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Research Article

# An empirical analysis of inventory performance in Brazil commerce sector: 1996-2021

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## Abstract

**Paper aims:** This study investigates inventory performance in Brazil's commerce sector (retail, wholesale, and automotive) from 1996 to 2021. It examines how internal and macroeconomic factors influence inventory turnover, a key operational efficiency metric.

**Originality:** Using Annual Commerce Survey data by the Brazilian Institute of Geography and Statistics, this research offers a comprehensive analysis. A quasi-experimental approach explores a 2009 tax change, revealing how factors influence inventory performance in developing economies.

**Research method:** The study applies panel data econometrics with fixed and random effects models. Robustness checks include substituting inventory turnover with inventory days. A Difference-in-Differences approach is used to assess the tax reform's impact on inventory turnover in the retail sector.

**Main findings:** During the period under analysis, the data reveals a general decline in inventory performance. Retail firms are primarily influenced by factors such as profit margins, GDP growth, and both consumer and industrial confidence, whereas wholesale firms exhibit greater sensitivity to interest rates and wage levels. Capital intensity plays a affected inventory performance across all sectors. Surprise had no significant effect on inventory performance, challenging previous research.

**Implications for theory and practice:** Findings emphasize sector-specific inventory management strategies. Macroeconomic factors impact sectors differently, suggesting that tailored strategies are essential for improving operational efficiency and policy development in emerging markets.

## Keywords

Inventory. Retail. Wholesale. Econometrics.

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The author has no conflict of interest to declare

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This study did not involve any human participants or personal data. All data used in the research were obtained from publicly available sources. As such, ethical approval and informed consent were not required

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## 1. Introduction

Inventories constitute a significant portion of both current and total assets in most firms, presenting considerable management challenges. Effective inventory management necessitates the integration of purchasing, financing, and sales strategies, which frequently conflict. For example, financial managers often prioritize minimizing inventory levels to reduce holding costs, whereas marketing managers aim to mitigate the risk of stockouts to prevent lost sales. Central to inventory management is the optimization of inventory levels to balance the costs associated with overstocking—such as storage, insurance, and potential obsolescence—and the risks of understocking, including unmet demand and lost revenue. Excess inventory also immobilizes capital that could be allocated to other investments. Efficient inventory management is crucial for both retailers and wholesalers (Marzolf et al., 2024).

Operations management literature defines inventory as an outcome of mismatched production and consumption rates, categorizing it into types like Anticipation Inventory, Pipeline Inventory, Cycle Inventory, and Safety Stock (Slack et al., 2013). While Lean philosophy views inventory as a necessary evil to minimize, for retailers and wholesalers, it is essential for operational efficiency.The role of inventories has been extensively analyzed in the literature. Kahn (1987) suggests that variations in production and inventory often exceed demand fluctuations, reflecting optimal firm behavior. Firms maintain inventories not only to stabilize production but also to mitigate the substantial costs associated with stockouts (Kahn, 1992). Changes in inventory management practices can account for nearly half of the overall reduction in GDP volatility, with improved inventory management loosely linked to reduced industry-level volatility (Irvine & Schuh, 2005). However, Khan & Thomas (2007) argue that while there is a positive correlation between sales and inventory investment, inventory accumulation has a minimal impact on GDP cyclical variability.

Firms facing higher demand uncertainty, longer lead times, and broader profit margins are inclined to hold larger inventories (Rumyantsev & Netessine, 2007). Thomas & Zhang (2002) argue that demand shifts influence both profitability fluctuations and inventory adjustments, though the effects on profitability may be masked by earnings management practices, such as misreporting inventory levels. Retailers with high inventory turnover exhibit greater flexibility in adjusting purchase quantities in response to demand shocks, while those with low turnover primarily adjust prices (Kesavan et al., 2016). Additionally, factors such as gross margin, liquidity, inventory management skills, and resource availability are crucial for inventory agility (Udenio et al., 2018).

Shah & Shin (2007) argue that the increasing product variety driven by diverse consumer preferences contributes to higher inventory levels in wholesale and retail sectors. Conversely, manufacturers serving more concentrated customer bases often manage inventories more efficiently, reducing excess accumulation (Ak & Patatoukas, 2016). Additionally, inventory fluctuations in one store can affect the sales performance of other stores (Koschat, 2008).

Evidence suggests a correlation between inventory turnover and financial performance variables such as gross margin, capital intensity, and sales surprise (Gaur et al., 2005). Nonetheless, some studies report a weak or negligible relationship between inventory performance and overall financial performance (Cannon, 2008). Inventory turnover inversely correlates with the mean absolute percentage error in quarterly sales forecasts (Hançerlioğulları et al., 2016). Despite the potential utility of historical inventory data and gross margin information for sales forecasting, equity analysts often underutilize these resources (Kesavan et al., 2010). Furthermore, within-year inventory volatility and abnormal year-over-year growth are linked to abnormal stock returns (Steinker & Hoberg, 2013), and for U.S. retail firms, inventory productivity is a strong predictor of future stock performance (Alan et al., 2014).

Supply chain disruptions and their inventory-related consequences can negatively affect shareholder value (Hendricks & Singhal, 2003) and operating performance (Hendricks & Singhal, 2005). Market reactions to excess inventory announcements are generally milder for larger firms (Hendricks & Singhal, 2009). Eroglu & Hofer (2011) found a concave relationship between inventory levels and firm performance, indicating an optimal inventory threshold beyond which performance declines. Similarly, Kesavan & Mani (2013) identified an inverted-U relationship between abnormal inventory growth and one-year-ahead earnings per share for retailers. However, Isaksson & Seifert (2014) did not find evidence of an inverted U-shaped relationship for publicly traded U.S. firms between 1980 and 2008. Barker et al. (2022) suggest that supplier inventory leanness impacts focal firm financial performance indirectly through its interaction with the firm's own inventory leanness.

Several studies have analyzed inventory dynamics across various countries. Rajagopalan & Malhotra (2001) examined trends in materials, work-in-process, and finished-goods inventory ratios from 1961 to 1994 across 20 manufacturing sectors and the total U.S. manufacturing sector, identifying a consistent decline in inventory ratios over this period. Chen et al. (2005, 2007) reported a decrease in U.S. inventory days from 73 to 49 between

1981 and 2004. Their findings indicated that firms with abnormally high inventory levels tend to experience poor long-term stock returns, whereas firms with slightly below-average inventories enjoy better returns, and those with the lowest inventory levels yield average returns. Kolias et al. (2011) found that, for Greek retail firms during 2000–2005, there was a negative correlation between inventory turnover and gross margin, a positive correlation with capital intensity, and a positive correlation with sales surprise.

Several financial indicators are essential for evaluating inventory performance, including inventory days and inventory turnover. These metrics are crucial for comparing inventory management efficiency across firms. Inventory days, calculated by dividing inventory by the daily average cost of goods sold (COGS), reflects the number of days a company holds inventory before selling it. Conversely, inventory turnover measures how frequently inventory cycles through a period. These indicators are inversely related: high inventory turnover corresponds to low inventory days, and vice versa. For instance, Gaur et al. (2005) developed a methodology to analyze inventory turnover in the U.S. retail sector, incorporating variables such as gross margin, capital intensity, and sales-related factors. This approach has been adapted by Kolias et al. (2011) in Greece and Shan & Zhu (2013) in China. Marzolf et al. (2024) categorize existing research based on sector-specific focus and the use of internal versus external variables.

This study examines the determinants of inventory performance in the Brazilian commerce sector, using data from the Annual Commerce Survey by the Brazilian Institute of Geography and Statistics (IBGE) covering 1996 to 2021 (Instituto Brasileiro de Geografia e Estatística, 2024). It builds on the econometric framework established by Gaur et al. (2005) by integrating macroeconomic variables and assessing the impact of government intervention following the 2008 financial crisis. Specifically, the intervention affecting household appliances provides a quasi-experimental setting to evaluate how sales surprises influence inventory performance. To ensure robustness, the study tested results by replacing the primary variable of interest from inventory turnover to inventory days, to confirm the reliability and generalizability of the findings.

The results of the econometric analysis confirm the findings of previous studies regarding the importance of gross margin and capital intensity. However, the sales surprise was not relevant in the Brazilian data. Additionally, we explore the significance of macroeconomic variables such as interest rates, inflation, consumer confidence, and business confidence on inventory days. The robustness test showed that some variables ceased to be significant when changing from inventory turnover to inventory days. Furthermore, we observed a decrease in inventory turnover across the entire period.

The remainder of this paper is organized as follows. Section 2 explains the dataset and provides descriptive statistics. Section 3 specifies the econometric model, and Section 4 contains the main findings. Section 5 discusses the implications of our results for operating and financial strategies, as well as the limitations of our study.

## 2. Data description - definition of variables

The information presented in this study was obtained from the Annual Commerce Survey (Pesquisa Anual de Comércio - PAC), conducted by the Brazilian National Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística, 2024). This survey began in 1988 and encompasses all companies engaged in any type of trade throughout Brazil with more than 20 employees. While the classification of companies underwent changes initially, the same pattern has been followed since 1996. Consequently, the data for this study covers the period from 1996 to 2021. Despite all information provided about these companies, data pertaining to the Cost of Goods Sold (COGS) is not available in the survey. However, information regarding Sales and Gross Margin is available, enabling the calculation of COGS using the following formula:

$$Sales - COGS = Gross\ Margin \tag{1}$$

COGS is calculated by rearranging the formula as follows:

$$COGS = Sales - Gross\ Margin \tag{2}$$

This information can then be used to determine Inventory Days and Inventory Turnover, which can be calculated using the following formulas:

$$Inventory\ Days = \frac{Inventory}{\left(\frac{COGS}{365}\right)} \tag{3}$$

$$Inventory\,Turnover = \frac{COGS}{Average\,Inventory} \quad (4)$$

where

$$Average\,Inventory_t = \frac{Inventory_t + Inventory_{t-1}}{2} \quad (5)$$

Table 1 presents a summary of PAC survey.

**Table 1.** Summary data of PAC survey.

| Companies: Average number of companies from 1996 to 2021. Employees: Average number of employees per company. Inventory days: Minimum, Mean and Maximum values during the 1996 to 2021 period. Gross Margin: Average Gross Margin from 1996 to 2021 (presented in %) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sector | Subsector | Average number of Companies | Average number of Employees | Inventory days | | | Gross Margin (%) |
| | | | | Min | Mean | Max | |
| Vehicles, parts and motorcycles | Total | 5184 | 65 | 39.1 | 53.2 | 71 | 16.7 |
| | Auto-vehicles | 1978 | 92 | 29.4 | 42.4 | 52.7 | 12.5 |
| | Vehicle parts | 2147 | 48 | 83.4 | 115.3 | 145.6 | 33.1 |
| | Motorcycles, parts and accessories | 476 | 53 | 33.5 | 57.1 | 87 | 25.8 |
| Wholesale | Total | 10562 | 75 | 44.9 | 51.5 | 59.4 | 20 |
| | In natura agricultural products and food products for animals | 431 | 130 | 33.3 | 58.1 | 74.1 | 14.3 |
| | Food products, beverages and tobacco | 3047 | 70 | 43.2 | 58 | 92.5 | 21.7 |
| | Personal and household items | 2278 | 70 | 68.5 | 91.6 | 112.3 | 42.6 |
| | Intermediate products, waste and scrap | 2579 | 61 | 20.7 | 28.5 | 41.3 | 13.3 |
| | Machinery and equipment for agricultural, commercial, industrial and professional purposes | 1223 | 60 | 75.5 | 110.4 | 149.7 | 34 |
| | General merchandise | 743 | 155 | 52.4 | 59.5 | 77.5 | 17.2 |
| | Sale of information and communication technology equipment and products | 314 | 91 | 43.5 | 52.6 | 60.9 | 22.7 |
| Retail | Total | 27581 | 81 | 62.6 | 77.7 | 94.7 | 31.8 |
| | Non-specialized trade | 6090 | 160 | 44 | 55.2 | 67.2 | 26.2 |
| | Food products, beverages and tobacco | 3012 | 35 | 39.1 | 63 | 97.4 | 46.1 |
| | Fabrics, clothing and footwear | 4619 | 66 | 170 | 207 | 342 | 71.2 |
| | Fuels and lubricants | 3214 | 37 | 12.4 | 14.8 | 23.1 | 16.6 |
| | Sale of other products in specialized stores | 11217 | 64 | 107 | 119 | 140 | 43 |
| | Used goods trade | 11 | 27 | 65.2 | 496 | 2979 | 165 |

**Source:** Author based on PAC data.

In addition to the data derived from the PAC survey, several macroeconomic variables relevant to inventory decisions will be considered. These variables include the Brazilian risk-free interest rate (Selic rate) established by the Central Bank of Brazil, the official inflation rate (IPCA index) disclosed by the IBGE, the Economic Uncertainty Indicator (Indicador de Incerteza da Economia – IIE) measured by the Getúlio Vargas Foundation (FGV), the Industrial Business Confidence Index (Índice de Confiança do Empresário Industrial – ICEI) measured by the FGV, and the annual variation of Brazil's GDP for both the current and previous years.

Gaur et al. (2005) analyzed inventory performance using Gross Margin, Capital Intensity, and Sales Surprise, along with fixed effects for firms and years. This approach was similarly adopted by Kolias et al. (2011) and Shan & Zhu (2013). Gaur et al. (2005) suggested that capital intensity, reflecting technology investment, enhances inventory turnover. In this study, sales efficiency will be measured as FTE/Sales, where higher technology reduces the number of employees needed per unit of sales.

Rumyantsev & Netessine (2007) integrate lead time with the cash conversion cycle and interest rates (TBill rate). In the 1970s, inflation, driven by oil shocks, led researchers to include interest rates and inflation in inventory studies (Bechter & Pollock, 1980; Blinder et al., 1981; Pearce & Wisley, 1983). Recent studies have largely excluded these factors, possibly due to reduced relevance in developed countries like the U.S. (Larson & Sijbrands, 1991). However, in developing countries such as Brazil, inflation and interest rates remain critical issues.

This study employs the Consumer Confidence Index and the Industrial Business Confidence Index to measure sales expectations, following the methodologies of Bechter & Pollock (1980) and Blinder et al. (1981). The Consumer Confidence Index reflects anticipated downstream sales for commercial enterprises, while the Industrial

Business Confidence Index indicates upstream pressure by showing industries' intent to increase production, potentially leading to higher inventory levels. Additionally, the study incorporates GDP growth for the current and previous years as backward-looking indicators of sales growth and inventory planning.

The variables utilized in this study are detailed in Table 2.

**Table 2.** Variables.

| Variable | Description | Source |
|---|---|---|
| Sector | A specific part of the economy that includes businesses and organizations with related products or services | PAC Survey |
| Inventory Turnover | A financial ratio that measures how many times a company's inventory is sold and replaced over a period, indicating the efficiency of inventory management. | PAC Survey |
| Number of Companies | The total count of distinct business entities operating within a specified sector or market. | PAC Survey |
| Margin | The difference between the cost of producing a product and its selling price, often expressed as a percentage, reflecting profitability. | PAC Survey |
| Average Salary | The mean compensation received by employees in a specific sector, region, or occupation, often used to gauge income levels and labor market conditions. | PAC Survey |
| FTE/Sales | A ratio indicating the number of full-time equivalent employees (FTE) relative to a company's sales, used to assess workforce efficiency. | PAC Survey |
| Consumer Price Index (IPCA) | An index measuring the average change in prices over time that consumers pay for a basket of goods and services, indicating inflation. | IBGE |
| Interest Rate (Selic) | The Brazilian Central Bank's benchmark interest rate used to control inflation and influence economic activity | Central Bank |
| GDP Growth Previous Year | The percentage change in the Gross Domestic Product (GDP) of a country from one year to the next, reflecting economic performance in the prior year. | IBGE |
| GDP Growth Current Year | The percentage change in GDP expected or recorded in the ongoing year, used to measure current economic expansion or contraction. | IBGE |
| ICC | The Consumer Confidence Index from Fundação Getulio Vargas, which measures consumer sentiment regarding the economic situation and their financial outlook. | FGV |
| ICEI | The Industrial Entrepreneur Confidence Index from Fundação Getulio Vargas, which gauges the confidence levels of industrial sector entrepreneurs about the economy and their business prospects. | FGV |

**Source:** Author.

Gaur et al. (2005) define Sales Surprise as the gap between actual sales and forecasts based on historical sales data. This study will use an exogenous shock from tax changes on specific product categories instead. Additionally, Gaur et al. (2014) include sales growth as a variable, while Hançerlioğulları et al. (2016) incorporate the mean absolute percentage error (MAPE) of quarterly forecasts.

From 1996 to 2021, Brazil experienced several significant economic events, encompassing periods of crises, high growth, and recessions. These events provide a diverse context to analyze inventory behavior across various retail and wholesale companies. Following a period of hyperinflation that persisted until 1994, the Real Plan successfully stabilized the currency. Nevertheless, subsequent economic disruptions, such as the Asian financial crisis in 1997, the devaluation of the Real in 1999, the subprime mortgage crisis in 2008, the economic downturn in 2014, and the COVID-19 pandemic in 2020, significantly impacted the Brazilian economy. In this study, sales surprise will be operationalized through the exogenous shock induced by a legislative change in 2009. This shock will be analyzed using an econometric strategy to evaluate its impact on the sector. Examples in the literature of utilizing exogenous shocks in inventory studies include Jola-Sanchez & Serpa (2021), who analyzed inventory management in Colombian companies using attacks by the FARC and ELN groups, and Kesavan & Kushwaha (2014), who employed macroeconomic shocks to assess their impacts on inventories.

## 3. Econometric analysis

Inventory turnover can be explained by various factors including sector, margin, interest rate, inflation rate, economic uncertainty, business confidence and GDP growth. Given the availability of these variables across the entire study period, regression analysis on panel data provides an avenue to assess potential correlations between these variables and inventory days.

Furthermore, in 2009, the Brazilian government implemented tax changes on white goods aimed at boosting sales and preserving jobs within this sector. Consequently, sales volume of these goods surged by 21% in the same year. The reduction in IPI (Tax on Industrialized Products) for white goods not only bolstered sales within

this category but also had a positive spillover effect on other segments, such as small household appliances, witnessing a 2% uptick in sales due to increased foot traffic in stores (Magalhães, 2010).

The occurrence of this exogenous shock within a specific sector over a defined timeframe presents a unique opportunity to conceptualize the event as a natural experiment. This framework allows for an examination of the differential responses in inventory turnover between retailers and wholesalers within the affected sector, particularly in the context of an unexpected sales shock. To rigorously analyze the impact of this policy change, the Difference-in-Differences (DiD) methodology will be employed. Retailers specializing in white goods will constitute the treatment group, while other retailers will serve as the control group. This approach ensures a robust identification strategy for isolating the causal effect of the policy intervention.

The full panel data model to be estimated, using all variables, is specified as follows:

$$\begin{aligned}\log\left(\text{Inventory Turnover}_{it}\right) &= \alpha_i + \beta_1 \text{Number of companies}_{it} + \beta_2 \log\left(\text{Margin}_{it}\right) + \beta_3 \text{IPCA}_t \setminus \\ &+ \beta_4 \text{ICC}_t + \beta_5 \text{ICEI}_t + \beta_6 \text{GDP Growth\_1}_t + \beta_7 \text{GDP Growth}_t + \beta_8 \text{Selic}_t + \beta_9 \log\left(\text{Average Salary}_{it}\right) \\ &+ \beta_{10} \log\left(\text{FTE\_Sales}_{it}\right) + \epsilon_{it}\end{aligned} \tag{6}$$

where:

• log(Inventory Turnover*it*): The natural logarithm of the dependent variable Inventory Turnover for entity *i* at time *t*.

• αi: The entity-specific fixed effect for entity *i*. This captures unobserved heterogeneity that is constant over time for each entity.

• β1,β2,...,β10: Coefficients for the independent variables.

• ϵit: The error term for entity *i* at time *t*.

It is important to note that this specification employs a fixed-effects model, wherein entity-specific intercepts (αi) are included to account for unobserved heterogeneity that is constant over time. These intercepts are eliminated during the estimation process, as detailed by Baltagi & Baltagi (2008).

Alternatively, a random-effects model will also be tested, wherein the entity-specific intercepts (αi) are replaced by a single common intercept ( $\beta_0$ ) across all entities. The choice between fixed-effects and random-effects models will be determined using the Hausman test (Baltagi & Baltagi, 2008), which evaluates the consistency and efficiency of the estimators under each specification.

Following the estimation of the full model, an optimized model will be derived by selecting the best combination of predictors. This selection will be guided by the Akaike Information Criterion (AIC), which balances model fit and complexity. The optimized model will thus represent the most parsimonious and statistically robust specification.

Finally, for the retail segment, the exogenous impact of the legislative change will be further investigated by incorporating treatment variables into the full model. This additional analysis will provide insights into the differential effects of the policy intervention on inventory turnover within the retail sector.

The analysis was conducted using the R language (R Core Team, 2023) along with the plm package (Croissant & Millo, 2025) for panel data estimation.

## 4. Results

The evolution of stock turnover in Brazilian commerce companies during the analyzed period is depicted in Figure 1.

In 1999, Brazil experienced a currency crisis. However, until the subprime crisis of 2008, the Brazilian economy performed well, and inventory turnover reached its peak during this period. Since then, inventory turnover has shown a downward trend. Inventory turnover demonstrates greater stability in retail firms, greater sensitivity to economic fluctuations in the automotive sector, and a more pronounced volatility in wholesale companies.

A panel data regression for each of the three commerce segments is conducted to analyze the relationship between inventory turnover and all available variables, The results are presented in Table 3. The Hausman test indicated the fixed effects model was the most suitable for Retail and Auto. The same test indicated that random effects model was the most suitable for Wholesale. Additionally, since the residuals showed autocorrelation (Bresch-Godfrey/Wooldridge test) and heteroscedasticity (Breusch-Pagan), robust standard errors were calculated using the Newey-West model.

Margin and inflation are negatively correlated with inventory turnover for both retail and wholesale companies. However, in the optimized model for wholesale companies, margin was excluded. In contrast, interest rates show a positive correlation with inventory turnover for these sectors.

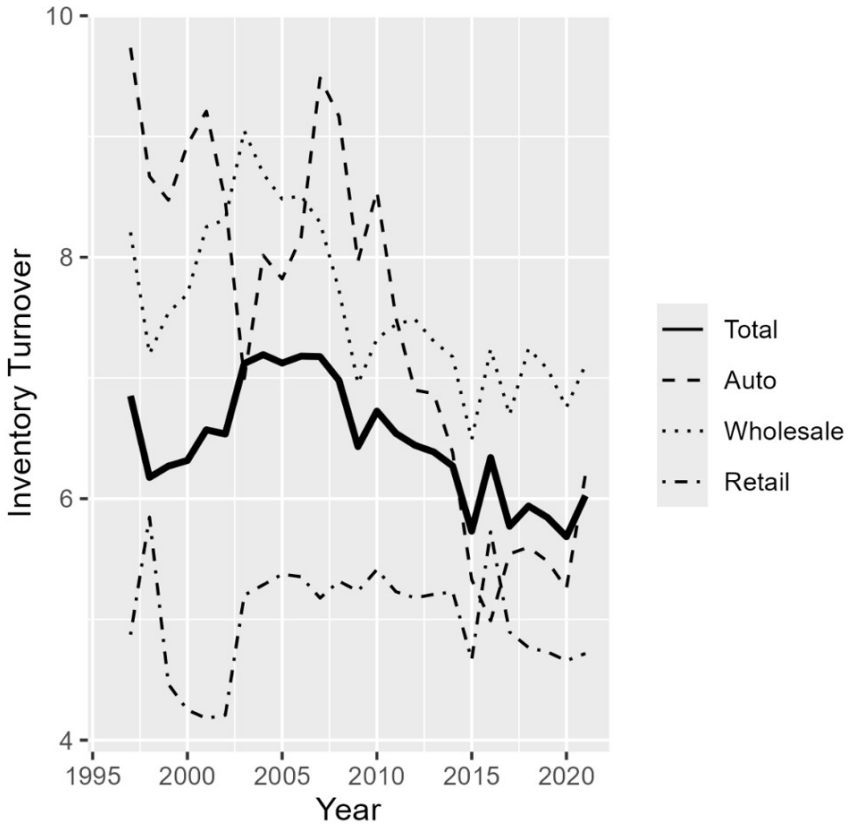


**Figure 1.** Inventory turnover in Brazilian commerce. Source: Author based on PAC – IBGE (Instituto Brasileiro de Geografia e Estatística, 2024).

The Consumer Confidence Index is positively correlated with inventory turnover for retail companies, but negatively correlated for auto companies. Similarly, the Industrial Owners Confidence Index has a negative correlation with inventory turnover for retail companies.

GDP growth is positively correlated with inventory turnover for auto companies, but negatively correlated for retail companies, though this relationship is observed only in the full model. Average salaries are negatively correlated with inventory turnover in both wholesale and auto companies. Additionally, the ratio of full-time employees to sales (FTE/Sales) is negatively correlated with inventory turnover across all sectors.

The final column of the table introduces a model incorporating two additional variables to assess impact using a Difference-in-Differences (DiD) approach. This is achieved by adding a dummy variable, "Law," to indicate the period affected by the tax rate change. In 2009, the government altered the tax rate on industrialized white goods, such as refrigerators and freezers. This exogenous shock serves as a quasi-experiment on sales deviations for select retail companies. The impacted sectors—"Non-specialized trade," "Food products, beverages, and tobacco," and "Sale of other products in specialized stores"—are marked during the period of the law change with a dummy variable called "DiD." By treating these companies as the "treated" group and other retail companies as the "control" group, the DiD model evaluates the impact of this quasi-experiment.

The sales surprise itself also has no impact on inventory turnover. This result holds even when changing the companies impacted by the change in the law.

These outcomes prompt an inquiry into the adaptability of retail companies, particularly small and medium-sized enterprises (SMEs) that are the focus of this study, in responding to unexpected fluctuations in sales. The lack of observed impact from both GDP growth and sales surprises on inventory turnover suggests that these firms may possess limited flexibility in adjusting their inventory management practices to accommodate unforeseen sales variations.

Regarding the sample size used for model estimation, while a common empirical rule suggests at least 10 observations per variable in regression models—potentially raising concerns for the auto sector—this issue is mitigated by selecting a reduced-variable model that aligns closely with the full model in terms of results.

**Table 3.** Panel Data Regression with Dependent Variable: Log (Inventory Turnover).

| | Dependent Variable: Log (Inventory Turnover) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Auto | | Wholesale | | Retail | | |
| | Full | Optmized | Full | Optimized | Full | Optimized | Experiment (DiD) |
| Number of Companies | -0.0001<br>(0.0001) | | 0.0001<br>(0.0001) | 0.0002**<br>(0.0001) | -0.0001***<br>(0.000004) | -0.0001**<br>(0.00003) | -0.0001***<br>(0.000004) |
| Log(Margin) | 0.347<br>(0.242) | | -0.078***<br>(0.032) | | -0.596***<br>(0.155) | -0.600***<br>(0.144) | -0.596***<br>(0.155) |
| Inflation | 0.074<br>(0.964) | | -1.191*<br>(0.679) | -1.410**<br>(0.697) | -1.981*<br>(1.082) | -1.774*<br>(1.075) | -1.977*<br>(1.088) |
| Consumer Confidence Index | -0.002*<br>(0.001) | -0.002**<br>(0.001) | 0.001<br>(0.001) | | 0.004***<br>(0.001) | 0.003***<br>(0.001) | 0.004***<br>(0.001) |
| Industrial Owners Confidence Index | 0.001<br>(0.004) | | 0.003<br>(0.003) | 0.001<br>(0.002) | -0.009**<br>(0.004) | -0.006***<br>(0.002) | -0.009**<br>(0.004) |
| GDP Growth Last Year | 0.005<br>(0.005) | | 0.007<br>(0.005) | 0.005<br>(0.004) | -0.011<br>(0.008) | | -0.010<br>(0.008) |
| GDP Growth Current Year | 0.015**<br>(0.004) | 0.016***<br>(0.005) | -0.0004<br>(0.0004) | | -0.008*<br>(0.005) | | -0.008<br>(0.006) |
| Interest Rate | -0.002<br>(0.005) | | 0.024**<br>(0.006) | 0.020***<br>(0.006) | 0.012*<br>(0.006) | 0.014**<br>(0.005) | 0.012*<br>(0.006) |
| Log(Average Salaries) | -0.979***<br>(0.103) | -0.927***<br>(0.090) | -0.404**<br>(0.083) | -0.531***<br>(0.102) | -0.119<br>(0.162) | | -0.118<br>(0.161) |
| Log(FTE/Sales) | -0.791***<br>(0.101) | -0.779***<br>(0.103) | -0.501**<br>(0.079) | -0.559***<br>(0.096) | -0.304**<br>(0.126) | -0.261***<br>(0.050) | -0.303**<br>(0.126) |
| Constant | | | 0.892*<br>(0.499) | | | | |
| Law | | | | | | | -0.002<br>(0.065) |
| DiD | | | | | | | -0.052<br>(0.073) |
| Number of Observations R2<br>(Coefficient of Determination)<br>Adjusted R2: F Statistic | 69 0.849<br>0.817<br>31.463*** | 69 0.838<br>0.822<br>80.127*** | 409 0.364<br>0.348<br>223.275*** | 409 0.310<br>0.261<br>24.410*** | 391 0.338<br>0.290<br>18.552*** | 391 0.332<br>0.290<br>26.030*** | 391 0.338<br>0.287<br>15.384*** |

**Note:** Auto and Retail: Fixed Effects; Wholesale: Random Effects. Full Model: Includes all variables; Optimized Model: Selected based on the best Akaike Information Criterion (AIC). Experiment (DiD): Full model with two additional variables to test the exogenous shock of the 2009 law change promoting white goods in certain retail segments. Standard Errors: Heteroscedasticity-robust standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.
**Source:** Own analysis.

Concerning potential multicollinearity, Variance Inflation Factor (VIF) calculations were conducted, confirming that no model exhibited significant multicollinearity issues. This ensures the robustness of the estimated coefficients and the reliability of the findings. Also, fixed effects models, used in auto and retail, includes individual-specific intercepts (the constant parameter). These intercepts are not shown explicitly because they are *differenced out* during the estimation process. Therefore, only Random effects model, used in Wholesale, presents the constant parameter.

## 4.1. Robustness checks

Gaur et al. (2005) and Kolias et al. (2011) employed inventory turnover as the dependent variable in their analyses, while Chen et al. (2007) utilized Inventory Days as their dependent variable. To assess the robustness of the findings, this study conducted robustness tests by estimating the models with Inventory Days as the dependent variable in place of Inventory Turnover. Given the inverse relationship between these two variables—where an increase in Inventory Days corresponds to a decrease in Inventory Turnover, and vice versa—it is anticipated that the results will mirror those obtained with Inventory Turnover, albeit with reversed signs.

The results, presented in Table 4, remained similar with minor fluctuations in the parameters.

Margin is positively correlated with inventory days for both retail and wholesale companies, However, in the optimized model for wholesale, margin is excluded. Inflation no longer affects inventory days for retail companies, and similarly, it is not selected in the optimized wholesale model. Interest rates are positively correlated with inventory days for auto companies but negatively correlated for wholesale companies.

Table 4. Panel Data Regression with Dependent Variable: Log (Inventory Days).

| | Dependent Variable: Log (Inventory Days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Auto | | Wholesale | | Retail | | |
| | Full | Optimized | Full | Optimized | Full | Optimized | DiD |
| Number of Companies | 0.0001<br>(0.0001) | 0.0001*<br>(0.0001) | -0.0001<br>(0.0001) | -0.0002**<br>(0.0001) | 0.0001***<br>(0.000004) | 0.0001**<br>(0.00004) | 0.0001***<br>(0.000004) |
| Log(Margin) | -0.298<br>(0.282) | -0.312<br>(0.260) | 0.103***<br>(0.019) | | 0.425***<br>(0.155) | 0.430***<br>(0.157) | 0.424***<br>(0.155) |
| Inflation | -0.210<br>(0.939) | | 1.433*<br>(0.666) | 1.171<br>(0.722) | 1.616<br>(1.201) | 1.347<br>(1.002) | 1.633<br>(1.201) |
| Consumer Confidence Index | 0.001<br>(0.001) | 0.001*<br>(0.001) | -0.001<br>(0.001) | | -0.004***<br>(0.001) | -0.004***<br>(0.001) | -0.004***<br>(0.001) |
| Industrial Owners Confidence Index | 0.002<br>(0.004) | | 0.002<br>(0.003) | | 0.013***<br>(0.003) | 0.014***<br>(0.004) | 0.014***<br>(0.004) |
| GDP Growth Last Year | 0.004<br>(0.007) | | -0.004<br>(0.005) | -0.005<br>(0.004) | 0.016*<br>(0.009) | 0.018**<br>(0.008) | 0.016*<br>(0.009) |
| GDP Growth Current Year | -0.002<br>(0.005) | | 0.006<br>(0.004) | | 0.013**<br>(0.005) | 0.012**<br>(0.005) | 0.011*<br>(0.006) |
| Interest Rate | 0.014*<br>(0.008) | 0.010*<br>(0.005) | -0.016**<br>(0.006) | -0.016***<br>(0.005) | -0.005<br>(0.008) | | -0.004<br>(0.008) |
| Log(Average Salaries) | 0.977***<br>(0.134) | 0.938***<br>(0.135) | 0.413***<br>(0.087) | 0.374**<br>(0.148) | 0.206<br>(0.172) | 0.234<br>(0.158) | 0.202<br>(0.171) |
| Log(FTE/Sales) | 0.674***<br>(0.092) | 0.674***<br>(0.099) | 0.446**<br>(0.081) | 0.387***<br>(0.135) | 0.310**<br>(0.118) | 0.298**<br>(0.124) | 0.307***<br>(0.118) |
| Constant | | | 4.354***<br>(0.542) | | | | |
| Law | | | | | | | -0.056<br>(0.062) |
| DiD | | | | | | | 0.087<br>(0.071) |
| Observations R2 (Coefficient of Determination) Adjusted R2: F Statistic | 69 0.745<br>0.690<br>16.348*** (df =10; 56) | 69<br>0.7420.708<br>28.825*** | 413 0.442<br>0.430<br>206.517*** | 413 0.172<br>0.116<br>13.381*** | 391 0.276<br>0.224<br>13.863*** | 391 0.275<br>0.225<br>15.377*** | 391 0.277<br>0.221<br>11.546*** |

**Note:** Auto and Retail: Fixed Effects; Wholesale: Random Effects. Full Model: Includes all variables; Optimized Model: Selected based on the best Akaike Information Criterion (AIC). Experiment (DiD): Full model with two additional variables to test the exogenous shock of the 2009 law change promoting white goods in certain retail segments. Standard Errors: Heteroscedasticity-robust standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.
**Source:** Own analysis.

The Consumer Confidence Index is negatively correlated with inventory days for retail companies and shows little correlation for auto companies. In contrast, the Industrial Owners Confidence Index is positively correlated with inventory days for retail companies.

Both current and previous year GDP growth show a positive correlation with inventory days for retail companies. Similarly, average salaries are positively correlated with inventory days in both wholesale and auto companies. Additionally, the ratio of full-time employees to sales (FTE/Sales) is positively correlated with inventory days across all sectors.

The variables that remained significant within the same segments, even after changing the dependent variable to inventory days, are the Industrial Owners Confidence Index, Average Salaries, and FTE to Sales.

Including the exogenous shock as sales surprise in the model, with inventory days as the dependent variable, presented in the last column, has no impact on inventory days.

## 5. Discussion

This paper focuses on studying the inventory turnover behavior of commerce companies in Brazil from 1996 to 2022 and identifying the variables that explain this behavior. The variables considered include both sector-specific factors and macroeconomic variables impacting all companies.

For the sector-specific factors, margin showed a relationship with inventory turnover in the Retail and Wholesale segments but not in the Auto sector. These findings are consistent with prior research. The FTE/Sales ratio, which serves as a proxy for technological infrastructure (replacing Capital Intensity in previous studies), has a direct and statistically significant relationship with both Inventory Turnover and Stock Days for

all segments. Improved technological infrastructure likely enhances inventory control, directly impacting the inventory management indicators analyzed in this study, corroborating previous findings. Salaries, serving as a proxy for cost control, had a significant relationship with inventory management for the Wholesale and Auto segments, but not for the Retail segment.

Recent literature, building upon the findings of Gaur et al. (2005), demonstrates a negative correlation between inventory turnover and Gross Margin, alongside a positive correlation with Capital Intensity and Sales Surprise. Comparable results are reported in studies by Kolias et al. (2011) in Greece, and Shan & Zhu (2013) in China. In the present study, Sales Surprise is operationalized as a macroeconomic variable, specifically represented by the legislative change in 2009 affecting taxes on white goods, which led to increased sales of these products for certain retailers. This exogenous shock constitutes a quasi-experiment, facilitating an evaluation of the causal relationship between Sales Surprise and inventory management.

Contrary to previous research, the Sales Surprise variable showed no discernible impact on the inventory metrics of the sectors examined. This result diverges from earlier studies and prompts an investigation into whether Brazilian retail companies exhibit sufficient flexibility to effectively adapt to unexpected sales fluctuations.

Regarding the other macroeconomic variables, inflation had a negative relationship with Inventory Turnover (and a positive relationship with Inventory Days) for the Retail and Wholesale segments, indicating a potential impact of rising prices on consumer purchases. The interest rate showed a positive relationship with Inventory Turnover (and a negative relationship with Stock Days) only for the Wholesale segment, suggesting that wholesalers may be more sensitive to interest rates and their impact on working capital.

These results differ from previous studies, such as Larson & Sijbrands (1991), where inventory levels and interest rates were unrelated, and Bechter & Pollock (1980), where interest rates significantly affected inventory-to-sales ratios for both retail and wholesale. Other authors, like Blinder et al. (1981), reported inconclusive results, and Rumyantsev & Netessine (2007) found no significant relationship between holding costs and inventory. The speculative motive for holding inventories was reported by Akkina (1983), where the relation between inventories, inflation, and carrying costs was significant from 1967 to 1979.

In the retail segment, the Consumer Confidence Index (CCI) had a positive relationship with Inventory Turnover, implying that higher consumer confidence leads to higher turnover. However, the Industrial Confidence Index (ICEI) had a negative relationship with Inventory Turnover, suggesting that industrial optimism may lead to increased production and more inventory in distribution channels. This industrial optimism does not reflect in the Inventory Turnover for the Wholesale segment. Additionally, same-year GDP growth had a negative relationship with Inventory Turnover in the retail segment, raising questions about whether the Retail segment has less forecasting ability compared to the Wholesale and Auto segments. Pearce & Wisley (1983) noted that retailers have a short forecast horizon and react quickly to unexpected sales or deviations from desired inventory levels.

This study falls within the quadrant defined by Marzolf et al. (2024), as it examines sector-specific data using a mix of internal and external variables. It highlights the continued relevance of variables like inflation and interest rates in developing countries, unlike in developed countries.

Another important takeaway is the lack of robustness in the results for certain variables depending on the choice of the response variable. Some variables exhibited a statistically significant relationship when the response variable was Inventory Turnover but lost statistical significance when the response variable was Stock Days, and vice versa.

The only variable that was significant across all sectors and models was the ratio of FTE (Full-Time Equivalent) to Sales, which serves as a proxy for organizational efficiency and technology. This suggests that companies with greater inventory visibility and control may experience better inventory management.

In the Retail sector, the significant variables were Margin and confidence indicators, both from consumers and the industry. For the Wholesale sector, the variables that remained significant in all models were Interest Rate and Salaries, the latter acting as an indicator of cost control. Lastly, in the Automotive sector, Salaries remained significant across all models.

The findings from this study, particularly the relationship between sector-specific factors and macroeconomic variables, can be extended to other emerging markets with similar characteristics where regulatory environments and consumer behavior may share similarities with Brazil's. However, the specific impacts of cultural and regulatory nuances must be considered when applying these results in other contexts. For example, in countries where informality plays a significant role, inventory management strategies may differ substantially from formal retail environments, requiring further adaptation of practices to local conditions. The results diverge from previous studies, particularly regarding inflation, interest rates, and sales surprise, highlighting unique dynamics in developing economies like Brazil. Methodologically, the choice of response variable (Inventory Turnover vs. Stock Days) affects the robustness of results, underscoring the need for careful variable selection in similar studies.

## 6. Conclusion

This study provides a nuanced understanding of inventory management in developing economies, emphasizing the continued relevance of macroeconomic factors like inflation and interest rates. It highlights the importance of technological infrastructure and sector-specific dynamics, offering actionable insights for improving inventory control. Researchers in similar contexts should consider the interplay between internal and external variables and the sensitivity of results to the choice of metrics.

Future research could prioritize two key directions: first, a granular assessment of how regional heterogeneity, physical infrastructure quality, and transportation network efficiency condition inventory management efficacy; second, an identification strategy leveraging exogenous shocks to establish robust causal inference regarding the variables operationalized in this study. Such extensions would significantly strengthen the theoretical and policy relevance of this line of inquiry.

## Data availability

Research data is only available upon request.

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## Author Contributions

Felipe Tumenas Marques: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing.

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