Vanilla Value Chain: Risks, Equity and Economic Growth

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ABSTRACT

Madagascar supplies almost 80% of the global market for vanilla, making it the world's top producer. Vanilla farming has grown to be a significant source of revenue for the country since it was first introduced in the 19th century. A complicated value chain that includes small scale producers, collectors, exporters and government regulators characterizes the governance of vanilla. The question of what framework conditions are required to enhance value chain governance and guarantee equity among its players is brought up by this complexity. To address this issue, the goal is to pinpoint the critical elements that promote the fair growth of the vanilla value chain with the intention of promoting economic expansion. Interviews with stakeholders at all levels: public sector, government ministries, business sector, cooperatives, and producer groups, were conducted as part of a systemic approach to context analysis. Institutional, economic, social, and environmental issues were identified through risk analysis. Although producers play a crucial part in the chain, the study emphasizes the unequal distribution of revenue across stakeholders, with economic profitability analysis highlighting the disadvantages encountered by producers. The vanilla chain value has a low but expectedly favorable impact on Madagascar's economic growth, according to econometric modeling. In order to effectively control Madagascar's vanilla industry, a multilevel, integrated strategy that fosters fair economic growth is needed. To guarantee that the advantages of vanilla production contribute significantly and equitably to the nation's economic and social growth, this entails putting in place price regulating systems, inclusive policies, and sustainable practices. All parties participating in the value chain should benefit from this conclusion, but producers, who form the system's core, should receive special attention.

Keywords: *Structural weaknesses, price control, equity, stakeholders.*

1 INTRODUCTION

The vanilla industry in Madagascar constitutes a cornerstone of the national economy, particularly in the SAVA region and along the East Coast, which together produce between 70% and 80% of the world's bourbon vanilla supply (Hänke, 2018). Furthermore, the governance of this Value Chain (VC) is of strategic significance for the country's economic development. In 2021, exports of vanilla and cloves represented the primary source of foreign exchange earnings, surpassing those generated by Special Economic Zones. These exports totaled USD 731.7 million during the period, up from USD 573.5 million in 2020 (Banque Centrale de Madagascar, 2021). According to a report by the International Trade Centre (ITC, 2020), vanilla exports alone account for approximately 25% of the country's total export revenues. This proportion underscores the strategic importance of vanilla within the Malagasy economy, not only as a key source of foreign exchange but also as a driver of rural development (ITC, 2020). As a result, the Malagasy government has sought to assert control over the industry in order to safeguard its strategic position in the international market. Beyond the international regulations enforced by importing countries, the vanilla sector is among the most tightly regulated industries in Madagascar. Production is governed by Decree No. 2001-234, which regulates the profession of vanilla growers and requires a professional identification card (Interministerial Order No.35 255/2013), as well as the mandatory marking of green vanilla through a punching system (Decree No. 60 187). The start of the green vanilla marketing season is determined by Law No. 97 046, while transport is

regulated under Interministerial Order No. 35 255/2013. Marketing is subject to six ministerial decrees covering all stages from collection to packaging (No. 35 255/2013).

Processing is regulated by five separate laws and decrees that govern preparation methods. Export activities are governed by Interministerial Decree No. 36 255/2013 and Decree No. 2006-681, which respectively regulate the export profession and certification controls. Finally, the calendar for the marketing campaign of processed vanilla and the framework for interprofessional coordination are set by Law No. 97-046 (Chakib, 2018).

From an economic standpoint, the vanilla sector remains highly regulated, with strict oversight of stakeholders, as previously noted. While this framework initially produced positive outcomes, these were soon eclipsed by adverse effects on the market. The average export price of Malagasy vanilla dropped by 19.7%, falling to USD 244.3 per kilogram in 2021, down from USD 304.4 in 2020. However, this price decline was offset by a 51.0% increase in export volume over the same period, resulting in a 21.2% rise in nominal export value, from USD 509.5 million in 2020 to USD 617.4 million in 2021 (Banque Centrale de Madagascar, 2021).

The vanilla market is shaped by a phenomenon of dual market power, with Madagascar occupying a central role in price-setting and control over domestic production (Melo, 2000). While vanilla cultivation presents highly lucrative opportunities, it also exposes stakeholders to significant economic vulnerabilities, notably stemming from price volatility, climate change, and rising incidents of theft (Celio, 2023). Contract farming systems have demonstrated potential benefits for smallholder farmers, such as improved access to higher vanilla prices; however, challenges persist particularly for female headed households (Franke et al., 2018). The country's path toward sustainable economic development remains constrained by deep-rooted structural barriers, including social fragmentation and the concentration of power within elite groups (Razafindrakoto, 1996). Promoting sustainable development in Madagascar's vanilla producing regions requires a holistic approach that integrates the complex interdependencies of economic, social, and environmental factors. Nevertheless, the vanilla VC continues to face significant challenges, including price fluctuations, theft, and persistent inequalities in income distribution among stakeholders from local producers to international exporters (Hänke, 2018).

These conflicting realities give rise to the following research question: What are the enabling framework conditions for improved governance of the vanilla VC, with a view to ensuring equity among stakeholders? The overarching objective is to identify the key factors that promote equitable development within the vanilla VC, ultimately contributing to economic growth. Three hypotheses are proposed: first, the governance of the vanilla VC is hindered by external factors beyond the control of its principal actors; second, the current pattern of income distribution within the chain reflects systemic inequities, with producers being disproportionately disadvantaged compared to downstream stakeholders; and third, the underappreciation of vanilla's contribution to national economic growth constrains its strategic role in the country's development.

2 MATERIALS ET METHODS

2.1 Risk analysis

Failure Mode, Effect and Criticality Analysis (FMECA) was employed to assess the severity of each identified risk. This risk mapping approach is designed to identify, evaluate, prioritize, and manage risks associated with the vanilla circuits within the VC. The risk map is structured along two axes:

- The horizontal axis represents the probability of risk occurrence along the commercial circuit, ranging from "Unlikely" to "Very Likely".
- The vertical axis reflects the potential impact of each risk on the development and effective functioning of the VC, ranging from "Minor" to "Catastrophic".

The applied calculation method (Equation 1) allows for the construction of a criticality matrix (Table 1), which visualizes the level of risk impact/level across the vanilla VC (Table 2). Table 3 shows the mobilized variables.

Equation 1: Risk criticality
Criticality = Frequency index * Severity index * Detection index

The risk decision rule facilitates the determination of the risk level and informs the corresponding mitigation actions based on the assessed criticality value.

Table 1: Risk scoring

Probablity	Rating	Frequency	Rating	Severity	Rating
Unlikely	1	Exceptional	1	Minor	1
Less likely	2	Rare	2	Major	2
Probable	3	Frequent	3	Critical	3
Highly probable	4	Certain	4	Catastrophic	4

Source : Les cahiers de l'innovation, 2018

Table 2: Risk decision rule

Criticity(C)	Risk level	Color code	Action to be planed
1 à 27	**Moderate**	**yellow**	**Preventive action if possible**
28 à 47	**High**	**Orange**	**corrective action required**
48 à 64	**Critical**	**Red**	**Immediate and priority action**

Table 3: Variables for risk mapping

Risks	Codification	Risks	Codification
Corruption	: P1_Corp	Uncertain market	: E3_MarIncrt
Granting of export approval	: P2_Agrem	Price fluctuation	: E4_FluxPx
Preeminence of importers	: P3_Dom_Impt	International requirements	: E5_ChgtExgI
Lack of enforcement of regulatory texts	: P4_MqApT	Upfront funding	: E6_PrefComp
Representativity of CNV	: P5_RepCNV	synthetic vanilla	: E7_SubSynt
Misunderstanding of the government's role	: P6_IncEtat	market competitions	: E8_ConcurS
Cross-sector communication	: P7_ComInter	farmer's level of education	: S1_NivEdu
Field campaign	: P8_DtComp	lack of trust	: S2_MqConf
Public-private conflict	: P9_PubPriv	on-site theft and pillaging	: S3_VolPied
Populism influenced decision	: P10_DecPop	Climatic hazards	: B1_ALClim
Informal/ boycott	: E1_InfBoy	Deforestation	: B2_Defrich
Price-setting mechanism	: E2_FixPx	Crop diseases and pest attacks	: B3_MalRav

2.2 Analysis of Equity in value Distribution Among Stakeholders in Vanilla VC

Equity within the VC is evaluated by analyzing the Internal Rate of Return (IRR) over a 10-year horizon for the VC's key stakeholders. The IRR computation, defined in Equation 2, represents the discount rate at which the Net Present Value (NPV) equals zero within the TSIM (Simulation Test) framework. This methodology also enables the derivation of an IRR to quantify equity in wealth distribution among direct sectoral actors.

Equation 1 : IRR

$$\sum_{t=0}^{n} \frac{C_t}{(1+ IRR)^t} = 0$$

with

- C_t represents the cash flows at time t
- IRR is the internal rate of return to be determined
- n is the total number of periods

This simulation was conducted to determine the conditions and timing under which the internal rate of return (IRR) achieves equity across stakeholders. Equity is defined as the convergence of IRR values across all participants. The calculation of each stakeholder's IRR incorporates key variables, including investments and capital expenditures, production and sales volumes, as well as operating income.

2.3 Analysis of the correlation between GDP (Gross Domestic Product) and other economic indicators

The econometric model ARDL (AutoRegressive Distributed Lag) was employed to analyze the relationship between GDP and key economic variables, including vanilla exports, exchange rates, and import values. Following the analysis, the study evaluated the effect of vanilla exports on GDP. GDP served as the endogenous variable, while exports, exchange rates, and imports of specific finished cash goods were designated as exogenous/explanatory variables in Equation 3. The model tracked the evolution of GDP, vanilla exports, exchange rates, and imported finished goods from 2002 to 2020. The results of the ARDL model enabled the distinction between the system's capacity to revert to its balanced state following a shock and the immediate short term effects of vanilla exports, exchange rates, and imports on GDP. This separation reflects the model's ability to differentiate long run equilibrium adjustments from short-run dynamics.

Equation 2

$$\mathbf{GDP = Constant + \beta\ 1*Vanille\ exported + \beta\ 2*Exchange\ rate + \beta\ 3*Imported\ cash\ crop\ product + \varepsilon}$$

$\beta 1, \beta 2, \beta 3$: coefficients to be estimated
ε : Error term

3 RESULTS

3.1 Vanilla VC analysis

The risk mapping

The risk mapping generated through the FMECA analysis identified the failure modes that threaten VC across its institutional, economic, social, and environmental dimensions (Figures 1 to 4).

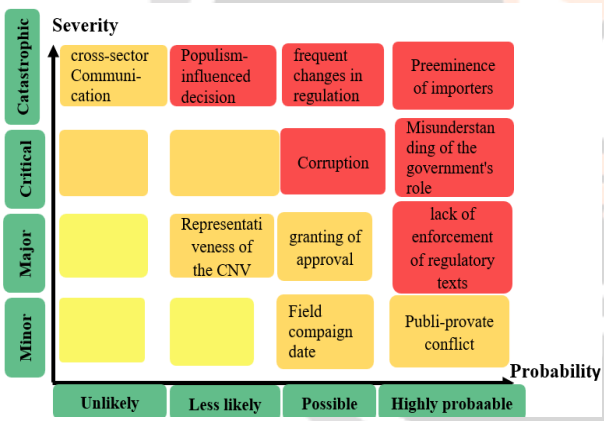

Figure 1: Institutional Risks

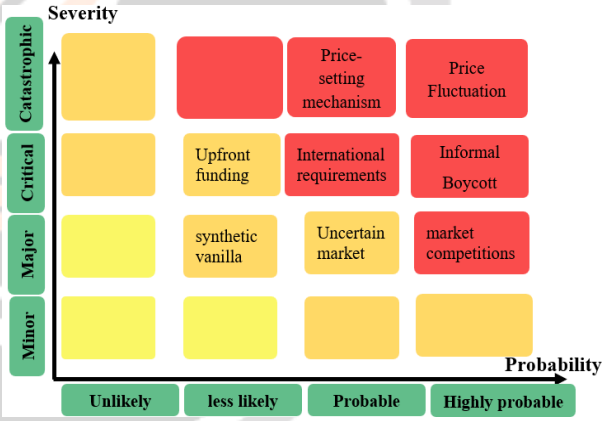

Figure 2: Economic Risks

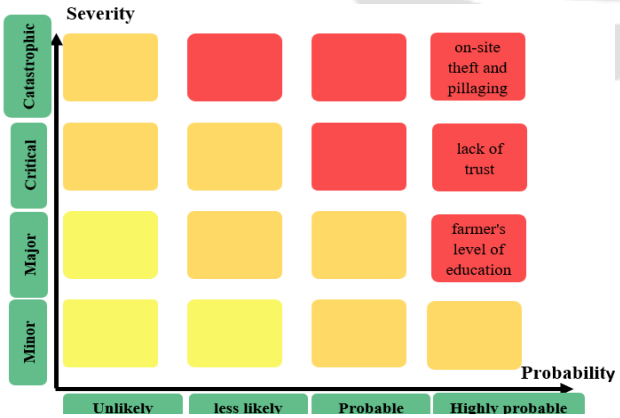

Figure 3: Social Risks

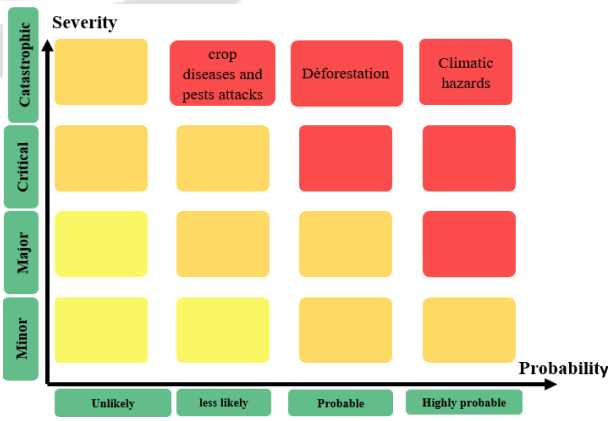

Figure 4: Environnemental Risks

According to the FMECA analysis, the predominance of importers in decision making processes related to the governance of the vanilla VC constitutes a critical risk factor for sector management. Additionally, corruption, competition from other vanilla producing countries, and weak enforcement of laws and regulations are also situated within the highly sensitive production zone (Figure 1).

Regarding economic factors, the analysis highlights that reduction and non-compliance with commitments represent the most critical risks to Vanilla VC governance. Other significant risks, including boycotts, informality, and decreased demand, also exhibit high criticality and require targeted mitigation measures (Figure 2). Regarding the social dimension, the theft or looting of green vanilla pods from local fields is identified as the most detrimental risk to local governance within the VC. The presence of informal actors also constitutes a significant source of criticality. Although grower's illiteracy is categorized within a moderate criticality zone, it remains a crucial factor for the socio-economic development of growers, particularly in relation to precautionary practices, savings, and children's education (Figure 3).

Finally, climatic hazards, due to their increasing significance, represent a risk of very high criticality for the governance and development of the vanilla VC in Madagascar. Land clearing and diseases directly affecting vanilla plants are also classified within the high criticality zone (Figure 4).

Comparative analysis of the four dimensions of risk

A comparative analysis of the four dimensions of risk within the vanilla value chain reveals that the most critical risks predominantly occur at the international level. These include the dominance of importers, intense market competition, the substitution of synthetic vanilla, and frequent regulatory changes in the global market. Such risks necessitate immediate and prioritized attention. Subsequently, security related risks such as on-site theft crops and pillaging and environmental challenges, including crop diseases and climatic hazards constitute significant threats that require the implementation of both corrective and preventive measures to safeguard the sustainability and resilience of the vanilla value chain (Figure 5).

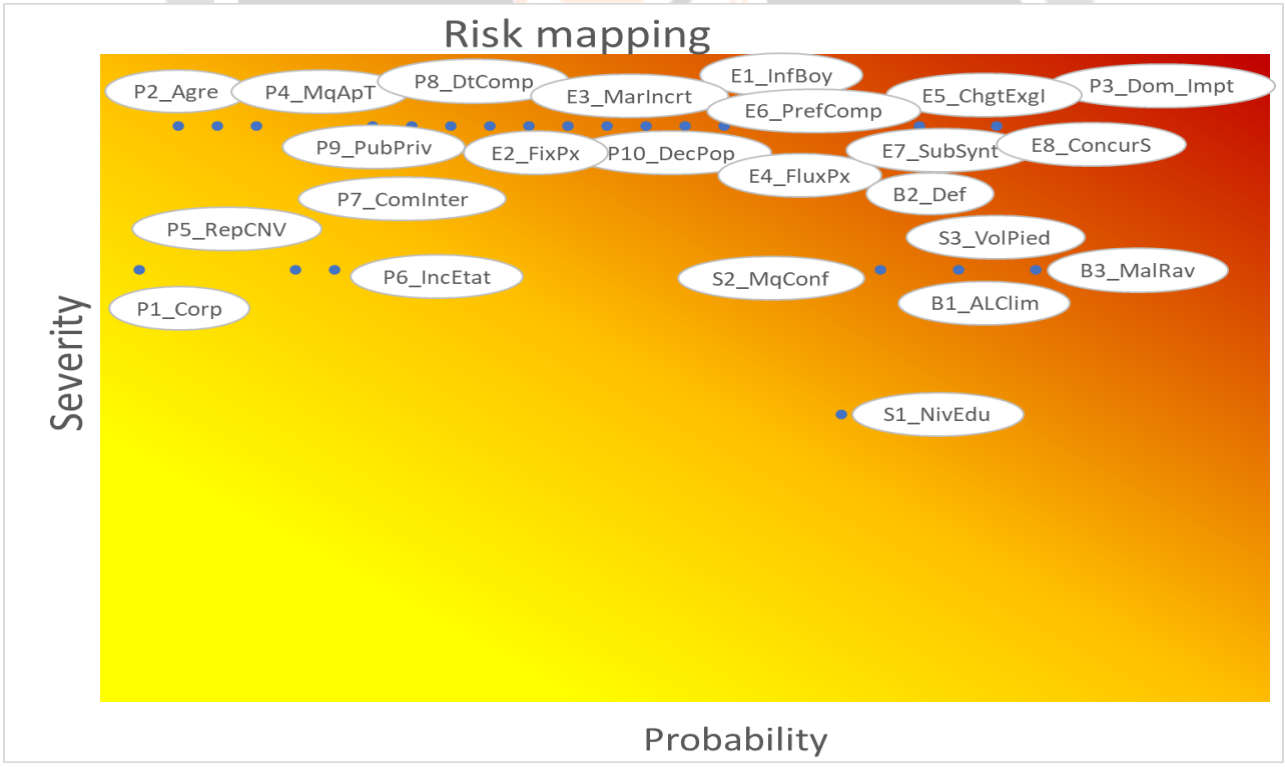

Figure 5: Risk mapping in vanilla VC

Most of the risks are concentrated within the red and orange zones, which highlights the complexity and severity of the challenges threatening the vanilla value chain (CdV vanille). This distribution indicates that a significant portion of the identified risks fall into high and medium high criticality categories, underscoring the intricate and multifaceted nature of the risk environment faced by the vanilla sector. Such clustering in the upper risk categories reflects not only the frequency and potential impact of adverse events but also the difficulty in managing and mitigating these risks effectively.

3.2 Equity in the VC

The study reveals that at the critical milestone of year 5, the internal rates of return (IRRs) for each stakeholder, calculated without accounting for equity adjustments are 23% for producers, 78% for processors, and 80% for exporters, respectively (Figure 6). Adjusting the selling prices at the relevant stages for each stakeholder to achieve equity results in a convergence of IRRs to a standard rate of 74% among all three actors (Figure 7).

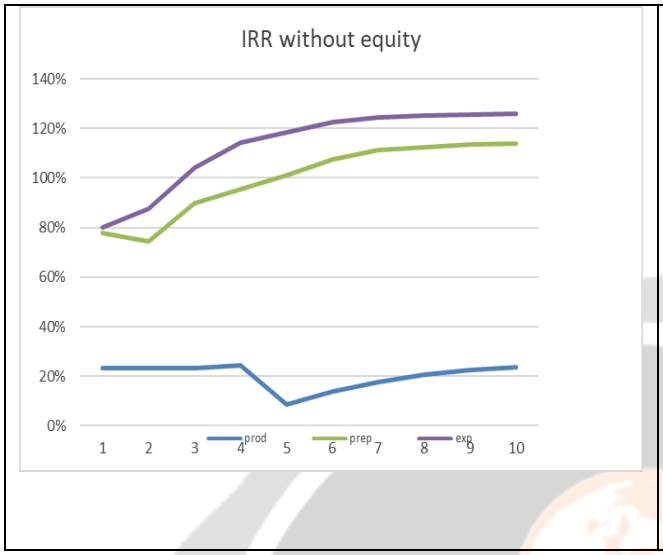

Figure 6: IRR without equity

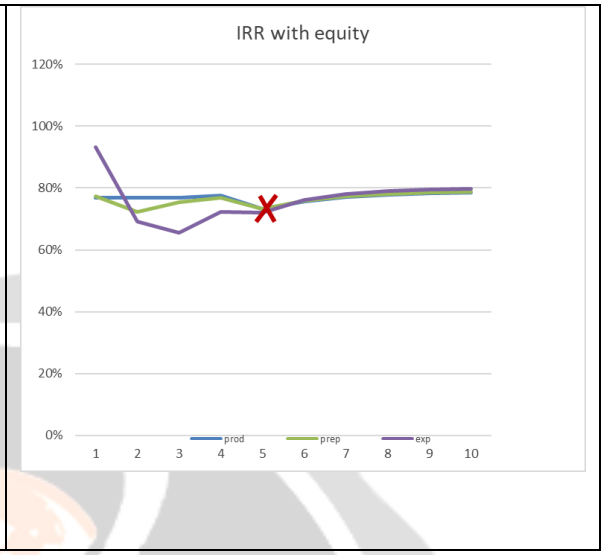

Figure 7: IRR with equity

The internal rate of return (IRR) for producers is significantly lower than that of other VC actors, such as processors and exporters, whose IRRs are considerably higher. To enhance equity among stakeholders, the profitability trajectories of processors and exporters should decrease during years 2 and 3 before subsequently increasing, thereby converging toward and aligning more closely with the IRR profile of producers.

3.3 Relationship between GDP and vanilla exports from Madagascar

GDP is positively correlated with vanilla exports, the exchange rate, and imports of certain finished products, which serve as the explanatory variables (Equation 4). The model's adjusted R^2 of 0.947 indicates that 94.7% of the variance in GDP is accounted for by these independent variables. This exceptionally high value demonstrates the model's strong predictive capability regarding GDP fluctuations, confirming the relevance of the explanatory variables and the model's good fit to the data (Table 4).

Table 4: ARDL Estimation: linear regression results

Variable	Coefficient	P-value	F-Test	R ajusté
Constant	1904,918	0,034**		
Exported vanilla	0,407	0,071*		
Exchange rate	1.674	0,049**		
Cash imported crop	0,145	0,141	0,000***	0,947

(***): Significant at 1%: highly significant
(**): Significant at à 5%: significant
(*): Significant at à 10%: not significant

Equation 4: GDP Model

PIB = 1904 + 0.407* Exported vanilla + 1,67*Exchange rate + 0.145*Cash crop

This model presents the results of a linear regression analysis aimed at assessing the impact of various explanatory variables on GDP (Table 4). The intercept is estimated at 1904.91 and is statistically significant at the 5% level (p-value = 0.034). The exchange rate exhibits a positive coefficient of 1.674, also significant at the 5% level (p value=0.049). In contrast, vanilla exports, with a coefficient of 0.407 (p-value = 0.071), and cash crop imports, with a coefficient of 0.145 (p-value = 0.141), do not demonstrate a statistically significant relationship with GDP.

The overall regression model is statistically significant, as evidenced by the F-test p-value of 0.000, and demonstrates strong explanatory capability with an adjusted R^2 of 0.947.

Constant GDP represents the real term change in Gross Domestic Product. Vanilla exports, measured in tons, reflect the volume of vanilla exported by Madagascar and are expected to have a positive effect on GDP. The annual exchange rate, expressed as the price of the US dollar (USD) in Ariary, is anticipated to exert a negative influence on economic growth. Finally, imports of cash crops, particularly agricultural commodities such as spices, tea, coffee, and cocoa are also expected to negatively impact GDP (Table 5).

Table 5: ARDL Model. Expected Effects of Vanilla Exports on GDP

Variables	Descriptions	Expected results
GDP constant	Gross Domestic Product	
Vanilla exported in tons	Quantity of crushed and uncrushed vanilla exported by Madagascar	+
Annual exchange rate	Price of USD in Ariary	-
Imported cash crop	Agricultural product: spices, tea, coffee, cocoa imported by Madagascar	-

The correlation matrix reveals a relationship between GDP and the exchange rate, with an association exceeding 50% in both column 1 and row 1 (Table 6). It demonstrates a strong positive correlation between exchange rate growth and GDP, with a correlation coefficient of 0.859. In contrast, vanilla exports exhibit a weak correlation with both GDP and the exchange rate, indicating a limited effect. Imported cash crops show low correlations with the other variables, suggesting they are moderately influenced by GDP and the exchange rate, but much less so by vanilla exports.

Table 6: Correlation between variable

	GDP	Exported Vanilla	Exchange rate	Imported cash crop
PIB	1	0.227	0.859	0.304
Exported Vanilla	0.227	1	0.174	-0.103
Exchange rate	0.859	0.174	1	0.359
Imported cash crop	0.304	-0.103	0.359	1

4 DISCUSSION

4.1 Governance risks of the Vanilla VC

Institutional risks

The most serious institutional risks are global factors that are difficult to control. On one hand, there is the dominance of importers often headquartered in developed countries who exert substantial control over global markets (Figure 1). On the other hand, there is widespread non-compliance with or inadequate enforcement of regulations, alongside shifting international market requirements imposed by these importers themselves. Their significant bargaining power enables them to dictate economic conditions throughout the supply chain, including regulatory frameworks, pricing, and contractual terms with exporters and producers (Neilson, 2009). The analysis underscores how actors further downstream in the VC, particularly importers, control profit margins and shape pricing policies in tropical commodity markets such as vanilla.

Under pressure from importers, governments in producing countries have implemented regulatory policies aimed at structuring the vanilla market. However, these decisions are often shaped by the interests of downstream actors, which do not always align with those of local producers (Goodman, 2008). The author explores how external pressures, particularly from importers, affect governance decisions within agricultural VCs, especially for niche products like vanilla. This dynamic creates ambiguity regarding the state's role both as a regulator and as a facilitator within the VC. Consequently, political decision making is influenced, giving rise to internal risk factors such as corruption and populist policy shifts concerning regulation and pricing during the production season (Figure 1). There remains a lack of clarity about the state's function as a facilitator, underscoring challenges related to the approval process and the representation of the National Vanilla Council (NVC).

Economic risks

Prices mainly result from the demands and strategic priorities of importers. Vanilla pricing typically aligns with importer's interests instead of accounting for producer's actual production costs or local economic conditions

(Figure 2). This price setting mechanism generates substantial income volatility for producers, thereby heightening their economic vulnerability.

Although the referenced study focuses on cocoa, it illustrates how importers exert influence over global prices, often to the detriment of producers, a dynamic similarly evident in the vanilla sector (Ruf, 2013). Limiting the number of approved vanilla exporters fosters informal trade. This situation arises because an exporter who is not authorized for a given year, despite having vanilla, already stocked for export still faces market demand and customers with existing orders. In the absence of official approval, the exporter is compelled to seek alternative channels to sell their stock, thereby increasing the risk of informal activities and corruption. Furthermore, if the producers are unable to export their vanilla, the viability of the market for these products is called into question, resulting in reduced income for producers. The vanilla sector is currently experiencing a crisis, with vanilla stockpiling at the level of producers, collectors, or intermediaries who refrain from selling because prices do not meet the floor price established by the government (Bellissens, 2023).

Social risks

Vanilla VC faces multiple social risks that threaten the stability and sustainability of the sector. Among the most urgent issues is the theft of vanilla beans (Figure 3), which causes significant economic losses for producers and fosters insecurity within rural communities. This problem is often intensified by a lack of trust among various actors in the VC; from producers to traders and exporters cooperation and transparency essential for enhancing the sector's resilience. Furthermore, the relatively low level of education among vanilla producers represents a significant risk. This lack of training limits their capacity to adopt improved agricultural practices, comprehend market dynamics, and engage effectively in negotiation and decision making processes. The producers' insufficient technical and economic knowledge weakens their position within the VC, increasing the sector's vulnerability to market fluctuations and unfair trade practices. Collectively, these social factors present substantial challenges to the sustainable development of the vanilla sector, necessitating targeted interventions to enhance trust, security, and education within producing communities. All identified social risks fall within the high risk category. Given that these factors primarily operate at a microeconomic level, producers bear the most severe consequences.

Environmental risks

The vanilla VC is particularly vulnerable to a range of environmental risks that jeopardize both its productivity and sustainability. Climatic hazards constitute the primary threats, as the intensification and increased frequency of cyclones adversely affect optimal vanilla cultivation conditions. These climatic variations also amplify hazards such as cyclones and floods, which can severely disrupt production cycles and diminish yields. The situation is worsening, as climate change is expected to increase the intensity of cyclones, posing the main environmental risk to this region of the island (Alizany, 2010). Due to its geographical location and climatic conditions, Madagascar is frequently exposed to natural disasters such as droughts, tropical cyclones, and floods, making it one of the most vulnerable countries globally to the impacts of climate change (UN News, 20/01/2023; ND-GAIN accessed 08/12/2023). Classified as "high risk," Madagascar ranks 27th out of 191 countries in the INFORM Risk Index 2024, an open-access global risk assessment tool that evaluates exposure, vulnerability, and capacity to cope with climate change consequences (UN News, 20/01/2023; ND-GAIN accessed 08/12/2023). High poverty levels, weak governance, and insufficient human and physical capitals, combined with dependence on rain-fed agriculture and inadequate infrastructure, collectively undermine community resilience to natural disasters. This vulnerability generates humanitarian needs and impedes long term development efforts (ACAPS, 2024). Furthermore, land clearing, often undertaken to expand cultivable areas, results in the degradation of forest ecosystems, thereby compromising local biodiversity and ecosystem services which are essential for maintaining optimal vanilla cultivation conditions. Additionally, the uncontrolled expansion of vanilla farming promotes the emergence and spread of diseases and pests, constituting another critical risk factor (Figure 4). These pathogens, frequently exacerbated by unsustainable agricultural practices and climate change, can cause substantial production losses, threatening the economic viability of vanilla producers.

As observed in the SAVA region, new vanilla plantations have been established through the degradation of forested areas and the conversion of land previously used for other crops. These new plantations were implemented without preventive measures, traceability of planting sites, or phytosanitary controls of plant material intended for the new plots. Such practices, driven by high vanilla prices, excessive pollination and shading, inadequate aeration, and significant field densification, have failed to increase productivity. Consequently, this has led to the proliferation of Fusarium and Phytophthora diseases, overproduction of vanilla, and a decline in yield per hectare (World Bank, 2022). By comparing the risks across the four dimensions, institutional and economic risks emerge as the most significant. This indicates that challenges related to governance structures, regulatory frameworks, and economic stability have a more pronounced impact on the system under study than risks in other dimensions. Such findings underscore the necessity for targeted strategies to mitigate institutional weaknesses and economic vulnerabilities, which are critical for ensuring the resilience and sustainability of the value chain (Figure 5).

Establishing a sustainable public-private partnership is a crucial strategy to mitigate institutional risks within the vanilla value chain. Collaboration with the private sector, particularly through contract farming, guarantees producers' access to markets and strengthens the resilience of the value chain. Such partnerships enable coordinated risk management by addressing institutional challenges and providing stable market conditions. Contract farming agreements reduce producers' exposure to market volatility and incentivize quality improvements, thereby supporting a more robust and sustainable vanilla supply system.

4.2 Unequal distribution of income in the CdV

While representing a significant source of revenue for producing countries like Madagascar, Vanilla venture capital is characterized by an inequitable distribution of profitability rates and net operating results among the various stakeholders. Vanilla producers, who shoulder most production costs and bear the cultivation risks, often receive the smallest share of the added risk capital. In contrast, downstream actors such as exporters and importers achieve substantially higher profit margins (Jaime, 2002).

Farmers: low margins and economic vulnerability

Primarily located in tropical regions such as Madagascar, vanilla producers, are the most economically vulnerable actors within the VC (Figure 6). High production costs, coupled with climate related risks and crop theft, render their situation highly precarious. Despite these challenges, they receive only a minimal portion of the final value generated along the product chain. This study demonstrates that small-scale raw material producers often obtain less than 10% of the final price of the processed product (Dorin, 2020).

Producers: a significant contribution with variable margins

Processors and preparers, especially those engaged in primary processing activities such as fermentation and drying, contribute significant added value to the raw product. However, their profit margins vary depending on their position within the VC and their access to markets (Ruf, 2004). Similarly, in the cocoa sector, a VC comparable to vanilla in terms of structure and profit margins processors play a crucial role in value creation.

Exporters and importers: dominant players with wide margins

Exporters and importers hold a dominant position in the vanilla market due to their significantly greater bargaining power, enabling them to capture a large share of the profits generated alongside the VC (Figure 6). These actors often set global vanilla prices rather than producers, contributing to economic inequities within the sector (Neilson, 2014). A study of the coffee VC in Côte d'Ivoire by Neilson similarly demonstrates how global VCs are structured to favor downstream actors such as exporters and importers, often to the detriment of local producers.

Inequitable Distribution: Consequences for Sustainable Development

Inequality in the distribution of benefits along the vanilla VC has adverse effects on sustainable development in producing regions. The low incomes of producers restrict their capacity to adopt sustainable agricultural practices and may contribute to deforestation and resource depletion (Riisgaard, 2019). This income disparity underscores the urgent need for reforms aimed at achieving a more equitable distribution of benefits. Such reforms could include initiatives to enhance producers' bargaining power and promote fair and sustainable trade practices (Gibbon & Ponte, 2020). Ultimately, income inequality within the vanilla VC limits producers' ability to invest in sustainable agriculture, thereby jeopardizing the long term viability of production (Riisgaard, 2010).

4.3 Contribution of vanilla to economic growth: relationship between GDP and vanilla exports

Analysis of the relationship between Gross Domestic Product (GDP) and vanilla exports reveals a positive effect (Table 4), consistent with the model's expected outcomes (Table 5). An increase in vanilla exports is associated with a favorable impact on GDP. As Madagascar's main export product, vanilla accounts for approximately 25% of foreign exchange earnings and contributes around 7% to the national GDP (Le Comptoire de Toamasina, 2022). This significant role is reflected in the country's export performance, with vanilla exports valued at about $583 million in 2022, primarily destined for major markets such as the United States, France, Germany, Canada, and the Netherlands. Increasing vanilla export volumes is therefore likely to stimulate economic activity, enhance external revenues, and support overall economic growth in Madagascar. However, despite having a positive coefficient, the variable related to vanilla exports is not statistically significant in the ARDL model (p-value > 5%), suggesting a possible underestimation of its true effect. Several factors may explain this outcome. First, indirect effects generated by vanilla exports such as job creation, increased household consumption, and investment in local infrastructure, may not be fully captured by the model. Second, multicollinearity could obscure the variable's impact, particularly if vanilla exports are highly correlated with other explanatory variables, such as structural risks within the sector.

In this context, private initiatives which are focused on the local processing and export of vanilla extracts warrant greater support. These initiatives enhance the valorization of Malagasy production within the national territory, create

added value, generate skilled employment, and attract investment. Consequently, they contribute to the implementation of the national industrial policy, which aims to transform Madagascar's economic structure by increasing the industrial sector's role in wealth creation, job generation, and the development of expertise (Reuters, 2021). Regarding the annual exchange rate, the model predicts a negative effect on GDP (Table 5), whereas empirical results indicate a positive effect (Table 4).

Theoretically, depreciation of the local currency (Ariary), indicated by an increase in the exchange rate, tends to elevate import costs, diminish domestic purchasing power, and induce imported inflation. This process may result in reduced domestic consumption and a consequent deceleration of economic growth. Continued depreciation of the Ariary could suppress demand for imported goods; however, the associated inflationary pressures pose a risk to macroeconomic stability and GDP growth. Concerning imported cash crops, the estimated effect on economic growth is negative.

An increase in imports of these products may lead to the substitution of domestic production, a decline in demand for locally produced goods, and a reduction in the competitiveness of Malagasy producers. This dynamic exacerbates the trade deficit and consequently applies downward pressure on economic growth (Eworldtrade, 2021). Model estimations further indicate that vanilla exports exert a positive influence on GDP, whereas depreciation of the local currency and increased imports of cash crops negatively affect economic growth.

These process highlights the critical role of foreign trade performance and currency fluctuations in shaping Madagascar's development trajectory. Madagascar, as the world's leading vanilla exporter, derives about 25% of its foreign exchange earnings and 7% of its GDP from vanilla, underscoring the crop's economic significance (Le Comptoir de Toamasina, 2022). Finally, the overall results confirm that Madagascar's economic dynamics are strongly influenced by the performance of its export sector, particularly vanilla, as well as by the management of macroeconomic balances, notably the exchange rate and import flows. These factors should be regarded as strategic levers to guide the formulation and implementation of the country's economic policies.

5 CONCLUSION

An analysis of the institutional, economic, social, and environmental risks facing Madagascar's vanilla sector reveals a complex set of challenges that undermine the sustainability and equity of this strategic industry. Institutional dysfunctions including regulatory instability, lack of transparency in export procedures, and weak governance mechanisms, compromise the sector's efficiency and resilience. These institutional risks heighten uncertainty among stakeholders, limiting their capacity to engage in long term planning and invest in sustainable practices.

Economically, the volatility of international vanilla prices, coupled with the local economy's heavy dependence on the sector, exposes producers to significant economic shocks. The absence of income stabilization and economic diversification mechanisms further increases the vulnerability of rural communities reliant primarily on vanilla production. Social inequalities within the sector are pronounced, with profits concentrated at intermediary levels while vanilla producers receive disproportionately low wages. This disparity contributes to rising rural poverty and social tensions, thereby undermining social cohesion and stability in vanilla producing areas. Environmentally, the pressure to increase vanilla production drives intensive agricultural practices that threaten biodiversity and local ecosystems. Unsustainable land use and deforestation are direct consequences of this pressure, compromising conservation efforts and exacerbating climate change challenges.

The analysis reveals a significant imbalance in revenue distribution within the VC. Producers, who assume the greatest risks, receive a disproportionately small share of the revenue compared to intermediaries and exporters. This inequality not only restricts producers' capacity to invest in sustainable practices but also contributes to the erosion of trust within the sector.

Despite these challenges, the vanilla sector remains a vital pillar of the Malagasy economy, contributing significantly to GDP and export earnings. However, to maximize this contribution, it is essential to strengthen governance, enhance equity in the distribution of benefits, and promote sustainable agricultural practices. These measures will help stabilize the sector, foster more inclusive economic development, and reinforce the resilience of rural communities against fluctuations in the global market. An integrated and systemic approach is therefore essential to address the institutional, economic, social, and environmental risks impacting the vanilla VC, while ensuring a more equitable distribution of benefits and a sustainable contribution to Madagascar's economic growth. To what extent can a holistic and integrated strategy which combine institutional reforms, economic development, social justice, environmental protection, and responsible valuation of ecosystem services guarantee the sustainability and equity of the vanilla VC in Madagascar, while at the same time securing the active commitment of all actors and stakeholders in the VC including the public and private sector, producers, and consumers?

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