Journal of Rural Studies 114 (2025) 103570

Contents lists available at ScienceDirect

Journal of Rural Studies

journal homepage: www.elsevier.com/locate/jrurstud

Agricultural value chain transformations: A comparative analysis of milling segment upgrading in the rice value chains in Ghana and Ivory Coast

Rémi Laurent [a,*], Guillaume Soullier [a,b], Jean-François Le Coq [a,c], Carolina Milhorance [a]

[a] ART-DEV, Univ Montpellier, CIRAD, CNRS, Univ Montpellier 3, Univ Perpignan Via Domitia, Montpellier, France
[b] ISSER, University of Ghana, Legon, B-1210, Accra, Ghana
[c] Agriculture and Society, Rural Federal University of Rio de Janeiro (CPDA/UFRRJ), Rio de Janeiro, Brazil Av. Pres. Vargas, 417 - Centro, Rio de Janeiro - RJ, 20071-003, Brazil

ARTICLE INFO

Keywords:
Quiet revolution
Rice value chain
Milling segment
Upgrading
West Africa

ABSTRACT

This paper investigates the extent of technical and organisational transformations in the milling segment of the rice value chains in Ghana and Ivory Coast, which is discussed against the literature on agricultural value chain transformations. The method is based on rice miller's quantitative data and stakeholders' interviews. The results reveal that both countries are undergoing technical change and a shift of value chain governance towards vertical integration, implemented at larger scale in Ghana. The differences observed are attributed to variations in production systems, demand for local rice, currency conditions, and policy approaches in the respective countries.

Résumé: L'article examine l'ampleur des changements techniques et organisationnels en cours dans le segment de la transformation des chaînes de valeur du riz au Ghana et en Côte d'Ivoire, qui est discuté par rapport à la littérature sur les transformations des chaînes de valeur agricoles. La méthode est basée sur des données quantitatives et des entretiens. Les résultats révèlent que les deux pays connaissent un changement technique et un changement de gouvernance de la chaîne de valeur qui tend vers l'intégration verticale, mise en œuvre à plus grande échelle au Ghana. Les différences observées sont attribuées aux variations dans les systèmes de production, la demande pour le riz local, les conditions monétaires et les approches politiques dans les pays respectifs.

1. Introduction

Agricultural value chains (AVC) play an important role for economic development, poverty reduction and food security (OECD and FAO, 2019). Over the past three decades AVC have undergone transformations in developing countries, as a result of urbanisation, liberalisation, privatisation and income growth (Reardon et al., 2021). According to the contexts and products, AVCs are experiencing varying degrees of change in structure and conduct, transitioning from three stages: traditional, transitional and modern (Barrett et al., 2022). As markets expand, companies grow in scale leading to changes. These include shifts from labour-intensive to capital-intensive technologies, transitions from spot markets to coordinated markets involving contracts and standards, greater vertical integration, shifts from short local supply chains to longer ones that encompass a larger share of post-harvest segments, and a move from sourcing investment capital locally to obtaining it internationally through foreign direct investment (FDI) (Barrett et al., 2022).

At the transitional stage, recent studies reveal that staple food markets in Asian and African countries are being transformed by a 'quiet revolution'. The term refers to the rapid proliferation of midstream (millers, wholesalers) Small and Medium Enterprises (SME) which upgrade their technologies through investments, move into higher quality products, and further engage into vertical coordination mechanisms (Reardon et al., 2021). The expansion of SMEs parallels the rapid growth of the volume and lengths of AVCs, which are highly responsive to meet consumers' expectations about quality and product differentiation as a result of urbanisation and diet transformation (Reardon et al., 2014; Reardon, 2015). Favourable policy interventions have also facilitated these transformations, through the provision of 'hard infrastructure', especially transport and electricity infrastructure, as well as 'soft infrastructure' via the establishment of regulations and standards (Reardon, 2015). In

* Corresponding author.
E-mail addresses: remi.laurent@cirad.fr (R. Laurent), guillaume.soullier@cirad.fr (G. Soullier), jean-francois.le_coq@cirad.fr (J.-F. Le Coq), carolina.milhorance@cirad.fr (C. Milhorance).

https://doi.org/10.1016/j.jrurstud.2025.103570
Received 10 April 2024; Received in revised form 29 November 2024; Accepted 7 January 2025
Available online 3 February 2025

developing regions, the midstream segment of AVC handles approximately two-thirds of the food consumed (Reardon et al., 2021). It therefore exerts a significant influence on various aspects of the food industry, including employment opportunities, agricultural income, food pricing, safety standards, and the quality of products available to consumers.

While 80 per cent to 90 per cent of the agri-food economy in Africa is in the 'transitional stage' (AGRA, 2019), few studies shed lights on the ongoing 'quiet revolution'. Some empirical evidence emerge in the teff supply chain in Ethiopia (Minten et al., 2014), the maize-feed chicken system in Nigeria (Liverpool-Tasie et al., 2016), the maize and wheat value chains (VC) in Tanzania (Alphonce et al., 2019 in AGRA, 2019), millet products in Senegal and Nigeria (Badiane, 2015 in AGRA, 2019), and the rice VC in Senegal (Soullier and Moustier, 2021; Ilie and Kelly, 2021). However, the transformational dynamics of the midstream segment of AVC in Africa still requires further academic attention. First, the performance of the midstream segment and its enabling conditions are important to the food security of African consumers (AGRA, 2019). Second, there is a dearth of research exploring the extent of AVC transformations and its determinants, notably by comparing the upgrading patterns of midstream actors of the same AVC across different countries. Finally, because the midstream segment of these AVCs in Africa are referred to as a "hidden middle", indicating that the important role played by midstream SMEs tends to be largely overlooked by policy-makers and data collection on VCs (AGRA, 2019).

This study seeks to fill this gap by undertaking a comparative analysis of milling segment upgrading in the rice VC of two neighbouring countries: Ghana and Ivory Coast. More specifically, we analyse the extend of technical and organisational changes ongoing in the milling segment of the rice VC since 2010, for which research remains limited (Custodio et al., 2023). In turn, we aim to contribute to the existing literature on AVC transformations in developing countries by offering empirical evidence regarding the extent of a 'quiet revolution' in West African contexts and its determinants.

2. Context of the rice value chains in Ghana and Ivory coast

Rice is an important staple food in Ghana and Ivory Coast, especially for economic development and food security. This section provides a functional analysis of the rice VCs in both countries and the challenges associated with their import dependency.

2.1. Overview of the rice value chains in Ghana and Ivory coast

The rice VCs in Ghana and Ivory Coast involve stakeholders performing complementary roles in production, trade, processing, and marketing. Most producers are smallholders. In Ghana, rice is cultivated by about 332,504 households, primarily in lowland rain-fed systems (78%), irrigated systems (16%) and upland systems (6%), on an average farm size of 1.1 ha (Ouedraogo et al, 2021b; Ghana Statistical Service, 2014). The regions situated in the eastern part of Ghana constitute the predominant source of rice production (Fig. 3). In Ivory Coast, approximately 675,324 households cultivate rice on plots averaging 0.8–1 ha (Ouedraogo et al., 2021a). Only 4% of rice land is irrigated, while 48% is under rain-fed lowland and upland systems each (Aderiz, 2021). The main producing areas are located in the Northern, Central and Western parts of the country (Fig. 4). Post-harvest, some paddy is retained for self-consumption, while the rest is sold to collectors, to millers, or milled and sold by farmers to wholesalers. Collectors act as intermediaries, purchasing paddy directly or storing it before transferring it to millers.

The milling segment includes artisanal, medium-scale, and industrial units. In Ivory Coast, a 2021 Aderiz census identified 2185 artisanal mills (theoretical capacity of up to one tonne per hour), 402 medium-scale mills (one to two tonnes per hour), and six industrial mills (two to five tonnes per hour). These processed 83%, 15%, and 2% of the country's paddy, respectively (Aderiz, 2021). Ghana's milling sector includes 419 artisanal and medium-scale mills and nine industrial units (Ouedraogo et al, 2021b). Millers engage in four non-exclusive business models: 1) service provision, where customers pay for milling and retain the rice; 2) direct payment, where millers buy paddy, mill, and sell rice independently; 3) pre-financing, where millers advance cash or inputs to farmers, repaid in paddy; and 4) self-production, where millers grow and process their own rice. Milled rice is distributed by wholesalers and small-scale traders who procure it from mills and sell it to retailers in urban and rural markets.

2.2. A persistent rice structural deficit

Rice consumption is increasing more rapidly than any other commodity and is driven by the triple effect of population growth, urbanisation and changing of consumer behaviour (Arouna et al., 2021). It represent 2.106 million tonnes in Ivory Coast and 1.036 million tonnes in Ghana per annum on average since 2008, and increasing at a 5 per cent and 10 per cent rate per annum respectively (USDA 2023). However domestic production falls short of demand, which has translated into increasing import dependency (Fig. 1). From the 1960s to 2020, the import dependency ratio increased from 26 per cent to 60 per cent in Ivory Coast, and has remained at around 60 per cent in Ghana. This exposes the two countries to potential external shocks and risks of food insecurity. In effect, the Coalition for African Rice Development (CARD) was initiated following the 2008 price crisis to achieve rice self-sufficiency through the National Rice Development Strategies (NRDS) (NRDS, 2009; SNRD, 2012). Under their first NRDS, paddy rice output increased dramatically from 181 million tonnes to 681 million tonnes in Ghana, and from 442 million tonnes to 962 million tonnes in Ivory Coast (USDA 2023).

Nonetheless consumer preferences for imported rice, exacerbated by an urban-bias, contributes to maintaining a persistent structural deficit (Demont, 2013). From a VC perspective, upgrading the milling segment of domestic rice VCs is considered as a means to increase quality-based competitiveness of domestic rice to reduce rice import dependency (Demont and Ndour, 2015). This involves improving post-harvest standards to compete against imported rice in terms of both intrinsic attributes (e.g. cleanliness, homogeneity, sensory attributes) and extrinsic quality attributes (packaging, branding) by means of technical improvement and vertical coordination mechanisms at the milling segment level.

Research have demonstrated the ability of the milling segment to drive the upgrading of rice VCs (Reardon et al., 2014). Factors, including capital-led intensification, private extension services, and investments in milling and marketing, have collectively contributed to enhanced technology adoption, quality differentiation, and market competitiveness in the rice sector across Asia. Some evidence of ongoing transformations in the rice milling segment is emerging in Africa. Rice millers in Senegal have established new modes of coordination and implemented technical change (Soullier and Moustier, 2021; Ilie and Kelly, 2021), while a limited number of semi-industrial and industrial mills have been established in West Africa (Soullier et al., 2020). Additionally, local branding is emerging in the rice market in Ghana (Andam et al., 2015), and technical upgrading has been documented in Kenya's rice VC (Mano et al., 2022).

3. Conceptual framework: the interplay between governance, upgrading and uncertainty

The value chain approach, elaborated by Porter (1985), has become a fundamental framework in agri-food analysis. It defines "the entire set of activities necessary to take a product or service from conception to various stages of production, consumer delivery, and final disposal after use" (Kaplinsky and Morris, 2001, p.4). As an analytical framework it provides a method to explore value chain actors and structures, focusing on actor positioning, market relations, value distribution, and upgrading opportunities (Mausch et al., 2020). Several conceptual streams have

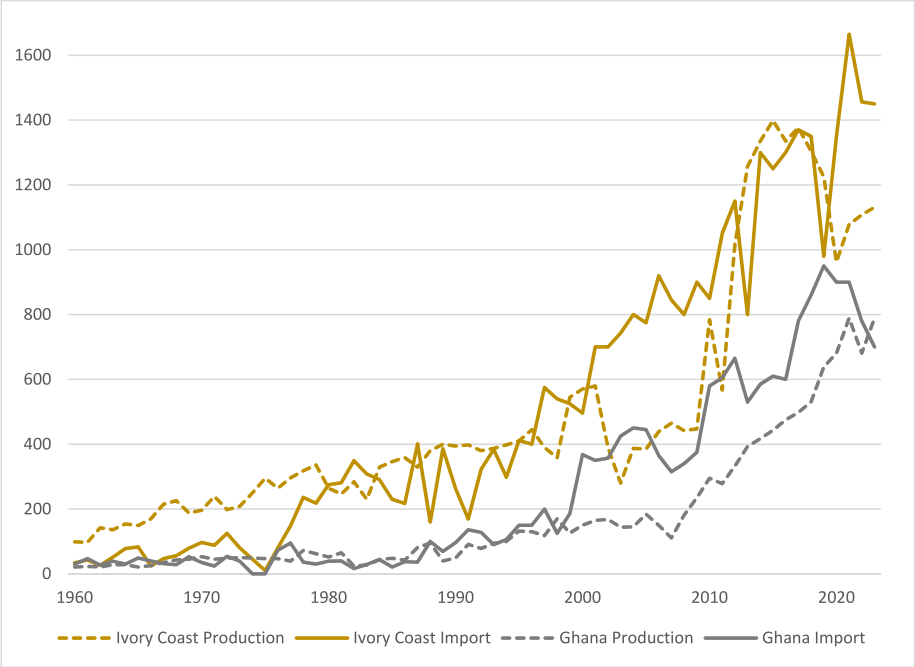

Fig. 1. Evolution of production and importation in Ghana and Ivory Coast expressed in 1000 MT. Source: Authors from USDA data (2023).

constituted value chain analysis, such as Supply chain management (Porter, 1985), Global Commodity Chains (Gereffi and Korzeniewicz, 1994), Global Value Chains (GVC) (Gereffi et al., 2005) or New Institutional Economics (Williamson, 1979), offering diverse insights into value-chains dynamics and inter-company relationships.

To analyse technical and organisational changes in the midstream segment of rice value chain in Ghana and Ivory Coast, we develop a conceptual framework adapted from the GVC framework (Gereffi et al., 2005) (Fig. 2). The GVC framework has been developed to study the relationships and modes of coordination between stakeholders in value chains. It stems from the theoretical combination of the Global Commodity Chain (Gereffi and Korzeniewicz, 1994), and transaction costs economics by incorporating asset specificity and uncertainty as factors of transaction costs (Coase, 1937; Williamson, 1979, 1985). The framework posits that the characteristics of the production process and the capabilities of VC actors will determine the type of governance, defined as 'the authority and power relations that determine how financial, material and human resources are allocated and flow within a chain' (Gereffi and Korzeniewicz, 1994). Five modes of governance are defined, ranging from the market governance to hierarchical governance.

Governance by the **market** concerns simple spot transactions which are transactions carried out at market price with no ex-ante coordination between the suppliers (farmers) and a firm (miller). In **modular** governance, there are 'turn-key suppliers' (marketers, aggregators, cooperatives) who aggregate and provide the raw material (paddy rice) from 'material suppliers' (farmers) to the lead firm (miller). The transaction is regulated by the market price. **Relational** governance describes transactions, often informal, in which the stakeholders are socially close, exchange information, and may develop personalised relationships, thus reducing uncertainty but also creating a situation of interdependence. Trust and proximity are key attributes to this type of governance. **Captive** governance refers to the strong involvement of a lead firm in the operations of its suppliers. This involves formal contracting with specifications regarding quantity and quality of the raw material to be supplied. Finally, in **hierarchy** governance, the body of operations is controlled by the same stakeholder. All activities, from production to commercialisation, are vertically integrated.

'Upgrading' is a key concept in the GVC literature (Gereffi, 1999; Humphrey and Schmitz, 2000). It is defined as 'a process of improving the ability of a firm or an economy to move to more profitable and/or technologically sophisticated capital and skill-intensive economic niches' (Gereffi, 1999, p.52). Scholars have identified four upgrading opportunities encompassing process, product, functional, and inter-chain upgrading. For the purpose of our research, we focus on process upgrading (transforming inputs into output more efficiently by reorganising the production system or introducing superior technology) and product upgrading (improving existing products and/or developing new ones). Both types are intimately connected, considering that changes in products often lead to changes in processes and vice-versa (Mossie Birhanu, 2023). In the milling segment of rice VCs, process upgrading is intricately tied to the applied milling technology. We introduce a classification system for mills categorised based on capacity and step processes criteria, as detailed in Table 1. The former pertains to the volume of paddy milled per hour while the latter delineates the diverse functions undertaken by the mill. The greater functionality of the mill tends to result in superior intrinsic attributes of the final product. Nonetheless, product upgrading is not solely contingent on the breadth of milling functions. The degree of control exerted over the production process also plays a pivotal role in improving intrinsic quality, while improving extrinsic attributes are achieved through deliberate interventions in packaging and branding strategies.

The governance typology is dynamic considering that governance types can shift and evolve from one type to another. This depends on the level of technology, uncertainty and frequency of transactions as posited by the transaction cost theory. Firms vertically integrate when the value of these parameters is high, and turn towards market mechanisms when they are low. Additionally, process upgrading tends to shift the governance structure towards vertical coordination when it aims to improve the quality of the final product (product upgrading) by controlling the quality of supplies (Gereffi et al., 2005). We therefore expect that increasing level of milling technology stemming from process and/or product upgrading, coupled with the prevailing level of uncertainty, will steer the governance system towards vertical coordination.

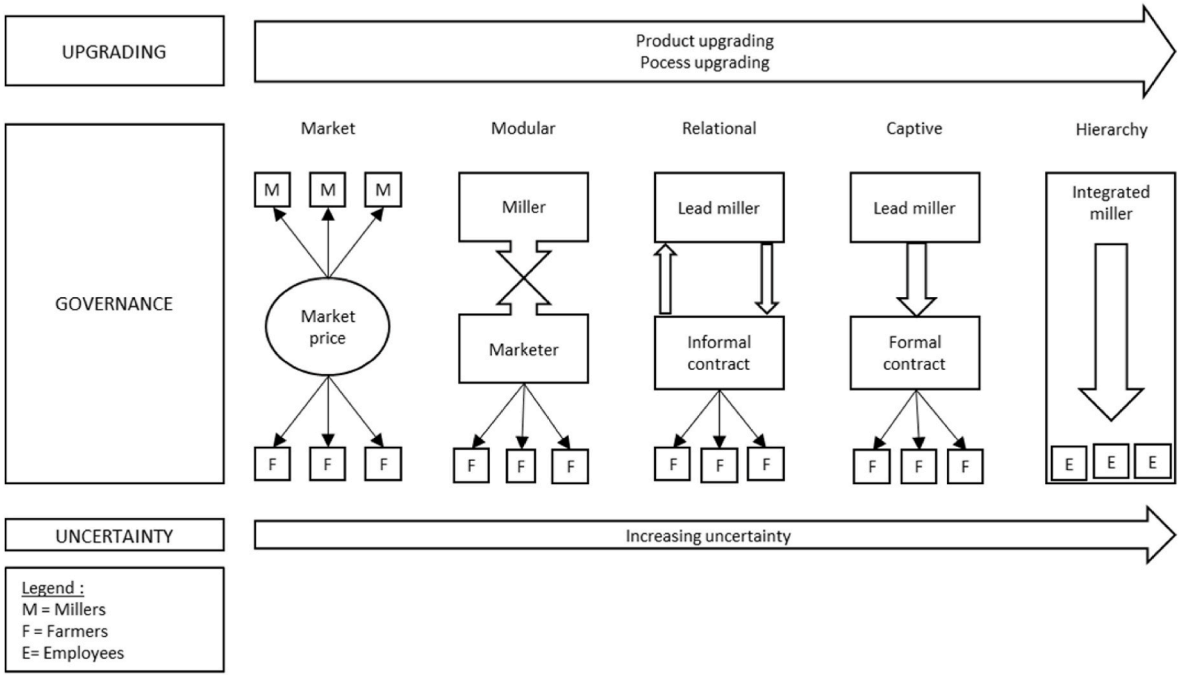

Fig. 2. Conceptual framework. Source: Adapted by the authors from Gereffi et al. (2005).

Table 1
Typology of milling technology.

Type of mill	Capacity (KG per hour)	Number of step processes	Description	Process upgrading
Monobloc mill	0–1.000	1	Simple huller	
Improved monobloc mill	400–1.500	2–5	Performing at least destoning and hulling, and other functions such as grading, separating, cleaning.	
Medium scale mill	1.000–3.000	6–10	Performing at least destoning, hulling, separating, whitening, polishing and grading	
Large scale mill	>3.000	>9	Performing at least drying, cleaning, destoning, hulling, separating, whitening, polishing, grading, packing.	

Source: The authors (2024).

4. Methodology

We selected the highest rice production areas in each country which were indicated as the places where upgrading might be ongoing. In Ghana, the study area comprised the Kpong irrigation scheme, the Dawhenya irrigation scheme, the South Tongu district and the Weta irrigation scheme (Fig. 3). These are located in the Greater Accra and Volta regions which account for nearly 20 per cent of the national rice production (MoFA, 2021). In Ivory Coast we targeted part of the Sassandra-Marahoue region and Goh region (Fig. 4). This geographical area is the largest concentration of national rice production, accounting for nearly 30 per cent of it (USDA 2020). In Ghana the study area consists of irrigated rice with total water control, while in Ivory Coast it is lowland irrigated rice with partial water control, relying on rainfall.

To carry out our data collection we adopted both qualitative and quantitative approaches. For the quantitative approach, we conducted 215 quantitative questionnaires with rice millers, between 2021 and 2022, as part of two projects aimed to develop a comparative analysis between Ghana and Ivory Coast. The questionnaires were grounded in our conceptual framework, and gathered information related to technical changes of milling equipment, the modes of coordination that exist between rice millers and their upstream and downstream partners, the motives to improve rice quality and increase volumes, and the challenges faced.

For the sampling procedure, we conducted a stratified sampling method in Ivory Coast and an exhaustive survey in Ghana. The initial phase involved compiling a comprehensive list of rice millers present in the study areas through databases provided by the rice agency in Ivory Coast (Aderiz) and information provided by the rice desk and district officers of the Ministry of Agriculture in Ghana. In total, 320 milling units were identified in Ivory Coast, and 40 in Ghana. In Ivory Coast, we applied a stratified sampling (probability sampling) of the data based on the localisation of milling facilities. Out of the 320 milling units present in the study area, 196 milling units were identified in urban areas, major villages, and their surroundings, designated as units with a more commercial focus. The limited number of milling units in Ghana (40) did not necessitate a stratification strategy. Consequently, we employed an exhaustive approach by surveying all the rice mills present in the study area. The response rate of the milling units surveyed was 90 percent in Ivory Coast (177 out of 196 rice millers identified) and 95 percent in

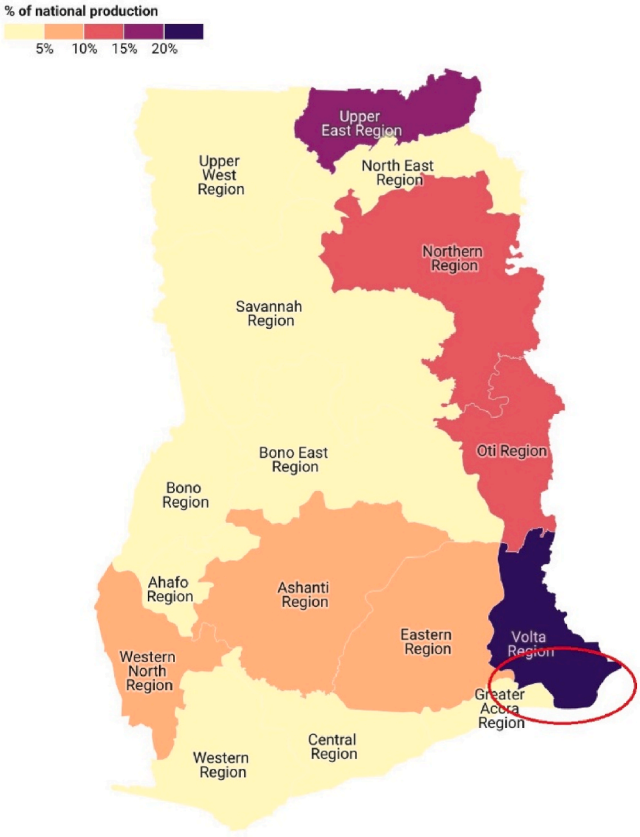

Fig. 3. Study area in Ghana. Source: From the authors based on MoFA data (2021).

Fig. 4. Study area in Ivory Coast. Source: From the authors based on USDA data (2020).

Table 2
Primary quantitative data collected through questionnaires.

Type of rice millers	Ghana	Ivory Coast
Monobloc	3	105
Improved Monobloc	29	70
Medium-scale	3	2
Large-scale	3	0
Total	38	177

Source: The authors (2021 and 2022).

Table 3
Primary qualitative data collected through semi-structured interviews.

Stakeholders	Ivory Coast	Ghana
Government agencies	9	3
Development agencies	4	5
Development banks	1	2
Research centres	2	2
NGOs	2	4
Advocacy/Private	1	6
Total	**19**	**22**

Source: The authors (2021 and 2022).

Ghana (38 out of 40 rice millers identified) (Table 2).

Additionally, we conducted 41 semi-structured interviews, audio-recorded with consent, with key informants selected through purposive sampling (non-probability sampling) who work in the rice sector in both countries (Table 3).The questions were related to issues identified in the rice sector, the policy environment that conditions the rice VCs and potential changes observed in the rice sector over time.

To analyse the quantitative data, we conducted statistical descriptive analysis using Excel to characterise the level of technology among millers, to determine technical change over time, to identify the modes of organisation with other VC actors, and to characterise the types of business models adopted. The qualitative data were transcribed and analysed through the software MAXQDA to extract quotes related to the determinants of upgrading and the state of the value chains prior to 2010 (reference situation). We examined the dynamics of change by comparing two distinct temporal states: a reference situation and the current state, that we conceptualised within our framework. The microdata collected from rice millers formed the foundation for our meso-level analysis, enabling us to explain the change dynamics over time, relative to the reference situation. The reference situation was established through the qualitative data and relevant literature to substantiate the employed data.

5. Results

The primary objective of this study is to analyse the extent of technical and organisational changes occurring in the milling segment of the rice VCs in Ghana and Ivory Coast since 2010. To accomplish this, we first present the reference situation prior to 2010, then examine trends in technical change and organisational changes, and compare current trends with the reference situation based on our conceptual framework. Finally, we analyse the factors influencing upgrading.

5.1. Traditional value chains prior to 2010

Multiple respondents described the milling segment of the rice VCs prior to 2010 as utilising low-technology methods that produced poor-quality rice with impurities. Descriptions such as "very crude technology", "basic rice with stones and impurity", "mills that did not have destoners" or "before 2008 the quality wasn't good" were used to describe the milling segment before 2010. These present the characteristics of a traditional VC, as evidenced in the literature.

The prevailing milling technology was characterised in the literature

as the 'Satake-type mill' powered by diesel engines, 'huller-type', 'one-pass type milling machines', 'Engelberg type milling machine', 'SB30', and 'SB 15' all falling under the category of monobloc mills (Day and Acheampong, 1996; Becker and N'guessan, 2004; Furuya and Sakurai, 2005; Sakurai et al., 2006). These mills solely undertook husk and bran removal without incorporating additional functionalities such as destoning, sorting, polishing, or grading. Research conducted in Ghana highlighted that 'large portions of the millers are using the Engelberg type of rice mills, the recovery and quality rates of which are so low that it is prohibited in some Asian countries' (Paasch et al., 2007, p.42). Consequently, the resultant milled rice exhibited poor quality attributes, containing broken grains and foreign materials (Sakurai et al., 2006; Kra Djato et al., 2006).

In terms of governance system, the literature highlights an array of intermediaries within the VC who operated through spot market transactions and/or tied output-credit (Furuya and Sakurai, 2005; Becker and N'guessan, 2004; Harre, 1992). On one hand, rice millers are depicted as operating as service providers without explicit coordination with other VC actors. They primarily offer milling services to farmers and intermediaries at market prices, indicative of a market governance structure. One the other hand, few millers were directly applying informal contracts with farmers, establishing a relational governance. Methods of 'paddy delivery agreements' or 'tied output-credit arrangements' were observed in both countries (Day and Acheampong, 1996; Furuya and Sakurai, 2005; Harre, 1987). The governance system prior to 2010 can therefore be described as a market governance with a trend towards a relational governance (Fig. 5).

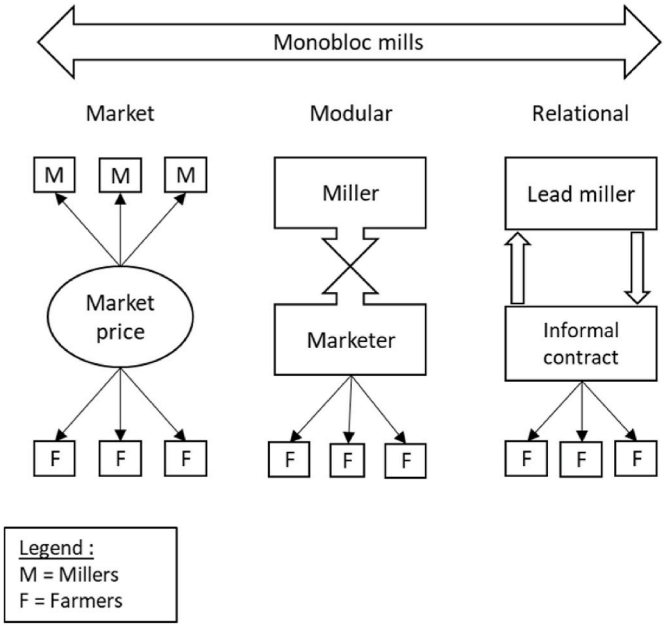

Fig. 5. Situation of reference in the rice value chains of Ghana and Ivory Coast before 2010. Source: The authors (2024).

5.2. Technical change after 2010

The period following 2010 is characterised by a notable transition towards improved milling technology. While in Ghana the share of technologically improved milling units has drastically increased over time, technical change in Ivory Coast is a gradual process (Fig. 6).

Technical change in Ghana has been drastic over the last decade. In 2010 monobloc mills constituted 79 per cent of the milling segment, decreasing to 8 per cent by 2022. In the same year, improved monobloc mills constitute 76 per cent of the milling segment, while medium and large-scale mills equally make up 8 per cent. This transition occurred through creating new milling businesses (16) and existing enterprises replacing their monobloc machines (16). In the latter case, 94 per cent transitioned from monobloc to improved monobloc mills, and the remaining 6 per cent shifted from monobloc to medium-scale mills. This transformation in milling technology had a profound impact on the quality of rice produced, as articulated by a local agent of the Ministry of Agriculture who indicated that 'the milling quality that we have now is very recent, in the last 5 years […] even 10 years ago there was no destoner, no functions on the machines, we now have the machines that are challenging the overseas rice' (Senior Irrigation Development Agency officer, Ghana, 9 December 2022).

In Ivory Coast, monobloc mills continue to represent the majority of milling units in the segment (59%), although their share has gradually diminished owing to the increasing prevalence of improved monobloc mills. Prior to 2010, milling units with more advanced technology accounted for less than 20% of the total mills in the study area. By 2021

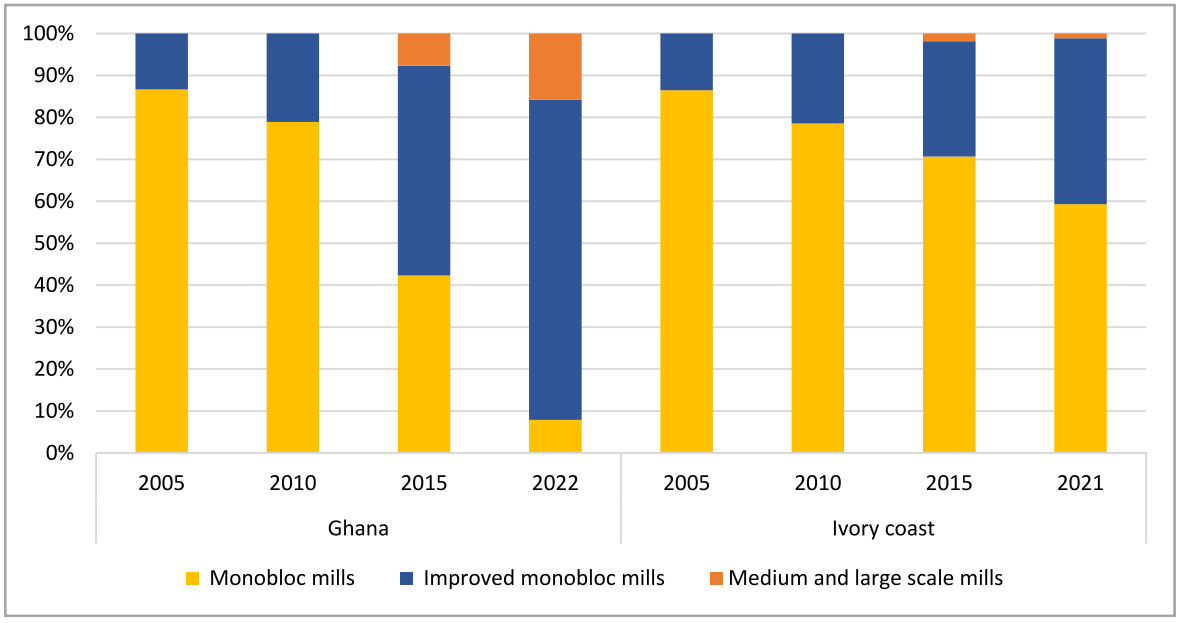

Fig. 6. Type of mills in activity over time (expressed in % of total mills) in Ghana and Ivory Coast. Source: The authors from the data collected (2021 and 2022).

they constituted more than 40% of all observed mills, reflecting a substantial shift towards process upgraded facilities. However, while the study area features 2 medium-scale mills, there are no active large-scale mills observed Table 4. In contrast to the situation in Ghana, only 5 mills in Ivory Coast have undergone technical changes from monobloc to improved monobloc mills. This suggests that, despite the general increase in more technologically advanced mills, the specific transition from monobloc to improved monobloc mills has been less common in the Ivorian context.

5.3. Organisational change tending towards vertical coordination

According to their business model, rice millers make use of a combination of business activities to acquire paddy that progressively involve vertical coordination mechanisms (Fig. 7). While Ghana exhibits a progressive transition towards vertical coordination driven by technical change, there is a significant heterogeneity of business activities per type of mill in Ivory Coast that does not respond to the same logic.

The Ghanaian context reveals three distinctive business models that encompass various forms of business activities for paddy supply. Firstly, 65 per cent of millers operate as **service providers**, consisting exclusively of monobloc mills and improved monobloc mills. These entities engage in milling paddy for customers, including marketers, individuals, farmers, and aggregators, charging a service fee ranging from 8 to 12 cedis per 50 KG bags on average. Secondly, 24 per cent of improved monobloc mills (7 units) depart from the predominant service provision model and instead embrace a commercial milling approach. This involves the sale of their own branded rice, categorising them as '**improved monobloc commercial mills**'. These mills brand rice sourced through direct payment (39% of their total activity) and prefinancing (19% of their total activity). They also continue to engage in service provision, constituting approximately 40 per cent of their business activity. Lastly, there are **medium and large-scale commercial mills** (6 units). These mills prioritise quality and quantity control by managing the supply chain through self-production. It constitutes 70 per cent of large-scale mills' business activity, which possess an average of 500 ha of land per milling unit. Medium-scale mills, with an average of 67 ha of land, produce around 380 tonnes of paddy per season. Large-scale mills supplement their paddy sourcing through direct payment, whereas medium-scale mills employ a combination of pre-financing and milling services in their operations.

The prevailing business model in Ivory Coast is **service provider**, constituting 77 per cent of all observed business models. Remarkably, this category is evenly distributed between monobloc and improved monobloc mills. Compared to their counterparts in Ghana, Ivory Coast's service providers are less diversified in their operations considering that 96 per cent of their business activity revolve around service provision. The **mix strategy mills**, comprising 13 per cent of all business models observed, represent mills that gradually diversify away from exclusive service provision without fully venturing into commercial milling. Service provision still constitutes a significant portion of their business activity (69%), but they also engage in direct payment and prefinancing to acquire paddy, showcasing a modest expansion into additional business activities. On the other hand, **commercial millers**, constituting 10 per cent of all business models, tend to adopt more vertically coordinated activities, primarily focusing on prefinancing and direct payment, which collectively make up 70 per cent of their business activities. These mills actively exercise control over the acquisition of paddy, aligning with their primary goal of commercialising milled rice. Commercial millers are generally characterised by higher technologically advanced mills, with all medium-scale mills adopting this business model and an increased proportion of improved monobloc mills compared to monobloc mills.

Three notable observations arise when comparing the business models of mills between Ghana and Ivory Coast. First, the relationship between the type of business model adopted and the type of milling technology does not follow the same logic from one country to another. In Ghana the more advanced the technology, the more vertically coordinated is the mode of organisation. On the contrary, Ivoirian millers adopt similar business activities irrespective of their technological level. Second, self-production is more prevalent in Ghana compared to Ivory Coast where mills do not resort to vertical integration. In Ivory Coast self-production constitutes less than 0.5 per cent of rice millers' business activities, with an average of 2 ha, suggesting that it aligns more with a self-consumption strategy rather than a commercial one (Table 5). Finally, both countries demonstrate increasing but limited use of formal contract farming. Sixteen per cent of millers in Ghana and only 4 per cent in Ivory Coast practise contract farming in so far that they sign written contracts with their suppliers, provide services (input provision and/or cash and/or technical advice) to accompany the phase of production and agree at least on the volumes of paddy to be supplied for the purpose of commercialising the milled rice (Table 5). Our research indicates that contract farming is perceived as a risky venture by millers, associated with opportunistic behaviour by farmers. As one respondent

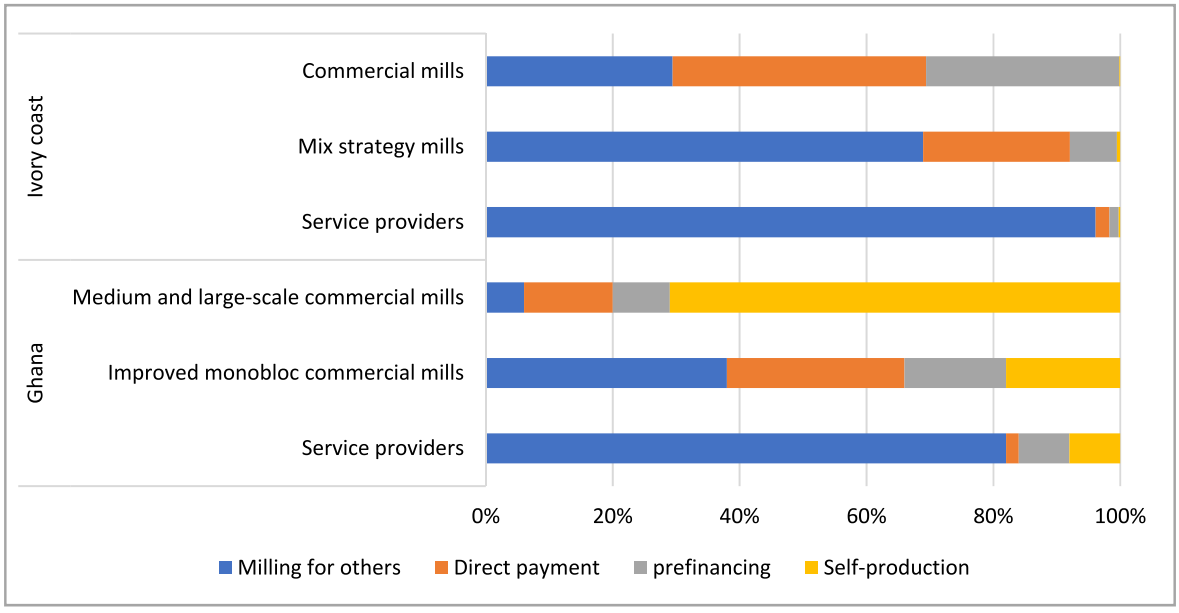

Fig. 7. Mode of paddy supply (in % of volumes) according to the business model of mills in Ghana and Ivory Coast. Source: The authors from the data collected (2021 and 2022).

indicated, 'contracting does not happen very often because millers don't want to be cheated. They usually sponsor (prefinance) people they trust but do not give too much money' (representative of the rice interprofessional body, Ghana, 2 November 2022). As a result prefinancing is mostly practised on an informal basis, through trust and proximity ties.

5.4. Upgrading and changing governance in the rice value chains

Process upgrading, product upgrading and uncertainty are key elements that influence the governance structure of the rice VCs. Since 2010 we observe a progressive transition of governance driven by technical change and commercial strategies (Fig. 8). As millers improve their milling machines with more advanced technologies, they venture progressively into commercial milling, which induces the control exercised over paddy supply. According to their financial capacity, and in the face of uncertainty, they will adopt different strategies to control paddy quantity and/or quality, shifting the governance structure towards vertical integration. Nevertheless, Ghana and Ivory Coast present different patterns of upgrading.

In Ghana, millers have undergone significant process upgrades, involving mill replacement and the adoption of advanced technology, leading to a decline in the share of small mills. In parallel, product upgrading emerges with the rise of branded rice (32% of Ghanaian millers), that implicates increased vertical coordination for quantity and quality control (Table 4). High-specific-asset firms resort to vertical integration to reduce uncertainties, fostering disintermediation. Overall, vertical integration constitutes 46 per cent of all paddy volumes processed in the study area (Table 5). In contrast, medium-specific-asset millers in Ghana adopt 'hybrid' governance systems, employing modular and relational systems. In Ivory Coast there is a parallel trend of increasing investment in more advanced technologies, notably with the emergence of improved monobloc mills and two medium-scale mills. Despite these technical improvements, the milling segment remains largely dominated by monobloc mills (59%), while service provision make up 85 per cent of all paddy supplied in the study area (Table 5). Many millers therefore continue to function primarily as service providers with limited vertical coordination mechanisms and no vertical integration. Some commercial milling facilities emerge, who mostly resort to a mix of market, modular and relational modes of governance.

5.5. Factors influencing millers upgrading

Three incentivising factors emerge as determinants that have induced milling upgrading: the irrigated production system, the increasing demand for local rice and the macroeconomic condition. First, the reliability of irrigated rice in Ghana has incentivised millers to invest and upgrade because it presents a greater assurance of paddy quantity and quality compared to rain-fed production. Some stakeholders assert:

> "*The factors that have motivated the investments [of millers] is the irrigated rice, which presents no risk compared to rain-fed agriculture. Milling in rain-fed areas is not a good business venture. In rain-fed areas […] the mills don't have destoners or graders nor platforms for drying*" (MoFA regional officer, Ghana, 12 December 2022).

> "*Because of the dam and the irrigation scheme in the area (Weta irrigation scheme), there is now double cropping which has attracted investors to mill the rice produced. For example in Akatsi area, which is mostly rain-fed production, there are no mills around, because of the uncertainty of production*" (Irrigation scheme manager, Ghana, 8 December 2022).

Secondly, millers' upgrading in Ghana is perceived as a "demand-driven change" (director of a millers' association, Ghana, 8 November 2022), whereby the rise of demand for local rice has incentivised millers to upgrade:

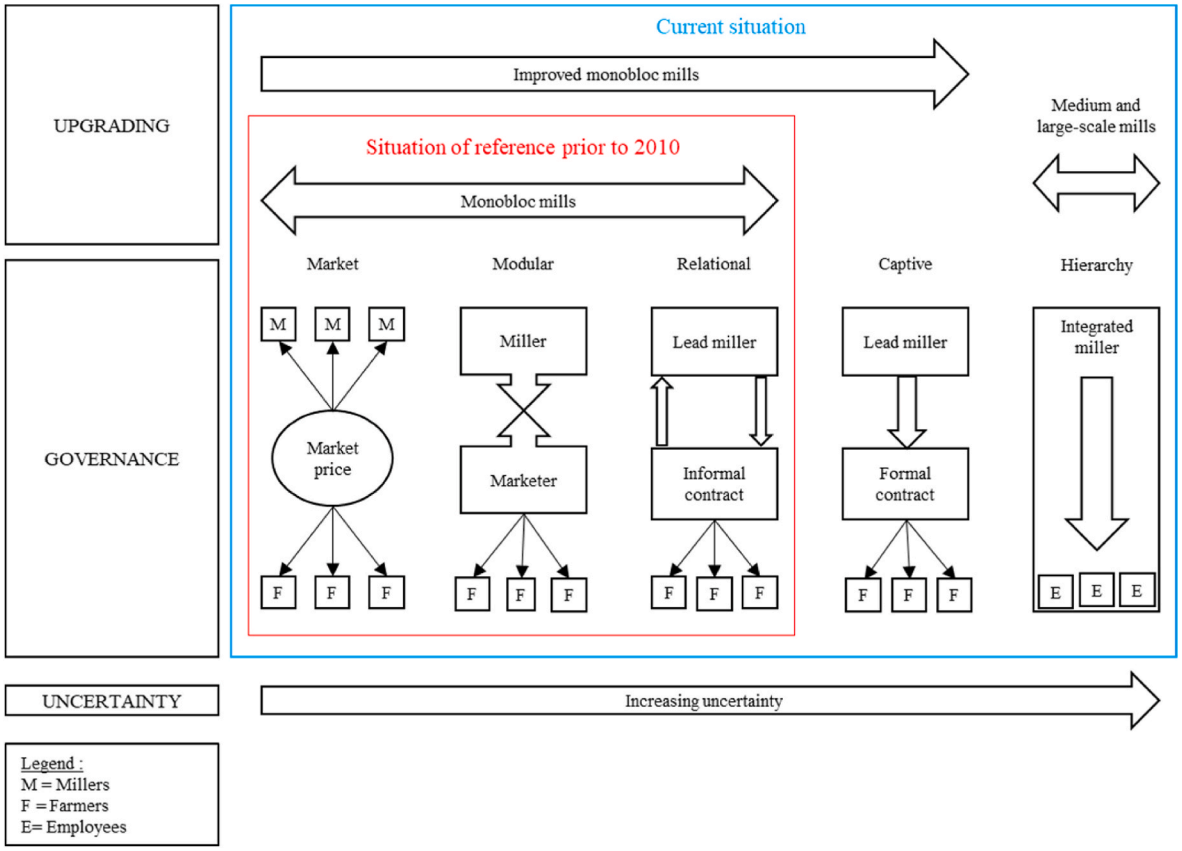

Fig. 8. Evolution of governance structure since 2010. Source: The authors.

Table 4
Technological and business characteristics of rice mills.

Elements	Unit of analysis	Ghana					Ivory Coast				
		Total	Monobloc	Improved monobloc	Medium-scale mills	Large-scale mills	Total	Monobloc	Improved monobloc	Medium-scale mills	Large-scale mills
No of millers	Sum	**38**	3	29	3	3	**177**	105	70	2	0
Typology	Volume per hour	0–3000	0–1.000	400–2.000	1.000–3.000	>3.000	0–3000	0–1.000	400–2.000	1.000–3.000	>3.000
	Step processes	1 to 10	1	2 to 5	6 to 10	>8	1 to 10	1	2 to 5	6 to 10	>8
Milling characteristics											
Capacity in KG per hour	Average	**1.256**	333	991	1.833	4.167	**690**	485	937	2.000	0
	Standard deviation	**669**	76	468	1.041	1.607	**375**	218	321	707	0
Milling unit with destoner	Percentage	**92%**	0%	100%	100%	100%	**41%**	0%	100%	100%	0%
Milling unit with colour sorter	Percentage	**5%**	0%	0%	0%	66%	**0%**	0%	0%	0%	0%
Business characteristics											
Years established	Average	14	19	15	7	8	10	10	8	7	N/A
Year of current milling machine in activity	Average number of years	**6**	5	6	2	6	**8**	8	10	6	0
Cost of machine in Euro	Average	**165.418**	2.109	18.853	342.000	1.686.666	**6.009**	1.821	11.024	15.245	0
	Standard deviation	**638.565**	597	17.190	0	795.760	**5.692**	1.158	1.470	4.312	0
Employees	Average	**6**	2	6	11	10	**3**	2	4	7	0
	Standard deviation	**5**	1	4	12	3	**2**	1	2	1	0
Storage capacity	Average in ton	**305**	53	277	275	815	**21**	5	44	113	0
	Standard deviation	**10.186**	115	10.087	707	15.503	**2.288**	178	3.571	2.475	0
Brand of rice	Percentage	**32%**	0%	24%	67%	100%	**2%**	0%	1%	100%	0%
Source of financing											
Own financial means	Percentage	**88%**	100%	85%	100%	100%	**84%**	83%	87%	50%	0%
Credit from bank	Percentage	**4%**	0%	5%	0%	0%	**3%**	1%	4%	50%	0%
Other	Percentage	**8%**	0%	10%	0%	0%	**13%**	16%	7%	0%	0%
Owner characteristics											
Female owner	Sum	5	1	3	1	0	6	2	3	1	0
	Percentage	13%	33%	10%	33%	0%	3%	2%	4%	50%	0%

Legend: M (Monobloc mill); IM (Improved monobloc mill); MSM (Medium-scale mill); LSM (Large-scale mill).
Source: The authors from the data collected (2021 and 2022)

Table 5
Organisational characteristics and modes of paddy supply of rice mills.

Elements	Unit of analysis	Ghana					Ivory Coast				
		Total	M	IM	MSM	LSM	Total	M	IM	MSM	LSM
No of millers	Sum	38	3	29	3	3	177	105	70	2	0
Business activity and paddy supply											
Service provision	% of activity on average	**69,8%**	73,3%	77,3%	39,3%	2,5%	**85,6%**	88,1%	83,8%	14,9%	0%
	Volume in ton	**6.281**	147	5.530	310	294	**66.346**	28.153	37.972	221	0
	% of total paddy milled	**32%**	**0,7%**	**27,8%**	**1,6%**	**1,5%**	**84,2%**	**35,7%**	**48,2%**	**0,3%**	**0,0%**
Pre-financing	% of activity on average	**7,2%**	13,3%	6,8%	11,7%	0,0%	**5,3%**	4,6%	5,6%	29,9%	0%
	Volume in ton	**606**	27	486	92	0	**4.451**	1.470	2.538	443	0
	% of total paddy milled	**3%**	**0,1%**	**2,4%**	**0,5%**	**0,0%**	**5,7%**	**1,9%**	**3,2%**	**0,6%**	**0,0%**
Direct payment	% of activity on average	**8,0%**	1,7%	8,5%	0,0%	27,5%	**8,8%**	7,0%	10,3%	54,9%	0%
	Volume in ton	**3.839**	3	605	0	3.231	**7.718**	2.237	4.667	814	0
	% of total paddy milled	**19%**	**0,0%**	**3,0%**	**0,0%**	**16,2%**	**9,8%**	**2,8%**	**5,9%**	**1,0%**	**0,0%**
Self-production	% of activity on average	**14,5%**	11,7%	7,4%	49,0%	70,0%	**0,3%**	0,3%	0,3%	0,3%	0%
	Volume in ton	**9.165**	23	529	387	8.225	**236**	96	136	4	0
	% of total paddy milled	**46%**	**0,1%**	**2,7%**	**1,9%**	**41,4%**	**0,3%**	**0,1%**	**0,2%**	**0,0%**	**0,0%**
Total paddy milled	Volume in ton	**19.890**	200	7.154	790	11.750	**78.751**	31.956	45.313	1.482	0
	Percentage	**100%**	1%	36%	4%	59%	**100%**	41%	58%	2%	0%
Paddy milled per milling unit	Average in ton	**523**	67	247	263	3.917	**445**	304	647	741	0
Pre-financing and self-production											
Hectars (Ha) of land for own production	Sum of Ha	**1.949**	7	241	201	1.500	**29**	15	11	3	0
	Percentage of units doing self-production	**55%**	66%	49%	100%	100%	**12%**	13%	9%	50%	0%
	Average Ha per mill doing SP	**93**	4	19	67	500	**2**	2	3	3	0
	Standard deviation	**198**	2	26	76	300	**1**	1	2	0	0
Formal contract farming (FCF)	Percentage of mills practising FCF	**16%**	33%	10%	67%	0%	**4%**	3%	4%	50%	0%
	Number of farmers on average	**17**	3	19	22	0	**78**	10	71	300	0
	Average budget per farmer in Euro	**573**	600	453	740	0	**106**	136	92	61	0
Informal contract farming (ICF)	Percentage of mills practising ICF	**24%**	33%	28%	0%	0%	**21%**	20%	23%	50%	0%
	Number of farmers on average	**15**	7	16	0	0	**18**	15	23	6	0
	Average budget per farmer in Euro	**550**	800	514	0	0	**106**	90	131	76	0

Legend: M (Monobloc mill); IM (Improved monobloc mill); MSM (Medium-scale mill); LSM (Large-scale mill).
Source: The authors from the data collected (2021 and 2022)

"Some [millers] have evolved within the value chain, from small to medium or big size […] this is due because there is a better perception of Ghana rice by the consumers" (Senior researcher from an institutional research centre, Ghana, 17 November 2022).

"Consumers are a powerful engine to value chain change […] with the demand, millers are now driving the change, millers have emerged recently as a big industry player […] There have been huge investments made over the years, from 2007 until today. People saw an opportunity" (President of a NGO working in the rice sector, Ghana, 14 November 2022).

Millers upgrade their equipment to enhance the rice quality in order to meet the expectations of their customers. More specifically, it is the competitive environment that compels millers to continually upgrade their equipment and the quality of the final products. As two Ghanaian millers stated, "if you don't change your mill, you go out of business" or "it [improving the mill] is what the aggregators demand, otherwise you lose market, customers" (rice millers, Ghana). Process and product upgrading therefore appear as strategies to maintain competitiveness in the face of increasing demand for local rice.

Third, the economic circumstances in Ghana appear to have influenced rice importation patterns and created opportunities for the domestic VC. Several respondents observed that the country's unfavourable macroeconomic conditions have increased the cost of rice importation, thereby enhancing the demand for local rice while improving the competitiveness of the domestic VC.

"Because now, the dollar has become higher, and everybody, all the imported rice, even our competitors […] like Thailand Rice, are selling their rice for 150 Ghana cedis, and the Ghana rice is for 60 Ghana cedis. So, it is twice the price, twice the amount. So, now everybody is venturing into it, and people want to make money out of it" (Representative of the interprofessional body, Ghana, 02 November 2022).

"The importation business is becoming difficult. The dollar exchange rate is complicated so the government is limiting the importation of rice. The costs associated to importation is high also […] because local rice is very nutritious and the cost of importation is increasing, people are turning to local rice" (representative of a rice import company, Ghana, 21 November 2022).

"The foreign exchange has become a main constrain to many importers in recent years […] the recent financial and banking crisis in Ghana has made importation more difficult" (representative of a rice import company, Ghana, 10 November 2022).

These three factors collectively provide a conducive environment for millers to engage in process, product, and governance upgrading. First, irrigated rice cultivation reduces uncertainty and mitigates risks associated with rain-fed production, thereby enhancing the viability of investments. Second, the competitive pressure arising from increasing demand compels millers to address quality expectations. Third, the unfavourable economic conditions have affected the price of imported rice and created opportunities for the domestic market in terms of price competitiveness and demand. These elements are discussed in the following section.

6. An ongoing quiet revolution?

Prior to 2010 the rice VCs of both countries featured low level of technology and limited vertical coordination mechanisms, characteristics of the traditional stage. Drawing upon the characteristics of the quiet revolution, Ghana's rice VC presents all the criteria of a quiet revolution (the transitional phase of AVC transformation), while Ivory Coast exhibits features of both traditional and transitional VCs (Table 6). In the latter case, this suggests a phase-out from the traditional stage and entry into the transitional stage. Several factors account for the differences observed, which are discussed below.

The literature on Asia's quiet revolution suggests that government policies were crucial in transforming the midstream segment (Reardon et al., 2012; Reardon, 2015). In the context of emerging staple VCs in Sub-Saharan Africa, some scholars emphasise the necessity for policy interventions to focus on upgrading midstream SMEs in traditional VCs (Resnick et al., 2020), although this segment being a "hidden middle" (Reardon, 2015). In this regard, distinct policy strategies are evident in Ghana and Ivory Coast for upgrading milling SMEs. Ghana's policy documents emphasise upgrading artisanal milling equipment and fostering public-private partnerships (PPPs) (NRDS, 2009). The NRDS proposes to improve milling into national minimum standards by providing standard rice mills and improving existing mills with additional equipments and storage facilities (NRDS, 2009, p.15). In contrast, Ivory Coast's 'pole leaders' policy involves 30 large-scale mills acquired by the government and operated under PPP agreements, although only 4 mills are currently operational (Ministry of agriculture and rural development, 2018). The policy's strategic components include rice development poles and grouping these poles into rice-growing zones (Ministry of agriculture and rural development, 2018). This approach mirrors the agricultural growth pole model implemented in the country, focusing on attracting large-scale foreign investments (Tyrou et al., 2023). Consequently, there is limited policy focus on small-scale millers, who are expected to cater to lower-tier markets or supply paddy to the pole leaders.

Additionally, enabling infrastructures and availability of resources can alter the functioning and performance of VCs by favouring (or constraining) upgrading (Trienekens, 2011). The type of production systems emerge as a determinant to that respect. Irrigated rice is on average at least twice the productivity of rain-fed methods due to a number of factors related to water control, land ownership and tenant's rights, the appropriate use of fertilizer and certified seeds (Ragasa et al., 2014). Furthermore, irrigated agriculture not only mitigates the impact of rainfall shocks but also expands land endowments by enabling the possibility of a second harvest (Boudot-Reddy and Butler, 2022). From a miller's perspective, it reduces the uncertainty regarding paddy output in terms of quantity and quality, which also represent a safety net for return on investment. In effect, irrigated agriculture 'crowds in' private investment (Bathla and Dubey, 2017; Kumbhare and Sen, 2021) and favours the emergence of 'spontaneous clusters' described as 'sets of firms agglomerated spatially from common interest to be near sources of supply of raw materials' (Reardon et al., 2021, p.10).

In Ghana, the reliability of irrigated production in conjunction with the increasing demand for local rice have incentivised investors and induced the competitiveness among millers who upgrade and adopt vertical coordination strategies as a means to remain competitive and meet their costumers' quality expectations (Laurent et al., 2023). Similar process upgrading dynamics were observed in the rice milling segment in irrigated areas in Kenya (Mano et al., 2022). In Ghana millers increasingly market their own brand of rice, which are commercialised in supermarkets and malls (Ayeduvor, 2018). On the contrary, the absence of such factors in Ivory Coast restrain investments, thus limiting the upgrading capability of the milling segment. Similar to our observations, Ouedraogo et al. observe that the majority of rice mills in Ivory Coast mostly practise service provision for traders who do not have specific requirements regarding the quality of paddy rice (Ouedraogo et al., 2021a).

Finally, the currency (in)stability of the Ghanaian Cedi and the Ivoirian CFA Franc has generated different effects. Despite the global market price of rice remaining relatively stable from the aftermath of the 2008 food price crisis until 2022, averaging 423 US dollars per ton (with a mean deviation of 40$), the exchange rates and inflation rates between Ghana and Ivory Coast exhibit noteworthy distinctions, as illustrated in Fig. 9. The Ghanaian Cedi emerges as the second African currency with the poorest performance after the Zimbabwean Dollar (Zubairu et al., 2024). Since 2007, the Ghanaian Cedi has witnessed a persistent depreciation against the US Dollar, culminating in a full-blown

Table 6
Characteristics of the rice value chains in Ghana and Ivory Coast in relation to those of the quiet revolution.

Transformation	Characteristics of the quiet revolution	Ghana	Ivory Coast
Technology	Upgrading and upscaling of milling equipment	Replacing monobloc mills by improved monobloc mills and medium-scale mills. Emergence of large-scale mills	Increasingly investing into improved monobloc mills and few medium-scale mills.
	More expensive milling equipment	Cost of investment average from 18.850 euros to more than 370.000 euros for more advanced mills, compared to 2.100 euros for a monobloc mill	Cost of investment average more than 11.000 euros for improved monobloc mills, compared to 1.800 euros for a monobloc mill
Marketing and finance	Emergence of packing and branding in rice	12 brands observed (1/3 of millers)	3 brands observed (<2% of millers)
	Decline of service provision	Diminishes as mills upgrade their equipment. Declining: 32% of all paddy milled is under service provision	Diminishes as mills upgrade their equipment Strongly present: 84% of all paddy milled is under service provision
	Geographical lengthening of VCs	National	Regional
	Increasing disintermediation	Increasing disintermediation due to vertical integration	Intermediaries still strongly involved for paddy supply
	Emerging vertical integration/coordination	Increasing vertical integration and coordination	Few vertical coordination, no vertical integration
	Emergence of contractual relationships	Emerging: 16% of prefinancing is done through formal contracts	Limited: 4% of prefinancing is done through formal contracts
Structure	Decrease of the share of the small mill	Small mills are less than 3%	Small mills constitute 60% of mills, but are diminishing in share
	Reduction of the role of village trader	Local, regional and cross-national traders involved	Local and regional traders involved

Source: Adapted from Reardon et al. (2014) by the authors.

macroeconomic crisis in 2022 where the Cedi experienced a 50 per cent devaluation against the US Dollar leading to a high inflation rate (World Bank, 2023). Consequently, the price of imported rice expressed in local currency has increased by the same magnitude of the currency depreciation. Conversely, the exchange rate of the Franc CFA has maintained stability over the same period, with inflation rates oscillating between 5 per cent and −2 per cent. In turn, importing rice to Ghana has been consistently and increasingly more expensive compared to Ivory Coast.

Nonetheless, the adverse currency situation in Ghana has reinforced the competitive edge of the domestic VC against imported rice. Considering the relationship between local rice production and rice import, a surge in rice imports correlated with a stagnation in local production growth during the 2000s in Ghana (Lançon and David Benz, 2007). We now observe a reverse tendency. Over the period 2008–2020, domestic paddy production in Ghana experienced a growth rate of 336 per cent, surpassing the 156 per cent growth observed in Ivory Coast

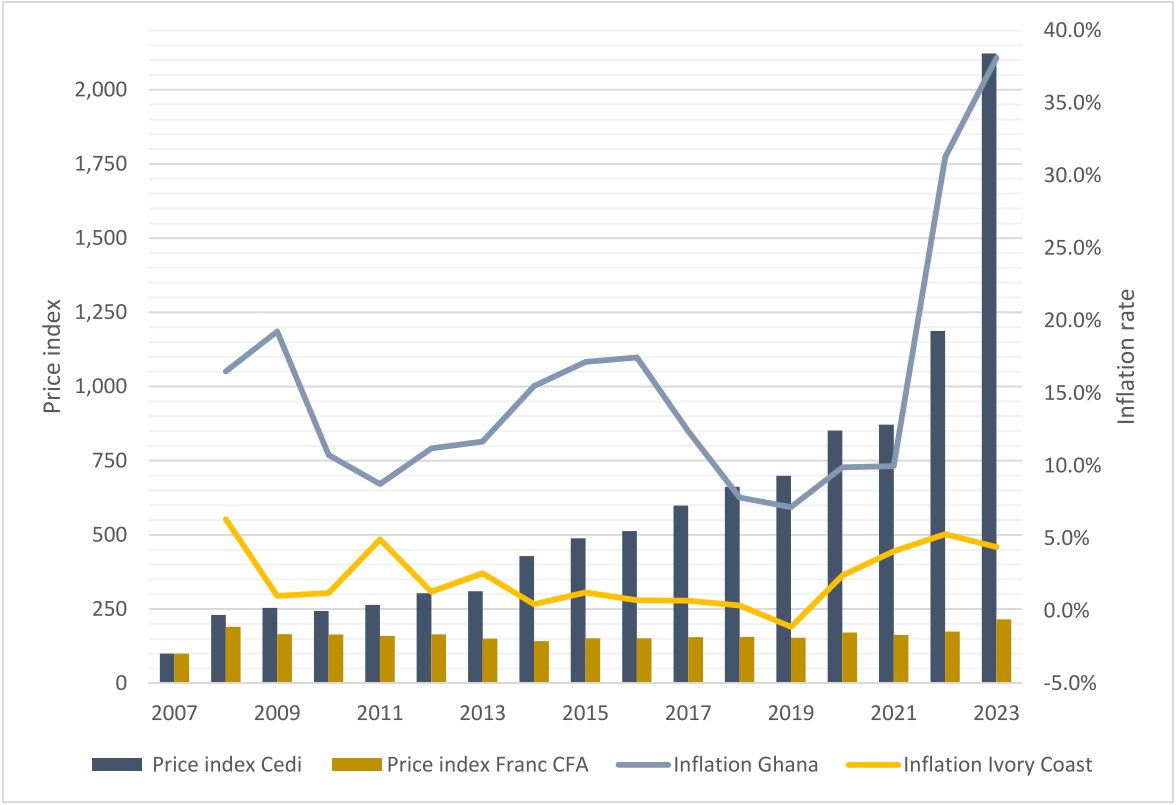

Fig. 9. Price index of international rice prices in local currency and annual inflation rate. Source: The Authors. Price index calculated from the average annual global rice prices (Infoarroz, 2024) and the average annual exchange rate (World Bank, 2023). Annual inflation rates calculated from the Consumer Price Index (International Monetary Fund, 2024).

(USDA, 2023). Despite the continued import of rice to bridge the demand gap, Ghana's self-sufficiency ratio doubled during the same timeframe, reaching 53 per cent in 2023. This contrasts with Ivory Coast, where the self-sufficiency level increased by 23 per cent, reaching 44 per cent in 2023.

7. Conclusion

In this paper we compare the extent of technical and organisational transformations ongoing in the milling segment of the rice VCs in Ghana and Ivory Coast, and discuss it in relation to the literature on AVC transformations. Different patterns of upgrading are observed between the two countries. While Ghana embodies the 'quiet revolution' and the transitional phase of AVC transformation, Ivory Coast is still transitioning from the traditional stage. These differences are related to factors such as the systems of production, the demand for local rice, the policy approach to rice development and the currency situation which incentivise or constrain millers to invest and upgrade.

It is important to acknowledge, however, that this study presents certain limitations. First, the absence of econometric methodologies precludes the establishment of causal inferences. Second, the cross-sectional nature of the research design impedes longitudinal comparisons of the study areas across multiple time points. Third, the observations made concern the study areas and cannot be generalised to the national level.

This comparative analysis contributes to the existing AVC literature that recognises the role of public policy in fostering AVC transformations through 'public infrastructures' and 'enabling conditions', or highlights the absence of the midstream segment in policy debates as posited by the 'hidden middle' claim (Reardon, 2015). However, there remains a dearth of research exploring the content of these policies and the way they target beneficiaries as an explanatory factor to varying patterns of AVC transformations. Consequently, we propose that future research should employ methodologies from policy science to investigate the nature of public policy instruments and their approach to targeting midstream segment actors.

CRediT authorship contribution statement

Rémi Laurent: Writing – original draft. **Guillaume Soullier:** Writing – review & editing, Validation, Supervision, Funding acquisition. **Jean-François Le Coq:** Writing – review & editing, Supervision. **Carolina Milhorance:** Writing – review & editing, Supervision.

Declaration of AI-assisted technologies in the writing process

During the preparation of this work the author(s) used Paperpal in order to improve the readability and language of the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Funding

This work (2002-012) was funded through Labex AGRO 2011-LABX-002 (under I-Site Muse framework) coordinated by Agropolis Fondation, France.

Declaration of competing interest

The authors report there are no competing interests to declare.

Data availability

The data that has been used is confidential.

References

Aderiz, 2021. Tableau de bord de la filière riz 2012-2021. Abidjan. Unpublished.
AGRA, 2019. The Hidden Middle: A Quiet Revolution in the Private Sector Driving Agricultural Transformation, pp. 1–220. https://agra.org/wp-content/uploads/2019/09/AASR2019-The-Hidden-Middleweb.pdf. Nairobi, Kenya.
Arouna, A., Fatognon, I., Saito, K., Futakuchi, K., 2021. "Moving toward rice self-sufficiency in sub-saharan Africa by 2030: lessons learned from 10 Years of the coalition for african rice development.". World Development Perspectives 21, 1–15. https://doi.org/10.1016/j.wdp.2021.100291.
Andam, K., Al-Hassan, R., Asante, S., Diao, X., 2015. Is Ghana Making Progress in Agro-Processing? (Ghana Strategy Support Programme - IFPRI No. 41).
Ayeduvor, S., 2018. Assessing Quality Attributes that Drive Preference and Consumption of Local Rice in Ghana. International Food Policy Research Institute, Washington DC, USA. https://ebrary.ifpri.org/digital/collection/p15738coll2/id/132707.
Barrett, C., Reardon, T., Swinnen, J., Zilberman, D., 2022. "Agri-food value chain revolutions in low- and middle-income countries". J. Econ. Lit. 60 (4), 1316–1377. https://doi.org/10.1257/jel.20201539.
Bathla, Seema, Dubey, Amaresh, 2017. Introduction. In: Seema, Bathla, Dubey, Amaresh (Eds.), Changing Contours of Indian Agriculture. Springer Singapore, Singapore, pp. 1–11. http://link.springer.com/10.1007/978-981-10-6014-4.
Becker, L., N'guessan, Y., 2004. « Le riz dans l'ancienne « Boucle du cacao » de Côte d'Ivoire. Autrepart 31 (3), 133–150. https://www.cairn.info/revue-autrepart-2004-3-page-133.htm?ref=doi.
Boudot-Reddy, C., Butler, A., 2022. Agricultural productivity and local economic development: evidence from private investment in irrigation. Paper Presented at the European Economic Association, Milan, Italy. https://congress-files.s3.amazonaws.com/2022-08/Draft_Irrigation.pdf.
Coase, R., 1937. "The nature of the firm". Economica 4 (16), 386–405. https://doi.org/10.1111/j.1468-0335.1937.tb00002.x.
Custodio, M.C., Demont, M., De Steur, H., 2023. Market intelligence for guiding crop improvement: a systematic review of stakeholder preference studies in the rice sector in the global South and beyond. Compr. Rev. Food Sci. Food Saf. 1–29. https://doi.org/10.1111/1541-4337.13228.
Day, G., Acheampong, J., 1996. Improving the competitiveness and market ability of locally-produced rice in Ghana. Dep. Int. Development, Crop Post Harvest Programme 1–81.
Demont, M., 2013. Reversing urban bias in african rice markets: a review of 19 national rice development strategies. Global Food Secur. 2 (3), 172–181. https://doi.org/10.1016/j.gfs.2013.07.001.
Demont, M., Ndour, M., 2015. Upgrading rice value chains: experimental evidence from 11 african markets. Global Food Secur. 5, 70–76. https://doi.org/10.1016/j.gfs.2014.10.001.
Furuya, J., Sakurai, T., 2005. "Capacity utilization of the rice milling industry and interlinkage in the rice market in Ghana.". The Japanese Journal of Rural Economics 7, 88–99. https://www.jstage.jst.go.jp/article/jjre/7/0/7_88/_article.
Ghana Statistical Service, 2014. Ghana living standards survey round 6 (GLSS 6). https://statsghana.gov.gh/gssmain/fileUpload/Living%20conditions/GLSS6_Main%20Report.pdf.
Gereffi, G., 1999. International trade and industrial upgrading in the apparel commodity chain. J. Int. Econ. 48 (1), 37–70. https://doi.org/10.1016/S0022-1996(98)00075-0.
Gereffi, G., Humphrey, J., Sturgeon, T., 2005. The governance of global value chains. Rev. Int. Polit. Econ. 12 (1), 78–104. https://doi.org/10.1080/09692290500049805.
Gereffi, Gary, Korzeniewicz, Miguel, 1994. Commodity Chains and Global Capitalism. Cambridge University Press.
Harre, D., 1987. « Le système de commercialisation du riz en Côte d'Ivoire : le marché interne des produits agricoles, support de la politique alimentaire. » PhD diss., Université Paris I - Institut d'étude du développement économique et sociale.
Harre, D., 1992. Le Riz en Côte d'Ivoire: Origine et Performance des Secteurs de Transformation Artisanal et Industriel. Solagral, Montpellier, France.
Humphrey, John, Schmitz, Hubert, 2000. Governance and Upgrading : Linking Industrial Cluster and Global Value Chain Research, vol. 120. Institute of Development Studies Working Paper, pp. 1–37. https://www.ids.ac.uk/download.php?file=files/Wp120.pdf.
Ilie, E., Kelly, S., 2021. *The Role of Small and medium agrifood Enterprises in food systems transformation: the Case of rice Processors in Senegal.* FAO Agricultural Development Economics Technical Study, Rome: Italy, pp. 1–104. http://www.fao.org/documents/card/en/c/cb3873en.
International Monetary Fund, 2024. Inflation Rate, Average Consumer Prices. https://www.imf.org/external/datamapper/PCPIPCH@WEO/OEMDC/ADVEC/WEOWORLD.
Kaplinsky, R., Morris, M., 2001. A Handbook for Value Chain Research. Institute of Development Studies, University of Sussex and School of Development Studies, University of Natal.
Kra Djato, K., Dugué, P., Pecqueur, B., 2006. « Interventions publiques pour le Développement d'un système agroalimentaire localisé dans le secteur de la production rizicole irriguée en Côte d'Ivoire. ». Mondes Développement 4 (136), 101–118. http://www.cairn.info/revue-mondes-en-developpement-2006-4-page-101.htm.
Kumbhare, S.L., Sen, M., 2021. Investments in irrigation projects - an impact analysis. Agric. Econ. Res. Rev. 21, 377–385. https://doi.org/10.22004/ag.econ.47888.
Lançon, F., David Benz, H., 2007. "Rice Imports in West Africa : Trade Regimes and Food Policy Formulation.". Poster prepared for presentation at the 106th seminar of the

European Association of Agricultural Economists, Montpellier, France. October 2007.
Laurent, R., Soullier, G., Asante-Poku, N.A., 2023. Changes in the Milling Segment of the Rice Value Chain in Ghana. Institute of Statistical, Social and Economic Research (ISSER), University of Ghana, Accra, Ghana. https://isser.ug.edu.gh/Changes%20in%20the%20Milling%20Segment%20of%20the%20Rice%20Value%20Chain%20in%20Ghana.
Liverpool-Tasie, S., Omonona, B., Sanou, A., Ogunleye, W., Padilla, S., Reardon, T., 2016. Growth and transformation of chicken and eggs value chains in Nigeria. Feed the Future Innovation Lab for Food Security Policy Research. (Accessed 22 September 2016).
Mano, Y., Njagi, T.N., Otsuka, K., 2022. Rice milling in Kenya: an inquiry into the process of upgrading rice milling services. Food Pol. 106, 1–11. https://doi.org/10.1016/j.foodpol.2021.102195.
Mausch, K., Hall, A., Hambloch, C., 2020. Colliding paradigms and trade-offs: agri-food systems and value chain interventions. Global Food Secur. 26, 100439. https://doi.org/10.1016/j.gfs.2020.100439.
Minten, B., Stifel, D., Tamru, S., 2014. Structural transformation of cereal markets in Ethiopia. J. Dev. Stud. 50 (5), 611–629. https://doi.org/10.1080/00220388.2014.887686.
Ministry of Food and Agriculture (MoFA), 2021. Rice Strategic Brief. https://mofa.gov.gh/site/agribusiness/strategic-brief-business-model/385-rice-strategic-brief-and-business-model.
Ministry of agriculture and rural development, 2018. Promotion of private sector investment in Ivoirian rice farming. Presented during the 7th CARD general meeting. https://riceforafrica.net/gm-7-meeting-oct-2018/.
Mossie Birhanu, M., 2023. "Theoretical underpinnings of value chain analysis.". In: Stanton, John, Caiazza, Rosa (Eds.), Sustainable Development, pp. 1–16. https://doi.org/10.5772/intechopen.110841.
NRDS, 2009. National rice development strategy. Ministry of Food and Agriculture, the Republic of Ghana, pp. 1–25. https://riceforafrica.net/wp-content/uploads/2021/09/ghana_en.pdf.
OECD and FAO, 2019. Background notes on sustainable, productive and resilient agro-food systems. Value Chains, Human Capital, and the 2030 Agenda. Rome, Italy. 1-70. https://www.oecd-ilibrary.org/agriculture-and-food/background-notes-on-sustainable-productive-and-resilient-agro-food-systems_dca82200-en.
Ouedraogo, S., Bockel, L., Gopal, P., Arouna, A., Fatognon, I.A., 2021a. Analyse de la chaîne de valeur riz en Côte d'Ivoire - Optimiser l'impact socio-économique et environnemental d'un scénario d'autosuffisance à l'horizon 2030. FAO, Accra, Ghana. http://www.fao.org/documents/card/en/c/cb1506fr.
Ouedraogo, S., Bockel, L., Abedi, A., Gopal, P., Arouna, A., 2021b. Rice Value Chain in Ghana – Prospective Analysis and Strategies for Sustainable and Pro-poor Growth. FAO, Accra, Ghana. https://doi.org/10.4060/cb1659en.
Paasch, A., Garbers, F., Hirsch, T., 2007. Trade Policies and Hunger: the Impact of Trade Liberalisation on the Right to Food of Rice Farming Communities in Ghana, Honduras and Indonesia. Ecumenical Advocacy Alliance, Geneva, Switzerland. https://www.fian.org/fileadmin/media/publications_2015/Trade-Policies-and-Hunger-2007.pdf.
Porter, M.E., 1985. Competitive Advantage. Creating and Sustaining Superior Performance. Free Press, New York, USA.
Ragasa, C., Takeshima, H., Chapoto, A., Kolavalli, S., 2014. Substituting for Rice Imports in Ghana. Ghana Strategy Support Programme - IFPRI. https://www.ifpri.org/publication/substituting-rice-imports-ghana.
Reardon, T., Chen, K., Minten, B., Adriano, L., 2012. The Quiet Revolution in Staple Food Value Chains: Enter the Dragon, the Elephant and the Tiger. Asian Development Bank and International Food Policy Research Institute, Philippines. https://www.adb.org/publications/quiet-revolution-staple-food-value-chains.
Reardon, T., 2015. "The hidden middle: the quiet revolution in the midstream of agrifood value chains in developing countries.". Oxf. Rev. Econ. Pol. 31 (1), 45–63. https://doi.org/10.1093/oxrep/grv011.
Reardon, T., Chen, K.Z., Minten, B., Adriano, L., Dao, T.A., Wang, J., Gupta, S.D., 2014. The quiet revolution in asia's rice value chains. Ann. N. Y. Acad. Sci. 1331 (1), 106–118. https://doi.org/10.1111/nyas.12391.
Reardon, T., Liverpool-Tasie, L.S.O., Minten, B., 2021. "Quiet revolution by SMEs in the midstream of value chains in developing regions: wholesale markets, wholesalers, logistics, and processing.". Food Secur. 13 (6), 1577–1594. https://link.springer.com/10.1007/s12571-021-01224-1.
Resnick, D., Diao, X., Tadesse, G., 2020. Sustaining Africa's Agrifood System Transformation: the Role of Public Policies. International Food Policy Research Institute, Washington, DC. https://doi.org/10.2499/9780896293946 and AKADEMIYA2063.
Sakurai, T., Furuya, J., Futakuchi, K., 2006. "Rice miller cluster in Ghana and its effects on efficiency and quality improvement.". In: Paper Presented at the International Association of Agricultural Economists Conference. Gold Coast, Australia. August 2006.
SNRD, 2012. *Stratégie Nationale Révisée de Développement de la Filière Riz en Côte d'Ivoire* (2012-2020). Ministère de l'Agriculture, Office National de Développement de la Riziculture ONDR. https://riceforafrica.net/wp-content/uploads/2021/09/Cote_dIvoire_fr.pdf.
Soullier, G., Demont, M., Arouna, A., Lançon, F., Mendez del Villar, P., 2020. "The state of rice value chain upgrading in West Africa.". Global Food Secur. 25, 1–10. https://doi.org/10.1016/j.gfs.2020.100365.
Soullier, G., Moustier, P., 2021. "The modernization of the rice value chain in Senegal: a move towards the asian quiet revolution?". Dev. Pol. Rev. 39 (S1), 81–101. https://doi.org/10.1111/dpr.12459.
Trienekens, J.H., 2011. "Agricultural value chains in developing countries A framework for analysis.". Int. Food Agribus. Manag. Rev. 14 (2), 51–82. https://edepot.wur.nl/189057.
Tyrou, E., Soullier, G., Coulibaly, M., 2023. Unpacking policies for the development of agricultural growth Poles in West Africa. Can. J. Dev. Stud./Rev. Can. Études Dev. 1–21. https://doi.org/10.1080/02255189.2023.2165484.
USDA, 2020. Grain and Feed Annual (Report IV2020-0002). USDA Foreign Agricultural Service. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Grain%20and%20Feed%20Annual_Accra_Cote%20d%27Ivoire_04-15-2020.
USDA, 2023. "Imports, Production, Supply and Distribution" database. Foreign Agriculture Service. https://apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery.
Williamson, O.E., 1979. "Transaction-Cost economics: the governance of contractual relations.". J. Law Econ. 22 (2), 233–261. https://www.journals.uchicago.edu/doi/10.1086/466942.
Williamson, O.E., 1985. The economic institutions of capitalism : firms. Markets, Relational Contracting. The free press, New York, USA.
World Bank, 2023. Seventh Ghana Economic Update: Price Surge - Unraveling Inflation's Toll on Poverty and Food Security. World Bank Group, Washington, D.C.. http://documents.worldbank.org/curated/en/099072023055014341/P177994046644e0e20b3dd057c81347c0ef
Zubairu, I., Alenezi, M., Iddrisu, A., Dawson, S., 2024. The dynamics of the Ghanaian currency depreciation: a case analysis of the performance of Ghana cedi (ghc) against its major trading currencies. Int. J. Econ. Finance Manag. Sci. 12 (1), 18–43. https://doi.org/10.11648/ijefm.20241201.13.
Infoarroz, 2024. Database. https://infoarroz.org/blog/category/market/. Database available at: