ford. The company was lacking in competencies for the development and manufacture of its products and needed a new factory to produce trucks and busses. The executive in charge of VW's operations in Latin America, José Ignacio Lopez de Arriortúa, proposed that the new truck and bus plant adopt the MC arrangement (Correa, 2001).

The new VWTB plant opened in 1996, in the city of Resende, Rio de Janeiro, and immediately attracted attention from industry observers and academics for being the first automotive factory in the world to use the pure MC configuration. In this context, many discussions emerged in industry and academe regarding the pros and cons of the MC productive model (Collins et al., 1997; Doran & Hill, 2008; Marx et al., 1997; Sacomano & Iemma, 2009; Sako & Murray, 1999).

Now after two decades of operation, having passed through global and local financial crises, changes in the vehicle market and legislative alterations, the VW Truck and Bus MC (VWTBMC) continues operating and has achieved significant results in the market, allowing the company to assume and maintain leadership (ANFAVEA, 2018). This longevity and innovative character whet interest in this productive system, stimulating a series of questions, such as: How has the VWTBMC performed during its existence? Is the MC really a more efficient model in comparison with others? Did

VWTB obtain advantages/positive results by adopting the MC? To respond to these questions, this article analyzes the performance of the VWTBMC during its existence, based on a multidimensional approach that considers the macroeconomic, market and technological conjunctures in the period.

The article is organized in five sections including this introduction. The next section contains a brief literature review about the MC productive model, covering its main characteristics, risks and opportunities. It also discusses the evolution of the performance measurement techniques utilized by companies, in particular the changes in those methods, and describes the PESTEL model, widely used by managers to map the external macro-environment. The third section presents the multidimensional analysis method developed and applied, which includes aspects of Balanced Scorecard (BSC) and PESTEL, for internal and external analysis of the organization. The fourth section describes the evolution of the VWTBMC from the standpoints of the indicators of the MPAM and responds to the questions posed in this introduction. Finally, the last section presents our concluding remarks.

2 Theoretical framework

2.1 The modular consortium: configuration, advantages and risks

The modular consortium involves the congregation of suppliers of modules at the assembly plant, with the vehicle maker having responsibility for the overall assembly of these modules to produce the final product (Sacomano & Truzzi, 2009). To simplify the productive chain and boost efficiency, starting in the 1990s vehicle makers defined a new set of requirements for global supply of components and modules to facilitate final assembly (design for assembly) (Abreu et al., 2000; Pires & Cardoza, 2007). The assembler had responsibility for the plant and selecting and coordinating the module suppliers, besides testing the vehicles.

Many manufacturers remain skeptical about the benefits of this configuration, alleging that it is fraught with risks of various types (Sacomano & lemma, 2009). Researchers, even though considering the arrangement to be innovative, have carefully examined the results to confirm the possible benefits (Collins et al., 1997). Chart 1 presents the advantages and risks of the MC, from the standpoint of the assembler, as identified in the literature.

Chart 1: Advantages and risks attribute to the MC

| Advantages | Risks |
|---|---|
| - Reduced costs (Collins et al., 1997, Doran & Hill, 2008; Sako & Murray, 1999). | - Loss of competencies in areas essential to the business (Sacomano & lemma, 2009); excessive dependence on suppliers (Sacomano & lemma, 2009). |
| - Increased efficiency (Collins et al., 1997). | - Difficulty of maintaining contracts when suppliers face adversities (Marx et al., 1997). |
| - Better quality (Collins et al., 1997). | - Loss of technical knowledge (Marx et al., 1997). |
| - Better management of suppliers and development of products (Doran & Hill, 2008; Sako & Murray, 1999). | - Difficulty of maintaining levels of quality and efficiency (Marx et al., 1997). |

Chart 1: Continued...

| Advantages | Risks |
|---|-------|
| - Sharing of investments with suppliers (Doran & Hill, 2008; Sako, 1996; Sako & Murray, 1999). | |
| - More agile development of new products (Baldwin & Clark, 2000; Doran & Hill, 2008; Sako & Murray, 1999; Ulrich, 1995). | |
| - Better productive flexibility of models (product mix) and volume (Doran & Hill, 2008; Olhager, 1993; Pires, 1998; Sako & Murray, 1999). | |

Source: Prepared by the authors.

For the first-tier suppliers (which deliver parts directly to the production line), the MC is a way to stabilize the supply of their products, since the contracts with the assembler have long durations (Sacomano & Iemma, 2009). Hence, they manage to soften variations in demand and assure their market share for the contractual period. In the case of suppliers at the second and third levels, which deliver parts to the first-tier suppliers, the modular arrangement enables an overview of the productive chain, so these suppliers will not only be focused on production of their own parts, but also on the interface between the modules (Pires, 1998).

With respect to technological aspects, the modular suppliers have a chance to acquire know-how in new areas. Although the supply contracts typically contain conditions for protection of industrial secrets, which can be enforced judicially, the assembler still runs the risk of sharing its new technology and sensitive information with its suppliers, which can use these to produce new products and/or enter into agreements with new customers, without the participation of the assembler (Collins et al., 1997).

2.2 Evolution and aspects of performance measurement

Performance measurement is not a recent discipline, but in each era organizations focus on different business aspects in their assessments. Until the 1960s, the majority of firms evaluated their performance based only on financial aspects, like costs, revenues and profits (Neely et al., 2000), or productive aspects, such as quantities produced, error rates and productivity per employee. In the 1990s, the traditional one-dimensional way of evaluating performance was transformed by the multidimensional models proposed by authors like Eccles, Kaplan and Norton. For example, the Balanced Scorecard (BSC) was proposed by Kaplan & Norton (1996) as a tool for strategic communication, with the objective of examining the accomplishment of the company's mission through a broad measurement system, facilitating strategic management. The authors argued that the use of a single metric, such as profit, was no longer adequate.

The catalytic effect of the BSC method added new elements to studies of performance measurement systems, making it acceptable to use various types of indicators to evaluate corporate performance, such as costs, production rates, quality, flexibility, learning and innovation (Kaplan & Norton, 1992).

The current approach to performance measurement relies on a series of aspects, such as evaluation of market conditions, financial and nonfinancial metrics and

measurement of cost categories, covering the majority of strategic aspects of organizations (Meyer, 2003).

2.3 Business climate analysis model

The condition of the environment outside the company is an important variable in the model proposed in this article. The challenge is to deal with a large set of variables in organized form without a hidebound relation regarding the possible impacts of the variation of these factors on the firm. One of the best-known tools to map external scenarios is PESTEL (an acronym for Political, Economic, Sociocultural, Technological, Environmental and Legal), denoting the factors that influence the organization (Yüksel, 2012). Chart 2 summarizes the literature on the theme.

Chart 2. Factors of PESTEL Analysis.

| Factors | Description |
|---------------|--|
| Political | These factors involve the influences of government decisions and policies on the company's operations. They are not restricted to the country where the firm is located, because political decisions made in foreign countries can affect the policies of the home country and thus of firms that do not operate in these foreign markets. Consideration should also go to the political influence of supranational entities and regional economic blocs/accords, which have been increasing considerably (Bivolaru et al., 2009). |
| Economic | These factors are derived from the economic system adopted by the country and the level of control that the formulators of this system have over private initiative. Some important indicators are growth rate of gross domestic product (GDP), confidence levels in various market sectors, inflation rate, exchange rate, monetary and fiscal policies, level of debt and sectorial incentive policies. The economic factors are also affected by international variables like crises and policies of regional economic blocs (Shilei & Yong, 2009). |
| Sociocultural | These factors are composed of the characteristics of the region/country where the company operates and that can be considered in their strategic decisions, such as demographic profile, customs, norms and values, cultural openness to outside influences, and symbols of status and lifestyle. It is important for the local subsidiaries of multinationals to absorb the values of the countries where they operate, because this facilitates good relations with employees and customers (Wheelen & Hunger, 1986). |
| Technological | Among the technological factors considered are those for reducing pollution, spending on research and development (R&D), governmental R&D incentive policies, and introduction of new technologies (Cadle et al., 2014). |
| Environmental | These factors include laws and regulations on environmental protection, the impacts on the business of global warming, emissions of pollutants by vehicles and the production process, and level of recycling (Dockalikova & Klozikova, 2014). |
| Legal | These factors consist of laws and regulations on taxes, labor relations, environmental matters, competition (antitrust) and consumer protection (Saaty & Vargas, 2013). |

Source: Prepared by the authors.

3 Methodology

This article is based on applied research, with an exploratory and explanatory purpose, supported by a single broad and participatory case study. The study was possible because of the collaboration of the company's management and the existence of an in loco observer, namely an employee of the company who oversaw the collection of data and selection of the aspects relevant to the analysis. The company made channels available for us to resolve doubts and enhance understanding of its performance (such as historical factors that affected the performance of the VWTBMC).

Starting from a multidimensional performance analysis model (MPAM), described in item 3.1, covering the internal and external aspects of the company, we gathered data in 2016 and 2017 and formulated the initial version. This article was prepared after reflection regarding the conclusions and interaction with the company.

This type of method where one observer is a full participant, collecting information unsystematically (Silva & Fantinel, 2014), has some risks and limitations, such as biasing the work and making it a mere compilation of the official marketing spiel of the company. The participation of researchers without any connection with the company served to balance the views.

3.1 The multidimensional performance analysis model (MPAM)

The MPAM is composed of three dimensions: vision, perspectives and historical factors, and allowed a multidimensional qualitative analysis of the performance of the VWTBMC (Figure 1).

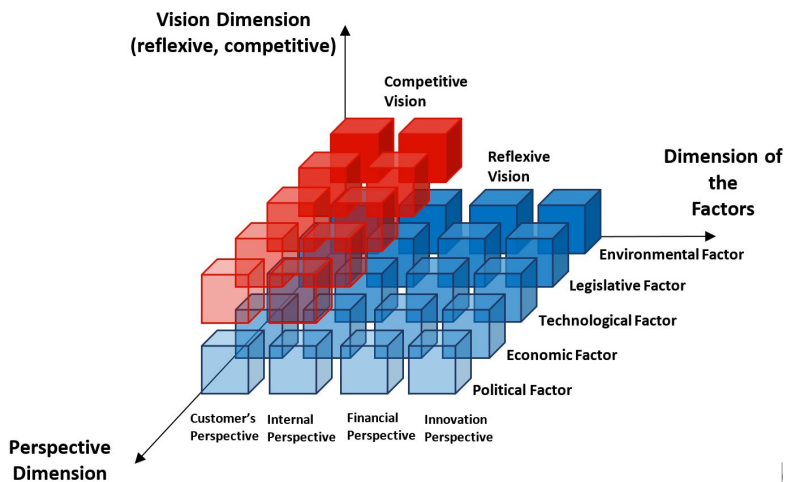


Figure 1. Multidimensional Performance Analysis Model (MPAM). Source: Trintini (2016).

The historical factors dimension functions as the background of the phenomenon studied, with the factors of the PESTEL model serving as variables. These factors permit a broad analysis of the environmental events that affect the strategy and performance of companies. Here the political, economic, technological, environmental and legal factors compose this dimension. We do not consider the sociocultural factor because we did not find in the literature any objective variables regarding this factor. Chart 3 summarizes the historical factors and the variables used in the analysis of each of them.

Chart 3. Indicators of the historical factors dimension.

| Factors | Variables | References |
|-------------------|----------------------------|---------------------------|
| Political (P) | Tax System | (Yüksel, 2012) |
| | Development Macro-policies | |
| Economic (E) | Macroeconomic Matrix | (Al-Malkawi et al., 2014) |
| | Interest Rate | |
| | Exchange Rate | |
| | Sectorial Scenario | |
| Technological (T) | Control of Emissions | (Kahn, 2015) |
| | Engine Efficiency | |
| Environmental (E) | Emission of Gases | (Kaplan & Norton, 2008) |
| | Fuel Consumption | |
| Legal (L) | Environmental Legislation | (Kaplan & Norton, 2008) |

Source: Trintini (2016).

The dimension involving vision has two categories: reflexive and competitive. In the reflexive category, the VWTBMC's performance is analyzed comparatively in different periods, while in the competitive category its performance is compared with that of its direct competitors in the Brazilian market. The dimension called perspective has four categories, inspired by the BSC, an instrument recognized for generating business evaluation indicators, in this case for the indicators of the vision categories, providing a two-dimensional vision of the company. These indicators reflect the impact of the evolution of the historical factors inspired by the PESTEL model.

Chart 4 summarizes the indicators identified in the literature to analyze the performance in the reflexive and competitive categories. The innovation and financial perspectives are not considered in the analysis of competitiveness for lack of data regarding competing companies.

Chart 4. Indicators.

| Perspective | Indicators | References |
|--|--------------------------------------|--|
| Indicators for the reflexive category | | |
| Innovation | Number of employees allocated to R&D | (Smith, 2005) |
| | Hours of training | (Mahdieh & Pedram, 2011) |
| | Investments in R&D | (Senvar et al., 2014) |
| | Evolution of product portfolio | (Kaplan & Norton, 1992) |
| Internal | Annual sales | (Mahdieh & Pedram, 2011) |
| | Defects per vehicle (DPV) | (Hon, 2005) |
| Customers | Annual production | (Meier et al., 2013) |
| | Market share | (Mahdieh & Pedram, 2011) |
| Financial | Revenue/profitability | (Meier et al., 2013; Neely et al., 2000) |
| | ROS | (Meier et al., 2013) |
| Indicators for the competitive category | | |
| Internal | Annual production | (Meier et al., 2013) |
| | Annual exports | (Olve et al., 1997) |
| Customers | Market share | (Mahdieh & Pedram, 2011) |

Source: Prepared by the authors based on Trintini (2016).

3.2 Collection and analysis of the data

The data to compose the vision dimension were mainly obtained from internal documents of the VWTBMC, complemented by data available at the site of the trade association ANFAVEA (National Association of Automotive Vehicle Manufacturers), for both the categories. These data were organized in the perspective dimension to formulate the proposed indicators. With respect to the information on historical factors, besides review of the literature the participating observer experienced most of the relevant historical events, enabling relating these events and their impact.

Regarding the way of treating the data, we opted first to organize the historical factors and then analyze them to relate and understand the impact of these factors (Chart 3) on the performance indicators (Chart 4). We decided to end the analysis in 2014 because of the unavailability of some more recent data, and the economic crisis faced by the country starting that year.

4 Analysis of the VWTBMC's performance

This section is organized in four parts. In the first part the topic of study is presented (VWTBMC). Next, the historical factors are summarized. The third part describes the trajectory of the VWTBMC during its 20 years of operation (vision dimension) and the fourth part analyzes its performance.

4.1 The VWTBMC

Opened in November 1996, the VWTBMC is responsible for producing the trucks and buses of the VW brand in Brazil. At the factory in Resende, RJ, all the assembly operations were transferred to the first-tier suppliers, called modular suppliers. VWTB does not have any employees involved directly in the assembly of the vehicles. Instead, employees of the modular suppliers are allocated to the production line to assemble the components supplied by them and their second-tier suppliers. VWTB performs the activities of coordination, logistics, quality control, product development, marketing and sales.

The relationship between the companies is governed by a contract with duration of five years, which can be renewed without limit (Di Serio et al., 2007). With respect to the geographic scope, the relationship of VWTB and the suppliers is considered local, since although they are multinational companies, the partnership is limited to the plant in Resende (Sacomano & lemma, 2009).

The idea behind the MC model is to reduce production costs, investments, inventories and production time (Abreu et al., 2000). The modular suppliers were responsible for an initial outlay of US\$ 250 million for operation of the plant (Trintini, 2016), although over the years some pieces of equipment have been purchased by VWTB.

The plant uses an independent internal logistics operator, which moves the parts and components and supplies the assembly line according to the production schedule prepared by VWTB (Sacomano & lemma, 2009). In recent years, the company JSL has served as internal and external logistics operator (Trintini, 2016).

In 2009 the Volkswagen Group was restructured and the VWTBMC plant was transferred from VWTB to MAN, a longstanding maker of trucks, which renamed the company MAN Latin America. In 2018, after several international acquisitions, the

holding company Traton was created to the segment of truck and bus. The name VWTB was restored to the plant.

With respect to the integration between the modular suppliers and the assembler, the former started out in the relationship with VWTB by performing just the assembly activity. Subsequently, efforts were made to consolidate the logistics system. In the next step they improved their productive processes, to enhance the integration with the other modular suppliers and with the assembler. At present, seven companies act as modular suppliers, as described in Chart 5.

Chart 5. Modular Suppliers of the VWTBMC.

| Company | Description |
|---------------|--|
| lochpe Maxion | A Brazilian company responsible for assembling the chassis and subsets, and also for supplying the chassis, air reservoirs and fuel tanks. |
| ArvinMeritor | A multinational company based in São Paulo, which supplies and assembles the suspension system and axles. |
| Remon | A joint venture between lochpe Maxion and Bridgestone, responsible for supplying and assembling the wheels and tires. |
| Powertrain | A joint venture between Cummins and MWM/International, responsible for supplying the engines and transmissions and for assembling the power train. |
| AKC | A Brazilian company of the Aethra Group, which supplies the stamped parts, dashboards and cab frameworks. |
| Carese | A company of the German Eisenmann Group, which performs cab painting services. |
| Continental | A German company, responsible for mounting the internal and external cab finish items, and supplying the instrument panels and seats. |

Source: Prepared by the authors based on Trintini (2016).

4.2. Historical factors dimension

The main historical factors that affected the VWTBMC between 1990 (before creation of the arrangement) and 2014 are presented in Chart 6. The environmental and legal factors are combined because the environmental regulations requiring reduced engine pollution and better safety aspects are based on laws. Therefore, the two factors are presented together (Legal-Environmental, or LE).

Chart 6. Summary of Historical Events.

| No | Description | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|----|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| E1 | Start of market opening (President Collor) | X | X | X | | | | | | | | | | | | | | | | | | | | | | |
| E2 | Control of hyperinflation | | | | | X | X | X | X | X | X | | | | | | | | | | | | | | | |
| E3 | Implementation of the <i>Plano Real</i> | | | | X | X | X | X | X | | | | | | | | | | | | | | | | | |
| E4 | Mexican crisis | | | | | | X | X | | | | | | | | | | | | | | | | | | |
| E5 | Southeast Asian crisis | | | | | | | | X | X | | | | | | | | | | | | | | | | |
| E6 | Russian crisis | | | | | | | | | X | X | | | | | | | | | | | | | | | |
| E7 | Abandonment of the exchange rate anchor | | | | | | | | | | X | X | | | | | | | | | | | | | | |

Chart 6: Continued...

| No | Description | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | |
|-----|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|---|
| E8 | Crisis of confidence (1st election of President Lula) | | | | | | | | | | | | | | X | X | | | | | | | | | | | |
| E9 | Period of rising commodity prices (Chinese growth) | | | | | | | | | | | | | X | X | X | X | X | X | X | | | | | | | |
| E10 | Crisis of 2008 | | | | | | | | | | | | | | | | | | | X | X | X | | | | | |
| E11 | Deterioration of the Brazilian macroeconomic environment | | | | | | | | | | | | | | | | | | | | | | X | X | X | X | |
| P1 | Finame program for the automotive industry | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| P2 | Provisional Measure 1,024/1995 (Automotive Regime of 1995) | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| P3 | Law 99,449/1996 and Decree 2,072/1996 | | | | | | | X | | | | | | | | | | | | | | | | | | | |
| P4 | Exemption of IPI (Tax on Manufactured Products) on trucks | | | | | | | | | | | | | | | | | | | | X | X | X | X | X | X | X |
| P5 | BNDES/PSI (Reduction of interest rates on Finame loans) | | | | | | | | | | | | | | | | | | | | X | X | X | X | X | X | X |
| T1 | Improvement of the fuel injection and combustion chamber system | X | X | X | X | | | | | | | | | | | | | | | | | | | | | | |
| T2 | Introduction of the turbocharger intercooler | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| T3 | Introduction of high-pressure injection pumps | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| T4 | Introduction of electronic fuel injection | | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| T5 | Introduction of the selective catalytic pollution reduction system | | | | | | | | | | | | | | | | | | | | | | | X | X | X | |
| T6 | Introduction of the gas recirculation system | | | | | | | | | | | | | | | | | | | | | | | X | X | X | |
| LE1 | Phase P1 of Proconve | X | X | X | X | | | | | | | | | | | | | | | | | | | | | | |
| LE2 | Phase P2 of Proconve | X | X | X | X | | | | | | | | | | | | | | | | | | | | | | |
| LE3 | Phase P3 of Proconve | | | | X | X | X | X | | | | | | | | | | | | | | | | | | | |
| LE4 | Phase P4 of Proconve | | | | | | | | X | X | X | X | X | | | | | | | | | | | | | | |
| LE5 | Phase P5 of Proconve | | | | | | | | | | | | | X | X | X | X | X | X | X | X | X | X | | | | |
| LE6 | Phase P7 of Proconve | | | | | | | | | | | | | | | | | | | | | | | X | X | X | |

Source: Prepared by the authors based on Miranda (2001), Silva (2002), Prado (2005), Fernandes & Guilhoto (2009), Pastore et al. (2014) e Trintini (2016).

In the 1990s, the Brazilian economy became progressively more open (economic event E1 of Chart 6). Besides this, the period from 1992 to 1996 is peculiar because it straddles the introduction (in 1994) of the *Plano Real*, which finally stabilized the economy after a long cycle of high inflation (events E2 and E3). With the improvement of the macroeconomic environment due to sectorial agreements among the government, automakers and labor unions, the automotive sector became stronger starting in 1993 (Salerno et al., 1998). The main points of these agreements were transformed into laws and decrees, creating the so-called Automotive Regime of 1995 (political events P2 and P3).

Between 1996 and 2002, in parallel with the process of reorganization and renewed growth of the Brazilian economy, various international economic crises occurred (Mexico, Southeast Asia, Russia) that affected the internal market (economic events E4 to E8) (Prado, 2005).

The external scenario became more favorable in 2003-2008, because of the run-up of international commodity prices (event E9), allowing strong growth of the global and Brazilian economies until the international financial crisis of 2008-2009 (event E10). Through expansive fiscal measures, the country managed to weather the crisis initially, but this was followed by gradual deterioration of the macroeconomic conditions, leading to a crisis starting in 2013 (Pastore et al., 2014).

Concomitantly with this macroeconomic scenario, there was strong influence of ANFAVEA on governmental policies, prompting various types of incentives (events P1 to P5). These policies were in response to the large participation of the automotive sector in the economy and the importance of road transportation of goods and people (ANFAVEA, 2018). In counterpart, the government also required improvements in engine emissions, through the Program to Control Vehicular Emissions (Proconve), which was phased in gradually under the coordination of the National Environmental Council (CONAMA), with participation of sectorial entities and companies (events LE1 to LE6). At the same time, to meet the demands of the Proconve and relying on technological advances from abroad, various new technologies were applied to trucks and buses (events T1 to T6) (Trintini, 2016).

4.3 Performance according to the competitive vision dimension

In this item we address the variables market share, production, exportation and expansion of the product portfolio in comparison with the company's main competitors.

4.3.1 Market share (domestic sales)

As a result of the improved macroeconomic climate and the new automotive regime (events E2, E3, P2 and P3), the total number of new trucks sold rose by 58% between 1992 and 1996 (ANFAVEA, 2018). This is the context in which the VWTBMC was created.

The company gained a much larger share of the expanding market from 1996 to 2003. In this period, the number of new trucks sold in Brazil increased by 58.6%, and the company's share rose by 15.4 percentage points (from 17.20% to 32.60%, almost doubling sales). Four years after the new factory in Resende started operations, VWTB reached second place in the market, and 2003 achieved leadership. Between 2003 and 2006, the positions in the market did not change, and from 2006 to 2012 the number of new trucks sold increased by 137%. VWTB consolidated its leadership, increasing its advantage over Mercedes-Benz. Figure 2 depicts the evolution of the market shares of the main makers of trucks with cargo capacity of three tons or more from 1992 to 2014, according to data from ANFAVEA (2018).

Twenty years performance...

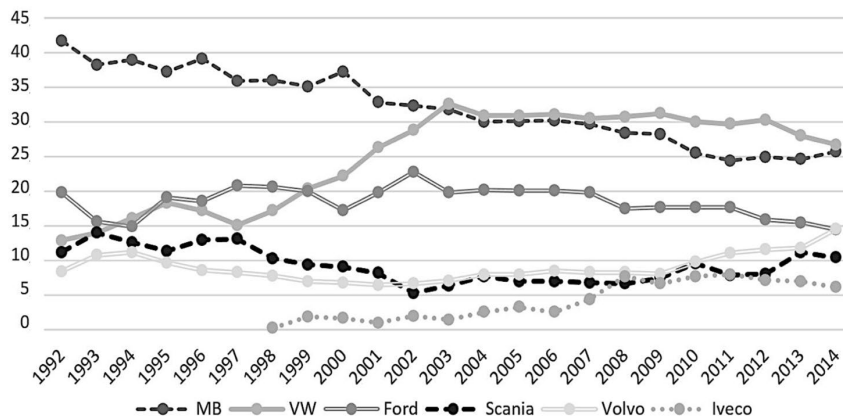


Figure 2. Truck market shares between 1992 and 2014. Source: ANFAVEA (2018), tabulated by the authors.

4.3.2 Production and exportation

Chart 7 shows the evolution of the VWTBMC. From 1997 to 2001, VWTB rose from fourth to second place (in production volume), overtaking Scania and Ford. In this period, the company increased its production by 183.5%. In turn, from 2001 to 2007, VWTB assumed leadership in production volume, increasing its output by 107.1% (ANFAVEA, 2018).

Chart 7. Evolution of production by the main truck makers.

| Year | Agrale | | Ford | | Iveco | | VWTB | | MB | | Scania | | Volvo | | Total | |
|------|--------|-----|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|---------|--------|
| | Prod | X | Prod | X | Prod | X | Prod | X | Prod | X | Prod | X | Prod | X | Prod | X |
| 1992 | 612 | 362 | 6,591 | 1,607 | - | - | 3,124 | 615 | 14,186 | 4,686 | 3,440 | 395 | 2,303 | 240 | 30,256 | 7,905 |
| 1993 | 1,444 | 480 | 8,922 | 3,520 | - | - | 6,212 | 719 | 19,108 | 5,495 | 5,130 | 138 | 4,702 | 249 | 45,518 | 10,601 |
| 1994 | 1,475 | 135 | 11,686 | 5,122 | - | - | 8,642 | 608 | 27,434 | 7,326 | 6,754 | 247 | 5,562 | 410 | 61,553 | 13,848 |
| 1995 | 1,232 | 102 | 13,286 | 2,192 | - | - | 14,353 | 1,982 | 27,059 | 3,216 | 6,550 | 297 | 5,820 | 286 | 68,300 | 8,075 |
| 1996 | 450 | 23 | 9,996 | 3,005 | - | - | 10,461 | 1,138 | 17,864 | 2,994 | 5,326 | 330 | 3,722 | 242 | 47,819 | 7,732 |
| 1997 | 489 | 17 | 16,382 | 4,262 | - | - | 6,697 | 1,735 | 25,039 | 4,976 | 7,793 | 400 | 5,058 | 564 | 61,458 | 11,954 |
| 1998 | 556 | 20 | 14,392 | 3,773 | - | - | 9,833 | 1,066 | 24,886 | 7,249 | 5,633 | 684 | 4,790 | 667 | 60,090 | 13,459 |
| 1999 | 244 | 61 | 12,154 | 1,568 | - | - | 10,641 | 1,072 | 21,817 | 4,718 | 4,671 | 420 | 3,398 | 318 | 52,925 | 8,157 |
| 2000 | 435 | 85 | 15,079 | 2,335 | 848 | - | 14,631 | 1,316 | 25,763 | 3,722 | 6,046 | 699 | 4,965 | 886 | 67,767 | 9,043 |
| 2001 | 546 | 45 | 14,617 | 1,739 | 3,962 | 993 | 18,989 | 766 | 23,653 | 2,090 | 5,679 | 306 | 4,605 | 561 | 72,051 | 6,500 |
| 2002 | 606 | 45 | 15,201 | 1,253 | 2,599 | 477 | 18,570 | 710 | 21,021 | 1,087 | 4,271 | 1,134 | 4,825 | 533 | 67,093 | 5,239 |
| 2003 | 737 | 52 | 16,237 | 2,791 | 1,589 | 481 | 22,649 | 1,917 | 23,507 | 3,018 | 6,806 | 2,629 | 5,582 | 792 | 77,107 | 11,680 |
| 2004 | 743 | 77 | 21,477 | 5,068 | 3,548 | 1,182 | 29,271 | 4,142 | 32,157 | 8,058 | 9,949 | 3,953 | 8,676 | 2,296 | 105,821 | 24,776 |
| 2005 | 816 | 340 | 24,945 | 7,929 | 3,453 | 1,918 | 32,781 | 7,141 | 32,333 | 8,784 | 12,223 | 7,022 | 10,126 | 4,151 | 116,677 | 37,285 |
| 2006 | 406 | 167 | 21,269 | 7,188 | 2,792 | 2,257 | 28,632 | 7,777 | 29,546 | 8,009 | 14,275 | 9,173 | 8,292 | 2,236 | 105,212 | 36,807 |
| 2007 | 832 | 239 | 27,120 | 7,100 | 5,258 | 1,775 | 39,328 | 9,578 | 37,195 | 9,713 | 15,773 | 9,195 | 10,631 | 2,778 | 136,137 | 40,378 |
| 2008 | 1,191 | 258 | 31,296 | 6,806 | 12,879 | 2,367 | 46,029 | 6,964 | 43,363 | 8,312 | 16,976 | 8,521 | 14,641 | 4,438 | 166,375 | 37,666 |
| 2009 | 588 | 63 | 25,293 | 2,078 | 7,508 | 1,647 | 36,994 | 3,954 | 34,231 | 3,091 | 9,030 | 1,145 | 9,693 | 1,154 | 123,337 | 13,132 |
| 2010 | 743 | 36 | 34,759 | 4,275 | 14,122 | 1,871 | 57,442 | 6,401 | 47,089 | 4,839 | 18,310 | 2,798 | 18,365 | 2,120 | 190,830 | 22,340 |
| 2011 | 1,036 | 76 | 40,686 | 6,001 | - | - | 69,275 | 7,660 | - | - | 22,523 | 7,306 | 24,759 | 3,049 | 158,279 | 24,092 |
| 2012 | 448 | 41 | 23,462 | 3,734 | - | - | 36,845 | 6,527 | - | - | 14,911 | 4,806 | 17,468 | 3,465 | 93,134 | 18,573 |
| 2013 | 429 | 28 | 25,975 | 4,753 | - | - | 50,923 | 6,020 | - | - | 25,255 | 5,419 | 26,124 | 3,534 | 128,706 | 19,754 |
| 2014 | 407 | 0 | 22,199 | 3,307 | - | - | 38,111 | 4,161 | - | - | 18,974 | 5,354 | 20,647 | 2,831 | 100,338 | 15,653 |

Source: ANFAVEA (2018), tabulated by the authors.

To meet the demand spurred by governmental incentives initiated in 2008 and expanded in 2009, VWTB started a third production shift in 2010, increasing its production capacity to 72,000 vehicles per year (MAN-LA, 2015; ANFAVEA, 2018).

However, in the period from 2011 to 2014, the number of new trucks sold dropped by roughly 26%, explained by the deterioration of Brazil's macroeconomic climate (event E11). To adjust to the lower demand, VWTB ended its third production shift in 2012 (MAN-LA, 2015). In 2014, the truck market contracted by 9.2% in relation to 2013, and the advantage in market share in relation to rivals shrank (ANFAVEA, 2018).

In relation to truck exports (X), the ratio of foreign sales to total production fluctuated at different moments, reaching 30% of output in 2005 and 2006 (Chart 7). However, since 2010 this level has been around 15%. The companies with the best performance in the period were MB (leader from 1992 to 2001 and again between 2003 and 2009), VWTB (leader from 2010 to 2013), and Scania (leader in 2008 and 2014).

With respect to inventories, according to Trintini (2016) the stock of unsold vehicles increased in 2005, 2007, 2008, 2009, 2010, 2011 and 2013, while it decreased in 2006, 2012 and 2014.

4.3.3 Portfolio of products and investment in production

Data prior to 2005 were not available, but in general the company's product portfolio was not renewed in that period, remaining basically the same since the 1990s (Trintini, 2016). From 2005 to 2014, there was expansion of the number of models made by VWTB, as shown in Figure 3. The renovation of the portfolio can be explained by the greater levels of integration with the modular suppliers, facilitating the launch of new products (Pires, 1998). That agility and flexibility can be exemplified by the launch of a new product line in 2005 called *Constellation*, initially composed by 14 models, which developed later into various others, allowing the company to offer more than 100 configurations in 2010.

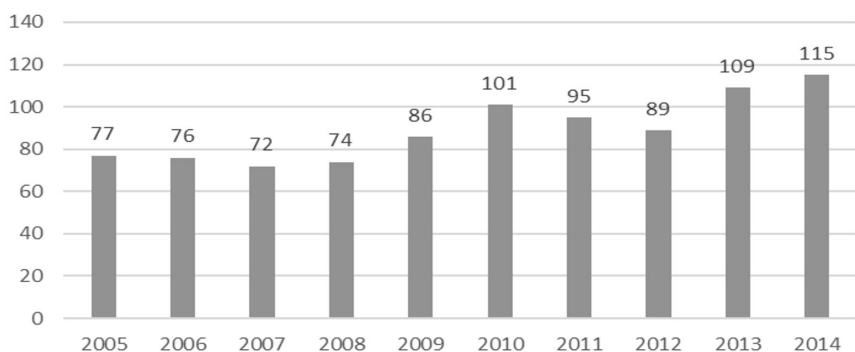


Figure 3. Evolution of the product portfolio of VWTB. Source: MAN-LA (2015).

In terms of investments in production, this was most significant in 2005, followed by decline in the ensuing years, and then a new cycle of investments in 2010 and 2011, to expand production and the product portfolio (Trintini, 2016).

It was not possible to obtain precise data on the portfolios of all the rivals in the period, which impaired the analysis. The information found indicates that VWTB had the largest number of configurations. VWTB created a partnership with BMB Mode

Center to make tailor made products, i.e., customized trucks for specific tasks (Trintini, 2016).

4.4 Performance according to the reflexive vision dimension

This section presents the following reflexive indicators: revenue, profitability, return on sales (ROS); investment in research and development (R&D) and training, and defects per vehicle (DPV). Since VWTB did not authorize disclosing the gross values, we decided to work with the annual and accrued variation of these indicators, to allow analyzing the evolution of the company and the production models without exposing its strategic plans.

4.4.1 Revenue, profitability and ROS

Data on these items are not available before 2005 because they were combined with the production of cars. From 2005 to 2006, VWTB achieved significant growth in these items even with the contraction of the number of trucks sold in Brazil. This phenomenon can be explained by the launch in 2005 of new lines of delivery trucks (5 to 8 tons) and the *Constellation* line (heavy trucks). There was a significant increase in exports from 2003 to 2006, of some 305%, contributing to the increase in revenue in this period (MAN-LA, 2015; ANFAVEA, 2018).

Chart 8 shows that between 2006 and 2008, the revenue, profitability and ROS of VVCO accompanied national growth of truck sales, increasing by 64%. Because of the revitalization of the product lineup, it was possible to take full advantage of the economic growth and expansion of the truck market (possibly related to economic event E7) (MAN-LA, 2015; Pastore et al., 2014).

Chart 8. Evolution of revenue, profitability and ROS*.

| Year | Revenue | | Profitability | | ROS | |
|------|--------------------|------------------|--------------------|------------------|--------------------|------------------|
| | Accrued (base 100) | Annual variation | Accrued (base 100) | Annual variation | Accrued (base 100) | Annual variation |
| 2005 | 100 | - | 100 | - | 100 | - |
| 2006 | 125 | 25% | 250 | 150% | 200 | 100% |
| 2007 | 170 | 36% | 500 | 100% | 294 | 47% |
| 2008 | 205 | 21% | 825 | 65% | 402 | 37% |
| 2009 | 141 | -31% | 710 | -14% | 505 | 25% |
| 2010 | 314 | 122% | 1850 | 161% | 590 | 17% |
| 2011 | 358 | 14% | 2000 | 8% | 560 | -5% |
| 2012 | 287 | -20% | 1145 | -43% | 400 | -29% |
| 2013 | 296 | 3% | 1100 | -4% | 370 | -8% |
| 2014 | 225 | -24% | 325 | -70% | 145 | -61% |

Source: Data from MAN-LA (2015), tabulated by the authors. *We used ROS because this is the metric used by VWTB to measure profitability.

Although the Brazilian economy decelerated in 2009 (GDP growth fell from 5.2% in 2008 to 0.3%), the company's revenue only declined by 31% and ROS continued to

increase. This result was possibly due to the expansion of the portfolio in the preceding years, which strengthened the brand versus its main competitors.

In 2012, a new law took effect on emission of gases, which limited the emission of pollutants from diesel engines (phase P7 of Proconve; legal-environmental LE6). Trucks were required to use EURO5 type emission treatment systems (events T5 and T6), which increased the final prices. Foreseeing that increase, many customers speeded up their purchase of new trucks in 2011 (Ferrarese et al., 2012). This behavior of consumers distorted the indicators of revenue and profitability in 2011 and 2012, increasing them in the former year and diminishing them in the latter year (MAN-LA, 2015; ANFAVEA, 2018).

From 2013 to 2014, the company's financial indicators deteriorated substantially due to the nation's economic crisis (event E11) and the consequent reduction of investments by firms, which directly affected truck sales (Pastore et al., 2014).

As shown by Chart 8, the profit and ROS followed the same general trend as revenue, but the magnitude of the profit variations was greater.

4.4.2 Investment in R&D and training

Investment in R&D grew significantly in 2006 (by 50%), and then remained steady until 2008. Afterward, there was a new upward cycle in 2010 and 2011, during which investment grew by 3.3x and 4.6x in relation to 2005. VWTB did not authorize disclosure of the gross figures, but according to Trintini (2016), the growth of R&D investments corresponded to the increase of the company's portfolio, where a significant part of this investment went for modularization of the products and integration of the modules composing the products, therefore making the MC arrangement more flexible.

Regarding investment in training, Figure 4 shows that between 2005 and 2014 the average number of training hours per production worker basically increased linearly, except in 2011, when there was a spike due to the introduction of the third production shift.

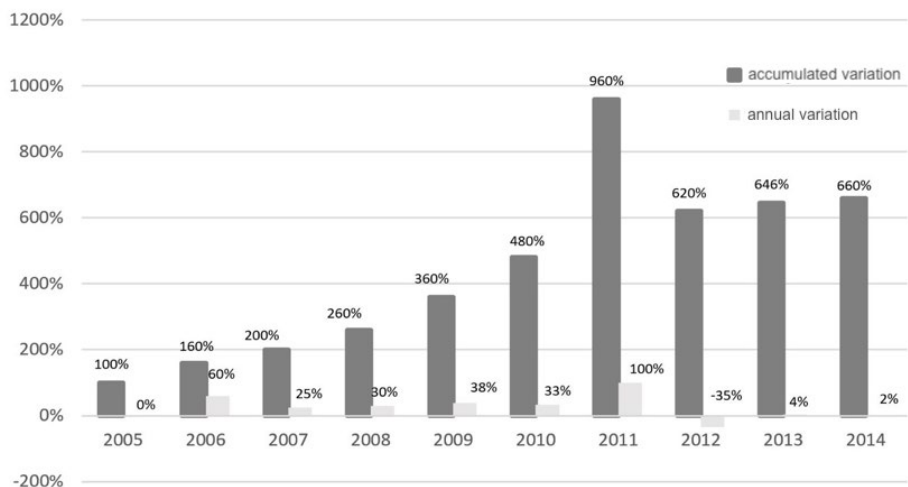


Figure 4. Evolution of the average number of hours of training per production employee. Source: Trintini (2016).

4.4.3 DPV

An important internal aspect of the company is the quality of its processes, which is directly influenced by the portfolio and investments in production, R&D and training. WVCO uses the DPV indicator, which is the ratio between the defects that are found during the production process and the production volume. In this case, the company permitted access to the data but did not authorize their disclosure. It was possible to observe instability during the period from 2005 to 2008, possibly because of the introduction of new products in the portfolio. As of 2008, the indicator dropped precipitously. For each 100 defects identified in 2005, only 21 were identified in 2012. Between 2009 and 2013, there were fluctuations with smaller amplitude. The indicator grew in 2013 and 2014 due to negative economies of scale with the reduced production and the selection of some new second- and third-tier suppliers (Trintini, 2016).

4.5 Analysis of performance

To answer the questions presented in the introduction, in this item we construct (and deconstruct) some arguments.

Initially, regarding the historical factors, the economic factors had impacts that were both positive (event E9) and negative (events E10 and E11). The environmental-legal factors brought demands for modernization (represented by technological factors), generally imposed by the government. On the other hand, the government was a major sponsor of the sector, with specific policies to increase demand (events P1-P5).

With respect to the VWTBMC's performance, the data show an increase of 1,100% in output and 600% in productive capacity between 1997 and 2011 (Chart 7). Production grew intensely since the plant in Resende started operating, allowing the affirmation that the MC arrangement had a positive influence on the growth of production, without which VWTB might have been unable to take advantage of the favorable market conditions.

To explain the growing production volume and diversity of the portfolio, Trintini (2016) mentioned the flexibility of the MC model, both with respect to volume and mix of products. The productive flexibility is influenced by the architecture of the product, so that the way to increase it is to expand the modularity (by investment in R&D and training). A modular architecture allows using a limited number of interchangeable modules to compose the entire portfolio of products. The variety of possible products requires flexibility in the mix, which can be obtained by machines with various possible setups and rapid changes in them. Another important factor for the flexibility of the mix is the workforce, with versatile operators able to perform different operations at a variety of work posts. The flexibility of volume is also achieved by adjusting the work shifts. From 2005 to 2011, for example, WVCO's portfolio increased by 24% and output rose by 111%, while the increases of investment and worker training were 91% and 860%, respectively. Furthermore, there was an increase of investment to develop new products of 365% in the period (Trintini, 2016).

It appears reasonable to argue that the product modularity enables flexibility of the mix, but for flexibility of volume, the data on profitability, ROS and inventory level do not fully confirm this argument. The establishment of a third work shift also is not a characteristic peculiar to the MC model to increase volume flexibility. Output can be expanded in any productive model by this strategy. On the other hand, even during the economic crisis of 2009, VWTB managed to increase its ROS by 103% despite the

lower sales and production, suggesting that the MC model made the company more resilient.

Regarding the argument that the MC is indeed a more efficient model than other productive arrangements, it would be necessary to conduct a comparative study with other productive models under similar market circumstances, a fairly complex task. Based on an assumption that the other companies in the sector continued using traditional models and that WVCO consolidated its leadership since 2004, it can be presumed that the MC model is more efficient, but this cannot be affirmed with total certainty. Therefore, the question does not have a clear and simple answer. It can also be argued that the MC allows greater modularity of the product and this can positively affect the portfolio (flexibility of the mix) and better meet the needs of customers.

Finally, regarding whether or not WVCO obtained advantages/positive results from adopting the MC, this question appears easier to answer positively, since the company became market leader and highly lucrative in the period. It can be argued that the rapid expansion of the product portfolio enabled the growth of the company's sales and revenues. Between 2005 and 2011 the revenues and sales volume grew by 258% and 85%, respectively. In this same period, net profit and ROS expanded by 1900% and 460%, respectively (Trintini, 2016).

In summary, according to the data presented in this article, it is possible to state there was a positive influence of the MC on various aspects of VWTB, such as:

- Expansion of productive capacity: the MC allowed growth of the volume produced, principally from the use of the experience of the modular suppliers (as argued by Pires & Cardoza, 2007; Trintini, 2016);
- Expansion of the product portfolio (between 2005 and 2014): The launch of new products was facilitated by the participation of the suppliers in the development of the functional modules, which were developed in parallel instead of sequence. This model enhances the modular characteristic of the trucks, by stimulating the use of the same modules in different models. Therefore, it can be stated that the MC streamlined the development and launch of new products, besides stimulating the modularization of the main functional systems (as argued by Pires & Cardoza, 2007; Trintini, 2016);
- Productive flexibility: In light of the variations in the product portfolio and production volumes, it can be argued that the MC promoted an increase in productive flexibility (via investments to develop new products and production, as well as in training workers), despite being a difficult characteristic to measure (as argued by Pires, 1998; Trintini, 2016).

Regarding the MPAM, the model is very suitable for analyses like the one proposed in this article, by allowing the collection and organization of a significant volume of data. In the case of VWTB, it was able to capture the ability to take advantage of opportunities to increase revenues and profits during cycles of economic expansion, and to withstand downturns through greater resilience. The model also captured the effects of the changing legislative and regulatory framework and technological changes in the sector. Therefore, it is possible to affirm that it is a complete analytic model, allowing associating the environmental and/or market conditions with the behavior of the company. Although it is possible in this case to identify direct influences of some variables on others, on the other hand the model does not make the analysis inflexible with static or permanent relationships.

5 Conclusions

The article analyzed the VWTBMC's performance during the 20 years of its existence. By examining the modular consortium, an innovative system that stands apart from the traditional Fordist conception of the production line, mainly regarding the relationship with suppliers, a series of questions emerged and were addressed in this article, through a multidimensional approach.

The article discussed the company's performance, which was very positive since it assumed and maintained leadership in the market, satisfying the objective of presenting a panorama of the 20-year history of the modular consortium. However, it cannot be stated that the MC is more efficient than other production models. This would require a comparative study with other models and identification of specific parameters for such comparison. Nevertheless, it can be stated that VWTB obtained advantages from adopting the model.

The assumption that the MC is a more efficient configuration from the standpoint of productive flexibility, allowing better reaction to market variations, cannot be confirmed entirely, but there are indications of a positive relationship between the MC and the company's performance (variation of output and flexibility of the product portfolio).

As limitations of this study, we can mention the absence of data on finance, sales volume and quality in the period from 1996 to 2005 and of effective measures of profitability and return on investment (which would allow clearer findings on the success of the model). Limitations of the model are the large volume of data necessary and lack of a reflection of the influence between the variables.

Regarding the discussion of productive flexibility (of mix and volume), a specific statistical analysis would be necessary involving the VWTBMC and another similar plant using a traditional production model. This limitation points the way to various opportunities for future research, such as expansion of the period by including more recent years and the application of the MPAM to analyze similar companies and firms in different niches and/or that have different productive models. This would allow validating the model and realization of comparisons.

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