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Vulnerabilities In Brazil's Fertiliser Imports: External Shocks And Pathways For Diversification

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Abstract:
Brazilian agriculture relies on imported fertilisers, which raises costs and exposes the sector to supply shocks. The National Fertiliser Plan 2022–2050 (PNF) aims to reduce the share of imports from 85% to 45% by 2050 and advocates both the promotion of organic fertilisers among smallholders and the diversification of foreign suppliers alongside the expansion of domestic input production. Using the Heckscher–Ohlin framework, it argues that Brazil can reallocate resources to activities aligned with its endowments of land, water and labour and thereby strengthen comparative advantage. This study's proposal to replace fertiliser imports with domestic production combines a logical framework (theory of change) and impact evaluation methods to identify causal pathways and quantify policy effects on prices, output and imports.

Keywords: *Russian Fertilisers; International Sanctions; Import Substitution; Brazilian Agribusiness; National Fertiliser Plan.*

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I. Introduction

In 2024, farmers in Brazil faced an increase in fertiliser prices while production of these inputs fell. Demand for fertiliser also rose with expansion of soybean cultivation, the crop that uses the largest share of the input. This development raises concerns because fertiliser costs may account for up to 30% of production costs, according to CONAB (2025). As production competes across countries, increases in input costs erode farm income because commodity prices set by markets often do not allow pass-through of input cost increases. Consequences include an outward transfer of income, a reduction in farm output, a fall in public revenue and a reduction in resources for investment.

The dependence on imported fertilisers stems from the incompleteness of Brazil's industrial agribusiness complex's productive structure. In particular, the country lacks an integrated production chain capable of manufacturing essential inputs domestically.

The longer the agribusiness production matrix, the greater the intersectoral expenditures, since spending in one sector stimulates purchases in others and generates income throughout the agribusiness system. Consequently, the more complete the chain, the greater its income generation. If the sector must import products, income losses and supply shortfalls may occur. These conditions can create an atmosphere of uncertainty. For example, during the 2021/2022 fertiliser crisis, soybean planting progressed 11 percentage points more slowly than in the previous season. This delay postponed about 10–11% of the intended area in the early stages. Farmers in the Central-West, notably in Mato Grosso, postponed sowing by up to 45 days amid shortages and rising input costs (Conab, 2021a, 2022a; Agricensus, 2021). These events corroborate Keynes's proposition that firms tend to postpone investment decisions in times of uncertainty.

In view of this, the article adopts an approach grounded in dependency theory and productive linkages, with the aim of analysing how reliance on inputs converts external shocks into domestic volatility. The study also aligns with the nationalist developmental current presented by Simonsen (1937).

The analysis is situated within the literature on dependency, as articulated originating from foundational works such as Prebisch (1950) and by Cardoso and Faletto (1979), and within debates on productive linkages that emphasise the role of concentrated supply chains in amplifying the effects of external shocks on domestic prices and output. During the war in Ukraine, for example, Russia, a fertiliser exporter, was subject to sanctions. This reduced global supply and raised prices. As a result, Brazil was directly affected given its dependence on that supplier. Within this framework, the vulnerabilities of Brazilian agribusiness associated with fertiliser import dependence are examined

Supplier concentration has made world supply chains more exposed and fragile. As a result, the sector faces higher economic risks (Christopher & Peck, 2004; Chopra & Meindl, 2019). Fertiliser production is concentrated in a few countries. China produces about a quarter of the total, Russia is responsible for close to one-fifth of exports, and the United States contributes less than 10%.

In Brazil, the supply of fertilisers is dependent upon a limited number of foreign producers. When prices fluctuate abroad or political tensions arise, the effects are immediately transmitted to the rural sector. Whereas large soybean producers are unable to adjust due to the intensive reliance of the activity on chemical fertilisers, small family farms also incur losses, as they face higher average and marginal costs. Their profit margins are already narrow, and therefore even a modest increase in costs may result in bankruptcy. Hence, only state support for the domestic production of chemical fertilisers, together with the development of biofertilisers, can reduce the country's dependence on imports and provide farmers with a more stable foundation for agricultural activity.

Methodologically, the study combines documentary analysis, official statistics and comparative case studies to assess impacts and policy responses. It asks how supplier concentration and recent trade disruptions have affected input prices and availability and which policy instruments can reduce external exposure. The paper's contribution is threefold: it documents recent shocks and transmission mechanisms; evaluates the National Fertiliser Plan (PNF) and related instruments; and proposes practical diversification and industrial measures suited to Brazil's constraints.

The study is organised into three main sections. Section I sets out the context and describes the problem, detailing dependence on imported fertilisers, the economic and geopolitical impacts and the institutional and technological constraints. Section II reviews current public policies, including governmental initiatives, industry responses and financing measures. Section III puts forward concrete policy recommendations, proposing diversification targets, fiscal incentives, financing for domestic production and investment in research and innovation. The conclusion succinctly brings together the main findings and the policy recommendations developed throughout the paper.

II. Context And Description Of The Problem

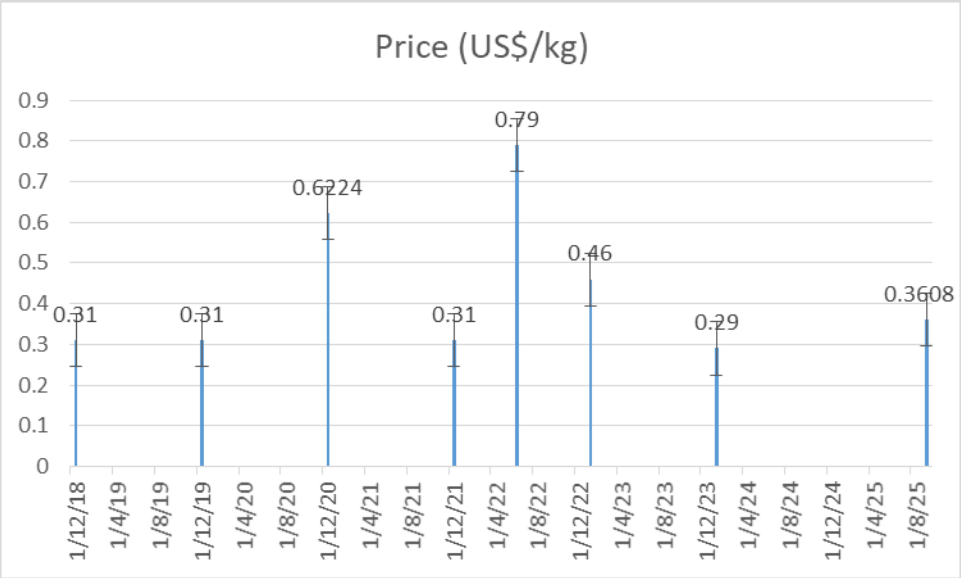
Brazil occupies a prominent position in global agricultural production: agribusiness accounts for 23.2 per cent of GDP and nearly half of the country's exports. nceIn fact, Brazil ranks as the fourth largest global buyer of fertilisers, reflecting the scale of its agricultural sector and the depth of its reliance on external supply chains. The crops with the highest fertiliser consumption are soybeans, maize and sugarcane, which together account for 71 per cent of all fertiliser use in the country. Brazil is also the fourth largest global consumer of fertilisers and is responsible for 8.5 per cent of total agricultural output worldwide. While products such as coffee and sugar tend to exhibit moderate demand elasticity, staple crops like soybeans and maize generally maintain stable demand even under price fluctuations. This reinforces Brazil's strategic role in global supply chains. However, not all producers can benefit from export opportunities. Small and medium-sized farms, in particular, face structural barriers such as limited access to infrastructure, financing and international certification, which restrict their participation in global markets and reinforce income disparities within the sector.

According to data from the Ministry of Agriculture and the OECD–FAO, Brazilian exports represented around 8.2 per cent of the world total in 2024 (Ministry of Agriculture, 2025; OECD–FAO, 2025). In 2024 agribusiness exports totalled USD 164.4 billion (MAPA, 2025), while products such as coffee and sugar tend to exhibit moderate demand elasticity, staple crops like soybeans and maize generally maintain stable demand even under price fluctuations. Although soybeans and maize exhibit a relatively inelastic demand, which in theory allows producers to pass on cost increases to prices, this dynamic does not apply uniformly across the sector. Small and medium-sized farms, in particular, lack the market power and logistical capacity to transfer rising input costs to buyers, leaving them more exposed to price shocks and margin compression.

External markets absorb surpluses and allow the sector to expand, but Brazilian production remains vulnerable to climatic variability, alternating between surplus and shortage and increasing sectoral volatility. This volatility has contributed to fluctuations in GDP growth over recent decades. Since the mid-1980s, the manufacturing share of GDP fell from 28.7 per cent in 1985 to 23.2 per cent in 1990, 17.2 per cent in 2000, 14.5 per cent in 2010, 11.5 per cent in 2020 and 13.3 per cent in 2023 (World Bank, 2025), which makes measures to strengthen rural production and reduce macroeconomic exposure even more pertinent.

Given the volatility of fertiliser prices, shown in Figure 1, values remained broadly stable between 0.30 and 0.40 US$/kg from 2019 to 2021. They rose sharply to 0.79 US$/kg in early 2022, when global supply chains were disrupted by the Russia–Ukraine conflict and the surge in energy costs. Prices then fell back to between 0.29 and 0.46 US$/kg in 2023–2024 and appear to have stabilised around 0.36 US$/kg by 2025. This pattern has significant macroeconomic effects: higher fertiliser costs feed into inflation and weaken export competitiveness. Access to more diversified and stable external markets can help offset these pressures by supporting economies of scale, lowering average costs and improving productive efficiency. The fluctuations also reveal Brazil's structural vulnerability, as the country imports 85 per cent of its fertilisers, which directly affects the cost of producing crops such as soybeans and maize.

Figure 1. Fertiliser Price Volatility (US$/kg), January 2019 to January 2025.



Source: Farmnews.com.br and afnews.com.br

The growth of agro-industry generates productivity gains (Schmookler, 1966), possibly explained by the learning-by-doing proposition. As firms in the sector prosper, they can invest in research and development, which contributes to increased productive efficiency. This process reinforces competitiveness, creating a positive cycle of export growth. However, the evolution of productivity in the agro-industry has shown modest gains. This indicates that the sector needs more investments, such as those in research by Embrapa, subsidized rural credit and technical extension policies. Thus, investment in the rural sector can increase macroeconomic stability.

However, a structural vulnerability persists: Brazil imports more than 80% of the fertilisers used in the production of soya, maize and coffee (USDA, 2025). Russia is the primary supplier, accounting for 28% of the 44.34 million tonnes in 2024, and deliveries increased by 30% at the beginning of 2025 (Secex, 2025). This external dependence raises production costs and exposes the country to significant risk. The situation is further exacerbated by the concentration of global fertiliser production in a limited number of countries, including Russia, China, Canada, Morocco and Belarus, which renders international supply chains particularly susceptible to geopolitical disruptions and market fluctuations.

In 2025, with sanctions related to the war in Ukraine still in force, the international landscape remained unstable. The United States enacted broad measures that raised ad valorem tariffs on certain Brazilian exports by 40 percentage points in July, bringing the nominal rate to 50%; these measures increased trade costs and created supply-chain frictions that affect the fertiliser sector indirectly rather than imposing direct duties on fertiliser imports (Trading Economics, 2025a). Given the resulting price pressures and heightened geopolitical risk, attention must also turn to domestic alternatives. One strategic option is to assess Brazil's underutilised mineral reserves for potassium and phosphate while explicitly recognising environmental constraints and the requirement for rigorous safeguards. Brazil currently imports the large majority of potassium and phosphate used in agriculture, underscoring the urgency of developing extraction and processing capacity that complies with environmental and social standards.

Provided that environmental safeguards are rigorously applied, initiatives of this nature may lessen Brazil's reliance on external suppliers, encourage development in underutilised regions, and help resolve logistical bottlenecks. In doing so, they also offer a pathway for reconciling resource extraction with biodiversity preservation and the country's climate policy objectives.

Continuing to import fertilisers from Russia may be interpreted as an implicit alignment with that country, exposing Brazil to potential reactions from NATO or the United States (Trading Economics, 2025a). Comparable situations have marked Brazilian foreign policy history: in the 1930s and 1940s, the country negotiated simultaneously with the United States and Germany to secure strategic inputs and sustain industrialisation (Nunes, 2024a). This parallel demonstrates that the current dependence on Russian fertilisers repeats a pattern of external vulnerability in the face of international shocks.

A historical precedent illustrates the risks: the Great Famine in Ireland in the 1840s showed how trade restrictions can intensify scarcity and result in approximately one million deaths. Similarly, Brazil today faces vulnerabilities that threaten food security and economic stability in the event of external shocks.

Moreover, there is an absence of a consistent industrial policy aimed at domestic production of these inputs, despite Brazil possessing substantial mineral resources, productive capacity and technical expertise to advance in this field. Reducing this dependence presupposes the adoption of fiscal and regulatory incentives capable of strengthening local production chains and diminishing external exposure in the agricultural sector. The experience of the "forced march towards industrialisation" in the 1970s illustrates how coordination between the state and the productive sector can stimulate investment expansion (Castro & Souza, 1985).

Dependence on external sources extends beyond trade and encompasses both capital and technology. The establishment of new firms requires financial resources and technical capability, which tend to increase start-up costs, particularly when production relies on imported technologies that have not yet been integrated into domestic practice. There is often a shortage of trained labour and limited managerial expertise, and new firms typically operate at higher costs. This situation mirrors a broader pattern in international production, where differences in factor endowments, access to technology and the availability of skilled labour shape the competitive position of developing economies. The ability to internalise technology and build local capacity thus becomes a decisive element in reducing dependence and improving productivity. Nunes (2024c) notes that the dependence of developing economies on foreign inputs heightens their vulnerability by reducing control over the complete cycles of research, development and innovation. As the author remarks, "the importation of technology often hinders local efforts in research and development" (Nunes, 2024c, p. 6).

In Brazil specifically, the lack of technological infrastructure dedicated to fertiliser manufacturing increases susceptibility to external disruptions and restricts independence in production. This restriction arises from the unequal dissemination of knowledge: developed nations transfer only fragments of technology, retain R&D activities at their headquarters, and thereby weaken the innovative capacity of peripheral economies. To strengthen productive infrastructure, it is necessary to provide funds for investment, incentives for firm formation and measures that integrate the elements of the production chain.

The substitution of 10 million tonnes annually cannot be achieved immediately, but it is an essential measure to mitigate shocks like those recently observed in the steel sector due to budget cuts. In the absence of effective policies, Brazil, as a major food exporter, exposes not only its own economy to significant risk.

III. Current Public Policies For The Fertiliser Sector

In 2025, Petrobras is advancing the reactivation of manufacturing units in the Brazilian Northeast through tender processes for facilities capable of meeting approximately 20% of national demand for nitrogenous fertilisers from 2026, prioritising the production of urea and ammonia. Concurrently, the 2025/2026 Harvest Plan allocates BRL516.2 billion in financing with controlled interest rates, directed towards the acquisition of agricultural inputs and the promotion of sustainable production methods, including subsidised credit lines for operating and investment costs. Complementing these measures are international initiatives, such as the memorandum of understanding signed with the United Kingdom for the development of sustainable fertilisers, as well as increased imports from Morocco and Saudi Arabia, particularly during periods of lower seasonal demand.

State intervention through subsidies, as seen in programs like the Harvest Plan, often aligns with Category III of Friedman and Friedman's (1980, pp. 116-117) framework (spending others' money on oneself), where the emphasis is on maximizing value received, but with limited incentives for cost control. However, the government can mitigate inefficiencies in subsidies by implementing two key strategies. First, it can use a selective process for beneficiaries. This is already foreseen in the program's eligibility criteria, such as prioritising sustainable practices or small/medium producers. Second, it can enforce rigorous expenditure monitoring through audits and mandatory reporting. These steps encourage more careful decision-making, similar to personal incentives. As a result, they enhance the overall effectiveness of these measures in promoting domestic production and diversification.

This approach aligns with Friedman's broader critique of technical monopolies, in which he argues: *"There is unfortunately no good solution for technical monopoly. There is only a choice among three evils: private unregulated monopoly, private monopoly regulated by the state, and government operation"* (Friedman, 1962, p. 128). In the context of Petrobras's role, this highlights the challenges of state production as a necessary 'evil' to combat import dependence, while emphasising the need for regulatory safeguards to avoid inefficiencies"

This strategy, however, proves insufficient, as the National Fertiliser Plan (PNF) focuses on domestic production, disregarding the excessive use of synthetic chemical inputs and their environmental impacts (Brasil, 2022) and (Rodrik, 2007). Moreover, Russian dependence remains around 25-30%, rendering the sector susceptible to sanctions imposed by the European Union and the United States (Trading Economics, 2025a). Total imports rose by 13% in the first months of 2025 (11.54 million tonnes), but without mandatory diversification targets, price fluctuations and shortage risks persist (Tridge, 2025a).

IV. Discussion

Government Recognition and PNF Targets

The Government recognises that this dependence undermines the productive autonomy of the agricultural sector and has instituted the National Fertiliser Plan (Plano Nacional de Fertilizantes, PNF 2022–2050), which sets a target to reduce import dependence from 85% to 45% by 2050 through investment in domestic production. Domestic fertiliser manufacture reduces production costs and diminishes vulnerability to international market volatility. Although the sector remains competitive, sustained investment in fertiliser manufacturing is essential for continued agribusiness expansion and for safeguarding trade advantages (Embrapa, 2018a; Brasil, 2022). Given that agricultural commodities are largely homogeneous, competition occurs principally on price, so profitability depends on cost reductionta

Import substitution for fertilisers is technically feasible because production does not require exceptionally high technological intensity. Legislative measures such as Bill 669/2023, which eliminate taxation on equipment for approved fertiliser projects, facilitate capital formation in the sector(Senado Federal, 2023).

To address instability generated by sanctions and tariffs, Brazil must diversify supply sources and strengthen domestic production(Trading Economics, 2025a). A practicable target is to direct 30% of imports to Morocco by 2027; Morocco possesses extensive phosphate reserves and has expanded exports to multiple markets, including Brazil. This objective can be pursued through bilateral agreements and fiscal incentives for importers, thereby reducing dependence on Russia and contributing to price stabilisation(Trading Economics, 2025a).

International experience demonstrates that combining supplier diversification with domestic capacity building is effective. Canada increased private and public investment in nitrogen production capacity and associated technologies after supply shocks(Government of Canada, 2021; Nutrien, 2023). India has relied on subsidy programmes, support for domestic production and cooperative structures such as IFFCO to curtail import dependence(Ministry of Chemicals and Fertilisers, 2018; IFFCO, 2017). These cases suggest Brazil can pair diplomatic engagement with incentives for innovation and national production (Brasil, 2022; Embrapa, 2018b).

At the domestic level, targeted measures—such as the equalisation of natural-gas prices for ammonia plants (up to BRL 1.7 billion per year) and expanded credit under the Harvest Plan—support the National Fertiliser Plan's (PNF) objectives(Brasil, 2022). Strengthening domestic input production is also a social policy because it protects farmers from external price shocks and enhances price stability for consumers.

The adoption of organic and sustainable alternatives, exemplified by the memorandum with the United Kingdom, could contribute to partial self-sufficiency in nitrogen and potassium by 2030. These measures are technically feasible and should be prioritised to protect producers and the national economy. A priority review of the PNF by the Ministry of Agriculture is therefore warranted to align the Plan with current market and geopolitical conditions(Trading Economics, 2025a).

This analysis goes beyond media and market commentary by linking supplier vulnerability to shortcomings in domestic policy design, notably the absence of mandatory diversification targets within the PNF. Integrating economic diplomacy (bilateral negotiations for alternative sources) and sustainability measures (transition to organic inputs) would reduce geopolitical risk and align agricultural competitiveness with global sustainability goals, as observed in Canada and India (FAO, 2019; OECD, 2020).

Adopting a combined strategy of supplier diversification, reinforcement of domestic production and promotion of sustainable practices will reduce agribusiness vulnerability, bolster food security and contribute to macroeconomic stability. Public investment in science and technology expands productivity and innovation in sectors where Brazil enjoys comparative advantage, particularly agriculture (Nunes, 2024b). These gains, however, depend on sufficient logistical infrastructure and coherent trade policy.

Evaluation of Public Policies in the Fertiliser Sector

The application of the Impact and Logical models permits a systematic, multidimensional evaluation of public policy. The Impact Model quantifies effects at individual, institutional and societal levels, while the Logical Model organises programme elements into a causal chain, facilitating identification of gaps and improvement opportunities.

Impact evaluation differs from prior assessments by seeking to quantify causal effects and by comparing observed outcomes with appropriate counterfactuals; interventions should be pursued where measurable impact can be demonstrated.

The selection of these models is justified by the complexity of the fertiliser sector, which involves multiple actors, resources and external variables and therefore requires an approach that integrates diagnosis, action and outcome. The objective is to assess policy effectiveness in reducing external dependence, the economic impact and contributions to food security.

Process (implementation) evaluation examines whether policies are executed in accordance with their design, identifying whether the links among inputs, processes and outputs conform to expectations or require

improvement. This perspective complements impact and economic evaluation by verifying not only results but also the coherence and efficiency of the mechanisms employed.

Beyond chosen instruments, it is essential to scrutinise implementation means and processes: beneficiary selection criteria, monitoring arrangements and factory-reactivation efficiency. These operational steps transform available inputs—natural resources, finance and technology—into concrete outputs such as domestically produced fertiliser. Their effectiveness depends on coordination between public and private actors, installed technical capacity and the resolution of logistical and regulatory bottlenecks.

It is also necessary to assess the alignment between adopted measures and intended objectives, verifying whether selected instruments can deliver desired effects and whether means and ends are coherent. Operational design influences observed outcomes and must be incorporated into evaluation in accordance with regulatory impact-analysis principles.

The study evaluates distributional effects of public policies, paying particular attention to impacts on smallholders, large agribusiness firms and society at large. It examines whether benefits exceed costs, emphasising subsidy efficiency, reductions in external vulnerability and strengthening of national competitiveness.

Scenario construction in this study rests on assumptions that may not materialise. Although the analysis presumes availability of inputs, that hypothesis depends on multiple contingencies; fiscal pressures and rising public debt may constrain resources to finance the PNF. Political and environmental constraints further complicate implementation: Congress may reject exploitation of environmentally sensitive Amazonian areas where required deposits lie, creating an additional obstacle that necessitates alternative strategies compatible with Brazil's socio-environmental commitments.

Modelo Impact

The Impact Model facilitates analysis of programme effects at multiple levels:

Component	Application in the Study	Evaluation by Level
Context	- 85% import dependence; fertilisers may represent up to 30% of agricultural costs; - vulnerability to higher import tariffs.	**-Small firms and family farms:** disproportionately affected**.** **- Large firms and public institutions:** Petrobras and Embrapa as technology promoters and funders. - **Society:** risks to food security and national competitiveness.
Input	- Mineral deposits, financial resources (BRL 516 billion Harvest Plan; PL 669/2023), qualified research.	- **Small firms and family farms:** Limited access to credit and capacity building. - **Large firms and public institutions:** factory reactivation and partnerships - **Society**: employment gains in agribusiness and enhanced international cooperation.
Processes	Import diversification, subsidy provision (BRL1.7 billion/year), and incentives for the substitution of chemical fertilisers by organic alternatives, and bilateral agreements.	**-Small firms and family farms**: improved credit access. - **Large firms and public institutions:** public–private coordination. **- Society:** PNF review and alignment with climate targets.
Outcomes:	short term—price stabilisation; medium term—productivity increases; long term—GDP growth and food security.	**-Small firms and family farms**: cost reduction and improved margins. **-Large firms and public institutions:** expanded national production. **-Society:** reduced exposure of domestic production to external demand shocks.

The Logical Model organises the programme strategically:

Element	Description in the Study
Inputs	Deposits, technical research, public budget, international partnerships.
Activities:	Factory reactivation, bilateral agreements, fiscal incentives, financing via the Harvest Plan.
Outputs	Increased national production, reduction of import dependence to 45% by 2050, price stabilisation..
Outcomes	Short term—reduced tariff impact; Medium term—greater competitiveness; Long term—food security and macroeconomic stability.
Contextual variables	International sanctions, supplier concentration, absence of mandatory PNF diversification targets.

Application conclusion
The analysis demonstrates coherence with both models:

- The Impact Model shows how inputs and processes affect outcomes across multiple levels.
- The Logical Model maps internal consistency and highlights gaps such as the absence of mandatory targets and insufficient monitoring.

Both frameworks underscore the necessity of coordinated, sustainable and measurable actions to reduce Brazil's vulnerability in the fertiliser sector. Economic evaluation must be directly linked to cost–benefit analysis of adopted measures to verify whether public resources are allocated efficiently and in line with strategic objectives, and continuous assessment is required to ensure that policy benefits exceed costs, especially regarding subsidy efficiency, reduction of external vulnerability and enhancement of competitiveness.

V. Conclusion

Brazil imports most of the fertilisers used in agriculture. This condition affects production costs and creates exposure to external disruptions. Recent events, including trade sanctions and supply shocks, have shown the effects of this dependence. The National Fertiliser Plan (PNF 2022–2050) sets a target to reduce imports and expand domestic production. The plan includes measures such as factory reactivation, fiscal incentives, and bilateral agreements.

This study examined the structure of the fertiliser sector and evaluated public policies using logical and impact models. The analysis identified transmission mechanisms, policy gaps, and implementation constraints. It also assessed the effects of current instruments on producers, institutions, and national output.

The findings suggest that import substitution and supplier diversification are feasible. These measures require coordination between government, firms, and research institutions. The study recommends revisions to the PNF, including mandatory diversification targets and support for sustainable inputs. These steps may reduce exposure to external shocks and improve production stability.

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