

Competitiveness of Paraguay international agricultural trade: An analysis of the soybean complex

Competitividad del comercio internacional agropecuario paraguayo: un análisis del complejo de la soja

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ABSTRACT

Agribusiness has become a cornerstone of the Paraguayan economy, with soybeans and their derivatives serving as key contributors to the country's main source of foreign income. This study investigates Paraguay's competitiveness in its primary commodities, such as soybeans and their derivatives, as well as their market concentration, highlighting its comparative advantage. The study employs the Revealed Comparative Advantage Index (RCA) and the Hirschman-Herfindahl Index (HHI) to assess export competitiveness and concentration. The results indicate that Paraguay maintains a comparative advantage in exporting soybean grain and oil, although soybean meal exhibits a weaker market share. An increase in export concentration toward Argentina was observed, raising concerns about vulnerability to demand fluctuations. However, exports of soybean-derived products are more diversified, which provides stability. The study concludes that to enhance competitiveness, Paraguay must focus on the industrialization of its products and adopt policies that strengthen its export capacity while minimizing dependence on specific markets.

Keywords: agribusiness; agri-food logistics; comparative advantage index; Hirschman-Herfindahl; raw materials, trade

RESUMEN

El agronegocio se ha convertido en una piedra angular de la economía paraguaya, siendo la soja y sus derivados los principales aportantes a la fuente principal de ingresos externos del país. Esta investigación analiza la competitividad de Paraguay en sus principales productos, como la soja y sus derivados, así como su concentración de mercado, destacando su ventaja comparativa. El estudio emplea el Índice de Ventaja Comparativa Revelada (RCA) y el Índice de Hirschman-Herfindahl (HHI) para evaluar la competitividad y concentración de las exportaciones. Los resultados indican que Paraguay mantiene una ventaja comparativa en la exportación de granos y aceite de soja, aunque la harina de soja presenta una participación de mercado más débil. Se observó un aumento en la concentración de exportaciones hacia Argentina, lo que genera preocupación por la vulnerabilidad ante fluctuaciones en la demanda. Sin embargo, las exportaciones de productos derivados de la soja están más diversificadas, lo que aporta estabilidad. El estudio concluye que, para mejorar la competitividad, Paraguay debe enfocarse en la industrialización de sus productos y adoptar políticas que fortalezcan su capacidad exportadora, minimizando la dependencia de mercados específicos.

Palabras clave: agronegocios; comercio; hirschman-herfindahl; índice de ventaja comparativa revelada; logística agroalimentaria; materias primas

INTRODUCTION

International trade in agri-food products has expanded rapidly in recent decades, significantly altering its structure and generating profound implications, particularly for developing economies (Schwarz *et al.*, 2015). A nation's development depends on wealth generation, which involves both intrinsic and extrinsic factors affecting its competitiveness. Białowąs and Budzyńska (2022) emphasize the importance of global value chains for developing countries such as Paraguay, as they facilitate access to international markets, advanced technologies, and improvements in production practices.

According to the United States Department of Agriculture (USDA, 2025), Paraguay has emerged as one of the leading suppliers of raw materials in two key sectors: soybeans and meat. Regarding soybeans, Paraguay cultivates 3.5 million hectares, produces 10.9 million tons, and markets products from the soybean complex such as meal, oil, and grain. In soybean grain exports, the country ranks fourth globally, with limited domestic consumption that is mainly used for poultry and swine farming (USDA, 2023). In the meat sector, Paraguay produces 600,000 tons of carcasses annually, of which 75% are exported (Servicio Nacional de Calidad y Salud Animal, 2024).

Enhancing agricultural export capacity within the framework of international competitiveness is crucial for national economic growth. This necessitates a comprehensive approach that encompasses not only production and exports but also structural and public policy factors influencing competitiveness (Urba *et al.*, 2023). To facilitate improved access to export markets in industrialized nations, alongside import liberalization, there is a pronounced need for proactive industrial policies that foster growth through investment and trade rather than relying solely on free-market mechanisms (Williamson, 2003).

Primary production is highly dependent on climatic factors, as evidenced by the impact of droughts that have caused economic shocks in Paraguay during recent agricultural seasons, negatively affecting GDP (Báez *et al.*, 2023). Porter (1990) argues that a nation's competitive advantage is not inherited but created through a dynamic process driven by innovation and sustained efforts by businesses, workers, and institutions. Krugman (1991) complements this view by incorporating innovation dynamics, entrepreneurship, and structural change into the framework of the new economic geography. However, the industrialization and economic development process tends to alter a country's patterns of comparative advantage (Balassa, 1965). As emerging economies develop, their comparative advantage shifts from primary products to higher-value-added manufactured goods and services.

In a study using Balassa's methodology, Shukla *et al.* (2023) analyzed international agricultural trade between India and China, revealing that both countries exhibit strengths and weaknesses. India demonstrates greater product diversification, whereas China exhibits higher export concentration. This finding highlights that primary-producing countries must capitalize on market opportunities and enhance their competitiveness (Tossou *et al.*, 2023).

According to Báez *et al.* (2023), primary production is significantly dependent on climatic factors, such as drought, which can severely impact economic activity. This phenomenon, recently observed in the last agricultural harvests in Paraguay, has had negative repercussions on the Gross Domestic Product (GDP). Additionally, trade policies and health events, such as the COVID-19 pandemic, have also adversely affected international trade. In this context, the present study aims to determine Paraguay's

competitiveness regarding its main commodity, soybeans and their derivatives, as well as to analyze the concentration of these products in international markets during the period from 2014 to 2023.

MATERIALS AND METHODS

Revealed Comparative Advantage Index (RCA)

The RCA index provides an indicator of the export structure of a specific commodity for a country or region over time. Shukla *et al.* (2023) highlight that the RCA evaluates the extent to which a country's export structure deviates from the expected trade pattern based on its size. Its benchmarking capability, dynamic analysis, and transparency make it a reliable and competent index.

For the analysis, values were expressed in United States dollars (USD) under Free On Board (FOB) valuation and disaggregated at the four-digit level of the Harmonized System. The unit of observation corresponds to the country–product–year relationship, covering the period from 2014 to 2023.

For the study of the soybean complex, three main products were considered: soybean grain (code 1201), soybean meal (2304), and soybean oil (1507). The data were obtained from official secondary sources, specifically the Banco Central del Paraguay (Báez, 2025) and the United Nations Commodity Trade Statistics Database (United Nations, 2025).

The methodological approach was quantitative, descriptive, and longitudinal. To ensure consistency and comparability, the data were subjected to a cleaning process that included the identification and correction of outliers, as well as the harmonization of statistical series across both sources. The temporal evolution of the RCA was analyzed for each product to assess the relative competitiveness and degree of export specialization of Paraguay's soybean complex.

The RCA was calculated following the formulation proposed by Béla Balassa (1965) (Equation 1), as follows:

$$RCA_{ij} = (X_{ij}/X_i)/(X_{wj}/X_w) \quad (1)$$

Where:

X_{ij} : Value of Paraguayan exports of product j

X_i : Total value of Paraguayan exports

X_{wj} : Total global export value of product j

X_w : Total global export value

An RCA value greater than 1 indicates that the country exhibits a revealed comparative advantage in the analyzed product, reflecting a level of specialization above the global average. Conversely, values below 1 indicate a comparative disadvantage. Values substantially higher than 1 suggest a strong export specialization, whereas values close to 1 indicate a structure similar to that of world trade

Hirschman-Herfindahl Index (HHI)

The Hirschman–Herfindahl Index (HHI) was used to assess the degree of export concentration within Paraguay's soybean complex. The analysis considered three main products: soybean grain (HS code 1201), with exports directed to Argentina, Brazil, and the European Union; soybean oil (1507), mainly exported to India, Argentina, and Brazil;

and soybean meal (2304), with Argentina, Chile, and the European Union as principal destinations.

The study covered the period from 2014 to 2023, using trade data expressed in United States dollars (USD) obtained from the United Nations Commodity Trade Statistics Database (UN COMTRADE) and the Central Bank of Paraguay.

As outlined by Bahta and Mbai (2023), the shares of Paraguay's main export destinations were calculated following the methodology proposed by Herfindahl (1950). The market share of each destination country was calculated as shown in Equation 2:

$$S_i = \frac{X_i}{X} \quad (2)$$

Where:

S_i : market share of country i in exports of a given product

X_i : export value of the product to country i

X : total export value of the product to all countries in the corresponding year

Once the market share for each country is determined, the square of this proportion is calculated for every country. The Hirschman-Herfindahl Index (HHI) is obtained by summing the squared market shares across all countries. The general formulation is expressed in Equation 3:

$$HHI = \sum_{i=1}^n S_i^2 \quad (3)$$

Where:

n : is the total number of countries receiving exports of the products

s_i : is the market share of country i

The HHI ranges between 0 and 1. A value close to 1 indicates a high concentration of exports in a few countries, whereas a value close to 0 suggests a highly diversified export structure. This index allows to evaluate the degree of trade dependence and the vulnerability of Paraguay to changes in international markets.

RESULTS

Revealed Comparative Advantage Index (RCA)

Figure 1 presents the concentration of Paraguay's exports to different countries and regions of the world. According to the data presented during the analysis periods, the classification is made by countries and regions with the nomenclature of 1201, 1507, and 2304, which indicates different categories of commodities. In the export of grain (1201), Argentina shows a high participation compared to other countries or regions, gaining space in the import of Paraguayan grains, a space that was left by the Russian Federation during the study period, which demonstrates a decrease in the import of

Paraguayan soybeans. The same phenomenon occurred with the European Union-27, which is also reducing its import of soybeans.

However, soybean exports offer economic development opportunities for Paraguay, as the production and sale of oilseeds add value to the land productivity dynamics to generate the food the world demands. Furthermore, the soybean complex, being highly tradable, makes it possible to examine the probable impacts that changes in external demand cause on the Gross Domestic Product (GDP).

Regarding soybean oil (1507), India leads in imports of this byproduct, followed by other countries to a lesser extent, and also by Argentina. In several countries or regions, a downward or stabilization trend is observed, suggesting that, after a period of growth or high activity, these regions are experiencing a phase of consolidation or slowdown. There is a disparity during the study period, with extremely high figures in some cases and much more modest values in others. This demonstrates a variation in the destinations of Paraguay's exports.

Soybean meal (2304) is dominated by Chile, the European Union, and the rest of the world, showing a greater dispersion. The results demonstrate a disparity among different regions or countries, reflecting the variation in global trade. The fact that some figures stabilize or decrease suggests that these regions could be reaching a limit in their growth under current conditions, which could lead to significant changes in policies or development strategies to avoid a prolonged slowdown. Alternatively, a change in the direction of product exports might be considered.

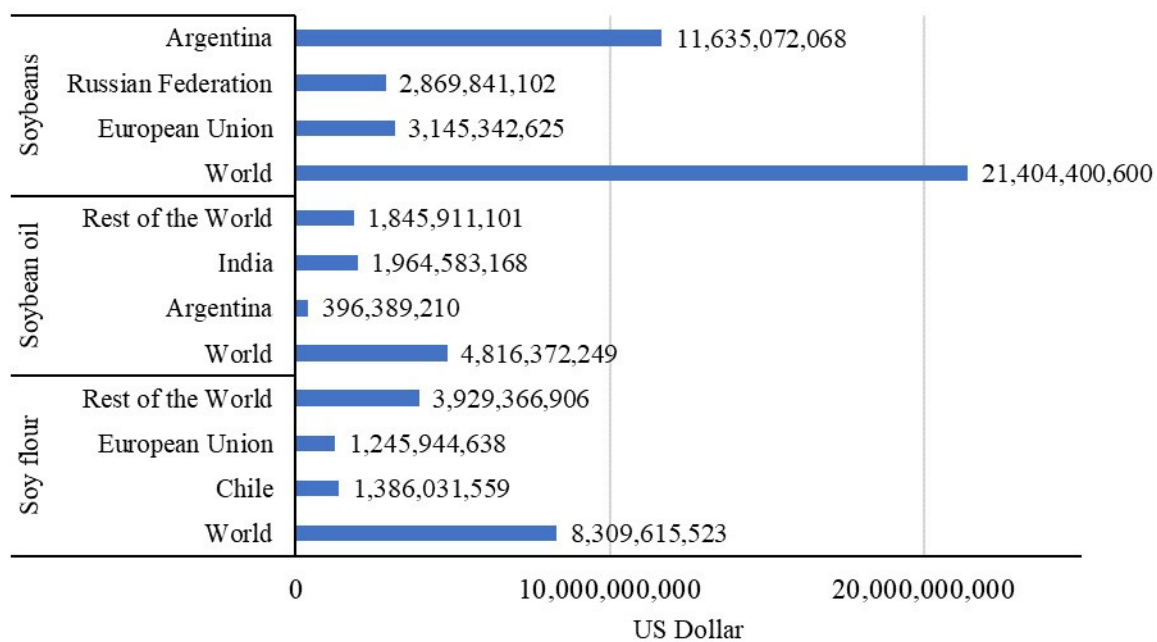


Figure 1. Export of the soybean complex in US dollars from 2014 to 2023. FOB Value

Regarding the IVCR study presented in Table 1, it is shown that there is sustained growth for the export of soybeans and soybean oil, indicating competitiveness for both byproducts. However, the export participation of soybean meal is weaker, reflecting that trade is more focused on the soybean grain sector. This is an indicator that can be improved through industrialization, which would generate more investment in the agro-industrial sector.

Table 1. *Productivity Advantage Index of the Soybean Complex*

Year	Soybean	GrainSoybean	OilSoybean Meal
2014	36.14	7.54	0.05
2015	24.99	6.98	0.03
2016	28.52	7.31	0.04
2017	33.43	7.48	0.04
2018	34.57	7.36	0.05
2019	24.71	6.09	0.04
2020	33.66	6.53	0.04
2021	46.65	9.74	0.04
2022	19.24	8.38	0.05
2023	53.68	8.10	0.06

Hirschman-Herfindahl Index (HHI)

In the HHI study of Paraguay, presented in Table 2, the countries and regions with the highest imports during the study period were selected as the most representative, including Argentina, the Russian Federation, and the EU-27. During the period 2014-2016, the HHI with Argentina remained at low levels, ranging from 0.00 to 0.02, indicating a highly diversified market. However, between 2017 and 2019, the index showed a progressive increase, reaching 0.46 in 2018, which indicates a growing concentration towards this market. Then, in the period 2020-2023, a constant increase in the HHI was observed, reaching 0.87 in 2023, reflecting an extremely high concentration in Argentina. This evolution indicates that Argentina has shown sustained growth and could generate vulnerability to possible changes in demand.

In the export to the Russian Federation for soybeans (code 1201), during the period 2014-2017, the Hirschman-Herfindahl Index (HHI) remained at low values, fluctuating between 0.02 and 0.06, reflecting that Paraguay does not depend on this market. However, during the period 2018-2023, a decrease in the index was observed, reaching 0.00 in 2022 and 2023. This trend suggests that the Russian Federation represents a non-dependent import market for Paraguay. Nevertheless, before the Ukraine-Russia conflict, according to the Ministry of Finance, now the Ministry of Economy and Finance, in 2020, Russia was one of the main trading partners for Paraguayan meat and soybeans, becoming the 4th largest importer of Paraguayan soybeans.

Another region with significant representation in the import of Paraguayan soybeans during the analyzed period was the European Union (EU-27). During the period 2014-2016, the Hirschman-Herfindahl Index (HHI) showed a temporary increase, rising from 0.08 to 0.26 in 2016, indicating moderate concentration in exports. However, from 2017 to 2023, the index dropped sharply to 0.00, remaining constant at this level. This situation reflects that the EU has significantly decreased its participation as a destination for Paraguayan soybeans.

Regarding soybean oil (1507), it has a stronger relationship with countries such as India, Bangladesh, and Argentina. However, there is no strong concentration in any of the mentioned countries in the soybean complex. This indicates that, according to the HHI, there is no significant dependency on any of these countries. India's highest concentration was 0.28 in 2017, and its lowest concentration was 0.07 in 2022. Bangladesh's highest concentration was 0.07 in 2014 and 2015, with a lower concentration in 2021 and 2023. Argentina had a concentration of 0.07 in 2022, mostly with lower concentrations or zero participation.

Soybean meal (2304) exports do not have a high concentration in any of the countries or regions studied, indicating no absolute dependency on them. As shown in Table 1, Chile's highest concentration in 2018 was an HHI of 0.06, and its lowest concentration in 2022 was 0.00, reflecting a notable decline in recent years. Similarly, Peru's highest concentration was in 2015 with an HHI of 0.03, and its lowest concentration was 0.00 in 2020 and 2022, indicating low concentration with minor fluctuations. Lastly, the European Union (EU) had a higher concentration in 2015 with an HHI of 0.17, and a lower concentration in 2020-2023 with an HHI of 0.00 and 0.01, respectively, showing a significant decrease. This last region experienced a more pronounced decline, starting the period with relatively high levels of concentration, peaking in 2015. However, from 2017 onwards, a sharp decline in concentration was observed, remaining at very low levels until the end of the period.

Table 2. *Hirschman-Herfindahl Index (HHI) of the Soybean Complex (grain, oil, and meal)*

Export Code	Countries/Region	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Cod. 1201	Argentina	0.00	0.00	0.02	0.05	0.46	0.45	0.57	0.52	0.64	0.87
	Russian Federation	0.04	0.06	0.04	0.02	0.02	0.03	0.01	0.02	0.00	0.00
	UE-27	0.08	0.15	0.26	0.08	0.01	0.01	0.00	0.00	0.00	0.00
Cod. 1507	India	0.20	0.20	0.15	0.28	0.24	0.23	0.14	0.13	0.07	0.13
	Argentina	0.01	0.00	0.01	0.00	0.01	0.00	0.02	0.00	0.07	0.00
	Bangladesh	0.07	0.07	0.06	0.04	0.03	0.04	0.02	0.00	0.01	0.01
Cod. 2304	Chile	0.05	0.01	0.02	0.03	0.05	0.06	0.05	0.03	0.00	0.02
	Perú	0.01	0.03	0.01	0.01	0.01	0.02	0.00	0.01	0.00	0.01
	UE-27	0.12	0.17	0.13	0.01	0.01	0.01	0.00	0.01	0.00	0.00

DISCUSSION

Revealed Comparative Advantage Index (RCA)

Paraguay has demonstrated sustained and structural growth in the performance of the soybean complex, characterized by an increase in processing capacity and in the participation of industrial derivatives within the export basket. Although the country maintains a smaller production scale compared to Brazil and Argentina, a deepening of the industrialization process is observed, which translates into a proportional increase in exports of oil and meal. This pattern reveals a strategy oriented toward generating greater added value and consolidating a more integrated and competitive export structure (Gabbi *et al.*, 2022).

According to Morinigo *et al.* (2018), estimates based on the input-output matrix indicate that for every 15% decrease in soybean complex exports, Paraguay's Gross Domestic Product (GDP) declines by 1.04%. Paraguayan exports are characterized by primary products (commodities), which entail fluctuations in international prices and

climatic conditions. As noted by the Ministry of Economy and Finance, in 2023, 74% of Paraguayan exports consisted of primary products and agro-industrial manufactures (Ministerio de Economía y Finanzas, 2023).

These fluctuations reflected in the RCA index of products are influenced by external factors such as international trade, climate, and the dynamics of the soybean complex itself. In Paraguay's case, there was no negative impact on competitiveness during the COVID-19 health crisis, unlike what occurred in Southeast Asia. Jamhari *et al.* (2021) highlight that agricultural trade was boosted and member countries' competitiveness improved through regional integration. However, the COVID-19 pandemic significantly disrupted this, reducing the growth of agricultural exports and imports by more than 10%.

According to Devadoss *et al.* (2021), countries with abundant production factors, such as Paraguay, have lower production costs, thereby increasing their comparative advantage in agricultural trade. This enhances their competitiveness, despite the landlocked condition being another factor to consider in Paraguay's international trade.

Hirschman-Herfindahl Index (HHI)

Market concentration is an important indicator for assessing market structure and the level of competition in a sector. Markets, volume, and destination of Paraguayan soybean complex products denote the importance of the Paraguayan market and foreign policy. Devadoss *et al.* (2021) conclude that strong institutions and open trade policies are essential to promote agricultural trade. Similarly, Bahta and Mbai (2023) state that diversification of market structures favors a country's economic stability. However, Van Zyl and Matswalela (2016) mention that, for developing countries, the impact of labor costs and trade policies on the international positioning of emerging economies, such as Paraguay, is significant in logistics. Being a landlocked country with low asphalt pavement coverage, which, according to the Ministry of Environment and Sustainable Development (Ministerio del Ambiente y desarrollo sostenible, 2023), is around 11% in Paraguay, presents additional challenges.

Another factor that stands out in Paraguay is the lack of trade relations with China, which has been consolidating as the world's leading soybean importer. This consolidation is driven by the animal nutrition sector and the growing industrialization of oils, which could be another option to consider for opening up the market in Asian countries. According to Zeng *et al.* (2024), China expanded its agricultural trade with its trading partners from 1995 to 2020.

Moreover, the European Union (EU) imports a large volume of soybeans from South America and North America (Rotundo *et al.*, 2024) and is highly dependent on them for use as animal feed (Karlsson *et al.*, 2021). Despite being the second-largest importer after China, due to its unmet domestic demand, the EU has been tightening its trade and environmental policies, which play a decisive role in the market. These conditions may have affected Paraguay's exports to this market, according to reports from the United States Department of Agriculture (USDA, 2023, 2025). Nevertheless, Thom *et al.* (2023) argue that import restrictions on food products such as soybeans significantly affect agri-food value chains in the EU and will impact the welfare of its population.

Paraguay has the potential to enhance its comparative advantage in soybean production, particularly considering that the Gran Chaco region exhibits significant growth capacity. As highlighted by Henderson *et al.* (2021), its productive potential is estimated at approximately 742,000 hectares, with a more moderate expansion scenario reaching up to 940,000 hectares, primarily driven by technological innovation and land market dynamics.

Another dimension not addressed in the present research concerns socio-environmental factors, despite the fact that Paraguayan agricultural production operates under sustainable practices. According to the Paraguayan Federation of Direct Seeding for Sustainable Agriculture (Fepasidias), in 2022, nearly 99% of agricultural production employed the direct seeding system, which reflects appropriate land-use management (Fepasidias, 2022). Nevertheless, sustainable production does not solely depend on conservation technology systems. As emphasized by Czyżewski *et al.* (2019), achieving sustainability requires balancing economic efficiency, natural resource management, and the socio-economic conditions of rural environments, all of which are fundamental to sustainable agricultural production.

CONCLUSIONS

The soybean complex remains solid as the main axis of Paraguayan agribusiness, consolidating a strong competitive position that is, nonetheless, structurally vulnerable. The study determines that Paraguay maintains a positive Revealed Comparative Advantage (RCA) index across its three main commodities—grain, oil, and meal—which confirms an export specialization that exceeds the world average.

The results further suggest that the industrialization of soybean derivatives represents a resilient development pathway. Value-added products not only exhibit greater market diversification but also act as a buffer against external shocks, contributing to the stability of the sector's role in Gross Domestic Product.

The evolution of the Hirschman-Herfindahl Index (HHI) in Paraguay's soybean exports reveals patterns of both concentration and diversification. Soybean grain exports to Argentina have shown increasing concentration, reaching a level of 0.87 in 2023, which exposes the national economy to systemic vulnerabilities regarding external shocks in that country. Conversely, derived products such as soybean oil and meal have maintained greater diversification, thereby reducing concentration risks. Furthermore, Paraguay has successfully reduced its dependence on the Russian Federation and European Union markets, as evidenced by a decline in HHI concentration.

To strengthen its competitiveness, Paraguay must mitigate its dependence on the grain market through diversification strategies and public policies that promote industrial transformation, thereby ensuring greater resilience against fluctuations in global demand for raw materials.

AUTHOR CONTRIBUTIONS

Conceptualization, N.D.L.D., and G.D.V.B.; Methodology, N.D.L.D.; C.R.L.D.; S.B.P.; Software, N.D.L.D.; J.A.V.D.; C.R.L.D.; Validation, N.D.L.D., G.D.V.B., and L.P.P.L.; Formal Analysis, N.D.L.D.; Investigation, N.D.L.D.; Data Curation, N.D.L.D.; G.D.V.B.; M.A.F.A.; Writing—Original Draft Preparation, N.D.L.D.; Writing—Review & Editing, N.D.L.D.; G.D.V.B.; C.R.L.D.; S.B.P., and M.A.F.A. Visualization, N.D.L.D.; Supervision, N.D.L.D., and G.D.V.B.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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