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Trade Liberalization and Rural Poverty in Developing Countries: Evidence from Cambodia

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Abstract

ASEAN members has achieved economic development through trade liberalization. One of the remaining challenges is the still high level of domestic income inequality. One of the factors to this domestic economic disparity is the gap between urban and rural areas. This paper provides an empirical analysis of how rural economic welfare is affected by trade liberalization, using Cambodia as a case study. Using household surveys and satellite imagery, the following two research questions are addressed. The first is; how does trade liberalization affect rural economic welfare in developing countries? Second; does its impact affect disparities in rural economic welfare? Estimation result shows that increased agricultural exports raise rural economic welfare, but that higher international prices for agricultural products do not have a significant impact. On the other hand, the increase in exports raises the level of economic welfare only for the highest welfare groups, with no effect on the poorest household groups. In other words, the results suggest that trade liberalization may increase intra-rural inequality.

Key words: ASEAN; Trade liberalization; Rural poverty; Household survey; Satellite imagery

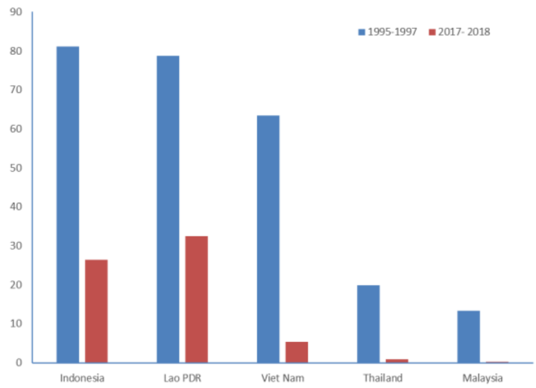
JEL classification codes: F14; F15; F61; F63; I32; O12; O18; Q12.

1. Introduction

Since the 1990s, supported by expanding trade and foreign direct investment under regional trade integration, ASEAN countries have made progress in increase in income level rapidly. According to the World Bank, Cambodia, Indonesia, Lao PDR, Myanmar, and Vietnam, which were classified as low-income countries in 1990, all became the upper middle-income countries by 2030. In the meantime, the poverty rate in each of these countries has fallen significantly to date. As Figure 1 shows, the most of the population in Indonesia, Lao PDR and Viet Nam lived below the poverty line of less than USD 3.65 a day in 1995. However, the proportion had fallen significantly to less than around 30 per cent by 2018.

Although ASEAN countries have achieved economic development under the regional economic integration, there are many challenges remaining in terms of their economic development. One of these challenges is the large income inequality within the country. As shown in Table 1, the overall Gini index has increased over the past 25 years, except in Malaysia and Thailand. The relative poverty rate has been on the rise in these countries. Income inequality in the country remains a major challenge in the region.

Figure 1: Poverty headcount ratio at 3.65$ per day



Data: World Development Indicators

Table 1: Income distribution in 1992, 2018

	Gini index		Proportion of people living below 50 % of median income (%)	
	1992	2018	1992	2018
Indonesia	33.2	38.4		
Lao PDR	34.3	38.8	6.9	10.3
Malaysia	47.7	41.2	20.4	17
Thailand	47.9	36.4	13.6	11.3
Viet Nam	35.7	35.7	7.9	14

Data: World Development Indicators

One of the most important factors contributing to the skewed distribution of income within each country is the income gap between urban and rural areas. In many developing countries, the poor are predominantly in rural areas. Therefore, several regional economic policies have been implemented to improve living standards in rural regions, such as infrastructure development and agricultural pricesupport. However, in many ASEAN countries, improving rural living standards remains a major challenge. For example, poverty ratios in the mountainous areas of Northeast of Thailand and Northern Vietnam are much above the country's average. Both Thailand and Viet Nam have achieved economic growth through trade liberalization as a result of ASEAN regional economic integration. However, the income gains from trade liberalization have not been spread evenly across the countries.

This study focuses on changes in income levels in rural areas of ASEAN countries that have achieved economic development through trade liberalization. In particular, we examine the impact of agricultural trade on rural economic welfare, using rural Cambodia as a case study[1].

Cambodia had been one of the least developed and the lowest income countries in Southeast Asia. Its GDP per capita is only 2.2% of the highest, Singapore, at around USD1,500 in 2022. However, the income level has risen rapidly since joining ASEAN in 1999. This economic development has been supported by international trade. In particular, exports from the garment and sewing industry and the accompanying inward foreign direct investment have supported Cambodia's high growth over the past two decades. On the other hand, it is worth noting that agriculture continues to play a significant role in Cambodia's industrial structure, with approximately 37% of the population engaged in agricultural activities in 2022.[2] Rural Cambodia produces rice and other commodity crops including natural rubber, oil palm, sugar cane and coconut. However, low productivity compared to international standards keeps wage and income levels low in rural areas. As a result, the income gap between rural and urban areas remains very large.

According the Cambodia Socio Economic Survey (CSES) by the National Institute of Statistics Cambodia, the average monthly disposable income per household in rural areas in 2021 is about 2 million Riels, which is only 60% of the average income level in the capital city, Phunom Penh[3]. According to the International Fund for Agricultural Development (2023), as of 2021, about half of Cambodia's rural households are close to the poverty line, and at immediate risk of falling into poverty. The income gap between rural and urban areas is a major factor of income inequality in Cambodia.

This paper examines how domestic income inequality in developing countries changes in the process of economic development through trade, focusing on Cambodia, which has achieved

[1] As of June 2024, the analysis only covers Cambodia, but will be progressively extended to the Philippines and Indonesia, where household surveys are available.

[2] Referenced from the World Development Indicators

[3] The average monthly disposable income per capita is 455 thousand Riel (around 110 US$) in rural areas and 773 (around 178 US$) thousand Riel in the capital city.

economic development through trade liberalization. Empirical analysis is conducted on the following two research questions. One is the question of how international trade affects income inequality within Cambodia, whose economy continues to grow as a result of increased international trade. In particular, we examine how increased trade under trade liberalization affects income levels and poverty rates in rural areas. Second, we analyze how the impact of trade on household income levels affects income inequality within rural areas.

While numerous empirical studies have been conducted in the field of development economics on the impact of trade liberalization on a country's overall economic development, there are still few empirical studies that examine the impact of trade liberalization with a focus on economic welfare in rural areas. The main reason for this is the lack of disaggregated data of economic activities by region. We combine household-level surveys with satellite imagery to estimate the impact of trade liberalization on economic welfare at the household level. By combining agricultural trade value and price with the area under crop cultivation in each region, we examine the direct and indirect impacts of trade on the economic welfare of household in rural areas.

There are several empirical studies on the impact of trade liberalization on rural incomes and poverty rates in developing countries. However, to the best of my knowledge, no study has been conducted to capture the impact of international trade on economic welfare in rural areas in Southeast Asian countries. As a case study of developing countries, this study is the first to examine the impact of agricultural trade on economic welfare in rural areas in Cambodia.

The rest of this paper has the following structure. The next section reviews previous literature on trade and domestic income inequality. Section 3 provides the theoretical background to the empirical analysis. Section 4 explains the estimation methodologies. Section 5 describes the data used in the estimation. Section 6 discuss the estimation results. Finally, Section 7 provides conclusions.

2. Related Literature

Several empirical studies examine the impact of trade liberalization on rural income or poverty rates. Topalova (2007) estimated the impact of India's trade liberalization in the 1990s on district-level poverty rates using difference in difference estimation based on household survey and district-level exposure to international trade values. Contrary to expectations, the results found that tariff reductions due to trade liberalization increased poverty rates in rural areas. Meanwhile, Wang and Hu (2008) examined the relationship between rural poverty rates and trade liberalization in China using panel data at household level. They found that economic growth and financial expenditure under trade liberalization reduce rural poverty rates.

Previous empirical studies have found both positive and negative impacts of trade liberalization on rural incomes and poverty rates varying depending on the research methodology and countries studied. The reason for these inconsistent results is that trade liberalization leads to changes in many aspects of the economy. Trade liberalization causes not only changes in the value of exports and imports, but also changes in the prices of traded goods and factor prices. It is therefore necessary to consider the consequences of trade liberalization on the basis of a general equilibrium framework.

Solaymani (2017) examined the impact of changes in agricultural commodity prices on rural poverty based on a general equilibrium model. In a simulation analysis for Malaysia, he found that whether agricultural prices rise or fall, rural poverty rates increase in both cases. However, it was also found that lower agricultural prices are more likely to increase rural poverty than urban poverty. Nwafor, Adenikinju and Ogujuba (2007) examined the impact of trade liberalization on poverty in Nigeria using a dynamic CGE model. They found that trade liberalization has a positive impact on capital-intensive sectors but reduces labor income. As a results, trade liberalization increases urban household incomes, but decreases rural household incomes, and increases rural poverty rates.

As discussed above, in order to examine the impact of trade liberalization on rural income and economic welfare, it is essential to analyze the pathways trough which the impact is transmitted to whole economy. In order to achieve this, it is necessary to conduct empirical analysis using various explanatory variables at the micro level. However, the collection of a substantial number of explanatory variables at the household or district level, particularly in developing countries, is challenging due to constrains on data availability. We address this issue by creating proxy variables related to detailed point-level income and production environment from geographic data and satellite imagery. Our study presents a micro-level empirical investigation that considers the impact of trade liberalization on economic welfare of rural households.

3. Theoretical background

According to the traditional trade theory, namely Heckscher-Ohlin model, trade liberalization changes the distribution of income by raising the relative factor price that are intensively used in the production of goods in which there is a comparative advantage. In developing countries with a comparative advantage in agriculture, trade liberalization raises relative wage in the agricultural sector.

Therefore, rural income is expected to rise. Exports of agricultural products can be a factor that raises relative wage and income in rural areas.

Based on the new spatial economics, trade liberalization can create or, conversely, reduce industrial agglomerations in cities. Industrial agglomerations may be promoted cities with locational advantage in trade, such as cities near ports and national borders. In such cases, the rising demand for labor will also increase wage rates, causing labor to move out of rural areas close to these cities. This could reduce labor surpluses in rural areas, increases incomes and welfare.

The impact of trade liberalization on rural economic welfare can have different results depending on the assumptions of the theoretical model. Therefore, based on a simple general equilibrium model, we derive an economic welfare function for rural households for which trade liberalizations is an exogenous explanatory variable.

As a theoretical background for the estimation, the impact of trade liberalization on household economic welfare is considered in the Dixit-Stiglitz model of monopolistic competition constructed by Fujita, Krugman and Venables (1999).

Consider a small economy comprising two sectors; a non-tradeable goods sector X_N with perfect competition and a constant return to scale, and a tradable goods sector X_T with monopolistic competition and economies of scale. The tradable goods are assumed to be agricultural products and may be traded internationally or consumed domestically. The only production factor in both sectors ia labor. It is assumed that the consumer's utility function can be represented by a Cobb-Douglas type utility function, consisting of a total X_N of non-traded goods and total X_T of traded goods. The consumer utility maximization problem is as follows;

$$max. \quad U = X_T^{\alpha} X_N^{1-\alpha}, \quad X_T = [\int_0^n x_T(i)^{\rho} di]^{1/\rho} \quad \rho = \frac{\sigma-1}{\sigma}$$

$$s.t. \quad Y = p_N X_N + \int_0^n p_T(i) x_T(i)\, di$$

where, σ denotes a elasticity of substitution. p_N denotes price of non-tradable product. $p_T(i)$ and $x(i)$ is price and consumption of tradable good i respectively. n represents the number of varieties of tradable goods. Household's budget constraint is set that total income is qual to the sum of expenditure on tradable and non-tradable goods. The utility maximization problem is the solved, and the solution allows the derivation of the following compensated demand function for tradable goods.

$$x_T(i) = \frac{p_T(j)^{\frac{1}{\rho-1}}}{\left[\int p_T(i)^{\frac{1}{\rho-1}} di\right]^{1/\rho}} X_T$$

Using the price index for tradable goods as $G = [\int p_T(i)^{\sigma-1} di]^{\frac{1}{\sigma-1}}$; the demand functions for tradable and non-tradeable goods are expressed as follows;

Tradable good; $x_T(i) = \left(\frac{p_T(i)}{G}\right)^{-\sigma} \frac{\alpha Y}{G} = \alpha Y \frac{p_T(i)^{-\sigma}}{G^{-(\sigma-1)}}$, $X_T = \frac{\alpha Y}{G}$,

Non-tradable good; $X_N = \frac{(1-\alpha)Y}{p_A}$

Substituting these demand functions into the utility function yields the following indirect utility function.

$$V = \alpha^{\alpha}(1-\alpha)^{1-\alpha} Y G^{-\alpha} (p_N)^{-(1-\alpha)} \qquad (1)$$

Now, we consider the behavior of producer at location r. Assume that the production function of tradable goods sector can be expressed in terms of fixed costs F and marginal cost c_T. The producer of the tradable good at location r maximizes profit, which can be expressed as follows;

$$\pi_r = p_T x_T(i) - w_r^T (F + c_T x_T(i))$$

Therefore, the production and the number of varieties of tradeable good in equilibrium are as follows;

$$x_T^*(i) = \frac{F(\sigma-1)}{c_T} = x(i)^*, \qquad n^* = \frac{L_{T,r}}{l^*} = \frac{L_{T,r}}{F\sigma}$$

where, $L_{T,r}$は denotes labor force employed in tradable good sector at location r.

Next, we consider both domestic and international trade. The ice-berg type trade cost from location r to s is reflected in the price of tradable good as; $p_{T,rs}(i) = p_{T,r}(i)\tau_{rs}$.

Price indices for tradable agricultural goods differ at each location. The price index at location s is as follows;

$$G_s = \left[\sum_{r=1}^{R} n_r \left(p_{T,r}\tau_{rs}\right)^{1-\sigma}\right]^{1/(\sigma-1)} \qquad (2)$$

As the price of the tradable good includes ice-berg type transport costs τ, the price at the destination is the transport costs with a mark-up. The price of non-tradable good is a numeraire. Thus, the demand and total sales at location s for the goods produced at location r are expressed as, $\alpha Y_s \left(p_{T,rs} T_{rs}\right)^{-\sigma} G_s^{1-\sigma}$ and $x_{T,r}(i) = \alpha \sum_{s=1}^{R} Y_s \left(p_{T,r} T_{rs}\right)^{-\sigma} {G_s}^{1-\sigma} T_{rs}$ respectively.

In addition, from the equilibrium demand, production and price of tradable goods, the wage rate of tradable sector in equilibrium is expressed as follows;

$$w_{Tr}^{*} = (\sigma - 1/\sigma c_T)\left[\frac{\alpha}{x_T(i)}\sum_{s=1}^{R} Y_s(\tau_{rs})^{1-\sigma} {G_s}^{\sigma-1}\right]^{\frac{1}{\sigma}} \quad (3)$$

The equilibrium wage at location r r increases as income at location s Y_s rises or as the trade cost from r to s falls. For example, assume that the location r is home country and s is foreign country. If foreign income rises or trade cost between home and foreign country, then the home country's exports will increase and the wage will raise.

Equation (1), the indirect utility function, $V = \alpha^{\alpha}(1-\alpha)^{1-\alpha} Y G^{-\alpha}(p_N)^{-(1-\alpha)}$ is a function of price index of tradable goods G, price of non-tradable goods p_N, and income Y. Income Y is determined by the equilibrium wage rate w_{Tr}^{*}. Therefore, the indirect utility function in equilibrium is expressed by price of tradable goods and non-tradable goods, labor force in tradable good sector, income level and trade cost.

$$V = f(p_T, L_T, Y, \tau) \quad (4)$$

Based on equation (4), an estimation equation is constructed to examine the impact of trade liberalization, i.e., an increase in exports due to a fall in trade cost τ, and changes in international prices on the level of utility at the household level in the next section.

4. Estimation methodology

In the simple general equilibrium model of the previous section, the indirect utility function in equilibrium is explained by trade costs τ, and prices of goods, labor force and wage rate. This paper analyses the factors affecting the level of economic welfare of households in rural areas, using the level of household utility derived from the model. In particular, the effects of increase exports due to trade liberalization and changes in the prices of tradable goods on economic welfare are examined. In addition, by examining whether the magnitude of the impact varies by household welfare level, it is observed whether trade liberalization has an impact on the disparities in economic welfare of rural households.

The data used to measure the level of welfare of rural households is the 'quality of living standard' from Demographic and Health Survey (DHS). DHS is funded by the United States Agency for International Development (USAID) and conducted in cooperation with national statistical offices in developing countries. The wealth index, which is one of the survey items in this household survey, is used as the quality of living standard. The wealth index is a composite measure of living standards, calculated by several indicators related to quality of life, such as sanitary conditions, housing types and quality, ownership of consumer durables. This indicator is used as the dependent variable in the estimation equation.

The wealth index is a dataset at the household level, but the geographical information at the household level is not disclosed for privacy reasons. Instead, geographical information on sub-districts, i.e., clusters with a radius of 5 km to which each household belongs, is disclosed. Based on the indirect utility function in equilibrium expressed by equation (4), household income and labor force, prices of tradable goods and trade cost are used as independent variables. The dependent variable is household level, while its geographical information is given at cluster level. Therefore, the dependent variables are both household level i and cluster level c. The estimation equation is as follows;

$$lnV_{ict} = \alpha_0 + \sum_k \beta_k lnX_{it}^H + \sum_y \beta_Y lnX_{ct}^Y + \beta_L lnL_{ct} + \sum_\tau \beta_\tau lnX_{ct}^\tau + \beta_E lnEX_{ct} + \beta_P lnP_{ct}^T + u_{ict} \quad (5)$$

where, X_{it}^H is a vector of independent variables at household level including household attributes. The number of people, the number of babies and infants, the number of school children, gender, age and educational level of head of household, and ownership of agricultural land. These are variables that affect household income.

X_{ct}^Y, L_{ct}, X_{ct}^τ, EX_{ct}, P_T are vectors and variables at cluster level. X_{ct}^Y is a vector of variables affecting crop harvests which are determinants of income, are water abundance, rainfall and vegetation activity. Water abundance and vegetation activity measured by weighted averaged the Normalized Difference Vegetation Index (NDVI) and by cultivated area of each crop the Normalized Difference Water Index (NDWI) respectively. NDVI and NDWI are indices calculated from multispectral imagery by satellite optical sensors. The NDVI is an index that measures abundance of vegetation activities on the land surface using satellite imagery. Likewise, NDWI is an index that measures abundance of water resources on surface such as river, lake and irrigation canal.

The proxy variable of labor force at cluster level, L_{ct} is a data of night-time light intensity. Previous studies have shown that night-time light intensity is highly correlated with the level of economic activity and population density at a given location. X_{ct}^τ is a vector of variable of proxies of trade cost, namely the length of roads in the cluster, the distance from each cluster's center point to the nearest city and the nearest sea port.

Furthermore, income level of foreign country and international trade costs are determinants of domestic wage rate. When foreign income increases or international trade cost decreases, domestic wage rate will raise by increased demand and export of tradable goods. Therefore, as an indirect explanatory variable for the level of economic welfare, the value of exports of crops which are produced in cluster is used. The export exposure, EX_{ct} is the sum of export value of Cambodia's main crops, weighted by the area under crop cultivation for each crop at cluster level. This is a variable constructed in a similar way to Bartik instrument, which measure the impact of macro shocks at the regional level.

P_T denotes international price of tradable goods, namely Cambodia's major agricultural commodities. Price of agricultural commodity is affected by international prices. By using the area under crop cultivation for each crop, the weighted averaged international commodity price is used for P_T. As with EX_{ct} above, this variable constructed for each cluster using the Bartik instrument method with weights for each area of cultivated crop as the exposure level for the impact of international prices. The impact of trade liberalization on the economic welfare of rural households is examined by the magnitude of the cluster-specific export exposure EX_{ct} and international crop price exposure P_T.

4.1 Multilevel regression model: Estimation of hierarchical data

The wealth index used as the household-level utility in the estimation equation described in the previous section is a standard of living indicator from the household survey.

The DHS household data does not include geographical location information for each household, but geographical information of cluster consisting of 20-30 households. The data used for the estimation are therefore hierarchical. They are nested at two levels: households and clusters. When performing regression analysis on these two levels of household and cluster data, estimation without taking into account the intra-cluster correlation (ICC) will lead to a down ward bias in the standard errors, which may misinterpret non-significant parameter estimates as significant. In fact, the ICC of each estimation model is above 0.3 and there is intra-cluster correlation. Therefore, a multi-level model estimation method with a random intercept is utilized. The multi-level model uses a random intercept, which is a stochastically varying constant term, where the intercept is set to be different for each cluster. The estimating equation (5) is transformed as follows;

$$lnV_{ict} = \alpha_{0c} + \sum_{k} \beta_k lnX_{it}^{H} + u_{ict}$$

$$\alpha_{0c} = \gamma_0 + \sum_{y} \beta_Y lnX_{ct}^{Y} + \beta_L lnL_{ct} + \sum_{\tau} \beta_\tau \, lnX_{ct}^{\tau} + \beta_E lnEX_{ct} + \beta_P lnP_{ct}^{T} + \mu_j$$

where, α_{0c}, u_{ict} and μ_j are random intercept, residuals at household level and cluster-level respectively.

4.2 Quantile regression: Estimation of the impact of trade on welfare disparity

The distribution of economic welfare levels is skewed towards lower levels. In particular, in 2021 the distribution is highly skewed towards a two-peak distribution with one peak at the lower level. The second research question of this study is; Does trade liberalization affect disparities in the level of rural economic welfare? Therefore, it is necessary to examine whether the increase in foreign demand, i.e., exports, and changes in international commodity prices due to trade liberalization differ between households with low and high levels of economic welfare. Quantile regression method is used to examine whether the impact of changes in exports and international prices in agricultural products differs by location in the distribution of economic welfare levels.

Quantile regression, introduced by Koenker and Bassett (1978) is a regression method estimates the conditional quantile function and estimates the parameters at quantile points. If the regression equation is $y_i = X_i\beta + \varepsilon_i$, estimate the parameter β that minimizes the loss $\sum_i \rho_\theta(y_i - X_i\beta)$ evaluated at the loss function that gives the quantile points. Given the quantile point θ, the loss function is as follows;

$$\rho_\theta(u) = \begin{cases} \theta u & if\ u > 0 \\ (\theta - 1)u & if\ u \leq 0 \end{cases}$$

The parameters estimated in a quantile regression are the values at each quantile of the distribution of the dependent variable. In this study, the quantiles are estimated at the 20th, 40th, 60th and 80th percentiles.

Figure 2a:Distribution of wealth index in 2014

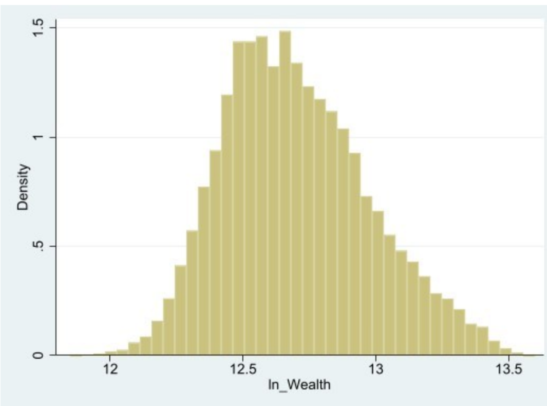
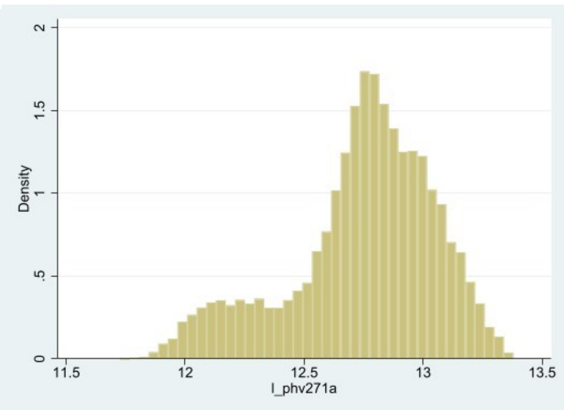


Figure 2b:Distribution of wealth index in 2012



5. Data

5.1 Household level data

The level of economic welfare at household level is used as dependent variable in estimating equation (5). The data used is the wealth index of the DHS. The DHS is a household survey on medical health status for developing countries provided by the U.S. Agency for International Development (USAID).

The household survey uses a two-stage random sampling procedure to select the sample; after determining a sample size proportional to the population per region, the municipalities to be surveyed are selected by random sampling, taking into account the rural/urban balance. Then, the households to be surveyed are selected by random samplings from the municipalities. The surveyed households are grouped into clusters and the geo-reference data of each cluster is disclosed. The number of households in a cluster is around 20-30. Each household is located within a radius of 5km from the center of the cluster in rural areas[4].

The wealth index is a composite indicator of living standards. The index is a weighted average and standardized score of items reflecting living standards, including the availability and quality of living facilities such as electricity, gas, water and toilets; housing environment in terms of roof and floor materials; household appliances, cars, and motorbikes; and ownership of livestock such as cattle, houses, sheep and chickens. The surveyed items for construction of wealth index differs slightly between rural and urban areas. Two survey periods, the 2014 and 2021 survey in Cambodia are used, each survey with 11459 and 13747 rural households, and 423 and 468 clusters respectively.

Independent variables at household level are the number of household members, the number of babies and infant in the household, the number of school children, gender, age and educational level of the head of household, and ownership of agricultural land, which are all DHS survey items. These are used as variables that affect household-level income.

5.2 Cluster level data

X_{ct}^{Y}, L_{ct}, and X_{ct}^{τ} in estimating equation (5) are income level, labor force and trade cost at cluster-level. We utilize satellite imagery and various geographic data to measure these variables. Satellite imagery is used to generate indices of water availability, rainfall, harvested areas, vegetation activity, which determine the income level of the cluster in which the households are located, and night-time

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[4] The radius for urban cluster is 2 km.

light intensity as a proxy for labor endowment at the cluster level. As proxies for internal trade costs, the total length of roads in each cluster, the distance from the cluster center point to the nearest city and the distance to the nearest seaport are calculated using map data and GIS. Detailed data source and calculation methods for each variable are explained below;

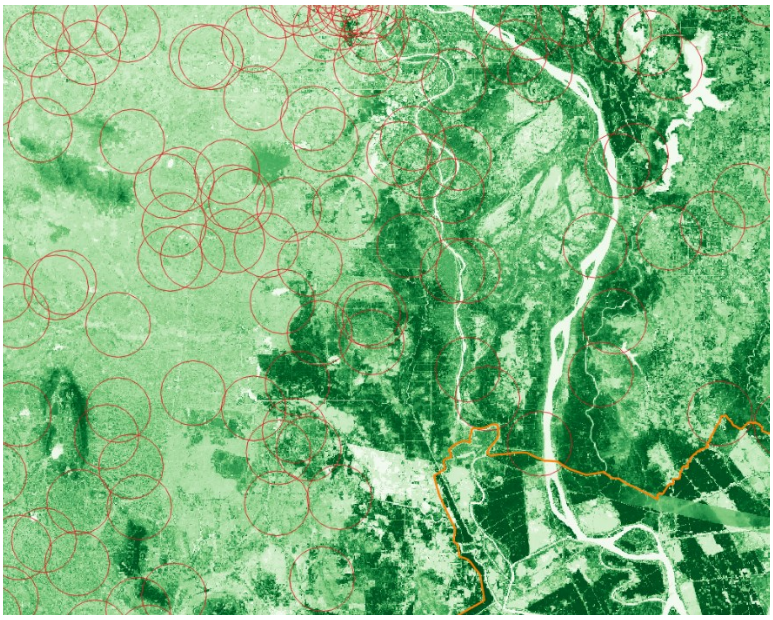
A） Vegetation activity: NDVI

Crop harvests are determinant of the income level of a cluster. Vegetation activity of cultivated land at cluster level is used as a proxy variable for crop harvests. The NDVI is used to measure of plant activity by utilizing property of plant that chlorophyll absorbs red visible light and reflects near-infrared light. Using satellite multispectral imagery data, the NDVI for each location is calculated as follows;

$$NDVI = \frac{IR - Red}{IR + Red}$$

where, IR and Red denotes near-infrared light dose and red visible light dose respectively. The closer the NDVI value is to 1, the more active the vegetation. Figure 3 shows an example of the NDVI for the Southern rice-growing areas of Cambodia in 2021. The yellow line is the national border with Vietnam and the red circles are clusters. Dark green indicates locations with high NDVI values.

Figure 3: An example of NDVI: South-eastern Cambodia in 2021

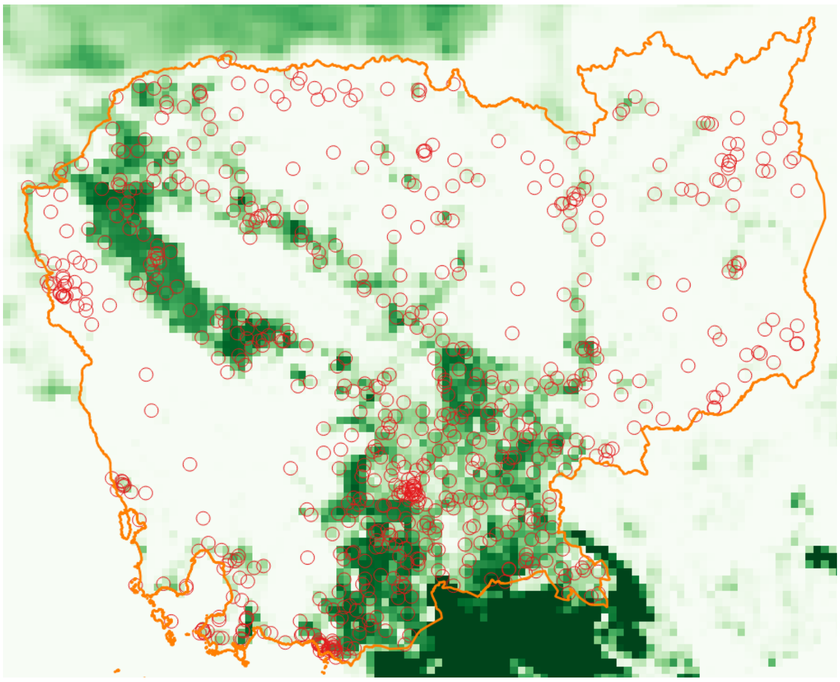


Note: Darker green denotes the higher NDVI.

Data is used from satellite imagery of Landsat8-9 provided by the United States Geological Survey (USGS). Images with cloud cover less than 10% from January to March, the dry season in Cambodia are collected and used. The NDVI multiplied by the share of total area under cultivation of Cambodia's major exported crops, rice, oil palm, sugarcane, coconut and banana, is used as an independent variable in the estimation equation. Data on the area under cultivation of each crop is taken from CROPGRIDS, a database of cultivated land around the world constructed and published by Tang, Nguyen, Conchedda, Casse, TUbiello and Maggi (2024). CROPGRIDS publishes the dataset of cultivation area for 173 crops at 5km grid level.

We use the data of cultivated area for rice, coconut, oil palm, sugarcane, and banana of each cluster in 2014 and 2020. When using these data as weights for construct the international price and export exposure variables discussed below, the area of cultivated land for cassava and pepper, which are also the major exported crops, are also used.

Figure 4: Example of CROPGRIDS data：Rice cultivation in Cambodia in 2020



Note: The darker green indicates the more land rice cultivation. Yellow line shows national border, and red circles are the location of cluster on DHS survey in 2021.

B）Availability of water: NDWI

The amount of available water resources influences crop harvests. It is expected that agricultural productivity will be higher in areas where irrigation facilities are well developed and where water resources such as rivers are available. Therefore, the availability of water resources at cluster-level, i.e., the area of irrigation channels, rivers and lakes, is used as a variable that influences crop harvests.

As with NDVI, satellite multispectral imagery is employed to quantify the amount of water on the surface, utilizing shortwave infrared and red visible light dose as index. Water on the earth's surface strongly reflects red visible light band and absorbs short-wavelength infrared radiation. This property is used to capture the area of water in rivers, lakes and irrigation channels at the earth's surface. NDWI is calculated using the following formula;

$$NDWI = \frac{Red - SWIR}{Red + SWIR}$$

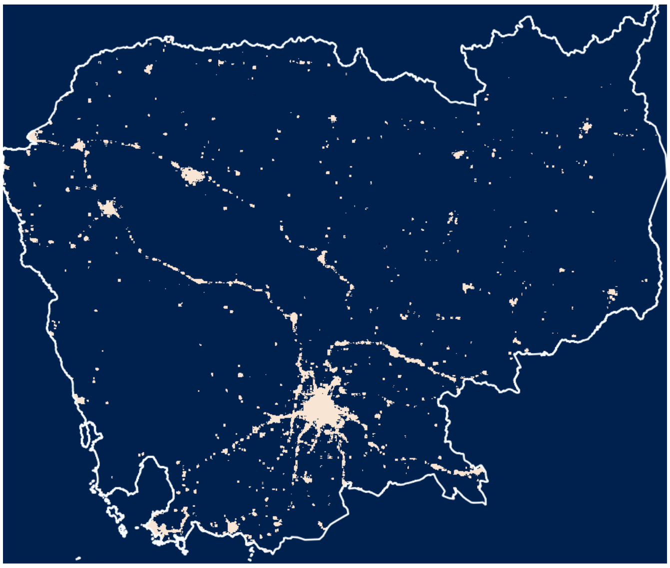
The closer the NDWI is to 1, the more abundant the water resources are. As with NDVI, Landsat imagery are taken during the dry season from January to March, and on days with minimal cloud cover, defined as less than 10%. Consequently, the NDWI enables the assessment of the availability of water resources in the area, even during the dry season.

C）Labor force at cluster-level: Nighttime light intensity

Night-time light intensity for each cluster is used as a proxy variable for labor force at the cluster-level in estimation equation. According to the World Bank's World Development Indicators, the electricity penetration rate in Cambodia was more than 80% by 2020. This suggests that it is feasible to use the night-time light intensity at each location as a size proportional to the population living there.

Night-time light intensity is calculated using 0.5 km grid cell-level imagery captured by the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor on the United States of America's National Aeronautics and Space Administration (NASA)-operated Suomi National Polar-orbiting Partnership (NPP) Mission satellite. The annual averaged satellite imagery which is filtered to exclude the natural luminescent phenomenon such as lunar illumination and thunder lights, fire and cloud mask, is provided the Colorado School of Mines, the United States of America. Figure 5 shows the averaged night-time light intensity in Cambodia in 2021.

Figure 5 Night-time light density in Cambodia in 2021.



Note: The higher the night-time light intensity, the lighter the white color.

D) Geographical and climate conditions for agricultural production

In addition to the water index mentioned above, weather and geographical conditions also affect crop harvests significantly. The average rainfall and elevation at cluster-level are used for estimation. As for the average rainfall, the annual average rainfall data, provided by the WorldClim is used to estimate the average amount at cluster-level. The WorldClim which is a database of global climate layers with a high spatial resolution of 1 km^2, provided a worldwide climate data for each location in time series from 1970 to the present. Elevation at cluster-level is used from ASTER Global digital elevation model (GDEM). ASTER GDEM is a terrain database which is maintained and provided by the Ministry of Economy, Trade and Industry of Japan and the NASA, the USA. The terrain data on the Earth's land surface are observed by the satellite-borne sensor, Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). The averaged elevation within a 5 km radius of each cluster is used.

E) Domestic trade costs

As proxy variables for transportation costs for the estimation equation, X_{ct}^{τ}, the length of roads in each cluster, the distance from the center of cluster to the nearest city, and the distance to the nearest port are used. As for the length of roads, the Global Roads Open Access Data Set, Version 1 (gROADSv1) provided by NASA is used to calculate the total length in each cluster.

The nearest city is considered to be the transport hub for agricultural products. Therefore, the closer the distance to the city, the lower the trade costs. Geographical information of cities in Cambodia is used from the Natural Earth's "populated places" data for cities with a population of 100 thousand or more.

Distance to seaport is also added as a proxy variable of trade costs, as exports to foreign countries go through ports. As for geographical information of seaport, the World Port Index database provided by the Maritime Safety Office of the National Geospatial-Intelligence Agency, the USA is used. The main two seaports in Cambodia are Sihanoukville port and Kampot International Port. The straight-line distance from the center point of each cluster to any of the nearest seaport is used.

F）International trade exposure

The independent variable EX_{ct} in the estimation equation is the change in exports caused by changes in foreign income levels and international trade costs, and represents the degree of trade exposure on each cluster. As the trade exposure, the weighted averaged export value of Cambodia's major crops. The weights are the areas of each crop cultivated in each cluster. Export value of rice, oil palm, sugarcane, coconut, cassava, banana and pepper are used as the major exported crops from Cambodia. The data are used from the United Nations' Commodity Trade Statistics database. As for the cultivated area by crop, the CROPGRIDS constructed and provided by Tang, Nguyen, Conchedda, Casse, Tubiello and Maggi (2024) explained above, is used to calculate the weight for each cluster.

As the independent variable P_{ct}^{T}, which presents a tradable good price reflecting international prices, weighted average of international prices of major crops, with the ares under cultivation of the major exported crops in each cluster as weights. As for international prices, the annual average of the world commodity price of rice, palm oil, sugar, coconut oil and banana are used from the World Bank's commodity price data. The basic statistics for all the data used in the estimations are presented in Table 2.

Table 2: Summary of basic statistics

	Rural				
Variable	Obs	Mean	Std. dev.	Min	Max
ln (Wealth index)	25,206	12.7246	0.2935	11.7258	13.5989
ln (Household size)	25,206	1.3687	0.4765	0.0000	3.0910
ln (Number of infant children)	25,206	0.3505	0.4182	0.0000	1.9459
Gender of head of household (male=1/female=0)	25,206	0.7272	0.4454	0.0000	1.0000
ln (Age of head of household)	25,206	3.8080	0.3156	2.3979	4.5850
Owner of agricultural land (Yes=1/No=0)	25,206	0.7285	0.4447	0.0000	1.0000
ln (Educational level of head of household)	25,203	0.6486	0.4056	0.0000	2.1972
ln (Number of schoolchild)	25,206	0.4981	0.5142	0.0000	2.3026
ln (NDWI, River and lake)	25,206	-2.3006	0.8738	-15.8269	-0.4666
ln (Nighttimelight density, mean)	25,206	0.0449	0.1304	0.0000	1.4873
ln (Rainfall amount)	25,206	2.2471	1.0008	0.0000	3.8600
ln (Elevation)	25,206	3.3260	1.1411	0.5645	6.7155
ln (Road length)	25,206	7.1366	3.9327	0.0000	10.4511
ln (Distance to the nearest city)	25,206	3.3913	0.6379	1.0698	4.7615
ln (Distance to the nearest port)	25,206	5.4467	0.5798	2.3090	6.3204
ln (NDVI*Harvested areas)	25,206	6.2824	1.8565	0.0000	9.0448
ln (Export value of agricultural commodities)	25,206	12.3139	1.1238	0.0000	12.9556
ln (International price of agricultural commodities)	24,971	4.3447	1.9882	-0.0149	7.4002

6. Estimation Results

6.1 Multilevel regression

First, multilevel regression analysis is carried out. Data from rural households are pooled for the years 2014 and 2021. Variables of international trade exposure, the weighted export values EX_{ct} and international price of exported goods P_{ct}^{T} in estimation equation (5) are both constructed by using the same weight, the share of crop cultivated areas of each crop at cluster level. To avoid the problem of multicollinearity caused by the high correlation of these two variables, each variable is estimated separately. In addition, the equation is estimated using urban household data for comparison.

All estimation equations include province dummy variables to capture provincial-level effects, such as economic policies conducted by provincial government. In addition, a year dummy variable of 2021 is added to control for the impact of exogenous shocks, as the impact of the covid-19 is expected to have an impact on economic welfare at the household-level. The estimation results are presented in

Table 3.

The estimated coefficients of the explanatory variables that might affect household income levels were all statistically significant, except for the number of school children. The coefficient of age and educational level of head of household are both positive. Also, the gender of the head of the household being male, and household owing agricultural land also have a positive impact on economic welfare. Moreover, the larger household size and fewer infants also increase economic welfare at household level. In other words, a higher labor force participation rate is likely to increase household income and improve economic welfare in rural areas.

These household attributes that affect the level of economic welfare of households differ slightly between rural and urban areas. In rural areas, economic welfare is higher when the number of infants is lower, while in urban areas the number of infants has no effect on the level of economic welfare. As for the gender of household head, male household head has positive impact in rural areas, while gebder was not relevant in rural areas. In rural areas, most people are employed in the agricultural sector, while in urban areas a higher proportion of people are employed in manufacturing and service sectors. Therefore, the determinants of income level at household level are likely to be different.

The estimated coefficient for the cluster-level variables related to crop harvests show that the higher the NDWI, in other words, the more abundant the water resources such as canals and rivers, the higher the economic welfare. Also, the higher the vegetation index NDVI of cultivated land, the higher the economic welfare. Clusters where water resources are abundant and the land can be cultivated throughout the year, such as where irrigation facilities are well developed or close to rivers and lakes are expected to yield higher crop harvests and incomes and have higher economic welfare.

Looking at the impact of domestic trade costs, the coefficient estimate for total road length in a cluster is positive. In other words, the more roads there are, the lower the trade cost and the higher the economic welfare. Likewise, the estimated coefficients of the distance to the nearest city and seaport are negative and statistically significant. Both negative coefficients imply that the lower trade costs raise the economic welfare. Regarding labor force at cluster-level, proxied by night-time light intensity, the average population of cluster, namely the more densely populated a cluster is, i.e., the more labor intensive it is, the higher the level of household economic welfare.

The impact of trade exposure, namely export values and international price of agricultural products weighted by the area of each exported crop cultivated per cluster on economic welfare is relevant to the examination of the first research question of this study. The coefficient of the weighted export value was positive and statistically significant. This result implies that export in agricultural products has the effect of increasing rural economic welfare, in turn, reducing rural poverty rates. A direct effect of increased agricultural exports could be higher incomes for rural households. There could also be indirect effects, such as higher wages due to increased crop production.

On the other hand, the coefficient of the weighted average of international price of agricultural products was negative but not statistically significant. This result suggests that international price of agricultural products is not a factor in increasing rural incomes and welfare. Higher international prices for crops increases the incomes of rural household as producers, but also cause higher expenditure on foods by rural households, who are also consumers. Therefore, the impact of international prices of agricultural products on household economic welfare may be both positive and negative at the same time, which may offset their effects. Moreover, higher export prices do not always translate smoothly into incomes for rural households. In other words, the price transmission of agricultural products and input prices may not be smooth.

In summary, the economic welfare of rural households is expected to increase as a result of increased agricultural exports.

On the other hand, the effect of international price of agricultural products on the economic welfare of rural households is unclear. Trade liberalization allows goods with a comparative advantage to be exported at international prices that are higher than domestic prices. However, the impact of changes in international agricultural prices due to trade liberalization on the economic welfare of rural household is not clear.

Table 3: Estimation Results, multilevel regression

	Rural region						Urban region	
	Coefficient	Std.	Coefficient	Std.			Coefficient	Std.
ln (Household size)	0.038153	(0.0040) ***	0.038235	(0.0040) ***	0.039685	(0.0040) ***	0.029866	(0.0087) ***
ln (Number of infant children)	-0.031721	(0.0040) ***	-0.03193	(0.0040) ***	-0.03304	(0.0040) ***	-0.012861	(0.0093)
Gender of head of household (male=1/female=0)	0.007209	(0.0033) **	0.00714	(0.0033) **	0.007334	(0.0033) **	-0.008456	(0.0072)
ln (Age of head of household)	0.040656	(0.0049) ***	0.040696	(0.0049) ***	0.040168	(0.0049) ***	0.033027	(0.0116) ***
Land owner of farmland (Yes=1/No=0)	0.013792	(0.0034) ***	0.013896	(0.0034) ***	0.015024	(0.0034) ***	0.012775	(0.0073) *
ln (Educational level of head of household)	0.154202	(0.0037) ***	0.154365	(0.0037) ***	0.153478	(0.0037) ***	0.204052	(0.0088) ***
ln (Number of schoolchild)	-0.003793	(0.0033)	-0.00413	(0.0033)	-0.00535	(0.0033) *	-0.002842	(0.0074)
ln (NDWI, River and lake)	0.021540	(0.0025) ***	0.021325	(0.0025) ***	0.020065	(0.0025) ***	0.041746	(0.0164) ***
ln (Nighttimelight density, mean)	0.194656	(0.0197) ***	0.200342	(0.0198) ***	0.197685	(0.0197) ***	0.042157	(0.0133) ***
ln (Rainfall amount)	-0.038875	(0.0054) ***	-0.03882	(0.0054) ***	-0.03498	(0.0055) ***	-0.024547	(0.0246)
ln (Elevation)	0.002904	(0.0034)	0.002625	(0.0034)	-0.00479	(0.0035)	0.063493	(0.0125) ***
ln (Road length)	0.004936	(0.0006) ***	0.004899	(0.0006) ***	0.004823	(0.0006) ***	0.000450	(0.0044)
ln (Distance to the nearest city)	-0.032595	(0.0045) ***	-0.03112	(0.0045) ***	-0.02797	(0.0045) ***	-0.069009	(0.0077) ***
ln (Distance to the nearest port)	-0.145270	(0.0066) ***	-0.14584	(0.0066) ***	-0.14665	(0.0067) ***	-0.110840	(0.0157) ***
ln (NDVI*Harvested areas)	0.013633	(0.0016) ***	0.010564	(0.0019) ***	0.007649	(0.0018) ***	0.009731	(0.0057) *
ln (Export value of Agricultural products)			0.007833	(0.0025) ***				
ln (International price of agricultural commodities)					-0.00392	(0.0023)		
Province dummies	Yes		Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes		Yes	
Constatnt	13.365060	(0.0592) ***	13.28934	(0.0639) ***	13.44131	(0.0637) ***	12.979830	(0.1522) ***
Random effects parameters								
var(_cons)	0.020989	(0.0014)	0.021022	(0.0014)	0.022222	(0.0015)	0.057111	(0.0048)
var(Residual)	0.045665	(0.0004)	0.045645	(0.0004)	0.045226	(0.0004)	0.105286	(0.0014)
ICC	0.314897	(0.0145)	0.32	(0.0145)	0.33	(0.0150)	0.351675	(0.0197)
LR test vs. logit model	5462.3		5470.6		5557.0		3153.8	
Prob >= chibar2	0.00000		0.00000		0.00000		0.00000	
Number of observation	25203		25203		24968		11343	
Number of clusters	589		589		588		353	
Observation per cluster, minimum	23		23		23		21	
Observation per cluster, maximum	58		58		58		54	
Observation per cluster, average	42.8		42.8		42.5		32.1	

Note: ***, ** and * denotes significant level at 1%, 5%, and 10% respectively.

6.2 Quantile regression

As demonstrated in the above section, the multilevel analysis indicates that an increase in agricultural exports has a positive impact on the economic welfare of rural households. Nevertheless, the consequences may vary depending on the levels of economic welfare. If the positive effect of increased agricultural exports on economic welfare is greater for households with higher levels of economic welfare, it is possible that increased exports may increase the disparity in economic welfare within rural areas. Conversely, if increased agricultural exports have a greater positive effect on households with lower economic welfare, then the increased exports would reduce the disparity in economic welfare within rural areas.

The application of quantile regression analysis enables the observation of coefficients at the 20%, 40%, 60% and 80% quantiles from the lowest point of the economic welfare. Table 4a and 4b shows the estimation result by applying quantile regression. The coefficient estimates for agricultural exports show that positive effect of increased exports on the economic welfare was observed only in the top 80% of households in terms of economic welfare level. In other words, the positive effect of agricultural exports on economic welfare is significant only for the group with higher economic welfare. Given this result, an increased exports of agricultural products may increase the disparity in the level of economic welfare among households in rural areas.

On the other hand, does the impact of changes in international prices of agricultural products on the economic welfare of rural households differ depending on the position of the distribution of economic welfare levels? The estimates presented in Table 4b show that the impact of international prices of agricultural products on the economic welfare of rural households is significantly positive for the groups in the bottom 40% and 60% of the welfare level. In other words, a change in international prices of agricultural products has no impact on the economic welfare of the poorest and richest household groups in rural areas. For households in the 40^{th} an 60^{th} percentiles of the distribution of economic welfare, i.e., the middle layer of rural households, the result shows that they may benefit from higher international prices of agricultural products, which would increase their economic welfare.

Overall, the bottom 20% of rural households, i.e., the poorest households, see no change in their economic welfare when exports increase under trade liberalization or then international prices of agricultural products rise. On the other hand, when trade liberalization increases exports of agricultural products, which are goods of comparative advantage, economic welfare increases for the richest household group. An increase in the prices of agricultural products also increases economic welfare for households with intermediate levels of economic welfare.

In developing countries, trade liberalization leads to increased exports values and price of agricultural products, which are products of comparative advantage. The extent to which the change affects economic welfare of households depends on the level of household economic welfare. The results of the estimation indicates that an increase in agricultural exports or an increase in the international prices of agricultural products will result in an increase in economic welfare for the richest households or the middle-class households in rural areas. Nevertheless, the poorest household group do not appear to benefit from trade. Consequently, changes in agricultural exports and international prices due to trade liberalization may increase disparity in economic welfare among households in rural areas.

Table 4a: Estimation result: quantile regression

	20%		40%		60%		80%	
	Coefficient	Std.	Coefficient	Std.	Coefficient	Std.	Coefficient	Std.
ln (Household size)	0.046976	(0.0062) ***	0.0411846	(0.0056) ***	0.0363965	(0.0052) ***	0.0329983	(0.0069) ***
ln (Number of infant children)	-0.037898	(0.0056) ***	-0.0328078	(0.0065) ***	-0.0363874	(0.0052) ***	-0.028143	(0.0073) ***
Gender of head of household (male=1/female=0)	-0.004876	(0.0047)	-0.0070606	(0.0042) *	-0.0023305	(0.0044)	-0.0000541	(0.0044)
ln (Age of head of household)	0.050756	(0.0078) ***	0.0635966	(0.0075) ***	0.0602809	(0.0071) ***	0.0626648	(0.0074) ***
Land owner of farmland (Yes=1/No=0)	0.016609	(0.0051) ***	-0.0016642	(0.0045)	-0.0129864	(0.0049) ***	-0.033772	(0.0050) ***
ln (Educational level of head of household)	0.154883	(0.0069) ***	0.1772033	(0.0060) ***	0.1957694	(0.0056) ***	0.2243824	(0.0054) ***
ln (Number of schoolchild)	-0.004547	(0.0050)	-0.003615	(0.0044)	-0.0000999	(0.0043)	0.002223	(0.0061)
ln (NDWI, River and lake)	0.024480	(0.0037) ***	0.0228787	(0.0032) ***	0.018907	(0.0026) ***	0.0160033	(0.0040) ***
ln (Nighttimelight density, mean)	0.186767	(0.0206) ***	0.2240943	(0.0204) ***	0.253415	(0.0169) ***	0.2554675	(0.0214) ***
ln (Rainfall amount)	-0.011970	(0.0052) **	-0.0010454	(0.0051)	0.0076432	(0.0047) *	-0.0038173	(0.0061)
ln (Elevation)	-0.021079	(0.0037) ***	0.0019599	(0.0030)	0.0083652	(0.0025) ***	0.015609	(0.0034) ***
ln (Road length)	0.006003	(0.0006) ***	0.0058679	(0.0005) ***	0.0062051	(0.0005) ***	0.0054269	(0.0007) ***
ln (Distance to the nearest city)	-0.025652	(0.0043) ***	-0.0257034	(0.0035) ***	-0.0218883	(0.0036) ***	-0.0132981	(0.0052) ***
ln (Distance to the nearest port)	-0.111305	(0.0062) ***	-0.1125445	(0.0049) ***	-0.1080637	(0.0052) ***	-0.0932288	(0.0056) ***
ln (NDVI*Harvested areas)	0.024326	(0.0023) ***	0.0203483	(0.0020) ***	0.0138432	(0.0018) ***	0.0093158	(0.0018) ***
ln (Export value of Agricultural products)	-0.003691	(0.0033)	0.0019425	(0.0024)	0.0024951	(0.0021)	0.0099956	(0.0038) ***
ln (International price of agricultural commodities)								
Province dummies	Yes		Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes		Yes	
Constatnt	12.983250	(0.0723) ***	12.93608	(0.0565)	13.01345	(0.0508)	12.92352	(0.0699)
Number of observation	25203		25203		25203		25203	
Pseudo R2	0.2083		0.1812		0.1632		0.1459	
Rau sum of deviations	2179.33		2892.88		2809.10		1985.92	
Min sum of deviations	1725.29		2368.82		2350.67		1696.10	

Note: ***, ** and * denotes significant level at 1%, 5%, and 10% respectively.

Table 4b: Estimation result: quantile regression

	20%		40%		60%		80%	
	Coefficient	Std.	Coefficient	Std.	Coefficient	Std.	Coefficient	Std.
ln (Household size)	0.048316	(0.0056) ***	0.0418255	(0.0057) ***	0.0383175	(0.0060) ***	0.0310831	(0.0062) ***
ln (Number of infant children)	-0.037644	(0.0068) ***	-0.0337047	(0.0058) ***	-0.0371763	(0.0054) ***	-0.0261099	(0.0057) ***
Gender of head of household (male=1/female=0)	-0.004698	(0.0053)	-0.0060168	(0.0041)	-0.0034676	(0.0047)	0.0002539	(0.0050)
ln (Age of head of household)	0.052813	(0.0079) ***	0.063066	(0.0071) ***	0.0613355	(0.0072) ***	0.0632766	(0.0075) ***
Land owner of farmland (Yes=1/No=0)	0.015229	(0.0051) ***	-0.0028843	(0.0055)	-0.0126041	(0.0050) ***	-0.032897	(0.0056) ***
ln (Educational level of head of household)	0.155121	(0.0073) ***	0.1789979	(0.0060) ***	0.1966396	(0.0042) ***	0.2229623	(0.0058) ***
ln (Number of schoolchild)	-0.006555	(0.0047)	-0.0031958	(0.0045)	-0.0007335	(0.0042)	0.0033901	(0.0048)
ln (NDWI, River and lake)	0.023513	(0.0045) ***	0.0217639	(0.0034) ***	0.0188931	(0.0025) ***	0.0161756	(0.0034) ***
ln (Nighttimelight density, mean)	0.179978	(0.0167) ***	0.220312	(0.0215) ***	0.2552379	(0.0140) ***	0.2587874	(0.0241) ***
ln (Rainfall amount)	-0.009256	(0.0054) *	0.005901	(0.0056)	0.0126276	(0.0046) ***	0.0004119	(0.0050)
ln (Elevation)	-0.021392	(0.0038) ***	0.0016079	(0.0026)	0.0074394	(0.0025) ***	0.0154164	(0.0032) ***
ln (Road length)	0.006182	(0.0006) ***	0.0062487	(0.0005) ***	0.0061731	(0.0005) ***	0.0054789	(0.0006) ***
ln (Distance to the nearest city)	-0.026988	(0.0038) ***	-0.0256792	(0.0038) ***	-0.0217045	(0.0038) ***	-0.013636	(0.0044) ***
ln (Distance to the nearest port)	-0.110304	(0.0064) ***	-0.1074923	(0.0054) ***	-0.1056842	(0.0050) ***	-0.0921837	(0.0046) ***
ln (NDVI*Harvested areas)	0.023901	(0.0021) ***	0.020089	(0.0017) ***	0.0144933	(0.0018) ***	0.0107353	(0.0018) ***
ln (Export value of Agricultural products)								
ln (International price of agricultural commodities)	0.002670	(0.0025)	0.0061221	0.00271 **	0.0086325	(0.0023) ***	0.0031007	(0.0028)
Province dummies	Yes		Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes		Yes	
Constatnt	12.911010	(0.0652)	12.88801	(0.0573)	12.97103	(0.0549)		
Number of observation	24968		24968		24968		24968	
Pseudo R2	0.2046		0.1782		0.1615		0.1439	
Rau sum of deviations	2148.86		2851.14		2770.52		1959.23	
Min sum of deviations	1709.16		2343.03		2323.05		1677.21	

Note: ***, ** and * denotes significant level at 1%, 5%, and 10% respectively.

7. Conclusion

Trade liberalization has been actively implemented in the world. In particular, developing countries in East Asia have achieved notable economic growth through their participation in the regional production networks. At the same time, these countries have experienced a considerable degree of income inequality, which represents one of significant remaining challenges. One of the most important factors of income inequality in developing countries in ASEAN is the disparity in income between urban and rural areas. One of the most significant challenges facing developing countries in ASEAN is the need to sustain the country's overall economic development while simultaneously addressing the considerable income disparities between urban and rural areas. This issue is particularly important given the region's reliance on trade liberalization.

This paper examined the impact of increased agricultural exports and changes in international prices due to trade liberalization on the level of economic welfare of rural households in Cambodia, a developing country in ASEAN. DHS household surveys conducted in 2014 and 2021 in Cambodia were combined with data from satellite imagery to analyze the determinants of economic welfare in rural areas. The estimation results reveled that an increase in agricultural exports has a positive impact on the economic welfare of rural Cambodia. Conversely, the effect of changes in international prices of agricultural products in the context of trade liberalization on the economic welfare of rural household remained uncertain. Further, we found that the effect of increased agricultural exports on economic welfare was confined to households with the highest levels of economic welfare. On the other hand, the rise in international prices of agricultural products resulting from trade liberalization had the consequence of enhancing economic welfare for household groups in the middle of the distribution of economic welfare levels. Nevertheless, it was also found that for the household group with the lowest level of economic welfare, namely the poorest household group, there was no change in the level of economic welfare, and increase in exports of agricultural product or the increase in international prices, would not impact their level of economic welfare in any case.

In summary, the findings of the estimation indicate that changes in exports and international prices due to trade liberalization can enhance the economic welfare of rural households. Conversely, the analysis demonstrated that the positive impact of enhanced economic welfare may not be fully realized by the most vulnerable household groups. In other words, trade liberalization has the potential to enhance the average level of economic welfare of rural households. However, it may also increase intra-rural disparities.

Therefore, when aiming to improve rural economic welfare through the expansion of agricultural exports via trade liberalization, it is imperative that economic policies also address the reduction of disparities within rural areas. For example, the enhancement of agricultural infrastructure, such as irrigation facilities for regions with low agricultural productivity, and the improvement of transport infrastructure to reduce trade costs, would facilitate the realization of trade benefits through agricultural exports to impoverished rural areas. It will also be necessary to improve economic efficiency so that a increase in international prices for export products translate into higher wages and incomes in rural areas.

This paper employs Cambodia as a case study to illustrate the characteristics of developing country in ASEAN. However, it is difficult to generalize and discuss the results of an analysis of a single country. Therefore, the analysis must be further expanded to cover more countries. Furthermore, the impact of trade liberalization on households is not limited to exports. It is also important to consider the impact of imports on households, as they are also consumers. In addition, due to data limitations, international trade costs were not explicitly treated in the estimation in this time. To enhance the coherence between the theoretical model and the empirical analysis, further research should address these issues and refine the estimation model for more precise analysis.

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