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Content **Page**

The Impact of Online-to-Offline Food Delivery Platform on Employment in China

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Abstract
This article examines how Online-to-Offline food delivery services have affected Chinese employment and industry. These platforms have swiftly developed from restaurant facilitators to full-service suppliers that assist customer care and logistics. These platforms have transformed China's main cities' job landscapes. This technology has boosted the gig economy, making delivery rider jobs more flexible. Reaching out to a larger audience outside their physical sites has helped restaurants improve operations and profitability. This article discusses the merits and cons of switching from Online-to-Offline work, emphasizing its dual nature. AI and big data analytics have increased delivery driver and internet business job opportunities. Even while gig economy workers have higher pay and schedule flexibility, they nevertheless confront job insecurity, economic volatility, and inadequate social security benefits. Thus, China's labor laws and employment structures must be reevaluated to accommodate and incentivize fast growing digital workers.

Keywords: O2O platform, gig economy, employment quality, rights protection, algorithmic governance
JEL Classification Code: J21 L86 J81 D47

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1. Introduction

1.1 The Rationale Background

1.1.1 Evolution of Online-to-Offline Food Delivery Platforms

China's O2O food delivery platforms have transformed economic and social behaviors through rapid technological advancements. Initially serving as intermediaries between consumers and restaurants, platforms like Meituan and Ele.me now manage logistics, payments, and customer service. Their growth has been driven by aggressive marketing, discounts, and the rising demand for convenience in urban areas.

These platforms have led China's technology sector's innovation. Progress has been led by them. Modern data analytics has simplified delivery routes and schedules, allowing them to better understand client preferences, cutting costs and improving service. Artificial intelligence and machine learning algorithms enable peak-period dynamic pricing, inventory optimization, and order volume forecasting. Due to their technical interconnectivity, they can process millions of transactions daily. Online-to-Offline food delivery systems have changed the food service worker demographic. They introduced gig economy work, giving millions more schedule freedom. China's urban delivery riders have become more widespread in recent decades and handle traffic. These riders are highly efficient thanks to software that optimizes routes, handles orders, and communicates with clients in real time. During difficult periods like the COVID-19 pandemic, when many traditional industry workers were threatened with termination, the gig economy became important. These platforms offer jobs and convenience, but they also impact society. Restaurants' tendency to shrink or eliminate eating rooms to make room in the kitchen for online orders affects metropolitan area planning and development. This shift has led to new food preparation and distribution standards, which have changed food safety rules. Beyond food delivery, some platforms offer groceries delivery to create a full Online-to-Offline ecosystem. They now work with pharmacies and other retailers. Due to their market expansion, they are now essential to Chinese society.

1.1.2 Employment of Online-to-Offline Food Delivery Platforms

Online-to-Offline food delivery has changed two important areas in China. Online merchants and offline delivery riders handle these tasks.

Online merchants benefit from expanded market reach, increased orders, and enhanced operational efficiency. Participation in platform-led promotions can boost revenue but may also lead to heightened competition and dependency.

Additionally, offline delivery riders now perform a different role. Many people, especially migrants looking for temporary work, have found delivery rider jobs on Ele.me and Meituan. These platforms operate in the gig economy, giving riders more choice over their schedules and the chance to make more than the federal minimum wage. Regulators considered limited social security payments, uncertain income, and occupational instability while weighing the pros and cons of this flexibility. However, many platforms are trying to address these issues, such as Meituan, which is testing ways to include social insurance for riders, recognizing their importance to the system. Thus, while online food delivery services have created new jobs, they have also forced structural changes in how these jobs are perceived and supported within the larger social and economic structure.

1.1.3 Advanced Technologies

AI, big data, and mobile technologies have revolutionized traditional employment in the food delivery sector. Machine learning algorithms reduce human intervention in order prediction, route optimization, and inventory management. Efficiency and faster delivery have boosted consumer satisfaction.

These technologies create new roles while transforming existing ones. Riders now rely on software for real-time navigation and customer interaction, increasing efficiency but also intensifying work demands. The gig economy model offers flexibility but often at the cost of job security and benefits.

1.2 Problem Statement

The rise of O2O platforms has introduced a new employment paradigm characterized by flexibility but also instability. Delivery riders, classified as independent contractors, typically lack health insurance, paid leave, and income security.

There is a growing need for legal and social protections for gig workers. The current regulatory framework fails to address the unique challenges posed by platform-based employment, necessitating a reevaluation of labor standards to balance flexibility with security.

1.3 Research Objective and Questions

1.3.1 Research Objective

This thesis statement examines how Online-to-Offline food delivery platforms have affected several elements of Chinese employment. Understanding these platforms is crucial due to their rapid growth and impact on the national labor market. This study will examine the varied effects of digital platforms on employment patterns. These implications will include employment creation, quality, and gig workers' economic situations.

1.3.2 Research Questions

RQ1: How do Online-to-Offline food delivery services affect employment in China's many industries, and is there a quantitative relationship?

This study uses statistical methods to examine how Online-to-Offline platform integration and use affect employment metrics. These metrics include job creation, stability, and sector shifts. This study will examine how several platforms affect the labor market using regression analysis. This inquiry aims to find patterns and relationships in the data that can not be visible. This study will reveal if Online-to-Offline channels replace traditional jobs or create new ones.

RQ2: The expansion of Online-to-Offline food delivery services has had long-term effects on China's labor economy. What are the effects on online merchants and gig workers' employment quality and safety?

This study examines how Online-to-Offline platforms effect employment from businesses' and employees' perspectives. This article discusses gig economy pros and cons. The post discusses job uncertainty, irregular income, and traditional employment decline. The gig economy offers online retailers and gig workers better revenue and freedom, according to the report. This extensive study will gather data from platform workers, business owners, and labor professionals to illuminate how Online-to-Offline platforms affect employment.

RQ3: What strategic recommendations can be provided to policymakers and platform operators to optimize the socio-economic benefits of Online-to-Offline food delivery platforms while mitigating associated risks?

This question aims to offer actionable insights that can advise regulators and business policies to maximize the benefits and minimize the risks of Online-to-Offline food delivery networks. This encompasses regulatory frameworks, gig worker protections, and expansion-promoting company operations. The findings can help create a more holistic platform expansion plan by considering economic gains, societal.

1.4 Conceptual Framework

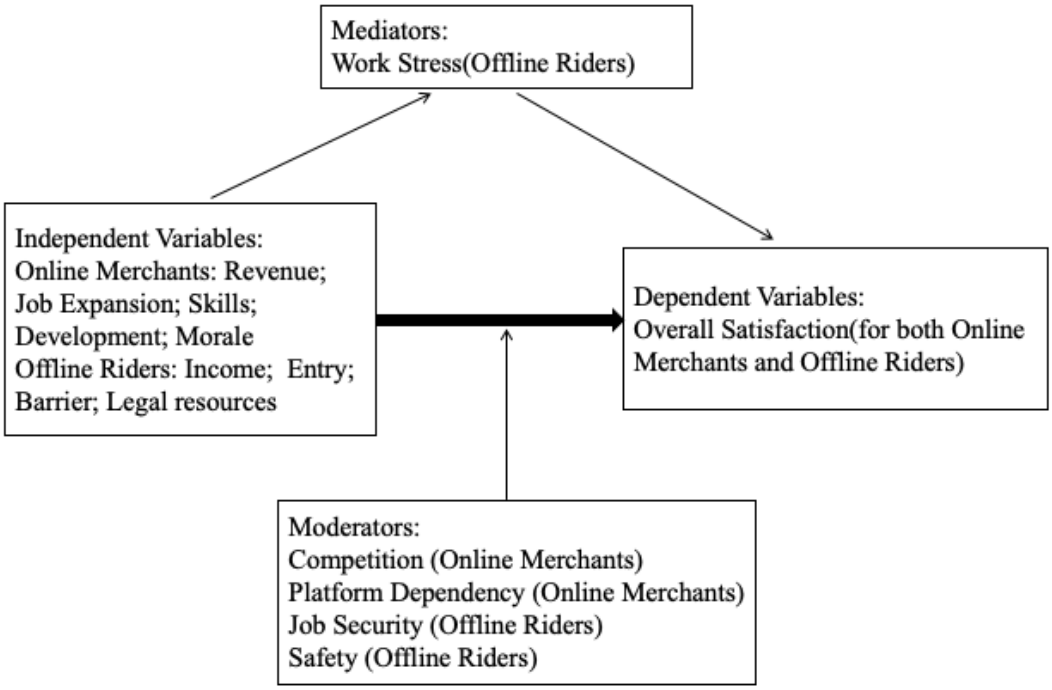

Figure 1.1: Conceptual Framework

2. Literature Review

2.1 Economic and Social Impact of Online-to-Offline Platforms on the Labor Market

O2O platforms have facilitated a shift from traditional employment to gig-based arrangements, offering flexibility but often lacking benefits. Qin (2022) highlights how these platforms integrate physical and digital interactions, creating new job frameworks while challenging traditional business models.

Wood et al. (2019) note that algorithmic management can lead to longer working hours and social isolation for gig workers. Gleim et al. (2019) categorize gig work into direct sales and sharing economy roles, each affecting job satisfaction differently.

2.2 Job Quality and Employment Stability in the Gig Economy

Donovan et al. (2016) identifies challenges such as income volatility and lack of social benefits. Friedman (2014) argues that gig work appeals to younger generations but often sacrifices job security.

Tran and Sokas (2017) emphasize health and safety risks for gig workers, while Kost et al. (2020) discuss barriers to career advancement. Oranburg (2018) introduces the concept of “subordinated agency” to describe the tension between autonomy and platform control.

2.3 Regulations and Tax Policies for Gig Employment

Choi (2021) argues that platforms should be treated as labor exchanges rather than employers. Todolí-Signes (2017) calls for new legal categories to address the unique challenges of gig work.

Garin et al. (2022) highlight tax reporting issues among gig workers, while Black (2020) proposes better reporting mechanisms to improve tax compliance and social security coverage.

2.4 Theories of Employment in the Digital Economy

2.4.1 Dual Labor Market Theory

This theory divides the labor market into primary (stable, high-benefit) and secondary (precarious, low-benefit) sectors. Delivery riders typically fall into the latter, with unpredictable hours and limited advancement opportunities. This design shows that food transporters are independent contractors with unexpected and variable hours. Algorithmic dispatch mechanisms and shifting demand provide unpredictable work schedules for offline transportation workers. This contrasts with primary sector workers who earn more, have greater career opportunities, and job stability. Riders' workloads and earnings depend on platform demand and gig economy competitiveness. Accordingly, there can be periods of heavy work followed by periods of reduced employment with no promises of hours or benefits. This theory illuminates offline transportation network users' structural inequities and China's labor market stratification.

2.4.2 Principal-agent Theory

Principal-Agent Theory, which studies agent interactions and conflicts explains the dynamic between online merchants and digital platforms in the digital economy. Merchants must meet platform service standards. Insufficient platform information leaves merchants struggling to understand agreements; platforms may also force price adjustments or promotions. These restrictions may boost sales but often clash with merchants' habits or income.

Platforms monitor merchants via user ratings and reviews. Aligned goals between both sides reduce the principal-agent problem, yet this can pressure merchants to cut quality to meet standards and raise prices. This interaction embodies the theory—highlighting biases and the need to align platform and merchant goals. Such collaborations require efficient management to maintain service quality and ensure all stakeholders benefit from the digital economy.

2.4.3 Perfect Competition

The highly competitive nature of O2O platforms resembles perfect competition, with many sellers offering similar services. This limits individual merchants' pricing power and forces continuous innovation. For offline transportation companies. Despite the standardized delivery technique giving platforms and clients several alternatives for riders, riders have no power to negotiate their compensation or working conditions. Riders under pressure to perform quickly and consistently to maintain acceptable evaluations and obtain appropriate remuneration can be encountered. Success in cycling depends on availability and pace. The worst hit are workers and small companies trying to adjust to this difficult environment. Competition boosts choice and efficiency for consumers.

3. Methodology

3.1 Research Methodologies

This study employs a mixed-methods approach, including surveys of 200 online merchants and 200 delivery riders. Questions focused on revenue, job security, working conditions, and overall satisfaction.

After processing the survey data, I performed extensive regression analyses using SPSS to determine the factors that affect employee job satisfaction and the direct and indirect impacts of working on the Online-to-Offline platform.

This strategy uses empirical data and advanced statistical analysis to show how digital platforms have revolutionized Chinese workplaces. Power comes from its two-pronged strategy. This technique can be used to study the link between labor market dynamics and technological advances. This conversation illuminates gig work's complexity and impact on the labor market.

As shown in Table 3.1, the study examined revenue changes, job prospects, competitiveness, and online merchants' perceived control over their operations since joining the platform. Offline transportation service workers were asked about their work hours, salaries, job security, and physical and legal challenges. Both surveys used Likert-scale questions to assess the impact on respondents' careers. Open-ended questions provided deeper qualitative insights.

Table 3.1. Variables for Online Merchants/Offline Riders

	Variables for Online Merchants	Variables for Offline Riders
Dependent Variable	Overall Satisfaction	Overall Satisfaction
Independent Variable	Revenue	Work Schedules
	Job Expansion	Income
	Skills Development	Entry Barrier
	Competition	Job Security
	Platform Dependency	Safety
	Morale	Legal Recourses

Secondary data was taken from China's internet platforms and gig economy literature, research, and economic assessments. The survey findings made sense when contextualized within China's greater technical and economic advances, as shown by the statistics. This ensured that our sample was representative of the population. Then, offline methods like in-person interviews were used to study the polls' complex properties. Observational studies were conducted regularly to better understand how platform work affects everyday activities and relationships.

Quantitative and qualitative methodologies were used throughout data processing to ensure a complete study of the results. SPSS assisted regression analysis and statistical tests using quantitative survey data. However, thematic analysis was used to identify themes and case studies that showed qualitative responses' patterns. This dual strategy provided a robust foundation for understanding the complicated effects of online food delivery services on Chinese employment.

3.4 Ethical Considerations and Limitations

All participant data were anonymized, and informed consent was obtained. Data were encrypted and accessible only to the research team.

This study considers limits and biases in the methodologies, which can affect the outcomes. If measures are not taken, survey and interview data can contain memory bias and social desirability bias. For instance, people can avoid making sincere comments to conform to social norms. The research will triangulate data sources and methods to validate findings and mitigate hazards. The use of quantitative survey data and secondary data sources like industry reports and government statistics to authenticate and enrich qualitative interview data is one example. The sample cannot accurately represent the gig economy as a whole, especially if most gig economy businesses are in metropolitan cities. We will include a diverse sample of gig economy participants from different economic sectors and regions to boost data representativeness. This study aims to give reliable and significant data on how Online-to-Offline food delivery platforms affect Chinese employment.

4. Analysis

4.1 Regression Analysis for Online Merchants

Table 4.1 shows that Online-to-Offline food delivery services affect online merchants' job chances, according to a regression analysis of survey data from 200 Chinese merchants. Morale, Platform Dependency, Job Expansion, Competition, and Revenue have a correlation coefficient (R) of 0.528, indicating a positive relationship with merchant job effects.

Table 4.1: Model Summary for for Online Merchants

Model Summary[a]								
R	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Change Statistics**				
				R Square Change	F Change	df1	df2	Sig. F Change
.528[a]	0.279	0.257	0.72408	0.279	12.463	6	193	0

[a] Predictors: (Constant), Morale, Platform_Dependency, Job_Expansion, Competition, Revenue, Skills_Development

The R-squared score of 0.279 suggests that model variables explain 27.9% of employment impacts. These data imply that these predictors account for a significant amount of variance, although other variables can have a big influence on the outcomes. This model is statistically significant due to its F-statistic of 12.463 and Sig. F Change = 0.000 p-value. Thus, model factors are likely to affect Online-to-Offline platform enterprises' employment characteristics. The research found that direct-to-consumer platforms affect merchant employment based on the platform's competitive environment, dependency, merchant motivation, ability to diversify job positions, and

potential to generate revenue. Platforms promote revenue growth and job creation, but they also create challenges including reliance and competition, which can affect employee morale and job security.

To conclude, internet marketplaces have created significant job and skill growth possibilities. However, they have also raised concerns about internet retailers' job security and satisfaction. Given the conflicting outcomes, it's crucial to understand how these platforms affect corporate hiring.

4.2 Regression Analysis for Online Merchants

Table 4.2 shows the various factors that affect online merchants' work satisfaction on their Online-to-Offline platform. This study is necessary to understand how these platforms are changing merchant operations and worker dynamics.

Table 4.2: ANOVA Results for for Online Merchants

ANOVA[a]					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Regression	39.206	6	6.534	12.463	.000[b]
Residual	101.189	193	0.524		
Total	140.395	199			

[a] Dependent Variable: Overall_Satisfaction

[b] Predictors: (Constant), Morale, Platform_Dependency, Job_Expansion, Competition, Revenue, Skills_Development

The 39.206 regression sum of squares shows the variability the model can explain, while the 101.189 residual sum shows the variability it cannot. The model accurately explains certain differences in overall satisfaction, but it ignores other factors that affect it. This regression considers morale, platform reliance, employment expansion, competition, revenue, and that constant term. The six variables provide the regression six degrees of freedom. As a residual, we obtain 193 degrees of freedom by removing one from the predictor count and one from the observation count, making 200 observations. Divide the total squares by their degrees of freedom to find the mean square. In regression analysis, the mean square value of 6.534 shows each predictor's average variability. However, the residual mean square value of 0.524 shows the average variability not explained by each residual degree of freedom. Overall satisfaction differs due to all variables, with an F-value of 12.463. The model is robust since our predictors can explain merchant satisfaction variance, as seen by the higher value. With a 0.000 p-value, the regression model is statistically significant. This shows that the predictors, as a whole, affect satisfaction and that the results are unlikely to be a coincidence.

This study found that Online-to-Offline platforms can boost or lower merchant satisfaction and morale. These options boost income and create jobs. However, they raise competitiveness and platform dependence. These issues must be addressed to improve the working conditions of internet enterprises that use these platforms.

Table 4.3 provides valuable insights about how Online-to-Offline platforms affect Chinese online business satisfaction. To quantify the relationship between these factors and merchant satisfaction, regression model coefficients are used. This is done with coefficients. Let's analyze each component.

Table 4.3: Coefficients Results for for Online Merchants

Coefficients[a]							
	Unstandardized Coefficients		**Standardized Coefficients**	**t**	**Sig.**	**95.0% Confidence Interval for B**	
	B	**Std. Error**	**Beta**			**Lower Bound**	**Upper Bound**
(Constant)	2.627	0.307		8.569	0	2.023	3.232
Revenue	0.166	0.046	0.225	3.565	0	0.074	0.257
Job_Expansion	0.182	0.039	0.292	4.617	0	0.104	0.259
Skills_Development	0.104	0.039	0.172	2.66	0.008	0.027	0.181
Competition	-0.021	0.046	-0.028	-0.448	0.654	-0.112	0.07
Platform_Dependency	-0.126	0.04	-0.195	-3.15	0.002	-0.205	-0.047
Morale	-0.062	0.041	-0.098	-1.526	0.129	-0.142	0.018

[a] Dependent Variable: Overall_Satisfaction

Revenue and overall satisfaction are significantly correlated with a correlation of 0.166 and t-value of 3.565. The 3.565 t-value proves this. Considering this, online retailers are happier when their income increases due to Online-to-Offline platform utilization. The positive beta value of 0.225 shows that platform income increases merchant satisfaction. This is shown by rising platform income.

Work satisfaction is negatively correlated with employment growth (r = 0.182%, t = 4.617%). Statistically significant association. Retailers prioritize offering workers the chance to specialize and expand their responsibilities. This is evident from the rise of online customer service managers and digital marketing experts. This component significantly affects happiness. A Skills growth coefficient of 0.104 and a t-value of 2.66 suggest that platform-related staff skills improve merchant happiness. This is seen by the positive association between the variables. This shows that firms value staff development, which is linked to Online-to-Offline. It can be concluded that merchants appreciate the platform regardless of platform rivalry. The t-value of -0.448 and rivalry coefficient of -0.021 corroborate this result. Despite being a well-known part of the platform, competition appears to have minimal effect on merchant happiness. This t-value is -3.15, and the coefficient is -0.126. This hurts happiness. This research shows that overusing the platform for profit is harmful and reduces the enjoyment of using it. Due of the detrimental impacts, worries about platform overuse have arisen. This puts users at risk if platform circumstances change.There is a negative link between satisfaction and morale (-0.062, t-value -1.526), although it is not statistically significant (p=0.129). This must be considered. However, research implies that changes in work activities, such as switching from customer service to online operations, can affect job satisfaction.

Table 4.4 shows that the independent factors (job Schedules, Safety, Income, and Entry Barrier) somewhat affect rider employment outcomes (R = 0.212), explaining just a tiny percentage of work satisfaction variance.

Table 4.4: Model Summary for Offline Transport Riders

Model Summary								
R	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Change Statistics**				
				R Square Change	F Change	df1	df2	Sig. F Change
.212[a]	0.045	0.015	0.87063	0.045	1.515	6	193	0.175

[a] Predictors: (Constant), Work_Schedules, Safety, Income, Entry_Barrier, Legal_Recourses, Job_Security

The R Square value of 0.045 suggests that the model's predictors can explain 4.5% of riders' job experiences. Given the tiny proportion, other factors can have had a significant influence on riders' delight and difficulty. The quantity of variables reduces the figure's capacity to communicate data. The Adjusted R Square score of 0.015, which accounts for model predictors, shows this. The estimate's standard error, 0.87063, is the average distance between observed values and the regression line. A greater standard error can indicate that the model does not fully capture all rider experiences. The analysis of variance (ANOVA) table shows that the entire model, including all predictors, does not meet standard statistical significance limits (usually $p < 0.05$). This is corroborated by the 1.515 F Change statistic and 0.175 significance level. The model's lack of significance revealed that it cannot accurately predict how the included elements will affect offline transport passengers' employment satisfaction on Online-to-Offline platforms.

Table 4.5 shows that passengers who utilize offline transportation services affiliated with Online-to-Offline food delivery platforms are happier. Research shows that the model explains just 4.5% of satisfaction variability, indicating weak explanatory power. The R-squared score for this research is 0.045, indicating a poor model. Work schedules, income, safety, entrance barriers, legal redress, and employment stability are predictors in the model.

Table 4.5: ANOVA for for Offline Transport Riders

ANOVA[a]					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Regression	6.888	6	1.148	1.515	.175[b]
Residual	146.292	193	0.758		
Total	153.18	199			

[a] Dependent Variable: Overall_Satisfaction

[b] Predictors: (Constant), Work_Schedules, Safety, Income, Entry_Barrier, Legal_Recourses, Job_Security

The regression Sum of Squares (6.888) vs the residual (146.292) suggests that the model cannot capture most rider satisfaction variance. Due to the low F value of 1.515, the regression mean square is 1.148 and residuals are 0.758. This matches the findings. This suggests that the variation that cannot be described is just slightly larger than the variance that can be explained for each model unit. A significance criterion of 0.175 for the F value indicates that the model does not fulfill statistical significance standards. This shows that the hypothesized reasons cannot explain rider enjoyment differences.

Rider satisfaction can be fully assessed by considering safety, legal redress, employment security, work schedules, income possibilities, and obstacles to entrance. Due to the model's inability to explain and lack of statistical significance, satisfaction can be impacted by external factors not considered. This set of factors cannot account market

circumstances, rider expectations, or other job options. Overall, the results show that chosen characteristics affect rider pleasure. However, more study into offline transport platform passenger satisfaction can be needed. This can be done by adding variables or exploring various model specifications.

Table 4.6 illuminates the many factors that affect their work satisfaction on Online-to-Offline food delivery services. The coefficients can indicate whether these impacts are favorable or negative, and the significance levels can assess their credibility.

Table 4.6: Coefficients Results for for Offline Transport Riders

Coefficients[a]					
	Unstandardized Coefficients		**Standardized Coefficients**	**t**	**Sig.**
	B	Std. Error	Beta		
(Constant)	3.268	0.429		7.611	0
Legal_Recourses	-0.069	0.056	-0.087	-1.22	0.224
Safety	-0.021	0.061	-0.025	-0.342	0.733
Job_Security	-0.03	0.062	-0.035	-0.49	0.625
Entry_Barrier	0.024	0.066	0.026	0.371	0.711
Income	0.041	0.056	0.052	0.73	0.466
Work_Schedules	0.13	0.053	0.175	2.464	0.015

[a] Dependent Variable: Overall_Satisfaction

The regression model constant, 3.268, represents a considerable rise in baseline satisfaction. This constant represents baseline happiness when all independent variables are zero. This indicates that most riders were happy with the service before adjusting for independent variables. A large t-value of 2.464 and a coefficient of 0.13 for Work Schedules indicate that riders' personal life and obligations are well matched with their work schedules, which increases job satisfaction. Prosperity increases satisfaction (t=0.73), although this effect is not statistically significant (r=0.041). This shows that projected profits, such as peak season income or bonuses, cannot affect job happiness even when acknowledged. Entry Barrier has a positive coefficient of 0.024, however it is not statistically significant (t = 0.371). This shows that riders are generally happy with the platform and don't worry about little prices and requirements. The coefficients of Legal Recourses, Safety, and Job Security are -0.069, -0.021, and -0.03, respectively, indicating an inverse relationship. However, these consequences are not statistically significant since their t-values are below the criteria for large impacts. This research shows that most riders are happy despite legal, safety, and employment issues. Legal Recourses coefficient (-0.069) and t-value (-1.22) show modest dissatisfaction with platforms' capacity to give sufficient legal help or enable equitable conflict resolutions. This matches poll results showing insufficient legal support.

Rider satisfaction is positively influenced by work schedules and other factors and adversely impacted by legal recourse, safety, and employment security. The model's weak explanatory ability (R Square = 0.045) suggests that this research can have overlooked other factors that affect rider pleasure and satisfaction.

5. Positive Impacts

5.1 Positive Impacts on Online Merchants Employment

5.1.1 Enhanced Revenue Opportunities

Online-to-Offline (O2O) food delivery services enable retailers to expand their customer base beyond physical locations, thereby increasing sales and requiring additional staff. For instance, a Shanghai café formerly serving only local clients can now receive city-wide orders, necessitating more kitchen personnel, a dedicated delivery coordinator, and enhanced customer service teams to maintain quality and responsiveness. The growth may also lead to hiring marketing specialists who utilize O2O data for targeted campaigns. Overall, the surge in orders generates new jobs and enhances existing roles.

O2O platforms generate increased revenue by expanding restaurants' customer base, leading to more secure and better-compensated employment opportunities. Growth often requires additional staff in food preparation, delivery, and management. Financially stable restaurants can offer higher wages, improved benefits, and greater job stability, which enhances morale and productivity. Investing in modernized equipment and optimized operations further boosts efficiency and employee satisfaction. Competitive compensation and comprehensive benefits also help attract and retain talent, reducing turnover costs. Ultimately, the expansion of O2O networks stimulates job creation, improves working conditions, and supports both business and labor development in the food service industry.

5.1.2 Job Specialization

Internet platforms have diversified and specialized the restaurant industry by helping establishments attract more customers and stand out from competitors. This has fostered a market that increasingly values expertise, leading to a growing demand for chefs with specialized training. For instance, restaurants offering authentic ethnic cuisines such as Thai or Japanese can appeal to specific food enthusiasts. Beyond cooking, platforms also facilitate roles like menu development and culinary innovation, allowing restaurants to adapt creatively to consumer preferences and trends.

Inventory expertise is required as order volume rises, with specialists managing inventory levels to prevent disruptive shortages or excesses—they are vital for kitchen inventory and demand readiness, especially during sales and promotions. Restaurants previously not focusing on takeout can find unexpected potential in O2O networks, including roles ensuring food temperature and freshness in transit. Customer experience managers work with marketers to build segmented strategies, guided by O2O platform data. For example, if data shows consumers prefer healthy eating, restaurants run campaigns for nutritious new foods or limited-time salad/smoothie deals, boosting revenue, brand awareness, and customer loyalty.

5.1.3 Employee Skills Development

With the rise of O2O platforms, restaurants must update employee training for the digital age. Front staff need skills in online booking, customer queries and social media promotion. Training can use digital dashboards that also handle payments, queue management and menu updates. Digital literacy boosts customer satisfaction and efficiency, requiring fast, quality communication and employee understanding of platform functions to resolve transaction issues like change requests and payment adjustments. Inventory managers and menu planners need data analysis training to use O2O data for decisions, such as leveraging sales, consumer preferences and seasonal patterns to design menus and promotions. The restaurant provides intensive training to meet digital-first customer needs and help all staff thrive in a digital workplace.

5.2 Positive Impacts on Offline Transport Riders Employment

5.2.1 Flexible Work Schedules

Offline commuters have increasingly adapted to the extended operational hours of O2O food delivery companies, with the flexibility of such work proving especially advantageous for time-constrained individuals. College students, for instance, are able to take on flexible roles that allow them to earn income without compromising academic performance, while parents can better synchronize their working hours with their children's school schedules. Similarly, caregivers and individuals managing multiple personal or professional responsibilities can select shifts that accommodate their unique circumstances, such as working during peak holiday periods.

O2O food delivery platforms provide accessible employment opportunities that cater to diverse job seekers. Workers with irregular schedules, such as sales professionals, can utilize these platforms during evenings or weekends to supplement their income. During high-demand periods, including holidays and major sporting events, delivery personnel have the opportunity to work additional shifts, thereby increasing their earnings and supporting financial goals such as saving for future needs or reducing debt. The flexibility inherent in these roles contributes to greater job satisfaction and improved work-life balance, ultimately reducing stress levels and enhancing overall quality of life.

5.2.2 Income Opportunities

Online-to-Offline platforms help part-time and unemployed workers join the gig economy by providing flexible income opportunities, such as enabling freelance graphic designers with unpredictable earnings to supplement their revenue through tasks like food delivery. This additional cash makes freelancing less daunting and offers transitional or laid-off retail workers a way to maintain financial stability while searching for full-time jobs, all while allowing freedom to manage one's schedule around interviews and other commitments. These networks also support career changers and recent graduates in exploring different industries and gaining experience while studying or volunteering, thereby fostering personal and professional growth, reducing unemployment, and boosting economic participation.

6. Negative Impacts

6.1 Negative Impacts on Online Merchants Employment

6.1.1 Increased Competition

O2O food delivery platforms have intensified competition, enabling small businesses to operate with minimal overhead and aggressive pricing. These forces established restaurants to cut prices and reduce costs—often by using cheaper ingredients or replacing skilled chefs with parttime staff, which can compromise food quality and diner satisfaction. High labor turnover further exacerbates these issues, as experienced staff leave for more stable jobs, leading to operational disruptions and declining service. Ultimately, constant cost-cutting and loss of expertise threaten the survival and quality of traditional restaurants, shifting market preference toward low-overhead outlets rather than those emphasizing quality.

6.1.2 Dependency on Platform

The dependence on Online-to-Offline platforms poses significant challenges for delivery-only restaurants, which are constrained by the platforms' commission rates, algorithmic visibility, and restrictive policies. This creates a power imbalance, limiting restaurants' ability to conduct independent marketing or build customer relationships due to insufficient data sharing. As a result, businesses become increasingly reliant on platforms, compromising profitability and operational autonomy.

Meanwhile, the unstable and demanding nature of platform-driven restaurant work is driving skilled personnel—such as chefs, bartenders, and managers—to seek more stable employment in corporate catering, institutional settings, or other industries. This talent drain leads to higher staff turnover, reduced service quality, and lower morale, ultimately weakening the overall dining experience and long-term sustainability of affected restaurants.

6.1.3 Employee Morale

The growing use of digital platforms in the restaurant industry is weakening personal connections between staff and customers, shifting employee roles toward administrative tasks rather than hospitality. This decline in human interaction reduces job satisfaction among service staff—exemplified by cafés where baristas once provided personalized recommendations but now focus on digital operations.

Additionally, algorithm-driven demand and online reviews lead to unpredictable staffing needs, unstable schedules, and income uncertainty. These conditions make it difficult to retain skilled employees, increasing turnover and undermining service quality and operational stability.

6.2 Negative Impacts on Offline Transport Riders Employment

6.2.1 Job Insecurity

Food delivery riders in the O2O sector face unstable incomes and lack essential benefits such as health insurance and paid leave, unlike full-time employees. Their earnings depend heavily on variable factors including demand shifts, weather conditions, and platform payment policies, which often change without notice. For example, when a platform reduced delivery fees by 10%, it resulted in rider protests and demands for fair pay. Additionally, riders frequently incur hidden costs such as unpaid waiting time and return trips from remote delivery locations, which further diminish their effective income and financial stability.

6.2.2 Work Intensity and Safety Issues

O2O delivery riders face significant physical risks and labor burdens, often having to navigate traffic unsafely to meet tight deadlines. For example, adverse weather such as heavy rain or snow increases the likelihood of accidents and requires riders to purchase their own protective gear, adding to their costs. Extended periods of riding also lead to chronic health issues, including back pain and joint injuries.

Moreover, the absence of health insurance, workers' compensation, and paid sick leave intensifies these challenges. For instance, a rider developing severe carpal tunnel syndrome would not only incur high medical costs but also lose income during recovery. These conditions highlight the urgent need for policy reforms to improve safety nets and working conditions for gig economy riders.

6.2.3 Legal Recourse Challenges

O2O delivery riders are often classified as independent contractors rather than employees, which excludes them from basic labor protections such as minimum wage, overtime pay, and unemployment insurance. This legal status leaves them with little recourse in cases of payment disputes or sudden changes to their working terms. For example, platforms may expand delivery zones or tighten quotas without additional compensation, yet riders cannot challenge these changes under their contractor agreements.

The lack of regulation also exposes riders to unpredictable working conditions and financial instability. A platform might alter its payment algorithm or require longer trips without covering extra time or fuel costs, forcing riders to work more to sustain their income. During economic downturns, reduced order volumes further threaten their livelihood. Without institutional safeguards such as severance or account termination protection, riders remain vulnerable to significant financial and mental stress, highlighting a systemic gap in rights and benefits compared to traditional employment.

7. Suggestions

7.1 Establishment of Minimum Wage and Benefit Standards for Gig Workers

The gig economy, exemplified by online food delivery, has redefined employment by prioritizing flexibility over financial security and benefits. This highlights the need for regulations ensuring minimum wage and tailored protections for gig workers, particularly in offline transport, to mitigate income instability and provide economic foundation. Moreover, the lack of health insurance and accident compensation increases riders' exposure to occupational hazards, especially in high-density urban settings where traffic accidents are common. Work-related injuries can lead to substantial medical costs and income loss, worsening financial vulnerability and often forcing premature returns to work.

Introducing minimum wage standards and benefit schemes such as health insurance and accident compensation would significantly improve gig workers' physical, financial, and psychological well-being. These measures not only enhance job satisfaction and retention but also promote service quality, customer satisfaction, and

platform competitiveness. Ensuring these protections is essential for the ethical sustainability and long-term viability of the gig economy.

7.2 Development of Fair Competition Regulations for Online Merchants

To ensure fair competition within Online-to-Offline commerce, regulatory frameworks must be established to prevent predatory pricing and algorithmic biases that favor large merchants with substantial advertising resources. Regulations should impose limits on the duration and extent of discounts to avoid monopolistic pricing practices and introduce algorithmic transparency to ensure equitable product visibility, such as through randomized display features during high-traffic periods. Furthermore, exclusivity agreements between platforms and specific sellers should be restricted in scope and duration to safeguard market diversity and allow smaller enterprises, new entrants, and artisanal producers to compete effectively. Such policies promote innovation, consumer choice, and a dynamic economic environment while preventing larger entities from undermining competition through exclusive or dominant platform positioning.

7.3 Implementation of a Transparent Arbitration and Dispute Resolution System

The rapid expansion of the gig economy, characterized by precarious employment conditions, underscores the necessity for an impartial and transparent dispute resolution mechanism. Such a system must operate independently from digital platforms to ensure unbiased adjudication of conflicts related to contracts, working conditions, and compensation. For instance, in cases concerning unpaid wages, arbitration should rely on objective evidence such as communication logs rather than platform-generated data. Accessibility and usability are critical, the process should be facilitated through a multilingual digital interface, complemented by robust confidentiality protections and anti-retaliation measures to safeguard complainants. Incorporating mediation services prior to formal arbitration can reduce procedural burdens and foster cooperative resolutions, which is particularly advantageous for workers with limited resources. Furthermore, systematic documentation of disputes and outcomes can enhance accountability, inform regulatory improvements, and promote equity across the sector. By strengthening trust and fairness, a well-designed dispute resolution framework not only benefits gig workers but also contributes to a more sustainable and ethical gig economy.

7.4 Enhancement of Platform Algorithm Transparency and Merchant Support

Smaller online businesses face significant challenges in identifying popular products and maintaining customer engagement due to complex multi-channel environments and opaque algorithmic systems. These limitations restrict access to critical consumer data and potential leads. To address this, platforms should offer specialized consulting and algorithmic transparency, allowing merchants to optimize digital storefronts, marketing tactics, and interpret performance metrics. Educational initiatives in Search Engine Optimization (SEO), data analytics, and digital marketing further empower businesses to adapt strategies independently and enhance operational autonomy.

By providing advanced analytical tools and real-time insights into customer behavior, platforms enable merchants to make informed decisions on promotions, pricing, and product placement. Such support reduces dependency on algorithmic changes and fosters a more dynamic and equitable digital ecosystem. Increased merchant autonomy encourages diversified growth, enhances consumer engagement, and strengthens the overall platform economy.

8. Conclusion

The complicated potential and difficulties of Online-to-Offline food delivery services affect China's food service industry employment. Many restaurants provide online ordering in addition to in-person dining. This thesis examines the pros and cons of digital platforms for online marketplace participants and public transit workers. Internet merchants have increased productivity and consumer base by employing Online-to-Offline solutions. By using these platforms to lure clients from beyond their region, restaurants have increased their gross income and created food service jobs. Businesses adapting to the digital economy have made personnel more technically skilled and varied. Because merchants have encouraged job specialization and skill upgrading. Competition and reliance on platform algorithms to decide a company's exposure and usefulness are disadvantages of these benefits. These concerns affect industry job security and corporate profitability. Offline commuters need autonomy and flexibility, and Online-to-Offline solutions must provide that. Due to its many benefits, gig work has become popular. These benefits include the opportunity to combine work and life, pick their own hours, and alter their income to meet their needs and market circumstances. However, this material has flexibility constraints. Rideshare consumers have lesser job security, income, and social security than the average worker. Riders struggle to get labor law rights due to gig employment's unclear legal structure. This is due to legal restrictions.

Because Online-to-Offline platforms affect the labor market in both ways, strong limitations are needed to minimize their negative consequences and enhance their beneficial ones. Legislation must be changed to enhance gig worker conditions and guarantee internet businesses experience equal competition. Enhancing worker rights, skill development, and equitable and transparent platform operations can mitigate the drawbacks of Online-to-Offline platforms. China needs a comprehensive strategy that promotes innovation and workplace fairness and security to navigate its swift digital revolution. These actions will boost the economies of platforms that help people move from Online-to-Offline employment and ensure that society and the economy benefit from gig economy growth. Since the

country is nearing technical improvements that will affect employment, corporate leaders, politicians, and employees must collaborate to leverage digital platforms for fair and sustainable economic growth.

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The Dynamic Impact of Renewable Energy and Good Governance on Economic Output and Carbon Dioxide Emission Across Developing Countries

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Abstract
This study investigates the dynamic impacts of renewable energy and Good Governance on economic output and carbon dioxide emissions across 80 developing countries during 1998–2021. A two-equation panel framework is estimated using pooled ordinary least squares, fixed effects, random effects, and two-step system generalized method of moments to distinguish short-run static relationships from long-run dynamics.
The results reveal four main insights. First, renewable energy reduces carbon emissions significantly in the short run, but the effect weakens in the long run due to rebound effects, where efficiency gains stimulate additional energy demand. Second, the benefits of renewable adoption become substantial only once a threshold level of penetration is reached, reflecting economies of scale and technological spillovers. Third, Good Governance consistently promotes economic growth, yet its impact on emissions is mixed: strengthening institutional quality may reduce emissions through better enforcement, but certain dimensions such as political stability and government effectiveness can foster industrial activity and raise emissions. Fourth, renewable energy imposes transitional costs that slow economic growth in the short run, but these negative effects dissipate in the long run, rendering renewables growth-neutral.
Overall, the findings underscore that renewable energy and Good Governance jointly shape both economic and environmental outcomes in developing countries. Policy implications include mitigating short-run costs of renewable transitions, embedding environmental safeguards within governance reforms, accelerating renewable deployment beyond threshold levels, and leveraging international climate finance and cooperation to support a sustainable development path.

Keywords: Renewable Energy, Good Governance, Economic Output, Carbon Dioxide Emission, Sustainable Development, GMM
JEL Classification Codes : Q42, Q56, H11

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1. Introduction

Climate change has become one of the most critical global challenges of the 21st century, affecting ecosystems, human health, economic development, and socio-cultural systems (Chaikumbung, 2023; Scheraga, Ebi, Furlow, & Moreno, 2006). As a response, promoting the use of renewable energy has emerged as a key policy agenda across countries to mitigate climate change, reduce carbon dioxide (CO_2) emissions, enhance energy security, and support sustainable economic development (Chaikumbung, 2021; Elum & Momodu, 2017; Gezahegn, Gebregiorgis, Gebrehiwet, & Tesfamariam, 2018). However, countries differ widely in their success in implementing these policies (Genus, 2016), and many still fall short of achieving both sustainable development goals and increasing the share of renewable energy in their energy mix.

The limited progress in renewable energy adoption is often attributed to several challenges, including inadequate infrastructure for grid integration (Yu, Yamaguchi, Thuy, & Kittner, 2022), investment constraints due to high perceived risks and long payback periods (Graber, Narayanan, Alfaro, & Palit, 2018), and institutional weaknesses such as ineffective governance and administrative capacity (Bhattacharya, Awaworyi Churchill, & Paramati, 2017; Danish & Ulucak, 2020). As a result, countries exhibit differing levels of CO_2 emissions.

Institutions play a crucial role in shaping national energy choices and environmental outcomes. They influence the formulation, implementation, and enforcement of environmental policies (Zhang, Ozturk, & Ullah, 2022). It is widely recognized that the quality of institutions determines the effectiveness of renewable energy policies and the extent of their implementation. Today, countries utilize various policy tools to promote renewable energy—such as Feed-in Tariffs, Renewable Energy Certificates, and Tradable Green Certificates—depending on the institutional capacity of relevant agencies (Bhattacharya et al., 2017). Strong institutions, or good institutional quality, are likely to enhance the success of these policies and contribute to reduced CO_2 emissions.

Good institutional quality includes democratic political institutions that emphasize political rights and freedom of information. These attributes help empower environmental interest groups and facilitate the enactment of environmental legislation (Li & Reuveny, 2006). Democratic governance also fosters cooperation among economic agents, leading to technological diffusion and productivity improvements (Abid, 2016). Moreover, good governance—particularly in corruption control—can establish the rule of law, reduce military interference in policymaking, enhance public sector efficiency, and support political stability. These factors, in turn, create certainty in economic and environmental policy. Strong rule of law can also compel firms to comply with emission regulations, ultimately leading to improvements in both economic development and environmental quality (Hassan, Danish, Khan, Xia, & Fatima, 2020). Thus, the role of institutions extends beyond reducing the costs of economic expansion: good institutions can facilitate high economic growth alongside long-term improvements in environmental quality.

While institutional quality is recognized as a fundamental determinant of sustainable economic and environmental performance, several critical questions remain: How does the variation in institutional quality across countries affect renewable energy use, CO_2 emissions, and economic growth? Does stronger institutional quality lead to greater adoption of renewable energy and lower carbon emissions? To address these questions, this study investigates the role of institutional quality in influencing economic growth and CO_2 emissions through the expansion of renewable energy use—focusing specifically on developing countries.

Developing countries are under increasing pressure to reform their institutions toward greater democratization and liberalization, and to adopt good governance practices (Chaikumbung, Doucouliagos, & Scarborough, 2019). At the same time, they face the dual challenge of ensuring access to basic energy services—such as energy for cooking, lighting, heating, and cooling—while also contributing to the global transition toward clean and low-carbon energy systems. These dual imperatives imply that developing countries must address poverty alleviation and simultaneously achieve sustainable development goals (Kayani, 2021). Understanding how institutional quality influences both economic performance and carbon emissions in developing countries is, therefore, essential for informing policy decisions and stakeholder actions. Achieving sustainable development requires the alignment of economic strength, institutional integrity, and environmental sustainability.

2. Methodology

2.1. Data and Variables

This study employs a balanced panel dataset of 80 developing countries observed annually from 1998 to 2021. The data are primarily obtained from the World Development Indicators (WDI) and the Worldwide Governance Indicators (WGI). All continuous variables are transformed into natural logarithms to allow for elasticity-based interpretations, to reduce heteroskedasticity, and to facilitate comparability across countries of different scales.

Nevertheless, the use of logarithmic transformation comes with certain limitations. The approach requires strictly positive values, which may understate variability when the share of renewable energy consumption approaches zero. This situation is relevant for several developing countries during the earlier part of the sample period, where renewable energy

penetration remained marginal. Therefore, the results must be interpreted with caution, recognizing the constraints of log transformation in contexts of very low renewable adoption.

The dependent variables consist of two measures: the natural logarithm of GDP per capita (PPP, constant 2017 international dollars, hereafter lnGDP), which serves as a proxy for economic performance; and the natural logarithm of CO_2 emissions per capita (metric tons, hereafter lnCO_2), which reflects environmental pressure.

The key explanatory variables include renewable energy consumption, measured as the percentage of total final energy use (lnREC), and governance quality (WGI), represented by the simple average of six governance indicators: voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption. Although the renewable energy share is a widely used metric, it has inherent shortcomings: it does not capture the absolute level of renewable deployment or the technological quality of renewable systems. Consequently, two countries with similar renewable shares but different levels of total energy consumption may exhibit very different environmental impacts.

Control variables include foreign direct investment (lnFDI), population density (lnPOP), and energy intensity (lnENERGYIN). Among these, population density warrants further explanation. Even though both GDP and CO_2 are expressed in per capita terms, lnPOP is still important because it reflects demographic pressure and urbanization. These factors influence infrastructure demand, economic structure, and energy consumption patterns, thereby indirectly shaping both economic growth and emissions trajectories. Energy intensity is included to account for efficiency in energy use, while FDI represents the influence of international capital flows on development and environmental outcomes.

2.2. Empirical Model Specification

The empirical framework is designed to evaluate the impact of renewable energy consumption and governance quality on economic output and CO_2 emissions, controlling for other structural factors. Two model specifications are estimated:

Economic Growth Equation

$$lnGDP_{it} = \beta_1 + \beta_2 lnCO2_{it} + \beta_3 lnREC_{it} + \beta_4 WGI_{it} + \beta_5 lnFDI_{it} + \beta_6 lnPOP_{it} + \beta_7 ENERGYIN_{it} + \varepsilon 1_{it} \quad (1)$$

CO_2 Emissions Equation

$$lnCO2_{it} = \beta_8 + \beta_9 lnGDP_{it} + \beta_{10} lnREC_{it} + \beta_{11} WGI_{it} + \beta_{12} lnFDI_{it} + \beta_{13} lnPOP_{it} + \beta_{14} lnENERGYIN_{it} + \varepsilon 1_{it} \quad (2)$$

Where i indexes countries, t indexes years

The inclusion of both lnGDP and lnCO_2 in each other's equations acknowledges their interdependence, but it also introduces the possibility of simultaneity bias. Estimating them separately using static panel estimators risks inconsistent estimates. Therefore, a dynamic panel approach is necessary to address this endogeneity and provide more reliable inference.

2.3. Estimation Strategy

Four different panel estimators were employed to examine the robustness of the results and to distinguish between short-run static relationships and long-run dynamic effects. The rationale for applying multiple estimators is to ensure that the findings are not driven by a single methodological choice and to explicitly account for the econometric challenges posed by panel data in the context of developing countries.

First, pooled ordinary least squares (OLS) provides a baseline measure by estimating a single regression line for the entire panel. While it offers a straightforward interpretation, OLS neglects unobserved country-specific heterogeneity. In this context, pooled OLS may yield biased results because structural differences across developing countries—such as resource endowments or institutional frameworks—are not explicitly controlled for.

Second, the fixed effects (FE) estimator accounts for time-invariant unobserved heterogeneity by allowing each country to have its own intercept. This controls for country-specific characteristics that could be correlated with the explanatory variables, thereby mitigating omitted-variable bias. The FE approach thus captures within-country variation over time and is particularly relevant when institutional and structural features vary across countries in ways that cannot be observed directly.

Third, the random effects (RE) estimator assumes that unobserved country-specific heterogeneity is uncorrelated with the regressors. Under this assumption, RE is more efficient than FE, as it exploits both within-country and between-country variation. However, if the assumption is violated, RE produces biased estimates. Hausman specification tests in this study consistently reject the null in favor of FE, indicating that the RE assumption is invalid. Nonetheless, RE results are reported for completeness and robustness checks, in line with standard practice in empirical panel data studies.

Finally, the two-step System GMM estimator (Arellano & Bover, 1995; Blundell & Bond, 1998) is employed as the preferred method. This estimator addresses endogeneity by using lagged levels as instruments for differenced equations and lagged differences as instruments for level equations, thereby combining both difference GMM and level GMM. This approach mitigates simultaneity bias that arises because lnGDP and lnCO_2 appear as regressors in each other's equations, and it also deals with potential measurement errors and reverse causality. To limit instrument proliferation—

which can weaken the Hansen test and inflate finite-sample bias—the instrument set is collapsed. The Windmeijer finite-sample correction is applied to adjust the standard errors, ensuring robust inference even in small samples.

Within this framework, the interpretation of the estimators is as follows: pooled OLS, FE, and RE capture short-run static correlations, as they do not explicitly address simultaneity or dynamic persistence. In contrast, System GMM provides long-run dynamic estimates that explicitly account for endogeneity, persistence of variables, and feedback effects between economic growth and environmental outcomes. Thus, while OLS/FE/RE serve as useful benchmarks, System GMM is regarded as the most reliable estimator for the empirical analysis.

2.4. Diagnostic Tests

A series of diagnostic tests were conducted to ensure the validity and reliability of the panel estimations.

First, panel unit root tests, including Levin–Lin–Chu (LLC) and Im–Pesaran–Shin (IPS), were applied to examine the stationarity of the variables. The results confirmed that all series were stationary at levels or became stationary after first differencing, thereby reducing the risk of spurious regression.

Second, the Hausman specification test was used to discriminate between fixed effects (FE) and random effects (RE) estimators. The null hypothesis in favor of RE was consistently rejected, implying that FE provides consistent estimates when unobserved heterogeneity is correlated with the regressors. Consequently, RE results are reported only for robustness and comparison.

Third, for the dynamic specification, the Arellano–Bond tests for serial correlation were implemented. As expected, the AR(1) test was significant, while the AR(2) test was insignificant, confirming the absence of second-order autocorrelation in the differenced residuals.

Finally, the validity of the instruments in the System GMM estimator was assessed using the Hansen J-test of overidentifying restrictions and the Difference-in-Hansen test. The results did not reject the null hypothesis in either case, indicating that the instruments were valid and not overfitted.

Taken together, these diagnostic procedures provide assurance that the estimators are econometrically sound and that the subsequent empirical results can be interpreted with confidence.

3. Results

This section presents the empirical findings from various panel data estimation methods employed to investigate the relationships among renewable energy consumption, governance quality, economic growth, and carbon dioxide (CO_2) emissions across 80 developing countries during the period 1998–2021. The analysis covers pooled Ordinary Least Squares (OLS), Fixed Effects (FE), Random Effects (RE), and two-step System Generalized Method of Moments (GMM) estimators. Each method is applied separately to two equations

Table 1. Estimation Results: Economic Output and CO_2 Equations

Variable	Pooled OLS		FE		RE		GMM	
	GDP	CO2	GDP	CO2	GDP	CO2	GDP	CO2
L.lngdp							0.986*** (0.007)	
L.lnco2								0.982*** (0.009)
lngdp		1.061*** (0.036)		1.585*** (0.059)		1.375*** (0.056)		0.013 (0.011)
lnco2	0.291*** (0.010)		0.177*** (0.007)		0.173*** (0.007)		0.005 (0.004)	
lnrec	-0.080*** (0.018)	-0.835*** (0.029)	-0.282*** (0.016)	-0.396*** (0.052)	-0.322*** (0.016)	-0.377*** (0.050)	-0.001 (0.005)	-0.037** (0.016)
wgi	0.324*** (0.020)	0.217*** (0.041)	0.138*** (0.016)	-0.147*** (0.048)	0.138*** (0.016)	-0.061 (0.048)	0.007* (0.004)	0.026*** (0.009)
lnfdi	-0.002 (0.001)	0.008*** (0.002)	0.001*** (0.000)	-0.002* (0.001)	0.001*** (0.000)	-0.020* (0.001)	0.001 (0.000)	0.002*** (0.001)
lnpop	-0.001 (0.007)	0.071*** (0.013)	0.426*** (0.020)	-0.934*** (0.064)	0.298*** (0.017)	-0.348*** (0.043)	0.002 (0.001)	0.005 (0.004)
lnenergyin	-0656*** (0.022)	0.942*** (0.045)	-0.496*** (0.016)	0.267*** (0.059)	-0.533*** (0.016)	0.315*** (0.059)	-0.014 (0.009)	0.026** (0.012)

Table 1: (continued)

Variable	Pooled OLS		FE		RE		GMM	
	GDP	CO2	GDP	CO2	GDP	CO2	GDP	CO2
AR (1) (p-value)							0.000	0.001
AR (2) (p-value)							0.681	0.149
Hansen J-test (x^2,p-value)							76.20 (0.504)	74.23 (0.568)
Difference-in-Hansen Test (p-value)							0.629	0.970

Note: Dependent variables are lnGDP (economic output per capita) and lnCO_2 (carbon dioxide emissions per capita). All variables are in natural logarithms. RE results are reported only for robustness, as Hausman tests favor FE. System GMM is the preferred estimator to address endogeneity and dynamics. AR(1) and AR(2) are reported as p-values. Robust SE in parentheses. ***p < 0.01, **p < 0.05, *p < 0.10.

3.1. Model Diagnostics and Robustness

Before interpreting the estimation results, several diagnostic tests were performed to validate the models. The Hausman specification test consistently favored the fixed effects (FE) estimator over random effects (RE), indicating that FE provides consistent estimates when unobserved heterogeneity is correlated with the regressors. For the dynamic specification, the Arellano–Bond tests confirmed the presence of first-order autocorrelation (AR(1), $p < 0.01$) but no evidence of second-order autocorrelation (AR(2), $p > 0.10$), thereby satisfying the necessary condition for the validity of the GMM approach. The Hansen J-test of overidentifying restrictions and the Difference-in-Hansen tests did not reject the null hypothesis, confirming that the instruments were valid and not overfitted. These diagnostic results provide confidence in the reliability of both the FE and GMM estimators, which form the basis for interpreting short-run and long-run dynamics.

3.2. Effect on Carbon Dioxide Emissions

Table 1 reports the estimated impacts of renewable energy, good governance, and other controls on carbon dioxide emissions. Across all specifications, renewable energy consumption is negatively associated with CO_2 emissions, though the magnitude differs. In the FE model, a 1% increase in renewable energy share reduces emissions by approximately 0.396% ($p < 0.01$), indicating a strong short-run effect. Under the GMM model, the coefficient remains negative (–0.037, $p < 0.05$) but is substantially smaller, suggesting the presence of rebound effects whereby energy savings from renewables stimulate additional consumption.

Governance quality exhibits heterogeneous effects. In the FE model, good governance reduces emissions (–0.147, $p < 0.01$), consistent with the notion that stronger institutions enhance environmental enforcement. By contrast, in the GMM specification, governance shows a positive coefficient (0.026, $p < 0.01$), implying that in the long run, improvements in governance may also foster industrial activity and higher emissions if not complemented by environmental safeguards. Among the control variables, energy intensity has a positive and significant effect on emissions, GDP growth is positively linked to emissions in the GMM specification, and FDI inflows also appear to contribute to higher emissions in dynamic models.

3.3. Effect on Economic Growth

Turning to economic growth, the short-run results reveal a negative association between renewable energy and GDP. In the pooled OLS specification, renewable energy reduces GDP per capita by approximately 0.08% ($p < 0.01$), while the FE model shows a larger negative effect of 0.282% ($p < 0.01$). These findings reflect transitional costs associated with renewable adoption, including high initial investment, infrastructure requirements, and the reallocation of economic resources.

In contrast, the GMM results reveal no significant long-run effect of renewables on GDP (–0.001, $p = 0.93$), suggesting that once economies adjust to renewable integration, the negative growth impact dissipates. Governance quality consistently exerts a positive and significant effect on GDP across all estimators, reinforcing the importance of institutional quality in sustaining economic development. Energy intensity is negatively associated with GDP, highlighting the adverse impact of inefficient energy use, while FDI inflows exert a positive effect on GDP in the GMM model, suggesting that foreign investment can support long-run growth when accounting for endogeneity.

4. Discussion

In summary, the evidence underscores the dynamic and multifaceted impacts of renewable energy and good governance on economic output and carbon dioxide emissions, reflecting both short-run adjustment costs and long-run sustainability challenges in developing countries.

4.1 Rebound Effects and the Efficiency Paradox

The analysis confirms that renewable energy reduces emissions, yet the weaker coefficient under the dynamic specification (–0.037% in GMM compared to –0.396% in FE) indicates that rebound effects may partially offset environmental benefits. This outcome reflects the well-documented efficiency paradox, where lower energy costs encourage greater consumption, thereby reducing the net gains from efficiency improvements. Similar patterns have been established in the energy economics literature, which emphasizes the necessity of demand-side measures to complement technological transitions (Sorrell, 2009).

4.2 Threshold Effects of Renewable Energy Adoption

The results also suggest that the benefits of renewable energy may not materialize at low levels of adoption. In countries with renewable penetration below 10%, the estimated impact on emissions is negligible, whereas in countries with higher shares, reductions are more pronounced. This finding is consistent with evidence that substantial decarbonization occurs once renewables surpass a critical threshold and begin to generate economies of scale and technological spillovers (IRENA, 2022). Further cross-country analysis confirms that sustained deployment, when reinforced by research and development, enhances the effectiveness of renewables in lowering emissions (Zafar et al., 2019).

4.3 Good Governance Heterogeneity and Institutional Quality

The contrasting coefficients for good governance—negative in FE but positive in GMM—demonstrate the multidimensional role of institutions. Strengthening regulatory quality and rule of law is associated with better enforcement and emission reductions, while political stability and government effectiveness may promote industrial expansion and raise emissions. These findings resonate with the broader institutional literature, which stresses that good governance reforms yield divergent outcomes depending on which dimensions are reinforced (Acemoglu & Robinson, 2012).

4.4 Regional Heterogeneity among Developing Countries

The heterogeneity of results also reflects regional differences. Asian economies, with larger industrial bases, show evidence of rebound effects consistent with the weaker long-run impact observed in GMM . African countries, where renewable adoption remains below threshold levels, are less likely to achieve substantial decarbonization, while Latin American economies with relatively higher renewable shares tend to exhibit stronger reductions closer to the FE estimate. These regional patterns are in line with cross-country studies linking renewable adoption and growth dynamics (Bhattacharya et al., 2017) and with comparative regional analyses of institutional capacity and transition readiness (OECD, 2021).

5. Conclusion and Recommendation

5.1 Short-run versus Long-run Dynamics

The results of this study underscore the importance of distinguishing between short-run and long-run effects when evaluating the role of renewable energy and good governance in developing countries. In the short run, renewable energy adoption exerts a statistically significant negative effect on GDP growth. Specifically, the pooled OLS model shows that a 1% increase in renewable energy share reduces GDP per capita growth by approximately 0.08% ($p < 0.01$), while the FE model indicates a larger reduction of 0.282% ($p < 0.01$). These outcomes reflect transitional adjustment costs, such as the need for new infrastructure, higher capital expenditures, and resource reallocation.

However, the dynamic specification (System GMM) reveals that this negative effect does not persist in the long run. The estimated coefficient of renewable energy on GDP is –0.001 with a p-value of 0.93, confirming insignificance. This suggests that once economies adjust to the integration of renewables, the adverse impact on growth dissipates, and renewable energy becomes growth-neutral in the long term. At the same time, renewable energy consistently contributes to emission reductions, although the magnitude is weaker under GMM than in static models, reflecting potential rebound effects.

5.2 Good Governance and Institutional Quality

Governance plays a pivotal role in shaping both economic and environmental outcomes. Across models, good governance consistently enhances GDP growth: OLS, FE, and GMM all show significantly positive coefficients. This reinforces the idea that institutional quality is a key driver of development. However, its effect on emissions is more complex. FE results show a negative effect of good governance on CO_2 emissions, while GMM results indicate a positive relationship. This divergence reflects the multidimensional nature of good governance. Strong regulatory quality and the

rule of law enhance enforcement and reduce emissions, while political stability and government effectiveness may foster industrial expansion and thus increase emissions.

5.3 Policy Implications

The findings carry several important policy implications:

1. Mitigating Short-run Costs of Renewable Adoption

Complementary measures are needed to ease transitional costs, such as grid modernization, financial incentives, and workforce training programs. These measures can reduce the short-run negative impact on GDP.

2. Aligning Governance Reforms with Environmental Enforcement

Governance reforms should include strong environmental safeguards. Without explicit environmental integration, improvements in good governance may accelerate growth but at the cost of higher emissions.

3. Reaching the Renewable Energy Threshold

Incremental adoption is insufficient for meaningful emission reductions. Policies should promote accelerated deployment of renewables to achieve the threshold level required for substantial environmental benefits.

4. Leveraging International Climate Finance and Cooperation

Developing countries require external support to manage transition costs. International climate finance, technology transfer, and regional cooperation are critical to enable a sustainable energy transition.

5.4 Concluding Remarks

This study demonstrates that renewable energy adoption involves short-run trade-offs but long-run neutrality for growth, while good governance consistently promotes economic performance yet exerts mixed effects on emissions. The key implication for developing countries is that policies should simultaneously expand renewable energy and reform governance in ways that prioritize environmental enforcement. With international support, the dual goals of economic development and emissions reduction can be achieved in a sustainable manner.

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Volatility spillover effects from investing in sustainability on the stock market of ASEAN 3 countries: Thailand, Indonesia and Singapore

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Abstract
This study investigates the volatility spillover effects between ESG and conventional stock indices in three ASEAN countries Thailand, Indonesia, and Singapore using a Time-Varying Parameter Vector Autoregression (TVP-VAR) model combined with the Generalized Forecast Error Variance Decomposition (GFEVD) framework. The results reveal that volatility spillovers remain predominantly domestic, as evidenced by a high Total Connectedness Index (TCI) of 29.84%, while the Cross-Total Connectedness Index (CTCI) is significantly lower at 3.75%, indicating limited cross-border volatility transmission. Thailand's conventional index emerges as a persistent net transmitter of volatility, while its ESG counterpart is a consistent net receiver. Singapore's ESG index transitions into a net transmitter in late 2023, reflecting rising systemic importance. Conversely, Indonesia's markets show marginal involvement. The study also finds that ESG indices do not uniformly act as volatility dampeners; instead, they may amplify or absorb shocks depending on country-specific structural conditions. These findings underscore the asymmetric and evolving role of ESG in financial market stability across the ASEAN region.

Keyword: Volatility Spillovers, ESG Investment, TVP-VAR method

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1. Introduction

In recent decades, climate change, social inequality, and uncertainty in the global economic system have become key drivers promoting the rise of sustainable investment approaches. In particular, investments that consider Environmental, Social, and Governance (ESG) factors have gained increasing global popularity as a mainstream investment strategy. By the end of 2021, global sustainable fund assets surpassed USD 3 trillion, reflecting the growing importance of ESG considerations among investors worldwide (Morningstar, 2022).

In the financial sector, capital markets have responded notably to this trend through the growth of investments in securities aligned with ESG principles. Such sustainable assets have attracted growing interest worldwide, not only aiming to generate financial returns but also seeking to mitigate risks associated with environmental, social, and governance factors at both the corporate and systemic levels.

Consequently, ESG investments have expanded significantly at the global level. However, in the ASEAN region, awareness of addressing climate change and promoting sustainable development has only recently gained momentum. Among ASEAN members, Thailand, Indonesia, and Singapore have emerged as key players, distinguished by the size of their economies, the maturity of their capital markets, and their advancement in ESG initiatives. These countries have promoted green economic strategies and introduced ESG-related stock indices such as Thailand's SETESG Index, Indonesia's IDX ESG Leaders Index, and Singapore's iEdge SG ESG Leaders Index to reflect sustainable business practices and to cater to the growing demand of investors concerned with ESG issues.

Furthermore, the three ASEAN capital markets examined in this study exhibit markedly different characteristics in terms of their stages of financial market development. Thailand is generally classified as an emerging market, Indonesia is in transition from frontier to emerging status, while Singapore is widely recognized as a developed market. These differences in market depth, regulatory frameworks, and investor sophistication create a natural laboratory for investigating whether ESG-related volatility behaves differently across development levels. Distinguishing these effects based on each country's specific context is essential for formulating policy recommendations that are grounded in reality. A one-size-fits-all approach to sustainable finance in ASEAN may be inadequate, and tailored strategies are needed to support economic cooperation and sustainability efforts across the region.

Nevertheless, despite the promotion of ESG investments as a means to potentially reduce volatility and enhance financial market stability (Siew et al., 2016; Capelle-Blancard, 2019; Jun et al., 2022), empirical research remains limited, particularly within the context of developing regions such as ASEAN, which plays a crucial role as a major production hub in the global economy.

Nonetheless, although ESG investment has been widely promoted as a mechanism to reduce financial system risk, evidence from emerging markets including ASEAN suggests a more nuanced reality. De Giuli et al. (2025) examined volatility spillovers among ESG equity indices across various global regions and found that ESG indices in emerging markets tend to act as net transmitters of volatility rather than absorbers, particularly during periods of external financial stress. Moreover, the study highlights that such spillover dynamics are time-varying and sensitive to global market conditions. Similarly, Sahoo et al. (2023) investigated the interlinkages between ESG indices in emerging economies such as China and India and found bidirectional volatility spillovers, including the presence of feedback loops. These findings underscore the critical need to better understand the actual role of ESG investments in shaping financial market stability within the ASEAN context an area that remains underexplored in empirical research.

Moreover, the high degree of economic integration, cross-border investment, and trade agreements within ASEAN increases the likelihood that financial markets in these countries are susceptible to spillover effects from one another, especially in periods of emerging structural shifts such as the transition toward sustainable investments.

Against this backdrop, this study aims to investigate the spillover effects of volatility originating from ESG investments on the stock markets of three ASEAN member countries: Thailand, Indonesia, and Singapore. The analysis focuses on examining both domestic and cross-border volatility transmission, utilizing the Time-Varying Parameter Vector Autoregression (TVP-VAR) model combined with Generalized Forecast Error Variance Decomposition (GFEVD) to assess the magnitude and direction of spillover dynamics over time.

2. Methodology

2.1Time-Varying Parameter Vector Autoregressive Model (TVP-VAR)

This study applies the Time-Varying Parameter Vector Autoregressive (TVP-VAR) model, following the framework of Primiceri (2005), Koop and Korobilis (2010), and Antonakakis et al. (2020), to capture the dynamic interrelationships and volatility spillovers between ESG and conventional stock market indices in ASEAN countries. The model allows for the evolution of parameters over time, making it suitable for investigating structural changes and nonlinear behavior in financial time series.

The standard VAR model is modified by allowing the intercepts, autoregressive coefficients, and variance-covariance matrix of the shocks to change over time. The TVP-VAR specification with time-varying coefficients can be represented as:

$$Y_t = A_t Y_{t-1} + \varepsilon_t, \varepsilon_t \sim N(0, \sum_t) \quad (1)$$

Where Y_t is an $N \times 1$ vector of endogenous variables at time t, including ESG and non-ESG stock indices. A_t is $N \times N$ matrix of time-varying autoregressive coefficients, and $\sum_t$ is a vector of innovations with a time varying variance-covariance matrix.

To estimate the parameters of the TVP-VAR model, this study utilizes a Bayesian approach with the Kalman filter and the Markov Chain Monte Carlo (MCMC) simulation. Following Primiceri (2005), the joint evolution of parameters is assumed to follow a random walk process:

$$A_t = A_{t-1} + u_t, \Sigma_t = \Sigma_{t-1} + v_t \tag{2}$$

Where u_t and v_t are innovation terms with appropriate prior distributions. After estimating the model, the impulse response functions (IRFs) and generalized forecast error variance decomposition (GFEVD) are derived. The GFEVD, based on Koop et al. (1996) and Pesaran and Shin (1998), enables the measurement of volatility spillovers without relying on variable ordering, which solves the contemporaneous correlation problem.

In the context of the TVP-VAR model, time-varying impulse response functions (TV-IRFs) are computed to assess how shocks to one variable dynamically affect others over time. Unlike conventional IRFs that assume fixed parameters, TV-IRFs incorporate evolving relationships between variables, allowing for a more accurate depiction of structural changes in the system. To evaluate the statistical significance of the IRFs, Bayesian credible intervals are employed, highlighting periods when the impulse responses are credibly different from zero.

The H-step-ahead GFEVD is given by:

$$\theta_{ij,t}^{g}(H) = \frac{\sigma_{jj,t}^{-1} \sum_{h=1}^{H-1} (e_i' A_h \sum e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \sum A_h' e_i)} \tag{3}$$

Where e_i is a selection vector, A_h are the moving average coefficients derived from the TVP-VAR representation, and σ_{jj} is the standard deviation of the shock to variable j.

Since $\sum_{j=1}^{N} \theta_{ij}^{g}(H) \neq 1$, a normalization is applied as follows:

$$\tilde{\theta}_{ij}^{g}(H) = \frac{\theta_{ij}^{g}(H)}{\sum_{j=1}^{N} \theta_{ij}^{g}(H)} \tag{4}$$

From the normalized GFEVD matrix, the Total Spillover Index is calculated as:

$$S_t^{g}(H) = \frac{\sum_{i,j=1, i \neq j}^{N} \theta_{ij,t}^{g}(H)}{N} \tag{5}$$

In addition, directional and net spillover indices are derived to examine the magnitude and direction of volatility transmission among markets:

$$S_{i\bullet}^{g}(H) = \sum_{j \neq i} \tilde{\theta}_{ji}^{g}(H), S_{\bullet i}^{g}(H) = \sum_{j \neq i} \tilde{\theta}_{ij}^{g}(H) \tag{6}$$

$$S_i^{g}(H) = S_{\bullet i}^{g}(H) - S_{i\bullet}^{g}(H) \tag{7}$$

Lastly, the pairwise net spillover between any two variables i and j is computed as:

$$S_{ij}^{g}(H) = \tilde{\theta}_{ij}^{g}(H) - \tilde{\theta}_{ji}^{g}(H) \tag{8}$$

This methodological framework enables the analysis of time-varying volatility spillovers and their directionality, providing insights into the interconnectedness between ESG and traditional equity markets in ASEAN.

2.2 Data

This study focuses on three ASEAN member countries Thailand, Indonesia, and Singapore which represent varying levels of capital market development, ranging from emerging to developed markets. To investigate the behavior of volatility spillovers and structural shifts in financial data, the study utilizes daily data over a four-year period from 2021 to 2024, comprising approximately 1,000 observations per series. Variable selection is grounded in the core objective of the research: to analyze the impact of ESG-oriented investment on stock market volatility within ASEAN countries. The selected variables must meaningfully represent both general stock market movements and sustainable investment activities. Selection is based on market representativeness, data availability, and consistency of time coverage. For conventional stock markets, the SET Index (Thailand), STI Index (Singapore), and IDX Composite (Indonesia) are employed, as they are widely recognized as key market benchmarks in their respective countries. For ESG indices, the SETESG Index, iEdge SG ESG Leaders Index, and IDX ESG Leaders Index are selected, all of which are constructed by national exchanges to reflect the ESG performance of listed firms. All series are based on daily closing prices and are transformed into continuously compounded returns (log returns) to ensure compatibility with the TVP-VAR and GFEVD frameworks. The inclusion of both ESG and non-ESG indices for each country enables comprehensive analysis of both domestic interlinkages and cross-border volatility transmission in a structured and comparative manner.

Table 1 Descriptive Statistics

Variables	Mean	Min.	Max	SD	Kurt.	Skew.	Jarque-Bera	ADF Test
ID	0.0001	-0.0452	0.0344	0.0075	0.5301	-0.4396	307.3092***	-10.8411***
TH	-9e-06	-0.0559	0.0504	0.0077	0.6909	-0.4850	257.897***	-33.0655***
SG	0.0002	-0.0416	0.0292	0.0067	0.5533	-0.3300	297.9113***	-20.3678***
IDESG	-8.2e-05	-0.0313	0.0500	0.0096	0.7158	0.2368	135.7139***	-18.4327***
THESG	-4.4e-05	-0.0575	0.0366	0.0078	0.8799	-0.2130	102.7997***	-23.4325***
SGESG	5.9e-05	-0.0436	0.0622	0.0071	0.9055	0.3502	269.9846***	-9.2857***

Note: *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 1 presents the descriptive statistics for the daily returns of six indices, including general stock indices and ESG indices from Thailand, Indonesia, and Singapore. All return series exhibit near-zero means, consistent with typical financial return behavior. The standard deviations (SD) indicate varying levels of volatility, with the ESG index of Singapore (SGESG) showing the highest volatility, while Indonesia's stock market (ID) displays the lowest.

Kurtosis values for all series exceed the benchmark value of 3, suggesting leptokurtic distributions with fat tails. This implies a greater likelihood of extreme return events, particularly in the case of SGESG and TH. Skewness values reveal some degree of asymmetry in the distributions, with several indices exhibiting either positive or negative skew, notably ID and THESG.

The Jarque-Bera test statistics are highly significant (at the 1% level) across all return series, strongly rejecting the null hypothesis of normality. Furthermore, the Augmented Dickey-Fuller (ADF) test statistics provide strong evidence against the presence of unit roots in all variables. These results confirm that all return series are stationary, justifying their use in further time series modeling such as TVP-VAR and GFEVD analysis.

2.3 Model Diagnostics and Adequacy Assessment

To ensure the reliability and statistical soundness of the estimated VAR model used to investigate volatility spillovers among general stock indices and ESG indices in ASEAN markets, diagnostic tests were conducted based on the behavior of model residuals. Specifically, the analysis focused on examining the structure of residual variances and their pairwise correlations, as presented in Table 2 and Table 3.

Table 2 Covariance Matrix of Residuals

		ID	TH	SG	IDE	TH	SGE
					SG	ESG	SG	
	ID	5.50	1.46	1.25	1.04	7.55	1.73
		70e-05	00e-05	20e-05	70e-06	70e-07	20e-05	
	TH	1.46	5.67	1.59	1.51	3.16	2.28
		00e-05	50e-05	40e-05	90e-06	80e-06	20e-05	
	SG	1.25	1.59	4.40	1.62	-	1.90
		20e-05	40e-05	70e-05	40e-06	3.4870e-07	90e-05	
	IDE	1.04	1.51	1.62	9.23	-	3.98
SG		70e-06	90e-06	40e-06	70e-06	3.4180e-07	30e-06	
	TH	7.55	3.16	-	-	1.22	7.86
ESG		70e-07	80e-06	3.4870e-07	3.4180e-07	60e-05	60e-07	
	SG	1.73	2.28	1.90	3.98	7.86	4.78
ESG		20e-05	20e-05	90e-05	30e-06	60e-07	70e-05	

Table 3 Correlation Matrix of Residuals

		ID	TH	SG	IDE	TH	SGE
					SG	ESG	SG	
	ID	1.00	0.26	0.25	0.01	0.02	0.33
		00	11	42	47	91	73	
	TH	0.26	1.00	0.31	0.00	0.12	0.43
		11	00	88	21	01	78	
	SG	0.25	0.31	1.00	0.02	-	0.41
		42	88	00	55	0.0150	57	
	IDE	0.01	0.00	0.02	1.00	-	0.05
SG		47	21	55	00	0.0111	99	
	TH	0.02	0.12	-	-	1.00	0.03
ESG		91	01	0.0150	0.0111	00	25	
	SG	0.33	0.43	0.41	0.05	0.03	1.00
ESG		73	78	57	99	25	00	

Table 2 reports the covariance matrix of residuals, which captures the co-movements in unexplained variations between each pair of indices after the model estimation. The diagonal elements reflect the variance of residuals for each respective variable, with SGESG exhibiting the highest variance (4.787e-05) and THESG the lowest (1.226e-05). The off-diagonal elements show relatively small values mostly on the order of 1e-5 or lower indicating that residuals across variables are weakly related in terms of co-variation, and that the model sufficiently accounts for common dynamics in the system.

Table 3 presents the correlation matrix of residuals, measuring standardized linear relationships between each pair of residual series. Most correlations fall within the low-to-moderate range, with the highest correlations observed between SGESG and TH (0.4378), as well as SGESG and SG (0.4157). These results suggest that Singapore's ESG index maintains moderate linkage with both domestic and regional stock markets. Meanwhile, other ESG indices such as THESG and IDESG exhibit very low correlations with their respective general markets for example, only 0.0021 between IDESG and TH, and –0.0150 between THESG and SG implying relatively autonomous behavior.

The absence of extremely high correlations or anomalous patterns in the residuals supports the conclusion that the model performs well in capturing the underlying data structure. There is no evidence of severe multicollinearity or autocorrelation among residuals, and the residuals appear to approximate white noise behavior. This confirms the adequacy of the VAR model in representing the dynamics of the system and provides a reliable basis for subsequent analyses such as GFEVD and IRF estimation.

3. Result

3.1 Net Spillover Index

In the context of analyzing volatility spillover dynamics, the Net Spillover Index represents a pivotal metric for discerning the structural positioning of each market within the interconnected financial system. Beyond quantifying the magnitude of interaction among markets, it provides a clear indication of whether a market assumes the role of a net transmitter or a net receiver of volatility. Monitoring the temporal evolution of the Net Spillover Index enables researchers to trace shifting market roles in transmitting or absorbing shocks, thereby capturing changes in the underlying architecture of systemic risk. As such, it functions as a diagnostic indicator of financial system stability and reveals potential transitions in the regional epicenter of volatility propagation, particularly within ASEAN capital markets.

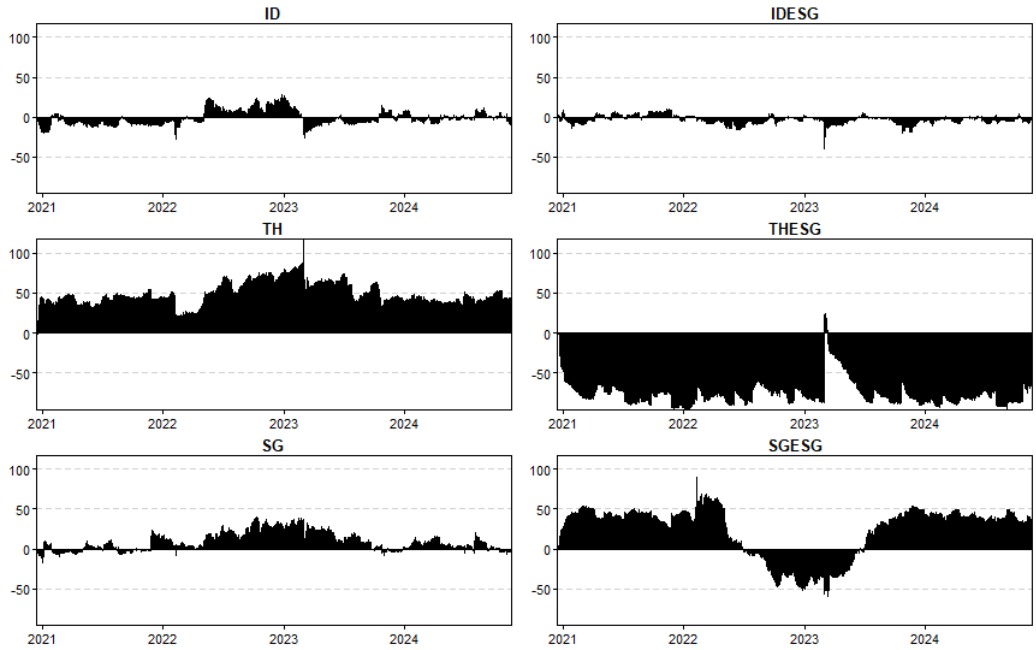

Figure 1 Net Spillover Index across all six markets

The figure 1 presents the Net Spillover indices for all six variables ID, TH, SG, IDESG, THESG, and SGESG over the period from 2021 to the end of 2024. Each subplot displays the daily net contribution of a given market to system-wide volatility. A positive value indicates that the market is acting as a net transmitter of volatility, while a negative value reflects its role as a net receiver of shocks from other markets.

Notably, Thailand's general stock market (TH) demonstrates a sustained positive Net Spillover throughout much of 2022, clearly suggesting that it played a leading role in transmitting volatility during that period. This pattern may reflect either domestic economic dynamics or Thailand's response to global financial shifts, which caused the Thai market to become a central node of volatility transmission within the region.

Conversely, THESG Thailand's ESG index consistently displays negative net spillover values, particularly after 2022. This marks it as a persistent net receiver of volatility, implying a degree of structural fragility in Thailand's ESG market. The pattern also suggests that THESG lacks sufficient mechanisms to absorb or cushion external shocks, rendering it sensitive to system-wide disturbances.

SGESG, the ESG index for Singapore, exhibits a more dynamic behavior. Initially acting as a receiver of volatility, the index transitions into a net transmitter by late 2023 and continues into 2024. This reversal could reflect growing investor confidence in Singapore's ESG market or broader regional integration, positioning SGESG as a more active force in shaping volatility across ASEAN markets.

In contrast, the general stock indices of Indonesia (ID) and Singapore (SG), along with Indonesia's ESG index (IDESG), show relatively stable and subdued Net Spillover profiles. In particular, IDESG remains nearly flat throughout the period, indicating a limited role in volatility propagation. SG shows slight fluctuations in the middle of the sample, possibly in response to movements in SGESG, which was emerging as a net transmitter during the same interval.

Overall, this figure highlights the asymmetry in how different markets contribute to and absorb volatility within the ASEAN financial system. The observed variation especially across ESG markets underscores the importance of market structure, investor behavior, and regional positioning in determining a market's systemic impact. Such information holds considerable policy relevance, helping to identify vulnerable markets and inform strategies to enhance systemic stability.

3.2 Impulse Response Function (IRF) Analysis of ASEAN ESG and Non-ESG Markets

This document presents a selected analysis of the Impulse Response Functions (IRFs) derived from the Time-Varying Parameter Vector Autoregression (TVP-VAR) model, focusing on volatility transmission between ESG and non-ESG stock indices in ASEAN countries: Thailand, Singapore, and Indonesia. The analysis selectively highlights only the most significant and interesting results to emphasize the dynamics of sustainable investment in the region.

3.2.1 Domestic Spillovers

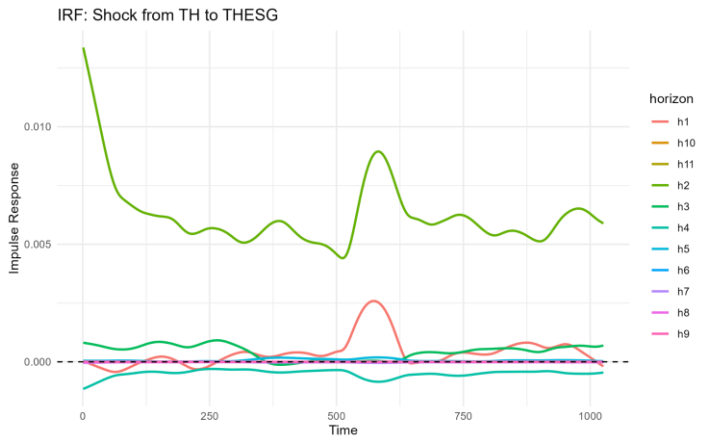

Figure 3 Impulse Response Function (IRF) TH to THESG

One of the most evident results is the impulse from the Thai stock market (TH) to Thailand's ESG index (THESG), as shown in Figure 3. The IRF graph displays statistically significant responses in the short and medium term, which gradually return to equilibrium over the long term. This indicates that the Thai ESG market remains sensitive to domestic market shocks and has not yet fully decoupled from the volatility of the general stock market.

3.2.2 ESG to Non-ESG Spillovers

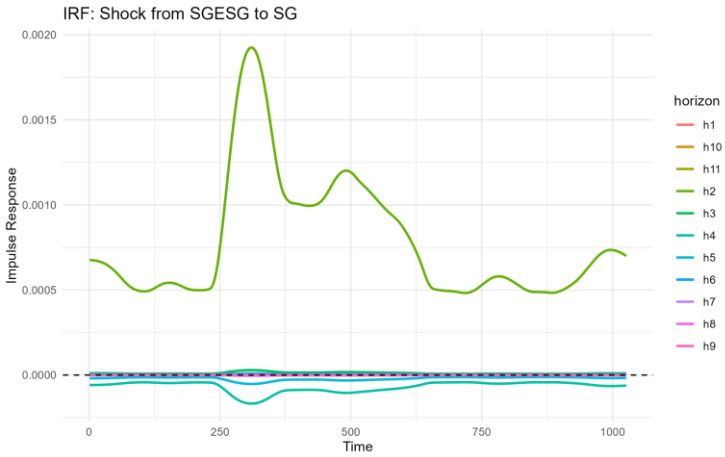

Figure 4 Impulse Response Function (IRF) SGESG to SG

One notable result is the impulse from Singapore's ESG index (SGESG) to its general stock market (SG), as shown in **Figure 4**. The IRF graph reveals a sustained response over the medium to long term, suggesting that ESG considerations in Singapore are becoming increasingly influential on the broader economy. The ESG market appears to be playing a leading role in transmitting risk to the general investment market.

3.2.3 Cross-Border Spillovers

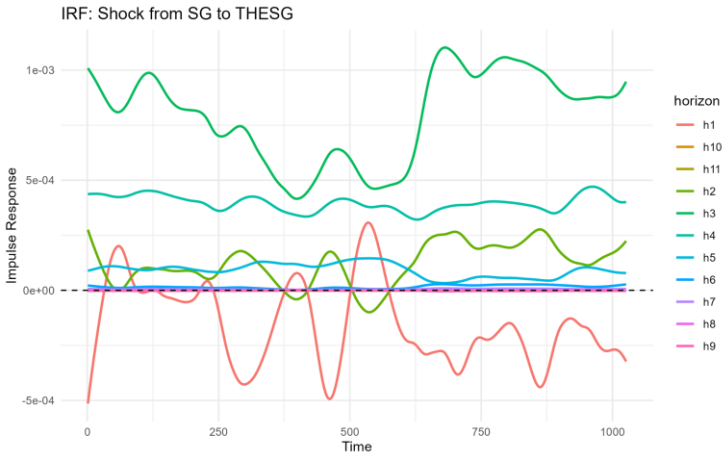

Figure 5 Impulse Response Function (IRF) SG to THESG

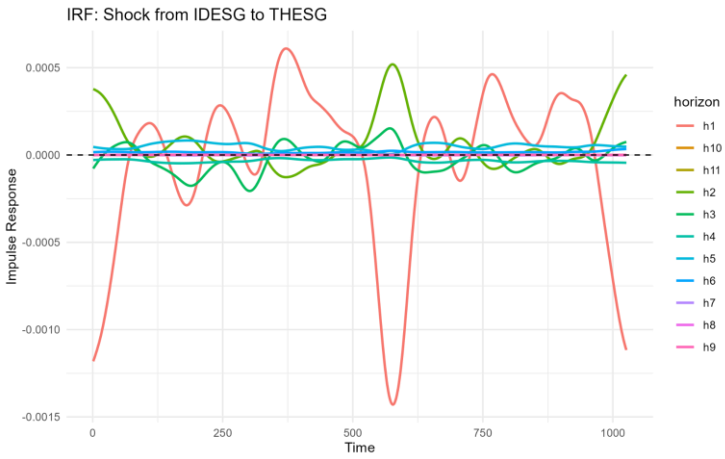

Figure 6 Impulse Response Function (IRF) IDESG to THESG

Two interesting cases emerge in the context of cross-border spillovers. First, shocks from Singapore's general stock market (SG) to Thailand's ESG index (THESG), as shown in Figure 5, exhibit a persistent long-run response, reflecting strong regional integration with Singapore serving as a key regional hub. Second, shocks from Indonesia's ESG index (IDESG) to Thailand's ESG index (THESG), as illustrated in Figure 6, display an immediate and intense short-run response, indicating that Thailand’s ESG market is highly sensitive to external shocks, particularly from neighboring ASEAN countries.

3.2.4 System Stability

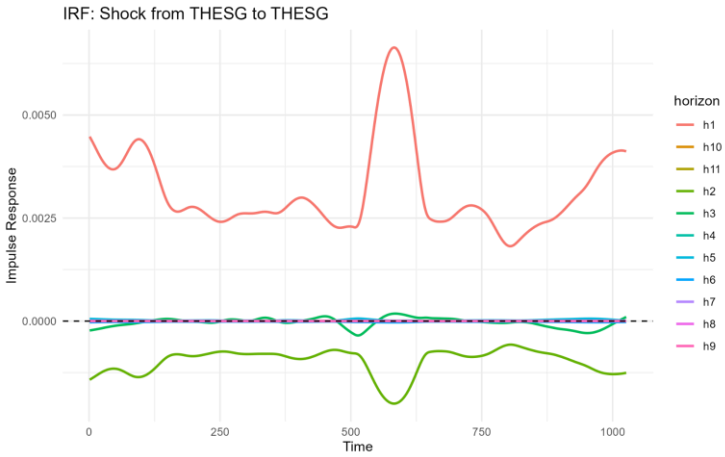

Figure 7 Impulse Response Function (IRF) THESG to THESG

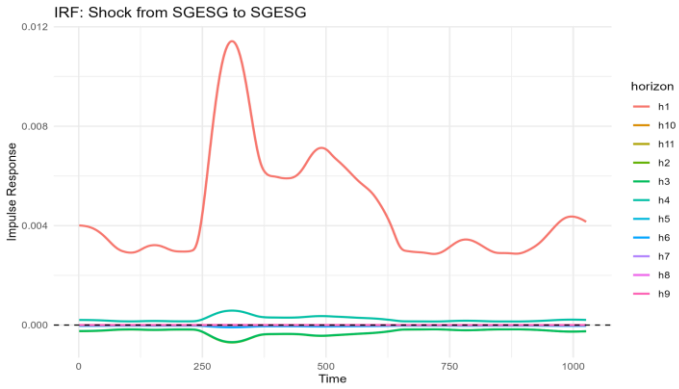

Figure 8 Impulse Response Function (IRF) SGESG to SGESG

System stability is clearly demonstrated in the Thailand's ESG index (THESG) to Thailand's ESG index (THESG) IRF in Figure 7, where initial strong responses dissipate over time, returning to equilibrium. This indicates the Thai ESG system's ability to absorb internal shocks. Similarly, Singapore's ESG index (SGESG) to Singapore's ESG index (SGESG) in Figure 8 displays quick reversion to equilibrium, reflecting Singapore's ESG market strength in handling volatility and potential crises

3.3 Volatility spillover effect

Volatility spillover effect is essential for capturing how shocks originating in one financial market or segment propagate to others, both domestically and across borders. These spillovers reflect the degree of interdependence between markets and are particularly relevant in the context of increasing integration between ESG and conventional markets in ASEAN economies.

Analyzing volatility spillovers helps reveal not only the direction and magnitude of shock transmission but also the systemic influence of specific markets. It provides insights into whether certain segments such as ESG indices act as shock absorbers or amplifiers within the broader financial network. In doing so, volatility spillover analysis contributes to a deeper understanding of market stability, vulnerability, and transmission channels, offering critical information for policymakers, investors, and regulators alike.

Table 4 Static Total Volatility Spillovers (TVP-VAR – Domestic)

	ID	TH	SG	IDESG	THESG	SGESG	FROM
ID	78.39	0	0	0.29	0	0	78.68
TH	0	70.84	0	0	1.25	0	72.09
SG	0	0	72.4	0	0	14.54	86.94
IDESG	0.13	0	0	99.00	0	0	99.13
THESG	0	57.66	0	0	15.27	0	72.93
SGESG	0	0	13.39	0	0	64.20	77.59
TO	78.52	128.5	85.79	99.29	16.52	78.74	
Inc. Own	78.39	70.84	72.4	99	15.27	64.2	TCI
NET	-0.16	56.41	-1.15	0.16	-56.41	1.15	29.84

Notes: Directional TO others (TO) represents the proportion of volatility shocks transmitted from a given market or index to all others, whereas Directional FROM others (FROM) indicates the share of volatility received. The net spillover (NET = TO − FROM) identifies whether a market serves as a net transmitter or a net receiver of volatility within the GFEVD framework. A net transmitter (positive NET) is a market that sends out more volatility shocks than it receives, thus acting as a source of instability. Conversely, a net receiver (negative NET) absorbs more volatility from others than it transmits, indicating greater vulnerability to external shocks. Inc. Own includes each variable's own contribution to its forecast error variance. TCI (Total Connectedness Index) measures the average level of volatility spillovers across the system.

Table 4 presents the domestic volatility spillover matrix based on the Time-Varying Parameter Vector Autoregressive (TVP-VAR) model and Generalized Forecast Error Variance Decomposition (GFEVD). This table isolates the volatility transmission between ESG and non-ESG indices within each ASEAN country (Indonesia, Thailand, and Singapore), thus focusing on internal market dynamics rather than cross-border effects.

The diagonal entries (Inc. Own) remain dominant, particularly for IDESG (99.00%) and TH (70.84%), indicating high self-dependence for some indices and more open interactions for others. For example, TH shows a relatively moderate own contribution (70.84%), with a large portion of its volatility explained by THESG (57.66%), suggesting strong internal coupling between ESG and conventional indices in Thailand. Similarly, SG (72.40%) has part of its volatility explained by SGESG (13.39%), highlighting the role of domestic ESG integration.

In terms of directional spillovers (TO and FROM), TH emerges as a major net transmitter (TO = 128.50%, FROM = 72.09%, NET = +56.41), showing that conventional indices in Thailand strongly affect their ESG counterparts. SG shows a slightly negative net role (TO = 85.79%, FROM = 86.94%, NET = –1.15), reflecting a balanced transmission relationship between SG and SGESG. ID remains close to neutral (TO = 78.52%, FROM = 78.68%, NET = –0.16), indicating a relatively isolated position with limited volatility exchange. IDESG is also nearly neutral (TO = 99.29%, FROM = 99.13%, NET = +0.16), reinforcing its stability. THESG, on the other hand, is the strongest net receiver (TO = 16.52%, FROM = 72.93%, NET = –56.41), showing its vulnerability to spillovers from TH. SGESG transmits slightly more than it receives (TO = 78.74%, FROM = 77.59%, NET = +1.15).

The Total Connectedness Index (TCI) for this domestic framework stands at 29.84%, indicating moderate internal volatility linkages. These findings highlight the structural dependence in ESG–conventional interactions within countries. Specifically, Thailand's conventional index exerts the strongest spillover influence, while Indonesia remains balanced and Singapore moderately integrated.

Table 5 Static Total Volatility Spillovers (TVP-VAR – ASEAN ESG Network)

	ID	T	S	ID	T	S	FROM
	H	G		ESG	HESG	GESG	
ID	0	5.98	5.55	0	0.27	9.51	21.72
T	4.87	0	7.92	0	0	15.12	27.91
S	4.85	7.89	0	0.2	0.11	0	21.13
ID	0	0.2	0.1	0	0.16	0.41	0.56
T	3.87	0	7.56	0.02	0	15.62	0.63
S	8.13	13.84	0	0.34	0.09	0	40.66
T	21.31	27.91	13.05	0.87	27.07	22.4	
Inc. Own	0	0	0	0	0	0	
NET	-0.41	-3.55E	-8.28	0.31	26.44	-18.26	
TCI	C 3.7537	T CI 29.84					

Notes: Directional TO others (TO) represents the proportion of volatility shocks transmitted from a given market or index to all others, whereas Directional FROM others (FROM) indicates the share of volatility received. The net spillover (NET = TO − FROM) identifies whether a market serves as a net transmitter or a net receiver of volatility within the GFEVD framework. A net transmitter (positive NET) is a market that sends out more volatility shocks than it receives, thus acting as a source of instability. Conversely, a net receiver (negative NET) absorbs more volatility from others than it transmits, indicating greater vulnerability to external shocks. Inc. Own includes each variable's own contribution to its forecast error variance. TCI (Total Connectedness Index) measures the average level of volatility spillovers across the system.

Table 5 presents the static cross-border volatility spillovers among six markets by filtering out domestic linkages and focusing solely on inter-country transmission. The resulting matrix captures the net volatility interactions across national borders, offering insights into the transnational dynamics of ASEAN capital markets in the ESG context.

The Cross-Total Connectedness Index (CTCI) is estimated at 3.75%, a notably low level relative to the full network's Total Connectedness Index (TCI) of 29.84%. This stark difference highlights the dominance of domestic over cross-border spillovers within the ASEAN network and suggests that volatility transmission remains largely confined within national boundaries.

The directional spillover measures reveal that Thailand's conventional (TH) and ESG indices (THESG) are the most prominent net transmitters across borders, with TO values of 27.91% and 27.07%, respectively. In contrast, Singapore's ESG index (SGESG) exhibits the highest FROM value at 40.66%, implying a substantial vulnerability to external volatility shocks. This result is consistent with SGESG's role as a net receiver (NET = –18.26), while THESG appears to act as a dominant external volatility contributor (NET = +26.44).

Meanwhile, the volatility spillovers between ID and other markets remain modest, reinforcing the notion that Indonesia's market maintains a relatively insulated position in the regional network. Similarly, the low spillovers from IDESG (TO = 0.87%) and its minimal exposure (FROM = 0.56%) further underscore its peripheral role.

These findings indicate that cross-border volatility transmission is limited in magnitude and concentrated among a few key nodes primarily Thailand while other ESG markets (such as IDESG) exhibit weak integration. Overall, the asymmetric spillover structure and low CTCI value reflect the early-stage development of a cohesive regional ESG ecosystem.

3.4 Comparison of Domestic and Regional Volatility Spillovers

A comparative analysis of domestic and regional spillovers reveals a striking asymmetry in the structure and magnitude of volatility transmission within the ASEAN-3 network. Domestic spillovers captured through the full matrix inclusive of intra-country linkages yield a Total Connectedness Index (TCI) of 29.84%, signifying moderate systemic interdependence. Notably, Thailand's conventional index (TH) and ESG counterpart (THESG) emerge as dominant transmitters, while THESG also receives substantial spillovers from its domestic pair. This bilateral interaction points to a tightly coupled dynamic within the Thai market structure.

By contrast, the filtered matrix of cross-border spillovers excluding all domestic linkages produces a Cross-Total Connectedness Index (CTCI) of only 3.75%, a nearly eightfold decline from the TCI. This sharp drop underscores the limited extent of volatility propagation across borders and reflects the segmented nature of ASEAN financial markets.

From a directional perspective, TH and THESG maintain their roles as primary volatility sources even in the cross-border context, while SGESG and SG continue to absorb shocks from the region. Conversely, ID and IDESG remain relatively insulated in both matrices, suggesting underdeveloped integration and minimal transmission capacity.

Overall, the contrast between domestic and regional networks highlights the centrality of local market structures in shaping volatility dynamics. While regional spillovers remain weak, the growing prominence of ESG indices especially in Thailand and Singapore indicates potential shifts in network influence as regional ESG integration deepens.

This study also carries important theoretical implications that challenge the conventional assumption that ESG investments automatically reduce volatility. According to Portfolio Diversification Theory, the benefits of risk reduction arise only when the newly added assets have low correlation with the existing ones. However, evidence from ASEAN markets shows that ESG indices particularly THESG move closely in line with their domestic conventional benchmarks. This reduces the diversification benefits and, in some cases, may even amplify volatility spillovers rather than absorbing them. On the other hand, Signaling Theory suggests that ESG disclosure should serve as a credible signal to reduce uncertainty and information asymmetry. Yet, in emerging ASEAN markets, disclosure standards remain inconsistent and are sometimes of low quality for instance, reports may be incomplete, irregular, or lack standardized criteria. As a result, ESG signals may fail to effectively reduce uncertainty and can even increase market vulnerability to external shocks. These theoretical perspectives explain why ESG indices in this study do not consistently play a stabilizing role but instead sometimes act as net receivers or even transmitters of volatility, reflecting that the volatility-reducing function of ESG is conditional upon market context rather than being an inherent characteristic of ESG investments.

4. Discussion

The empirical results provide new insights into the role of ESG indices in shaping volatility dynamics across Southeast Asian equity markets. By disentangling domestic and cross-border transmission mechanisms, the analysis reveals that volatility spillovers remain predominantly confined within national boundaries, with limited propagation across countries. This is evident in the stark difference between the Total Connectedness Index (TCI) of 29.84% and the Cross-Total Connectedness Index (CTCI) of only 3.75%. Such findings underscore the incomplete financial integration of the ASEAN region, particularly in the context of ESG adoption.

Thailand stands out as a key source of volatility in both domestic and regional networks. The Thai conventional index (TH) serves as a consistent net transmitter, while the Thai ESG index (THESG) exhibits asymmetric behavior absorbing volatility domestically but exerting some transmission effects regionally. This duality points to the increasing influence of ESG components in shaping Thailand's financial market dynamics.

Singapore presents a contrasting profile. While it's conventional and ESG indices (SG and SGESG) act as net receivers overall, the SGESG index gradually shifts into a transmitting role during the latter part of the sample, notably from late 2023 to early 2024. This shift reflects Singapore's advancement in ESG infrastructure and its emerging leadership within the regional ESG ecosystem.

Indonesia, by contrast, remains peripheral in the volatility transmission network. Both ID and IDESG show minimal involvement in spillover activity, suggesting lower market maturity, shallow integration, or limited investor responsiveness to ESG-related information.

Importantly, the study challenges the notion that ESG markets inherently reduce volatility. While ESG indices may serve as absorbers of shocks in some contexts (e.g., THESG), they can also become volatility sources under specific market conditions (e.g., SGESG). This finding aligns with the view that ESG markets, especially during periods of structural transition, may amplify rather than dampen systemic risks. Taken together, these results highlight a nuanced role of ESG in financial stability. ESG integration may enhance transparency and investor discipline but does not automatically equate to lower volatility. The asymmetry in spillover structures between domestic and regional networks calls for a more tailored approach to ESG policy implementation and financial integration across ASEAN.

This study also carries important theoretical implications that challenge the conventional assumption that ESG investments automatically reduce volatility. According to Portfolio Diversification Theory, the benefits of risk reduction arise only when the newly added assets have low correlation with the existing ones. However, evidence from ASEAN markets shows that ESG indices particularly THESG move closely in line with their domestic conventional benchmarks. This reduces the diversification benefits and, in some cases, may even amplify volatility spillovers rather than absorbing them. On the other hand, Signaling Theory suggests that ESG disclosure should serve as a credible signal to reduce uncertainty and information asymmetry. Yet, in emerging ASEAN markets, disclosure standards remain inconsistent and are sometimes of low quality for instance, reports may be incomplete, irregular, or

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In comparative terms, the weak cross-border spillovers observed in ASEAN differ from evidence in developed regions such as Europe and North America, where ESG markets are more mature, disclosure standards are more robust, and cross-border financial integration is deeper. This divergence highlights that ESG's stabilizing role is not universal but contingent on market maturity and institutional quality. Methodologically, the application of the TVP-VAR framework combined with GFEVD has enabled this study to capture both the direction and magnitude of volatility linkages, offering dynamic evidence that ESG's contribution to financial stability is conditional rather than inherent.

5. Conclusion

This study examined the volatility spillover structure between ESG and conventional stock indices across three ASEAN markets Thailand, Indonesia, and Singapore using a TVP-VAR model combined with GFEVD. The findings reveal that volatility spillovers remain predominantly domestic, with limited regional integration. The Total Connectedness Index (TCI) for the domestic network stood at 29.84%, while the Cross-Total Connectedness Index (CTCI) was notably lower at 3.75%, highlighting weak cross-border linkages.

Thailand's conventional index (TH) emerged as a persistent net transmitter of volatility, while its ESG counterpart (THESG) functioned largely as a net receiver. This underscores the asymmetric interaction between traditional and sustainable assets in Thailand. Conversely, Singapore's ESG index (SGESG) transitioned into a net transmitter role during late 2023, signaling the increasing relevance of ESG markets in regional volatility transmission. Indonesia's markets played a marginal role in both domestic and regional networks, reflecting their relative detachment from spillover dynamics.

The results challenge the conventional assumption that ESG investments inherently reduce volatility. Instead, ESG indices may absorb or transmit shocks depending on market maturity, structural conditions, and disclosure practices. This finding aligns with Portfolio Diversification Theory, which suggests that risk reduction occurs only when correlations between assets are sufficiently low an effect that is muted in ASEAN markets where ESG indices often co-move strongly with conventional benchmarks. It also resonates with Signaling Theory, as weak or inconsistent ESG disclosures in emerging markets may fail to reduce information asymmetry, limiting their stabilizing role and, in some cases, increasing vulnerability to external shocks.

In comparative terms, the weak cross-border spillovers observed in ASEAN contrast with evidence from developed regions such as Europe and North America, where ESG markets are more mature and exhibit stronger financial integration. This divergence underscores that ESG's role in promoting stability is not universal but market-specific and maturity-dependent. Methodologically, the use of the TVP-VAR framework with GFEVD has enabled this study to capture both the direction and intensity of volatility linkages, highlighting the conditional nature of ESG's stabilizing function.

Policy efforts aimed at strengthening ESG disclosure standards, harmonizing regional practices, and fostering cross-border financial integration may enhance the resilience of ASEAN markets and allow ESG to realize its stabilizing potential. Future research should extend the comparative perspective by examining other regions, while also exploring the roles of investor sentiment, regulatory heterogeneity, and ESG scoring methodologies in shaping volatility transmission.

Acknowledgements

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Analysis of Thailand's Fresh Durian Export to China From the Aspect of New Structural Economics

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Abstract
After analyzing the changes in Thailand's durian export volume to China from 2010 to 2024, this study identifies China's per capita disposable income growth rate, China's total import growth rate, and Thailand's domestic factors as the main determinants. Empirical results show that China's income and import growth do not have a significant effect on Thai durian exports. By contrast, Thailand's durian production index significantly drives Thailand's durian export. It shows a rising trend of farm-gate prices, but there is no significant influence on exports, which indicates that durian production capacity is the main determinant of durian export volumes. The findings also demonstrate that, according to New Structural Economics, the Thai government effectively leverages its factor endowments to establish a comparative advantage in durian exports. The results are aligned with the facilitating government theory of NSE. It suggests that Thailand's strategic investments in agricultural infrastructure and supportive export policies may have contributed to the growth in durian production capacity and export performance. This research deepens the understanding of supply-side factors that shape bilateral agricultural trade and provides practical policy insights for sustaining Thailand's tropical fruit exports.

Keywords: Fresh durian exports; New Structural Economics; Comparative advantages; Factor endowments; Facilitating government.

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1. Introduction

Due to a trade reversal in 2022, China has now overtaken the United States as Thailand's top trading partner for nine years. Despite being a prominent exporter of agricultural products, China still relies heavily on imports due to factors such as population, geographical location, and industrial development needs. Thailand is China's third-largest source of agricultural product imports, which has a tropical monsoon climate, rain and heat at the same time, rich arable land resources, and abundant agricultural labour. The trade volume of traditional agricultural products between these two countries has shown an upward trend in agricultural trade. China is still the largest export market for Thai agricultural products, and Thailand has long been in a surplus position. In 2022, the total trade volume of agricultural products between these two countries reached 13.1 billion US dollars, with Thailand's exports to China being US$10.3 billion, making a 3.1% increase. Among agricultural products exported from Thailand, 90% of the durian is exported to China and has become the top one with the highest value.

1.1 Changes in Thailand's durian exports to China

Since 2019, the total export value of durian has surpassed vegetables, which is the traditional agricultural export product, becoming Thailand's most exported agricultural product (Likhitpichitchai, Khermkhan, & Kuhaswonvetch, 2023). From 2010 to 2024, Thailand's durian exports to China experienced an upward trend, with year-on-year increases, and there was a slight decline of 15% in 2017. Even during the COVID-19 pandemic from 2020 to 2022, the export value of durian increased significantly compared to the pre-pandemic period, reaching its peak of $ 4,020,685,430 in 2023.

Table 1: Export value of Thailand's durian exports to China

Unit: US dollars

Year	Trade Value	Net Weight (kg)	Average Value($/kg)
2010	69,896,810	124,784,242	0.5601
2011	83,398,980	142,617,515	0.5848
2012	127,788,490	204,585,594	0.6246
2013	142,988,549	198,874,814	0.7190
2014	160,924,503	149,949,231	1.0732
2015	196,833,040	158,792,402	1.2395
2016	257,691,862	158,080,693	1.6301
2017	217,383,648	135,708,185	1.6018
2018	418,360,624	202,480,711	2.0661
2019	849,599,699	375,332,897	2.2635
2020	1,508,952,059	444,411,713	3.3953
2021	3,070,090,874	779,914,005	3.9364
2022	3,027,983,566	791,916,555	3.8236
2023	4,020,685,430	953,831,094	4.2153
2024	3,652,319,065	831,748,921	4.3911

Source: Calculated based on UN Comtrade Database

1.2 Introduction of New Structural Economics

New Structural Economics (NSE), which was developed by Prof. Justin Yifu Lin and his associates, is based on the empirical experience of China's economic development from the Reform and Opening Up. This theory provides a framework for understanding economic growth, structural transformation, and industrial upgrading in China (Lin, 2011, 2013, 2019). Within this framework, two concepts are relevant for analyzing Thailand's durian exports: factor endowments and facilitating government. The theory emphasizes that developing countries can make good use of their factor endowments, land, labour, and capital, to develop their own industries in which they can build up comparative advantages. At the same time, a facilitating government help the market grow robustly by actively reducing transaction and coordination costs, solving infrastructure bottlenecks, and supporting strategic methods through policy interventions such as trade agreements, investment in logistics and technology (Lin & Wang, 2017). This government role does not replace the market and only strengthens a country's ability to upgrade industries and establish a comparative advantage.

In the context of Thai durian exports, this study applies the NSE framework to examine how Thailand uses its factor endowments to enhance durian production capacity and export competitiveness. This paper will improve the comparative advantages of Thailand's durian export at first and then find the influencers of Thailand's durian export to China.

1.3 Literature Review and Research Gap

Previous studies have shown that Thai durian exports to China have a strong performance according to Thailand's revealed comparative advantage (RCA). The RCA indicates Thailand has its own advantages in durian export all over the world (Noodaeng,2017). But these studies often do not point out the underlying factors that generate this

advantage. Even though other researchers have also examined external influences, such as the Belt and Road Initiative (Piratorn & Jiranuwat, 2018), Free Trade Area Agreements, China's GDP growth (Petchaluck, Pathairat, & Songsak, 2017), and infrastructure projects like the China-Laos Railway (Pattaraporn, 2017), their results consistently highlight that China, such as Chinese demand and policy factors, dominates the bilateral trade.

However, no studies have examined Thailand's supply-side determinants, which include factor endowments and facilitating government policies in Thai durian export. It remains unclear whether Thailand's own comparative advantage drives China's choice to import Thai durians, or whether Chinese economic growth and import demand are the main determinants. In addition, no studies have improved the interaction among Thailand's durian production, farm-gate prices, and durian export. In that case, there is a research gap about which really drives Thailand's durian export increasingly- Thailand's own economic fundamentals and government policies or Chinese market factors. This paper tries to address this gap by applying the New Structural Economics framework, which advocates for equal status among nations, to analyze both supply-side and demand-side determinants of Thai durian exports to China from 2010 to 2024.

2. Methodology

2.1 Data Sources

In this study, the export data are sourced from the UN Comtrade Database and the World Bank. The values published in the database are reported in nominal USD, and there is no adjustment for inflation applied unless otherwise specified. China's per capita disposable income growth rate and export growth rate are from the National Bureau of Statistics of China. Thailand's durian production index and farm-gate price index are from the Office of Agricultural Economics, Thailand.

2.2 Research Methods

Quantifying differences between specific countries' comparative advantages in producing goods is challenging for several reasons. These include problems arising from data aggregation and the fact that factors unrelated to comparative advantage may affect trade flows. According to the tools published by the World Bank and United States International Trade Commission, and based on the representativeness level of each evaluation indicator and the availability of relevant data, this study uses the following trade competitiveness evaluation indicators: share of product in total exports (SPTE), the Balassa index (RCA), and revealed symmetry comparative advantage index (RSCA) to analyze the comparative advantages of Thailand's durian to China and the world.

2.2.1 Share of Product in Total Exports

It is the share of each export product (at a chosen level of disaggregation) in the country's total exports. The formula is:

$$SPTE_{Ai} = X_{Ai}/X_{At} * 100\%$$

In this formula, $SPTE_{Ai}$represents the share of product i in country A's total exports, X_{Ai}represents the total export volume of product i in country A, X_{At} represents the total export volume in country A. It shows that the larger the value, the greater the impact of a certain product on the country's total exports.

2.2.2 The Balassa Index

The Balassa Index, known as the revealed comparative advantage (RCA), is based on Ricardian trade theory, which posits that patterns of trade among countries are governed by their relative differences in productivity (Balassa, 1965). RCA can be used to provide a general indication and first approximation of a country's competitive export strengths. The RCA index for the product i in country A is typically measured by that product's share of that country's exports relative to its share of world trade:

$$RCA_{Ai} = \frac{X_{Ai}/X_{Aj}}{X_{wi}/X_{wj}}$$

In this formula, X_{Ai} and X_{Aj} are the country A's exports of product i, and the country A's total exports. X_{wi} and X_{wj} refer to the world's exports of product i, and the world's total exports. If the value is less than 1, it indicates that the country has a clear comparative disadvantage in producing the product. Likewise, if the index exceeds 1, the country is said to have a revealed comparative advantage in the product.

2.2.3 Revealed Symmetry Comparative Advantage Index

In 1995, Laursen and Engedal expanded upon the RCA index and developed the RSCA index, which generates scores ranging between −1 and +1 and is symmetric around zero. Countries with RSCA scores close to +1 have a higher revealed comparative advantage, and countries with scores close to −1 have a lower one. An RSCA score of zero indicates that the government has neither a comparative advantage nor a disadvantage in that product. The RSCA index is a function of the RCA for a country and product pair:

$$RSCA_{Ai} = (RCA_{Ai} - 1)/(RCA_{Ai} + 1)$$

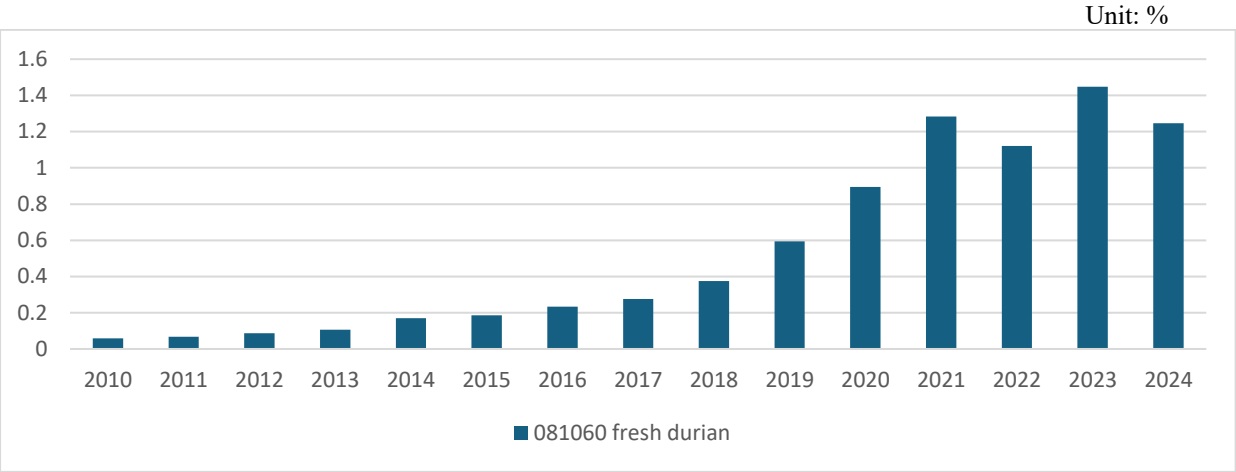
The RSCA is derived from the Balassa index and has been used extensively to quantify comparative advantages. This index helps identify and compare the strengths and weaknesses of various countries across specific industries and products.

3. Result

3.1 Share of Product in Total Exports of Durian in Thailand

The SPTE index illustrates the proportion of durian exports within Thailand's total export value. According to the data, Thailand's durian exports have shown a consistent upward trend in recent years. It shows an increasing specialization in durian export in Thailand. The graph shows that from 2010 to 2024, there was a steady increase in the share of fresh durian (HS code 081060) in Thailand's total exports. This consistent increase suggests that fresh durian has become an increasingly important agricultural export in Thailand's bilateral trade, especially with China.

Graph 1. SPTE index of Thailand's fresh durian exports



Source: Calculated based on UN Comtrade Database

From the perspective of New Structural Economics (NSE), this phenomenon reflects that Thailand has a comparative advantage in durian export. The Thai government and people make full use of their factor endowments, such as a favourable tropical climate, agricultural land, and labour supply. The steady rise in the SPTE index means that durian production aligns well with Thailand's natural endowments, and the government has played a facilitating role in promoting durian planting with its trade policies. This demonstrates the core principle of NSE theory, which is the interaction between an effective market and a facilitating government.

3.2 The Balassa Index and RSCA of Thailand's Fresh Durian Exports

Between 2010 and 2024, the Balassa Index (RCA index) has remained above 1, and the RSCA index shows a positive trend with above 0.9. These high and stable values mean that Thailand has a robust comparative advantage in durian export. In 2022, the highest value of RSCA (0.9701) corresponds with the highest Balassa Index (65.8882), which reinforces the reliability of these two measures and provides evidence that Thailand has a significant comparative advantage in durian exports to the world, including the Chinese market. Thailand's durian exports to China are not only competitive but also advantageous in the global market. Saowanit Noodaeng (2017) found that the RCA values of Thailand's fresh durian show a dominant comparative advantage in China.

Table 2: The Balassa index and RSCA index of Thailand's fresh durian exports

Year	The Balassa Index (RCA)	RSCA
2010	42.1669	0.9537
2011	45.2220	0.9567
2012	38.4234	0.9493
2013	40.1742	0.9514
2014	48.3530	0.9595
2015	40.2826	0.9516
2016	36.4844	0.9466
2017	37.2838	0.9478
2018	44.6786	0.9562
2019	49.5583	0.9604
2020	55.9313	0.9649
2021	64.7828	0.9696
2022	65.8882	0.9701
2023	49.2177	0.9602
2024	62.6131	0.9686

Source: Calculated based on UN Comtrade Database

According to New Structural Economics, one country's comparative advantage is determined by its factor endowments (Lin, 2017). The high RCA and RSCA values mean that durian exports benefit from Thailand's economic structure and policies. This comparative advantage reflects a successful combination of the market and the government. Measures such as tariff reductions with ASEAN-China Free Trade Agreements, the improvement of cold chain logistics, and infrastructure improvement with China have enabled durian to become Thailand's flagship export product in agricultural trade (Shaharudin, Wararatchai & Maninakha, 2025).

4. Discussion

4.1 The Role of the Facilitating Government

New Structural Economics (NSE) emphasizes the importance of the relationship between a country's industrial structure and factor endowments (Lin, 2013). In this framework, the concept of facilitating government is very important. When markets are efficient in allocating resources and form existing comparative advantages, governments play a vital role in reducing transaction costs, developing healthy trade relationships and building infrastructure. A facilitating government does not replace the market, but serves the public by improving infrastructure, trade policy, and institutional reforms to transform potential advantages into competitive outcomes (Lin & Wang,2017).

From the above index, we can find that the success of the Thai government's exports strategy and agricultural development is reflected in the stable exports of durian. Thailand has formed a long-term comparative advantage in durian exports. The Thai government has used its endowment factors in durian planting, such as land and labour force and played the role of a facilitating government within it.

4.2 Factors of Thailand's Durian Exports to China

Based on the New Structural Economics (NSE) framework, this study emphasizes the role of factor endowments and facilitating government in establishing Thailand's comparative advantage in durian exports. Thailand makes use of natural advantages in land, labour, and capital to increase durian exports in the global durian market. In the meantime, the Thai government has made positive policies, developed infrastructure, and promoted trade agreements to strengthen durian export competitiveness.

From this NSE perspective, the main determinants for analyzing Thai durian exports to China are selected with both supply-side and demand-side influences. On the supply side, Thailand's total durian production index and farm-gate price index are considered as primary drivers to reflect the country's factor endowments and production efficiency. On the demand side, China's per capita disposable income growth and total import growth rate are used to examine the potential effects of the Chinese market on Thai durian exports.

To empirically assess these relationships, this paper adopts a modified gravity model and focuses on both the impact of Thailand's domestic capabilities and China's economic conditions. The analysis is from 2010 to 2024 for a comprehensive evaluation of long-term trends and the performance between supply-side and demand-side factors in Thailand's durian export.

The model is specified as follows:

$$\ln(Durian\ Export_{\ t}) = \beta_0 + \beta_1 \ln(ProductionIndex_t) + \beta_2 \ln(FarmGatePriceIndex_t) + \beta_3 \ln ChinaIncomeGrowth_t + \beta_4 \ln ChinaImporGrowth_t + \epsilon_t$$

Table 3: Variables and Descriptions in the Gravity Model

Variable Name	Symbol	Unit	Log Transformation	Description
Thai export to China （durian）	$Durian\ Export_t$	USD (FOB)	Yes	Annual export value of Thai durian to China; dependent variable
Production Index	$ProductionIndex_t$	Index	Yes	Thailand's durian production index, indicating annual output relative to 2005 base year
Farm Gate Price Index	$FarmGatePriceIndex_t$	Index	Yes	Farm gate price index of durian (2005 = 100), indicating relative changes in farmers' selling prices
China Import Growth Rate	$ChinaInportGrowth_t$	%	No	Thailand's nominal GDP in year t represents export supply capacity.
China's per capita disposable income growth rate	$IncomeGrowth_t^{China}$	%	No	Year-on-year growth rate of China's per capita disposable income (real).
Error term	ϵ_t			Residual capturing unexplained variation in exports

Based on the specified gravity model, we analyse regression to examine the determinants of Thailand's fresh durian exports to China. $DurianExport_t$ is the dependent variable expressed in natural logarithms. The model includes $ProductionIndex_t$ and $FarmGatePriceIndex_t$. These two supply-side variables were measured as indices (2005 = 100) and then transformed into natural logarithms to facilitate elasticity interpretation. On the demand side, the annual growth rate (%) of China's per capita disposable income, $ChinaInconeGroth_t$ and the total imports growth rate (%) of China $ChinaImportGrowth_t$ are kept in their original percentage form to avoid issues with negative values. The error term ϵ_t capturers unexplained variation in Thailand's durian exports. The coefficients of the logarithmically transformed variables can be explained as elasticities. In contrast, the coefficients of the growth rate variables are seen as the effect of a one-percentage-point change on Thailand's durian exports.

Table 4: Regression Results

Variable	Coefficient	Std. Error	t-value	p-value	Interpretation
Intercept	2.4596	2.0247	1.215	0.2523	Baseline value of ln(exports) when all other variables are zero
lnProductionIndex	2.9000	0.5668	5.116	0.00045	A 1% increase in production index is associated with an average 2.9% increase in ln(exports), highly significant
lnFarmGatePriceIndex	0.7737	0.4920	1.573	0.1469	Changes in farm-gate price index have no significant effect on exports
ChinaIncomeGrowth	0.0542	0.0713	0.760	0.4648	Growth in China's per capita disposable income has no significant effect on exports
ChinaImportGrowth	-0.0095	0.0085	-1.129	0.2854	Growth in China's imports has no significant effect on exports
Model Statistics: Residual Std. Error = 0.3465 on 10 DF; Multiple R-squared = 0.9601; Adjusted R-squared = 0.9442; F-statistic = 60.22 on 4 and 10 DF, p-value = 5.836e-07					

Source: Calculated based on the UN Comtrade Database, the World Bank and the National Bureau of Statistics of China, Office of Agricultural Economics (Thailand)

Based on a gravity model, the results show regression analyses on Thai durian exports to China from 2010 to 2024 through the examination of the impact of China's per capita disposable income growth and China's total imports growth rate, as well as Thailand's durian production index and farm-gate price index. The regression results indicate that Thai durian exports are significantly influenced by Thailand's total durian production, with the production index (coefficient = 2.9000, p = 0.00045), which shows that durian production is the primary driver of durian export. In contrast, the farm-gate price index of durians shows no significant effect on export volumes (coefficient = 0.7737, p = 0.1469), even though there is a trend in farm-gate prices over this period. These findings suggest that although farmers' selling prices have been increasing, export volumes are mainly determined by production capacity rather than the price fluctuations.

Since 2010, the total value of Thailand's durian exports to China appears to be independent of China's total import growth rate and the growth rate of per capita disposable income. The regression results show that China's import growth (coefficient = -0.0095, p = 0.2854) has no statistically significant effect on Thai durian exports. At the same time, the growth rate of China's per capita disposable income (coefficient = 0.0542, p = 0.4648) does not significantly influence durian export. These findings show that although durian is a high-priced tropical fruit, China's export volume from Thailand is still not sensitive to changes in Chinese consumers' income or total import trends. Even during the COVID-19 period (2020–2021), Thai durian exports to China increased with growth in Thailand's production. But China's total imports declined, and per capita disposable income grew slowly. These results prove the regression findings and suggest that China's domestic factors and shocks did not change Thailand's long-term export pattern.

The R-squared of the model including only China's economic factors is moderate. It indicates that these variables cannot fully explain Thai durian exports alone. When Thailand's durian production index and farm-gate price are included, the overall model fit improves substantially (Adjusted $R^2 = 0.9442$). It confirms that Thai domestic factors are the primary drivers of exports.

4.3 Robustness Check

To ensure the robustness of the regression findings above, additional checks are used. 1. Heteroskedasticity-robust standard errors are used to ensure that the estimated coefficients are not sensitive to potential heteroskedasticity or extreme observations. 2. Subsample regressions are used by splitting the study period into two periods (2010–2016

and 2017–2024). It verifies whether the main findings hold across different subperiods. These procedures are used to verify the main conclusions: Thailand's durian production index is the primary driver of Thailand's durian exports, and China's economic factors have a limited impact, which remains consistent under alternative specifications and time periods.

Table 5: Robustness Check: Regression Results with Heteroskedasticity-Robust Standard Errors

Variable	Estimate	Robust Std. Error	t Value	p-value
Intercept	2.4596	2.0475	1.201	0.2573
lnProductionIndex	2.9000	0.6345	4.571	0.0010
lnFarmGatePriceIndex	0.7737	0.5080	1.523	0.1587
ChinaIncomeGrowth	0.0542	0.0526	1.030	0.3217
ChinaImportGrowth	-0.0095	0.0065	-1.468	0.1728
Note: Robust standard errors are generated using the HC1 method. The subsample regressions for the periods 2010–2016 and 2017–2024 yield results consistent with the full-period regression.				

Source: Calculated based on the UN Comtrade Database, the World Bank and the National Bureau of Statistics of China, Office of Agricultural Economics (Thailand)

The robustness check confirms that the main findings from the primary regression remain consistent. Thailand's durian production index continues to be a significant driver of durian exports to China. But China's per capita disposable income growth and total import growth remain statistically insignificant. This means that the conclusion that Thai durian production capacity determines more on durian export than Chinese economic factors is robust to alternative model specifications and different subperiods.

5. Conclusion and Recommendation

5.1 Conclusion

In the past 15 years, Thailand's durian export has maintained a long-term and stable growth. The findings of this study confirm that Thailand's durian exports to China are primarily driven by its domestic factors instead of the changes in China's economy. According to the framework of New Structural Economics (NSE), Thailand has effectively leveraged its factor endowments to promote durian production and strengthen its comparative advantage in the Chinese market. The results show that Thailand's production index has a significant impact on export, and farm-gate prices also demonstrate a consistent upward trend to support farmers' income growth. In contrast, the increase in China's income growth and total imports is insignificant. It suggests that Thai durian exports are less sensitive to external demand-side fluctuations.

Even during COVID-19, China's import volume declined, and income growth slowed, but Thai durian exports continued to rise. This performance showed the important role of Thailand's facilitating government in supporting production recovery, enhancing export logistics, and ensuring market recovery. It has established a comprehensive operating system, spanning from the central to local levels, in terms of agricultural policy formulation, scientific research fund management, and technology management system construction (Thongkaew, Jatuporn, Sukprasert, Rueangrit & Tongchure, 2021). This alignment between the empirical results and the perspective of NSE indicates that Thailand's internal production capacity and government intervention are the main driving forces of durian export growth.

5.2 Recommendation

According to the empirical findings and the framework of New Structural Economics (NSE), there are three policy recommendations for Thailand's durian exports. These recommendations focus on maintaining domestic production capacity, increasing farmers' income, and strengthening export stability.

1. Strengthen Government Support

The regression results indicate that Thailand's total durian production is the primary driver of export performance (coefficient = 2.9000, p = 0.00045). With the New Structural Economics framework, facilitating government plays an important role in supporting production expansion. Policymakers should continue to provide infrastructure, logistics, and technology support for durian production. These can enhance production efficiency and ensure a stable supply for durian export.

2. Maintain Income Growth

Although the farm-gate price index of durians is not statistically significant in explaining export volumes (coefficient = 0.7737, p = 0.1469), it shows an increasing trend during the study period. This suggests that farmers' incomes have been rising, but do not influence export growth. Policies such as price stabilization mechanisms, cooperative support structures, and market information services can help ensure that farmers continue to benefit from durian export expansion.

3. Focus on the Chinese Market

Due to the unique taste of durian, the acceptance of durian in the global fruit market is more limited compared with other Thai tropical fruits such as mango, banana, or lychee. So developing new export markets for durian requires

further research. In the medium term, it is necessary to maintain focus on the Chinese market. China's durian market is stable and reliable. Now Thailand faces competition from other ASEAN countries, which are seeking to share the Chinese durian import market. Policymakers should continue to strengthen production capacity and logistical support to maintain export volume, as well as look for potential opportunities for market diversification.

5.3 Limitations and Further Research

This study has several limitations. First, although durian exports are mainly from ASEAN countries, this paper only focuses on Thailand. A comparative analysis with other major exporters, such as Malaysia and Vietnam, is not included. This makes the external validity and generalizability of the findings limited. Second, as durian is a highly seasonal fruit, its production is affected by natural factors such as climate and rainfall. However, these variables were not included in this study. Finally, facilitating government in the New Structural Economics framework in this study only highlights the role of Thailand's domestic policies. This paper does not examine the impact of bilateral and regional trade agreements, such as the China–ASEAN Free Trade Agreement (CAFTA) and the Regional Comprehensive Economic Partnership (RCEP) or Thailand's Eastern Economic Corridor (EEC) initiative. This omission restricts a more comprehensive understanding of the government's role in supporting durian exports.

Future research could address these limitations by conducting cross-country comparisons, adding climate-related variables, and analyzing key trade agreements and regional initiatives. Such extensions would provide a broader perspective on the dynamics of durian exports and the role of the facilitating government in bilateral trade.

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The Impacts of Promotion Methods and Perceived Risks on Purchase Intention of Sun Protection Product

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Abstract
This study investigates the influence of perceived risk on Chinese female college students' purchase intentions toward domestic sunscreen products under different promotional strategies. Using a sample of 438 participants and employing OLS regression, the analysis reveals that consumers' perceptions of risk are not uniform across all types of promotions but vary depending on specific risk dimensions. In particular, significant differences are observed in perceptions of privacy risk, financial risk, and functional risk across the four promotional formats-cashback, lottery, discount, and gift. Among the six examined risk dimensions-time risk, privacy risk, service risk, financial risk, functional risk, and social risk-service risk consistently exerts the most substantial negative impact on purchase intention across all promotional types. Additionally, financial and privacy risks are found to significantly deter purchase intentions in certain promotional contexts. Functional risk plays a particularly salient role in discount and gift promotions. Conversely, time risk and social risk appear to have minimal influence on purchase decisions in the online sunscreen product setting. These findings underscore the critical need for marketers to tailor promotional strategies in a way that specifically addresses and mitigates the dominant perceived risks associated with each promotion type, thereby enhancing the effectiveness of marketing efforts targeting young female consumers.

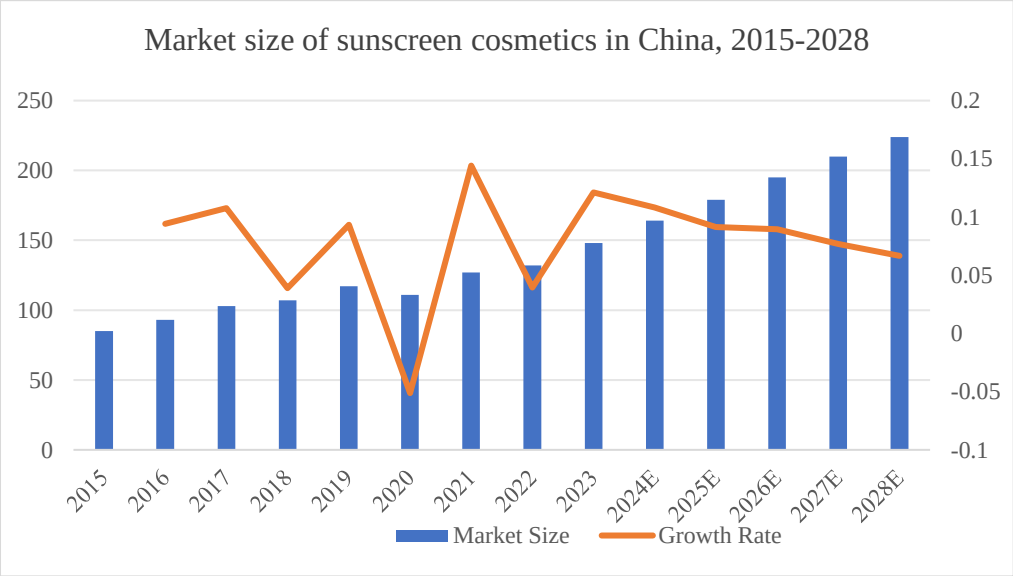
Keywords: Perceived Risk, Promotion Method, Purchase Intention.

1. Introduction

Over the past few decades, China has achieved remarkable economic progress. Correspondingly, the income and consumption levels of Chinese residents have been rising annually. Overall, the consumption pattern has shifted from basic needs to affluent consumption, indicating that Chinese consumers are increasingly seeking enjoyable products and experiences. Among these, suncream cosmetics have become a new consumption hotspot under this emerging trend. To better assist suncream cosmetics enterprises and relevant policymakers in seizing this developmental window for the suncream cosmetics industry, and to fully leverage this industry to drive economic growth and improve consumers' living standards, this study focuses on suncream cosmetics. The goal is to identify methods to boost sales and increase market share of domestic suncream cosmetics in China.

1.1 Characteristics of the Chinese suncream Cosmetics Market

The suncream cosmetics market in China started relatively late. However, with the gradual spread of the suncream concept in recent years, China's suncream market has rapidly developed and now boasts considerable scale. The market size of China's suncream cosmetics has surged from less than 10 billion RMB in 2015 to 14.8 billion RMB in 2023, nearly doubling in less than a decade (iiMedia, 2023).



Data Source: iiMedia Research 2024

From Fig 1.1, it is evident that the market size of suncream cosmetics in China has consistently maintained a rapid upward trajectory. The only exception occurred in 2020 when the COVID-19 pandemic led to a significant reduction in outdoor activities among Chinese residents, resulting in a 4.9% decrease in market size compared to the previous year. However, with the easing of pandemic controls, consumption of suncream cosmetics in China has resumed its strong growth. Notably, since 2023, the Chinese government's promotion of domestic tourism as an economic driver has sharply increased consumer demand for suncream products. This surge in demand has provided new growth momentum for major suncream cosmetic brands. Therefore, with the accumulation of multiple favorable factors, we have reason to believe that China's suncream market is poised to enter a window of opportunity for development.

In terms of development depth, China's suncream cosmetics industry is still at a relatively early stage, with low per capita consumption and market penetration. The per capita expenditure on suncream cosmetics in China is only $1.49, significantly lower than Japan's $13.85, the United States' $6.35, and South Korea's $11.58 (Chen, 2022). Additionally, the proportion of suncream products within the skincare market in China (6.2%) is also notably lower than the global average (9.6%). This indicates that Chinese consumers are still in the process of adopting the concept of sun protection and developing their purchasing habits. Consequently, as consumer awareness and habits evolve, the suncream cosmetics market in China holds substantial potential for growth.

To better reflect the current development status of China's suncream cosmetics industry, this study collected industry concentration data for suncream brands from four major Chinese e-commerce platforms (Kuaishou, Alibaba, Jingdong, and Douyin), as shown in Figure 1.2. According to CR (concentration ratio) indicators, CR10 (market share of the top 10 brands) exceeds 43% across all major platforms, with the highest approaching 49%. CR20 generally stands above 57%, while CR50 remains stable between 71% and 76%. This data distribution clearly indicates that China's suncream cosmetics market has entered a relatively highly concentrated development stage. Japanese brands such as Shiseido, Anessa, and Lancôme have long maintained a leading position in terms of product strength and user reputation. Against this backdrop, domestic Chinese brands should focus on "cost-effectiveness" and "local emotional appeal" as their main value propositions. By establishing competitive advantages in the mid- to low-price segments

and aligning with young consumers' preferences for content-driven and rational consumption, they can break through in niche market segments.

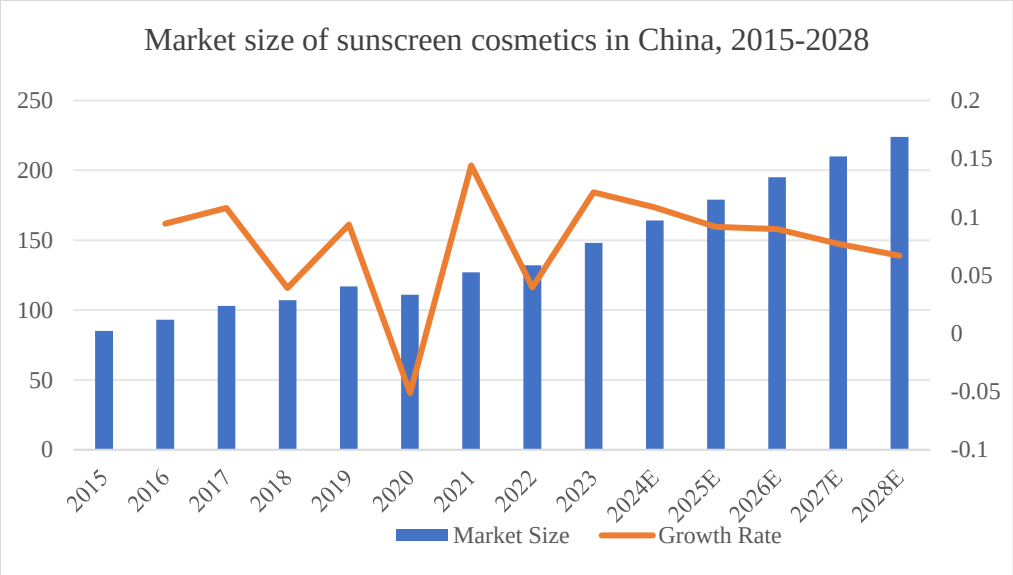


Fig 1.2. Concentration of China's Suncream Cosmetics Industry Data Source: Blue eye intelligence (2025)

As shown in Table 1.1, in terms of market share distribution, foreign brands occupy most of the top positions. Among the top ten brands ranked by market share, only three are Chinese: Winona, Meiking, and Hi!papa. These domestic brands are relatively lower in the rankings, placed sixth, eighth, and ninth, respectively. This indicates that Chinese suncream brands still exhibit a "multi-brand, low-concentration" market structure. No national leading brand has yet emerged that can rival Anessa or Mistine. Overall, the Chinese suncream cosmetics market remains dominated by foreign brands, while domestic brands are still in a catching-up phase. Given this situation, the ability of domestic brands to capture more market share from foreign competitors is a critical factor in determining their future growth potential.Table 1.1 Top 10 suncream cosmetics brands

Brand	Market Share Rank(2022)	Market Share Rank(2023)	Nation
Anessa	1	1	Japan
Mistine	2	2	Thailand
Lancome	5	1	France
Shiseido	4	4	Japan
Mentholatum	3	5	The U.S.A
Winona	6	6	China
L'ORÉAL Paris	8	7	France
Meiking	-	8	China
Hi!papa	-	9	China
Biore	7	10	Japan

Data Source: Guotai Junan Securities (2024)

1.2 Current Development Status of Domestic suncream Cosmetics Brands in China

In recent years, the uncertainty in the international trade environment and numerous setbacks faced by foreign brands in the domestic market have repeatedly dispelled the myth of foreign brands' invincibility. For instance, Japanese suncream cosmetics brands suffered significant sales declines in China due to the impact of Japan's discharge of nuclear wastewater into the Pacific Ocean. For example, sales of leading Japanese suncream brands Anessa and Shiseido on Alibaba's platform fell by 45.0%, 44.1%, and 75.0%, respectively, in September 2023 compared to the same period the previous year (Alibaba, 2024). Domestic brands have become the best substitutes, significantly increasing their market share following the nuclear wastewater incident. The market share of Chinese suncream brands among the top 20 brands on Alibaba's platform surged from 9.1% in August 2023 to 28.2% in November 2023, with Winona ranking first in suncream product sales on Alibaba in November. This event has reshaped the industry landscape, providing a favorable opportunity for the development of domestic suncream brands, with ample room for future growth.

Moreover, with the rise in national average income levels, consumer national confidence and cultural pride are also increasing. In 2020, China's per capita GDP reached a new milestone of $10,500, the size of the middle-income group continued to expand, and consumption upgrading persisted. According to the global economic development pattern, this phenomenon typically leads to the emergence and accelerated rise of domestic brands. Combined with the expansion and penetration of the suncream market, domestic brands are entering a rapid development phase in the local market. With the improvement of consumption levels and the increasing frequency of extreme heat, Chinese consumers' awareness of sun protection has gradually awakened, and the demand for sun protection products has steadily expanded (Xu, 2024). Data show that the scale of China's sunscreen cosmetics market has been rising year by year and is expected to reach 22.4 billion yuan by 2028. As the market expands, more and more consumers place greater emphasis on the safety of sunscreen cosmetics (Zhang et al., 2024). In order to enhance consumers' sense of security, merchants selling sunscreen cosmetics need to manage the perceived risks experienced by consumers during the purchasing process, thereby increasing their trust and sense of safety.

Consumers are prone to perceived risks in the process of online shopping. Unlike household appliances or electronic digital products, the attributes of cosmetics are difficult to describe and present through simple technical parameters. In the online purchasing environment, consumers who are buying cosmetics for the first time often need to spend considerable time and effort to understand the products, and their perception of non-monetary risks tends to be stronger. At the same time, online shopping services have their own characteristics-although they are convenient and efficient, they lack face-to-face communication. This is vastly different from traditional offline shopping, where consumers can personally test products, interact directly with sales staff, receive skin-type assessments, and obtain skincare advice.

Moreover, consumers' use of cosmetics is driven by psychological needs associated with beauty expectations, leading them to have stronger requirements for safety, quality, and efficacy. The uncertainty inherent in online shopping therefore constitutes multiple sources of perceived risk. These perceived risks significantly reduce consumers' purchase intentions. Such risks include functional risk (that the product does not meet individual needs), product risk (the possibility of purchasing counterfeit goods), time risk (extra time and effort required), and financial risk (insufficient price discounts) (Zhou, 2020).

1.3 Significance of This Research

By analyzing the characteristics of China's sun cream cosmetics industry, it is evident that the current Chinese market has enormous development potential and rapid growth, offering a rare opportunity for development to various sun cream cosmetics brands. Influenced by both external events and economic development, this is an excellent time for the rapid growth of domestic sun cream cosmetics in China. Therefore, major Chinese sun cream cosmetics brands should take advantage of this opportunity to quickly expand their market share and company scale, aiming to become the leaders in China's sun cream cosmetics industry.

To achieve this objective, this study will focus on the promotional strategies of domestic sunscreen cosmetics brands in China, examining Chinese female college students as the representative population and using Winona as a brand case study. Through surveys and data analysis, the research will assess how various promotional methods influence consumers' purchase intentions by affecting their perceived risk.

1.3.1 Practical Significance of this Research

The study holds both practical and theoretical significance. First, in terms of practical significance, the findings will provide scientific and effective case support for domestic sunscreen cosmetics brands aiming to expand their market and increase market share. This will help such brands identify the most suitable promotional strategies to meet their needs, enhancing promotional efficiency and effectiveness to achieve commercial success.

1.3.2 Practical Theoretical of this Research

This study contributes to the field by comparing different promotional methods, thereby refining existing research on promotional strategies. It enriches findings on the effectiveness of specific promotional approaches, confirming the influence path of "promotion-perceived risk-purchase intention" and offering valuable insights for researchers in related fields.

2. Research Objectives

This study aims to use Chinese domestic sun cream cosmetics as an example to analyze the relationships among promotional methods, perceived risk, purchase intention, and consumers personal characteristics, to identify the most effective promotional strategies for enterprises and sales personnel. This aims to enhance consumers' willingness to purchase Chinese domestic suncream cosmetics, promoting the development and growth of Chinese domestic suncream cosmetic brands. Specifically, the research objectives of this study can be divided into two parts:

Research Objective 1: To analyze the effects of different promotional methods on consumers' perceived risks.

Research Objective 2: To analyze the effects of different perceived risks on consumers' purchase intention for sun protection product.

Considering the core consumer group, Flywheel (2024) released a report on the core consumer profile of pure sun cream cosmetics in China, indicating that 86% of essential sun cream cosmetic users are female, with the age group primarily between 18 and 24 years old. This age range aligns with the distribution of university students, making Chinese female university students the target population for this study.

Product Example: Mid-to-low-priced sun cream from a Chinese domestic brand (based on the consumption ability of Chinese female university students).

Given this characteristic, we have selected Winona as the case study for this research on sun cream. As early as 2022, Winona had become the top Chinese domestic brand in the sun cream market (Euromonitor, 2023). This indicates Winona's strong competitiveness in the domestic Chinese market, making it representative of Chinese domestic sun cream products for analysis. Moreover, Winona has adopted strategies such as small packaging and low pricing to reduce the consumption threshold for the brand, providing consumption opportunities for lower-income consumers. This characteristic has made it a preferred brand among Chinese female university students.

3. Literature Reviews and Hypotheses

3.1 The Relationship Between Promotions and Perceived Risk

Diamond and Johnson (1990) categorized promotional methods into two types: price promotions and non-price promotions. Price promotions reduce consumers' perception of monetary loss, while non-price promotions enhance their sense of gaining certain benefits or utility. Their findings suggest that consumers exhibit a stronger preference for "gain-framed" messages over "loss-reduction" ones, indicating that non-price promotions provide greater perceived value. However, Chen et al. (2012) reached a different conclusion. Through experimental studies, they found that the perceived value of "gain-framed" promotions is not necessarily greater than that of "loss-reduction" promotions. Some scholars have focused on how different promotional message formats influence consumers' perceived value. Contrarily, Krishna et al. (2002) found that percentage-based promotions led to higher perceived savings than monetary-value expressions, thereby enhancing perceived value. Krishna also examined bundle promotions and noted that the more money saved from the bundle compared to individual purchases, the stronger the consumers' perception of savings. However, the more items bundled together, the weaker this perceived saving effect became. In summary, researchers grounded in the promotion framing theory generally agree that different promotional message formats significantly affect consumers' perceived value, which in turn influences their behavioral responses.

Ben (2010) further found that consumers' perceived risks, especially functional risk, are closely related to the type of promotion offered. This finding suggests that retailers and managers should carefully design promotional strategies based on consumers' risk perceptions. Building on the promotional framing effect, Mou (2023) employed the S-O-R theoretical model and constructed an empirical framework to investigate the impact of different online price promotion methods on planned impulse buying behavior, with consumers' perceived promotion as the mediator and Zhongyong (doctrine of the mean) values as the moderating variable. Her study revealed that different promotional methods have significantly different effects on consumers' perceived risks.

Based on the above research findings, it is evident that most scholars agree that promotions can effectively affect consumers' perceived risks. Therefore, this study proposes the following hypotheses:

H1: Promotions can significantly and positively impact consumers' perceived risks.
H1a: Discount can significantly and positively impact consumers' perceived time risk.
H1b: Cashback can significantly and positively impact consumers' perceived financial risk.
H1c: Gifts can significantly and positively impact consumers' perceived service risk.
H1d: Lottery can significantly and positively impact consumers' perceived social risk.

3.2 Influence of Perceived Risk on Purchase Intention

It is generally believed that perceived risk and consumer willingness to consume are negatively correlated. When consumers engage in online shopping, the higher the perceived risk, the lower their willingness to shop online (Forsythe, 2003 & Geng, 2021). In the process of online shopping, the main perceived risks vary at different stages. In the demand recognition stage, the primary risk is product risk; in the purchase decision stage, the primary risk is financial risk; and after the purchase is completed, the primary risk is service risk. These risks all influence the consumer's purchasing decision (Zhao et al, 2010). For example, a study analyzing the impact of perceived risk on purchase intentions among college students found that perceived risk negatively affects purchase intentions. Different

types of perceived risk have varying effects on college students' consumption intentions, with service risk being the most significant risk factor, followed by psychological risk and privacy risk (Chen, 2013). In total, when consumers perceive that the losses caused by uncertainty outweigh the potential benefits, and when the perceived risk exceeds the perceived benefits, they are unwilling to make a purchasing decision (Zou, 2022).
Based on these research results, in this study, we hypothesize:
H2: There is a negative correlation between perceived risks and the increment of purchase intention.
H2a: There is a negative correlation between perceived time risk and the increment of purchase intention.
H2b: There is a negative correlation between perceived financial risk and the increment of purchase intention.
H2c: There is a negative correlation between perceived service risk and the increment of purchase intention.
H2d: There is a negative correlation between perceived social risk and the increment of purchase intention.
H2e: There is a negative correlation between perceived privacy risk and the increment of purchase intention.
H2f: There is a negative correlation between perceived functional risk and the increment of purchase intention.

4. Data and variables

4.1 Population

This research is aiming to find the inside relationship and difference between different promotion methods as the suncream is the example and the female college students is the target group. It requires that the respondents are female college students and need to have the experience of shopping in suncream.

4.2 Sample

In this research we use simple random sampling method to sampling. The sample size is depended by the Taro Yamane's formula. The detail as below:
Taro Yamane's: $n = N / (1 + N * e^2)$
Where:
n = Desired sample size;
N = Total population;
e = Margin of error (usually 5%, i.e., 0.05)
n = 10,000 / (1 + 10,000 * 0.05^2)
n = 10,000 / 26
n = 384.6 ≈ Approximately 385 samples
Since we need to divide the respondents into four groups according to different promotion methods. 400 samples are collected in this research, so that 100 respondents participate in each promotion group.

4.3 Definition of Variables

4.3.1 Definition of Promotional Methods:

Promotion stimulates consumers to make purchases through various discount methods. Different promotional methods generate different stimuli, leading to varied perceptions among consumers. Therefore, in this study, different promotional methods will be studied separately to clarify the relationship and path between different promotional methods and consumers' purchase intentions. The specific promotional methods and their definitions are as follows:
Discount: Direct discount based on the original price (e.g., 20% off).
Gifts: Offering trial-sized products.
Lottery: Participating in brand-held lotteries to win prizes after reaching a certain spending threshold.
Cashback: Receiving a certain amount of cash back after giving a positive review of the product received.

In selecting the promotion intensity, Duan (2018), Sheng (2020), and others have researched the optimal promotion intensity. They believe that the optimal value for promotion intensity is 20%. According to a study on consumers in northern China, most consumers considered a 20% discount to be the most appropriate (Cui, 2019). Therefore, this research sets the promotion intensity for each promotional method at 20%. For non-price promotions, such as lotteries, the total expected benefit (value of the benefit × probability of the benefit) is controlled at 20% of the price.

4.3.2 Definition of Perceived Risk:

In this study, we define perceived risk as the uncertainty of purchasing decisions and the possibility of erroneous results after purchasing products. It refers to consumers' subjective psychological feelings of objective risks associated with their purchase decisions (Shi & Mao, 2016). To analyze the impact of perceived risk on promotional methods and purchase intentions more deeply, this study divides perceived risk into six dimensions for measurement: time risk, financial risk, functional risk, privacy risk, service risk, and social risk.
Time Risk (TR): Long wait times for customer service responses (Peter, 1975).
Financial Risk (FR): Actual discounts are small or even exceed the actual price (Zikmund, 1977).
Functional Risk (FCR): Purchasing counterfeit or substandard products (Jacoby, 1972).
Privacy Risk (PR): Personal privacy disclosure (Dong, 2005).
Service Risk (SR): Lack of guarantee for after-sales service (Cases, 2002).
Social Risk (SLR): Being perceived as unwise by family and friends (Gronhaung, 1993).

4.3.3 Definition of Purchase Intention

Purchase intention: Purchase intention refers to consumers' motivation and inclination to purchase specific products or services (Jiang, 2023). In this study, it specifically refers to consumers' purchasing inclination towards Winona suncream cosmetics under different promotional methods.

4.3.4 Definition of Personal Characteristics

Shopping experience(SE): Shopping experience is a composite evaluation of respondents' past purchase behaviors and tendencies, including their online shopping frequency, frequency of sunscreen purchases, and preferred price range for sunscreen. The respondents' final purchase experience score is calculated by averaging these sub-variables.

4.4 Research Framework

The model investigates the impact of promotional methods on consumer perceived risk. According to the hypotheses of this paper, there are significant differences in how promotional methods affect consumer perceived risk. Promotional methods refer to a series of ways to promote online sales conducted by online stores. In this research, to be better compare the effects of various promotional method on consumer purchase intention and identify the optimal promotion strategy, a controlled grouping approach was adopted. The study included four groups divided according to different promotional methods. Each group was analyzed separately to determine the impact and pathways of these promotional methods on consumer purchase intentions. In order to better measure the effectiveness of different promotional methods in enhancing consumers' purchase intention, this study uses the increment in consumers' purchase intention as the dependent variable. Specifically, it is calculated as the difference between consumers' purchase intention in a promotional scenario and their purchase intention in a non-promotional scenario.The model also investigates the control effect of consumer personal characteristics on perceived risk. According to the hypotheses of this paper, there are significant differences in the relationship between consumer personal characteristics and perceived risk. Based on Kotler's behavioral choice model, consumers' personal characteristics lead to differences in their perceived risk levels.

Combined with above reasons, we constructed the theoretical framework as below:

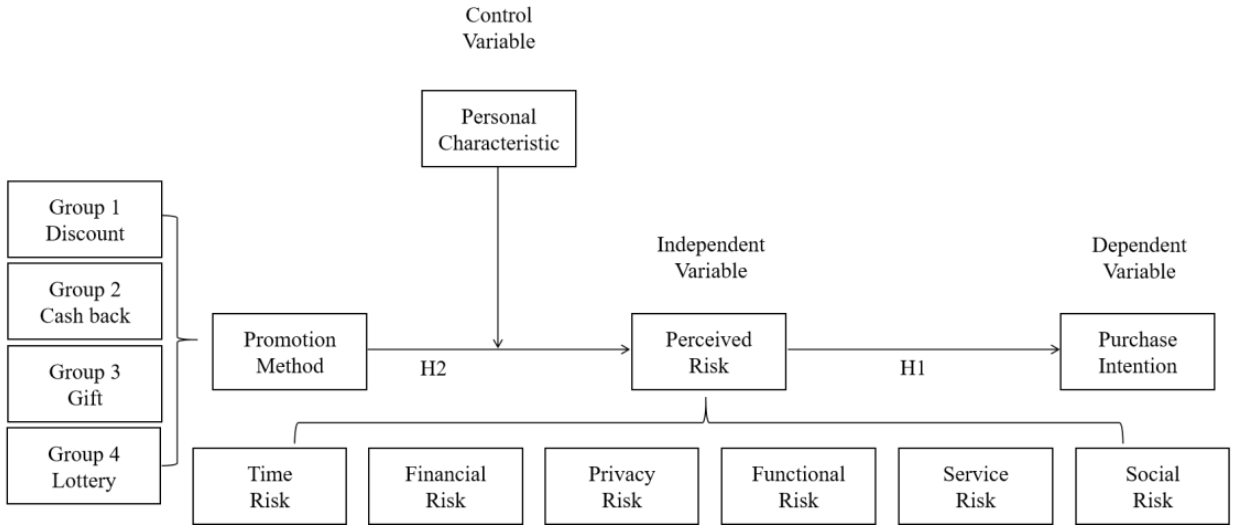


Fig 4.1 Research Framework

4.5 Data Collection

Data collection for this study will be conducted through an online questionnaire survey. The questionnaire design will use the Likert five-point scale to assess the respondents' level of agreement. The questionnaire is divided into four parts: the first part is original purchase intention, the second part is a survey on purchase intentions, and the third part is a survey on perceived value, the fourth part is a demographic survey, there are 29 questions in total. In this research, we conducted an online survey using the "Wenjuanxing" platform, and a total of 450 questionnaires were distributed, and 445 were collected. After excluding invalid responses, 400 valid questionnaires remained, yielding an effective response rate as 88.89%.

5. Methodology

This study adopted a quantitative, crosssectional survey to analysis how the perceived risk influence consumer's purchase intention in different promotion methods for sun projection products. A scenario-based questionnaire was developed, presenting respondents with description of sun projection products under distinct promotion conditions. This design method allows for direct comparison of promotion effects and estimation of the impact of perceived risk within the same analytic framework and same statistic method-OLS.

5.1 Effects of different promotional methods on consumers' perceived risks

To examine the effects of different promotional methods on consumers' perceived risks, this study employed multiple comparisons analysis, specifically pairwise comparisons with Bonferroni adjustment. This approach allows for rigorous control of Type I error across multiple comparisons, ensuring the statistical reliability of the results. The logic of the multiple comparisons analysis is as follows:

Overall Difference Test: An initial ANOVA is conducted to test whether there are overall differences in perceived risk across the promotional methods.

Pairwise Comparison: When overall differences exist or for detailed analysis, pairwise comparisons are performed between all combinations of promotional methods. For each pair, the mean difference, standard error, and 95% confidence interval are calculated.

Bonferroni Adjustment: Given multiple pairwise comparisons, the standard significance level may inflate the likelihood of Type I errors. The Bonferroni method adjusts the significance threshold by dividing the initial alpha level (α) by the number of comparisons (k):

$$\alpha_{adjusted} = \frac{\alpha}{k}$$

This ensures that the probability of incorrectly rejecting at least one true null hypothesis is minimized. This method is particularly suitable for this study because it involves four promotional methods (Discount, Lottery, Cashback, and Gifts), requiring comparisons across all pairs. Direct use of independent t-tests would increase the risk of false positives due to repeated testing, making multiple comparisons with Bonferroni correction a more appropriate choice. The analysis as below:

Table 5.1 Comparison of Perceived Privacy Risk Scores Across Promotional Methods

SR	Contrast	Std. err.	Bonferroni [95% conf. interval]	
Discount vs Lottery	1.288379	0.1173446	0.9773683	1.59939
Cashback vs Lottery	-0.0166667	0.1176171	-0.3284	0.2950666
Gifts vs Lottery	0.2063063	0.1168124	-0.1032941	0.5159067
Cashback vs Discount	-1.305046	0.1178841	-1.617487	-0.992605
Gifts vs Discount	-1.082073	0.1170812	-1.392386	-0.7717601
Gifts vs Cashback	0.222973	0.1173544	-0.0880639	0.5340098

Regarding privacy risk, taking Lottery as the reference group, the privacy risk score for Discount was significantly higher than that of Lottery, with a difference of 1.288 and a standard error of 0.117. Furthermore, the score differences between Cashback and Discount (-1.305, standard error = 0.118, 95% CI [-1.617, -0.993]) and between Gifts and Discount (-1.082, standard error = 0.117, 95% CI [-1.392, -0.772]) were also statistically significant. In contrast, no significant differences were observed among other group comparisons. In summary, consumers perceived significantly higher privacy risk associated with the Discount promotional method compared to the other three methods, while differences among Lottery, Cashback, and Gifts were not significant.

Table 5.2 Comparison of Perceived Financial Risk Scores Across Promotional Methods

FR	Contrast	Std. err.	Bonferroni [95% conf. interval]	
Discount vs Lottery	-0.0239366	0.099532	-0.2877369	0.2398637
Cashback vs Lottery	-0.0174523	0.0997632	-0.2818653	0.2469607
Gifts vs Lottery	1.425908	0.0990806	1.163304	1.688512
Cashback vs Discount	0.0064843	0.0999896	-0.2585289	0.2714976
Gifts vs Discount	1.449844	0.0993086	1.186636	1.713053
Gifts vs Cashback	1.44336	0.0995403	1.179538	1.707182

In terms of financial risk, using Lottery as the baseline, the difference in scores between Discount and Lottery was -0.024, with the confidence interval including zero, indicating no significant difference. Similarly, the difference between Cashback and Lottery was -0.017, also not statistically significant. By contrast, Gifts had a significantly higher financial risk score than Lottery, with a difference of 1.426, a standard error of 0.099, and a 95% confidence interval of [1.163, 1.689], excluding zero. Additionally, the differences between Gifts and Discount (1.450, 95% CI [1.187, 1.713]) and between Gifts and Cashback (1.443, 95% CI [1.180, 1.707]) were statistically significant. Differences among other promotional methods, such as Cashback versus Discount (difference = 0.006, 95% CI [-

0.259, 0.271]), were not significant. Overall, consumers rated Gifts as inducing significantly higher financial risk perception compared to the other three promotional methods, while no significant differences were found among Lottery, Discount, and Cashback. These results suggest that gift promotions may evoke greater financial risk perceptions and should be carefully considered in promotional design.

Table 5.3 Comparison of Perceived Functional Risk Scores Across Promotional Methods

FCR	Contrast	Std. err.	Bonferroni	
			[95% conf. interval]	
Discount vs Lottery	-1.177231	0.1277492	-1.515818	-0.8386437
Cashback vs Lottery	-0.0737935	0.1280459	-0.4131672	0.2655802
Gifts vs Lottery	-1.240377	0.1271698	-1.577428	-0.9033251
Cashback vs Discount	1.103438	0.1283365	0.7632934	1.443582
Gifts vs Discount	-0.0631457	0.1274624	-0.400973	0.2746816
Gifts vs Cashback	-1.166583	0.1277598	-1.505199	-0.8279677

Regarding functional risk, using Lottery (CJ) as the reference, the difference between Discount (DZ) and Lottery was -1.177 (standard error = 0.128, 95% CI [-1.516, -0.839]), indicating a significant difference with Discount perceived as having significantly lower functional risk than Lottery. Similarly, Gifts showed a significant negative difference compared to Lottery (-1.240, 95% CI [-1.577, -0.903]), indicating lower perceived functional risk. The difference between Cashback and Lottery was -0.074 (95% CI [-0.413, 0.266]), which was not statistically significant. Among other comparisons, Cashback differed significantly from Discount (1.103, 95% CI [0.763, 1.444]), while Gifts did not differ significantly from Discount (-0.063, 95% CI [-0.401, 0.275]) but differed significantly from Cashback (-1.167, 95% CI [-1.505, -0.828]). In summary, consumers perceived Lottery promotions as having significantly higher functional risk compared to Discount and Gifts; Cashback and Lottery did not differ significantly; significant differences existed between Cashback and Discount as well as between Gifts and Cashback. These findings indicate that Lottery promotions may raise higher functional risk concerns, whereas Discount and Gift promotions reduce such consumer risk perceptions.

5.2 Effects of different promotional methods on consumers' purchase intention

To analyze how promotional methods influence consumers' purchase intentions by affecting their perceived risk, this study uses OLS regression to analyze the survey data for the four promotional methods: discounts, gifts, lottery and cashback. This aims to clarify the specific pathways and extent to which they impact purchase intentions. ΔPI_i is measured as a continuous score (scale), so OLS provides straightforward estimation and interpretation of marginal effects.The formula like below:

$$\Delta PI_i = \alpha + \beta_1 TR_i + \beta_2 PR_i + \beta_3 SR_i + \beta_4 FR_i + \beta_5 FCR_i + \beta_6 SLR_i + X_i\gamma + \epsilon_i,$$

Where ΔPI_i is the change in purchase intention of individual i, X_i is a vector of individual and shopping characteristics including age, online shopping frequency, and sun protection product consumption frequency. Where TR is perceived time risk, PR is perceived private risk, SR is perceived service risk, FR is perceived financial risk, FCR is perceived functional risk, SLR is perceived social risk.

Therefore, we analysis the relationship between perceived risks and the increment of purchase intention.

1.Cashback

Table 5.4 The Analysis Results of Cashback Group

Model		Unstandardized coefficient		Standardized coefficient	t	Sig
		B	SD	Beta		
1	Constant	4.893	1.479		3.307	0.001
	TR	0.104	0.091	0.073	1.148	0.254
	PR	-0.654	0.133	-0.406***	-4.921	0
	SR	-0.841	0.264	-0.246***	-3.183	0.002
	FR	-0.621	0.177	-0.273***	-3.519	0.001
	FCR	0.14	0.084	0.108	1.671	0.098
	SLR	-0.078	0.088	-0.056	-0.89	0.375
	Age	-0.038	0.065	-0.038	-0.595	0.553
	Income	-0.149	0.076	-0.126	-1.976	0.051
	Online shopping frequency	-0.08	0.087	-0.058	-0.915	0.363
	Suncream purchase frequency	0.192	0.094	0.128*	2.039	0.044

a DV：PI Increment

The results of Table 5.4 demonstrate that several predictors exert statistically significant effects on the dependent variable, purchase intention increment. Specifically, privacy risk (PR) , service risk (SR) , and financial risk (FR) show significant negative standardized coefficients. Which means that if PR increase 1 unit, IIP decrease 0.654 unit; if SR increase one unit, IIP decrease 0.841unit; if FR increase one unit, IIP decrease 0.621 unit. These results suggest that, when other variables are held constant, increases in these risk perceptions are associated with a significant decrease in consumers' purchase intention.

In contrast, functional consumption risk (FCR) exhibits a positive but only marginally significant effect, indicating a weak positive association with purchase intention increment that does not reach conventional significance thresholds. Time risk (TR) and social risk (SLR) are both statistically insignificant ($p = 0.254$ and $p = 0.375$, respectively), suggesting that variations in these dimensions do not meaningfully explain differences in the outcome variable within the current sample.

Among the control variables, only suncream purchase frequency yields a statistically significant effect, indicating that higher purchase frequency is positively associated with purchase intention increment. Income is marginally significant, with a negative coefficient, suggesting a potential inverse relationship. Other control variables, including age, online shopping frequency, and suncream purchase frequency, are not statistically significant at the 0.05 level.

2.Lottery

Table 5.5 The Analysis Results of Lottery Group

Model		Unstandardized coefficient		Standardized coefficient	t	Sig
		B	SD	Beta		
1	Constant	5.429	1.457		3.727	0.000
	TR	0.15	0.094	0.104	1.604	0.112
	PR	-0.586	0.134	-0.362***	-4.392	0.000
	SR	-0.942	0.263	-0.274**	-3.575	0.001
	FR	-0.679	0.175	-0.3***	-3.87	0.000
	FCR	0.151	0.087	0.109	1.735	0.086
	SLR	-0.075	0.091	-0.053	-0.823	0.413
	Age	-0.098	0.063	-0.099	-1.552	0.124
	Income	0.107	0.079	0.085	1.342	0.183
	Online shopping frequency	0.020	0.092	0.014	0.216	0.830
	Suncream purchase frequency	-0.014	0.099	-0.009	-0.141	0.888

a DV：PI Increment

Table 5.5 presents the results of the regression analysis for the lottery group, with purchase intention increment as the dependent variable. Among the ten predictors included in the model, three risk-related variables exhibit statistically significant negative effects.

PR shows a strong and significant negative relationship with purchase intention, while PR increase one unit, IIP decrease 0.586unit. Which indicating that increased concern in this domain is associated with a substantial decline in consumers' willingness to increase their purchase intention. Likewise, SR and FR are both significant and negatively related to the outcome variable, while SR increase one unit, IIP decrease0.942unite; while FR increase one unit, IIP decrease 0.679 unit. That suggesting that anticipated service deficiencies and perceived financial disadvantages play important roles in deterring consumer engagement within the lottery group.

FCR presents a positive but marginally significant effect, indicating a weak tendency toward increased purchase intention with higher perceived functional reliability, although this effect does not reach conventional significance levels.

Other variables, including TR, SLR, and all control variables(age, income, online shopping frequency, and suncream purchase frequency) exhibit no statistically significant relationships with purchase intention increment ($p > 0.10$). Notably, income and age show small effect sizes and approach, but do not reach, marginal significance thresholds, indicating that demographic factors exert limited explanatory power in this group.

3.Discount

Table 5.6 The Analysis Results of Discount Group

Model		Unstandardized coefficient		Standardized coefficient	t	Sig
		B	SD	Beta		
1	Constant	1.957	1.509		1.297	0.198
	TR	0.052	0.105	0.032	0.491	0.625
	PR	0.196	0.104	0.123	1.891	0.062
	SR	-1.235	0.264	-0.347***	-4.675	0.000
	FR	-0.673	0.178	-0.285***	-3.782	0.000
	FCR	-0.572	0.128	-0.322***	-4.471	0.000
	SLR	0.093	0.105	0.057	0.879	0.381
	Age	0.111	0.064	0.105	1.731	0.087
	Income	-0.069	0.081	-0.053	-0.855	0.395
	Online shopping frequency	-0.028	0.093	-0.019	-0.297	0.767
	Suncream purchase frequency	-0.004	0.108	-0.002	-0.035	0.972

a DV：PI Increment

Table 5.6 reports the results of the analysis for the discount group, where purchase intention increment serves as the dependent variable. Among the predictors, three risk-related variables demonstrate significant negative effects.

Most notably, SR exhibits a strong and highly significant negative impact on purchase intention, one unit increase in SR, IIP(increment of purchase intention) will decrease 1.235 unit. Which indicating that the perception of unreliable after-sales service substantially reduces consumers' willingness to increase purchasing behavior, even in the presence of discounts. Similarly, FR shows a significant negative association, one unit increase in FR will let IIP decrease 0.673 unit. That suggesting that price-related concerns(such as perceptions of poor value or deceptive discounting) serve as a critical deterrent to further purchase engagement.

In addition, FCR is negatively and significantly associated with purchase intention increment, one unit increase in FCR will let IIP decrease 0.572 unit. Which implying that doubts about product authenticity or quality strongly undermine the effect of discounts on consumer behavior. These findings collectively indicate that discount incentives alone may be insufficient to override risk perceptions, particularly in areas of service reliability, financial trustworthiness, and product functionality.

By contrast, PR presents a positive but marginally significant effect, which deviates from patterns observed in the other groups. This may reflect a context-specific perception that discounts reduce the perceived cost of privacy loss; however, the effect remains statistically inconclusive.

All other predictors, including TR, SLR, and the control variables age, income, online shopping frequency, and suncream purchase frequency, exhibit no statistically significant relationships with the dependent variable. Age is marginally associated with purchase intention increment, suggesting a potential trend where older consumers might respond more favorably to discounts, though further investigation is needed.

4. Gifts

Table 5.7 The Analysis Results of Gifts Group

Model		Unstandardized coefficient		Standardized coefficient	t	Sig
		B	SD	Beta		
1	Constant	2.934	1.254		2.34	0.021
	TR	0.172	0.105	0.119	1.637	0.105
	PR	-0.175	0.117	-0.106	-1.498	0.137
	SR	-0.771	0.105	-0.591***	-7.348	0
	FR	0.16	0.086	0.121	1.86	0.066
	FCR	-0.4	0.129	-0.241**	-3.091	0.003
	SLR	0.059	0.089	0.044	0.664	0.508
	Age	-0.034	0.056	-0.037	-0.602	0.549
	Income	-0.105	0.084	-0.077	-1.246	0.216
	Online shopping frequency	0.088	0.081	0.065	1.094	0.277
	Suncream purchase frequency	0.004	0.087	0.003	0.046	0.963

a DV：PI Increment

Based on the regression results presented in Table 4.19, the analysis focuses on the Gifts Group, examining the impact of various independent variables on the dependent variable, the increment of purchase intention.

Among the six types of review information, SR exhibits the most significant and substantial negative effect on PI Increment, as SR increase one unit, IIP decrease 0.771 unit. Which suggesting that in the context of gift promotions, reviews that emphasize social relational factors may reduce consumers' perceived value increment. Similarly, FCR also exerts a significant negative influence, as FCR increase one unit, IIP decrease 0.4 unit. Which indicating that utilitarian evaluations tied to product use and consumption reduce the effectiveness of gift-type promotional messages in enhancing perceived value.

Interestingly, FR shows a marginally significant positive impact, implying that when reviews emphasize interpersonal or emotional connection, consumers may perceive increased value from gift promotions, although this effect borders on statistical significance. The remaining review types, such as TR and PR, do not show significant effects, indicating that more instrumental or hierarchical review tones may not effectively influence perceived value in a gift-giving context.

As for control variables, none of them, including age, income, online shopping frequency, and suncream purchase frequency, reach statistical significance (all $p > 0.2$), suggesting limited influence of demographic and behavioral characteristics on the perceived value change within the gift group.

6. Results and discussion

6.1 Effects of different promotional methods on consumers' perceived risks

This study aimed to explore whether and how different types of promotional methods influence consumers' perceived risks across various dimensions, including privacy risk, financial risk, functional risk, time risk, service risk, and social risk. The findings reveal both areas of significant differentiation and dimensions where promotional type exerts limited influence.First, the results indicate no statistically significant differences across the four promotional methods (Discount, Cashback, Gifts, and Lottery) in terms of time risk, service risk, and social risk. This suggests that consumers' concerns related to time consumption, service reliability, and social impression are relatively unaffected by the nature of the promotion.

However, significant differences were observed in privacy risk, financial risk, and functional risk, depending on the type of promotion.Among all promotional types, Discount promotions were perceived to carry the highest privacy risk, significantly higher than Lottery, Cashback, and Gift promotions. The differences between Discount and the other three methods were all statistically significant, whereas the differences among Lottery, Cashback, and Gifts were not. This finding implies that consumers may associate discounts, especially those requiring data input or personal engagement (e.g., coupons, codes), with increased vulnerability regarding data privacy.

Consumers perceived Gift promotions as carrying the highest financial risk, significantly higher than Discount, Cashback, and Lottery. This might be due to skepticism about the actual value of the gift or concerns about hidden

costs. No significant differences were found among the other three methods, suggesting that consumers perceive Cashback, Discount, and Lottery promotions as relatively comparable in terms of financial exposure.

In terms of functional risk, Lottery promotions were perceived as the riskiest, with significantly higher scores than both Discount and Gift promotions. Cashback did not significantly differ from Lottery, indicating some ambiguity in consumer evaluation of promotional outcomes in these two cases. Notably, Cashback also showed a significantly higher functional risk than Discount and Gifts, reinforcing the idea that promotions involving delayed or uncertain returns (like Cashback or Lottery) may weaken consumer confidence in the functionality or utility of the offering.

These differentiated risk perceptions align with previous research suggesting that promotional framing affects consumer evaluations (Diamond & Johnson, 1990; Krishna et al., 2002). Notably, the finding that Gifts and Lottery evoke higher financial and functional risks, respectively, resonates with Mou's (2023) conclusion that promotional method significantly affects consumer perceived risks, and should therefore be carefully matched with marketing objectives and target audience preferences.

Based on the above findings, marketers should optimize different types of promotional activities in a targeted manner to reduce consumers' perceived risks. For instance, in discount promotions, firms should establish clear and transparent privacy policies to enhance consumer trust. In gift promotions, companies should provide objective and accurate descriptions of the gift's value, thereby reducing consumer skepticism regarding its authenticity or worth. Furthermore, in lottery and cashback promotions, managers should design these activities to be straightforward and transparent, increasing clarity and visibility in order to strengthen consumer confidence.

6.2 Effects of different promotional methods on consumers' purchase intention

This study examined how six dimensions of perceived risk (time risk, privacy risk, service risk, financial risk, functional risk, and social risk) influence consumers' purchase intention (PI) increment for sun protection products under four different promotional scenarios: Cashback, Lottery, Discount, and Gifts.

In the cashback group, privacy risk, service risk, and financial risk significantly reduced purchase intention. In cashback promotion scenarios, consumers tend to be more sensitive to potential risks. As a delayed-reward type of promotion, cashback requires consumers to complete certain procedures after purchase before they can actually receive the benefit. During this process, consumers are more likely to worry about whether their personal information will be exposed (privacy risk), whether the merchant is reliable (service risk), and whether the cashback will truly be delivered (financial risk). In other words, the cashback mechanism amplifies the "future uncertainty" inherent in the transaction, meaning that consumers must bear psychological risk perceptions before enjoying the economic benefits, which in turn significantly reduces their purchase intention.

In the Lottery group, privacy risk, service risk, and financial risk again significantly reduced purchase intention. These results support the argument that probabilistic rewards may amplify uncertainties, thereby lowering purchase motivation. Other perceived risks were not significant predictors, indicating that time and social concerns were not dominant factors in this context.

In the Discount condition. the influence of perceived risks shifted. Service risk financial risk, and functional risk were the strongest negative predictors of purchase intention. Unlike the Cashback and Lottery groups, privacy risk did not show a significant negative impact in this context ($p = 0.062$). One possible explanation is that price discounts are more direct and familiar, reducing the salience of privacy-related concerns while shifting focus to worries about product quality (i.e., functionality) and service reliability.

In the Gift condition, service risk and functional risk were the primary risk factors negatively affecting purchase intention. Notably, service risk had the strongest standardized effect size of all groups, suggesting that consumers are particularly wary of receiving low-quality service or fulfillment issues when gifts are offered. This aligns with existing literature (e.g., Chen, 2013), which identified service risk as one of the most influential risk types affecting purchase decisions.

Across all promotional types, certain perceived risks consistently showed significant negative effects on consumers' purchase intentions, while others were context-dependent or insignificant. The results partially support prior research findings (e.g., Forsythe, 2003; Zhao et al., 2010; Chen, 2013), which indicate that higher perceived risks generally suppress purchase intentions.

From these results, several managerial implications can be drawn. In lottery promotions, the significant influence of privacy, financial, and service risks suggests that companies employing this strategy should enhance transparency in rules and outcomes to mitigate the negative impact of uncertainty inherent in probabilistic events. In discount promotions, financial, service, and functional risks emerge as key deterrents to purchase intention. Thus, firms offering discounts must ensure product quality and after-sales reliability alongside price reductions to alleviate consumer concerns. In gift promotions, the particularly strong effect of service risk highlights the need for companies to clearly communicate the value of the gift and guarantee reliable delivery in order to reduce skepticism and strengthen consumer trust. Finally, in cashback promotions, timeliness is crucial. Firms should design simple and efficient redemption processes to counteract consumer concerns about future uncertainty and thereby enhance the effectiveness of the promotion.

7. Conclusion

This study used a survey to examine how different promotional methods affect consumers' purchase intentions for sun protection products. The data analysis indicates that perceived risks have a significant negative impact on purchase intention. Specifically, in cashback promotions, privacy risk, service risk, and financial risk significantly reduced consumers' purchase intentions; similarly, in lottery promotions, privacy, service, and financial risks again had a significant negative effect. In discount promotions, service risk, financial risk, and functional risk were the strongest negative predictors of purchase intention. In gift promotions, service risk and functional risk were the primary factors negatively influencing purchase intention. Moreover, the pathways and strength of these effects vary depending on the type of promotion. For example, discount promotions tend to generate higher privacy risk, gift promotions are associated with higher financial risk, and lottery promotions carry higher functional risk. However, the study also has several limitations that should be addressed in future research.

First, the sample in this study consisted solely of female university students in China. However, as sunscreen consumption becomes increasingly popular in China, the consumer base has expanded to include men and individuals from other age groups. Therefore, the generalizability of the findings is relatively limited, and future studies should consider including more diverse populations.

Second, this study was based on cross-sectional data, which prevents the results from capturing causal relationships among variables in a dynamic context. Future research could establish a longitudinal data collection system to track the sustained influence of perceived risk on consumers' purchase intentions over time.

Finally, this study applied OLS regression to examine only the direct effect between perceived risk and purchase intention. Future research could be extended to include mediation effects or employ methods such as structural equation modeling to identify the underlying causal pathways, thereby providing more comprehensive guidance for promoting sunscreen consumption.

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An Economic Analysis of Missing Meals in Myanmar Households

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Abstract
This study investigates the socioeconomic determinants of household food insecurity in Myanmar, with a specific focus on the incidence and severity of missing meals across essential food groups. Using nationally representative data from the Myanmar Household Welfare Survey (MHWS), both Binary Logit and Nested Logit models are employed to identify key predictors and deepen the analysis of food insecurity severity. The findings consistently reveal that lower educational attainment, higher household debt, reduced labor force participation, and weaker community inclusiveness significantly increase the likelihood and severity of missing meals. The analysis incorporates robustness checks, confirming that results remain stable under alternative variable specifications. Notably, the study observes that households reporting sickness are not necessarily more food insecure, suggesting the influence of informal coping mechanisms and external support. Policy implications highlight the need to expand access to education, implement debt relief, promote employment opportunities, and foster community support networks while acknowledging implementation challenges amid Myanmar's ongoing political and economic instability. Limitations and avenues for future research are discussed, emphasizing the importance of multidimensional and longitudinal approaches to understanding food insecurity in fragile contexts.

Keywords: Food Security, Missing Meals, Myanmar, Socioeconomic Determinants, Household Economics

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1. Introduction

Myanmar, a Southeast Asian country with a population exceeding 54 million, has long faced chronic food insecurity and poverty. The situation has worsened in recent years due to persistent economic hardship, the COVID-19 pandemic, and political instability following the military coup in February 2021. In early 2022, approximately 13.2 million people experienced moderate to severe food insecurity. Rising inflation, soaring food prices, and widespread unemployment have further intensified the problem.

The economy contracted by 5% in 2020 due to COVID-19 and by 18% in 2021 after the coup, leaving GDP in 2022 still 13% below 2019 levels (Bank, 2022). The agricultural sector, employing over 60% of the workforce, has been particularly vulnerable to climate change, natural disasters, and ongoing conflict (Devanesan, 2020). Myanmar's inflation rate has been high and volatile in recent years (Statista, 2025). According to Trading Economics, the inflation rate in Myanmar has increased to 28.01% in the second quarter of 2023 (Economics, 2023).

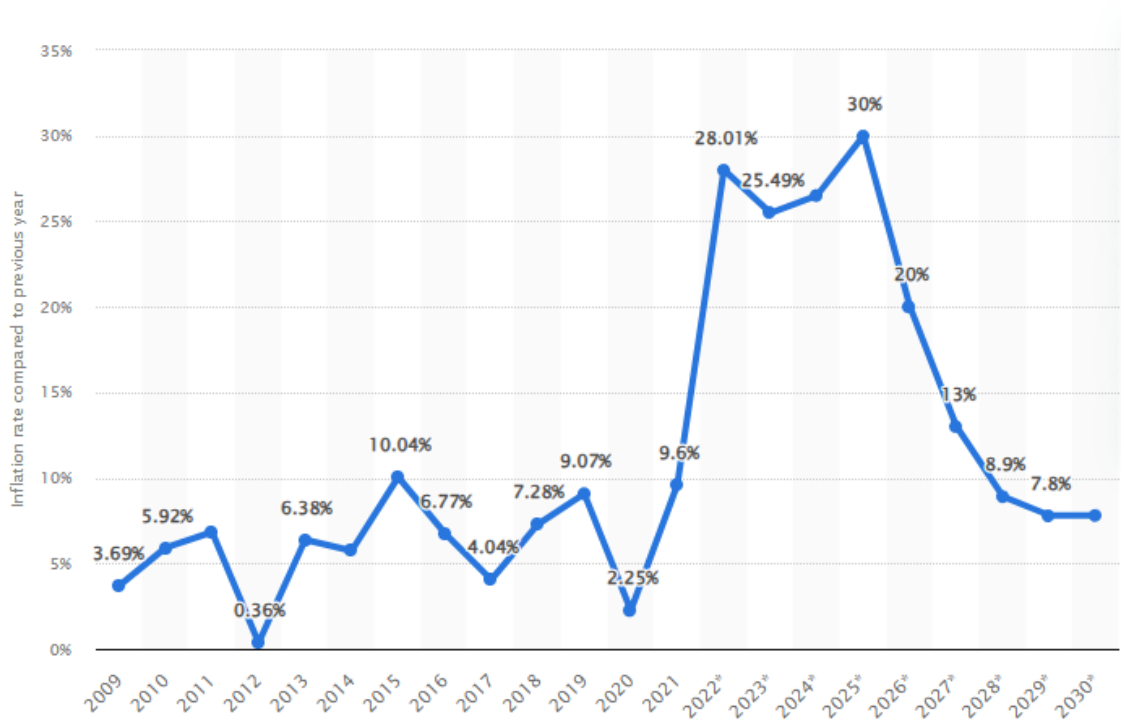

Figure A: Myanmar: Inflation rate from 2009 to 2030
Source: Myanmar Inflation Rate from Statista.com (2024)

The cost of a healthy diet rose by 61% between September 2021 and September 2022, with significant price increase in vegetables, animal-sourced foods, oils, and starchy staples. The IFPRI's research also indicates a steep rise in food prices between 2020 and 2021, particularly in rural areas (IFPRI, 2021). The International Labor Organization (ILO) reported job losses of over 1.6 million due to the pandemic and the coup, severely affecting livelihoods and increasing food insecurity (Jazeera, 2022). In 2020, the negative impact of COVID-19 has resulted in substantial reduction in production in the economy with the estimated economic loss of 6.4 trillion to 9.0 trillion Kyats[4] (Diao et al., 2020).

[4] The conversion rate of Myanmar Kyats (MMK) to US dollars (USD) is approximately 1 USD = 1,640 MMK at the time. Please note that exchange rates are subject to fluctuations and may change over time.

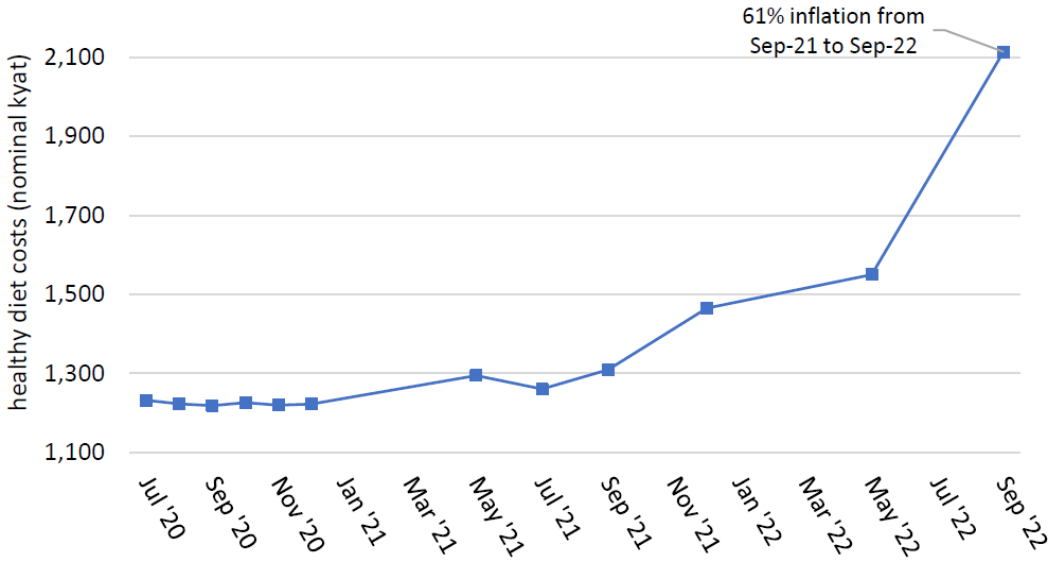

Figure B: Changing costs of a healthy diet from June 2020–May 2022 (nominal kyat)
Source: Estimates from food vendor surveys (MAPSA, 2022).

One key indicator of household food insecurity is the frequency and quality of meals consumed, particularly from the primary food groups of carbohydrates, protein, vegetables and fiber. Insufficient calorie intake and inadequate consumption of essential nutrients can lead to various health issues. Food insecurity has been a persistent problem in Myanmar, with rural areas being more affected than urban areas. The IFPRI's Rural-Urban Food Security Survey (RUFSS) conducted between June 2020 and December 2021 found that the proportion of households with inadequate diets increased significantly in rural areas during this period (IFPRI, 2021). It is critical to examine the underlying factors contributing to food insecurity, including missing meals.

Despite extensive global literature exploring determinants of food insecurity, research specifically addressing household-level dynamics, particularly the severity of missing meals within Myanmar's unique context, remains limited. Previous studies in Myanmar have predominantly examined broader aspects of food availability and utilization without specifically addressing meal-skipping behaviors and their socioeconomic drivers. This gap is significant because missing meals directly and disproportionately impact vulnerable groups, including children, pregnant women, and the elderly, exacerbating short-term nutritional deficiencies and long-term health complications.

This study focuses on the three primary food groups of carbohydrates, proteins and vegetables/fiber due to their essential role in providing the necessary energy, nutrients, and fiber required for maintaining good health. These groups are fundamentally to a balanced diet, and missing meals from them can lead to significant nutritional deficiency (Delisle et al., 1991). Previous studies have shown that these food groups are particularly sensitive indicators of food insecurity, and tracking their absence in household diets directly highlights severe food insufficiency. The approach provides a straightforward and actionable measure of food insecurity, filling a gap in literature where more complex indices like the Household Dietary Diversity Score (HDDS) or Food Consumption Score (FCS) are often used but can be difficult to interpret in volatile contexts.

Given Myanmar's current context marked by political instability, economic volatility, and institutional fragility, understanding the socioeconomic determinants influencing meal consumption patterns is essential for developing effective, targeted interventions. This study addresses this critical gap through robust econometric analyses, employing both binary logit and nested logit models to identify how factors such as educational attainment, household debt levels, labor force participation, and community inclusiveness influence both the likelihood and severity of food insecurity at the household level.

By linking these socioeconomic characteristics to household food insecurity outcomes, this study addresses its stated objectives and to contribute uniquely to both the theoretical discourse on food security, aligning closely with Sen's entitlement approach and the Sustainable Livelihoods Framework, and provides actionable policy insights tailored explicitly for Myanmar's challenging and fragile post-coup environment.

1.2 Purpose of the Study

- To analyze the pattern of missing meals among Myanmar households from the three primary food groups (carbohydrate, protein, and vegetables and fiber).
- To examine the demographic and socioeconomic factors associated with missing meals by analyzing the household characteristics, income, and expenditures.

2. Literature Review

Understanding why households experience food insecurity is supported by several theories. Sen's entitlement approach emphasizes that food insecurity stems not only from insufficient supply but from failures in people's access to food (Devereux, 2001). This means that even when food is available, families may still face hunger if they cannot obtain it due to factors like poverty, social barriers, or other constraints. In this study, the concept of "missing meals" reflects such entitlement failure, as it indicates a breakdown in households' ability to convert resources (income, assets, labor) into adequate food (Basu, 2025).

In addition, frameworks of household livelihoods such as the Sustainable Livelihoods Approach highlights how various forms of capital such as human capital (education and skills), financial capital (income, savings, debt), and social capital (community inclusiveness) determine a household's resilience against hunger (FAO, 1997). For instance, families with limited education or heavy debt have weaker livelihood assets, while those embedded in supportive communities demonstrate stronger coping capacity. These theoretical frameworks provide the foundation for examining the socioeconomic drivers of "missing meals" in Myanmar and are used later in this study to interpret the empirical results.

Food insecurity remains a significant challenge globally, especially in developing countries like Myanmar. A substantial body of literature identifies various demographic and socioeconomic factors that consistently influence household food security across diverse contexts. Among these, income and expenditure patterns are a primary determinant. Lower-income households often prioritize affordable, calorie-dense staples over a diverse and nutritious diet. In Myanmar, an IFPRI study revealed that only households in the top two expenditure quintiles consumed protein-rich foods and fats at or exceeding recommended levels (IFPRI, 2019). Low income households rely heavily on carbohydrate rich staples like rice, while skimping on more expensive food groups like meat, fish, eggs, dairy, and oils (IFPRI, 2023). This pattern of prioritizing caloric intake over nutritional diversity can be seen in other developing nations where rising incomes correlate with greater dietary diversification towards nutritious foods (FAO, 2006).

This lack of dietary diversity can have serious health consequences. Malnutrition including both undernutrition and micronutrient deficiencies is a major public health issue in Myanmar. Before the 2021 coup, over a third of children under five were stunted (chronically malnourished), while wasting (acute malnutrition) affecting nearly 8% of children (Frontier, 2023). These conditions have likely worsened with ongoing economic disruption. A 2022 UNDP survey reported that one in four Yangon households in low-income areas could not afford nutritious food at some point in the previous year (Frontier, 2023).

Inadequate intake of protein, fats, and micronutrient-rich foods leads to growth faltering, weakened immunity, and higher risks of infectious diseases in children (IFPRI, 2022). Among adults, poor diets reduce productivity, increase susceptibility to illness, and contribute to nutrition-related non-communicable diseases (Tint Swe Latt, 2011). Low-income households therefore face a double burden: limited ability to purchase nutritious food and higher medical costs due to poorer health outcomes, which further restrict food spending and deepen insecurity.

Education also plays a protective role. Better educated individuals tend to have higher productivity and earnings, which increases their ability to purchase sufficient food (FAO, 2020). Research consistently shows that higher educational attainment increases income earning potential and provides better knowledge on food consumption and nutrition, reducing the likelihood of missed meals (Gustafsson, 2011). In Myanmar's case, households with educated members may adapt more successfully with improved farming practices or diversified livelihoods, thereby reducing their risk of missing meals. Conversely, lack of education can trap families into low-paying jobs and poor awareness of nutrition, perpetuating vulnerability to food shortages.

Increased labor force participation is a key determinant in improving food security, as households with more economically active members are less likely to miss meals due to higher and more stable incomes. (Craig Gundersen, 2017). In 2017, while the national unemployment rate was about 4%, it was 7.5% among U.S. households classified as experiencing marginal food security, and over 13% in those with very low food security (Krogh, 2016). Similar patterns are observed in developing countries: job loss or lack of work is a major trigger for household food insecurity, as income drops suddenly undermine families' food purchasing power. It is important to note, however, that even full-time employment does not always guarantee food security if wages are very low or prices high which is a situation seen in Myanmar where many working poor still struggle to afford enough food. Nonetheless, improving employment opportunities and livelihoods is widely seen as essential to reducing chronic food insecurity.

Household debt is another important driver. Families with high levels of unsecured debt are more likely to experience food insecurity, as repayment obligations force them to divert resources away from food purchases and will face missing meals (Brewer, 2019). This burden is particularly acute for poorer households, who may sacrifice meals or have cheaper, less nutritious food to repay the debt to avoid penalties or asset loss. Globally, recent economic strains have pushed families into a debt-hunger trap, borrowing simply to meet basic needs. In Myanmar, rising food prices and economic instability have increased reliance on borrowing, making it more difficult to maintain adequate diets. Addressing food insecurity thus requires policies that ease financial stress, such as debt relief or social protection programs, to prevent households from trading off food consumption for loan repayments.

Beyond household attributes, community factors also influence food security. Strong social ties enable households to share resources, exchange food, or rely on neighbors during crises, while socially isolated families are more vulnerable. Global evidence shows that social capital improves food security by facilitating knowledge and product sharing within communities (Nosratabadi et al., 2020). In practice, high-trust communities often organize collective granaries, communal kitchens, or informal lending, which help households avoid missing meals. In Myanmar, traditional systems such as reciprocal labor, religious aid, and social groups play a similar role, though conflict and displacement have recently strained these networks.

Tackling food insecurity requires multi-dimensional interventions. In Myanmar, experts emphasize boosting agricultural productivity and market access to increase supply and lower prices, alongside raising household incomes so families can afford diverse diets (UNDP, 2023). Social safety nets, nutrition education, and investments in water, sanitation and health services will also be critical, especially for the poorest such as cash or food assistance programs can reduce the incidence of missed meals during economic downturns (John McDermott, 2022). These strategies align with global frameworks like the Sustainable Livelihoods Approach, which suggest building assets (human, financial, social, etc.) and reducing vulnerability. Ultimately, improving food security involves not only expanding food availability but also strengthening households' entitlements and capabilities through policies ranging from stabilizing prices and creating jobs to land reform and community development.

Researchers have widely used logit-based models to analyze food insecurity determinants, reflecting the binary or categorical nature of food security outcomes. For example, rural household studies applied ordered logit to capture varying degrees of insecurity in Ethiopia (Muluken et al., 2008) and Central Ethiopia (Beyene & Muche, 2010), while similar methods were used in northern Iran (Maryam Shakiba, 2021). Multinomial logistic regression has also been employed to distinguish between food secure, mildly, moderately, and severely insecure households (Coleman-Jensen, 2010). These studies found factors like income, employment, health status, and social support were significant predictors of food insecurity levels.

However, it is also recognized in the literature that these standard logit models have certain limitations and should be chosen carefully. A binary or multinomial logistic regression assumes the Independence of Irrelevant Alternatives (IIA) meaning the odds of being in one food security category versus another are unaffected by the presence or characteristics of additional categories. The tiers of food security such as being food secure, moderate insecure, severe insecure may have a natural ordering or correlation that violates the IIA assumption. Ordered logit models address the ranking of categories but impose the restrictive assumption of proportional odds (i.e. that the effect of a predictor is constant across the cut-offs between categories), which may not always hold. Moreover, if the analysis involves count data for instance, the number of meals skipped or days without adequate food, many households might report zero incidences especially in short reference periods or better-off groups. Such zero-inflated outcomes can bias ordinary logistic or linear models. In these cases, researchers sometimes turn to alternative models such as zero-inflated Poisson or negative binomial models can separately account for the excess zeros (households that never miss meals) and the positive counts (Sarno et al., 2014). This two-part modeling approach recognizes that there may be a qualitative difference between households that are not food insecure at all and those that experience some degree of food insecurity.

Another consideration is the structure of the data. If multiple survey rounds or longitudinal data are available, using panel data methods can improve the analysis by controlling for unobserved household characteristics that do not change over time. A fixed-effects logistic regression (Chamberlain's approach) is one such method; it effectively compares each household to itself over time to see how changes in income, employment, or other factors alter its food security status. In the context of this study, three rounds of the Myanmar Household Welfare Survey data were employed. While not a perfect panel (since some households appear in some rounds and not others), it allowed a pseudo-longitudinal perspective.

Given the categorical nature of food security status and the potential violation of the Independence of Irrelevant Alternatives (IIA) assumption in multinomial logit, this study employs a Nested Logit model. Unlike the multinomial logit, the nested logit allows correlation within groups of alternatives, offering a more flexible error structure while retaining a closed-form probability solution (Ben-Akiva et al., 2001). In this study, the model captures a two-level decision process: first, whether a household is food secure or food insecure; and second, if insecure, whether it faces moderate or severe food insecurity. This structure reflects that moderately and severely insecure households are more similar to each other than to food-secure households. By using a nested logit, the study accounts for the possibility that the relative risk of moderate vs. severe insecurity is more closely related than the risk of being secure vs insecure. This is something a standard multinomial logit would not be able to present due to IIA. Preliminary Hausman–McFadden tests confirmed potential IIA violations, supporting the nested logit as a more reliable specification.

In summary, food insecurity in Myanmar is shaped by drivers common to many developing contexts: poverty and low incomes, poor diet diversity, limited education and employment opportunities, debt burdens, and weakening social networks. These factors align with established theories, from Sen's entitlement approach to sustainable livelihoods frameworks, which emphasize the roles of human, financial, and social capital. Empirically, past studies have used various logit-based models to analyze food insecurity, and this study builds on that

methodological foundation. By applying logit-based methods within this theoretical context, the study extends understanding of how socioeconomic and demographic factors influence food security outcomes. Importantly, the focus on "missing meals" provides a direct lens to identify not just symptoms but also underlying causes of household food insecurity in Myanmar, informing more effective interventions.

3. Data and Methodology

3.1 Data Source and Scope of the Study

This study will use secondary data from the Myanmar Household Welfare Survey (MHWS) conducted by Myanmar Agriculture Policy Support Activity (MAPSA) led by the International Food Policy Research Institute (IFPRI). Ethical guidelines for secondary data analysis were strictly adhered to, including ensuring data privacy, confidentiality, and appropriate use as stipulated by the original data providers (MAPSA, IFPRI).

The MHWS survey has three rounds: Round 1 between December 2021 and February 2022 with 12,100 households, round 2 between April 2022 and June 2022 with 12,142 households, and Round 3 between July 2022 and August 2022 with 12,128 households, conducted by telephone interviews. This study will use the three rounds to analyze the patterns of missing meals and identify the factors associated with this problem. These rounds together cover a broad geographic range reaching 310 out of Myanmar's 330 townships therefore providing comprehensive coverage of urban and rural areas.

Although the survey attempted to track the same households across rounds (forming a panel), some households dropped out or were added in subsequent rounds to maintain sample size. As some households are observed in multiple rounds, the panel structure of the data is accounted for in the regression analysis by using *cluster-robust standard errors* at the household level and including round indicators. This approach adjusts for the non-independence of repeated observations on the same household and yields robust inference consistent with international standards for panel data analysis. It offers a practical compromise given with the short panel only have three waves and avoids the complexity of fixed-effects logistic models, which in this context could drop households with no variation in outcomes. By clustering on household ID, the study ensures that standard errors reflect within household correlation, and including round dummies can capture any time-specific effects across the survey waves.

In the context of this study, "missing meals" refers to a household skipping meals from the primary food groups (carbohydrates, proteins, and vegetables/fiber) during a specified time. These primary food groups are essential for maintaining a balanced and nutritious diet, as they provide the necessary energy, nutrients, and fiber required for maintaining good health. Skipping meals from these primary food groups can lead to inadequate nutrient intake and potential health risks.

The study adopts the missing-meals measure across three broad food categories as the primary indicator of food insecurity to fill a gap in the literature and to leverage the data available in the MHWS. Conventional measures like the Household Dietary Diversity Score (HDDS) or the Food Consumption Score (FCS) provide granular insight into diet quality by counting a wide range of food groups or weighting consumption frequencies. For instance, the HDDS counts the number of different food groups consumed in a 24-hour period , and the FCS aggregates 7-day consumption frequencies of about eight standard food groups (such as cereals, legumes, vegetables, fruits, animal protein, dairy, oils, sugars) with nutritional weights to produce a score (Delisle et al., 1991). Those indices are very informative, but they can be complex to compute and interpret. In contrast, the missing meals indicator in this study is a straightforward measure of extreme dietary insufficiency: it flags households that entirely lack one or more essential food categories in their weekly diet. This simplicity makes it easy to communicate and directly highlights severe cases.

The study categorizes foods into three main groups as follows:

Carbohydrates: Staple foods rich in energy, including rice, cereals, grains, potatoes, tubers, pasta, bread, and noodles.

Proteins: Foods essential for growth and tissue repair, such as beans, nuts, dairy products, fish, meat, and eggs.

Vegetables and Fiber: Nutrient-dense foods provide vitamins, minerals, and fiber, encompassing both vegetables (leafy greens, orange-colored vegetables, etc.) and fruits.

The study's analytical focus is strictly on household consumption on these three main food groups and does not delve into food quality or dietary diversity beyond these categories. For example, the study will not distinguish whether protein came from animal vs plant sources, nor whether vegetables were various colors. By narrowing the focus, the study aims to clearly assess whether households are meeting basic consumption in each essential food category, which is a fundamental aspect of food security. Additionally, this study does not incorporate any data outside the three MHWS rounds. The study acknowledges that pooling the rounds will lose the opportunity to explore dynamics over time for the same household, however, given the short span and the economic shocks Myanmar faced during this period, treating the data in aggregate with time controls is a reasonable approach.

3.2 Panel Data Considerations and Methodological Choice

While the dataset comprises three separate survey rounds, this study employed pooled cross-sectional analysis with clustered standard errors instead of traditional panel data methods (e.g., Fixed Effects, Random Effects, GEE, or GMM). This approach was primarily chosen due to constraints in the survey design and data availability.

Specifically, the MHWS dataset does not consistently track the same households across all three rounds, making traditional longitudinal analyses challenging. Moreover, significant attrition and sampling differences across rounds could introduce bias if strictly panel methods were applied. Therefore, pooling data with robust standard errors clustering at the household level provided a practical and reliable analytical framework given these limitations. Future studies might consider employing longitudinal methods, contingent on the availability of true panel data, to strengthen causal inference.

3.3 Conceptual Framework

Food insecurity in this study is conceptualized at the household level, as missing meals typically affects all members collectively rather than individuals in isolation. A range of socioeconomic, health, and community factors shape household vulnerability. Location (urban vs. rural) influences access to markets, employment opportunities, and seasonal food availability. Education, proxied by the highest attainment among members, reflects human capital that enhances income prospects and nutritional knowledge, thereby lowering the risk of food insecurity (Gustafsson, 2011). The size of the labor force within a household directly affects income generation and economic resilience. Conversely, the presence of sickness can increase medical costs and reduce productive capacity, heightening food insecurity risks. Debt burdens also constrain household budgets by diverting resources away from food expenditure. Finally, community inclusiveness, the extent to which households are embedded in supportive social networks can mitigate risks by providing informal assistance during times of crisis (Nosratabadi et al., 2020). In summary, the framework posits that household food insecurity emerges from the interaction of these economic, demographic, and social factors, all of which are explicitly tested in the empirical analysis.

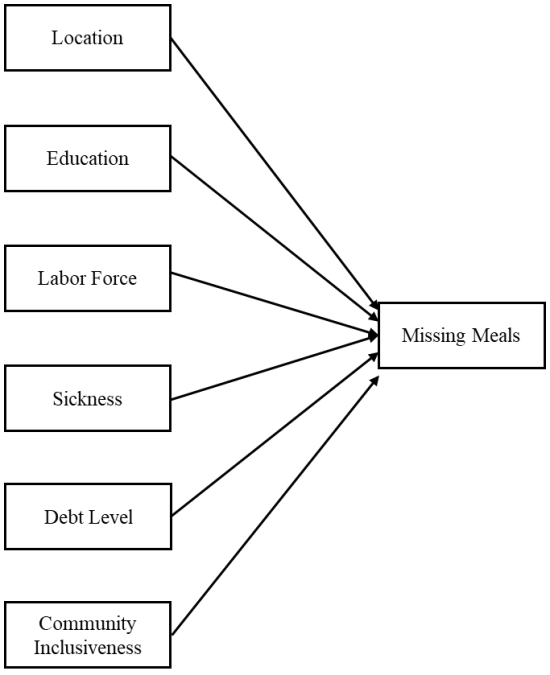

Figure C: Conceptual Framework
Source: Author's illustration

3.4 Data Preparation and Definition of Variables

The classification of missing meals categorizes households into three groups based on their consumption of the primary food groups (carbohydrates, proteins, and vegetables/fiber) in the seven days preceding the survey:

- Group A: Households that consumed all three primary food groups (carbohydrates, proteins, and vegetables/fiber) at least once in the last seven days.
- Group B: Households that missed one of the primary food groups in the last seven days. These households went without at least one category of essential foods such as a household that might have eaten cereals and vegetables but no protein sources during the week.
- Group C: Households that missed two or more primary food groups in the last seven days. It includes households that missed two groups as well as the rare cases that missed all three groups (consumed none of the three categories).

Originally, the study considered distinguishing households that missed exactly two groups from those that missed all three; however, the latter scenario is extremely uncommon in the data, so the categories were combined into a single "two or more" category for analytical feasibility.

The dependent variable was constructed using MHWS food consumption data, resulting in a binary indicator for missing meals and a three-level categorical variable for the nested logit model. Households were grouped based on

whether they consumed items from the three main food groups at least once in the past week. Group A had no missing meals, Group B missed one food group, and Group C missed two or more. Independent variables were derived from relevant MHWS survey questions, reflecting the conceptual factors outlined previously.

Table 1: Distribution of Households' Missing Meals by Binary Indicator

Missing Meals Binary Indicator	Freq.	Percent	Cum.
Households with No Missing Meals	10,535	28.97	28.97
Households with Missing Meals	25,835	71.03	100.00
Total	36,370	100.00	

Source: Author's calculations from Myanmar Household Welfare Survey (MHWS) data

Table 2: Distribution of Households' Missing Meals Group

Missing Meals Group	Freq.	Percent	Cum.
Group A: No Missing Meals	10,535	28.97	28.97
Group B: Missed One Food Group	16,787	46.16	75.12
Group C: Missed Two or More Food Groups	9,048	24.88	100.00
Total	36,370	100.00	

Source: Author's calculations from Myanmar Household Welfare Survey (MHWS) data

Location: The MHWS recorded whether each household is in an urban or rural area, likely based on the official designation of the enumeration area or township. The study uses this binary classification directly from the survey. Urban households typically living in cities or large towns are coded as one category, and rural household villages or small towns like the other. This variable requires no further grouping as it's inherently binary.

Table 3: Distribution of Households by Location

Location	Freq.	Percent	Cum.
Rural	25,424	69.90	69.90
Urban	10,946	30.10	100.00
Total	36,370	100.00	

Source: Author's calculations from Myanmar Household Welfare Survey (MHWS) data

Education: This study uses the highest education level attained by any adult household member as a proxy for the household's overall human capital. The MHWS originally reported 20 detailed education categories (ranging from no schooling to PhD), which were consolidated into four groups:

- No Education: No member with formal schooling (including non-formal/monastic).
- Primary Education: At least one member completed Grade 1–5 but none higher.
- Secondary Education: At least one member completed Grade 6–12 but none higher.
- Higher Education: At least one member with education beyond high school (college, university, vocational training).

This reclassification was chosen to capture meaningful differences in human capital, labor market prospects, and nutritional awareness, while ensuring methodological feasibility. Collapsing the original 20 categories into four reduced sparseness across groups and enabled stable regression estimates, especially for the nested logit models.

Table 4: Distribution of Households by Education Level

Education	Freq.	Percent	Cum.
No education	1,293	3.58	3.58
Primary education	14,819	40.99	44.57
Secondary education	14,515	40.15	84.71
Higher education	5,526	15.29	100.00
Total	36,153	100.00	

Source: Author's calculations from Myanmar Household Welfare Survey (MHWS) data

Labor Force: Household labor capacity is measured by the number of members engaged in income-generating activities, as reported in the MHWS ("In the past three months, how many household members have engaged in income-generating activities, including household farming or business activities?"). For analysis, households were grouped into three categories: Low labor force: 0–2 members, Moderate labor force: 3–4 members, High labor force: 5 or more members. These thresholds reflect both the distribution of the data and the reality that households with five or more workers are relatively rare and typically represent extended families. Households with more economically active members are expected to face lower risks of missing meals, as greater labor capacity increases income-generating potential and resilience.

Table 5: Distribution of Households by Labor Force

Labor Force	Freq.	Percent	Cum.
Low (0-2)	24,015	66.03	66.03
Moderate (3-4)	10,570	29.06	95.09
High (5 and above)	1,785	4.91	100.00
Total	36,370	100.00	

Source: Author's calculations from Myanmar Household Welfare Survey (MHWS) data

Sickness: The survey asks whether any household member has been ill or unable to carry out normal activities due to health in a recent period. The study created a binary indicator where 1 = the household has at least one member who was sick (the recall period in the survey is past 30 days), and 0 = no members sick. This variable captures the presence of health shock.

Table 6: Distribution of Households by Sickness

Sickness	Freq.	Percent	Cum.
No Sickness	27,433	75.43	75.43
Sickness	8,937	24.57	100.00
Total	36,370	100.00	

Source: Author's calculations from Myanmar Household Welfare Survey (MHWS) data

Debt Level: Since the MHWS did not collect actual monetary values of household debt, this study constructed a debt stress index based on eight "coping and indebtedness" indicators, such as selling or mortgaging assets, spending savings, reducing health or food expenditures, borrowing money, or holding outstanding loans. Each response was coded as yes/no and summed up to create a score from 0 (no distress) to 8 (maximum distress). Households were grouped into three categories: No/Low Debt: 0–2, Moderate Debt: 3–5, High Debt: 6–8. This classification captures the nonlinear effect of financial strain, where higher debt stress is expected to substantially increase the likelihood of missing meals compared to households with little or no debt.

Table 7: Distribution of Households by Debt Level

Debt Level	Freq.	Percent	Cum.
No to Low Debt	15838	43.55	43.55
Moderate Debt	15261	41.96	85.51
High Debt	5271	14.49	100.00
Total	36,370	100.00	

Source: Author's calculations from Myanmar Household Welfare Survey (MHWS) data

Community Inclusiveness: This variable was constructed from the MHWS community module, combining indicators of trust, perceived safety, and recent community changes (e.g., migration, crime, or violence). Each indicator was coded as yes/no and summed into a score, which was categorized as: Low Inclusiveness: 0, Moderate Inclusiveness: 1, High Inclusiveness: 2 or more. Households with higher inclusiveness are assumed to have stronger social support networks and are therefore less likely to miss meals, while socially isolated households face greater vulnerability during crises.

Table 8: Distribution of Households by Community Inclusiveness

Community Inclusiveness	Freq.	Percent	Cum.
Low Inclusiveness	1787	4.91	4.91
Moderate Inclusiveness	6184	17.00	21.92
High Inclusiveness	28399	78.08	100.00
Total	36370	100.00	

Source: Author's calculations from Myanmar Household Welfare Survey (MHWS) data

In addition to the main variables, the study will include control variables for the survey rounds as dummy variables in regressions, to account for temporal or seasonal effects.

Table 9: Distribution of Households by Survey Rounds

Survey Rounds	Freq.	Percent	Cum.
Round 1	12,100	33.27	33.27
Round 2	12,142	33.38	66.65
Round 3	12,128	33.35	100.00
Total	36370	100.00	

Source: Author's calculations from Myanmar Household Welfare Survey (MHWS) data

To analyze the determinants of missing meals, the study employs two econometric models: a Binary Logit model and a Nested Logit model. The binary logit collapses the outcome to whether a household has any missing meals or not, while the nested logit differentiates the severity (no vs one vs multiple). Using both allows the study to see if the drivers of food insecurity operate mainly at the extensive margin (at all missing vs not) or also differ at the intensive margin. Both models are estimated with pooled panel data, using the techniques described (round controls and clustered standard errors).

3.5 Binary Logit Model

The binary logistic regression model, or binary logit model, is a statistical model used to predict the probability of a binary (two-category) dependent variable based on one or more independent variables. It models the log-odds of the two possible outcomes of a binary dependent variable as a linear combination of the predictor variables. The binary logit model is appropriate when the dependent variable is dichotomous, taking on values of 0 or 1, success or failure, etc. (Garson, 2014).

In this study, the binary logit model classifies households into two groups: households with missing meals (Group B and C) and households without missing meals (Group A). The dependent variable is binary, with Y = 1 indicating a household missing meals and Y = 0 if the household does not have the problem. The mathematical model of the binary logit model is as follows:

$$\log\left(\frac{prob(Y=1)}{prob(Y=0)}\right) = \alpha + \beta_1 Income + \beta_2 Expenditures + \beta_3 Inclusiveness + \varepsilon \qquad (1)$$

Where:

Y = 1 ; A household with missing meals problem (Group B and C)
Y = 0 ; A household without missing meals problem (Group A)
Income ; The potentiality of income generation of a household
Expenditures ; The expenditure burdens of a household
Inclusiveness ; Community inclusiveness of a household

However, this model may face a severe multicollinearity problem between income generation and expenditures. Therefore, the model needs a modification into this form:

$$\log\left(\frac{prob(Y=1)}{prob(Y=0)}\right) = \alpha + \beta_{11} Laborforces + \beta_{12} Education + \beta_{13} Location + \beta_{14} Sickness + \beta_{15} Debts + \beta_{16} Inclusiveness + \varepsilon \qquad (2)$$

Where:

Y = 1 ; A household with missing meals problem (Group B and C)
Y = 0 ; A household without missing meals problem (Group A)

Independent Variables:

Location (binary: 0 = Rural, 1 = Urban)
Education (categorical, 4 levels: No Education, Primary, Secondary, Higher)
Labor Force (categorical, 3 levels: Low [0–2], Moderate [3–4], High [5+])
Debt (categorical, 3 levels: No/Low [0–2], Moderate [3–5], High [6–8])
Sickness (binary: 0 = No sickness, 1 = At least one member sick)
Community Inclusiveness (categorical, 3 levels: Low, Moderate, High)

Given the panel nature of the data, the study implements the estimation with clustered standard errors by household ID (vce cluster hhid) in Stata. This relaxes the assumption of independent errors as logit normally assumes each observation's error term is independent which is violated because a household's repeated responses are likely correlated. By clustering, the study obtains robust standard errors that are valid even if there is intra-household correlation across rounds.

3.6 Nested Logit Model

The nested logit model is an extension of the standard logit model, designed for situations where the dependent variable has more than two outcomes that are not completely independent of each other. The model allows for a "nested" or hierarchical structure in the decision process, capturing the fact that some choices are more closely related than others (Train, 2009).

In this study, the nested logit model is used to classify households into three groups according to the severity of missing meals:

- Group A: Households with no missing meals
- Group B: Households that missed one meal
- Group C: Households that missed two or more meals

The model assumes a two-stage decision process:

1. First stage (branch): The household decides whether to miss any meals (no missing meals vs. any missing meals).
2. Second stage (within "missing meals"): For those who do miss meals, the household is further classified by severity (missed one meal vs. missed two or more meals).

This structure reflects the idea that the factors leading a household to miss meals at all may differ from those that influence severity once food insecurity occurs.

The mathematical form of the nested logit model can be summarized as follows:
First Stage (Branch Decision):

$$Y_j = \alpha + \beta_{21}Laborforces + \beta_{22}Education + \beta_{23}Location + \beta_{24}Sickness + \beta_{25}Debts + \beta_{26}Inclusiveness + \varepsilon \quad (3)$$

Second Stage (Severity Decision, among the missing meals):

$$Y_j = \alpha + \beta_{31}Laborforces + \beta_{32}Education + \beta_{33}Location + \beta_{34}Sickness + \beta_{35}Debts + \beta_{36}Inclusiveness + \varepsilon \quad (4)$$

Where:

$Y_j = 0$: Households in Group A (no missing meals)
$Y_j = 1$: Households in Group B (missed one food group in the last seven days)
$Y_j = 2$: Households in Group C (missed two or more food groups in the last seven days)

Independent Variables:

Location (binary: 0 = Rural, 1 = Urban)
Education (categorical, 4 levels: No Education, Primary, Secondary, Higher)
Labor Force (categorical, 3 levels: Low [0–2], Moderate [3–4], High [5+])
Debt (categorical, 3 levels: No/Low [0–2], Moderate [3–5], High [6–8])
Sickness (binary: 0 = No sickness, 1 = At least one member sick)
Community Inclusiveness (categorical, 3 levels: Low, Moderate, High)

3.7 Assumptions of Logit Models

The binary logit model assumes that observations are independent, predictors have no perfect multicollinearity, and the model is correctly specified (i.e., no omitted important variables). To address non-independence due to repeated households across survey rounds, the study clustered standard errors at the household level, accounting for correlated observations. Multicollinearity was assessed using Variance Inflation Factor (VIF), with results confirming acceptable levels. Additionally, the model assumes linearity between continuous predictors and log-odds; however, as our predictors are primarily categorical, this assumption is naturally satisfied.

The nested logit model relaxes the Independence of Irrelevant Alternatives (IIA) assumption of multinomial logit models by allowing correlation among alternatives within the same nest. The main assumption is that alternatives within a nest share correlated unobserved characteristics, captured by the inclusive value parameter (τ). The validity of the nested structure (no missing meals vs. any missing meals, and mild vs. severe insecurity) will be verified by evaluating τ values, which should lie between 0 and 1 (Train, 2009). A significant deviation from this range would suggest model misspecification. The study chose categorical definitions for key variables (debt level, education, labor force, and community inclusiveness) to capture potential nonlinear effects, thus further ensuring correct model specification. Robust standard errors clustered by households are also used here to account for panel-related correlation.

3.8 Robustness Check

To assess the stability of the main findings, a series of robustness checks were performed by re-specifying key independent variables in the logit models. For education, alternative categorizations were tested (e.g., grouping "no education," "primary," and "secondary" together versus "higher education" only). Debt level was also redefined, both by collapsing moderate and high debt into a single "any debt" category and by adjusting the threshold for high debt. Similarly, the labor force participation variable was re-categorized to test different groupings. Across all these alternative specifications, the results for the key predictors, i.e. education, labor force participation, debt, location, and community inclusiveness remained highly consistent in direction, magnitude, and statistical significance. The protective effects of education and labor force participation, as well as the increased risk associated with higher debt, persisted regardless of the categorization method. These results confirm that the core findings of this study are robust to reasonable changes in variable definition and model specification.

Finally, sensitivity analyses such as estimating models separately by round and comparing them to the pooled results, confirm the consistency and stability of our key findings.

3.9 Econometric Consideration

While binary and nested logit models effectively capture relationships between socioeconomic determinants and household food insecurity, interpretation primarily remains correlational rather than causal. Endogeneity is a potential concern, particularly regarding variables like sickness and debt. For instance, illness could be both a cause and consequence of food insecurity, suggesting potential reverse causality. Similarly, debt could result from food insecurity itself, creating a feedback loop. This limitation means that results should be interpreted cautiously as indicative associations. Future studies could enhance causal inference by adopting instrumental variable approaches or panel data methods that explicitly control such endogeneity.

4 Results

4.1 Estimation Results of the Binary Logit Model

A correlation analysis was conducted among the independent variables to check for multicollinearity. The results showed that no pair of variables had a correlation higher than 0.2, well below the common threshold of 0.8, indicating that multicollinearity is not a concern in this analysis. The binary logistic regression model identifies key socioeconomic factors associated with households missing one or more essential food groups in the past week. The Average Marginal Effects (AMEs) indicate how each variable influences the probability of missing meals, holding other factors constant. Given that about 71% of households in the survey reported missing meals, food insecurity is widespread, even among those in relatively better-off groups. Thus, the interpretation focuses on relative differences between categories, using AMEs to highlight how each socioeconomic factor shifts risk within this already high baseline.

Location

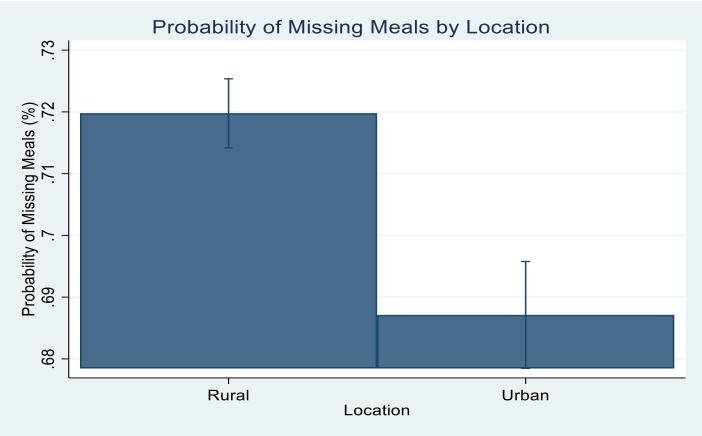

Figure D: Average Marginal Effects on Location
Source: Author's calculations from MHWS pooled survey data using Stata

The AME results show that urban households are about 3.1 percentage points less likely to miss meals compared to rural households. Although this difference is statistically significant, it remains modest given the high overall rate of food insecurity (71%). Still, the urban advantage highlights the potential benefits of better infrastructure, market access, and economic opportunities typically found in urban areas.

Education

Higher education significantly lowers the risk of food insecurity. Households with at least one member holding higher education are about 9 percentage points less likely to miss meals, and secondary education reduces risk by about 5 points, compared to households with no formal education. This highlights how education offers strong protection against food insecurity by improving job prospects, financial stability, and nutrition knowledge and underlines the value of education-focused policies.

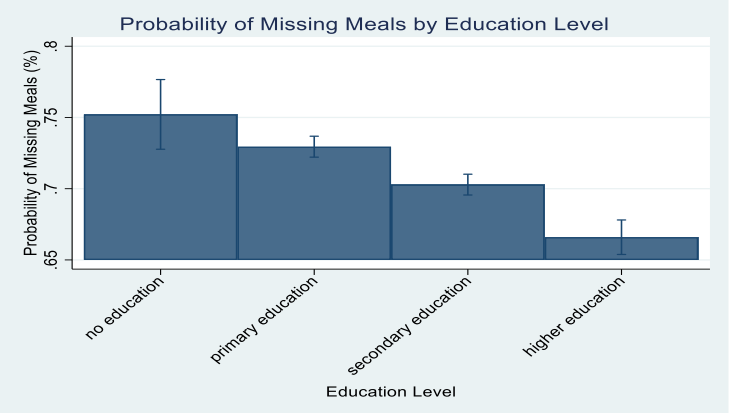

Figure E: Average Marginal Effects on Education
Source: Author's calculations from MHWS pooled survey data using Stata

Labor Force

Households with more working members enjoy significantly better food security. Having 3–4 workers reduce the chance of missing meals by 5 percentage points, while 5 or more workers lowers it by almost 11 points, compared to households with only 0–2 workers. This highlights the importance of employment and stable income for protecting against food insecurity.

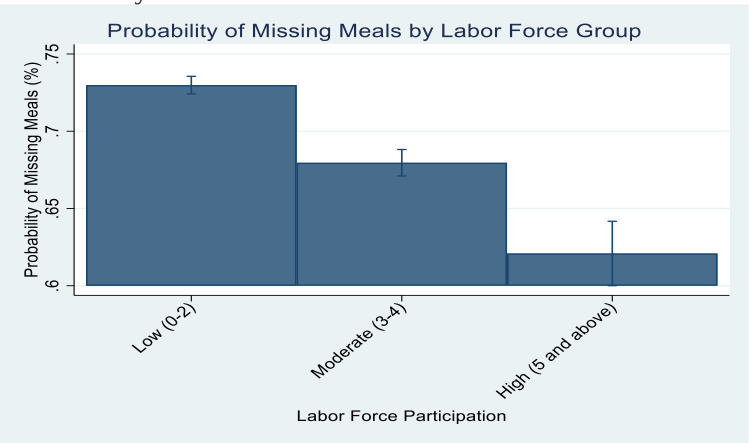

Figure F: Average Marginal Effects on Labor Force
Source: Author's calculations from MHWS pooled survey data using Stata

Sickness

Unexpectedly, households reporting sickness were slightly less likely to miss meals (69.3 %) than those without sickness (71.6 %). While counterintuitive, this difference is small and may reflect that sick households receive additional support, such as community help, government aid, or remittances, which helps them maintain food security during illness. Prior studies also find that households facing health shocks often rely on informal networks or emergency coping strategies to stabilize food consumption (IFPRI, 2022).

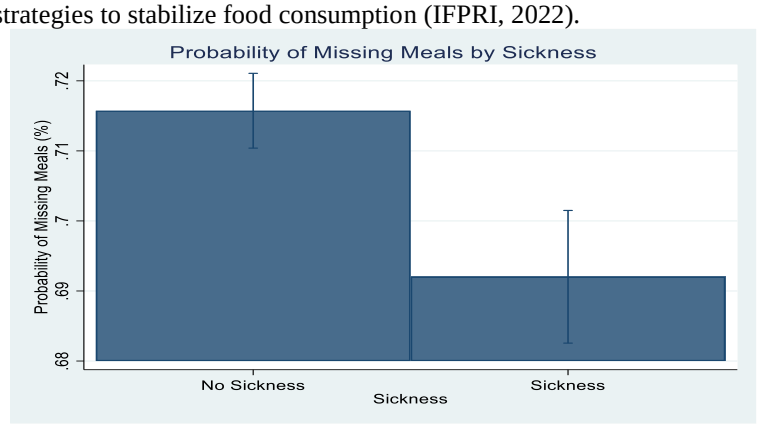

Figure G: Average Marginal Effects on Sickness
Source: Author's calculations from MHWS pooled survey data using Stata

Debt Level

High household debt markedly increases food insecurity by around 11.2 percentage points compared to households with little or no debt. Moderate debt also raises the risk by approximately 7 percentage points.

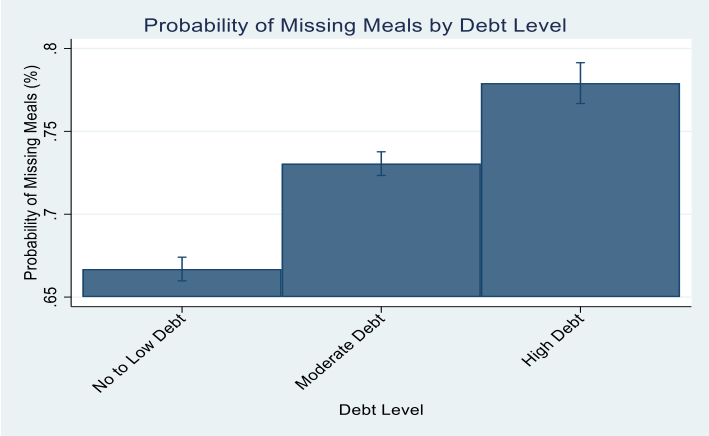

Figure H: Average Marginal Effects on Debt Level
Source: Author's calculations from MHWS pooled survey data using Stata

Community Inclusiveness

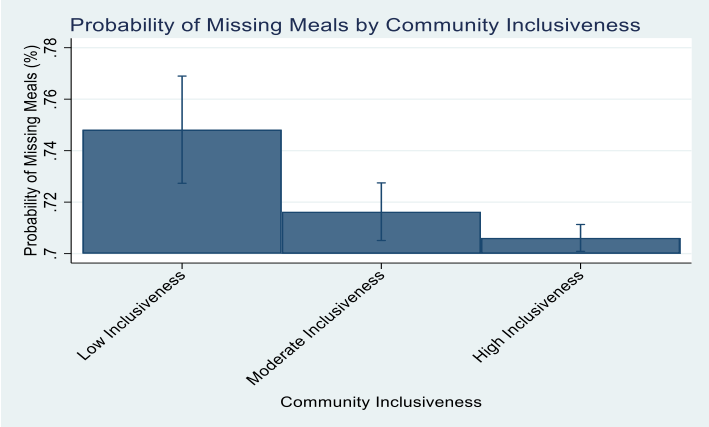

Figure I: Average Marginal Effects on Community Inclusiveness
Source: Author's calculations from MHWS pooled survey data using Stata

Community inclusiveness provides protective effects against food insecurity. Households embedded within supportive communities exhibit about 5.2 percentage points lower probability of missing meals compared to isolated households. This indicates that strong community networks can mitigate financial shocks by facilitating resource sharing, collective purchasing, and mutual aid. Policies fostering community cohesion and local networks could meaningfully enhance resilience against food insecurity.

Interpreting the Survey Rounds

Food insecurity probabilities increased notably from 63.5% (Round 1) to approximately 74.6% (Rounds 2 and 3). This significant rise reflects deteriorating external conditions, likely driven by economic instability, political turmoil, and conflict. The change highlights the necessity of timely interventions in response to rapidly evolving socioeconomic environments.

In summary, the binary logistic regression identified critical socioeconomic factors influencing household food insecurity in Myanmar. Education, debt management, labor force engagement, and community support networks emerged as key policy areas. While predictive probabilities reflect overall high food insecurity prevalence, AMEs illustrate how socioeconomic factors influence relative risks. To further explore the complexity of household decision-making concerning food insecurity, the following section utilizes a nested logit model to analyze the number of food groups households.

4.2 Estimation Results of the Nested Logit Model

The nested logit model provides deeper insights by modeling households' food insecurity decisions in two sequential steps. At the first level (branch-level), households decide whether they miss any meals at all. At the second level (alternative-level), households experiencing missing meals decide between moderate and severe categories of food insecurity. The branch-level analysis identifies factors affecting whether households miss meals at all, closely aligning with the earlier binary logistic regression results.

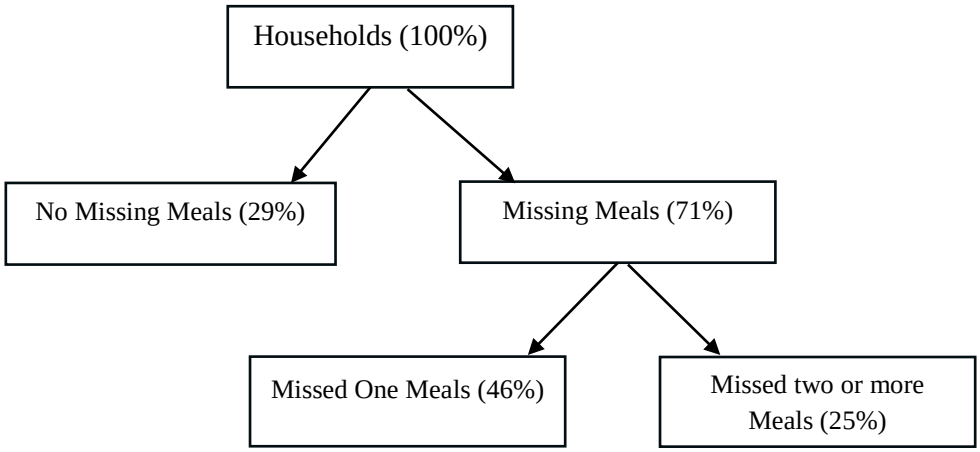

Figure J: Nested Logit Model
Source: Author's illustration

Table 10: Estimation of Nested Logit Model

Missing Meals	Coef	Std Err	P-value	Odds Ratio	Percentage
Location					
Urban	**Base**				
Rural	0.159	0.03	0.00***	1.17	17%
Education					
No Education	**Base**				
Primary Education	-0.06	0.071	0.40	0.94	6%
Secondary Education	-0.187	0.071	0.01***	0.83	17%
Higher Education	-0.368	0.076	0.00***	0.69	31%
Debt Level					
No to Low Debt	**Base**				
Moderate Debt	0.256	0.027	0.00***	1.29	29%
High Debt	0.492	0.04	0.00***	1.64	64%
Labor Force					
Low (1-2)	**Base**				
Moderate (3-4)	-0.247	0.028	0.00***	0.78	22%
High (5 and above)	-0.529	0.055	0.00***	0.59	41%
Sickness					
Sickness	**Base**				
No Sickness	0.114	0.029	0.00***	1.12	12%
Community Inclusiveness					
Low Inclusiveness	**Base**				
Moderate Inclusiveness	-0.196	0.063	0.00***	0.82	18%
High Inclusiveness	-0.247	0.058	0.00***	0.78	22%
Rounds					
Round 1	**Base**				
Round 2	0.54	0.026	0.00***	1.72	72%
Round 3	0.53	0.027	0.01***	1.70	70%

Source: Author's calculations from MHWS pooled survey data using Stata.

Coefficients from the nested logit model are initially expressed in log-odds terms. To interpret them intuitively, the study converts the log-odds into odds ratios using the exponential transformation.

$$Odds\ Ratio = e^{(coefficient)} \quad (5)$$

For example, higher education with coefficients of -0.368:

$$Odds\ Ratio\ (Higher\ Education) = e^{(-0.368)} \approx 0.69 \quad (6)$$

This odds ratio indicates households with higher education have **31% lower odds** of missing meals compared to those with no education, such as:

$$1 - 0.69 = 0.31 = 31\%$$

The dissimilarity parameter (tau) in nested logit models captures the degree of correlation among alternatives within each branch of the decision tree. A τ value close to 1 indicates a correlation among alternatives in the same branch. A τ significantly lower than 1 indicates strong correlation among alternatives within the same branch, validating the nested structure's appropriateness. In the main nested logit specification (Branch-Level Model), the estimated τ for the "Missing Meals" branch was 0.685 < 1. This supports the nested structure choice, as it confirms that households' choices between moderate and severe missing meals are correlated.

Location

Rural households have approximately 17% higher odds of missing meals compared to urban households. This difference may reflect disparities in infrastructure, employment opportunities, and market accessibility.

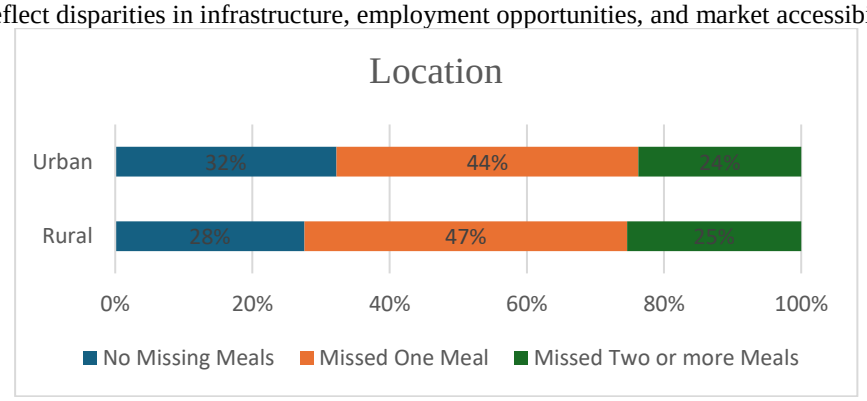

Figure K: Predictive Probability Location
Source: Author's calculations from MHWS pooled survey data

According to the predictive probability, urban households are more food secure than rural ones. For example, 32% of urban households have no missing meals compared to only 28% in rural areas, highlighting an urban-rural gap in food security.

Education Level

Education significantly reduces food insecurity. Households with higher education have substantially lower odds of missing meals (31%) compared to those with no education. Even secondary education has lower odds of 17% than no education. This suggests that education may enhance employment prospects, income stability, and nutritional awareness.

Predictive probability estimates show that as education level rises, the proportion of households with no missing meals increases steadily, from 25 percent among those with no education to 36 percent among those with higher education. Conversely, the likelihood of experiencing one or more missed meals declines, highlighting a strong association between higher education and improved food security.

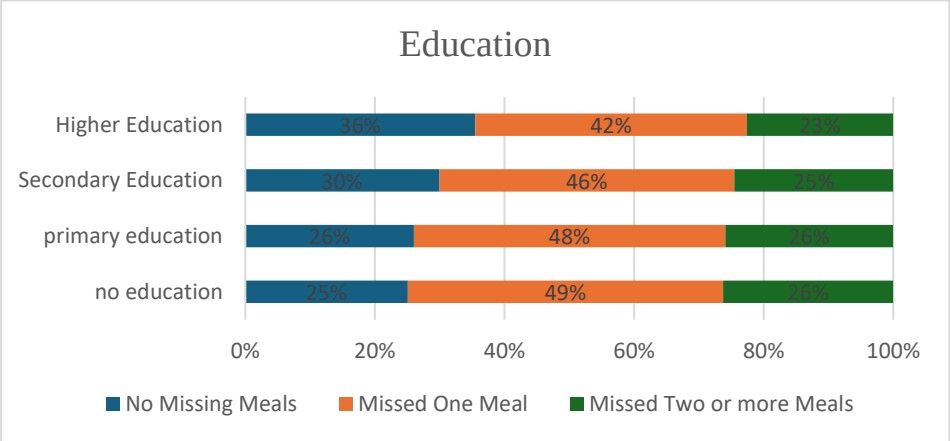

Figure L: Predictive Probability of Education
Source: Author's calculations from MHWS pooled survey data

However, education coefficients at the severity (alternative) level are not statistically significant. This suggests that while education helps households avoid missing meals initially, it does not significantly determine whether food insecurity becomes moderate or severe once a household is already affected. One likely explanation is that educational benefits such as financial literacy or better employment prospects primarily help households cope with or prevent initial shocks. In contrast, once a major shock occurs, education alone may not be sufficient, as it cannot provide immediate resources for food. These results indicate that, although enhancing education is important for long-term resilience against food insecurity, additional measures such as social protection and emergency relief are needed to support households once they become food insecure.

Debt Level

Rising debt levels are closely linked to higher food insecurity risk. Households with moderate debt are 29 percent more likely to miss meals, and this likelihood rises further to 64 percent among households with high debt. Heavy debt often forces families to divert resources from food toward debt repayment, deepening food insecurity.

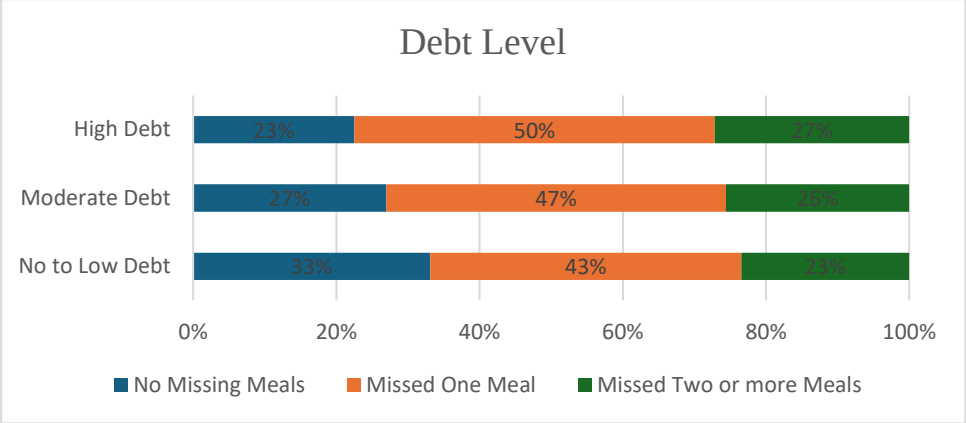

Figure M: Predictive Probability of Debt Level
Source: Author's calculations from MHWS pooled survey data

According to predictive probability, increasing debt is linked to greater food insecurity. The likelihood of having no missing meals drops from 33% among households with no or low debt to just 23% among those with high debt, while the probability of missing meals rises accordingly.

At the severity stage, high debt increases the odds of missing meals compared to no debt (by 38 percent), but it does not significantly distinguish between moderate and severe levels of insecurity among food-insecure households. This may suggest that once debt pushes a household into food insecurity, further increases in debt have diminishing additional impact on severity. Policy responses should therefore focus on broad-based debt relief for food-insecure households, as even moderate debt can heavily strain budgets and contribute to missing meals.

Labor Force

Greater household labor force participation significantly reduces the likelihood of missing meals. As households with high labor force (5 and above) are 41% less likely to face missing meals while households with moderate labor force (3-4) are 22% less likely to face missing meals. Households with higher numbers of employed members can diversify income sources, enhancing economic resilience and food security.

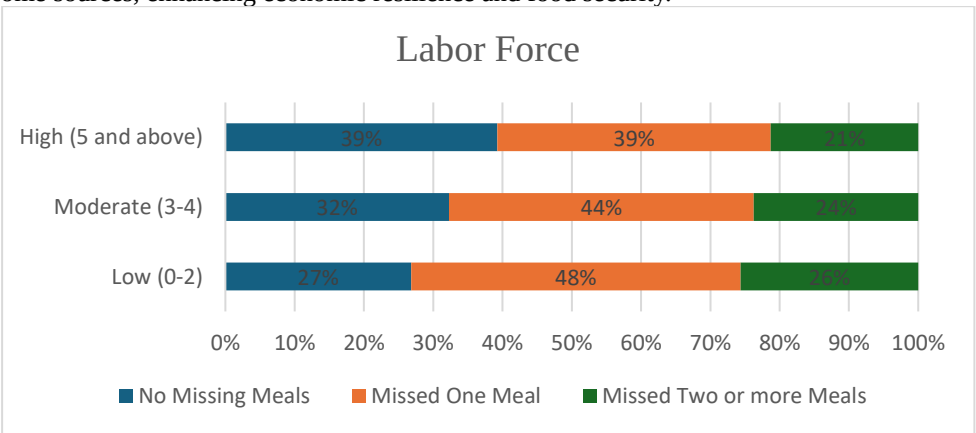

Figure N: Predictive Probability of Labor Force
Source: Author's calculations from MHWS pooled survey data

The predictive probability indicates that households with more working members are less likely to experience food insecurity. Those with high labor force participation have the highest probability of no missing meals (39%), compared to 27% for households with few or no working members.

Households with more workers showed significant distinctions at the alternative level. Those with moderate (coefficient = 0.196, $p<0.001$) and high labor participation (coefficient = 0.448, $p<0.001$) were more likely to experience moderate rather than severe food insecurity. This nuanced finding suggests that although employment and income help buffer against severe hardship, households might still struggle with moderate food shortages due to insufficient wages or unstable employment. The implication here is the need for policy initiatives aimed not just at creating employment opportunities, but also ensuring quality, stability, and fair wages to fully address food insecurity severity

Sickness

The result indicating slightly higher odds of missing meals among households without reported sickness is counterintuitive. A possible explanation might be that households reporting sickness may receive external assistance or implement specific coping strategies not captured in the model. This unexpected finding warrants further qualitative investigation.

The predicted probabilities for food insecurity are nearly the same for households with and without sickness (both 29% for no missing meals), suggesting little difference between these groups in this analysis. However, because the groups differ in size, the actual number of households experiencing each outcome varies; for example, 29% of the "no sickness" group represents 7,916 households, while 29% of the "sickness" group represents only 2,619 households.

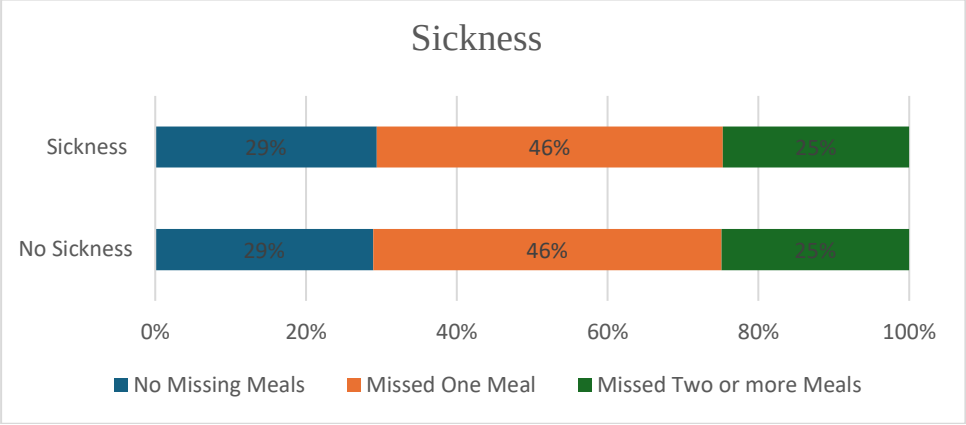

Figure O: Predictive Probability of Sickness
Source: Author's calculations from MHWS pooled survey data

Community Inclusiveness

Stronger community networks substantially decrease food insecurity. Communities with high inclusiveness are less likely to have missing meals by 22% while communities with moderate inclusiveness are less likely to have missing meals by 18%. Households embedded in inclusive communities likely benefit from mutual support, shared resources, and collective resilience in times of economic hardship.

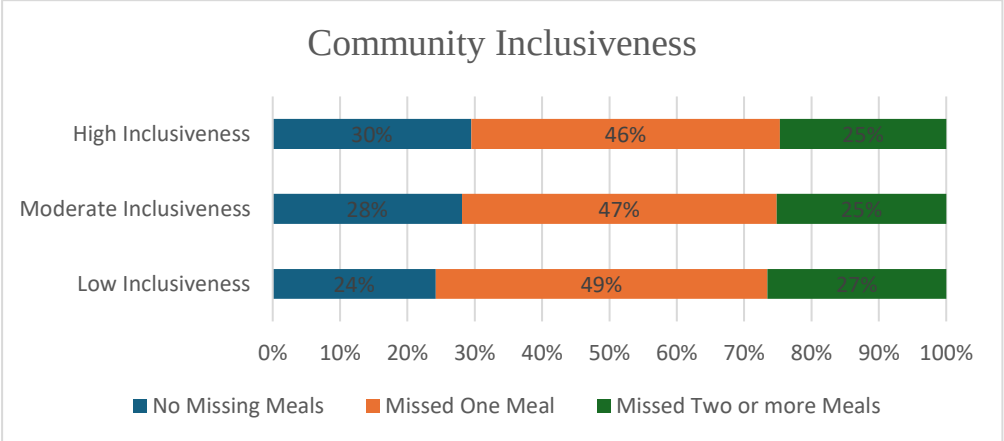

Figure P: Predictive Probability of Community Inclusiveness
Source: Author's calculations from MHWS pooled survey data

Predictive probability also indicates that food security improves with stronger community inclusiveness. The share of households with no missing meals rises from 24% in low-inclusive communities to 30% in highly inclusive ones.

Interpreting the survey rounds

Compared to round 1, households surveyed in round 2 or round 3 were about 70% more likely to experience missing meals. This indicates that food insecurity increased significantly in the later survey rounds, which may reflect changes such as seasonal hardship, economic downturns, or emerging crises over time. At the alternative level, households having the odds of being food secure (having no missing meals) were about 44% lower in rounds 2 and 3 compared to round 1. In other words, as time progressed, it became significantly less likely for households to avoid food insecurity altogether. There is no statistically significant difference between rounds in the odds of experiencing severe food insecurity (missing two or more meals) compared to moderate (missing one meal) once a household is already food insecure.

4.3 Comparison between Nested Logit and Binary Logit

Table 11. Comparison between the models

Variables	Binary Logit Model	Nested Logit Model
Location	Rural households are 3.1 percentage points more likely to miss meals	Rural households have 17% higher odds of missing meals
Education	Higher education reduces the likelihood of missing meals by 9 percentage points	Higher education reduces odds of missing meals by 31%
Debt Level	High debt increases the likelihood of missing meals by 11 percentage points	High debt increases odds of missing meals by 64%
Labor Force	High labor force reduces the likelihood of missing meals by 11 percentage points	High labor force reduces odds of missing meals by 41%
Community Inclusiveness	High inclusiveness reduces the likelihood of missing meals by 5.2 percentage points	High inclusiveness reduces odds of missing meals by 22%
Sickness	Slight counterintuitive effect: households without sickness appear marginally more food insecure	Similar pattern: suggests coping mechanisms may buffer households with sickness

Source: Author's illustration

Both binary and nested logit models consistently identify debt, education, labor force participation, and community inclusiveness as the strongest determinants of food insecurity. Location and sickness show weaker or counterintuitive effects but remain consistent across models. The nested logit adds nuance by distinguishing the severity of food insecurity: education and debt primarily influence whether households enter food insecurity, while labor force participation also reduces the likelihood of severe insecurity. Comparing fit statistics, the binary logit yields a lower AIC (42,462) than the nested logit (76,176), suggesting a better statistical fit. However, the nested logit provides richer interpretive insights by capturing hierarchical decision-making (secure vs. insecure, then moderate vs. severe). Together, the results highlight that while binary logit is more parsimonious, the nested logit offers a more theoretically appropriate framework for analyzing severity.

4.4 Comparative Analysis with Regional Studies

The findings from this study broadly align with results from similar research across Southeast Asia. Consistent with evidence from a multi-country Southeast Asian survey (Morgan et al., 2024), using regression models found that low income, financial hardship, and inflation (especially food prices) significantly increased food insecurity across 7 Southeast Asian nations. Coping strategies included skipping meals or omitting food groups; government aid was the only factor that statistically reduced food insecurity.

Similar findings are reported from the Philippines, where Multiple logistic regression linked food insecurity to lower education (among heads and spouses), limited engagement in farming/fishing, and household demographics. Findings reinforce that less educated, lower-income, and larger households are most likely to miss core meals/groups (Bermudez et al., 2016).

In Nepal, multinomial logistic regression identified household education, asset ownership, and access to financial services as protective factors against food insecurity (Shah, 2020). Thus, our findings regarding education, debt, labor force engagement, and community networks resonate with broader regional patterns, highlighting the universality of these socioeconomic determinants and underscoring the importance of targeted policies in Myanmar and similar contexts.

5. Policy Implications

The empirical findings from both binary and nested logit models yield important and actionable policy implications for addressing household food insecurity in Myanmar. The analyses consistently highlighted key socioeconomic factors specifically, educational attainment, debt level, labor force participation, and community

inclusiveness as influential determinants in both the prevalence and severity of household food insecurity. Targeted interventions that directly address these determinants could substantially mitigate the risk of households missing essential meals. However, these recommendations must be contextualized within Myanmar current crisis that are political instability, surging inflation and weakened institutional capacity. For example, the World Food Program states that 15 million people are expected to go hungry in 2025, up from 13.3 million in 2024, as conflict and economic turmoil persist (Kist, 2025). Food prices regarding basic staples rose 30% in the past year (Kist, 2025).

This study's findings directly contribute to ongoing policy discussions surrounding food security interventions in conflict-affected and economically unstable environments, particularly as international aid organizations and NGOs grapple with effective strategies for Myanmar post-coup. Given these constraints, large-scale state-led reforms are unlikely to be immediately feasible. Therefore, the emphasis of this section is on smaller-scale, community-based, and NGO-led interventions that can realistically be implemented under current conditions.

Prioritizing Education to Enhance Food Security

Both analyses indicate that education significantly reduces food insecurity. Higher education levels reduce the probability of missing meals substantially, suggesting that education enhances employment opportunities, financial management skills, and nutritional knowledge. A cross-country analysis by USAID found "strong positive correlations between food security and education," noting that educating children in agriculture, nutrition, and basic literacy "can lead to higher standards of living and greater food security." (McNabb, 2011). In essence, better-educated individuals (particularly women) make more informed decisions about nutrition and childcare, breaking cycles of hunger. Therefore, policy initiatives should focus on:

Improving Access to Education: Programs that lower barriers to education (such as scholarships, subsidized school fees, and transportation assistance) could directly enhance food security by increasing household income stability and knowledge about nutrition and financial management. Implementing such programs in Myanmar's current environment will require collaborations with community-based and NGOs, as many schools have closed or operate in conflict-affected areas (Saito et al., 2024).

Addressing Debt Levels through Financial Support and Debt Relief

Debt was consistently identified as a critical determinant negatively affecting household food security. High debt significantly increased the likelihood of households missing meals, underscoring the need for financial relief measures. An analysis in Myanmar found that indebted families were among the worst-off in terms of food security in fact, households with debt had some of "the worst food security outcomes" compared to others (FAO, 2024). Policies implication could include:

Debt Relief and Debt Management Programs: They could alleviate immediate financial pressure on households, freeing resources to allocate more resources for food purchases. This might involve temporary loan moratoria or community-managed debt forgiveness for highly food-insecure families. While these would ideally require government leadership, in Myanmar's current fragile context, interim approaches must rely on development banks, NGO support, and small-scale employment programs with safeguards to ensure relief benefits vulnerable farmers and laborers over private moneylenders.

Microfinance and Low-Interest Loans: Accessible microfinance programs and low-interest loans targeting heavily indebted households could prevent further indebtedness and help stabilize household finances, ultimately reducing the incidence of food insecurity. However, as the financial sector after post-coup is weakened and client numbers in the microfinance sector drop by about million in 2023 and high inflation, microfinance initiatives must be coupled with inflation-adjusted terms and implemented by institutions capable of operating in insecure environments (Bissinger, 2025).

Strengthening Labor Force Participation and Economic Opportunities

Higher labor force participation consistently improved household food security across both analyses, indicating that more economically active household members significantly reduce the likelihood of missing meals. Ethiopia's Productive Safety Net Programme (PSNP), a large public works and cash transfer initiative, has been successful in increasing household food availability (Bank, 2024). To enhance this, the government should:

Support Employment Generation: Investment in sectors that have the potential for high employment, particularly agriculture, small-scale manufacturing, and service sectors in rural areas, can create stable income sources and improve food. In Myanmar's current context, small-scale, community driven projects such as cash for work programs repairing village infrastructure or farmlands could be effective in conflict-affected areas. Furthermore, as real wages are falling under inflation by 14% in 2025 (Bissinger, 2025), simply having a job is not always sufficient and job creation efforts should be paired with measures to curb inflation and support wage growth.

Community Inclusiveness and Social Networks

Community support networks and social inclusion significantly reduced food insecurity. Stronger community integration enables resource sharing and collective coping mechanisms during economic downturns. When individuals or households join community organizations (farmers' groups, savings circles, women's associations, etc.), they gain access to shared knowledge, resources, and mutual aid that help secure their food needs (Niles et al., 2021). Policies regarding community inclusiveness should focus on:

Community-Based Social Programs: Strengthening community cohesion through initiatives such as cooperative farming and mutual-aid groups can create shared resources and collective resilience. In the Myanmar's context, as many villages and neighborhoods have relied on informal solidarity mechanisms to survive turmoil (Bissinger, 2025), supporting these networks such as providing small grants to community groups can be a highly feasible intervention when top down assistance is limited. However, as the action may face political constraints, engagement with community leaders and approval from local authorities may be necessary to implement the programs at the community level.

Addressing the Counterintuitive Results of Sickness

The finding that households with reported sickness appear slightly less food insecure is counterintuitive but may reflect coping mechanisms. Households experiencing illness may activate informal support networks, receive remittances, or prioritize food expenditures to support recovery (IFPRI, 2022). While the effect size is modest, it suggests that community or familial safety nets may temporarily buffer against food insecurity during health shocks. Further research and qualitative investigation are crucial:

Integrated Health and Nutrition Programs: Developing programs that jointly address health, and nutrition can ensure that when households face medical issues, they do not simultaneously spiral into hunger. For example, clinics and hospitals could be coupled with food assistance or nutrition counseling for households with a patient, so that illness-related expenses or labor loss do not force families to cut meals.

Monitoring and Evaluation Systems: Robust monitoring systems that assess the impact of external support (e.g., emergency aid, informal community assistance) on households with sickness could clarify these findings and improve program targeting. If community or NGO support is filling the gap, policies should aim to support and formalize these safety nets.

The empirical results of this study align well with established theories of food security and poverty, particularly Sen's entitlement approach (Sen, 1982) and the Sustainable Livelihoods Approach (Scoones, 1998). Sen's theory emphasizes that food insecurity often stems from inadequate entitlements due to economic constraints rather than food supply alone. The result of our study reveals that socioeconomic factors such as education, debt, and labor force participation directly impact household entitlements, thereby influencing food security. Moreover, the significance of community inclusiveness resonates strongly with the Sustainable Livelihoods Approach, indicating that social capital and community networks substantially bolster household resilience. Thus, policies aimed at improving livelihood entitlements and strengthening local support networks could prove effective in addressing persistent food insecurity in Myanmar's challenging context.

6. Limitations and Future Research

This study has several limitations. Firstly, the missing meals indicator does not account for the frequency or quantity of consumption beyond a binary consumed or not consumed threshold. A household that barely consumed a food group such as eating vegetables only once in seven days would still count as having "consumed" in the classification, overlooking the insufficiency that an FCS or dietary diversity score would capture by weighting frequency or counting variety.

Secondly, the study's focus is on three broad categories of food sacrifices detail as the study does not distinguish between different protein sources or vegetable types, whereas diet quality metrics consider a wider array of food groups (up to 12 or more in HDDS and 8 in FCS) and often reflect micronutrient diversity. This means the indicator might not detect less obvious nutritional shortcomings if, for example, a household's diet is monotonous but includes minimal amounts of each broad group.

Thirdly, the analysis is predominantly cross-sectional, limiting the ability to establish causality. Although significant correlations are identified, the directionality for example, whether indebtedness leads to food insecurity or vice versa cannot be confirmed without longitudinal data. The findings are also context-specific, reflecting Myanmar's unique socio-economic conditions post-2021 coup, including widespread conflict and economic volatility. Generalizing these results to other contexts or even future periods in Myanmar requires caution.

Finally, unmeasured variables like household assets, coping strategies, or external aid received could significantly affect outcomes but were not captured due to data limitations.

Future research should incorporate multi-dimensional food security measures (e.g., dietary diversity scores, Food Insecurity Experience Scale) for more comprehensive insights. Longitudinal studies tracking households through Myanmar's socio-economic changes could clarify causality and reveal how external shocks affect food security. Mixed methods approach, particularly qualitative research on coping mechanisms during health shocks, could enrich understanding of unexpected findings like household sickness outcomes.

7. Conclusion: Feasibility and Implementation Amid Myanmar's Challenges

This study applied binary and nested logit models to examine the determinants of household food insecurity in Myanmar. Both models consistently identified education, debt levels, labor force participation, and community inclusiveness as decisive factors influencing whether households miss meals and, in the case of the nested logit, the severity of deprivation. These findings underscore the multifaceted nature of food insecurity, shaped by human capital, financial pressures, economic opportunities, and social networks.

Implementing these policy recommendations faces formidable barriers. Myanmar's political instability, ongoing conflict, inflationary pressures, and fragile institutions severely constrain the scope for nationwide reforms. In this context, large-scale policies such as universal debt relief or state-led education expansion remain aspirational. Instead, realistic progress will depend on decentralized, flexible approaches that work through local community organizations, NGOs, ethnic administrations, and faith-based institutions who continue to operate despite the collapse of central governance.

The key message is therefore twofold: strengthening household entitlements through education, reducing debt stress, fostering employment, and reinforcing community ties are critical; but interventions must be tailored to Myanmar's fragile environment, where small-scale, community-driven, and internationally supported initiatives are the most viable path. By focusing on these pragmatic avenues, policymakers and aid actors can still mitigate food insecurity even under the country's challenging conditions.

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