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Sectoral Impact Assessment of the Export Financing Program – PROEX

Avaliação de Impacto Setorial do Programa de Financiamento às Exportações – PROEX

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Abstract: The Export Financing Program (PROEX – *Programa de Financiamento às Exportações*) is a federal government instrument designed to support Brazilian export of goods and services through two modalities: National Treasury Financing and Interest Rate Support. This study evaluates the impact of PROEX on Brazilian exports between 2010 and 2021, adopting a novel approach that examines different sectors of the Brazilian export industry. The net effect of PROEX on each sector's overall export capacity was analyzed, accounting for changes in firms' market power within each sector. To address unobservable endogenous factors affecting PROEX's performance, an exogenous term was developed to reflect the economic attractiveness of Brazil's 20 main export markets. The econometric analysis indicates that a 10% rise in PROEX-supported exports, combined with a proportional demand shock in the destination countries, leads to an average 21.3% increase in Brazilian sectoral exports.

Keywords: Exports; Export Financing Program (PROEX); Subsidies; Panel Data; Impact Assessment.
JEL Classification: F14, G20, H25

Resumo: O Programa de Financiamento às Exportações (PROEX) é um instrumento do governo federal destinado a apoiar as exportações brasileiras de bens e serviços por meio de duas modalidades: Financiamento e Equalização. Este estudo avalia o impacto do PROEX nas exportações brasileiras entre 2010 e 2021, adotando uma nova abordagem que examina diferentes setores da indústria exportadora brasileira. O efeito líquido do PROEX sobre a capacidade de exportação do setor como um todo foi analisado, considerando as mudanças no poder de mercado das empresas em cada setor. Para lidar com os fatores endógenos não observáveis que afetam o desempenho do PROEX, foi desenvolvido um termo exógeno para refletir a atratividade econômica dos 20 principais destinos das exportações brasileiras. A análise econométrica indica que o acréscimo de 10% nas exportações apoiadas pelo PROEX, combinado com um choque de demanda proporcional nos países de destino, resulta em um aumento médio de 21,3% nas exportações setoriais brasileiras.

Palavras-chave: Exportações; Programa de Financiamento às Exportações (PROEX); Subsídios; Dados em Painel; Avaliação de Impacto.
Classificação JEL: F14, G20, H25

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1. Introduction

This study aims to assess the sectoral impact of the Export Financing Program (PROEX – *Programa de Financiamento às Exportações*) on Brazilian exports between 2010 and 2021. PROEX is a key government instrument designed to enhance the competitiveness of Brazilian exports in the international market. The program offers financial and credit support, specifically in the post-shipment phase, and operates through two modalities: National Treasury Financing and Interest Rate Support. State support for exports is a widespread global practice, with over 110 countries maintaining their own Export Credit Agencies (ECAs), which aim to mitigate market failures commonly observed in international trade (Dawar, 2020).

These market failures largely stem from the private sector's inability to allocate resources efficiently, which justifies government intervention as a strategy to improve the distribution of goods and services and promote social welfare. In this context, endogenous growth theory, as discussed by Paul Romer (Jones, 2019), highlights the importance of innovation and knowledge—both non-rival goods—in generating increasing returns to scale and positive externalities along the production chain. This underscores government intervention, through programs like PROEX, as a crucial instrument for fostering medium- and long-term economic growth.

There is also evidence that access to export markets enables firms to produce higher-quality goods (Atkin *et al*., 2017), offer better wages (Verhoogen, 2008), and adopt more advanced technologies (Alvarez and Robertson, 2004; Bustos, 2011). Exporting firms in technology-intensive sectors not only benefit directly but also generate positive spillovers that boost the economy's overall investment levels.

In 2021, Brazil ranked as the thirteenth-largest economy globally, with a Gross Domestic Product (GDP) of US$ 1.6 trillion[2], and was the fourth most attractive country for Foreign Direct Investment (FDI), with a net inflow of US$ 50 billion[3]. However, it ranked only 23rd among the world's top exporters, with a mere 1.16% share of global exports[4]. Brazil's historical focus on import substitution contributed to an industrial structure characterized by outdated inputs, machinery, and equipment with low technological content, limiting the country's ability to achieve robust economic growth and contributing to its marginal share in the international market.

The impact of PROEX on the performance of supported firms has been analyzed in previous studies, which typically used matching techniques to compare supported and non-supported firms. However, these approaches face methodological challenges, particularly concerning the violation of key assumptions for impact estimation, since the use of PROEX by a firm may generate spillover effects that alter the behavior of other firms in the control group. To mitigate these issues, this analysis adopts a sectoral approach, rather than a firm-level one, ensuring that market concentration does not disproportionately favor supported firms within the same sector.

Additionally, this study addresses potential endogeneity associated with unobserved factors that influence both participation in the program and the volume of Brazilian exports. To account for this issue, an exogenous term was constructed to capture the economic attractiveness of Brazil's top 20 export destination, correcting potential biases related to reverse causality and omitted variables.

The economic literature provides ample evidence of the benefits of international trade, with a positive causal relationship between foreign trade and economic growth (Donaldson, 2015; Irwin, 2019; Love and Lattimore, 2009). Bacha (2022) argues that, while not all countries that opened up to foreign trade have developed, all developed countries experienced significant trade integration with the rest of the world. Among the economies that successfully integrated, Hong Kong, Israel, Singapore, and Taiwan stand out for their industrial exports;

[2] World Development Indicators (www.worldbank.org).
[3] OECD Report (2022).
[4] World Development Indicators (www.worldbank.org).

Spain, Greece, Ireland, and Portugal for service exports; and Norway, Australia, and New Zealand for natural resource exports.

Given Brazil's limited trade openness, this study evaluates the impact of PROEX from a new perspective, analyzing different sectors of the Brazilian export industry while considering potential variations in firms' market power in each sector. The analysis also seeks to isolate unobservable endogenous factors affecting PROEX's performance by constructing an exogenous factor aimed at capturing demand shocks in the main destinations of Brazilian exports, assessing its impact on sectoral export volume supported by PROEX.

The econometric results reveal significant differences between the Financing and Interest Rate Support modalities, with positive and statistically significant effects observed only for the Interest Rate Support modality. Another key finding is the identification of the export sectors that benefited most from the program, with a particular emphasis on the land transport sector, which exhibited significant positive impacts, especially in exports to Argentina, Russia, and Mexico. In sum, the findings suggest that PROEX-Interest Rate Support is an effective instrument for promoting exports, as a hypothetical 10% increase in exports supported by PROEX, combined with a proportional demand shock in these countries, resulted in an average 21.3% increase in Brazilian sectoral exports from 2010 to 2021.

In addition to this introduction, the subsequent chapters review the relevant literature on export support program evaluations, present the profile of exports supported by the program, detail the methodology used, and discuss the econometric results obtained, followed by their respective conclusions.

2. The Export Financing Program – PROEX

Official export credit typically aims to create favorable financial conditions for exporting companies, enabling them to compete based on product quality and price — a concept internationally known as the "level playing field", widely supported by the OECD Export Credit Arrangement.

In this context, PROEX is a federal government instrument designed to support Brazilian exports of goods and services at costs aligned with those in the international market. PROEX-Interest Rate Support is a modality in which the government assumes part of the financial charges on loans granted by financial institutions by making interest rate support payments, with a particular focus on promoting the export of higher-value-added goods. This modality is open to all exporters, regardless of its annual gross revenue. The beneficiary of the Interest Rate Support is the financial institution financing the Brazilian export, which receives payment through National Treasury Notes, Series I (NTN-I).

The second modality, PROEX-Financing, operates on two fronts. First, it offers support to micro, small, and medium enterprises (MSMEs) with annual gross revenues of up to R$ 1.3 billion[5]. Financing is provided with National Treasury resources under more favorable conditions than those available in the private market. Second, it provides a concessional credit line aimed at fulfilling governmental commitments arising from bilateral negotiations. This concessional credit is often offered to low-income countries that have limited access to private credit.

Thus, PROEX-Financing addresses market failures by offering low-cost financing. The interest rate applied to the program's operations is the Commercial Interest Reference Rate (CIRR), effective on the shipment date, depending on the term and currency of the financing. In terms of guarantees, the program provides flexible options

[5] GECEX Resolution No. 469, dated April 5, 2023, by the Executive Management Committee of the Foreign Trade Chamber (GECEX – *Comitê-Executivo de Gestão da Câmara de Comércio Exterior*), increased the previous limit from R$ 600 million to R$ 1.3 billion.

for exporters and importers, such as endorsements, guarantees, letters of credit from first-tier banks, or export credit insurance.

3. Literature Review

Before presenting the methodological approach employed in this research, it is important to review relevant evidence from the economic literature that evaluates the performance of export support programs, with particular attention to the impact of PROEX on Brazilian exports.

Internationally, official export support instruments are widely employed by most countries to enhance firms' competitiveness. Notably, Martincus and Carballo (2010) evaluated Costa Rica's Foreign Trade Promoter (PROCOMER) and found that the program significantly increased the export of differentiated products. Their study, covering the period from 2001 to 2006, analyzed nearly all exporting firms in Costa Rica and employed a combination of the differences-in-differences method and Propensity Score Matching (PSM). The results indicated that PROCOMER positively impacted the export of differentiated products already sold abroad, enhancing the extensive margin by increasing the number of destination countries.

In the Brazilian context, Galleti and Celio (2013) examined the impact of two export financing support programs—BNDES-Exim (BNDES – *Banco Nacional de Desenvolvimento Econômico e Social*) and PROEX—during the period from 2000 to 2007, focusing exclusively on manufacturing firms. Using the PSM methodology, they created a treatment group of firms that received program support and a control group that did not. After matching, they estimated a regression model using panel data with fixed effects to control for omitted variables that differed between firms but remained constant over time. Their results indicated that firms supported by BNDES-Exim experienced a positive and statistically significant effect, with export values 14.7% higher than those of the control group. This effect was especially pronounced among MSMEs, which, on average, exhibited exports 43.3% higher than the control group. Regarding PROEX, only MSMEs showed statistically significant results, with this group achieving, on average, exports 34.1% higher than comparable firms that did not receive PROEX support.

Kannebley *et al*. (2022) evaluated the impact of three widely used export support instruments in Brazil: BNDES-Exim, PROEX, and Drawback. Their study also employed PSM and panel data techniques to construct treatment and control groups for firms newly entering the international market between 1998 and 2003. In terms of the intensive margin, their results indicated that PROEX led to a 74% increase in export value. Regarding the extensive margin, the estimated increase in the number of export destinations for firms using PROEX ranged from 14% to 43%.

Carneiro (2017) specifically assessed the effects of PROEX under the Financing modality, using PSM between 2006 and 2014, along with a regression method based on doubly robust estimators. The statistically significant average effects included: (i) a 66.7% increase in exported value; (ii) a 33.67 percentage-point increase in export growth; (iii) the addition of approximately one country to the scope of destinations for exported Brazilian goods; (iv) a 10.25 percentage-point increase in the probability of firms continuing to export; and (v) a 9.97% increase in workforce size within these firms.

4. Overview of Brazilian Exports and PROEX

Between 2010 and 2021, Brazilian exports averaged approximately US$ 223 billion annually, with peak volumes recorded in 2011 (US$ 254 billion) and 2021 (US$ 281 billion). The early years of this period were marked by robust GDP growth in Brazil, with rates of 7.5% in 2010 and 4% in 2011. The growth in exports in 2021 was primarily driven by significant currency devaluation and rising commodity prices, with the agricultural sector

accounting for 43% of total exports that year (IPEA, 2022). In contrast, during the economic recession—when GDP contracted by 3.5% in 2015 and 3.3% in 2016—exports fell their lowest levels of the decade, amounting to US$ 188 billion in 2015 and US$ 180 billion in 2016. Figure 1 illustrates the evolution of Brazilian exports compared to the volume of exports supported by PROEX, under both its Financing and Interest Rate Support modalities.

The volume of exports supported by the Interest Rate Support modality significantly exceeds that of the Financing modality. This is because expenditures under the Interest Rate Support scheme can leverage exports by an average factor of 26, as shown in Table 1. Exports supported by PROEX-Interest Rate Support grew substantially, from US$ 3.5 billion in 2010 to US$ 7.7 billion in 2018, representing a peak share of 3.33% of total Brazilian exports during this period. However, in 2019, the volume of exports supported by Interest Rate Support dropped to US$ 2 billion due to budget cuts. Although the Interest Rate Support budget was initially set at R$ 1.6 billion, it was reduced to R$ 400 million, with only R$ 266 million executed. In 2020 and 2021, the volume of resources allocated to this modality increased, which appears to have had a positive impact on the growth of Brazilian sectoral exports.

The volume of exports supported by the Financing modality has remained relatively low, comprising around 0.2% of total annual Brazilian exports, with a declining trend in recent years. In 2021, exports supported by PROEX-Financing amounted to just US$ 169 million. As indicated in Table 1, the Financing budget remained stable at approximately R$ 2 billion annually, with an average financial execution of R$ 1.09 billion and no budget cuts during the period.

Figure 1: PROEX-Financing – Brazilian Exports vs. Brazilian Exports Supported by PROEX

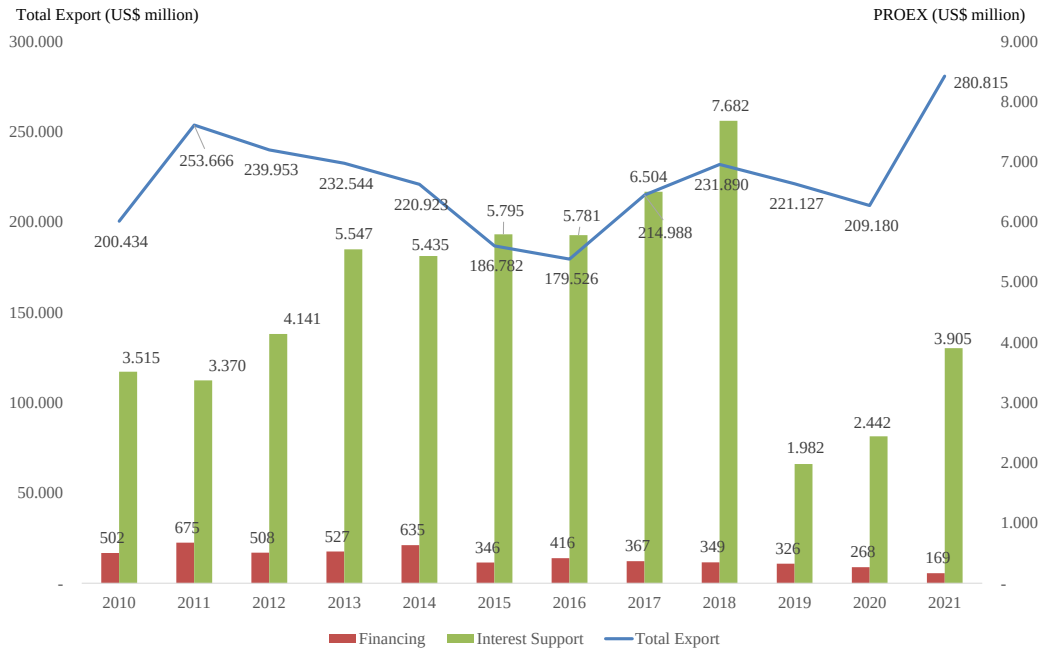


Table 1: Budgetary and Financial Execution of PROEX

R$ million

Year	INTEREST RATE SUPPPORT						FINANCING			
	Budget law	Updatted Budget	Paid (1)	Exchange Rate	Export (2)	Leverage (2) / (1)	Budget law	Updatted Budget	Paid	Export
2010	400,0	400,0	235,3	1,8	6.182,8	26,3	1.049,5	1.049,5	754,7	883,1
2011	1.039,4	1.039,4	404,9	1,7	5.637,6	13,9	1.300,0	1.300,0	922,4	1.129,3
2012	485,1	1.040,1	588,4	2,0	8.087,9	13,7	800,0	2.100,0	837,2	993,0
2013	1.060,8	1.660,8	556,7	2,2	11.958,9	21,5	1.500,0	1.500,0	962,0	1.137,0
2014	1.025,2	1.230,2	859,9	2,4	12.787,5	14,9	2.900,0	2.900,0	1.072,3	1.493,4
2015	1.594,7	1.594,7	778,4	3,3	19.279,3	24,8	2.000,0	2.000,0	1.071,7	1.151,2
2016	2.100,0	705,0	664,3	3,5	20.183,7	30,4	2.200,0	2.162,5	1.440,1	1.452,2
2017	2.260,0	686,9	620,7	3,2	20.757,7	33,4	2.500,0	2.500,0	1.143,7	1.171,9
2018	1.556,3	984,5	874,8	3,7	28.070,0	32,1	2.049,2	2.049,2	1.286,4	1.275,2
2019	1.600,0	400,0	266,3	3,9	7.817,3	29,4	2.100,0	2.100,0	1.292,5	1.286,4
2020	600,0	361,0	308,8	5,2	12.588,2	40,8	2.100,0	2.100,0	1.392,0	1.380,2
2021	560,0	742,5	576,1	5,4	21.065,3	36,6	2.000,0	2.000,0	896,7	911,3

Source: (i) Integrated Planning and Budget System - SIOP; (ii) Bank of Brazil; (iii) Ministry of Economy.

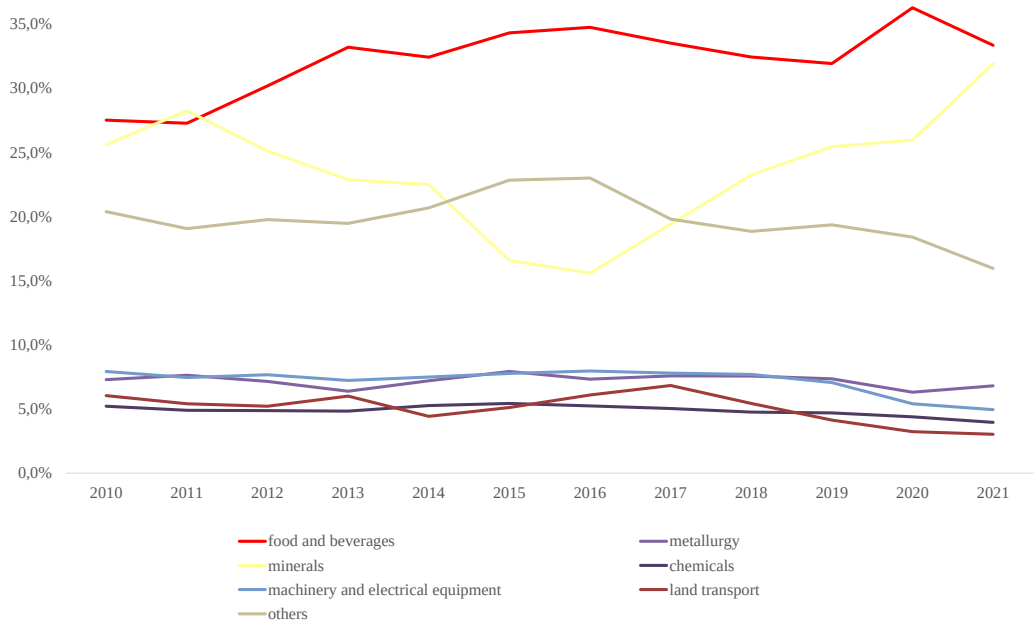
The Brazilian export portfolio is concentrated in a few economic sectors, primarily producing low-value-added goods. Figure 2 shows that the food and beverage sector averaged a substantial 32.3% share of total exports during the period. This sector includes the primary products in Brazil's export portfolio[6]. The minerals sector accounted for an average 23.6% share, with notable growth starting in 2016, increasing from 15.6% to 31.9% in 2021. Iron ore and its concentrates were the largest-volume export products in 2021, generating US$ 44.6 billion. Additionally, crude oil and petroleum products also made significant contributions, with revenues of approximately US$ 30 billion and US$ 7 billion, respectively[7].

Sectors producing higher value-added goods accounted for smaller shares, with machinery and electrical equipment (7.2%), metallurgy (7.2%), land transportation (5.1%), and chemical products (4.9%) leading the way during the analyzed period.

[6] In this classification, the following export values were recorded in 2021: soybeans (US$ 39 billion); sugars and molasses (US$ 9 billion); beef (US$ 8 billion); soybean Meal (US$ 8 billion); poultry meat (US$ 6 billion); unroasted coffee (US$ 5.8 billion); and unmilled corn (US$ 4.1 billion).

[7] The values of Brazilian exports for 2021 were collected from the government website: comexstat.mdic.gov.br/.

Figure 2: Brazilian Exports – Sector Participation

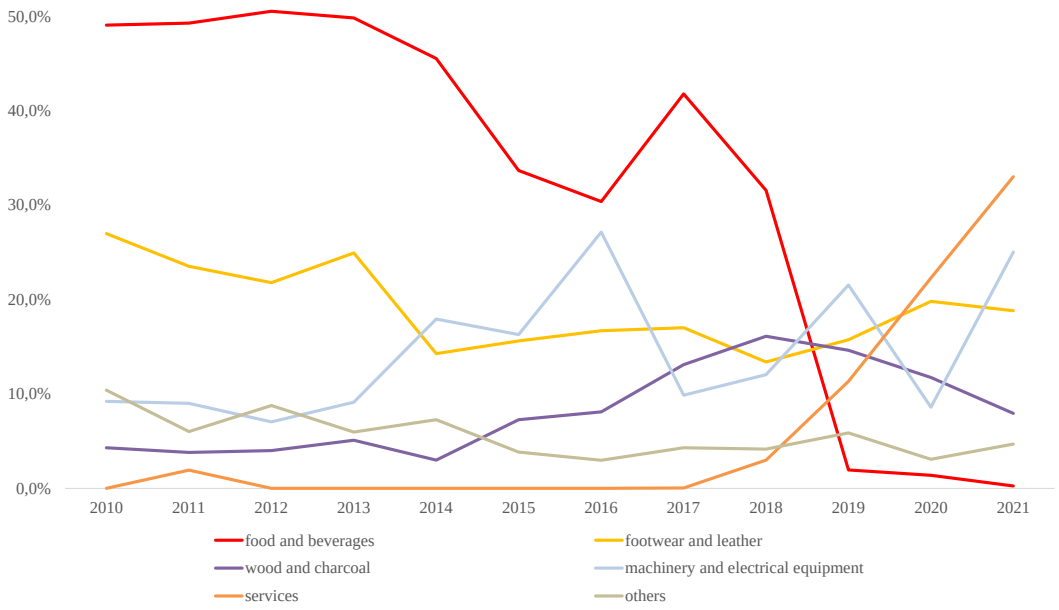


When examining the performance of exports supported by PROEX-Financing, as shown in Figure 3, it becomes clear that only a few sectors consistently receive support from the program[8]. The footwear and leather sector exhibited the most stable participation throughout the period, accounting for an average of 19.1% of total financing. The machinery/electrical equipment and wood/charcoal sectors also demonstrated regular participation, with average shares of 14.4% and 8.3%, respectively. The food and beverage sector had a significant share of approximately 42% until 2018, primarily because PROEX-Financing was the main instrument supporting exports in the bilateral agreement between Brazil and Cuba, aimed at boosting food exports to Cuba.

More recently, the export of services has gained prominence, rising from 2% in 2018 to 33% in 2021[9]. Despite PROEX-Financing's limited share of total Brazilian exports—approximately 0.2% during the analyzed period—a significant number of exporting firms utilized the program in recent years: 192 firms in 2019, 146 in 2020, and 94 in 2021.

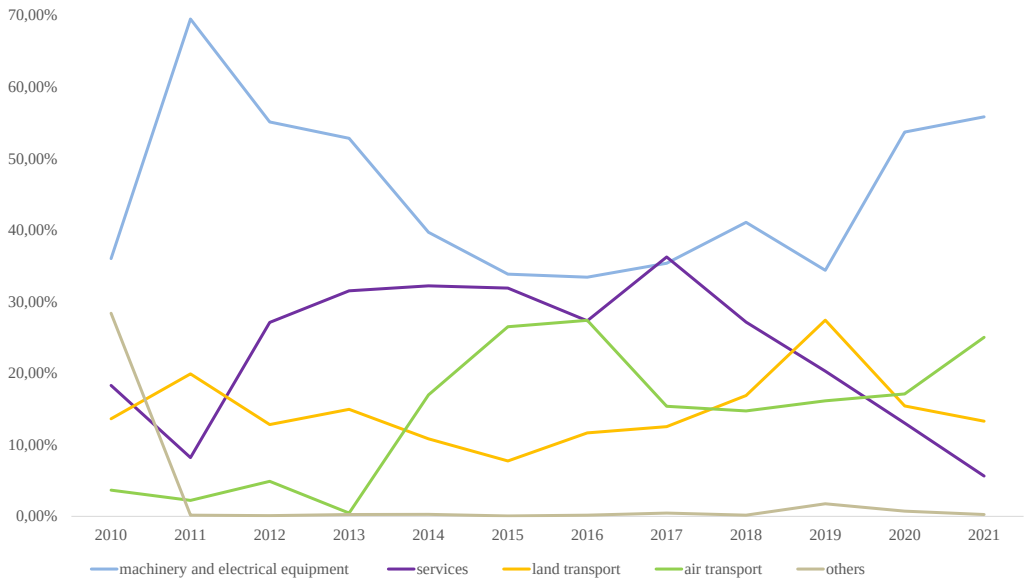
[8] The PROEX database was acquired through the Access to Information Act (LAI) and made available for this research only with the identification of the sectors supported by the Program, that is, the record of Brazilian exports identified by the first two digits of the Common Mercosur Nomenclature (NCM). Thus, it was not possible to analyze the specific products exported with the support of PROEX.
[9] It is noteworthy that, during the period from 2018 to 2021, service exports supported by PROEX-Financing totaled R$ 163 million, of which 98% were exclusively destined for Benin.

Figure 3: PROEX-Financing – Sector Participation



In terms of PROEX-Interest Rate Support, Figure 4 shows a high concentration of sectors producing higher value-added goods. The most prominent sectors and their respective average shares during the period were: machinery and electrical equipment (44.1%), services (24.8%), land transportation (14.9%), and air transportation (13.2%). This modality accounted for larger share of total Brazilian exports, averaging 2.1% over the period. However, the relatively small number of firms utilizing the program—25 firms in 2019, 19 in 2020, and 18 in 2021—explains the high concentration of supported economic sectors.

Figure 4: PROEX-Interest Rate Support – Sector Participation



5. Methodology

Various factors influence the performance of Brazilian exports, including macroeconomic variables such as exchange rates, inflation, and interest rates, which affect investment levels and, consequently, the trade balance. Additionally, characteristics of the Brazilian export industry, such as firm productivity, research and development (R&D) intensity, and sectoral diversity, also impact export volumes.

Despite the complexity of trade balance analysis, which involves multiple economic agents influencing Brazilian exports, this study aims to evaluate the impact of PROEX on the volume of Brazilian exports, focusing specifically on the economic sectors that benefit from the program. The primary objective is to determine whether the sectors supported by this public policy have contributed to an increase in sectoral exports.

Previous studies have examined the impact of PROEX on firm-level performance, often employing matching techniques to compare firms supported by the program with those that were not. However, these studies face certain methodological challenges. It is well understood that Brazilian export performance is influenced by a variety of domestic and international economic factors. A binary treatment variable indicating PROEX support is likely correlated with other unobservable variables that simultaneously affect participation in the program and export volume, potentially introducing biases into the estimation. Two key methodological issues stem from this.

First, the selection of firms and sectors supported by PROEX is endogenous, influenced by factors such as sectoral lobbying power—driven by the business owners—and possible correlations between supported firms and favorable macroeconomic conditions. For example, the program favors companies that significantly benefit from a currency devaluation, which could result in PROEX support coinciding with periods of significant devaluation. In such cases, comparing supported and unsupported firms would not capture the true impact of PROEX; rather, it would reflect a selection bias favoring firms that benefit from devaluation. This illustrates the potential challenge in determining whether the observed increase in exports was due to PROEX or whether these companies would have increased their exports regardless of the program's support.

Second, comparing supported and unsupported firms within the same sector can lead to market power shifts between firms, thereby violating key assumptions for estimating the program's impact. For instance, if only one of two firms in a sector receives PROEX support, it may gain a competitive advantage by lowering prices and increasing market share at the expense of the unsupported firm. As a result, the supported firm may show revenue growth, but the overall sector may not experience net gains in export volumes or employment, merely a redistribution of market share. This scenario illustrates how such comparisons may overestimate PROEX's impact by conflating it with the resource reallocation within the sector.

This issue is well explained by Melitz (2003), whose model highlights that firms with varying productivity levels coexist within the same industry and must decide whether to enter international markets. Only the most productive firms are typically able to export, leading to the expansion of efficient firms and the exit of less productive ones from export markets.

In the presence of firm reorganization within a sector, one might observe an increase in employment at the supported firm while the unsupported firm reduces its workforce, leading to the mistaken conclusion that PROEX had a positive impact on employment. In reality, this would reflect only a concentration of market power among supported firms. This dynamic highlights the importance of avoiding comparisons between firms within the same sector, as they can result in an overestimation of the program's true impact. Specifically, the assumption of no spillover effects to control group firms (Stable Unit Treatment Value Assumption – SUTVA)[10] is easily violated when support for one firm influences the behavior of other firms within the same sector.

[10] Schwartz *et al.* (2012).

Given these challenges, this study evaluates whether PROEX has been an effective instrument for supporting Brazilian exports over the past decade, addressing the two key issues identified above. The analysis focused on whether PROEX positively contributed to export volumes across economic sectors, while also considering exogenous factors that affect the relative attractiveness of exporting compared to producing for the domestic market.

To address the first issue—endogenous factors affecting the operation of PROEX—the study examined exogenous changes in market conditions in the primary destinations for Brazilian exports. The analysis assessed how such changes influenced the volume of sectoral exports supported by PROEX, with particular emphasis on demand shocks in these destination countries. An interaction variable was constructed following the methodology of Amodio and de Roux (2021), similar to the use of an exogenous Bartik instrument. This approach aims to mitigate issues of reverse causality and omitted variable bias.

The exogenous term was constructed by interacting two components: (1) a pre-determined vector representing each sector's share in total exports to each destination country, and (2) a measure of the economic attractiveness of each destination country relative to the Brazilian market, calculated as the real exchange rate between Brazil and the respective country.

To address the second issue—spillover effects on control group firms—the analysis was conducted at the sectoral level rather than at the firm level. The primary hypothesis was that no spillovers occur between supported and unsupported sectors. Thus, the study evaluated the net effect of PROEX on the export capacity of each sector, accounting for any intra-sectoral firm rearrangements. Following Melitz (2003), intense international competition drives the reallocation of resources within export sectors, with more efficient firms expanding at the expense of less productive ones. The study aimed to determine whether PROEX-supported sectors, as a whole, experienced greater export growth compared to unsupported sectors.

For sector classification, this study adapted the framework presented by Thorstensen (1994) to reflect Brazil's trade relationships, resulting in twenty economic sectors based on the Mercosur Common Nomenclature (NCM), as shown in Table 3.

Table 3: Economic Sectors – NCM Chapters

ECONOMIC SECTORS	CHAPTERS NCM	ECONOMIC SECTORS	CHAPTERS NCM
Food and Beverages	1 a 24	**Machinery and electrical equipment**	84 85
Minerals	25 a 27	**Transport - Railway**	86
Chemicals	28 a 38	**Transport - Land**	87
Plastics and Rubber	39 e 40	**Transport - Air**	88
Footwear and Leather	41 a 43; 64 a 67	**Transport - Waterway**	89
Wood and Charcoal	44 a 46	**Optics and Instruments**	90 a 92
Paper and Cellulose	47 a 49	**Weapons**	93
Textile	50 a 63	**Miscellaneous Products**	94 a 96
Non-Metallic Minerals	68 a 71	**Works of Art**	97
Metallurgy	72 a 83	**Services** [1]	99

Note[1]: There is no Chapter 99 in the NCM. Classification created to address the context of PROEX.

To assess the sectoral impact of PROEX, the study identified the twenty main destinations for Brazilian exports between 2010 and 2021[11], which accounted for approximately 73% of total Brazilian exports during the analyzed period. The study examined potential exogenous demand shocks from these countries, considering each sector's share of exports and the variation in the exchange rate (BRL/USD), multiplied by the ratio between the inflation index of the destination country and Brazilian inflation. Generally, when inflation in the destination country exceeds Brazilian inflation, Brazilian products become more competitively priced, potentially increasing export volumes.

5.1 Empirical Strategy

To evaluate the impact of PROEX from a sectoral perspective, this research employs an econometric methodology using panel data, applying fixed effects for both time and sector. The model also incorporates the interaction between the exogenous term "E" and the export volume supported by PROEX (Interest Rate Support and Financing). The first regression, consistent with methodologies used in previous studies, seeks to estimate the impact of PROEX on sectoral-level exports, using the following equation:

$$Y_{sdt} = \delta_s + \mu_t + \varphi * PROEX_{sdt} + u_{it} \quad (1)$$

where:

- Y_{sdt}: total monthly exports by sector and destination.
- δ_s: sector fixed effect (NCM).
- μ_t: time fixed effect (month/year).
- $PROEX_{sdt}$: monthly exports supported by PROEX (Financing and Interest Rate Support), by sector and destination.

The allocation of PROEX support across sectors is not exogenous and may correlate with export opportunities available to each sector and country at a given time. For instance, if inflation in Russia rises more rapidly than in Brazil, or if the market share of a specific importing sector expands, it may become more profitable for Brazilian firms to export to that country. Consequently, firms in the sector may request additional resources from PROEX to boost exports, potentially biasing the coefficient φ in equation (1).

To address this endogeneity, this study proposes the following equation:

$$Y_{sdt} = \delta_s + \mu_t + \rho * E_{sdt} + \varphi * PROEX_{sdt} + \gamma * E_{sdt} * PROEX_{sdt} + \theta\, SELIC\ real_t + u_{it} \quad (2)$$

where:

- Y_{sdt}: total monthly exports by sector and destination.
- δ_s: sector fixed effect (NCM).
- μ_t: time fixed effect (month/year).
- $PROEX_{sdt}$: monthly exports supported by PROEX (Financing and Interest Rate Support), by sector and destination.
- E_{sdt}: exogenous term "E".
- $SELIC\ real$: real SELIC (*Sistema Especial de Liquidação e de Custódia*) rate.

Following the methodology of Amodio and de Roux (2021), the exogenous term "E" captures potential revenue shocks experienced by each sector through exports. It is calculated as follows:

[11] On average during the analyzed period, the top 20 destinations were: China; United States; Argentina; Netherlands; Japan; Germany; Chile; Mexico; Spain; South Korea; Italy; India; United Kingdom; Belgium; Canada; France; Russia; Paraguay; Saudi Arabia; and Colombia.

First, the sector's share in the destination countries is calculated using the equation[12]:

1. $S_{sdt} = \frac{\text{Exp}_{\text{sdt}}}{\sum_{\text{d}} \text{Exp}_{\text{sdt}}}$, where Exp_{sdt} represents sectoral exports by month and destination.

Next, to estimate the economic attractiveness of each market, the nominal exchange rate (BRL/USD) is multiplied by the ratio of the consumer price index (CPI) of the destination country to Brazilian inflation:

2. $R_{dt} = R_{dt}^{n} \left(\frac{CPI_{dt}}{CPI_{t}^{Brazil}}\right)$, where:

R_{dt}^{n} : nominal exchange rate (BRL/USD).
CPI_{dt}: consumer price index in the destination country.
CPI_{t}^{Brazil}: consumer price index in Brazil.

Finally, the exogenous term E_{sdt} is calculated by multiplying the sectoral share by the economic attractiveness:

3. $E_{sdt} = S_{sdt} * R_{dt}$

Following Amodio and de Roux (2021), E_{sdt} serves a role similar to the Bartik instrument, though in this study, it is used only as an interaction term with the export volume supported by PROEX. We consider E_{sdt} exogenous, as its components—sectoral export shares and inflation variation—are plausibly exogenous.

To validate the accuracy of the exogenous term E_{sdt}, this study also estimates its impact across all sectors of the Brazilian export industry, independent of PROEX-supported exports. This broader analysis allows for a more comprehensive evaluation of the effect of E_{sdt} on the entire export base of Brazil, as shown in the following equation:

$$Y_{sdt} = \delta_s + \mu_t + \rho * E_{sdt} + \gamma * E_{sdt} * SECTOR_{dt} + u_{it} \qquad (3)$$

- Y_{sdt}: total monthly export by sector and destination.
- δ_s: sector fixed effect (NCM).
- μ_t: time fixed effect (month/year).
- E_{sdt}: exogenous term.
- $SECTOR_{dt}$: export sector, as defined in Table 3.

This framework advances the evaluation of PROEX by identifying whether sectors' responses to demand shocks (captured by E_{sdt}) vary based on the support received through PROEX. Specifically, the study examines whether the elasticity of Brazilian exports in response to demand shocks from destination countries increases when firms receive PROEX support. The underlying hypothesis is that PROEX facilitates firms' entry into international markets, enabling them to capitalize on demand shocks. A positive value of γ in equation (2) would support this hypothesis.

5.2 Data Set

This study utilizes the following data from 2010 to 2021:

- Monthly exports, in USD, supported by PROEX (Financing and Interest Rate Support), by NCM and destination country[13].
- Total monthly exports, in USD, by NCM and destination country[14].

[12] In this calculation, only the top 20 destinations of Brazilian exports were considered, taking into account the aggregation of the 20 economic sectors, as outlined in Table 3.
[13] Source: Access to Information Act – LAI.
[14] Source: www.basedosdados.org – Comex Stat / NCM Exportação.

- Consumer Price Indices (CPI) of destination countries[15].
- Nominal exchange rates (BRL/USD)[16].
- Real SELIC rate[17].

6. Empirical Results

First, equation (3) was estimated to calculate the effect of the exogenous term "E" across all sectors of the export industry, excluding linkages with exports supported by PROEX. The results of this estimation are presented in Table 4 below. The dataset used for this estimation covers the top 20 destinations for Brazilian exports, aggregated by destination country and economic sector, totaling 49,655 observations.

Table 4: Exogenous Term "E" X Sector – Elasticity – Dependent Variable: Brazilian Exports by Economic Sector

log(E)	0.865***	**log(E) × sector_paper and cellulose**	0.229***
	(0.005)		(0.003)
log(E) × sector_weapons	0.173***	**log(E) × sector_plastics and rubber**	0.083***
	(0.004)		(0.002)
log(E) × sector_footwear and leather	0.164***	**log(E) × sector_miscellaneous products**	0.099***
	(0.003)		(0.004)
log(E) × sector_wood and charcoal	0.100***	**log(E) × sector_chemicals**	-0.039***
	(0.002)		(0.001)
log(E) × sector_machinery and electrical equipment	0.009***	**log(E) × sector_services**	0.156***
	(0.002)		(0.003)
log(E) × sector_metallurgy	0.204***	**log(E) × sector_textil**	0.144***
	(0.000)		(0.002)
log(E) × sector_minerals	0.278***	**log(E) × sector_air transport**	0.137***
	(0.004)		(0.004)
log(E) × sector_non-metallic minerals	0.045***	**log(E) × sector_railway transport**	0.131***
	(0.003)		(0.005)
log(E) × sector_works of art	0.126***	**log(E) × sector_waterway transport**	0.150***
	(0.003)		(0.003)
log(E) × sector_optics and instruments	-0.051***	**log(E) × sector_land transport**	0.105***
	(0.002)		(0.004)
		Num.Obs.	49655
		R2	0.913
		R2 Adj.	0.913
		R2 Within	0.824
		R2 Within Adj.	0.824
		RMSE	0.82
		Std.Errors	by: sector
		FE: Time	X
		FE: sector	X

[15] Source: www.data.imf.org.
[16] Source: www.bcb.gov.br.
[17] Source: www.bcb.gov.br.

The results in Table 4 indicate that the exogenous term "E" functions as a reliable proxy for demand shocks in destination countries. The estimated coefficient suggests that Brazilian exports have the potential to increase in response to such shocks. Specifically, the logarithmic transformation of "E" indicates that a 100% increase in the demand shock leads to an average growth of 86% in Brazilian sectoral exports.

When we analyze individual sector performance, we find that all sectors showed statistically significant results[18]. Particularly noteworthy are the sectors exhibiting the most substantial positive impacts and sensitivity to demand shocks: minerals (114%), paper and pulp (109%), metallurgy (107%), and arms (104%)[19].

The econometric analyses of sectoral exports supported by the two PROEX modalities (Interest Rate Support and Financing) are presented next. The regressions were estimated in logarithmic form (elasticity). Table 5 provides the results for the Interest Rate Support modality[20].

Table 5: PROEX-Interest Rate Support – Elasticity – Dependent Variable: Brazilian Exports by Economic Sector

	Regression 1	Regression 2	Regression 3	Regression 4
E × log(PROEX)		0.006	0.012	0.099+
		(0.087)	(0.069)	(0.057)
log(PROEX)	0.378***	0.203**	0.252**	0.214*
	(0.074)	(0.060)	(0.071)	(0.081)
(Intercept)		13.452***		
		(0.847)		
E		2.902*	2.579*	1.361+
		(1.281)	(1.076)	(0.760)
log(selic_real)		0.110+	0.147**	
		(0.054)	(0.051)	
Num.Obs.	3652	3134	3134	3652
R2	0.372	0.510	0.590	0.639
R2 Adj.	0.346	0.509	0.589	0.624
R2 Within	0.207		0.505	0.544
R2 Within Adj.	0.206		0.504	0.544
AIC	135897.9	133487.8	132920.6	133879.3
BIC	135910.3	133524.1	132950.9	133904.1
RMSE	1.30	1.17	1.07	0.99
Standard Error	by: country	by: country	by: country	by: country
FE: sector	X		X	X
FE: time	X			X

The coefficients for log (PROEX) in the four regressions presented in Table 5 were positive and statistically significant. However, it is not yet possible to infer a causal relationship between PROEX-supported exports and the overall volume of Brazilian exports due to endogeneity issues, as unobserved variables may influence both the program's participation and the volume of supported exports.

[18] When running the regression, the food and beverage sector was removed from the results due to collinearity issues.
[19] For the calculation of elasticity, the coefficients of the following variables should be summed: log (E); log (E) x sector.
[20] All regressions used clustered standard errors by the destination country.

The findings illustrate how Brazilian sectoral exports responded to demand shocks with PROEX support. Given that PROEX participation is endogenous—driven by multiple economic and cyclical factors—additional steps were taken to address endogeneity and more accurately estimate the impact on sectoral exports. This included accounting for demand shocks in destination countries and the exports supported by PROEX.

The estimates employed fixed effects for time and sector, allowing the analysis to evaluate the average performance of each sector over the period. Sectoral variations were captured primarily by the exogenous term "E," reflecting each export sector's share in the destination country and the real exchange rate between Brazil and the destination country.

To further assess the robustness of the model, Regressions 2 and 3 were estimated. Regression 2 did not utilize fixed effects for time or sector, while Regression 3 employed only sector fixed effects. These regressions incorporated the real Selic rate, which accounts for inflation expectations from financial institutions[21]. Time fixed effects were excluded because the real Selic rate is defined on a monthly basis. In Regression 3, a 100% increase in the real Selic rate was associated with a 14.7% increase in Brazilian exports. This finding aligns with the objectives of the export support program, as rising domestic interest rates make private financing more expensive, encouraging exporters to seek more favorable financial instruments, such as PROEX.

6.1 PROEX and Demand Shock in the Destination Country

Regression 4 in Table 5 represents the primary estimate of this study. The results show how the sectoral exports increase in response to rising PROEX-supported exports and the opportunities presented by demand shocks in destination countries. To estimate the impact of PROEX more precisely, average sectoral export values for the top 20 destination countries (Y0) were calculated based on the coefficients from Regression 4. These values were applied to the average value of PROEX-supported exports and the average "E" term for each sector in the respective country.

Average sectoral export values (Y1) were then estimated, assuming a 10% increase in both PROEX-supported exports and the exogenous term "E." By subtracting the two estimated values (Y1–Y0), the potential impact on the export sector resulting from a 10% increase in PROEX-supported exports, combined with a proportional demand shock in the destination country, was quantified.

This impact estimation was performed for each sector in each destination country over the analyzed period. To assess the overall effect of PROEX on Brazilian exports, the average of the estimated sectoral impacts was calculated. Given the importance of sectoral export volumes, the calculation of the average impact for each destination country was weighted by the average export value of each sector.

Table 6 summarizes the estimates, with column (A) showing the average impact for each country, considering all analyzed sectors, based on a 10% increase in PROEX-supported exports and the demand shock. It was observed that this increase results in fluctuations in average Brazilian exports ranging from 58% (Argentina) to 1% (China). These values reflect the combined effect of PROEX and the variables that make up each country's "E" term (sectoral share and the real exchange rate). On average, a 10% increase in PROEX-supported exports, combined with a proportional demand shock, results in an average increase of 21.3% in sectoral exports across the 20 countries analyzed.

To illustrate these estimates more clearly, calculations for a standout sector in each country were presented. Column (B) shows the average export value of the sector supported by PROEX, Column (C) presents the average total export value of the sector, regardless of PROEX support, while columns (D) and (E) show the estimated

[21] Inflation expectations were collected from the Central Bank of Brazil's Focus Market Reports.

impact of a 10% increase in both exports supported by PROEX and the demand shock, expressed in both nominal and percentage terms relative to the sector's total average export value.

The combined 10% increase in PROEX-supported exports and the demand shock significantly impacts the land transport sector, with estimated percentages of 88%, 81%, and 30% for Argentina, Russia, and Mexico, respectively. However, in six countries (South Korea, the Netherlands, Spain, the United States, Japan, and China), the additional impact was below 10%.

Table 6: Impact Estimate - 10% Increase in Exports Supported by PROEX-Interest Rate Support and the Proportional Demand Shock

Country	% Average Impact (A)[1]	Calculation of the Highlighted Sector - Values in USD				
		Highlighted Sector	Average Value of Exports Supported by PROEX (B)	Average Total Sector Export Value (C)	Sector Impact with an additional 10% (D) = Y1 - Y0	Impact on the Average Total Sector Value (E) = (D/C)
Argentina	58,1%	**land transport**	8.682.607	497.995.319	439.438.076	88,2%
Russia	51,0%	**land transport**	15.080.213	20.149.710	16.398.947	81,4%
Mexico	49,8%	**land transport**	2.328.812	66.997.924	20.162.853	30,1%
Colombia	39,4%	**metallurgy**	2.283.534	36.177.288	12.599.349	34,8%
Paraguay	37,1%	**machinery and electrical equipment**	2.245.047	45.012.904	20.335.564	45,2%
Germany	26,9%	**optics and instruments**	29.591	88.293.557	29.657.221	33,6%
Chile	22,5%	**chemicals**	66.298	18.814.426	2.808.611	14,9%
Italy	20,8%	**optics and instruments**	44.429	51.239.272	12.040.728	23,5%
France	16,9%	**machinery and electrical equipment**	2.736.305	20.266.281	4.998.514	24,7%
Belgium	15,4%	**optics and instruments**	27.179	34.599.966	5.624.965	16,3%
United Kingdom	15,1%	**machinery and electrical equipment**	3.924.426	19.294.985	3.557.633	18,4%
Saudi Arabia	13,8%	**machinery and electrical equipment**	2.958.125	5.377.383	1.000.663	18,6%
India	11,2%	**machinery and electrical equipment**	957.400	9.852.434	1.025.464	10,4%
Canada	10,2%	**machinery and electrical equipment**	6.410.670	18.365.282	3.587.157	19,5%
South Korea	9,2%	**machinery and electrical equipment**	212.138	3.947.188	364.394	9,2%
Netherlands	8,5%	**machinery and electrical equipment**	903.863	23.398.611	739.874	3,2%
Spain	7,9%	**optics and instruments**	56.306	11.706.345	627.814	5,4%
United States	7,3%	**air transport**	128.974.464	204.136.598	16.193.907	7,9%
Japan	4,0%	**machinery and electrical equipment**	264	24.453.941	566.038	2,3%
China	0,9%	**machinery and electrical equipment**	2.192.725	36.855.910	540.681	1,5%
Average Impact	**21,3%**					

1: Average impact due to the 10% increase in exports supported by PROEX and the proportional demand shock, considering all economic sectors under analysis.

Next, Table 7 presents the estimated regressions for PROEX-Financing, reported in logarithmic form (elasticity). Although the coefficient for log (PROEX) was statistically significant and positive, causality cannot be inferred due to endogeneity arising from unobservable factors. Notably, the interaction between the exogenous term "E" and log (PROEX) was not statistically significant. Several hypotheses may explain this absence of causality. First, PROEX-Financing accounts for a small share of Brazil's total export portfolio (approximately 0.2%), which may limit the identification of the program's effects. Second, as shown in Figure 3, few sectors consistently utilize the Program, with the footwear/leather sector being the most stable. Other sectors, such as food/beverages, and services, show more fluctuation. Consequently, PROEX-Financing support did not yield statistically significant effects on sectoral export performance.

Table 7: PROEX-Financing – Elasticity – Dependent Variable: Brazilian Exports by Economic Sector

	Regression 1	Regression 2	Regression 3	Regression 4
E × log(PROEX)		0.181	0.032	0.035
		(0.359)	(0.279)	(0.275)
log(PROEX)	0.374***	0.263*	0.318**	0.333**
	(0.072)	(0.115)	(0.105)	(0.101)
(Intercept)		13.235***		
		(1.481)		
E		1478	2206	2314
		(4.320)	(3.362)	-3.286
log(selic_real)		0.256***	0.167**	
		(0.055)	(0.054)	
Num.Obs.	2703	2515	2515	2703
R2	0.456	0.457	0.538	0.570
R2 Adj.	0.424	0.456	0.535	0.544
R2 Within	0.136		0.299	0.317
R2 Within Adj.	0.136		0.298	0.316
AIC	97510.3	96890.9	96482.5	96881.1
BIC	97522.1	96925.8	96511.7	96904.7
RMSE	1.28	1.28	1.18	1.14
Standard Error	by: country	by: country	by: country	by: country
FE: sector	X		X	X
FE: time	X			X

7. Conclusion

This study highlights several advantages of the PROEX-Interest Rate Support modality, particularly: (i) its high potential to boost exports; and (ii) its role as a viable channel for exporting companies to capitalize on market opportunities arising from demand shocks in destination countries. The econometric results demonstrate that a 10% increase in PROEX-supported exports, combined with a proportional demand shock, results in an average increase of 21.3% in sectoral exports. Another key finding is the identification of sectors that benefited from PROEX-Interest Rate Support, with the land transport sector—particularly in Argentina, Russia, and Mexico—being the most prominent.

However, the program remains concentrated in a few sectors, with only 18 companies utilizing PROEX-Interest Rate Support in 2021. Despite the program's relatively small scale, it has proven to be empirically effective and shows potential for expansion, particularly in high value-added sectors such as machinery, electrical equipment, and transportation.

The PROEX-Financing modality serves a critically important purpose for Brazil's export industry—supporting the exports of micro, small, and medium-sized enterprises (MSMEs)—which represents a key public policy to encourage the expansion into new foreign markets. However, another feature of the program is that it also provides a concessional financing channel to enable low-cost operations, particularly aimed at benefiting low-income countries. As a result, during the period under analysis, the participation of economic sectors fluctuated considerably, mainly due to bilateral agreements signed between Brazil and other beneficiary countries. In this context, the econometric results were not statistically significant and failed to capture the performance of the PROEX-Financing modality.

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