A Study on the Income-Enhancing Effects of Upgrading Agricultural Value Chains in Southwest Border Regions

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Abstract: This paper investigates the mechanisms through which agricultural value-chain upgrading drives income growth among farmers in China's southwestern border regions, using eight land-border counties in Guangxi as a case study. It first establishes a theoretical framework linking the value chain, its upgrading, and income enhancement, explicitly integrating "border-region characteristics." Through field surveys, interviews, and data analysis, the study maps the current value-chain structure, upgrading pathways, achievements, and challenges. An econometric model confirms that participation in high-value processing, brand building, e-commerce, organizational development, and technology adoption significantly increases farm operating income. Crucially, the study identifies that the unique "port-economy" effect, advantages from the "border-trade market," and potential for "cross-border agricultural cooperation" play irreplaceable roles in shaping the region's "border-effect" and driving upgrading. Based on these findings, the paper proposes a systematic set of actionable recommendations. These focus on macro-guidance, enterprise leadership, cooperative bridging roles, and enhancing farmers' capabilities to promote systemic transformation. The ultimate goal is to achieve common prosperity for border residents, sustainable regional economic development, and strategic border stability.

Keywords: Agricultural Value Chain; Value-Chain Upgrading; Income-Increasing Effect; Border Regions; Border Counties

1. Introduction

1.1 Research Background and Significance

1.1.1 Research background

Rural revitalization and borderland stability are two national strategies that are deeply integrated and mutually reinforcing in the process of Chinese-style modernization in the new era. The southwestern border regions—characterized by a long land border, diverse ethnic composition, fragile ecosystems, and relatively underdeveloped foundations—are critical areas for the country's overall security and regional coordinated development strategy.

It occupies a pivotal and indispensable position. Agricultural development in this region generally exhibits a distinct characteristic of overlapping "multiple attributes": it serves as both a "frontier" safeguarding territorial integrity and a "ethnic region" inhabited by diverse ethnic groups and rich in cultural diversity; it is simultaneously a "mountainous area" with complex topography and ecological sensitivity, as well as a "late-developing region" constrained by historical, geographical, and other factors [1]. This composite nature has long subjected its agricultural development to a series of structural challenges: the region suffers from significant historical deficits in industrial infrastructure, its industrial chains are typically short and loosely connected, and agricultural products mostly enter the market in their raw or minimally processed forms, resulting in a severe lack of capacity to capture added value. Meanwhile, due to factors such as geographic distance from core consumer markets, information asymmetry, and fluctuations in cross-border markets, agricultural producers face substantial market risks and income uncertainties.

However, challenges also harbor unique opportunities. The southwestern border regions boast geographical advantages in border-area openness that are unmatched by China's inland areas, serving as the forefront of regional cooperation frameworks such as the China-ASEAN Free Trade Area and the Lancang-Mekong Cooperation Mechanism [2]. Their diverse, multi-layered climates and abundant biological resources provide natural

conditions for developing specialty, high-quality, and eco-friendly agricultural products. Moreover, the ethnic groups that have inhabited these regions for generations have, through long-term production practices, developed distinctive agricultural systems and farming cultures that are highly attuned to the local environment—forming a rich cultural foundation for branding and differentiated development. Therefore, the key question is how to transform the geographic "periphery" into an "advanced frontier" of open cooperation and turn the "latent advantages" of resources and culture into "competitive advantages" for industry and the economy—thus breaking the development dilemmas faced by border regions, accelerating the modernization of their agriculture and rural areas, and ultimately achieving the goal of ensuring border residents' "stability, security, and prosperity".

Against this broad backdrop, Agricultural Value Chain Upgrading is seen as a crucial pathway and core mechanism for addressing the challenges mentioned above. It refers to the proactive process by which agricultural producers and related stakeholders extend their reach—from traditional, low-value-added primary production stages such as cultivation and animal husbandry—to higher-value-added activities including sophisticated processing of agricultural products, modernized warehousing and logistics, branded marketing, diversified sales channels, and even product R&D and design—integrating and gaining control over these advanced stages. At its essence, this process represents a fundamental reshaping of the focus of industrial value creation and the pattern of profit distribution. For the southwestern border regions, promoting Agricultural Value Chain Upgrading not only means enhancing the overall competitiveness and risk resilience of the local agricultural sector but also ensures that a greater share of value-added benefits remains within the region, benefiting the border residents and thus laying a solid economic and social foundation for the stability of the frontier areas.

As the only provincial-level region in China that shares land and maritime borders with ASEAN countries, the Guangxi Zhuang Autonomous Region—specifically its eight land-border counties (Napo County, Jingxi City, Daxin County, Longzhou County, Pingxiang City, Ningming County, Dongxing City, and Fangcheng District)—forms an important segment of China's southwestern border area. These counties and cities embody a unique combination of "old, young, border, mountainous, and impoverished" characteristics, making them a vital part of the region. Observe typical case studies of development in border regions. Currently, with the deepening implementation of the Belt and Road Initiative and the accelerated establishment of a new development paradigm featuring dual circulation—both domestic and international—agricultural development in Guangxi's border areas is at a critical historical juncture: transitioning from traditional subsistence agriculture geared toward self-sufficiency to modern, market-oriented, and commodity-based agriculture; and shifting from being confined to domestic circulation to actively integrating into and aligning with both domestic and international dual circulation systems [3]. At this pivotal moment, systematically exploring concrete, practical pathways for upgrading the agricultural value chain in this region and scientifically measuring the genuine impact and underlying mechanisms of such upgrades on farmers' income growth will not only provide valuable decision-making references for Guangxi's own high-quality development but also offer significant theoretical insights and policy implications for other southwestern border provinces such as Yunnan and Tibet, as well as for similar regions across the country.

1.1.2 Significance of the study

Theoretical Significance: First, this study attempts to integrate across disciplines the relevant principles of global value chain theory, agricultural economics, regional economics, and development economics, and applies them to the context of the "southwestern border regions"—a region with unique geographical, political, economic, and socio-cultural characteristics. This approach helps to test and develop the explanatory power and applicability of classical theories in specific regional contexts, thereby enriching and expanding the theoretical underpinnings of development economics and agricultural economics in border areas. Second, by focusing on how "borders" function as active factors that specifically influence the governance structure, spatial layout, upgrading dynamics, and benefit distribution within agricultural value chains, this study can deepen the academic

community's understanding of the complexity of "border effects" at the micro-industrial level, and promote a shift from solely analyzing the "barrier effect" toward a more comprehensive examination of both "barrier" and "mediation" effects. Finally, by constructing an analytical framework that incorporates variables specific to border regions and conducting empirical tests, this study aims to provide micro-level empirical evidence and logical clues for developing a theoretical framework that is more distinctly Chinese in character and better aligned with the realities of border-region development.

Practical Significance: This study stems from real-world needs and is designed to serve practical realities. Its practical significance is reflected primarily in three aspects: First, its value as a reference for decision-making. Through systematic analysis of the current situation and rigorous impact assessment, this study aims to provide evidence-based decision-making support—grounded in field research and data—for relevant departments in Guangxi and across the country, enabling them to formulate more precise and effective policies for supporting agricultural industries in border regions, initiatives to boost rural development and prosperity, and plans for cross-border economic cooperation [4]. Second, its practical guidance value. By identifying the key drivers, major bottlenecks, and risk challenges in the current process of upgrading agricultural value chains, the study's findings can help local governments, agricultural enterprises, farmer professional cooperatives, and other new types of business entities—as well as the broader farming community—gain a clearer understanding of their own positions within the value chain and clearly First, it identifies potential directions and feasible pathways for upgrading and developing the region, thereby optimizing resource allocation and strategic choices. Second, it highlights the socio-strategic value of the research. The ultimate goal of this study is to contribute to the long-term stability and prosperity of frontier regions and the common prosperity of all ethnic groups. By exploring pathways for achieving sustainable income growth through intrinsic industrial upgrading, this research directly addresses the national strategic needs of "effectively linking the consolidation and expansion of poverty alleviation achievements with rural revitalization" and "stabilizing and strengthening border areas." It holds profound and significant practical value in enhancing the endogenous development momentum of border regions, promoting ethnic unity, and safeguarding national territorial security.

1.2 Innovation of This Paper

Building on the extensive reference to previous research findings, this paper strives to achieve potential innovation and breakthroughs in the following areas: Contextualized Innovation in Research Perspectives: Existing studies on agricultural value-chain upgrading have largely focused on agriculturally advantageous regions such as the eastern coastal areas or the central plains, paying relatively little attention to the special type of region along the southwestern border. Moreover, these studies often overlook the profound impact of the region's "border characteristics." This article undertakes a deep integration and correlation analysis between the spatial unit of "border regions"—which carries unique geopolitical and economic significance—and the industrial-economic process of "agricultural value-chain upgrading," with particular emphasis on how "border characteristics" (including border ports, border trade markets, cross-border cooperation, and national defense and security factors) profoundly shape and even reshape, from both external environmental and internal driving perspectives, the unique pathways, rhythms, and constraints governing local agricultural industry upgrades. This contextualized perspective facilitates the generation of knowledge that more accurately reflects the realities of border regions. The Integrative Expansion of the Analytical Framework: In applying the classic analytical framework for global value-chain upgrading—covering process, product, functional, and chain-level upgrades—this study does not merely adopt it wholesale but instead purposefully integrates a series of key variables specific to the southwestern border regions, such as "the degree of participation in border trade by local residents," "the depth of cross-border agricultural cooperation," "the level of facilitation in border-port customs clearance," and "the intensity of industrial policies in border areas". By endogenizing these variables into the analytical framework, the theoretical model becomes better able to capture the complex realities of border regions, enhancing its explanatory power and predictive capacity with

respect to local phenomena and providing clear variable guidance for subsequent empirical testing.

The micro-level targeting of empirical testing: Unlike indirect inferences based on macroeconomic statistical data or nationwide survey data, this study draws on primary micro-level survey data collected from 850 farming households and multiple business entities across eight border counties in Guangxi. Using econometric methods, it directly and meticulously assesses the net impact of different value-chain upgrading pathways on the income of border-area farmers. This empirical analysis, grounded in micro-level data from specific target regions, enables a cleaner identification of causal relationships and a more accurate quantification of effect sizes, thereby providing a solid foundation for formulating "drip-irrigation-style" and "precision-based" policies. The industrial and income support policies for border regions provide more robust and reliable micro-level empirical evidence, thereby addressing the shortcomings of existing empirical studies in this field.

2. Theoretical Analysis of the Income-Enhancing Effects of Upgrading Agricultural Value Chains in Southwest Border Regions

2.1 Definition of Relevant Concepts

To ensure the rigor of the study, we first define the core concepts addressed in this paper: The Southwest Border Region: In this paper, the Southwest Border Region refers primarily to the border areas under the jurisdiction of provinces and autonomous regions in southwestern China that share land borders with neighboring countries such as Vietnam, Laos, and Myanmar. While this study broadly encompasses regions like Guangxi and Yunnan, the empirical cases specifically focus on the eight land-border counties within the Guangxi Zhuang Autonomous Region. The most salient feature of this region is that its socio-economic activities are closely intertwined with "national borders," endowing its development with both "marginality" and "frontier characteristics." Domestically, it may face marginalization in terms of markets, information, and capital due to its distance from the nation's economic centers; externally, however, its proximity to international markets makes it a frontier window for opening up to the outside world and fostering international exchanges and cooperation. This dual nature profoundly influences resource flows, industrial layouts, and development dynamics in the region.

Agricultural Value Chain: Drawing on the theory of global value chains, this paper defines the agricultural value chain as the entire process—from the initial inputs such as seeds and fertilizers through field production, post-harvest handling, processing and transformation, warehousing and transportation, multi-level wholesale distribution, all the way to the final delivery into the hands of consumers. This is not merely a physical chain of material transformations; rather, it is an economic chain in which value is incrementally added at each stage, and in which information and capital flows move in opposite directions. It is also a complex network of relationships involving numerous actors, including farmers, cooperatives, family farms, agricultural enterprises, processors, logistics providers, distributors, retailers, and consumers . In border regions, this chain often crosses national borders, giving rise to "cross-border agricultural value chains," which increase both the complexity of governance and the potential for cooperation [5].

Agricultural value-chain upgrading refers to the process by which participants in the agricultural value chain—particularly producers and local enterprises located in developing countries—move within the value chain or into new value chains by enhancing their technological capabilities, improving organizational practices, and adjusting their strategic positioning, thereby engaging in higher-value-added activities and reaping greater benefits [6]. This study focuses on "functional upgrading"—that is, shifting the nature of the activities undertaken within the value chain, such as moving from production to design, marketing, or brand management—and "chain upgrading"—that is, transitioning to entirely new product value chains that feature higher technological content or greater added value—because these two types of upgrading hold the greatest potential for driving income growth.

Income-increasing effect: The income-increasing effect examined in this study is a multidimensional and comprehensive concept. It not only refers to the absolute increase in

farmers' monetary income resulting from their participation in higher-value segments of the value chain, but also encompasses the optimization of income structure—for instance, an increased share of household income derived from high-value-added activities, reduced reliance on the simple sale of primary products, or the acquisition of diversified wage and business income streams through engagement in new links within the value chain. Additionally, it includes enhanced income stability—meaning improved resilience against natural risks and market fluctuations, with reduced year-to-year income volatility. A comprehensive income-increasing effect is key to achieving sustainable livelihoods and ensuring lasting poverty alleviation [7].

2.2 Theoretical Analysis of the Income-Enhancing Effects of Upgrading Agricultural Value Chains in Southwest Border Regions

The role of agricultural value-chain upgrading in the southwestern border regions in boosting farmers' income growth is realized through a series of interconnected and mutually reinforcing economic mechanisms. In the special geographical context of the border regions, these mechanisms are endowed with unique connotations and forms of expression.

Value-capture mechanism: This is the most direct and core mechanism for increasing income. In traditional, loosely structured value chains, farmers engaged in primary production typically occupy the weakest bargaining position, with most of the added value captured by downstream processors, brand owners, and retailers [8]. As the value chain ascends—particularly through functional upgrades—farmers or their cooperative organizations begin to directly participate in or take control of high-value-added stages such as processing, packaging, brand building, and market sales. For example, farmer cooperatives in Jingxi City wash, slice, and dry local hawthorns, packaging them into individually sealed small packets under the unified brand "Bian Guan Xiu Pin." They then sell these products via e-commerce platforms and tourism channels, achieving significantly higher per-unit selling prices and profits than when selling fresh fruit directly. This process enables previously spillover value to be "settled" and "captured" locally, directly translating into higher incomes for producers.

Risk Mitigation and Smoothing Mechanisms: Agricultural production inherently faces dual risks—natural hazards and market fluctuations. For farmers who are confined to the production stage, their income is akin to "relying on the weather," with sharp and volatile swings. By extending the value chain both vertically and horizontally, farmers can build diversified buffers against risk. Vertically, developing primary processing and storage/conservation facilities can extend the shelf life of agricultural products, enabling off-season sales and helping farmers avoid price troughs that occur when products are concentratedly marketed during peak harvest periods. Horizontally, it is crucial to diversify market channels. Farmers in border regions can not only rely on traditional local and inland markets but also take full advantage of the "border resident mutual trade" policy to conveniently sell their products to neighboring countries; or they can leverage cross-border e-commerce platforms to reach consumers farther afield. This diversification of markets significantly reduces dependence on any single market, so that when one When one market experiences volatility, other channels can provide supplementary income, thereby smoothing out the household's overall income curve. The cross-border market spaces unique to border regions offer a distinctive option for risk diversification.

Learning, Innovation, and Capability-Enhancing Mechanisms: The upward climbing process itself is a powerful "learning by doing" and "learning through application" experience. To meet hygiene standards in processing stages, ensure consistent quality for brand sales, comply with quarantine regulations in export markets, or respond to feedback from e-commerce consumers, farmers must actively or passively learn and adopt new varieties, novel cultivation and breeding techniques, innovative management models (such as standardized production protocols), and fresh business knowledge (including marketing and finance). For instance, farmers participating in vegetable supply bases for Hong Kong must strictly adhere to a comprehensive quality and safety control system covering the entire process—from planting to harvesting. This continuous learning and practical application represents a long-term investment in farmers' human capital. The enhancement of human capital not only supports

the current upward climb but also lays a solid capability foundation for addressing future, more complex market changes and achieving higher levels of upgrading. Moreover, the frequent movement of people and cultural exchanges in border regions have turned these areas into vibrant hubs for innovation in agricultural technologies, market information, and business models, providing external sources of knowledge that fuel the upward climb [9].

The "Border Dividend" Transformation and Amplification Mechanism: This is the most distinctive—and also the most promising—income-generating mechanism in border regions. While traditionally viewed as barriers, geographical "borders" can, from an open-development perspective, be transformed into a unique resource—the "border dividend." This primarily includes: policy dividends—such as the national preferential policy allowing border residents to trade goods worth up to 8,000 RMB per person per day without tariffs or import taxes, which significantly reduces the costs of small-scale cross-border trade; locational dividends—where border ports serve as critical junctions connecting domestic and international markets and resources, providing an ideal location for developing port-side processing industries and cold-chain logistics; and cooperative dividends—stemming from complementary advantages with neighboring countries in agricultural resources, labor, technology, and markets. Through models such as "Two Countries, One Zone" and "Cross-Border Agricultural Cooperation Demonstration Zones," it's possible to optimize the layout of industrial chains across borders—for instance, leveraging neighboring countries' land and climate for cultivation while carrying out sophisticated processing and brand marketing within the home country. The advanced stage of upgrading the agricultural value chain precisely involves keenly identifying, effectively integrating, and creatively transforming these "border dividends"—turning latent advantages into tangible industrial competitiveness and real household "income dividends". Successful upward mobility can transform border regions from mere "corridors" into "industrial highlands," elevating the "passage economy" into a "port-based industrial economy." However, it is crucial to recognize clearly that the path for upgrading agricultural value chains in the southwestern border regions is by no means smooth; these regions face "border constraints" that are even more severe than those in inland areas. First is the "end-of-line constraint" on infrastructure. Although While the backbone transportation network has improved, the "last-mile" cold-chain logistics and storage/ facilities—critical for connecting production areas with ports and markets—remain severely underdeveloped. This results in high spoilage rates for fresh agricultural products and hinders value enhancement. Second, there is a constraint posed by the "small, scattered, and weak" nature of market players. The local area lacks leading agricultural enterprises with strong driving capabilities, and cooperatives are still immature, making it difficult to effectively integrate resources, lead value-chain governance, and connect with high-end markets. Third, there is the "uncertainty constraint" imposed by institutional and policy factors. Cross-border trade policies and inspection and quarantine standards may be adjusted due to bilateral relations or pandemics, thereby increasing business operational risks. Fourth, there is the "path dependency constraint" stemming from prevailing development thinking. For a long time, the "corridor economy" mindset has been entrenched, focusing merely on simple "goods transit" and collecting service fees, while insufficient attention and investment have been devoted to developing local deep-processing industries and cultivating independent brands. As a result, critical links in the value chain are missing, industrial roots are weak, and the industry exhibits a fragile structure characterized by "both ends external and the middle left hanging" [10].

Integration of the Theoretical Analytical Framework: To sum up, the theoretical analytical framework constructed in this paper can be outlined as follows: The "border characteristics" of the southwestern border regions—comprising a unique policy system, locational advantages, dual-market dynamics, and stringent security requirements—constitute the core external environment for local agricultural development. This environment acts like a double-edged sword: on the one hand, it gives rise to distinctive "border dividends," providing a rare window of opportunity for upgrading the value chain; on the other hand, it also imposes specific "border constraints,"

creating obstacles that must be overcome in the process of value-chain upgrading [11]. Under the combined impetus of this environment, their own resource endowments, and entrepreneurial spirit, local farmers and various new types of agricultural business entities are striving to elevate their agricultural value chains along two main pathways: "functional upgrading" (such as building their own brands, engaging in e-commerce, and developing leisure agriculture) and "chain upgrading" (such as shifting from primary production to agro-processing and cross-border agricultural services). This upward trajectory is facilitated by four key mechanisms—value capture, risk mitigation, learning and innovation, and conversion of border dividends—which ultimately translate into higher farmer incomes, improved income structures, and enhanced income stability. In turn, the increase in income, broadened horizons, and enhanced capabilities further bolster farmers' and their organizations' confidence and capacity to invest more deeply in value-chain upgrading, thus setting off a positive feedback loop of "upgrading-income growth-re-upgrading." As a result, these regions may break free from the trap of low-level equilibrium in development and embark on a path toward endogenous, sustainable modernization of agriculture and rural areas [12].

3. An Empirical Analysis of the Income-Boosting Effects of Upgrading Agricultural Value Chains in Southwest Border Regions—A Case Study of Eight Border Counties in Guangxi

3.1 Data Sources, Sample Characteristics, and Variable Selection

3.1.1 Data sources and sample description

To obtain first-hand, high-quality research data, the research team conducted a field survey lasting over two months from July to September 2023 in eight land-border counties: Napo County, Jingxi City, Daxin County, Longzhou County, Pingxiang City, Ningming County, Dongxing City, and Fangcheng District in Guangxi. The survey employed a combination of multi-stage stratified random sampling and purposive sampling. First, in each sampled county, 2–3 representative townships were selected based on their economic development levels, dominant agricultural industries, and geographic location (border-port type or inland-type). Next, in each sampled township, 3–5 administratively designated villages with agriculture as their primary industry were chosen. Finally, in each sampled village, using household rosters provided by the village committees, an equidistant random sampling method was applied to select 15–20 households as respondents for the questionnaire survey. A total of 900 questionnaires were distributed during the survey; after excluding invalid questionnaires with severe information missing or obvious logical inconsistencies, 850 valid household questionnaires were ultimately obtained, yielding an effective response rate of 94.4%.

The locations of the 8 sample border counties (Napo County, Jingxi City, Daxin County, Longzhou County, Pingxiang City, Ningming County, Dongxing City, and Fangcheng District).

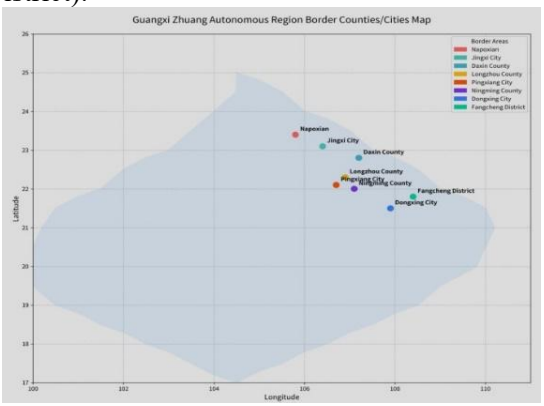
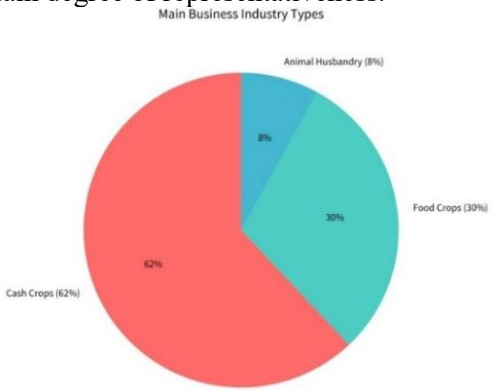
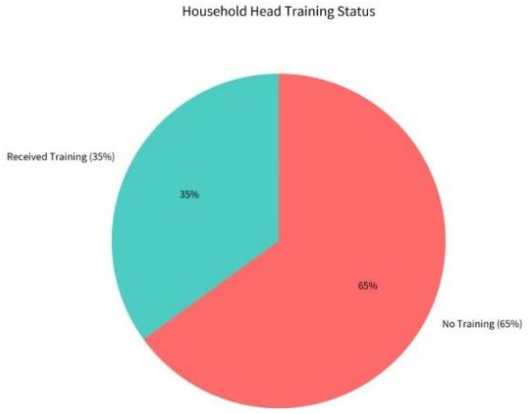


Figure 1. Distribution and Structure of the Survey Sample

Figure 1 visually illustrates the geographical origin and basic structure of the empirical study's sample, indicating that the sample covers major land-border counties in Guangxi and is predominantly composed of households engaged in the cultivation of cash crops, thus exhibiting a certain degree of representativeness.



A. Main Business Industry Types



B. Household Head Training Staus

Figure 2. Major Industries and Training Status of Household Heads

Figure 2 shows the basic characteristics of the surveyed agricultural enterprises and the training status of household heads as follows:

The average age is approximately 48, and the average years of education is 8.2 (roughly equivalent to the second year of junior high school). As shown in Figure 2B among household heads, 35% have received at least one formal training session in agricultural technology or management. The average number of family laborers per household is 2.8, and the average cultivated land area is 6.5 mu. The sample covers a variety of farming activities, including grain crops (rice and corn), cash crops (sugarcane, citrus, sericulture, Chinese medicinal herbs, tea), and livestock breeding (pigs and poultry). Among these, as shown in Figure 2A, households whose primary income source comes from cash crops account for 62%, which effectively reflects the diversified nature of the agricultural structure in border regions. In addition to the large-scale questionnaire survey, the research team conducted semi-structured in-depth interviews with officials from the agricultural and rural affairs bureaus and the commerce and port authorities of various counties (and cities), as well as with leaders of 12 local agricultural leading enterprises and 25 farmer professional cooperatives. Furthermore, the team systematically collected statistical yearbooks, government work reports, and agricultural industry development plans from each county and city, thereby establishing a data system that combines “point-to-area” approaches and mutually validates quantitative and qualitative data.

3.1.2 Variable selection, definition, and descriptive statistics

Based on the theoretical framework and research hypotheses, this study defines the following variables:

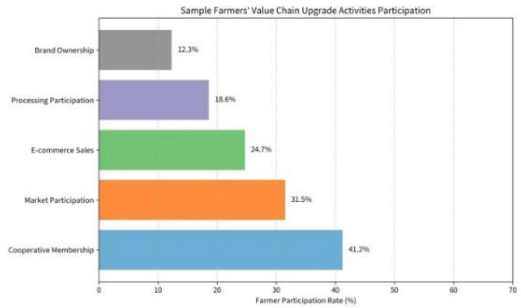


Figure 3. Participation of Sample Farmhouse in Value Chain Upgrading Activities

Figure 3 shows the participation of sample farmhouse in value chain upgrading activities dependent variable: Per capita annual net household income of farming households. This is a continuous variable; its natural logarithm is taken to mitigate heteroscedasticity and facilitate interpretation of coefficients (approximating percentage changes). In robustness checks, we will use per capita net agricultural income of households as an alternative dependent variable to more purely reflect the income effects stemming from activities along the agricultural value chain.

Core explanatory variable (value-chain upgrading indicator): Processing involvement: dummy variable. If a household engaged in any processing activities—beyond simple cleaning and sorting—for its main agricultural products produced in 2022 (such as drying, cured products, pickled vegetables, or primary packaging) and used these processed products for sale, the variable takes the value of 1; otherwise, it takes the value of 0. Among the sample households, the proportion involved in processing was 18.6%.

Brand ownership: A dummy variable. It takes the value of 1 if the primary agricultural products sold by a farmer household are branded with its own trademark, a unified cooperative brand, or have been authorized as geographical indication products; otherwise, it takes the value of 0. The proportion is 12.3%.

E-commerce sales: Dummy variable. If a farmer household had directly sold agricultural products via internet platforms such as Taobao, WeChat, Douyin, and Kuaishou in 2022, the value is 1; otherwise, it is 0. The proportion is 24.7%.

Cooperative Member: Dummy variable. If the household head is a formally registered member of a farmers’ professional cooperative, the value is 1; otherwise, it is 0. The proportion is 41.2%.

Intensity of Technology Adoption: A continuous variable. It is measured by the number of new varieties, new cultivation or breeding techniques, new agricultural machinery, or new management practices (such as standardized production records and green pest control) that farmers have successfully adopted over the past three years (2020–2022), with a range from 0 to 5 and an average value of 1.8.

Participation in Border Trade: A dummy variable. If a household has members who, in 2022, participated in border resident trade activities—either as operators, employees, or members of mutual aid groups (including both imports and exports)—the variable takes the value of 1; otherwise, it is 0. This is a key variable reflecting the distinctive characteristics of border regions, accounting for 31.5% of the sample. Control variables: To more accurately estimate the net effect of the core variables, the following control variables are introduced:

Household Head Characteristics: Age (years), Years of Education (years), Whether Received Agricultural Training (Yes=1). Household Resource Endowments: Number of Family Laborers (persons), Actual Area of Cultivated Land under Management (mu, logged), Whether Possesses Agricultural Machinery Valued at Over 10,000 Yuan (Yes=1).

Geographic location characteristics: Whether the township is located at a port of entry (Yes = 1); road distance (in kilometers, log-transformed) from the household address to the county seat center.

Industry Type Characteristics: Is the agricultural industry—the primary source of household income—a cash crop (1 = yes, food crop = 0)

3.2 Empirical Model, Results Analysis, and Discussion

3.2.1 Specification of the econometric model

To examine the impact of various value-chain upgrading activities on farmers' income, this study establishes the following multiple linear regression model (OLS) as the benchmark model:

$$\ln(\text{Income}_i) = \beta_0 + \beta_1 * \text{Processing}_i + \beta_2 * \text{Brand}_i + \beta_3 * \text{Ecommerce}_i + \beta_4 * \text{Coop}_i + \beta_5 * \text{TechAdopt}_i + \beta_6 * \text{BorderTrade}_i + \Sigma\gamma_j * \text{Controls}_{ij} + \varepsilon_i$$

Among them, i denotes the ith household; Ln (Income_i) is the dependent variable (the logarithm of per capita income); Processing_i through BorderTrade_i are the six core explanatory variables; Controls_ij represents the jth control variable; β0 is the constant term, β1 through β6 are the coefficients to be estimated for the core explanatory variables, γ_j is the coefficient for the control variables, and ε_i is the random error term. Our primary focus is on the signs, magnitudes, and statistical significance of β1 through β6. All analyses were conducted using Stata 16.0 software, and robust standard errors accounting for heteroscedasticity were employed.

3.2.2 Analysis of the baseline regression results

After controlling for household head characteristics, household endowments, location, and industry type, the main findings are as follows:

The coefficients for processing involvement, brand ownership, and e-commerce sales are all significantly positive at the 1% or 5% statistical significance level. This indicates that proactively extending into the downstream end of the value chain—whether through primary processing, building brand identity, or developing online direct-sales channels—can directly and effectively boost per capita household income among farmers. Judging from the magnitude of the coefficients, the income-increasing effect of e-commerce sales is the most prominent. This may be because e-commerce has greatly expanded the market radius and reduced intermediate links, enabling farmers to connect directly with end consumers and capture brand premiums—a path that delivers the most immediate and tangible results in "functional upgrading".

The coefficient for the cooperative member variable is significantly positive. This indicates that even if farmers themselves are not directly involved in processing, branding, or e-commerce, joining a farmer-specialized cooperative can still enable them to indirectly enhance their position in the value chain and increase their income by leveraging the cooperative's collective services—such as centralized purchasing and sales, technical guidance, quality monitoring, and bargaining power. As an important organizational platform, cooperatives lower the threshold and reduce the risks associated with smallholder farmers' individual efforts to climb up the value chain.

The coefficient for the intensity of technology adoption is significantly positive. This confirms that "process upgrading" serves as the cornerstone for ascending the value chain. By

adopting new varieties and technologies to enhance product yield, quality, consistency, or safety, firms can gain access to higher-value markets and meet the requirements of processing and branding. The accumulation of technological capabilities is the intrinsic driving force behind functional upgrading and chain upgrading.

The coefficient of the variable representing participation in border trade is significantly positive at the 1% level and has a relatively large magnitude. This result carries profound policy implications, strongly confirming that the "border dividend" indeed serves as a crucial engine for increasing farmers' incomes in the southwestern border regions. By participating in border trade, farmers can readily take advantage of price differentials between domestic and international markets, selling their locally distinctive agricultural products at more competitive prices to neighboring countries or importing specialty goods from neighboring countries for sale domestically. This opens up a "second market" beyond the traditional domestic market, significantly enhancing income potential and flexibility.

3.2.3 Heterogeneity analysis: differences in effects across different subgroups

To gain a deeper understanding of the complexities of the value-chain upgrading effect, we conducted grouped regression analysis:

Grouped by geographic location (port-townships vs. non-port-townships): The results show that the income-increasing effects of e-commerce sales and brand ownership are more pronounced among farmers in non-port-townships. This is likely because e-commerce and brands have, to some extent, broken down geographical barriers, enabling farmers in inland areas—far from ports and with relatively inconvenient transportation—to benefit more. By bypassing the traditional hierarchical distribution system and reaching consumers directly, companies have gained greater room for marginal improvement. Conversely, as expected, the income-increasing effect of participating in cross-border trade has been more pronounced and significant among farmers in township-level border areas, highlighting the critical role of geographic proximity.

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3.3 Comprehensive Discussion

The results of the empirical analysis generally and robustly support the theoretical analysis presented in Chapter 2. In the southwestern border regions, actively participating in the upgrading of agricultural value chains—whether through process improvements, functional extensions, or leveraging border-specific advantages—is an effective pathway for farmers to increase their incomes. Among these, e-commerce sales, representing modern distribution methods, and participation in border trade markets, which embody the unique advantages of border areas, have been shown to be the two most significant pathways for income growth at the current stage. These findings provide clear policy priorities: on the one hand, we must vigorously promote the deep integration of digital technologies with agriculture, helping farmers "go online and connect to the internet"; on the other hand, we need to make full and effective use of border policies, transforming the advantages of "transportation corridors" into "industrial" strengths.

However, descriptive statistics and interview data also reveal thought-provoking challenges: despite some positive cases, the proportion of respondents in the sample who own their own brands, engage in e-commerce sales, or participate in agricultural product processing remains relatively low (all below 25%), and most processing activities are still limited to rudimentary, home-based operations. This clearly indicates that, overall, the upgrading of agricultural value chains in Guangxi's border regions is still at an early stage—spontaneous, sporadic, and primarily at the primary level. Most farmers remain "locked" into the lower end of the value chain. Common difficulties reported in the interviews include: a lack of specialized knowledge and skills in e-commerce operations, brand design, and marketing promotion; insufficient start-up capital for equipment investment and cold-chain infrastructure development; unfamiliarity with and apprehension about the rules, standards, and settlement procedures involved in cross-border trade; and the absence of locally dominant leading enterprises with strong driving and

absorptive capacities, resulting in short supply chains and a lack of sophisticated processing and value-added stages. Furthermore, the infrastructure the "last-mile" bottleneck in distribution—particularly the lack of cold-chain logistics at the place of origin—remains a significant constraint hindering the upward climb of the value chain for fresh agricultural products.

In summary, the current agricultural value chain in the southwestern border regions is characterized by both enormous potential and severe challenges—a fundamental reality that underscores the need for upward mobility. Therefore, there is an urgent need for systematic external interventions and capacity-building efforts to unleash the intrinsic drivers of this upward trajectory, overcome external constraints, and transform the upward climb from a "bright spot" among individual farmers into a "widespread phenomenon" that boosts incomes for the majority of border residents.

4. Conclusions and Policy Recommendations

4.1 Main Research Conclusions

This study takes the eight land-border counties in Guangxi as an example and conducts a systematic investigation into the income-increasing effects of upgrading agricultural value chains in the southwestern border regions through theoretical construction, analysis of the current situation, and empirical testing. The main conclusions drawn are as follows:

Theoretical Perspective: In the southwestern border regions, the upward climb of agricultural value chains promotes farmers' income growth through four core mechanisms: value capture, risk mitigation, learning and innovation, and the conversion of border dividends. The "border nature" of this region has a dual impact: On the one hand, it provides unique locational, policy, and market dividends via channels such as ports of entry, border trade markets, and cross-border cooperation, creating special opportunities for value-chain upgrading that are unavailable in inland areas. On the other hand, it also brings about specific constraints—including bottlenecks at the infrastructure's end, weak market players, high policy volatility, and reliance on "corridor economy" thinking—thus increasing the difficulty and complexity of the upward climb. An effective upward-climb strategy must simultaneously focus on converting these dividends and overcoming the existing constraints.

Current Situation and Empirical Evidence: A survey of border counties in Guangxi indicates that practices aimed at upgrading agricultural value chains have begun to emerge, with initial successes particularly evident in areas such as cooperative-led initiatives, e-commerce trials, and participation in border trade fairs. Empirical evidence from econometric models confirms that engaging in agricultural product processing, using private brands, conducting e-commerce sales, joining farmer specialized cooperatives, actively adopting agricultural technologies, and participating in cross-border trade among local residents all exert statistically significant positive impacts on per capita household income of farming households. Among these factors, e-commerce sales (reflecting mastery of new marketing capabilities) and participation in border trade fairs (representing utilization of the border region's locational advantages) demonstrate the most pronounced income-increasing effects. However, overall participation in these upgrading activities remains low and at a relatively shallow level, indicating that they are still in the early stages. The vast majority of farmers continue to face multiple constraints—including limitations in capacity, financial resources, infrastructure, and market access—thus urgently requiring systematic support.

Overall Assessment: Promoting the systematic upgrading of agricultural value chains is the key to helping the southwestern border regions break through bottlenecks in industrial development, enhance agricultural efficiency, ensure sustainable income growth for farmers, and thereby consolidate the industrial foundation for the strategy of strengthening border areas and enriching local communities. The focus and core approach. This is not merely an economic issue; it is also a political issue that concerns the stability of the frontier regions and ethnic unity.

4.2 Systemic Policy Recommendations

Based on the above conclusions, this paper proposes a systematic policy recommendation framework—spanning the three dimensions of "empowerment of actors, optimization of the environment, and conversion of benefits"—to promote the upgrading of agricultural value chains in the southwestern border regions.

Implement a special action to enhance the agricultural value chain along border regions, strengthening top-level design and collaborative governance:

Provincial-level coordinated planning: It is recommended that the Guangxi Zhuang Autonomous Region take the lead in studying and formulating a Special Action Plan for Upgrading Agricultural Value Chains in Border Areas (2025-2030), clearly identifying value-chain upgrading as the core strategy for rural revitalization and border-area development aimed at enriching local residents. The plan should set phased targets, prioritize key industries, and specify critical tasks.

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Inter-departmental coordination mechanism: Establish a joint conference system involving multiple departments—including agriculture and rural development, commerce (port of entry), development and reform, finance, customs, immigration administration, and finance—holding regular consultations to break down departmental silos. Focus particularly on the "border resident barter trade + local processing" model, optimizing regulatory procedures and, while maintaining controllable risks, maximizing facilitation of cross-border flows and value addition of agricultural products.

Differentiated Assessment Guidance: Reform the performance assessment system for border counties and cities by reducing the weight given to traditional GDP growth rates and increasing the emphasis on indicators that reflect the depth of value-chain upgrading and tangible benefits for local residents, such as "agricultural product processing and transformation rate," "local brand value," "proportion of border residents participating in mutual trade and obtaining employment through processing," and "number of cross-border agricultural cooperation projects." This will guide local governments to shift their focus from "prioritizing infrastructure" to "prioritizing industries."

Precisely categorize and empower, fostering multi-level ascending action entities:

Strengthen Leading Enterprises and Supplement Industrial Chains: Implement the "Cultivation Project for Leading Agricultural Enterprises along Border Areas." Through measures such as fiscal interest subsidies, performance-based rewards, and land-use guarantees, we will focus on supporting a group of leading enterprises that engage in deep processing of agricultural products, central kitchens, and regional brand management locally. We encourage these enterprises to establish close-knit benefit-linking mechanisms with farmers and cooperatives, such as "guaranteed minimum purchase price plus equity dividends" and "order-based production plus entrusted services," enabling farmers to share in the profits generated from processing and sales. Upgrading and Enhancing Cooperatives: Launching a "Cooperative Capacity Building Year" initiative, in which the government purchases services and commissions specialized agencies to provide cooperatives with "one-stop" empowerment services covering financial management, brand design, e-commerce operations, quality certification, and more. Supporting multiple cooperatives in forming federations to enhance their market bargaining power and risk resilience. Activating the Intrinsic Motivation of Smallholder Farmers: Large-scale, free, and practical skills training programs—such as "Short Video + Live-Stream E-commerce," "Practical Guide to Cross-Border Small-Value Trade," and "Green Farming Techniques"—will be widely offered to ordinary farmers, especially young farmers. A "Micro-Ascension" incentive fund will be established to provide small cash rewards or material subsidies for farmers' first-time actions, including opening an online store, obtaining product certification for the first time, and successfully standardizing and packaging their products for sale—thus encouraging their initial "first-step action" toward upward mobility.

Overcome key bottlenecks and optimize the scaling support system and environment:

Infrastructure "Strong Foundation Project": Integrate funding from fiscal sources, rural revitalization initiatives, and agricultural-related programs, and actively attract social capital through the PPP model. In key industrial townships, large-scale production areas, and near border ports, plan and build a batch of shared,

public-interest facilities for on-site warehousing, cold-chain preservation, and commodity processing—including grading, packaging, labeling—and e-commerce/express delivery hubs. This will effectively reduce logistics costs and post-harvest losses. Brand and Channel "Smooth Flow Project": Led by municipal or county-level governments, this initiative will focus on the distinctive features of "ecology, border regions, and ethnic diversity" to develop 1–2 regionally recognized public brands with high credibility (such as "Southwestern Guangxi Border-Ecological Agricultural Products"). Strict admission and management standards will be established, and unified promotional efforts will be implemented. At the same time, active connections will be forged with major domestic e-commerce platforms and chain supermarkets. Additionally, "Guangxi Border-Agricultural Products Exhibition and Sales Centers" will be set up in key cities across ASEAN countries, creating an integrated, multi-dimensional marketing channel network that seamlessly combines online and offline, as well as domestic and international channels.

Deepen cross-border agricultural cooperation: Actively apply for and develop China-ASEAN cross-border agricultural cooperation demonstration zones, and within these zones, explore innovative mechanisms such as "one inspection for two countries," cross-border agricultural labor cooperation, and collaborative promotion of agricultural technologies. Encourage domestic enterprises to "go global" by establishing planting and breeding bases in neighboring countries, while keeping core links such as sophisticated processing, R&D, and marketing within domestic border parks, thereby creating an integrated industrial chain layout that spans both domestic and overseas markets and enhancing control over the value chain.

Innovate financial services and strengthen the blood supply chain:

Develop specialized credit products: Guide local commercial banks and rural credit cooperatives to develop products such as "Value-Chain Upgrading Loans," "Mutual Trade Loans," and "E-commerce Entrepreneurship Loans." Explore the use of agricultural product orders, warehouse receipts, and accounts receivable as eligible collateral to address the challenge faced by new types of agricultural business entities that lack traditional collateral for loans.

Leverage the role of government-backed financing guarantees: Increase support from government-backed financing guarantee institutions for projects aimed at upgrading agricultural value chains along border regions, reduce guarantee fees, and expand the coverage of these guarantees.

Explore the establishment of an industry guidance fund: It is recommended that the autonomous region-level government take the lead, in collaboration with social capital, to explore the establishment of a "Border-Area Agricultural Industry Investment Fund." This fund would directly invest—in the form of equity or "equity plus debt"—in local enterprises with growth potential in agricultural product processing, agricultural technology, cold-chain logistics, and cross-border e-commerce service platforms, thereby injecting long-term capital into their development.

Through the policy package—comprising "planning guidance, cultivation of key players, addressing, and financial support"—it is expected that the obstacles to upgrading the agricultural value chain in the southwestern border regions will be systematically overcome. This will transform the region's unique "border disadvantages" into sustainable "development advantages," ultimately painting a magnificent picture on the southwestern frontier of our country: one characterized by thriving industries, prosperous border residents, stable frontiers, and a beautiful ecological environment.

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