ECONOMIC IMPACTS OF PADDY PROCESSING UNITS ON THE RICE VALUE CHAIN IN THE SENEGAL RIVER DELTA

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Abstract

This paper investigates the economic effects of paddy processing units on the rice value chain in the Senegal River Delta, using primary survey data and a binary logit model to identify determinants of local market participation. The empirical results indicate that processing capacity, the absence of marketing frictions, and a higher share of white rice production significantly increase the probability of local commercialization. In contrast, official and market price variables, as well as supply structure characteristics, are statistically insignificant. The findings emphasize the relevance of upgrading processing technologies, improving logistical efficiency, and enhancing the market value of locally produced white rice. Policy interventions should prioritize equipment financing, capacity building, structured marketing channels, and quality promotion to strengthen the competitiveness of local rice**.**

Introduction :

In Senegal, rice is an essential staple food, with an annual per capita consumption of nearly 90 kg, representing about 1.5 million tons (COSTEA Committee, 2020). It occupies a strategic position in national agricultural policies and plays a major role in farmers' incomes and job creation in rural areas (within the Senegal River Valley, the value chain supports between 200,000 and 300,000 households, representing nearly 1.5 million people (SAED, 2020)).Since 2010, national rice production has increased significantly due to the expansion of cultivated areas and the implementation of public policies, along with the rapid development of processing units. This dynamic, supported by private investments and international partners (USAID, KOICA, JICA, AFD, etc.), has greatly contributed to improving the quality and competitiveness of locally produced rice. However, despite these achievements, the value chain continues to face numerous challenges, including weak commercial organization, low levels of mechanization, inconsistent paddy quality, limited storage capacity, and the obsolescence of part of the industrial processing infrastructure (World Bank, 2018; SAED, 2020). These constraints largely explain Senegal's continued dependence on rice imports.

In this context, this article addresses the following question: **What is the economic and social impact of the large-scale establishment of paddy processing units on the competitiveness of the rice value chain in the Senegal River Valley?**

The objective is to analyze how these units influence stakeholders, their economic conditions, organizational structures, and supply dynamics. The study uses descriptive statistics and multinomial regression to assess perceptions of this impact. The results reveal unevenly distributed benefits: vertically integrated actors (production–processing–marketing) appear to benefit more from these units, while persistent constraints remain regarding paddy quality, access to finance, and the coexistence of official and market prices. This highlights the need for further research to better understand these disparities and to more accurately assess the effectiveness of organizational arrangements and contractual mechanisms. Such studies would help design more targeted public policies to strengthen the socio-economic contribution of paddy processing and enhance the sustainable competitiveness of Senegal's rice sector.

Literature Review

The competitiveness of the rice sector in West Africa largely depends on the development of local processing units, which are considered a key leverage point for creating added value, reducing post-harvest losses, and limiting structural dependence on imports. The central role of processing units is confirmed by the pioneering work of Seck et al. (2010), who demonstrate that African rice demand is growing faster than local production, making the simultaneous improvement of productivity and processing capacity indispensable.

However, despite gains recorded since the 2010s, the competitiveness of Senegalese rice remains fragile. Seck et al. (2013) highlight several major constraints, including heterogeneous paddy quality, high processing costs, insufficient integration between producers, collectors, and processors, and inadequately coordinated governance. These authors emphasize the need for both institutional and technological reforms to ensure coherence between agricultural, industrial, and commercial policies.

The importance of coordination among actors is further explored by Demont and Rizzotto (2012), who show that contractual arrangements—such as cultivation contracts, forward purchase agreements, and price clauses—constitute a key tool to ensure stable supply and improve the quality of processed rice. According to these authors, the absence of formal contractual arrangements exacerbates price fluctuations and undermines industrial units that depend on a reliable and regular supply.

From a qualitative perspective, several studies emphasize the importance of technical improvements in rice processing. Cissé and Diagne (2018) demonstrate that the absence of grading, sorting, controlled drying, and standardized packaging undermines the competitiveness of local rice vis-à-vis Asian imports. They also highlight the fragmentation of marketing channels, which results in significant economic losses and hampers the development of a structured market for local rice.

Soulé et al. (2020), on the other hand, focus on dysfunctions within the rice market. According to these authors, the coexistence of official prices set by authorities and actual market prices creates distortions that disproportionately affect small producers. They advocate for more effective regulation to enhance price transparency and reduce information asymmetry among stakeholders.

Access to financing represents another critical determinant for the rice sector. Ndiaye (2017) describes the persistent difficulties faced by stakeholders, including the lack of collateral, high interest rates, and the mismatch between existing financial products and the seasonal needs of the sector. He recommends the establishment of tailored agricultural financing mechanisms, including group seasonal loans, risk-sharing arrangements, and partnerships between producers and processors.

These longstanding challenges are now being addressed through concrete recent initiatives. The RIZAO program, launched in 2024 by AfricaRice and the Mastercard Foundation, exemplifies the current orientation of rice development policies. This five-year program targets 441,000 jobs, 70% of which are dedicated to young women, and is structured around six strategic pillars: seed improvement, enhancement of processing, creation of rural employment, modernization of legal frameworks, access to financing, and promotion of local rice (AfricaRice, 2024). The program underscores the strategic role of processing in strengthening the West African rice value chain.

In Senegal, recent investments follow the same strategic direction. Over 42 billion CFA francs have been mobilized to improve local processing, reduce production costs, strengthen contractual arrangements between producers and processors, standardize grading and packaging, and structure marketing channels (MAER, 2024). These measures directly address the challenges identified by Cissé and Diagne (2018) and Soulé et al. (2020), seeking to rectify the technical and commercial weaknesses of local rice.

These efforts also align with the approach advocated by Ndiaye (2017), introducing innovative financial mechanisms tailored to the real needs of stakeholders, including seasonal loans, support for mechanization, and vertically integrated partnerships.

Overall, both historical and recent literature converge on a clear conclusion: **the development of paddy processing units in the delta and the Senegal River Valley constitutes a strategic lever for enhancing the competitiveness of local rice.** This development promotes job creation—particularly for women—integrates activities along the value chain, adds value to local rice, and contributes to national food sovereignty.

3. Methodology

3.1. Data Sources and Study Populations

This study is based on a quantitative survey conducted in the rice-growing area of the Delta. To carry out this research, two main data collection tools were employed: a questionnaire and interview guides. The questionnaire was administered to different categories of actors directly involved in the rice value chain, including owners of artisanal dehusking units (UDAs), managers of rice mills, agricultural producers, and households residing in the study area. Designed as a mixed-format instrument, combining closed- and open-ended questions, it enabled the collection of both measurable quantitative data and complementary qualitative information.

The interview guides, for their part, targeted key institutional and private actors, including rice mill managers, suppliers of artisanal dehusking machines, representatives of artisanal dehusker owners’associations, as well as various technical and financial support organizations such as the National Agricultural and Rural Advisory Agency (ANCAR), the Delta and Senegal River Valley Development and Exploitation Company (SAED),USAID-Dooleel Mbay (United States Agency for International Development – Dooleel Mbay Program), Crédit Mutuel du Sénégal (CMS), the Agricultural Bank, the Interprofessional Union for Marketing and Entrepreneurship (UIMCEC), and SYNGENTA. Local resource persons were also consulted to refine the understanding of ongoing dynamics.

The survey covered the main areas of concentration for artisanal dehusking units (UDAs) and rice mills in the Delta, namely Richard Toll, Rosso, Ross Béthio, Diama, and Ronkh. To determine the sample size, Fisher’s formula was applied (Fisher, 1925; Cochran, 1977). From a total population of 118 UDAs, the sample size was calculated using Fisher’s formula:

$$n_f = \frac{N}{1 + N \times d^2}$$

where N=118 and d=0,07. The application of this formula yields:

$$n_f = \frac{118}{1 + 118 \times (0,07)^2} \approx 75$$

Thus, 75 units were surveyed, corresponding to a 93% representativeness, consistent with a 7% margin of error. The list of artisanal dehusking units to be surveyed in each area was randomly selected using the “**RAND**” function in Excel.

Table 01: Survey situation of Number of dehusking machines

Municipalities	Localities	Number of dehusking machines	To be surveyed per locality	Weighting

DIAMA	NDELLE	1	1	**8%**
	DIAGAMBAL	2	1	
	NDIAYE	1	1	
	KASSACK NORD	2	1	
	KASSACK SUD	2	1	
	PONT GENDARME	1	1	
ROSS BETHIO	ROSS BETHIO	48	30	**41%**
ROSSO	ROSSO	26	16	**22%**
RONK	DIATENE	10	6	
	THIAGAR	5	3	**12%**
RICHARD TOLL	RICHARD TOLL	20	13	**17%**
TOTAL	**118**	**75**	**100%**	

3.2. Descriptive Statistics and Data Analysis

The majority of stakeholders perform multiple roles, reflecting a certain level of integration across activities. Processors dominate with 97.6%, indicating that paddy processing constitutes a central stage in the value chain. They are followed by white rice traders (81.0%), highlighting the importance of marketing within the sector. Producers account for 66.7%, showing that some of them are not limited to production but also engage in other segments of thevalue chain. Finally, service providers represent a minority (33.3%), likely specializing in logistical, financial, or technical activities.

Table 0.2: Distribution of Stakeholders by Their Role in the Rice Value Chain

Producers	**66,7%**
Processors	97,6%
White Rice Traders	81,0%
Service Providers	33,3%

In 2019, the average volume was 1,193 kg, with a maximum of 8,500 kg and a high standard deviation (2,364), indicating substantial variability among stakeholders, as shown in the table. In 2020, the average slightly decreased to 1,068 kg (maximum 9,000 kg), while the standard deviation declined to 2,193, suggesting a modest homogenization of supply. In 2021, the average remained stable at 1,068 kg, but the maximum increased to 10,500 kg, and the standard deviation rose again to 2,316, reflecting greater dispersion in volumes, with some actors supplying significantly more than before. Overall, these data indicate stable mean volumes, accompanied by growth at the extremes (increase in the maximum), signaling a polarization between small and large suppliers.

Table 0.3: Evolution of Average Supplied Paddy Quantities over Three Years (2019–2021)✅

Years	**Mean**	**Maximum**	**Standard Deviation**
In 2019	1193	8500	2364
In 2020	1068	9000	2193
In 2021	1068	10500	2316

Descriptive analysis shows a progression in cultivated areas over the period. In 2019, the mean cultivated area was 11.4 ha, with a median of 5 ha. The high standard deviation (20.1) reflects substantial heterogeneity, with some producers cultivating up to 150 ha. In 2020, the mean increased to 12.8 ha, while variability remained significant (standard deviation of 20.9). In 2021, the mean further rose to 16.2 ha. It is noteworthy that all producers cultivated a minimum area of 0.4 ha. These results indicate a slight trend toward expansion of cultivated areas.

Table 0.4: Evolution of Cultivated Areas (2019–2021) ✅

	Mean	**Standard Deviation**	**Maximum**
Evolution of Cultivated Areas in 2019	11,4	20,1	150,0
Evolution of Cultivated Areas in 2020	12,8	20,9	150,0
Evolution of Cultivated Areas in 2021	16,2	26,1	150,0

The analysis of cultivated areas indicates that the mode of financing influences the expansion of farmland. Producers financed by banks or by processors show a steady increase in cultivated areas, with a gain of 5 ha for each group over the 2019–2021 period. Those relying on own funds remain limited to 6–7 ha, suggesting that self-financing constrains expansion. Paddy collectors maintain stable cultivated areas (22 ha), which may reflect already large holdings or constraints independent of financing.

Table 0.5: Distribution of Cultivated Areas by Mode of Financing

Mode of Financing	**Evolution of Cultivated Areas in 2019**	**Evolution of Cultivated Areas in 2020**	**Evolution of Cultivated Areas in 2021**
	Mean	Mean	Mean
Bank	11	12	16
Processors	17	18	22
Paddy Collectors	22	22	22
Own Funds	7	6	6

Producers selling to processors gradually increased their cultivated areas, from 12.4 ha in 2019 to 17.7 ha in 2021. In contrast, those working with collectors experienced stagnation, with areas remaining around 6–8 ha. These results indicate that relationships with processors promote the expansion of cultivated land, likely due to more stable demand and secure supply conditions.

Table 0.6: Cultivated Areas by Type of Paddy Buyer

	Evolution of Cultivated Areas in 2019	**Evolution of Cultivated Areas in 2020**	**Evolution of Cultivated Areas in 2021**
	Mean	Mean	Mean
To whom do you sell your paddy? /Processors	12,4	13,9	17,7
To whom do you sell your paddy? /Collectors	8,3	6,1	6,4

The analysis shows that the perceived economic impact of processing units is more pronounced among women's groups and family-run businesses. Indeed, 37.5% of women's groups and 30% of family businesses consider that the establishment of processing units has had a positive effect, compared to only 22.5% of individual enterprises and 10% of collective enterprises. Thus, structures organized around the family or women's collectives benefit more from the opportunities created by paddy processing, likely due to better coordination in supply, marketing, or activity diversification. In contrast, individual enterprises and some collective enterprises appear less responsive to these effects, reflecting a more limited capacity to capitalize on the presence of processing units.

Table 0.7: Perceived Improvement in Living Conditions by Producer Categories and Organizational Type

Organizational Type	Do you think that the large-scale establishment of paddy processing units in the Senegal River Valley (VFS) has had an economic impact on the value chain actors? If yes, please explain how.		
	Non	Oui	Total
Collective Enterprise	0,0%	10,0%	9,5%
Family Business	0,0%	30,0%	28,6%
Individual Enterprise	50,0%	22,5%	23,8%
Women's Group	50,0%	37,5%	38,1%

The analysis of supply methods reveals that direct purchasing overwhelmingly dominates the value chain, with 95.2% of stakeholders using this approach. Sales contracts account for 38.1%, indicating limited reliance on formal agreements, while production financing with in-kind repayment concerns only 11.9% of respondents. These figures demonstrate that the majority of actors favor immediate and flexible transactions, whereas more formalized or integrated mechanisms remain minority practices, which may constrain supply security and production planning.

Table 0.8: Organization and Paddy Supply Methods

Sales Contract	38,1%
Direct Purchase	95,2%
Production Financing with In-Kind Repayment	11,9%

3.3. Econometric Model Specification

The analysis utilizes a **binary logit model** to identify factors that influence the probability of a paddy processing unit marketing its products within the Senegal River Valley[1]. The dependent variable (BF) is binary, taking the value 1 if the unit commercializes within the valley and 0 otherwise[2].

The explanatory variables include[3]:

- **Monthly processing capacity (M)**[444].
- **Marketing difficulties (BI)**[555].
- **Existence of an inter-professional official price (T)**[666].
- **Market price level (U)**[777].
- **Supply structure shares**, specifically individual producers (AC), economic interest groups (AD), producer unions (AE), and aggregators (AF)[888].
- **Main product purchased (AV)**, introduced via indicator (dummy) variables[999].

The model is specified as follows[10]:

$$\text{logit}(P_i) = \ln \frac{P(BF_i = 1)}{1 - P(BF_i = 1)} = \beta_0 + \beta_1 M_i + \beta_2 BI_i + \beta_3 T_i + \beta_4 U_i + \beta_5 AC_i + \beta_6 AD_i + \beta_7 AE_i \dots$$

In this equation, $P(BF_i = 1)$ is the probability that unit i commercializes in the valley, and ϵ_i represents the random error term[11]. The coefficients β_j measure the marginal effect of each variable on the log-odds of commercializing locally[12]. Estimation is conducted using the **maximum likelihood method**, and results are reported as raw coefficients and **odds ratios** to aid economic interpretation[13].

4. Results and Interpretation

The estimated coefficients of the logit model are interpreted in terms of variations in the **log-odds** of commercialization within the valley[1]. A positive value for a β coefficient indicates that the variable in question increases the probability of the unit commercializing in the valley, whereas a negative value reflects the opposite effect[2]. To facilitate interpretation, the coefficients are presented as **odds ratios** ($\exp(\beta)$)[3]. An odds ratio greater than 1 suggests a positive effect on the probability of commercialization, while a value less than 1 indicates a negative effect[4].

Average Marginal Effects (AME) are also calculated to express the impact of the explanatory variables on the average probability of commercialization. This approach allows for the direct interpretation of results in terms of probability points, which facilitates the economic reading of the findings.

4.1. Model Validation

The goodness-of-fit of the model is evaluated using the Likelihood Ratio (LR) test and McFadden's Pseudo R^2[1]. Predictive performance is measured by the Receiver Operating Characteristic (ROC) curve and the Area Under the Curve (AUC)[2].

The Hosmer-Lemeshow goodness-of-fit test is employed to verify the consistency between predicted and observed probabilities[3]. Furthermore, potential multicollinearity among the explanatory variables is examined using Variance Inflation Factor (VIF) indices[4].

Finally, robust standard errors are estimated to correct for potential heteroscedasticity or intra-group correlations between units[5]. These various diagnostic checks guarantee the reliability and stability of the estimated coefficients[6].

4.2. Regression Results and Interpretation

Table 1 presents the results of the logistic regression aimed at explaining the probability of a processing unit commercializing its products within the valley. The estimated coefficients are provided in both log-odds and odds ratios, accompanied by their respective significance levels.

The analysis reveals that processing capacity is the most significant determinant: each additional ton processed significantly increases the probability of local commercialization. This finding highlights the advantage of larger units, which are generally better equipped, better structured, and more integrated into the economic circuits of the valley.

Conversely, marketing difficulties negatively and significantly affect the probability of selling rice within the valley. Units facing logistical constraints, unstable demand, or increased competition are therefore less likely to sell their products locally. Finally, the fact that white rice is the most sold product exerts a significant positive effect: the strong local demand for white rice makes it a lever for commercial integration for processing units.

On the other hand, variables related to prices (official prices set by the interprofessional organization or market prices) show positive but insignificant effects. This lack of significance suggests that price variations still have very little influence on marketing decisions at this stage. Similarly, the share of suppliers (individual producers, economic interest groups, unions, aggregators) does not have a statistically significant effect, indicating that the supply structure is not yet a determining factor in the decision to sell locally.

Overall, the analysis highlights three major determinants of commercialization within the valley:

- Processing capacity.
- The absence of marketing difficulties.
- The predominant sale of white rice.

Variable	Coefficient (β)	Odds Ratio	p-value	Interpretation
Constante	-2,1	0,12	0,08	
M (monthly capacity)	0,07	1,07	0,03*	Positive and Significant Effect
BI (marketing difficulties)	-1,2	0,3	0,04*	Negative and Significant Effect
T (official price)	0,6	1,82	0,18	Positive but non-significant effect
U (market price)	0,25	1,28	0,32	Positive but non-significant effect
AC (individual production)	0,01	1,01	0,12	Weak effect
AD (GIE)	-0,02	0,98	0,22	Weak effect
AE (unions)	0	1	0,95	No effect
AF (aggregators)	0,01	1,01	0,6	Insignificant effect
AV_white rice	1,1	3	0,02*	Positive and significant effect

* : significant at the 5% level

These results are consistent with existing literature. The positive influence of processing capacity aligns with the findings of Njiti et al. (2023) in Cameroon, which demonstrate that larger processing units enjoy easier access to local and regional markets. In Senegal, Ndiaye (2017) similarly highlights the decisive role of technical investments in securing access to commercial outlets.

The negative impact of marketing constraints is in phase with the observations of Kouman (2024) in Côte d'Ivoire, who argues that logistical limitations, irregular demand, and competition severely restrict the local distribution of processed products. These findings underscore the necessity of improving market organization, transport, and stakeholder coordination to bolster the overall performance of the value chain.

The significant positive impact of white rice sales as the primary product further corroborates the findings of Demont and Rizzotto (2012), who emphasize the high economic value of white rice in local markets and its pivotal role in regional demand. Conversely, the lack of significant effects from price variables reflects the work of Soulé et al. (2020), which suggests that discrepancies between official and market prices still have limited influence on economic behavior in contexts where regulation remains partial and frequently bypassed in practice.

Furthermore, the absence of a significant effect regarding the share of various suppliers aligns with the results of Cissé and Diagne (2018), demonstrating that procurement structures remain poorly formalized and inadequately regulated, thereby limiting their actual influence on marketing decisions.

Overall, these results indicate that enhancing the technical capacities of processing units and mitigating commercial and logistical obstacles represent the primary levers for strengthening stakeholder integration within the local value chain. At this stage, price variables and the nature of suppliers appear to be secondary factors; however, they may become more influential as contractual mechanisms and sector regulations are progressively strengthened.

5. Discussion

The results of the logit model confirm that processing capacity is the primary factor influencing rice commercialization in the Senegal River Valley. Processing units with higher capacities demonstrate a significantly greater probability of selling their products within the valley. This advantage stems from several mechanisms: economies of scale, reduction in unit costs, supply consistency, and enhanced integration into distribution networks. This finding aligns with trends observed in the region, notably the case of the *Compagnie Agricole de Saint-Louis* (CASL), whose modern infrastructure—capable of milling and storing up to 60,000 tons per year—has strengthened the integration of local producers into regional commercial circuits (CASL, 2025).

Conversely, marketing difficulties exert a significant negative effect on the probability of local sales, highlighting the structural constraints affecting the rice value chain. These obstacles include logistical limitations, insufficient storage capacity, a lack of stable outlets, and a persistent reliance on informal intermediaries. These observations are consistent with reports from SODAGRI (2025), which suggest that irregular distribution channels and the absence of reliable commercial platforms increase the economic vulnerability of processors.

The economic importance of white rice is further validated, showing a significant positive effect on the probability of local commercialization. Sustained demand for white rice in the urban and peri-urban areas of the Delta establishes it as a strategic product for processing units. This dynamic aligns with the priorities of the National Strategy for Rice Development (2024), which emphasizes the development of competitive local white rice to reduce import dependency.

In contrast, price-related variables—whether the official price set by the inter-professional body or the market price—are non-significant. This result suggests that commercialization decisions are driven more by the operational capacity of the units than by price signals. This trend aligns with recent observations by Inter-Réseaux (2025), which indicate that market distortions and the low formalization of trade reduce the influence of price mechanisms within the Senegalese rice sector.

Similarly, the lack of significant effect from various supply structures (individual producers, GIEs, unions, aggregators) reveals a lack of differentiation in the procurement strategies of processing units. This situation highlights the weak formalization of commercial relations within the sector, which still relies heavily on informal arrangements. Furthermore, the MAER (2024) emphasizes the necessity of strengthening contractualization and developing inter-professional organizations capable of better stakeholder coordination.

In summary, the results highlight three major levers for strengthening the commercialization of processed rice within the valley:

- Enhancing the technical and operational capacities of processing units;
- Mitigating logistical and commercial constraints;
- Further promoting local white rice as the primary driver of regional demand.

6. Conclusion and Policy Recommendations

The study demonstrates that the commercialization of processed rice within the Senegal River Valley is highly contingent upon the technical capacities of processing units and their ability to mitigate logistical and commercial bottlenecks. The results indicate that larger units—characterized by superior equipment and production consistency—achieve better integration into local markets. In contrast, smaller units remain marginalized due to limited capacity, frequent equipment failures, high operational costs, and the lack of stable market outlets.

The sustained demand for white rice emerges as a critical lever for dynamizing the sector. However, efforts regarding standardization, packaging, grading, and quality enhancement must be intensified to enable local white rice to compete effectively with imports. While price signals and procurement structures currently play a secondary role, the enhancement of regulatory frameworks, contractualization, and inter-professional coordination remains essential for ensuring sustainable commercialization.

In light of the findings, several strategic recommendations emerge:

1. Strengthening the Technical Capacities of Processing Units

- Facilitate access to tailored financing (seasonal credit, equipment leasing, guarantee funds).
- Promote the modernization of facilities and the implementation of regular equipment maintenance programs.
- Encourage the emergence of regional processing hubs capable of pooling storage and transport costs.

2. Improving Logistical Infrastructure and Marketing Mechanisms

- Develop regular and formalized market platforms
- Invest in storage, drying, and preservation infrastructure
- Implement logistical frameworks capable of reducing transport costs and minimizing post-harvest losses.

3. Promote local white rice and strengthen its competitiveness

- Continue efforts toward standardization, packaging, and labeling
- Promote territorial marketing that highlights the unique qualities and freshness of local rice
- Consolidate collaborations between processors, distributors, and institutional actors to enhance the product's market visibility

4. Structuring and Formalizing Relations Between Stakeholders

- Develop more formalized sales, procurement, and production contracts
- Strengthen inter-professional organizations to ensure improved price regulation and effective coordination
- Foster partnerships between producers, processors, and financial institutions

Ultimately, the sustainable competitiveness of the rice sector in the Valley depends less on price adjustments and more on a technological, organizational, and logistical upgrade. The consolidation of processing units and their integration into local markets are essential conditions for strengthening food sovereignty and driving inclusive economic dynamics in Senegal.

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