WORKING PAPER Nº IDB-WP-01861

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Abstract:

Agricultural price stabilization policies are widely used to protect farmers from market volatility, yet their long-term consequences for production incentives and market efficiency remain poorly understood. This paper provides the first causal evaluation of Colombia's Dry Paddy Rice Storage Incentive Program, examining whether short-term price stabilization generated unintended distortions throughout the rice value chain. Using a Regression Discontinuity Design combined with Regression Kink Design on monthly data from 2013–2025, we estimate the program's effects on producer prices, farm revenues, production decisions, and consumer price transmission. The results show that the program achieved its primary objective of mitigating seasonal price declines and increasing producers' short-term revenues. However, these gains came at the cost of altered production incentives. Higher expected returns encouraged additional planting, contributing to oversupply in subsequent harvests and reinforcing dependence on recurrent government intervention. While the program stabilized producer prices, it also weakened price transmission to consumers, limiting broader welfare gains and reducing market efficiency. These findings reveal a fundamental trade-off inherent in commodity price stabilization policies: interventions that effectively protect farmers in the short run may simultaneously create incentives that undermine long-run market adjustment and fiscal sustainability. Beyond the Colombian case, the study contributes causal evidence to the broader debate on agricultural stabilization policies in developing economies and highlights the importance of complementing temporary market support with investments that enhance productivity, competitiveness, and structural resilience.

JEL Codes: Q18, Q11

Keywords: Agricultural Policies, Stock-Stabilization, Counterfactual, Discontinuous Regression, Rice Production, Effectiveness Analysis.

1. Introduction

Rice is part of the basic food basket that constitutes food security around the world. According to information from the Food and Agriculture Organization of the United Nations (FAO), rice is the main source of calories for approximately half of the world's population; furthermore, it is considered a staple food in at least 34 countries. Similarly, the cultivation and sale of rice is one of the main sources of employment and income for at least 2 billion people around the world.

In Colombia, the national rice production in 2023 reached approximately 2.8 million tons, making it the second-largest rice producer in Latin America and the Caribbean (FAO, 2023). Furthermore, more than 98% of Colombian households include rice in their daily diet, with a per capita consumption of 56.7 kg per person per year (2023), well above the regional average (FAO, 2023). Given these indicators, ensuring sustainable production and efficient supply chains are key to meeting a demand that is both affordable and fundamental to national food security. Besides, in terms of the production chain, rice has three specific links and five specific stages, as follows:

• **Paddy rice production activities**: In this first step, farmers grow rice for sale, generally in the form of green paddy rice, meaning this rice is normally sold without undergoing a cleaning and drying process. This step encompasses the stages of input procurement and primary production.

•**Green paddy rice processing activities**: In the second step, processing agents purchase green paddy rice from agricultural producers and proceed to clean, dry, store, and transform it into white rice, brown rice, or other by-products for marketing. In this step, not only is value added to the initial product, but its composition is also changed; to obtain one kilogram of white rice, approximately 1.68 kilos of green paddy rice are required, since the drying, cleaning, and polishing processes reduce the weight (Fedesarrollo, 2022). This step includes the processing and storage stages.

• **Distribution and marketing activities**: This last link considers distribution channels such as: i) selling white rice in bulk at the plant gate to wholesalers and distributors, who then sell it to retailers in supply centers; and ii) companies that have their own brand, which is already recognized by the end consumer, can distribute it to different points of sale, using their own means or through marketers and distributors. This link includes the distribution and marketing stages.

On the other hand, rice cultivation in Colombia presents three particularities that compromise its sustainability, which is why conventional policy instruments undertake multiple production and marketing efforts to ensure the grain supply. These are:

1. **Highly seasonal production**. The main planting is concentrated during the first half of the year (March–May), coinciding with the onset of the rainy season, while the secondary planting extends between June and September (Cadena Torres, Cuello Pérez, Romero Ferrer, & Pérez Cantero, 2021).. Furthermore, approximately 37% of the total planted area corresponds to the first half of the year

and 63% to the second half, confirming the seasonal concentration of production (Escobar Fernandez, 2025).

2. **Climate-sensitive production**. In Colombia, rice production is particularly vulnerable to climate factors due to the coexistence of irrigated and rainfed systems. This structural duality means that in some areas of the country, excessive irrigation can lead to aquifer depletion, while in others, rainfed systems suffer direct production losses (low yields) due to exposure to extreme weather events such as droughts (UPRA, 2022).
3. **Highly perishable production**. Freshly harvested rice often reaches a moisture content above 20%, making it especially vulnerable to mold damage, degradation, and pest attacks if not dried within 2 to 3 days (Juganas, Regalado, & Ramos, 2023). In many cases, post-harvest losses can reach 20%, especially in areas where farmers lack efficient drying systems or adequate storage infrastructure ((Ibrahim, 2018). In Colombia, rice is mainly sold fresh to the mills, which then proceed to dry and store it, making the harvest season a critical moment, as up to 70% of yearly production is sold during that period.

Against this backdrop, this paper evaluates the Colombian Paddy Rice Storage Incentive Program through a regression discontinuity design to estimate its effects on producer prices, farmers' income, production decisions, and price transmission. Beyond determining whether the program achieves its immediate objective of stabilizing prices, the analysis also examines the broader trade-offs associated with this type of intervention, including its implications for market efficiency, production incentives, and the long-term competitiveness of the rice sector. By doing so, this study contributes not only to the literature on agricultural price stabilization policies but also to the broader debate on how governments can balance short-term income protection with long-term structural transformation and fiscal sustainability.

2. Background: Dry Paddy Rice Storage Incentive Program, a strategy for innovation and rural development in Colombia

The primary objective of innovation in rural development is to enhance the quality of life for rural populations, including those primarily engaged in agricultural and livestock activities, as well as those not directly involved. Innovation should be oriented toward the preservation of natural and social resources to ensure long-term sustainability. Innovation is conceived in social, cultural, and technological terms (Arfini, et al., 2019).

Social innovation initiatives in rural development focus on the valorization of local productive resources and the creation of related networks, the preservation of natural and cultural resources, the revitalization of the identity of rural areas, the establishment of new production facilities in non-agricultural and service sectors, and the improvement of the quality of life in rural areas, particularly for disadvantaged groups such as women, youth, and people with disabilities (Novikova, 2021).

Innovation and the use of agricultural technologies have the potential to positively impact agricultural productivity, developing regions' economic well-being, and the rural population's quality of life (Shpykuliak & Sakovska, 2020).

However, the outcome and magnitude of these changes are difficult to estimate, as they depend in part on the type of technology or innovation used. In this sense, we present three different forms of innovation that lead to differentiated impacts on the population: i) innovations focused on natural resource management and pest control (improving soil quality, conserving natural resources, increasing production and yields); ii) integrated agriculture, which combines several agricultural practices such as crop rotation and diversification; and iii) agricultural mechanization, which involves the use of machinery and equipment to improve efficiency (Shpykuliak & Sakovska, 2020). Within these types of innovation and rural development, the Colombian government's Dry Paddy Rice Storage Incentive Program corresponds to an initiative related to mechanization and efficiency improvement, in the sense that by drying green paddy rice, which is perishable, it can be stored in perfect conditions to replenish the market at a time of low production, thus allowing the supply of rice, which is a vital food for the food security of Colombians, to remain constant.

The Dry Paddy Rice Storage Incentive Program is a policy instrument for the rice sector that was implemented from 1997 to 2023 with the conviction of avoiding disruptions to the country's rice harvest market and abrupt price fluctuations that could harm producers and consumers of the grain.

As a technical justification, rice cultivation and the entire agroindustry surrounding it are vital to the Colombian economy. It is the second most predominant short-cycle crop in the country, with approximately 13,000 producers (DANE, 2024) located in nearly 200 municipalities, whose income depends on this activity for 90% of their production (MINAGRICULTURA, 2021).

Furthermore, rice is a staple for food security and sovereignty in Colombia. According to the Agricultural and Rural Panning Unit, per capita consumption in 2021 was 42 kg, and according to the 2024 Life Quality Survey carried out by the National Administrative Department for Statistics (DANE), it reached 1.77 pounds per capita per week (around 45.8 kg per year) (DANE, 2025; DANE, 2014; MINAGRICULTURA, 2022).

Besides, the green paddy rice production is highly seasonal, especially in the Eastern Plains and Bajo Cauca areas, as they primarily use non-irrigated production systems, which depend on rainfall cycles. Thus, we observe high harvest periods in rice cultivation between July and September of each year, peaks that have represented an average of 52.1% of annual production (MINAGRICULTURA, 2021). Furthermore, green paddy rice is a highly perishable product, making it impossible to store.

The program acts as an incentive to withdraw a portion of available paddy rice inventories when they increase (second half of the year) and to market them when inventories naturally decrease (first half of the following year). Under this incentive, the government allocates resources to cover part of the mill´s storage costs in exchange for the adoption of a price band for the green paddy rice paid to the farmer. This prevents the mills from bearing the total cost of storing the harvest, stabilizes income for the producer, and guarantees supply to consumers during the deficit period (Fedearroz, 2023).

The Program acts as a price stabilizer through a supply control or stock stabilization mechanism. Price stabilization is one of the most important objectives of agricultural policy, especially in developing countries (Fertő, 1995)

The stock stabilization mechanism has been widely used in developing countries to prevent the price of agricultural products from falling. The government can usually control stocks at two stages in the production chain, either by restricting the area under cultivation or by stabilizing stocks through government purchases of surpluses (Fertő, 1995).

Before the implementation of the Program, the Colombian government operated an institute called the *Instituto de Mercadeo Agropecuario* (IDEMA), that controlled supply and demand of agricultural goods by managing purchases, imports, storage, sales and exports of non-perishable goods, such as rice. One of the most important tasks of the IDEMA was to intervene in times of high seasonal supply to buy, transport and store the goods to ensure later availability and prevent dramatic price falls. Due to inherent inefficiencies in the institution, this often led to cost overruns and quality issues that generated losses and hindered marketing. As the country moved towards a more open economy in the 1990´s, The IDEMA lost its monopoly on imports and exports, which led to operating losses of up to COP 90,161 million (around U$100 million) in 1995, that had to be covered by the government. In addition, the distribution processes faced major inefficiencies, including logistics failures, poor inventory and financial management, inadequate store placement, and lack of accountability (Ballesteros, 1998).

In this context, a version of the Program was created in 1996 as a way to shift responsibilities away from IDEMA towards private actors. The program was a success, with an average of 75,975 tons of paddy rice stored under the Program per month for four months at a total cost of COP 3,267 million (around U$3.1 million). As a comparison, in 1994 IDEMA intervened in the rice market for 82,431 tons at a loss of COP 12,267 million (U$ 14.8 million) (Ballesteros, 1998). In this case, the Rice Storage Incentive acted as an innovation that presented an alternative to the national government purchase program and solved many of the operational issues that plagued the previous system.

(Reutlinger S. , 1976) concludes that stock levels that are optimal in terms of direct costs and benefits are likely to be too low to allow for satisfactory levels of stabilization; however, buffer stock programs operated with insurance-oriented storage rules could provide adequate protection against extreme shortages. Along the same lines, (Abokyi, Strijker, Asiedu, & Daams, Buffer Stock Operations and Well-Being: The Case of Smallholder Farmers in Ghana, 2022A) report that stock control improves the objective and subjective well-being of small farmers by 20% and 15%, respectively.

The theoretical and methodological contextualization of how the Paddy Rice Storage Incentive Program corresponds to an innovation and rural development strategy in Colombia provides a systemic, evidence-based understanding of how each activity within the strategy contributes to the desired impact on the rice supply chain.

According to (Schut, et al., 2022), impact-oriented innovation must begin with a shift in perspective, moving from a fragmented view to a territorial approach. To achieve this, stakeholders must characterize existing innovations, analyze the current situation, design expansion strategies, negotiate with stakeholders, and implement and evaluate them. This structured approach is crucial for identifying and overcoming obstacles that hinder effective ownership, thus ensuring that strategies are optimized to achieve the most substantial possible impact.

3. Data and Methods

a. Theoretical framework: stock stabilization

Agricultural markets in developing economies are often highly vulnerable to price volatility, driven by seasonality, climatic shocks, and low short-term supply elasticity. This volatility poses significant risks to food security, rural incomes, and macroeconomic stability. In this context, price stabilization mechanisms based on inventory control have historically been used as public policy tools to smooth market fluctuations (Dana & Gilbert, 2009) (Wright & Williams, 1982).

Stock stabilization involves the accumulation of commodities during periods of surplus and their release during times of scarcity, with the goal of keeping prices within a desired band. This logic underpins buffer stock programs, usually managed by public or semi-public agencies, which aim to mitigate both price spikes that harm consumers and price drops that hurt producers (Galtier, Vindel, & Timmer, 2013) (Varangis, Gilber, & Dehn, 2004).

As an evaluation of this mechanism, (Reutlinger S. , 1976) concluded that stock levels that are optimal in terms of direct costs and benefits are likely to be too low to allow for satisfactory levels of stabilization. However, buffer stock programs operated under insurance-oriented storage rules could provide adequate protection against extreme shortages in grain supply at a reasonably low cost. On the other hand, (Abokyi, Strijker, Asiedu, & Daams, Buffer Stock Operations and Well-Being: The Case of Smallholder Farmers in Ghana, 2022A) found that participation in buffer stock operations improves the objective and subjective well-being of smallholder farmers by 20 % and 15 %, respectively. This highlights the short-term rationale for stabilization policies: under certain conditions, they can protect producers from sharp price declines and improve their welfare.

However, international experience suggests that, although price- and stock-based support programs can stabilize prices and farm incomes in the short term, they tend to generate fiscal dependence and structural distortion when sustained over time. This pattern is especially visible across several of Asia's large agricultural economies. In India, the Minimum Support Price scheme, with open-ended public procurement that absorbed about 92% of rice output in Punjab and 74% in Haryana, contributed to stocks reaching nearly ten times the buffer norm while worsening groundwater depletion and reinforcing rigid mono-cropping (Singh, Thangaraj, & Gulati, 2026).

In China, price-support and temporary reserve policies drove maize reserves above half of global stocks, prompting the government to end the maize support price and begin reducing inventories (Deuss & Adenäuer, 2020) (USDA Foreign Agricultural Service, 2020) and in Thailand, the rice-pledging scheme, which paid producers 40–50% above market prices, resulted in the accumulation of large unsellable stocks and substantial fiscal losses before the program ended amid a political crisis (Poapongsakorn & Pantakua, 2014).

Beyond Asia, the effects of these policies are not limited to public finances. In sub-Saharan Africa, purchases by Zambia's grain-reserve agencies protected maize producer prices but crowded out private traders and biased production toward this single crop (Dorosh, Minot, & Rashid, 2025) (Mason & Myers, 2013) (Mason, Jayne, and Myers, 2015) (Mason & Myers, 2013; Mason et al., 2015; Dorosh et al., 2025). In Latin America, Ecuador shows that a guaranteed minimum rice price is not, on its own, a viable alternative: the policy has produced distortions throughout the marketing chain while only partially achieving price stability, and the largest income transfers accrue to the more productive farmers rather than to smallholders (Food and Agriculture Organization of the United Nations, 2019).

Other international experiences point to a transition toward less distortionary policy instruments. The Philippines replaced its state monopoly and support price with a tariff system that finances productivity investments and reduced consumer prices by around 17% (Balié, Minot, & Valera, 2021) and the European Union shifted from intervention prices and public storage toward decoupled payments that support farm incomes without directly encouraging excess production (OECD, 2023).

Against this international background, Colombia’s Dry Paddy Rice Storage Incentive Program represents a hybrid form of stock stabilization. Rather than managing physical stocks directly, the government provides storage subsidies to private actors (such as mills or cooperatives), incentivizing them to withhold paddy rice during harvest peaks and release it during the off-season. This mechanism indirectly controls supply to maintain price stability (Fedearroz, 2023).

The program is particularly relevant in Colombia due to the pronounced seasonality of rice production and its central role as a staple food (DANE, 2024; MINAGRICULTURA, 2021). In this context, the storage incentive is consistent with the argument of (Galtier, Vindel, & Timmer, 2013), who suggest that, where futures markets are absent or ineffective, stock stabilization mechanisms can contribute to rural development and food security, provided that they are well designed and financially sustainable.

Colombia’s program can thus be understood as an institutional innovation within classical stock stabilization approaches, shifting logistical operations to the private sector while preserving a public objective of supply management, but also underscores the need to evaluate whether its short-term stabilization benefits are achieved without generating persistent fiscal dependence or production distortions (Schut, et al., 2022; Galtier, Vindel, & Timmer, 2013).

b. Data sources and variables

To evaluate the effect of the Dry Paddy Rice Storage Incentive Program, we primarily relied on secondary data available for various links in the Colombian rice market. The information on green paddy rice prices was obtained from two different sources that differ in the level of data aggregation. Firstly, Colombia’s National Statistical Office (DANE in Spanish) has collected monthly data for municipalities with rice mills from 2013 to 2024 through the Information System of Prices and Supply of the Agricultural Sector (SIPSA in Spanish). Additionally, Colombia's Mercantile Exchange (*Bolsa Mercantil de Colombia*) records daily data on green paddy rice at the departmental level since 2016. The evaluation was performed using the two variables as dependent variables to test the consistency of the results at both the geographical and time levels.

A time-specific database was created based on the legal acts issued for the Dry Paddy Rice Storage Incentive Program since 2013, which outlined the exact dates when the incentive would be active, the minimum prices at which paddy rice needed to be purchased in rice mills, and the quantity of rice covered by the program. The database was utilized at both the daily and monthly levels, depending on the price variable applied in the evaluation. Additionally, the actual amount spent by the program per year was included to account for its magnitude in the assessment.

To evaluate how the program impacted the rice farmers' income, a new variable, producers' profit margin, was created by subtracting total production costs from the green paddy rice price information mentioned above. The former is at the rice-producing region[1] level, while the latter is at both the municipal and departmental levels. The data on production costs is published by Colombia's National Federation of Rice Producers (FEDEARROZ) on a per-semester basis, by type of irrigation system (non-irrigated and irrigated rice crops).

c. Methods: RDD and RKD

To empirically assess the impact of the Dry Paddy Rice Storage Incentive Program on the price of green paddy rice and rice producers' income, we performed an evaluation using elements of both a sharp regression discontinuity design (RDD) and a sharp regression kink discontinuity (RKD) design. Initially proposed by (Thistlethwaite & Campbell, 1960), RDD is a quasi-experimental method for evaluating the causal effects of interventions, where the units' treatment status is determined by the threshold of an underlying variable X_i. An RDD is defined as sharp if the assignment D_i is a deterministic function of the forcing variable X_i:

$$D_i \begin{cases} 1 \; if \; X_i \geq c \\ 0 \; if \; X_i < c \end{cases},$$

So, all units with an X_i value of at least c are always treated, while those under the cutoff point (c) are assigned to the control group (Imbens & Lemieux, 2008). To estimate the effect of being treated by an intervention, the RDD approach compares the mean outcomes of the variable y_i between observations just above and just below the cutoff point (c) under the assumption that they only differ in their X_i values, therefore in their treatment status providing valid counterfactuals.

[1] In Colombia, there are six rice-producing regions based on their weather conditions and water availability: Llanos *Orientales* (East Plains), *Centro*, *Bajo Cauca* (southwest area), *Costa Norte* (north coast), *Santanderes*.

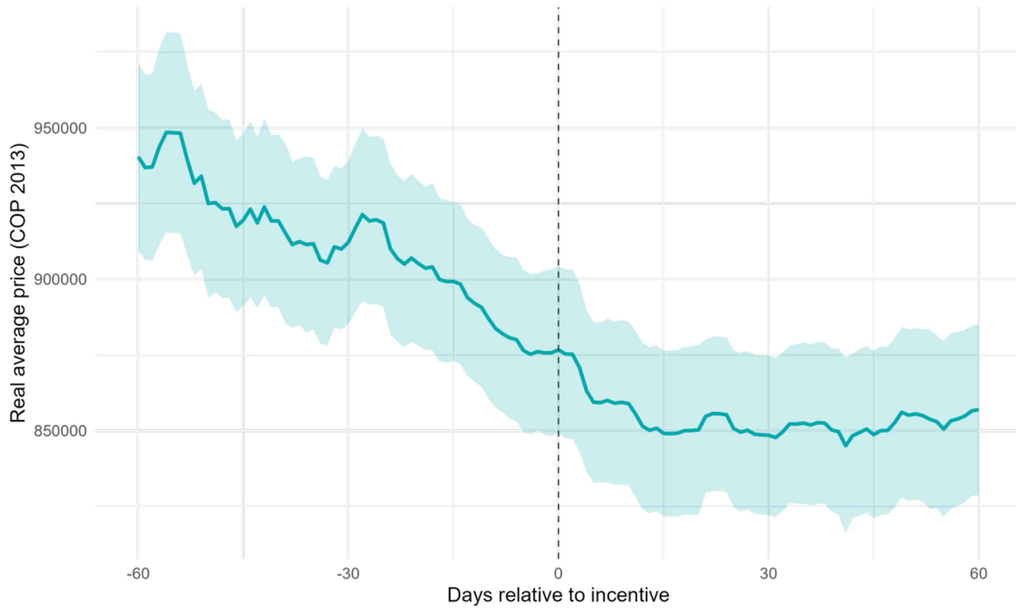
We used an RDD approach to evaluate the Dry Paddy Rice Storage Incentive Program, considering the exact day the legal act regulating it started operating as the cutoff point (c) and the days relative to it as the running variable X_i. As depicted in Table 1, the exact date the incentive was implemented varied by year between 2013 and 2023. Starting from that date onwards, rice mills had to buy green paddy rice from producers according to the conditions of that year's legal act. So, it seems plausible to assume that the rice purchased on the days close to the starting date of the policy, both before and after, was traded in similar market and environmental conditions with the only difference of being treated or not, based on their relative position to the cutoff point c.

Table 1. Starting date of the Dry Paddy Rice Storage Incentive Program per year (2013 - 2023)

Year of the incentive	**Starting date**
2013	16 of July
2015	4 of September
2016	5 of August
2017	11 of August
2018	31 of August
2019	1 of August
2020	15 of August
2021	9 of August
2022	4 of August
2023	24 of July

According to experts in the Colombian rice sector, this variation on the starting day of the policy was due to external, mainly political, factors that were not possible to anticipate by the farmers or the rice mills owners. This can be visualized graphically in Figure 1 where is possible to notice that the green paddy rice price, the outcome variable of interest y_i, do not have big shifts close to the starting date of the program.

Figure 1. Average price of green paddy rice relative to the day the Program started (+/- 60 days)



Source: Elaborated by authors based on data from *Bolsa Mercantil de Colombia*

Since the RDD approach focuses on assessing the intervention effect on the mean level of the outcome variable y_i, and we are also interested in evaluating the change rate of prices before and after the policy is implemented, we used elements of the RKD design. RKD emerges as a way to adapt the design to policy settings where the discontinuity in the treatment assignment is not a discrete jump but rather a change in the slope of the likelihood of being treated at certain levels of X_i, also known as a kink point (Card, Lee, Pei, & Weber, 2015; Dong, 2011). That is the case for interventions that are gradually implemented based on the values of an additional variable, which implies a discontinuity in the first derivative of the assignment function rather than the one depicted in equation (1). Although this type of discontinuity is not the case for the Dry Paddy Rice Storage Incentive Program, we took from RKD the focus on evaluating the change in slope of the outcome variable y_i just below and above the cutoff point c as observations move along the forcing variable X_i.

Its focus on observations in a range close to the cutoff point makes the effect estimate constrained just to those observations, formally defined as a Local Average Treatment Effect (LATE) and mathematically defined as:

$$Y_i = \alpha + \tau D_i + \beta_1 (X_i - c) + \beta_2 D_i * (X_i - c) + \varepsilon_i$$

Where Y_i is the outcome variable of interest, D_i is the binary variable for treatment assignment, τ is the LATE of the program (focus of the RDD approach), and $(X_i - c)$ is the relative position of observation i to the cutoff point. The coefficients β_1 and β_2 can be interpreted as the slope of the outcome variable before and after the cutoff point, respectively.

d. Limitations

This study provides novel evidence on the effectiveness of Paddy Rice Storage Incentive Program, yet several limitations must be acknowledged.

Our analysis is particularly limited by data constraints. Production cost information from FEDEARROZ is only available at the regional–semester level, creating a mismatch with municipal and departmental price data that may introduce measurement error and attenuate estimated effects. In addition, daily price data from *Bolsa Mercantil de Colombia* are available only from 2016 at the departmental level, limiting our capacity to evaluate earlier program years and reducing the sample size for high-frequency analysis.

Regarding methodological limitations**,** the regression discontinuity design provides credible causal identification under specific assumptions. The validity of estimates depends on the absence of other discontinuous shocks at the cutoff, an assumption that cannot be fully verified. The rice sector operates amid overlapping agricultural policies, trade measures, macroeconomic conditions, and climate shocks, which our empirical strategy cannot fully control. These factors, coupled with the high seasonality and perishability of rice in Colombia, may limit the consistency of the estimates. Moreover, RDD captures Local Average Treatment Effects within narrow bandwidths, limiting external validity to the specific periods analyzed.

Finally, the Program exhibited a particularly atypical episode between 2017 and 2018: the structural break caused by the mill withdrawal makes interpretation difficult, given that these were years in which, despite the active incentive, market power was not the same. This mill withdrawal reveals an ambiguous effect of the intervention on purchase prices. However, this structural limitation allows us to introduce a discussion on the role of the participation of different market agents in the policy's effectiveness, within the framework of our impact-based innovation narrative.

Addressing these limitations will require more robust datasets and methods capable of managing variation in treatment intensity. Qualitative research on farmer and mill behavior can enrich interpretation. Despite these limitations, our findings provide credible evidence on the causal effects of stock stabilization policies and contribute to the broader literature on agricultural policies in developing economies.

4. Results

a. Descriptive analysis and first considerations

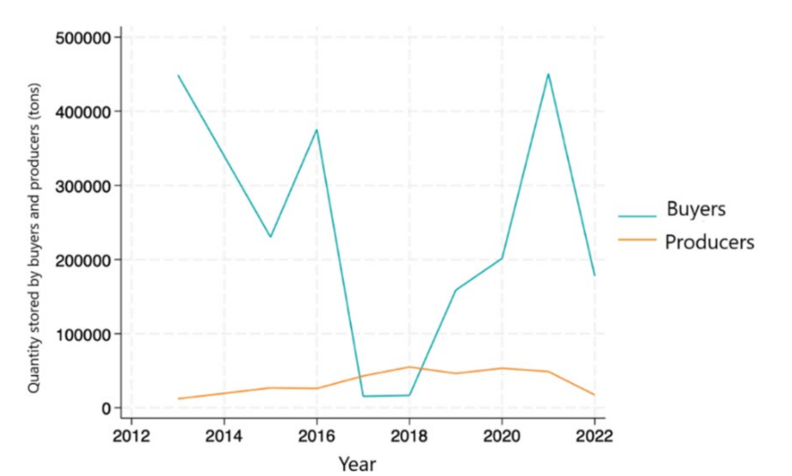
To analyze the impact of an agricultural public policy, it is necessary to rigorously review the conditions under which it is implemented: operational design, coverage, dynamics, and trajectory over time. In this regard, it is crucial to note that although the rice storage incentive program was in place for more than 20 years (from 1997 to 2023), its coverage has not been uniformed from year to year. Program records show that implementation does not follow a technical pattern; instead, variability appears to be primarily determined by budgetary decisions and specific circumstances each year.

Figure 2 shows the annual evolution of the quantity of paddy rice stored under the incentive program, differentiating between buyers (mills) and producers. We observe asymmetry in volumes: buyers account for most of the incentivized rice storage, with levels exceeding 300,000 tons in some years, while producers consistently remain below 50,000 tons. Between 2017 and 2018, an exception occurred: mills did not participate in the incentive, which showed a storage volume close to zero for mills and a greater relative participation by producers. It is also worth mentioning that on 2014the program was not implemented.

This operational discontinuity did not imply a proportional reduction in the total number of beneficiaries. Figure 3 shows that the total number of beneficiaries remained stable despite the withdrawal of buyers from the program in 2017 and 2018. This stability is achieved because most beneficiaries are producers who register to store their rice, but individual producers have very low storage capacity compared to green paddy purchasing companies.

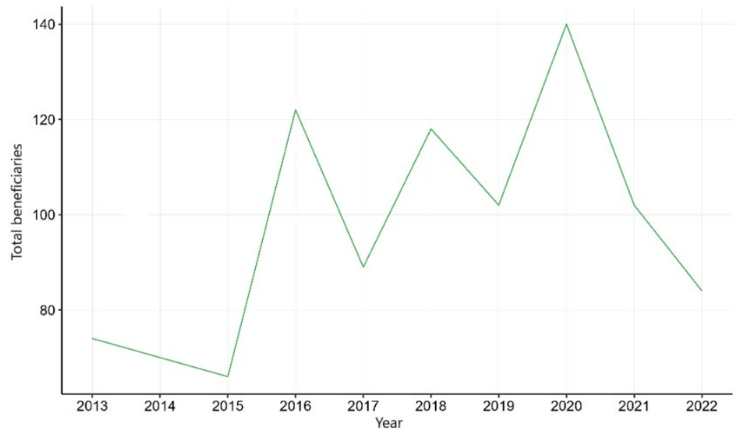
This finding suggests that, in those years, the program maintained its coverage through producer participation, albeit in significantly lower volumes. Conversely, peak beneficiary numbers in years such as 2016 and 2020 could be associated with temporary expansions of program coverage or specific budget adjustments.

Figure 2. Tons stored under the incentive by type of beneficiary



Source: Elaborated by authors based on data from *Bolsa Mercantil de Colombia*

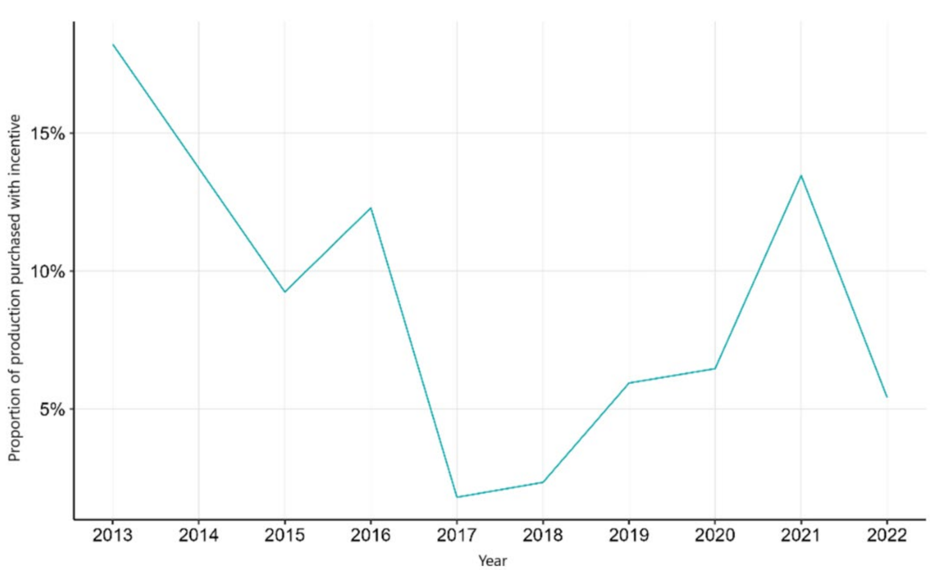
Figure 3. Number of beneficiaries under the incentive by type of beneficiary



Source: Elaborated by authors based on data from *Bolsa Mercantil de Colombia*

Now, we must analyze the scope of the incentive in relation to its ability to impact the market. Figure 4 shows the proportion of national rice production purchased through the incentive program. We observe a sharp decline in the program's share of total production starting in 2013, falling from over 17% in that year to levels below 3% between 2017 and 2018, precisely the years of lowest buyer participation. Starting in 2019, a gradual recovery is evident, reaching nearly 14% in 2021. However, in 2022, a drop in share is observed again, falling below 6%. This behavior not only reflects operational and budgetary changes but also the variability in the program's degree of intervention in the market, which must be considered when interpreting its impact. That is, beyond the number of beneficiaries or the amount of the incentive delivered, the actual scope of the program depends on the proportion of production purchased under its scheme, which determines its ability to influence prices and production decisions.

Figure 4. Proportion of production purchased by the incentive



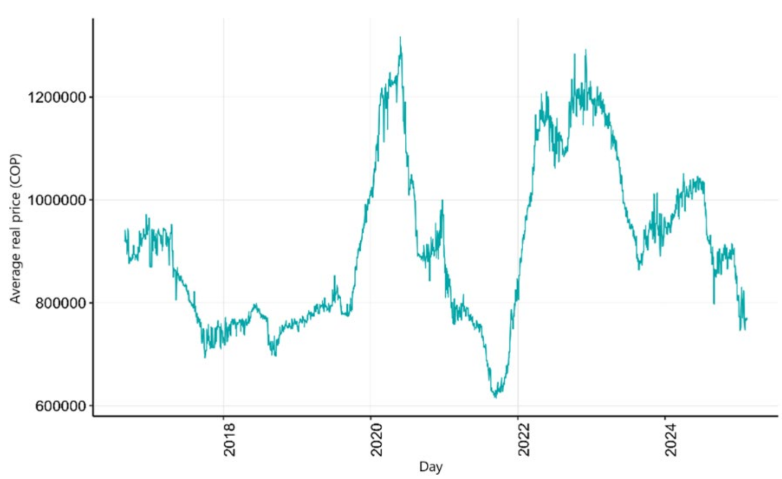
Source: Elaborated by authors based on data from *Bolsa Mercantil de Colombia*

It is also important to provide an overview of the behavior of prices, production costs, margins, and national rice production levels in this descriptive exercise. This information allows us to identify patterns, asymmetries between observation units, and preliminary relationships that help interpret subsequent quantitative results. Descriptive statistics also allow us to validate the consistency of the data available for analysis.

Figure 5 shows the evolution of the average daily real price of green paddy rice at the mills, expressed in constant 2013 pesos. The series shows marked intra-annual volatility, with recurring declines coinciding with harvest months (mainly between July and September), followed by recovery phases toward the end of the year or the beginning of the following year. This pattern is repeated throughout the observed period and reflects the market's structural seasonality. The steepest declines are observed in 2021 and 2023, followed by considerable increases, suggesting the possibility of market interventions or adjustments that cushioned the decline, such as the implementation of the storage incentive program. This series is especially useful for capturing the immediate effect of policy measures, given its high temporal resolution, and justifies the use of identification strategies based on time discontinuities.

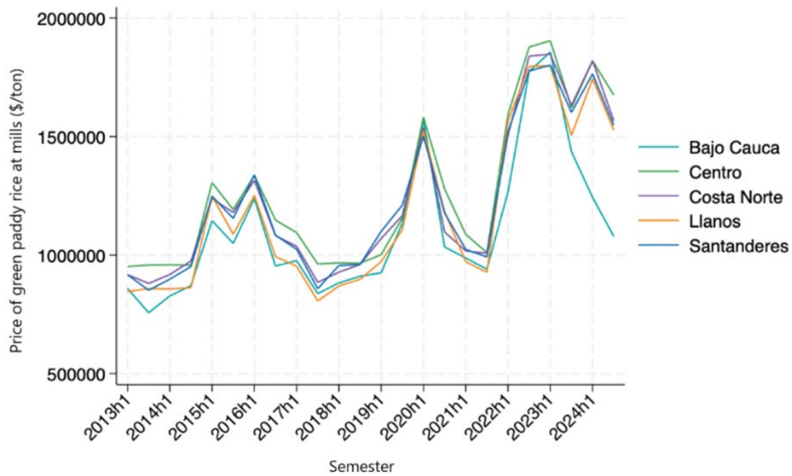
Figure 6 presents the average semiannual price paid per ton of rice at the mill, constructed from monthly data and disaggregated by rice-growing regions. Although there are differences in price levels across regions, a general trend is evident, indicating a certain degree of market integration. We observe three price spikes: the first in 2016, the second in 2021, and the most recent in 2022, all followed by downward adjustments. These fluctuations are primarily explained by variations in production and inventory levels, as well as institutional and logistical conditions, including the operation of the storage program. The relative stability of differences across regions suggests that, although local conditions influence prices, national determinants (aggregate supply, industrial demand, and the presence of policy instruments) play a dominant role.

Figure 5. Average daily green paddy rice prices (2013 constants)



Source: Elaborated by authors based on data from *Bolsa Mercantil de Colombia*

Figure 6. Green paddy rice prices at mills by rice growing area by semester



Source: Elaborated by authors based on data from DANE – SIPSA

Another aspect to consider when evaluating the profitability of production is the cost structure of producers. In Colombia, this structure is strongly shaped by the production system (irrigated vs. non-irrigated), not only because of the costs directly associated with irrigation, but also due to the limited availability of irrigated land, which drives up land values. This divide also has a geographical dimension: the Centro, Costa Norte, and Santanderes regions rely almost exclusively on irrigated systems, while the Bajo Cauca and Llanos regions depend predominantly on non-irrigated systems (see Table 2).

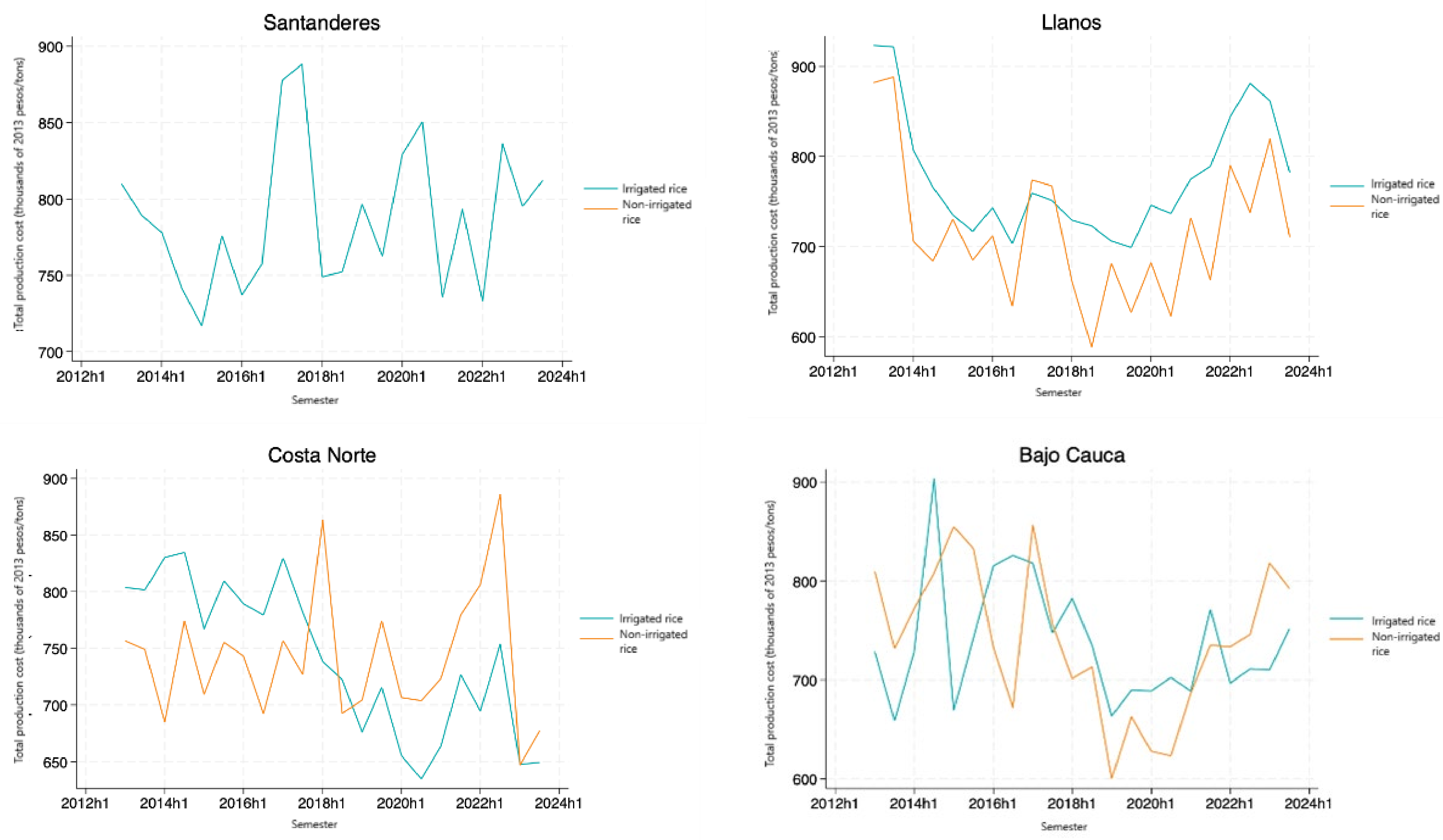
Table 2. Planted area under irrigated and non-irrigated systems, by production zone, 2023

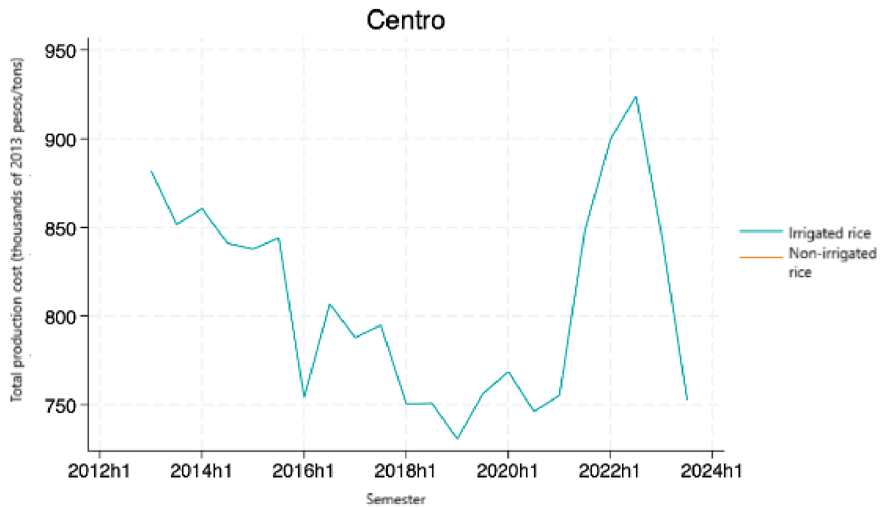
Zone	Planted Area (Hectares)			share (%)	
	Total	Irrigated	Non-irrigated	Irrigated	Non-irrigated
Total	589.848	254.319	335.529	43,1%	56,9%
Bajo Cauca	65.786	6.203	59.583	9,4%	90,6%
Centro	144.059	141.643	2.416	98,3%	1,7%
Costa Norte	23.198	22.387	811	96,5%	3,5%
Llanos	316.061	45.611	270.450	14,4%	85,6%
Santanderes	40.744	38.475	2.270	94,4%	5,6%

Source: Elaborated by authors based on data from (Fedearroz- FNA, DANE, 2024)

Figure 7 presents the semiannual evolution of total production costs per ton, differentiated by rice-growing area and cultivation system (irrigated vs. rainfed), in constant 2013 pesos. In general, costs under irrigation are higher and more stable, in line with the greater use of inputs, technology, and infrastructure requirements. However, in areas such as Bajo Cauca and Costa Norte, there are cases where rainfed costs exceed those of irrigation, although, given the small irrigated and non-irrigated system usage in the Bajo Cauca and Costa Norte regions, respectively, it is hard to draw general conclusions about the difference in cost in these regions. In Santanderes and the Centro, data are only available for irrigation, with high volatility throughout the period. These results reflect technical and productive heterogeneity across regions and systems, with implications for the design of differentiated support instruments and profitability analysis.

Figure 7. Production costs in rice-growing areas by type of irrigation

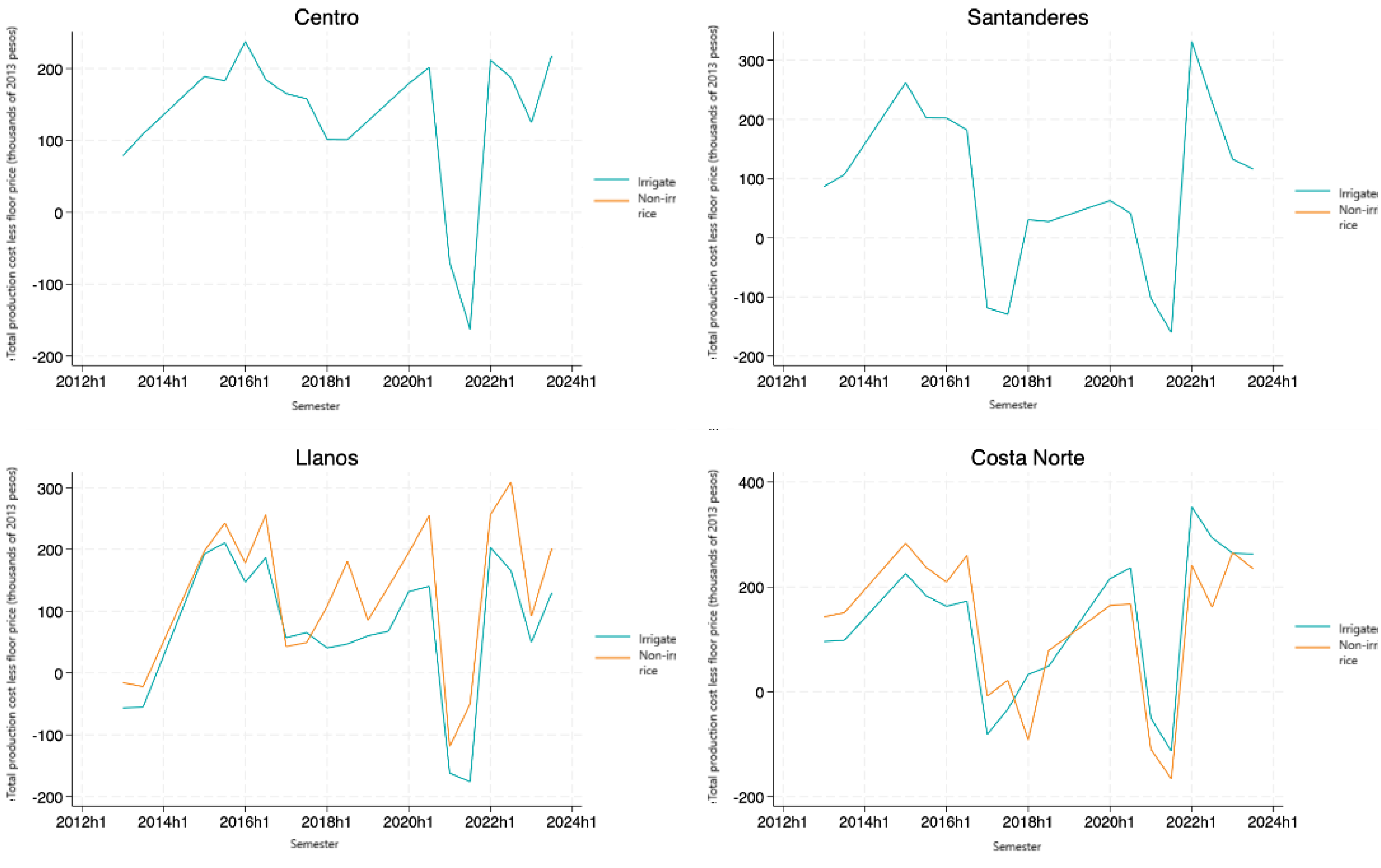


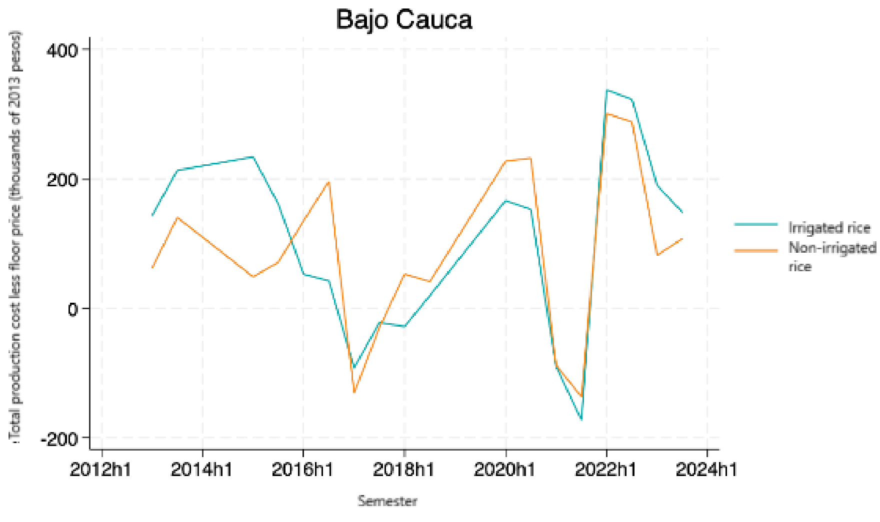


Source: Elaborated by authors based on data from DANE – SIPSA and Fedearroz

Figure 8 reveals the half-yearly evolution of estimated profit margins, calculated as the difference between the average price and the total production cost per ton, differentiating between irrigated and rainfed production in each rice-growing area. Overall, we observed positive margins, but with high volatility and episodes of negative margins in 2017 and 2021. In Llanos, rainfed producers tend to have higher profits, while in other areas, the difference between systems is less clear. We perceive that crop profitability is neither constant nor homogeneous, which must be considered when evaluating the economic sustainability of producers in different regions

Figure 8. Profit margins in rice-growing areas by type of irrigation

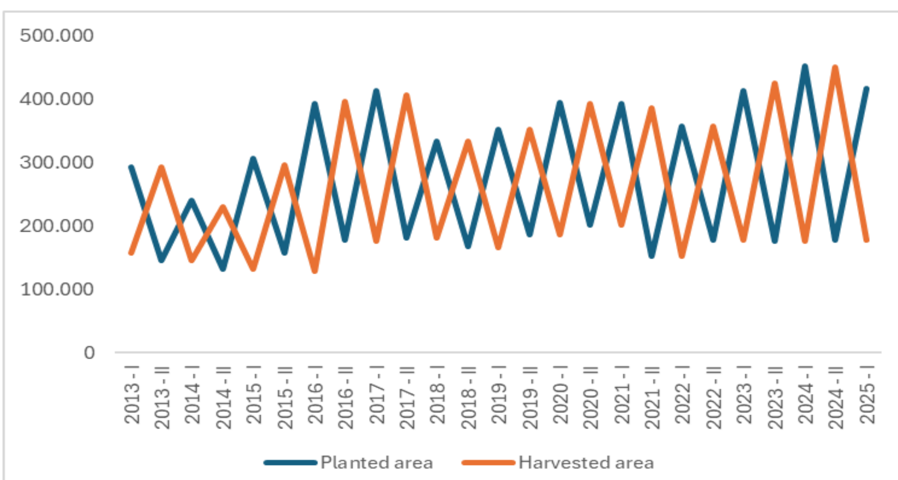

Centro
Santanderes
Llanos
Costa Norte
Total production cost less floor price (thousands of 2013 pesos)
Semester
2012h1
2014h1
2016h1
2018h1
2020h1
2022h1
2024h1
Irrigate
Non-irr
rice

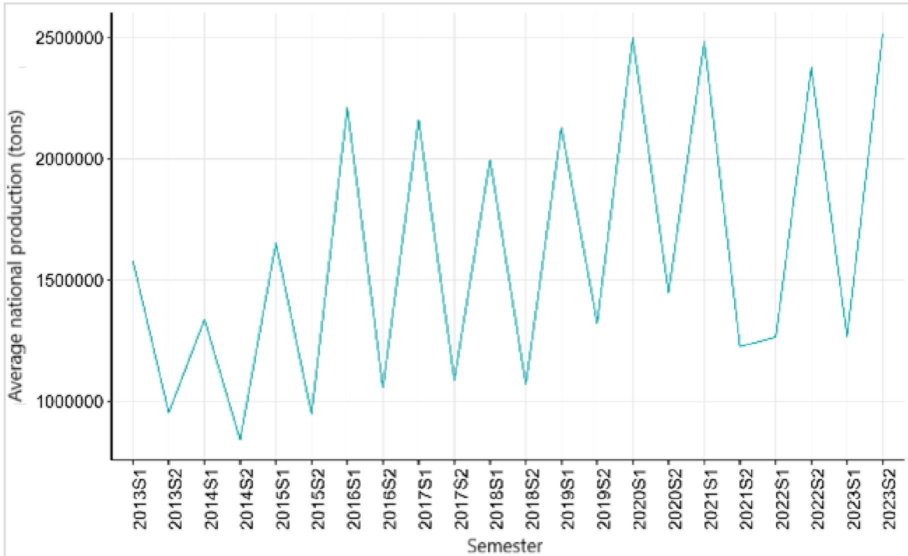


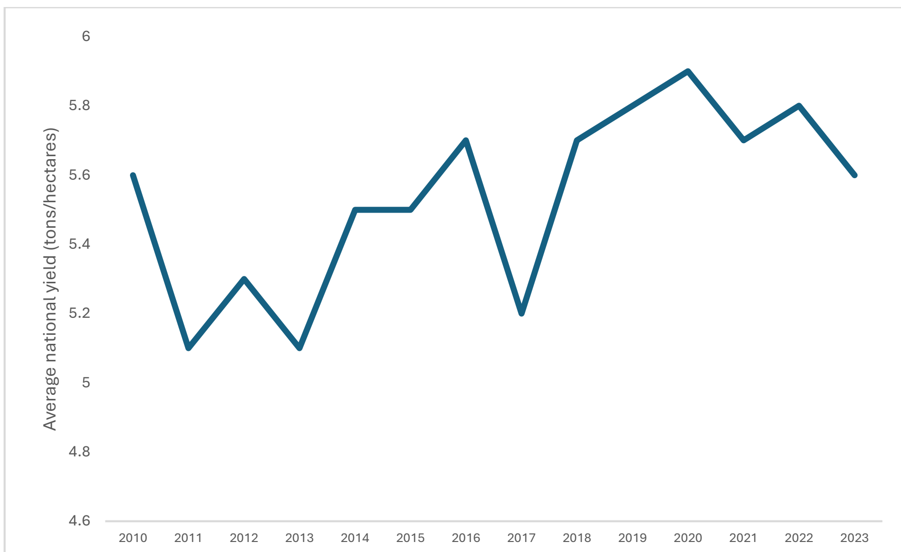
Source: Elaborated by authors based on data from DANE – SIPSA and Fedearroz

Figure 9 presents the semiannual evolution of three key variables at the national level: total paddy rice production (tons), planted and harvested area (hectares), and average yield per hectare (tons/ha) between 2013 and 2023. First, we observe strong semiannual seasonality in production, with a pattern alternating between high and low semesters each year. This fluctuation reflects regional planting and harvesting schedules, as well as the concentration of supply in certain periods. Despite this intra-annual variability, production shows a marked upward trend.

Figure 9. National dynamics of rice production, area and yield







Source: Elaborated by authors based on data from EVA

Taken together, the indicators presented allow us to understand the structural and operational context of the rice storage incentive program and the price, cost, margin, and production conditions faced by sector stakeholders during the analysis period. The statistical information documented here constitutes an input for interpreting the quantitative results. The high variability observed across regions, farming systems, and time periods highlights the need for differentiated approaches in the design and implementation of sectoral policy instruments.

b. Econometric results

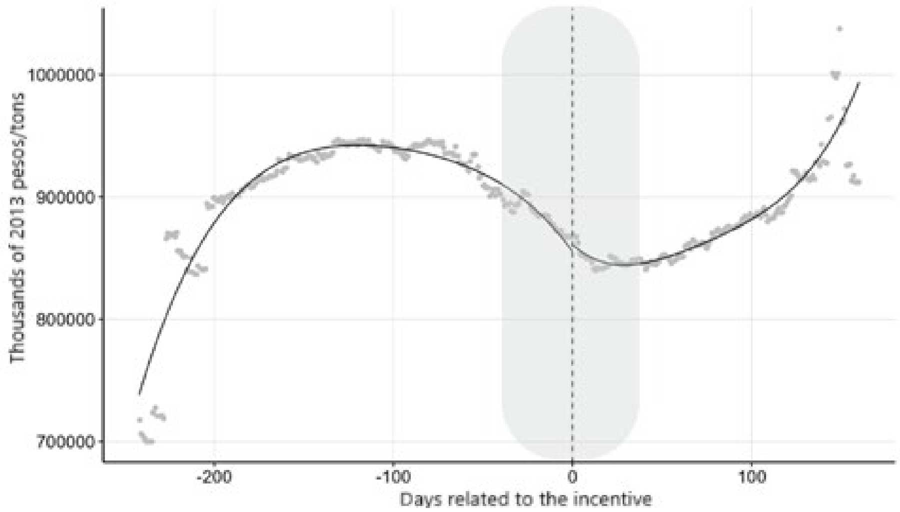
Below, we present an empirical evaluation of the impact of the Paddy Rice Storage Incentive Program on the price of green paddy rice and the income of rice producers. We base our analysis on four hypotheses: Hypothesis 1: The storage incentive stabilizes the market price; Hypothesis 2: The storage incentive smooths producers' income; Hypothesis 3: The storage incentive influences production decisions; Hypothesis 4: The storage incentive influences the prices of white rice that reach the final consumer.

Hypothesis 1: The storage incentive stabilizes the market price

Initially, we used daily rice prices at the departmental level. Uncertainty about the specific timing of the treatment creates a quasi-experimental condition; the incentive acts as an exogenous shock around which it is possible to compare the price trajectory just before and after its implementation. We conduct a comparative analysis in three contexts: i) years with the incentive and mill participation, ii) years with the incentive without mill participation, and iii) years without the incentive (2024). This analysis allows us to identify structural differences in price formation and policy effectiveness.

During the years in which the incentive was in operation with active participation of the mills (scenario 1), prices exhibited a markedly negative slope before the intervention, consistent with the seasonal harvest pattern. After the program went into effect, this trend moderated considerably, leading to stabilization and even recovery of prices (Figure 10). This break in the slope is consistent with the policy mechanism: by subsidizing storage through actors with operational capacity, the program reduces immediate supply pressure, as well as binding them to the price band mechanism. In Table 2, we observe that the slope before the harvest is negative, while the change in slope afterward (β_2) becomes positive and significant starting at 60-day windows. We also observe that in a 90-day window, the trend reverses, with a change in slope from −1,113 to +1,051 (β_1+β_2) pesos per day. We interpret this change as an endogenous price stabilization attributable to the incentive.

Figure 10. Daily price of green paddy rice relative to the days the Storage Incentive started (years with incentive and mill participation)



Source: Elaborated by authors based on data from *Bolsa Mercantil de Colombia*

Table 2. Results of discontinuous regression of daily green paddy rice price versus the effect of the incentive (years with incentive and mill participation)

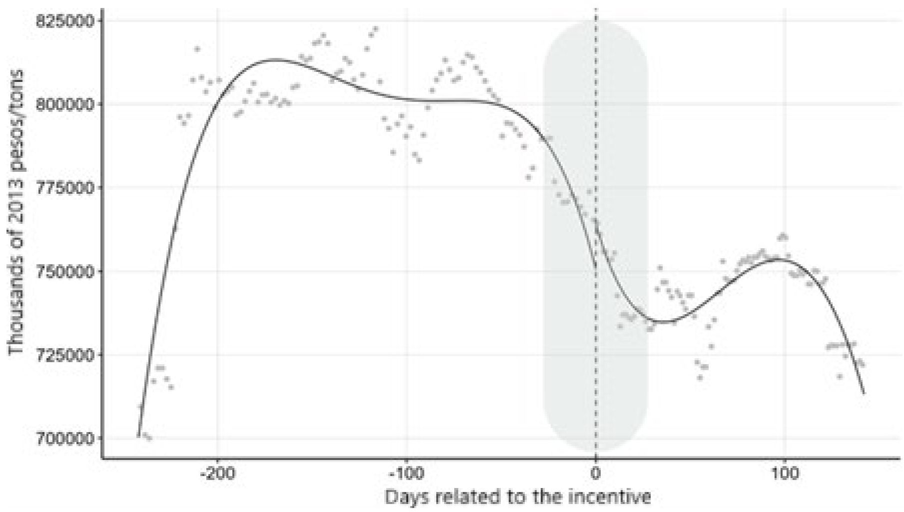
	Days related to the incentive		
	30 days	60 days	90 days
Pre-incentive trend (β_1)	-1524.424**	-1035.250***	-1113.56***
	(416.927)	(201.950)	(131.831)
Incentive effect (τ)	-1392.232	-12764.234**	-18393.54**
	(3256.720)	(4067.306)	(5288.485)
Change in trend (β_2)	627.375	723.375*	1165.02***
	(744.719)	(387.936)	(246.670)
Observations	4014	8184	12345
R^2	0.0297	0.0346	0.0469
R^2 adjusted	0.0261	0.0328	0.0458

Note: Standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1. Department-level fixed effects.

Source: Own elaboration (2025).

In contrast, when the program operates without mill participation (scenario 2), prices continue to follow a downward trajectory, with no statistically significant evidence of subsequent structural change (Figure 11). Similarly, we observe that the subsequent trend change is not statistically significant, suggesting that the incentive's transmission channel weakens (Table 3). These results indicate that, in the absence of purchasing agents with storage capacity, the program loses its ability to influence the market. The mere existence of the incentive is not sufficient if it is not linked to an effective collection and purchasing channel.

Figure 11. Daily price of green paddy rice relative to the days the Storage Incentive started (years without mill participation, 2017 and 2018)

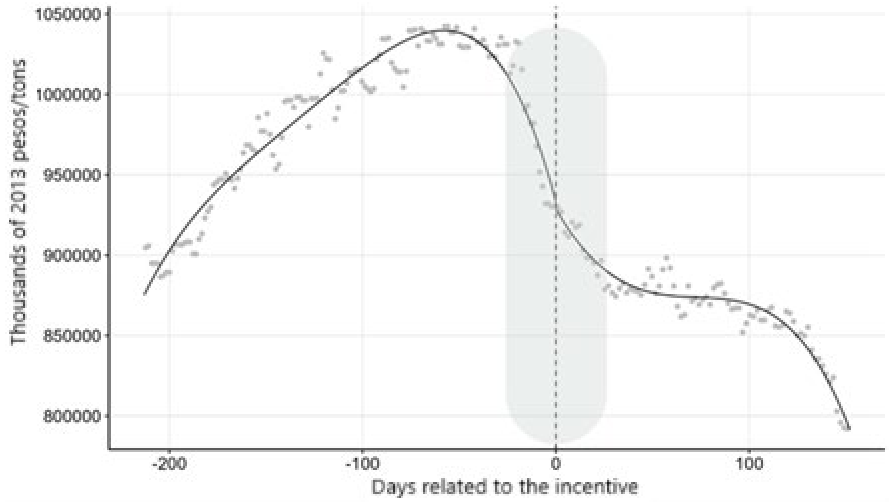


Source: Elaborated by authors based on data from *Bolsa Mercantil de Colombia*

In 2024, the year without the incentive (scenario 3), we observe a sustained decline in prices after the theoretical comparison point (the time when the program would typically have started[2]). Unlike scenarios 1 and 2, there is no sign of stabilization, and the negative slope remains constant, reflecting the seasonal pattern without any market buffer. Table 3 shows that the negative trend before the intervention is steeper, and although the subsequent slope change is positive, its magnitude is not sufficient to reverse the downward trajectory. In the 90-day window, prices decline 1,326 pesos per day before the cutoff, and the change in slope is only 630 pesos. As a robustness check, Annex 1 shows this exercise considering different random dates for the start of the incentive in 2024 with consistent results.

Figure 12. Daily price of green paddy rice relative to August 1 (non-incentive years)

[2] We randomly took a date from previous years: August 1st.



Source: Elaborated by authors based on data from *Bolsa Mercantil de Colombia*

Table 3. Results of discontinuous regression of daily green paddy rice price versus the effect of the incentive (years without incentive and without mill participation)

	Years without mill participation			Years without incentive		
	30 days	60 days	90 days	30 days	60 days	90 days
Pre-incentive trend (β_1)	-559.087	-643.685*	-644.28**	-4937.25**	-2425.7***	-1326.5***
	(453.29)	(342.682)	(216.19)	(438.878)	(154.153)	(119.824)
Incentive effect (τ)	-2832.32	-10897.566	-16304.5	13368.55*	-22375.1**	-50628.1***
	(6518.2)	(10159.74)	(13000.4)	(5506.666)	(7322.86)	(10115.2)
Change in trend (β_2)	-778.071	178.639	456.727	3236.02**	1320.16***	630.481**
	(440.84)	(503.618)	(375.675)	(596.603)	(299.164)	(283.089)
Observations	1403	2783	4163	793	1573	2353
R^2	0.4193	0.3792	0.3948	0.7863	0.7952	0.7785
R^2 adjusted	0.4135	0.3761	0.3928	0.7822	0.7932	0.7771

Note: Standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1. Department-level fixed effects

Source: Own elaboration (2025).

Finally, in 2024—without implementation of the program—prices show a sustained decline from the theoretical comparison point. Unlike in the years with intervention, no subsequent stabilization is evident. Table 4 shows that the slope prior to the cutoff is even steeper (up to −4,937 pesos per day in the 30-day window). Although the subsequent change in slope is positive and significant, its magnitude (+630 pesos per day in the 90-day window) is insufficient to reverse the downward trajectory.

The results show that although the market may exhibit some self-regulation at the margin, the storage incentive accelerates stabilization when accompanied by effective operating capacity (as a robustness exercise, annex 2 shows this exercise considering monthly green paddy rice prices at mills by municipality (2013-2024) with consistent results).

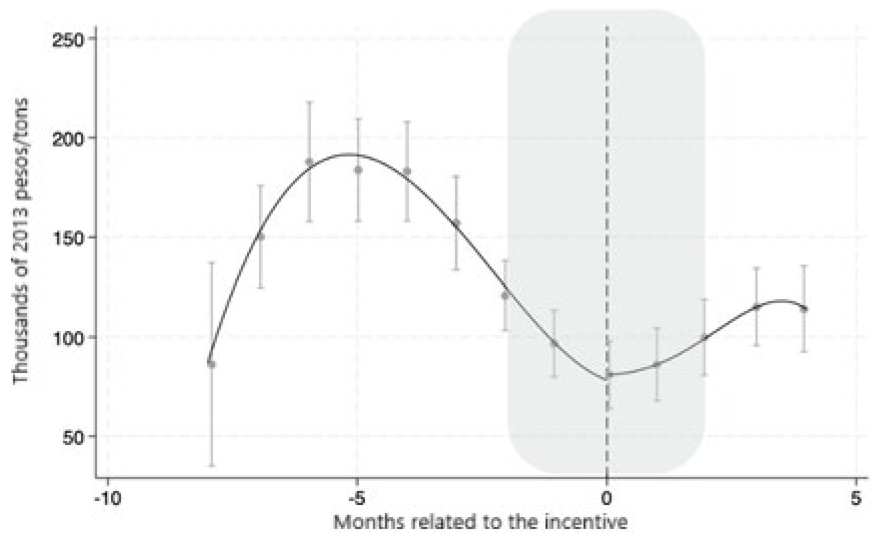
These results indicate that the program achieves its immediate objective of reducing seasonal price declines. However, price stabilization should not be interpreted as sufficient evidence of overall policy effectiveness, as maintaining producer prices through public intervention may also alter market incentives whose broader implications are explored in the discussion.

Hypothesis 2: The storage incentive smooths producers' income.

To infer the potential effect of the incentive on producers' income, we implemented a similar regression discontinuity model with the spread between the price of green paddy rice at the mills and total production costs as the dependent variable. Cost information is available at the rice-growing area level by semester and by irrigation system (irrigated and non-irrigated).

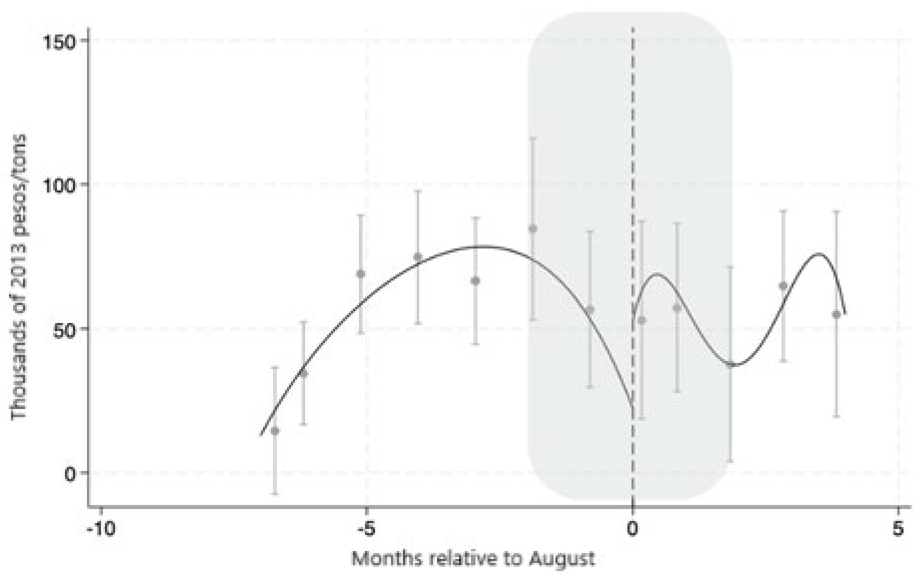
Figures 13 and 14 show the evolution of the spread in irrigated areas, in years with and without incentives, respectively. In years with incentives, the spread tends to stabilize more quickly after the program starts, in contrast to years without incentives, where the spread exhibits an inconsistent trajectory over the following months. This finding suggests that the program may be helping to smooth out producers' incomes at times when they would face steep seasonal declines in their margins.

Figure 13. Green paddy rice price differential with total production costs relative to the program start month (years with incentive) - IRRIGATION



Source: Elaborated by authors based on data from DANE – SIPSA

Figure 14. Green paddy rice price differential versus total production costs relative to August (years without incentive) - IRRIGATION



Source: Elaborated by authors based on data from DANE – SIPSA

In irrigated areas during years with incentives, the pre-program trend is negative and statistically significant after three and four months, indicating that margins had been deteriorating before the intervention. After the start of the incentive, we observed a statistically significant change in the trend: the coefficient of change in trend (β_2) is positive and statistically significant at all cutoffs, implying a progressive recovery in net income after the program's implementation. However, the immediate effect of the incentive (τ) is not statistically significant, suggesting that the improvement in income is not instantaneous, but materializes in the following months.

As for the total value of the incentive, the estimator is negative and statistically significant, which implies that bigger programs are associated with lower profitability for producers. This speaks of the supply and demands dynamics of the market, as higher supply involves a higher need for resources to evacuate inventory and drives prices down, reducing profitability. This means that, while the Program can cut downward trends in prices after its implementation, the overall market trends still impact the profitability of producers.

In contrast, in years without incentives, although there is a slight improvement in the trend after the reference month (August), it is not statistically significant. The immediate effect is also unclear. This finding reinforces the idea that the program could function as an income stabilization mechanism. Table 4 presents the results of a discontinuous regression applied to the different time windows used in the green paddy rice mill price model.

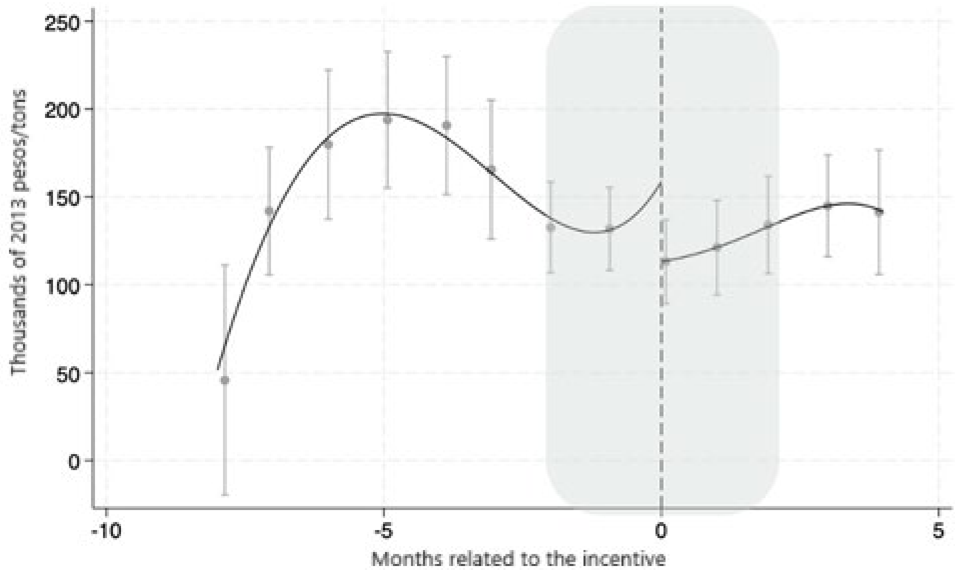
Table 4. Results of discontinuous regression of the effect of the incentive on the price differential less production costs of green paddy - IRRIGATION

Dependent variable: Green paddy price differential less rice production cost (thousands of 2013 pesos/ton)						
	Years with incentive			Years without incentive		
	2 months	3 months	4 months	2 months	3 months	4 months
Pre-incentive trend (b_1)	-20.26	-23.03***	-27.31***	-16.92	-11.89	-3.909
	(12.61)	(5.096)	(3.217)	(22.58)	(11.16)	(6.801)
Incentive effect (t)	3.823	5.926	10.45	14.10	9.678	-0.938
	(14.12)	(7.827)	(6.474)	(25.09)	(17.00)	(13.79)
Change in trend (b_2)	25.82**	32.23***	38.05***	21.73	10.46	3.070
	(13.12)	(5.619)	(3.702)	(23.37)	(12.24)	(7.841)
Incentive value (Millions COP 2013)	-.00154**	-.00158***	-.00174***			
	(0.00016)	(0.00015)	(0.00015)			
Constant	135.0***	127.6***	121.4***	-75.14***	-55.65***	-35.46**
	(15.80)	(10.08)	(8.915)	(25.28)	(17.19)	(13.94)
Observations	1116	1534	1918	118	161	208

Source: Own elaboration (2025).

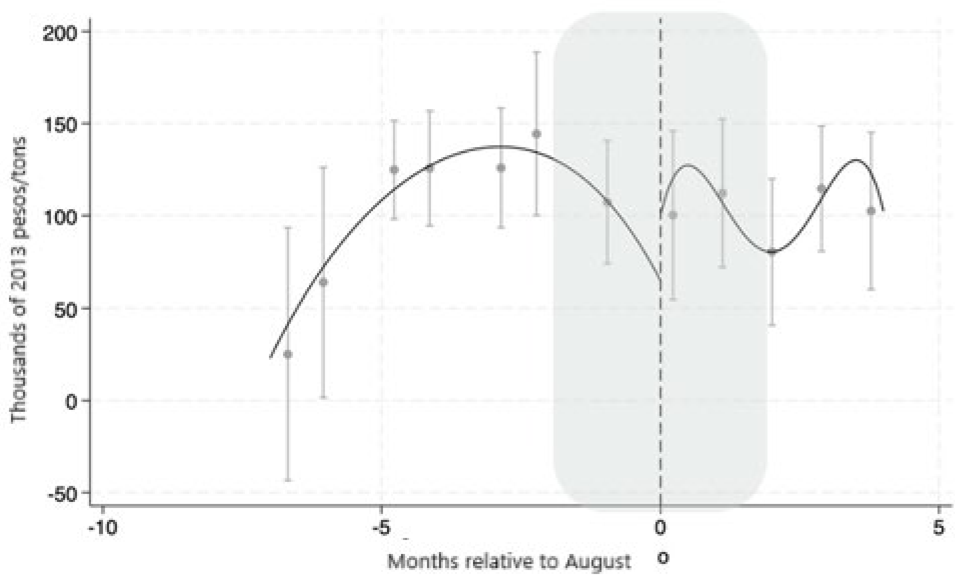
We analyze a similar pattern in Figures 15 and 16, but for non-irrigated areas. While visually, there also appears to be a stabilization of net income in the years with incentives, the results in Table 5 show that in rainfed areas, the program's impact is less clear. The pre-program trend is more erratic, and although we observe a positive change in the trend [β]_2 at four months, this is only significant in that time window.

Figure 15. Green paddy rice price differential versus total production costs relative to the program start month (incentive years) - NON-IRRIGATED



Source: Elaborated by authors based on data from DANE – SIPSA

Figure 16. Green paddy rice price differential versus total production costs relative to August (years without incentive) - NON-IRRIGATED



Source: Elaborated by authors based on data from DANE – SIPSA

In terms of the immediate effect (τ), the program does not appear to have a significant impact either in years with or without incentives, suggesting that, as with irrigation, the benefits of the program on producers' net income accumulate over time and are not immediately observed. As for the impact of the total value of the Program, we observe the same tendency as with the irrigated system, which suggests that the market dynamics are consistent across systems.

Table 5. Results of discontinuous regression of the effect of the incentive on the price differential less production costs of green paddy - NON-IRRIGATED

Dependent variable: Green paddy price differential less rice production cost (thousands of 2013 pesos/ton)						
	Years with incentive			Years without incentive		
	2 months	3 months	4 months	2 months	3 months	4 months
Pre-incentive trend (b_1)	7.717	0.998	-11.27**	-33.74	-23.54	-9.342
	(19.88)	(7.950)	(5.014)	(39.79)	(15.45)	(8.386)
Incentive effect (t)	-25.97	-18.95	-4.096	28.46	20.03	2.694
	(21.94)	(11.80)	(9.684)	(43.32)	(22.57)	(16.48)
Change in trend (b_2)	-0.127	8.895	21.54***	43.03	21.73	7.525
	(20.57)	(8.674)	(5.684)	(40.87)	(16.73)	(9.576)
Incentive value (M. COP 2013)	-.00260***	-.00259**	-.00272**			
	(0.00024)	(0.00022)	(0.00021)			
Constant	160.3***	148.9***	134.5***	2.019	18.59	39.07**
	(23.98)	(14.59)	(12.67)	(43.19)	(22.06)	(15.73)
Observations	591	799	995	63	84	109

Source: Own elaboration (2025).

In summary, the results suggest that the storage incentive has a smoothing effect on rice producers' net income, especially in irrigated areas, where production conditions are more stable, and market signals may be more effective. In these areas, the program's implementation reverses the negative trend in margins typically observed in the months prior to the start of the incentive. In non-irrigated areas, the effect is weaker and less consistent, possibly due to greater climate and productivity variability, which may limit the program's effectiveness as an income stabilization mechanism. In both cases, a higher total value of the Program is associated with a decrease in profitability for the producers.

Although these findings suggest that the incentive protects producers' income in the short term, they do not necessarily imply improvements in productivity or structural competitiveness. Rather, they reflect temporary income support associated with the intervention. Furthermore, the fact that a higher total value of the incentive correlates with a decrease in profitability suggests that the incentive cannot fully offset the broader market dynamics derived from oversupply.

Hypothesis 3: The storage incentive influences production decisions

To approach the influence of the storage incentive on producers' decisions, we ran the following model and obtained the results described in Table 6. Note that in the regression we took the total value of the incentive in the previous semester.

$$Y_{i,t} = a_i + \lambda_t + \beta_1 \cdot Incentive_{i,t-1} + \beta_2 \cdot Price_{i,t-1} + \beta_3 \cdot Cost_{i,t-1} + \varepsilon_i$$

Table 6. Linear regression results for production, yield, and planted/harvested area

	Production	Harvested Area	Planted Area	Yields
$\mathrm{Incentive}_{t-}$	2.4463**	0.3777*	0.4948	0.000083
	(0.9055)	(0.1667)	(0.2703)	(0.00007)
Price_{t-1}	0.0120*	0.0017*	0.0001	0.0000
	(0.0057)	(0.0007)	(0.0008)	(0.0000)
Cost_{t-1}	11.4468	1.1773	-2.7889	0.0075
	(10.013907)	(1.2832)	(2.1938)	(0.0023)
N	385	385	385	385

Source: Own elaboration (2025).

The results show that the storage incentive provided in the previous semester is associated with changes in farmers' decisions, particularly through increased production. The results show that, on average, for every additional million pesos of incentive provided in a semester, production in the following semester increases by 2.45 tons per municipality, a statistically significant result. This effect is not associated with yield improvements, but rather with an increase in the area harvested: the incentive is associated with 0.38 additional hectares harvested, suggesting an extensive response on the part of producers.

In this sense, the incentive is not only related to post-harvest market conditions but also appears to influence farmers' production decisions. This finding implies that its implementation can induce adjustments in the magnitude of available supply in the following cycle, through the continuation or expansion of areas designated for cultivation due to the reduction in perceived market risk.

The positive response in the harvested area indicates that producers react to the economic signal generated by the storage incentive. While this expansion may contribute to sustaining supply in the short term, it also suggests that the program influences production decisions beyond price stabilization, raising questions about whether the induced production growth remains aligned with underlying market conditions.

Hypothesis 4: The storage incentive influences the prices of white rice that reach the final consumer.

To explore whether the storage incentive influences the final consumer, we evaluated the relationship between the price of white rice at wholesale centers and the average price of green paddy rice at mills in previous semesters, with and without the incentive. To do this, we estimated the following model and obtained the results presented in Table 7. Since green paddy price data are only available in municipalities with mills, where there are not necessarily wholesale centers, we explored this effect at the municipal, departmental, and rice-growing area levels.

$$Y_{i,t} = \alpha + \beta_1 \cdot PriceGreenPaddy_{i,t-1} + \beta_2 \cdot PriceGreenPaddy_{i,t-1} \cdot Incentive_{t-1} + \beta_3 \cdot PriceGreenPaddy_{i,t-2} + \beta_4 \cdot PriceGreenPaddy_{i,t-2} \cdot Incentive_{t-2} + \varepsilon_i$$

Table 7. Linear regression results of white rice price versus green paddy price lags

Dependent Variable: Price of premium rice at wholesale centers (COP/kg)			
	Municipality	Department	Rice-growing area
Price Green Paddy rice$_{t-1}$	-0.417**	-0.456**	-0.373
	(0.201)	(0.188)	(0.311)
Price Green Paddy rice$_{t-1}$ * Incentive$_{t-1}$	0.593	0.901**	0.434
	(0.421)	(0.374)	(0.522)
Price Green Paddy rice$_{t-2}$	0.803***	0.618***	0.616**
	(0.195)	(0.172)	(0.289)
Price Green Paddy rice$_{t-2}$ * Incentive$_{t-2}$	-0.713*	-0.353	-0.619
	(0.410)	(0.366)	(0.513)
incentive value	0.0277**	0.0344***	0.0266*
	(0.0113)	(0.0120)	(0.0150)
Constant	1611.0***	1700.7***	1838.4***
	(282.7)	(277.7)	(392.6)
Observations	115	151	90

Source: Own elaboration (2025).

The results indicate that, in the absence of the incentive, the price of green paddy rice at the mills in the previous semester had a negative and statistically significant effect on the price of white rice. This suggests that, without intervention, an increase in the harvest price of raw rice translates into a decrease in the price received by the final consumer in the following semester. However, this effect disappears when the storage incentive is introduced. The interaction between the price of paddy rice and the incentive in the previous semester shows a positive relationship, significant at some levels of aggregation, indicating that the incentive alters the original relationship between the two prices. In other words, the existence of the incentive neutralizes or reverses the impact that the price of green paddy rice would have on that of white rice.

The observed changes in price transmission suggest that the policy affects market dynamics beyond producer prices alone. These findings indicate that the intervention may modify the functioning of the rice value chain, an aspect that becomes particularly relevant when assessing the broader efficiency of stabilization policies.

Taken together, these findings reveal a clear trade-off. On the one hand, the storage incentive achieves its immediate objective of mitigating seasonal price declines and protecting producers' incomes, particularly in irrigated systems. On the other hand, the evidence indicates that the policy also alters production incentives and market dynamics in ways that may have broader implications for the long-term efficiency, competitiveness, and sustainability of the sector. These trade-offs cannot be fully understood from the estimated impacts alone and therefore require a broader policy discussion, which is developed in the following section.

5. Discussion and Conclusion

The empirical evidence presented in this study suggests that the Colombian Dry Paddy Rice Storage Incentive Program embodies a fundamental trade-off that has been widely documented in the literature on commodity price stabilization policies. While the program succeeds in mitigating seasonal price declines and smoothing producers' income in the short term, these benefits are accompanied by structural distortions that may compromise the sector's long-run efficiency and competitiveness. Rather than interpreting the observed price stabilization as unequivocal evidence of policy success, our results indicate that the program achieves its objectives through mechanisms that distort market signals, encourage production expansion beyond competitive levels, and increase dependence on recurrent public intervention. This distinction is particularly relevant because the effectiveness of stabilization policies should be assessed not only by their immediate capacity to reduce price volatility, but also by their long-term implications for productivity, fiscal sustainability, and market efficiency (Newbery & Stiglitz, 1981; Wright & Williams, 1982; Galtier, Vindel, & Timmer, 2013)

This interpretation is consistent with international evidence on commodity storage and price support programs. Experiences in several developing countries show that although buffer stock schemes and storage subsidies can temporarily stabilize agricultural markets, they frequently generate unintended consequences such as artificial oversupply, fiscal dependence, delayed structural adjustment, and weaker incentives for technological upgrading when maintained over long periods (Galtier, Vindel, & Timmer, 2013; Timmer, 1989) (World Bank B, 2022). Consequently, the Colombian experience should not be interpreted as evidence that the storage incentive ought to be expanded or permanently maintained, but rather as an opportunity to understand both the benefits and the limitations of stabilization policies. From this perspective, the following discussion evaluates the program under a broader effectiveness framework, balancing its short-term achievements against the structural costs identified through the empirical analysis.

Against this background, the empirical evaluation of the Paddy Rice Storage Incentive Program yields four main findings regarding the hypotheses proposed. These findings are discussed not only in terms of the program's ability to stabilize prices and producers' income in the short run, but also considering their broader implications for market efficiency, fiscal sustainability, and the long-term competitiveness of the Colombian rice sector.

We plan the effectiveness and efficacy analysis using an approach based on the OECD Development Assistance Committee (DAC) Quality Standards for Development Evaluation, (OECD & Organization for Economic Co-operation and Development, 2010).That is, we will consider the criteria of relevance, efficiency, impact, and sustainability in the discussion regarding compliance with rice public policy instruments.

Thus, considering the results of the evaluation of the first hypothesis, we confirm that the storage incentive smooths price declines under oversupply scenarios, contributing to a faster stabilization of the green paddy rice market. The estimated discontinuity shows that the program reversed the pre-existing downward price trend in the treated scenario, whereas no comparable stabilization was observed in the comparison scenarios. These findings indicate that the program effectively achieved its immediate objective of mitigating seasonal price volatility.

Softening price declines under oversupply conditions was the primary objective for which the program was created. Therefore, the results confirm its relevance as a policy instrument to prevent abrupt income losses for producers and stabilize the market in the short term. Nevertheless, the mechanism through which stabilization occurred raises important questions regarding the program's broader effectiveness. Rather than reflecting a structural improvement in market performance, price stabilization appears to have resulted largely from externally supported price fixing associated with the storage incentive. Consequently, the program functioned primarily as a containment mechanism that alleviated immediate market pressures without addressing the structural drivers of competitiveness and modernization in the rice sector. As one representative from the milling industry summarized, *"The incentive solved short-term problems, but it failed to stem the market reaction."*

The absence of comparable effects in scenarios 2 and 3 further suggests that the program's effectiveness depends critically on the participation of rice mills, the main purchasers and storage providers in the value chain. Because participation required mills to comply with predetermined purchase prices, the observed stabilization may have resulted not only from increased storage but also from the implicit establishment of a price floor. This finding highlight that the effectiveness of the incentive depends less on the storage mechanism itself than on the incentives created for market participants, reinforcing the need to evaluate both the immediate benefits and the longer-term implications of this type of intervention.

The program’s dependence on the incentives created by the market participants also calls into question its future effectiveness. As the trade liberalization with the U.S. brings more agents into the market, the ability of the program to enforce the implicit price floor is reduced, especially for rice importers that have no need for storage or for local supply and, therefore, would not be subject to any of the program’s mechanisms.

Analyzing the results of the second hypothesis, we find that the storage incentive also contributes to stabilizing producers' income by reducing the decline in production margins. However, this effect is heterogeneous across production systems, suggesting that the effectiveness of the program depends on the structural characteristics of producers. While irrigated systems benefit from greater income stabilization due to their more stable cost structure, no comparable effect is observed in non-irrigated systems, where greater variability in production costs and productivity limits the program's ability to smooth income fluctuations.

This heterogeneity reveals a second trade-off in assessing the program's effectiveness. Although the incentive succeeds in cushioning income losses for a subset of producers, its benefits are unevenly distributed across production systems. In particular, producers with limited storage capacity or operating under non-irrigated conditions appear to benefit less from the intervention, which highlights important gaps in coverage and access. These findings suggest that a uniform price stabilization mechanism may be insufficient to address the diverse constraints faced by Colombian rice producers and reinforce the need for more differentiated policy instruments.

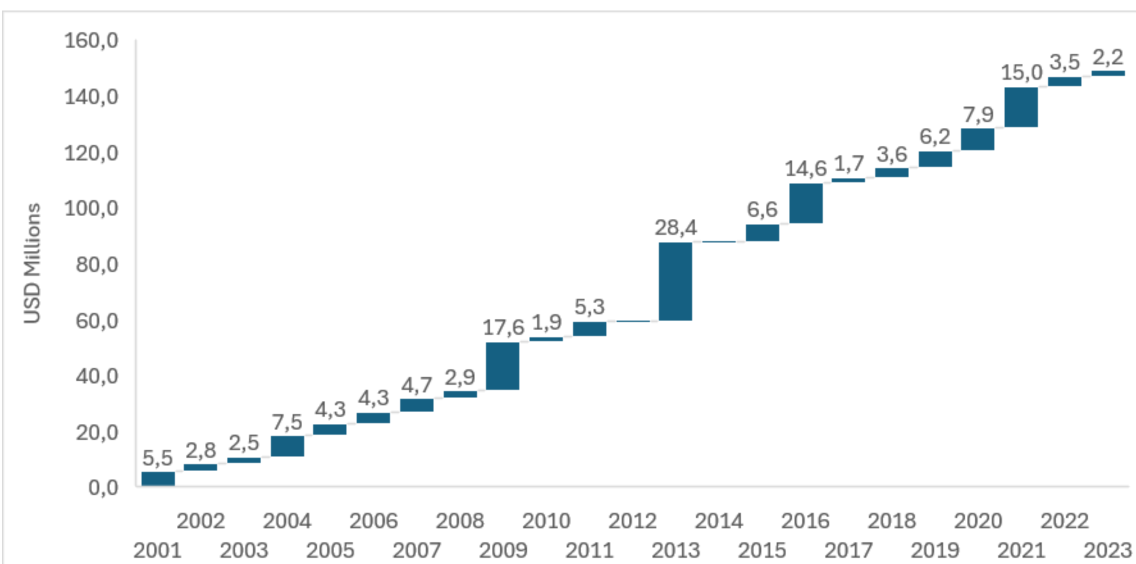
Moreover, the negative relationship between the total value of the program and producers' income suggests that, although the storage incentive mitigates immediate income losses, it cannot fully offset the market effects associated with larger production volumes and increased storage requirements. In other words, as the magnitude of market imbalances grows, the capacity of the program to compensate producers becomes progressively more limited, reinforcing the notion that recurrent storage support alone cannot address the structural sources of income instability.

These findings also underscore the importance of strengthening the information base on which agricultural policies are designed. The absence of integrated, disaggregated, and up-to-date agricultural information has historically constrained the development of differentiated interventions tailored to producers' heterogeneous conditions. Advancing interoperable information systems, such as those proposed under Colombia's Comprehensive Agricultural Risk Management Strategy (SIGRA), would facilitate the identification of vulnerable territories, improve policy targeting, reduce institutional duplication, and incorporate dimensions such as gender, land tenure, and climate vulnerability into agricultural decision-making, thereby strengthening both rural equity and sectoral resilience (MADR, 2018).

When analyzing hypotheses 3 and 4, we find that the storage incentive has a positive relationship with rice production, as the results suggest an anticipated response from producers, who adjust their harvesting decisions based on the program's expectations. We find that for every additional million pesos delivered through the incentive in the previous semester, production increases by approximately 2.4 tons, and the harvested area increases by 0.37 hectares. This could affect the efficient decision-making process of producers, as it no longer responds mainly to the expectations of what is going to happen in the market, but also to the expectations of future market interventions, as mentioned by (World Bank, 2022).

This dynamic has a clear impact on fiscal sustainability, as distorted market signals lead to greater supply-demand imbalances, which require more storage, and therefore a higher budget for the incentive. Figure 17 shows the annual budget for the Rice Incentive program, measured in millions of dollars. The graph shows how the incentive behaved cyclically, going from periods of steady growth to abrupt reductions. This responds to the dynamics of the sector, As the incentive distorted economic incentives, production grew the following year. This went on until the size of the distortion was great enough that the incentive could not offset market dynamics. As a result, prices lowered, discouraging production, and reducing the need for the storage incentive on the following year. The main issue with this dynamic is that market distortions became greater with every cycle, requiring a higher budget to offset them. In total, the government allocated 149.01 million dollars to this program between 2001 and 2023, 60% of which were allocated from 2013 onwards. This speaks to the sustainability of the program, as more resources were needed to cover the growing storage needs derived from greater production.

Figure 17. Total value of paddy rice storage incentive (2001 – 2023)



Source: Elaborated by authors based on data from MADR & (BanRep, 2026)

A second issue with the policy is that public resources destined to rice were assigned almost exclusively to this program, which left an ever-growing gap in the provision of public services such as irrigation, roads, research, and technology transfer. This impacted productivity on two fronts: On one hand, the price intervention mitigated the need to improve productivity; and on the other, the lack of resources made it harder for farmers to adopt new technologies and become more productive.

We also find that the existence of the incentive erases the effect that the price of green paddy rice at mills has on the future price of white rice at wholesale centers. By covering storage costs, the incentive may reduce the effect of green paddy rice on white rice.

These two results have several considerations in terms of effectiveness and efficiency according to OECD criteria. Although the incentive was able to smooth price volatility, it also led to greater oversupply due to excessive increases in production, increased fiscal costs, and dependence on subsidies. This finding would reinforce the idea that the incentive functioned more as a containment policy than as a structural policy for the rice sector.

Thus, through an evaluation of the storage incentive, the study identified structural problems in the Colombian rice sector, such as weaknesses in the competitiveness of the primary sector (production link), marked seasonality of production, high price volatility, and increasing vulnerability to climate events.

The results show that, while the incentive contributed to stabilizing prices in the short term, it also generated significant market distortions. This instrument has promoted overproduction, sustained artificially high prices, and reduced incentives and resources to improve the sector's productivity and competitiveness, perpetuating a dependence on subsidies and emergency intervention mechanisms.

These findings also suggest that improving the storage incentive alone is unlikely to address the structural constraints limiting the competitiveness of the Colombian rice sector. Although the program effectively mitigates seasonal price fluctuations, it does not directly address the underlying drivers of low productivity, high production costs, technological gaps, or the limited adaptive capacity of producers. Consequently, policy discussions should move beyond the question of whether the storage incentive should be expanded or refined and instead consider how public resources can be allocated across complementary policy instruments capable of generating more persistent productivity gains. This could include investments in irrigation infrastructure, agricultural innovation, extension services, access to tailored financial instruments, logistics infrastructure, digital market information systems, and climate adaptation measures, all of which strengthen competitiveness without relying on recurrent market interventions (OECD, 2020; OECD ; World Bank;, 2022) Repurposing Agricultural Policies and Support: Options to Transform Agriculture and Food Systems to Better Serve the Health of People, Economies, and the Planet)

From a public finance perspective, these findings also highlight the importance of considering opportunity costs when allocating scarce fiscal resources. Recurrent expenditure on storage subsidies may be justified under exceptional market conditions; however, maintaining such interventions as a permanent policy instrument may reduce the resources available for investments that generate long-term productivity growth and structural transformation. International evidence increasingly suggests that reallocating agricultural support toward public goods—including irrigation systems, research and development, rural infrastructure, agricultural financing, and innovation—generates higher and more persistent returns than recurrent price support mechanisms (Fan, Gulati, & Thorat, 2007)).

These findings have broader implications for the design of agricultural policies in Colombia. Beyond assessing whether the storage incentive achieved its immediate objectives, they call for a broader reflection on the opportunity costs, fiscal sustainability, and long-term efficiency of recurrent market interventions, particularly as the sector prepares for the complete elimination of tariffs under the United States–Colombia Free Trade Agreement by 2030.

Beyond evaluating the effectiveness of a specific agricultural policy instrument, this study contributes to a broader understanding of the trade-offs inherent in commodity price stabilization policies. The results demonstrate that public interventions can simultaneously achieve short-term stabilization objectives while generating incentives that may undermine long-term competitiveness and fiscal sustainability. In this sense, documenting modest or distortionary effects should not be interpreted as evidence of policy failure; rather, such findings provide essential evidence for improving policy design, strengthening the efficiency of public expenditure, and informing the reallocation of public resources toward more effective interventions. Rigorous evaluations identifying limited impacts are therefore as valuable as those documenting positive effects because they enable governments to distinguish between policies that merely buffer market fluctuations and those capable of promoting structural transformation (OECD B, 2020) (World Bank B, 2022).

From a policy perspective, the results also highlight the importance of considering opportunity costs when allocating public resources. The fiscal resources devoted to recurrent storage incentives could alternatively support investments in irrigation infrastructure, technological innovation, logistics, extension services, climate adaptation, market information systems, or productivity-enhancing programs that strengthen the sector's competitiveness over the long term. While storage incentives may be justified under exceptional market conditions, maintaining them as a recurrent policy instrument may delay structural adjustment and reduce incentives for innovation and productivity growth.

As Colombia approaches the complete elimination of tariffs under the United States–Colombia Free Trade Agreement, strengthening the sector's competitiveness will become increasingly important. Future agricultural policies should therefore move progressively from recurrent market interventions toward more targeted, evidence-based and productivity-enhancing instruments that improve resilience without generating persistent market distortions. More broadly, this study illustrates how rigorous impact evaluation contributes not only to assessing whether public policies achieve their intended objectives, but also to informing more efficient and sustainable public investment decisions.

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7. Annexes

Annex 1: Robustness test with alternative dates for 2024

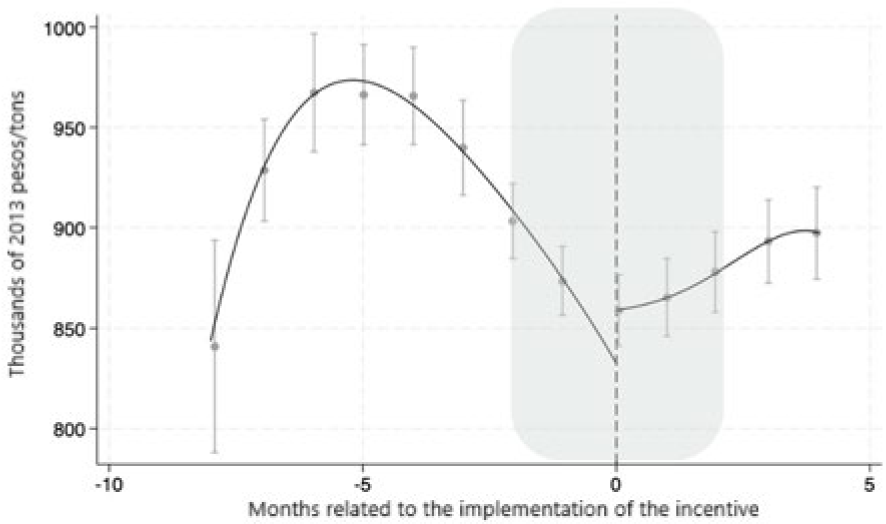
Since the Storage incentive program was not implemented in 2024, we assumed the counterfactual date of August 1 for the principal analysis of scenario 3, which approximates the midpoint of the program's historical implementation range. As a robustness check, we estimated the RKD models using two alternative dates: August 15 (the incentive implementation date in 2020) and September 4 (the latest date on record, 2015). The results of this sensitivity test indicate that the conclusions regarding the absence of the incentive in 2024 remain robust under different assumptions about the counterfactual implementation date.

	Assumption (August 1)			Alternative 1 (August 15)			Alternative 2 (September 4)		
	30 days	60 days	90 days	30 days	60 days	90 days	30 days	60 days	90 days
Pre-incentive trend (β_1)	-4937.25*** (174.896)	-2425.68*** (77.755)	-1326.47*** (48.376)	-1908.60** (176.296)	-2977.68*** (78.244)	-2117.53*** (48.523)	-1732.77*** (186.190)	-2215.32*** (82.238)	-2432.98*** (49.281)
Incentive effect (τ)	13368.55*** (3037.075)	-22375.05*** (2695.306)	-50628.10*** (2514.447)	-5771.46* (3061.392)	-3993.95 (2712.255)	-21994.00*** (2522.068)	6705.21** (3233.204)	18184.18*** (2850.717)	23606.14*** (2561.472)
Change in trend (β_2)	3236.02*** (239.728)	1320.16*** (108.202)	630.48*** (67.674)	765.99*** (241.647)	2594.22*** (108.883)	1812.30*** (67.879)	2080.77*** (255.209)	2059.44*** (114.441)	2163.49*** (68.940)
Observations	793	1573	2353	793	1573	2353	793	1573	2353
R^2	0.7863	0.7952	0.7785	0.7164	0.7656	0.7702	0.7060	0.6467	0.7234
Adjusted R^2	0.7822	0.7932	0.7771	0.7109	0.7633	0.7687	0.7003	0.6433	0.7216

Annex 2: Monthly green paddy rice price at mills by municipality (2013-2024)

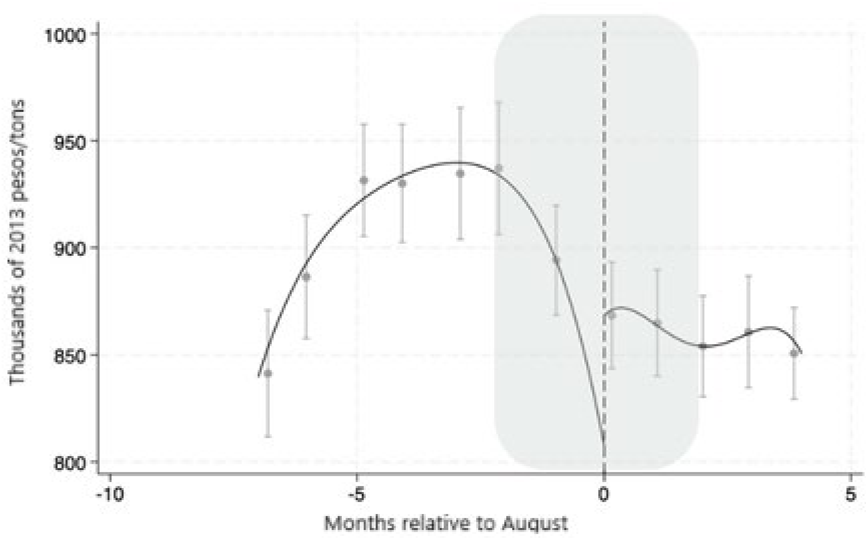
When we analyze green paddy rice prices at mills at the municipal level, we find consistent results. Below is the monthly average price trajectory for 2014 and 2024, years in which the storage incentive was in effect and years in which it was not. In both cases, we observe a pattern like the daily price data. During years with the incentive, the seasonal decline in prices prior to its implementation stabilizes more quickly than in years without the program.

Monthly price of green paddy rice at mills relative to the month in which the incentive began (years with incentive



Source: Elaborated by authors based on data from DANE – SIPSA

Monthly price of green paddy rice in mills relative to August (years without incentive)



Source: Elaborated by authors based on data from DANE – SIPSA

Dependent variable: Price of green paddy rice at mills (thousands of 2013 pesos/ton)						
	Years with incentive			Years without incentive		
	2 months	3 months	4 months	2 months	3 months	4 months
Pre-incentive trend (b_1)	-21.10**	-23.48***	-27.20***	-35.07	-29.02**	-18.42***
	(9.276)	(3.991)	(2.691)	(28.90)	(11.33)	(6.602)
Incentive effect (t)	4.606	6.133	9.840*	9.618	2.957	-10.58
	(10.39)	(6.130)	(5.415)	(32.39)	(17.50)	(13.47)
Change in trend (b_2)	26.21***	32.49***	38.00***	32.40	24.60**	14.07*
	(9.649)	(4.401)	(3.096)	(30.03)	(12.50)	(7.629)
Incentive value (M. COP 2013)	-.00024**	-.00033**	-.00051***			
	(0.00012)	(0.00012)	(0.00012)			
Constant	842.4***	842.9***	842.7***	762.7***	768.2***	779.0***
	(11.85)	(8.217)	(7.825)	(33.09)	(18.36)	(14.34)
Observations	1116	1534	1918	222	304	391