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Assessing impacts of income diversification on Vietnamese household welfare using quantile regression and longitudinal data

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ABSTRACT

This study examines the heterogeneous and dynamic effects of income diversification on Vietnamese household welfare measured by total income and consumption expenditure. Based on a risk management perspective and prior studies, households with different income levels may have different income diversification strategies. In the analysis, we use quantile regression for both pooled and cross-sectional data across regions. The effects from Simpson's diversity index, as the measure of income diversification, show mixed results. During the early period of study, income diversification raised the welfare of most households. However, the trend was reversed in the later period. This generates concern for low-income households and their income sources are less diversified. For higher-income households, the adverse effects are due to their focus on fewer economic activities, with wage earnings being their main source of income.

KEYWORDS

Income diversification; Simpson's index; household welfare; quantile regression; Vietnamese households

JEL CLASSIFICATION

C21; C23; G50; O15; Q12


I. Introduction

Income diversification is one of the main livelihood strategies of households in many developing countries. It is a strategy of seeking and combining income from various sources, especially on-farm and off-farm employment. Diversification provides numerous benefits for the household. It can reduce poverty and increase household income as the number of income-generating activities increases (Asfaw et al. 2019; Asfaw, Pallante, and Palma 2018; Bezu, Barrett, and Holden 2012; Do 2023; Holden, Shiferaw, and Pender 2004; Olale and Henson 2013; Rahut, Mottaleb, and Ali 2018; Reardon, Delgado, and Matlon 1992; Xu 2017). It also helps to allocate surplus labour in the agricultural sector into other high-return sectors. Additionally, income diversification can be considered as the ex-ante and ex-post risk coping strategies. While some argue that the additional income may increase the investment in productive technologies, others state that agricultural households adopting this livelihood strategy may face a reduction of efficiency in asset utilization, and lower return (Kimkong et al. 2023; Perz 2005).

Low-income and high-income households are affected by income diversification in different ways. In other words, diversification has a heterogeneous effect on household welfare. It can be a means of survival for the poor and thus will be more advantageous to households at the bottom level of the income distribution (Asfaw et al. 2019; Asfaw, Pallante, and Palma 2018; Etea et al. 2020; Mukoki et al. 2023; Perz 2005; Zhao and Barry 2014). In contrast, poor households may not have enough assets to diversify into high-return sectors, so they get caught in the low-return sector (Deininger and Olinto 2001; Kimengsi, Mukong, and Balgah 2020). In this case, the rich households benefit more from diversification.

In the last two decades, the agricultural sector has been a fundamental mechanism of Vietnam's economic growth. More than thirty percent of the labour in Vietnam is in this sector. Notably, Vietnam is one of the world's largest rice exporters. However, climate change has become a main threat to the agricultural sector. Recent studies show that climate change has affected revenue and crop yield in Vietnam (T. L. H. Nguyen, Bo, and Fahad 2019;

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T. T. Nguyen et al. 2022; T. A. Trinh 2017; T. Q. Trinh et al. 2018). In addition, N. T. Nguyen and Hoang (2015) estimated that in 2050 paddy yield in the Mekong River Delta would decrease by 2% to 6% due to climate change.

Income diversification will thus have an important role in Vietnam's agricultural development in the future because it can reduce vulnerability to climate hazards and enhance the resilience of Vietnamese households. Moreover, additional income from another source may release the household from credit constraints and lead to an increase in investment. Therefore, it can build strong agricultural productivity growth and will help to alleviate the poverty issue caused by climate change (T. T. Nguyen et al. 2022; Rozenberg and Hallegatte 2016). In addition to the agricultural sector, diversification might also be an effective risk-coping strategy for non-farm households.

Despite the significance of income diversification, few studies have explored this topic in the Vietnam context. Those studies only focused on the determinants of income diversification and its impact on welfare in a particular region of Vietnam (Do 2023; Le and Le 2020; Minot et al. 2006). In addition, previous studies do not determine the effect of income diversification on household welfare, especially the dynamic effect, while we assess both the dynamic and heterogeneous effects of such diversification. Thus, our study aims to examine the heterogeneous effect of income diversification on household welfare across regions of the country. Moreover, we also address the endogeneity issue and the dynamic of the welfare effect of income diversification. The outcome of this study will be used as evidence of the benefit from increased income diversification on the welfare of Vietnamese households.

To assess the heterogeneous effect, we use quantile regression to quantify the effect of the diversification on household welfare, measured by income and consumption expenditure, see more details on the quantile regression in Roger and Hallock (2001). We use the similar approach to determine the dynamic effect. Precisely, the different quantile levels of income and consumption expenditure represent heterogeneity. We also examine the endogeneity issue of income diversification using an instrumental variable (IV) regression. However,

we found no significant endogeneity issues; hence, the IV was omitted from our quantile regression models.

Our contributions are two-fold. First, we consider and quantify both the heterogeneous and dynamic effects of income diversification on Vietnamese household welfare in all regions using a quantile regression approach, while prior studies mainly focused on the heterogeneous effect and only in some regions. Second, our dynamic effect assessment over time is from pooled and each-year data, while others only used the pooled data. In addition, implications from our study can help policymakers design an effective tool to reduce the risks and vulnerabilities of Vietnamese households.

The organization of the rest of the paper is as follows. Section II reviews relevant literature and provides conceptual background. Section III describes the data and methodology. Section IV discusses the results. Section V concludes.

II. Literature review and conceptual background

Related literature

Many studies examined the relationship between income diversification and household welfare by focusing on its linear relationship. Those studies utilized several ways to express income diversification including the number of income sources (Perz 2005), two-dimensional diversification index (Asfaw et al. 2019; Liao, Barrett, and Kassam 2015; Xu 2017; Zhao and Barry 2014), and the role of non-farm income either in terms of non-farm income share (Bezu, Barrett, and Holden 2012; Reardon, Delgado, and Matlon 1992) or diversification into non-farm employment (Holden, Shiferaw, and Pender 2004; Olale and Henson 2013; Rahut, Mottaleb, and Ali 2018).

Perz (2005) collected household-level data in the Brazilian Amazon and found a higher number of income and product sources led to higher household welfare, which was proxied by the index of housing quality and the index of durable goods wealth. The result from the two-stage least square regression analysis suggested that livelihood diversification did not affect farm household welfare.

However, the regression result did not indicate that livelihood diversification was completely irrelevant to household welfare, as livelihood diversification and welfare were influenced by household assets.

Several studies used the two-dimensional diversification index as a proxy for income or livelihood diversification (Asfaw et al. 2019; Liao, Barrett, and Kassam 2015; Xu 2017; Zhao and Barry 2014). The result from estimating fixed effects instrumental variable regression model by Asfaw et al. (2019) suggested that a higher degree of income diversification, measured by the Gini-Simpson index, led to a higher income of a household in Malawi, Niger, and Zambia. In contrast, Liao, Barrett, and Kassam (2015) collected data from 159 households in northern Xinjiang. They found that income diversification was negatively associated with household income and households that relied almost solely on livestock earned higher total income than other livelihood strategies. Similarly, Zhao and Barry (2014) extended the dataset to cover 12 provinces of China. The results showed a negative relationship between income diversification and household income. However, Xu (2017) used data from the National Bureau of Statistics of China, which covered 31 provinces. He found that income diversification raised real consumption through income smoothing.

The linkage between the role of non-farm employment and household welfare has been investigated in various studies. Reardon, Delgado, and Matlon (1992) found an increase in non-farm income share contributed to a higher income across Burkina Faso, where a credit market was nearly missing. Also, non-farm employment increased calorie intake per adult equivalent only in some particular areas. Moreover, diversification in non-farm occupations supported rural household income in Ethiopia (Holden, Shiferaw, and Pender 2004), and Bhutan (Rahut, Mottaleb, and Ali 2018). This was also the case for fishing workers in western Kenya (Olale and Henson 2013). Holden, Shiferaw, and Pender (2004) focused on the role of non-farm employment on the welfare outcome by comparing the marginal effect of access to non-farm employment with the effect of access to the credit market. They found the diversification in non-farm employment provided a higher monetary premium than expanding the

credit supply to households in Ethiopia. The importance of non-farm employment was also apparent in Colombia as the specialization in the non-farm sector led to a high return to labour, while the specialization in the farm sector did not affect household expenditure in Colombia (Deininger and Olinto 2001).

In addition to examining the relationship between income diversification and welfare proxied by assets, income, or consumption, some studies considered income diversification and its impact on well-being, which represented household life satisfaction beyond economic utility. These studies utilized the well-being index based on the Human Development Index developed by the United Nations Development Programme. In Kilum-Ijim Forest areas, Cameroon and Nepal, diversification into high-return economic activities including trade and paid jobs led to a better well-being outcome (Deininger and Olinto 2001; Kimengsi, Mukong, and Balgah 2020). However, achieving a high-return livelihood portfolio required various asset endowments, such as education and social capital. Thus, low-income households could easily be trapped in low-return sectors.

Note that relatively few studies explored the non-linear effect of income diversification on household welfare. In Ethiopia, non-farm income share had a stronger positive impact on the consumption expenditure growth among rich households compared to poor households as low-income households may face constraints to climb up into the high-return sectors (Bezu, Barrett, and Holden 2012). As a way to assess the non-linear effect, the results from quantile regression showed that income diversification was a pro-poor welfare-enhancing strategy in Malawi, Zambia, and Niger illustrated by the diminishing welfare effect of income diversification towards the higher income quantiles (Asfaw et al. 2019; Asfaw, Pallante, and Palma 2018). This pattern of heterogeneity also existed in rural China. Using the same methodology as Asfaw, Pallante, and Palma (2018) and Asfaw et al. (2019), Zhao and Barry (2014) showed that income diversification led to an increase in income of Chinese households ranked below the middle of the income distribution, while the effect of the income distribution was reversed for households located above 75th income quantile.

Using the linear dynamic panel data models, Xu (2017) classified households by income level and found a U-shaped relationship between the marginal effect of income diversification on consumption and income level.

There were also some recent studies that investigated household income diversification in different aspects. Do (2023) used a panel dataset to find the relationship between households' risk attitudes and resilience-building strategies in rural Vietnam and attempted to assess the effect of these resilience strategies in reducing the impacts of shocks and poverty. This study is in line with our study, but we cover more households (not only in the rural area) and use different estimation methods. Mukoki et al. (2023) considered the impact of household livelihood diversification strategies on welfare and health outcomes such as child nutrition in Uganda, while Kimkong et al. (2023) analysed the life goals of people in rural areas and assessed the impact of income diversification on their wellbeing. These two studies are still under our research domain but addressed different questions and used different methodologies.

Overall, the existing literature showed that income diversification, measured either by the two-dimensional diversification index or the non-farm income share, increased household welfare in Sub-Saharan Africa. However, there are no agreements on the relationship between income diversification and welfare in other regions. That might be due to the differences in datasets and econometric models. Nevertheless, there is an obvious heterogeneous effect of income diversification on household welfare, but only a few studies have explored this non-linear relationship. Hence, this study attempts to analyse the effect of income diversification on Vietnamese household welfare, represented by total income and total consumption expenditure. Furthermore, while previous studies used dummy variables for diversification strategies, our study calculated the diversification index as a proxy of income diversification. This index can capture both the number of income sources and the amount of income. The result of this study will help extend the knowledge of income diversification in Southeast

Asian countries and formulate policy implications to improve Vietnamese household economic welfare.

Conceptual background

Income diversification can be defined as “an increase in the number of sources of income or the balance among the different sources” (Minot et al. 2006). However, there are also other ways to conceptualize and define income diversification depending on the context of the study. For example, some researchers focusing on non-farm employment or structural transformation refer to income diversification as an increase in non-farm income share or non-farm activities (Bezu, Barrett, and Holden 2012; Minot et al. 2006; Reardon, Delgado, and Matlon 1992). Note that income diversification considers household portfolio diversification in a narrower sense than livelihood diversification. A livelihood considers not only the role of income but also the role of social support, such as social institutions and public service, and an increase in the standard of living (Ellis 1998).¹ However, many studies used the terms “income diversification and livelihood diversification” interchangeably (Kimengsi, Mukong, and Balgah 2020; Liao, Barrett, and Kassam 2015).

The relevant theory of the relationship between income diversification and household welfare, which is an agricultural household model, can be classified into two major versions, the separable and non-separable models. The separable model assumes that on-farm and off-farm employment are a perfect substitute with no missing market, while the non-separable model assumes the difference between a preference for on-farm and off-farm employment with the existence of market failure (Lopez 1986). Moreover, risk can be incorporated into the optimization process of the non-separable model (de Janvry and Sadoulet 2006). Thus, the non-separable agricultural household model is more suitable to describe income diversification in developing countries. In the non-separable agricultural household model, the household has a dual role as a producer and a consumer.

¹Ellis (1998) defined livelihood diversification as “the process by which rural families construct a diverse portfolio of activities and social support capabilities in their struggle for survival and to improve their standards of living”.

Household intends to maximize utility, which is a function of consumption goods and the allocation of time between on-farm and off-farm employment subject to resource constraints (Lopez 1986). This model implies the heterogeneity in household asset endowments makes diversification strategies that yield the highest welfare differ across households.

In addition, the sustainable rural livelihoods (SRL) conceptual framework can explain the impact of income diversification on household welfare. The SRL framework shows, in different contexts, how sustainable livelihoods are achieved through access to a range of livelihood resources, i.e. natural, financial, human, and social capitals, and the risk faced as these resources are an influence on the different livelihood strategies; agricultural intensification or extensification, livelihood diversification and migration (Asfaw et al. 2019; Scoones 1998). That means, according to the SRL, the household is a decision maker who chooses the livelihood strategies based on resources and risk faced by their resources. Thus, the SRL has been adapted to a simplified non-separable farm household model in which on-farm crop diversification and off-farm income-generating activities are simultaneously determined and affected by the same set of exogenously expected or unexpected shocks and asset endowments (de Janvry, Fafchamps, and Sadoulet 1991; Wouterse and Taylor 2008).

From the reasons given above, the SRL is suitable for a study of income diversification. Therefore, this study applies this conceptual framework (Figure 1) where livelihood resources consist of natural and human capital while livelihood

strategies include farm employment, self-non-agricultural employment, wage job, and migration, and household welfare proxied by household inflation-adjusted income and household consumption expenditure. The risk faced by livelihood resources is proxied by the number of risks per year. Lastly, other control variables included in the study can be income from agricultural activities, self-business, farming, migration, poor, urban, and time dummy variables. Note that reverse causality may occur; that is, household welfare can affect income diversification as income and consumption expenditure may relate to the ability to overcome the constraints to diversify (Asfaw, Pallante, and Palma 2018).

III. Data and methodology

Data

We used the longitudinal or panel data from the Vietnamese Household Living Standard Survey (VHLSS) by the Vietnam General Statistics Office. Due to the data availability and to avoid the effect of COVID-19, the data used in this study cover eight waves/years in 2004, 2006, 2008, 2010, 2012, 2014, 2016, and 2018, yielding a total of 74,304 observations or households livings. The data includes Simpson's diversity index (SDI), education, age, gender, member, labour, area, risks, self-business, farm income, migration, poor, and urban. See more details of the variables in Table 1. Some of the variables used in this study are drawn from previous studies, e.g. Ellis (1998), Nguyễn and Bui (2011), Zhao and Barry (2014), Võ, (2015), and Ma et al. (2023).

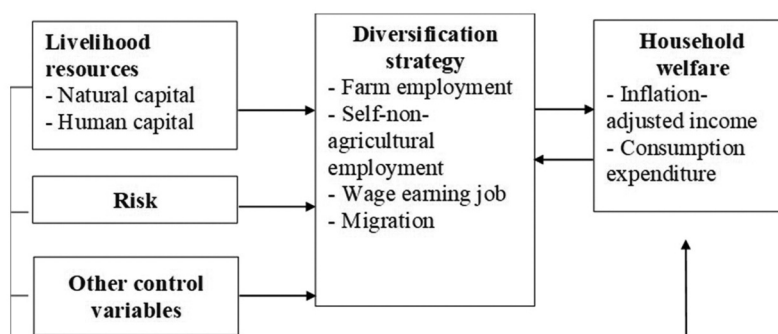


Figure 1. Conceptual framework.

Table 1. Details of variables.

Variable	Description	Variable	Description
Welfare		Region Dummy Variable	
Income_AFI*	Total inflation-adjusted income (1,000 VND/year)	Red River Delta (D1)	1 = Red River Delta; 0 = otherwise
Expenditure	Total household consumption expenditure	Northern midlands and mountainous (D2)	1 = Northern midlands and mountainous; 0 = otherwise
Diversification Degree		North Central and South Central Coast (D3)	1 = Northern Central & South Central Coast; 0 = otherwise
SDI*	Simpson's diversity index	Central Highlands (D4)	1 = Central Highlands; 0 = otherwise
Natural Capital Area*	Total cultivated area (m^2)	Southeast area (D5)	1 = Southeast area; 0 = otherwise
Human Capital Age**	Age of respondent (year)	Mekong River Delta (D6)	1 = Mekong River Delta; 0 = otherwise
Gender**	If 1 = male; 0 = female	Region Dummy Variable	
Member**	Number of family member (person)	Year06	1 = 2006; 0 = otherwise
Labour**	Number of working member in a household (person)	Year08	1 = 2008; 0 = otherwise
Education**	Education of respondent (year)	Year10	1 = 2010; 0 = otherwise
Migration*	Number of migrated members per household	Year12	1 = 2012; 0 = otherwise
Risk		Year14	1 = 2014; 0 = otherwise
Risk***	Number of risks faced per year	Year16	1 = 2016; 0 = otherwise
Other Control Variables		Year18	1 = 2018; 0 = otherwise
Farm income*	Income from agricultural activities (1,000 VND/year)	An Giang (P7)	1 = An Giang; 0 = otherwise
Self_business*	1 = business owner; 0 = otherwise	Kien Giang (P8)	1 = Kien Giang; 0 = otherwise
Poor	1 = poor household; (based on Vietnam standard); 0 = otherwise	Can Tho city (P9)	1 = Can Tho city; 0 = otherwise
Urban	1 = urban; 0 = otherwise	Hau Giang (P10)	1 = Hau Giang; 0 = otherwise
Mekong River Delta		Soc Trang (P11)	1 = Soc Trang; 0 = otherwise
Long An (P1)	1 = Long An; 0 = otherwise	Bac Lieu (P12)	1 = Bac Lieu; 0 = otherwise
Tien Giang (P2)	1 = Tien Giang; 0 = otherwise	Ca Mau (P13)	1 = Ca Mau; 0 = otherwise
Ben Tre (P3)	1 = Ben Tre; 0 = otherwise		
Tra Vinh (P4)	1 = Tra Vinh; 0 = otherwise		
Vinh Long (P5)	1 = Vinh Long; 0 = otherwise		
Dong Thap (P6)	1 = Dong Thap; 0 = otherwise		

*Following from Zhao and Barry (2014). Computing Time, and n.a. = not available.

Following from Nguyễn and Bùi (2011) and Võ (2015). *Following from Ellis (2000). VND = Vietnamese Dong.

In Table 1, we expect Area, Age, Member, Labour, Education, Migration, Farm income, and Self_business variables to positively affect the welfare. On the contrary, Risk variables might negatively affect welfare. For the SDI, it can have either a positive or negative effect on welfare.

Model and estimation methods

To measure the degree of diversification, we employed the SDI as it can capture the degree of diversification in terms of the number of income sources and the amount of income from each source. The SDI is calculated as follows:

$$SDI = 1 - \sum_{j=1}^k D_j^2 \quad (1)$$

where D_j is the share of income from source j (income from source j divided by total income from all sources) for $j = 1, \dots, k$. The index ranges from 0 (completely specialized) to 1 (completely diversified).

As mentioned in Section II, there exists the heterogeneous effect of income diversification on household welfare. However, there are two different viewpoints on this. On one hand, some studies indicate that diversification is more beneficial to low-income households than those of rich ones as the latter lose their efficiency in agricultural production when their income is diversified (Asfaw et al. 2019; Asfaw, Pallante, and Palma 2018; Zhao and Barry 2014). On the other hand, others argue that households with low income may face a constraint to diversifying their income into the high-return sectors (Deininger and Olinto 2001; Kimengsi, Mukong, and Balgah 2020). A possible cause of this conflict is considering only the mean effect of income diversification that may overlook and ignore some useful information, especially for households with different levels of income. Hence, this study used the quantile regression model to analyse the heterogeneous effect of income diversification on Vietnamese household welfare that can be modelled as:

$$y_i = \alpha_\tau + SDI_i' \beta_\tau + x_i' \gamma_\tau + \varepsilon_{\tau i} \quad (2)$$

The conditional quantile function of y_i can be written as follows:

$$Q_\tau(y_i | SDI_i, x_i) = \alpha_\tau + SDI_i' \beta_\tau + x_i' \gamma_\tau \quad (3)$$

where y_i is the welfare outcomes including household inflation-adjusted income and household consumption expenditure, SDI_i denotes the Simpson's diversity index, α_τ represents the marginal effect of income diversification on the welfare of household at quantile τ , x_i' is the vector of control variables considered in the regression analysis and γ_τ is the vector of coefficient at each quantile τ .

According to Section 2.2, welfare may affect the degree of income diversification. Moreover, there might be some unobserved characteristics of a household such as the household's social capital

and ability to access infrastructure. Thus, to deal with the endogeneity problem we employ an instrumental quantile regression proposed by Chernozhukov and Hansen (2008) and conduct the Wu-Hausman test to check the possible endogeneity issue between the SDI and the household welfare.

The instrumental variable (IV) used in this study is the absolute value of the 3-month standardized precipitation index (SPI) in the planting season (July-September), which refers to the probability that the household suffers from climate shock. Intuitively, households will adapt their diversification strategy to cope with climate shocks either drought or flood. Compared with other time scales, 3-month SPI effectively provides moisture and drought conditions (WMO, World Meteorological Organization 2012). SPI obtained from Vietnam's ENACTS dataset was calculated from the normal distribution of long-term time series monthly rainfall, which is transformed from the probability density function. The result from the Wu-Hausman test showed that there is no significant evidence of endogeneity (The Wu-Hausman test results can be found in the supplementary material). Hence, we did not include the IV in the quantile regression.

The quantile regression models, also known as least-absolute-value (LAV or MAD) and minimum L1-norm models, have the default form, which is median regression, where the objective is to estimate the median of the dependent variable, conditional on the values of the independent variables. Moreover, the quantile regression can also estimate the regression plane for quantiles other than 0.5 (median). Hence, in this study, we consider the effect in seven quantile levels of household welfare; that is, $\tau = \{0.05, 0.10, 0.25, 0.50, 0.75, 0.90, 0.95\}$, and expect that SDI can have either a positive or negative effect on the household welfare in each level. Note that we do not consider the unconditional quantile method in this study as it does not give the true conditional quantile effect where observations in other quantiles are excluded while the conditional quantile regression includes all observations but given different weights following the quantile of interest.

Additionally, the estimation of quantile regression can deal better with outliers and

heteroscedastic errors than the OLS regression. Note that quantile regression has two key differences from the subgroup OLS regression (Zhao and Barry 2014). First, the outcome of quantile regression is calculated at each specified quantile using the whole sample, whereas the predicted independent variable of OLS is calculated at the mean of each subsample. Second, the quantile regression minimizes the sum of the asymmetrically weighted absolute residuals; that is, at quantile τ , the positive residuals are weighted with τ and the negative residuals are weighted with $\tau-1$. In contrast, the OLS minimizes the sum of squared residuals, which are weighted equally.

However, the quantile regression expresses the median of the conditional distribution of the dependent variable as a linear function of the conditioning (independent) variables. Consequently, the coefficients of the quantile regression can be interpreted in the same way as OLS regression.

In summary, all various techniques we employed, IV and quantile regression, help us to address our research questions and fulfil our purposes to analyse and quantify the heterogeneous effect of income diversification on household welfare. Precisely, the quantile regression can assess

the non-linear effects, which is important for the analysis of households with different income levels. The panel data from the surveys also render us with the ability to assess the effects over time.

IV. Results

Preliminary data analysis

The average Vietnamese household income and consumption expenditure gradually increased from 2004 to 2018 indicating an improvement in the welfare situation in Vietnam (Figure 2).

According to the VHLSS data, we classified the income sources into five categories including farm income, non-farm self-employment income, wage income, income from migrated members, and other income. According to the income portfolio of Vietnamese households in Figure 3, we found on average that non-farm and wage income are the important components. Households in the Red River Delta, Northern Central, and South Central Coast rely less on farm income compared to other regions.

The diversification strategies are divided into four groups. The first is farm specialization, which refers to the event that households rely solely on farm

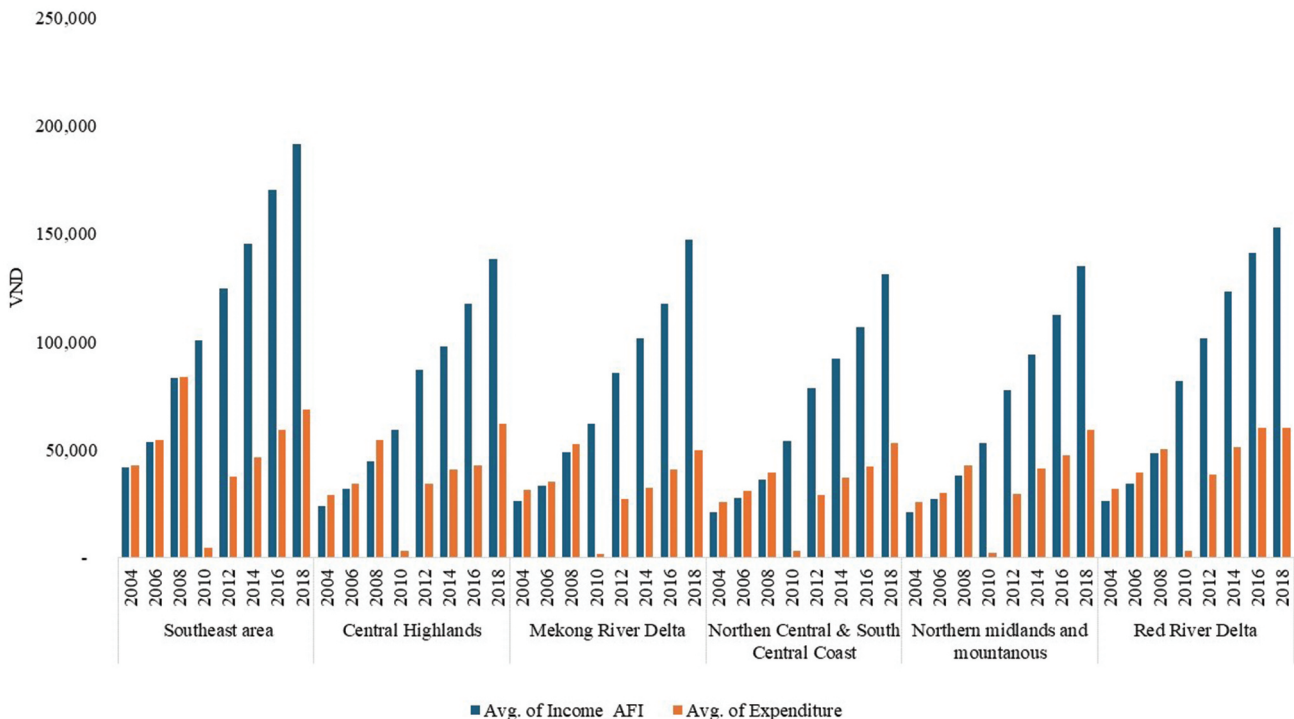


Figure 2. Average Vietnamese household income and consumption expenditure by region.

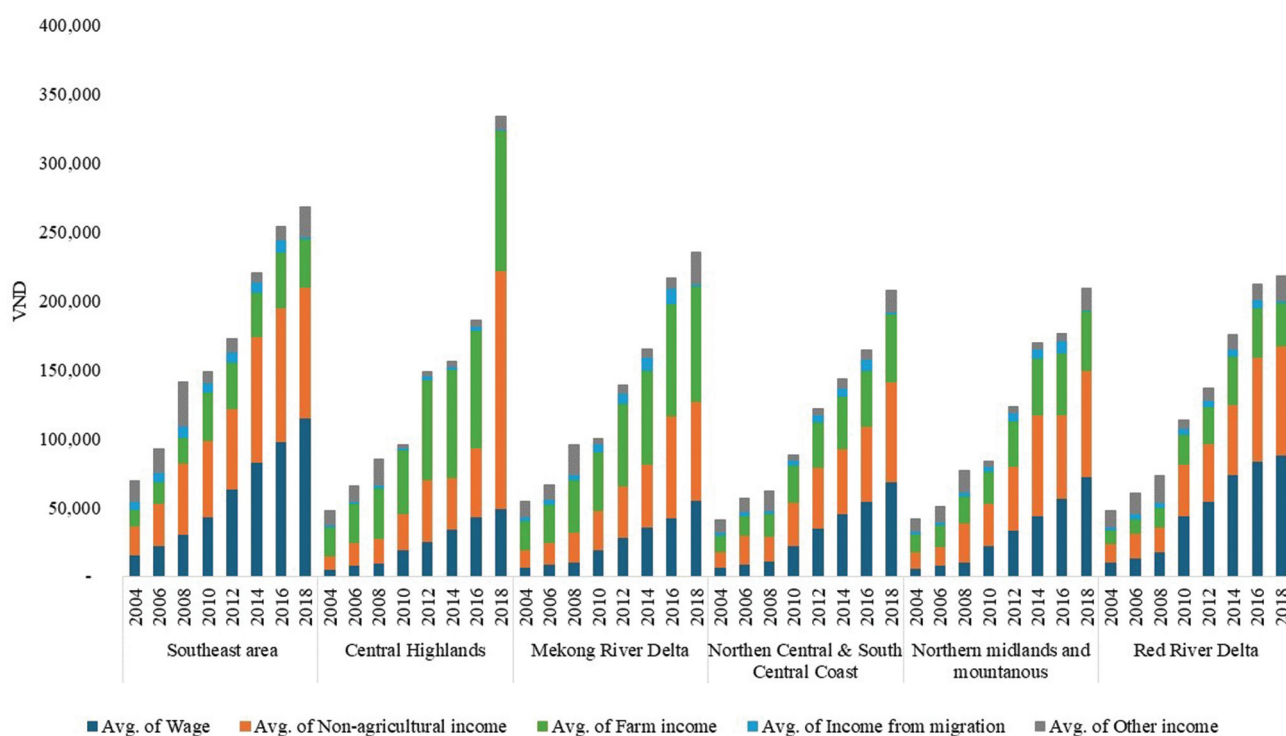


Figure 3. Average Vietnamese household income by source and region.

income. Second, other specialization is adopted by households whose income only comes from non-farm self-employment, wage jobs, migrated members, or others. Third, if a household has more than one income source, that is not from farm employment, they are considered as taking non-farm diversification. Lastly, households that have more than one income source, and one of those is from farm employment, will be placed into the mixed diversification category.

Most Vietnamese households rely on three main income sources, which are farm income, non-farm income, and wage income. Based on Figure 4, the majority of households use non-farm and mixed diversification strategies.

Measured by the SDI, on average, Vietnamese households become less diversified from 2004 to 2018 (Figure 5). Note that urban residents have a lower average SDI than those who live in rural areas. This is an interesting finding that indicates the vulnerability of urban households caused by the fewer sources of income.

Though the income source of most households in the Mekong River Delta (MRD) is from the farm (Figure 3), the one that has the highest average cultivated areas was actually in the Central Highlands.

Moreover, households in the MRD region have the highest average number of risks per year (Figure 6). That means most households in the MRD region that rely on farm income but do not own the cultivated areas or have fewer of them and face a high average number of risks are more vulnerable.

Effect of income diversification on Vietnamese household welfare

In this section, we used the quantile regression to analyse the heterogeneous effect of income diversification, proxied by the SDI, on Vietnamese household welfare, measured by the adjusted-inflation total income and total household consumption expenditure. To assess the non-linear effect, we considered the quantile in 7 levels including 0.05, 0.10, 0.25, 0.50, 0.75, 0.90, and 0.95.

With the pooled or panel data where the cross-sectional households are combined over time, the SDI strongly and positively affects the household income at a 1% level of significance for the 0.05 quantile but it becomes negatively significant at the 0.50, 0.75, 0.90, and 0.95 quantiles (Table 2). That means diversification helps increase the income (or welfare) for the lowest-income households. In

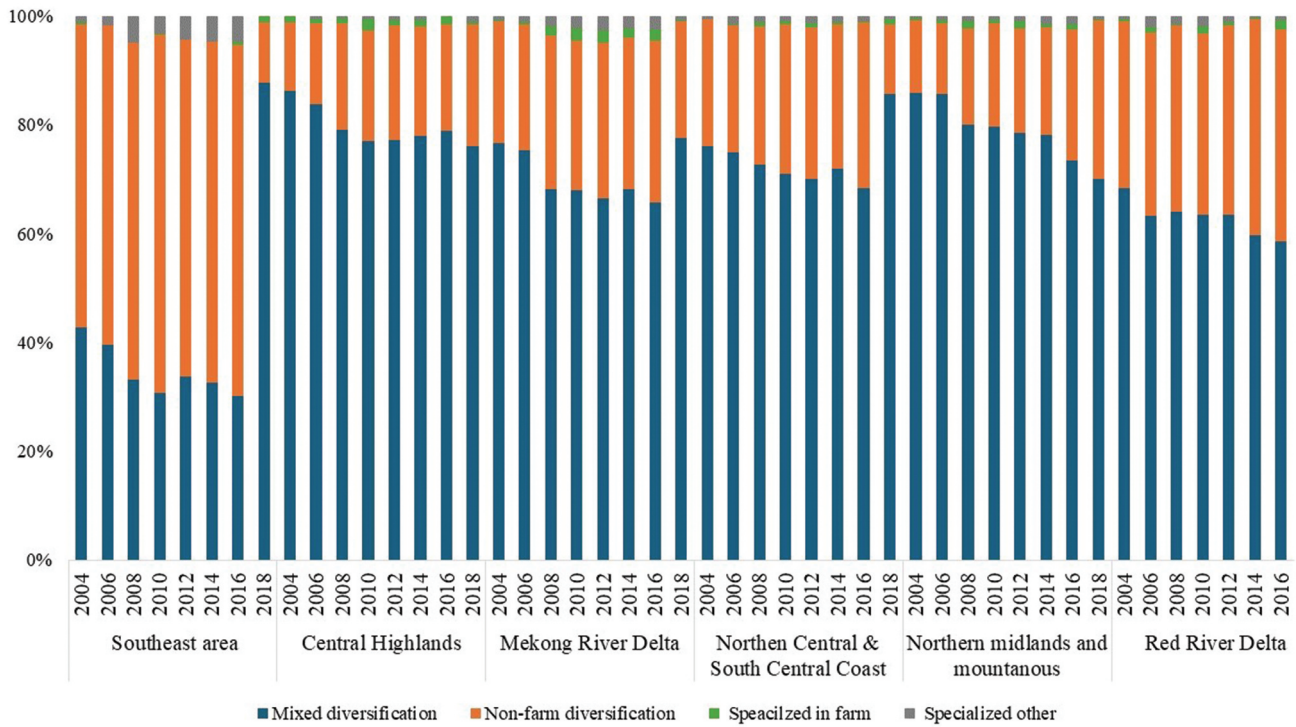


Figure 4. Diversification strategies by region.

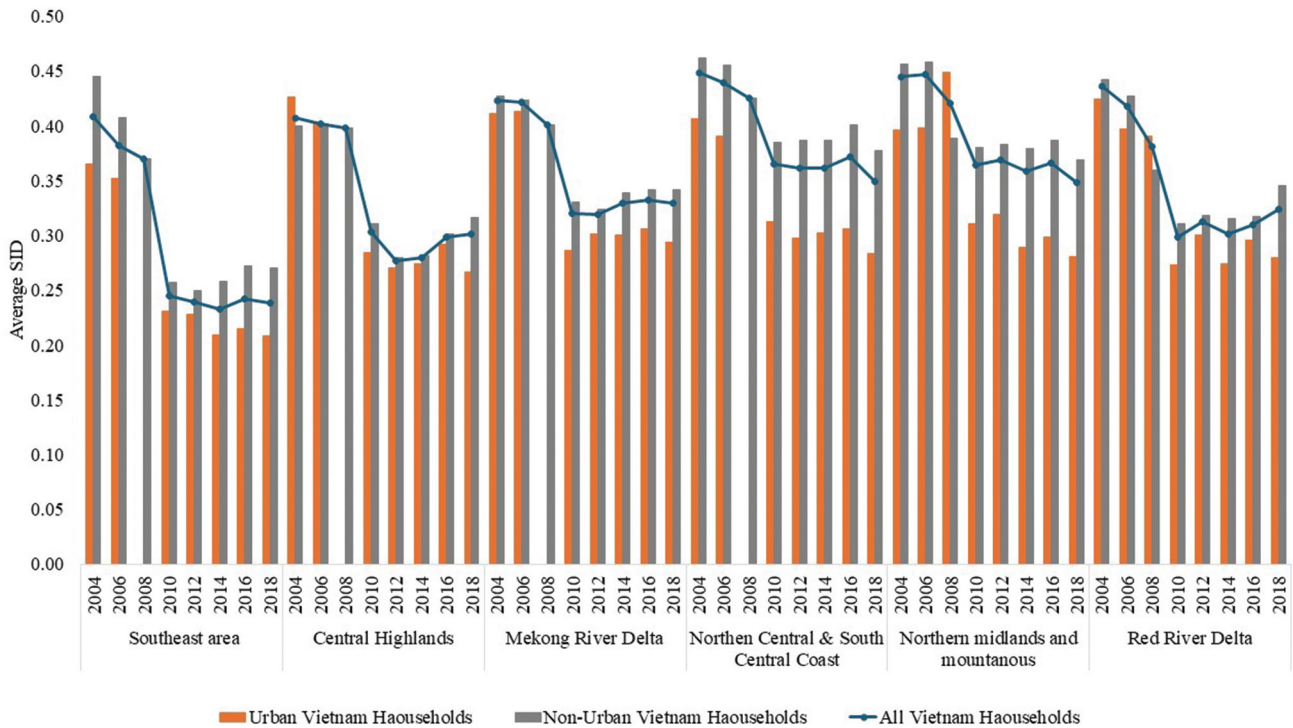


Figure 5. Average SDI of Vietnamese households.

contrast, for higher-income households, a careful interpretation is needed as it is counter-intuitive to conclude that more diversification lowers the

households' income and vice versa. Instead, the negative effect indicates that less diversification is more prevalent in medium to high-income

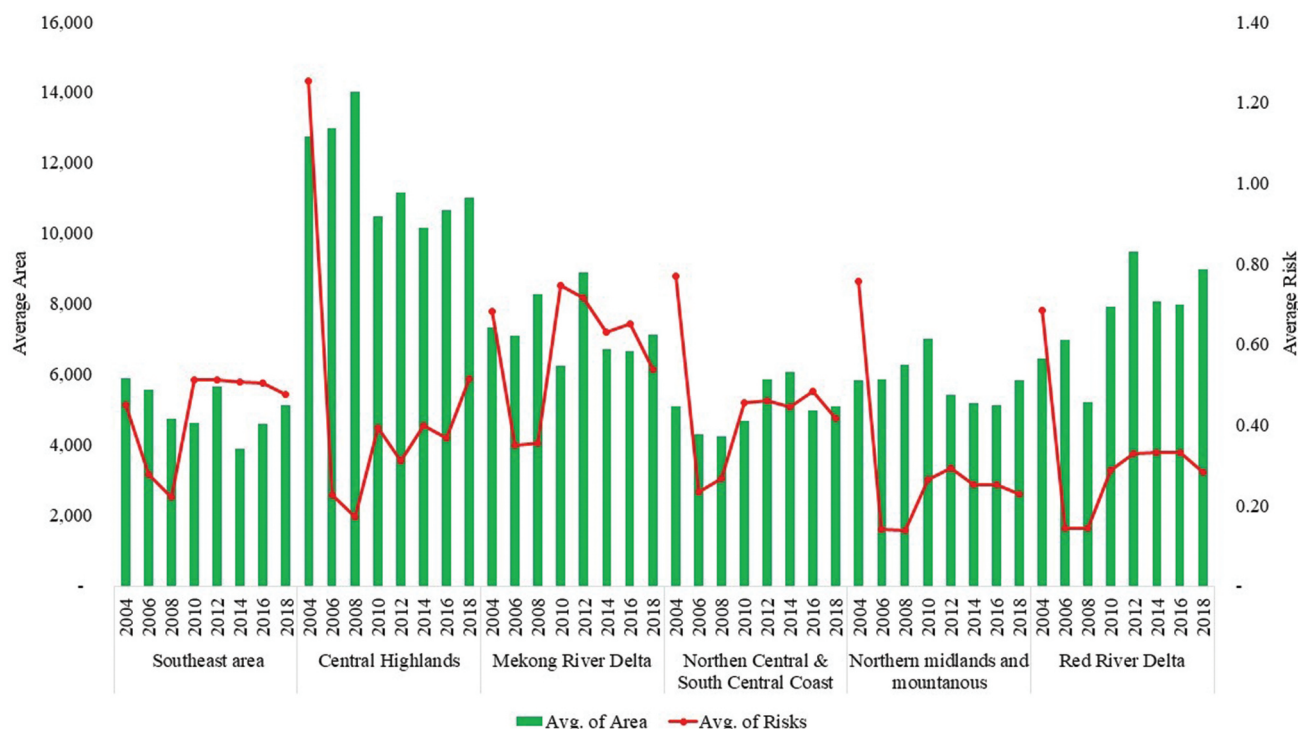


Figure 6. Average cultivated areas and risks by region.

Table 2. Effect of income diversification on inflation-adjusted household income.

	q05	q10	q25	q50	q75	q90	q95
Pooled Data	1,083*** (201.6)	-75.32 (152.7)	-32.21 (199.4)	1,062*** (279.3)	-1,630*** (419.5)	-4,711*** (746.5)	-53,663*** (8,863)
2004	982.0 (626.9)	1,481*** (457.0)	1,330*** (509.2)	1,343* (720.4)	346.5 (1,210)	-3,641* (1,986)	-11,338*** (4,124)
2006	1,194* (646.5)	1,401* (786.1)	1,172 (834.6)	-523.4 (1,043)	-4,775*** (1,594)	-13,689*** (2,045)	-18,467*** (4,110)
2008	2,020*** (715.4)	390.2 (783.0)	-321.9 (1,158)	-5,960*** (1,833)	-15,931*** (1,988)	-19,513*** (3,013)	-29,387*** (7,240)
2010	-3,743*** (1,249)	-4,810*** (1,226)	-6,136*** (1,537)	-13,188*** (2,219)	-18,034*** (2,720)	-21,349*** (3,828)	-36,406*** (5,517)
2012	-584.0 (2,257)	-690.5 (2,096)	-4,913** (2,144)	-17,626*** (2,457)	-35,751*** (4,202)	-56,600*** (6,462)	-75,278*** (7,598)
2014	5,796** (2,754)	2,147 (2,039)	-8,211*** (2,640)	-24,578*** (2,983)	-46,086*** (5,632)	-57,837*** (8,309)	-69,692*** (13,513)
2016	-1,892 (2,225)	-853.5 (2,623)	-12,772*** (2,664)	-31,745*** (2,230)	-54,038*** (4,541)	-74,021*** (9,084)	-78,635*** (10,354)
2018	-5,885 (3,620)	-8,016 (4,875)	-14,319*** (4,329)	-37,559*** (5,324)	-55,905*** (6,383)	-72,239*** (8,229)	-105,334*** (12,946)

***, ** and * indicate the statistical significance at 1%, 5%, and 10% level, respectively. Number in the parenthesis is the robust standard error.

households. This is consistent with the average SDI shown in Figure 5 above and can be confirmed from the cross-sectional results by years below. Our findings on heterogeneous effects of households with different income levels are in line with those of Zhao and Barry (2014) and Asfaw et al. (2019) that show different household incomes make a difference in their diversification strategies. We also found Ma et al. (2023) had similar results

where income diversity is likely to improve consumption expenditure at some lower quantiles but it has no effect on the higher quantiles.

The results by year and quantile in Table 2 also show the increasing trend of the negative effects of the diversifications on the inflation-adjusted household income in general. Note that the effects are unclear for the lower-income households from the 0.05 and 0.10 quantile groups. However,

though it is not statistically significant, the negative effects have observed in recent years, i.e. in 2016 and 2018. The effects for the medium-high income groups confirm what we discussed earlier in the case of pooled data. These dynamic impacts confirm our hypothesis that changing economic (and social) conditions can alter the diversification that affects household welfare, which is also shown by Mukoki et al. (2023). In conclusion, the increasing trend of negative effects generated a concern that Vietnamese households can become vulnerable from fewer diversifications, either to the limited resources or chances caused by the rapid economic growth during that period.

When adding the regional dummy variables to control the regional differences (Table 3), the effects of the SDI on the income are still similar, but in a smaller magnitude, to those without the dummy variables both with the pooled and cross-sectional data. The smaller SDI coefficients indicate that to some extent different regions have different degrees of negative effects from the diversifications. (The regression coefficients of regional dummy variables are not reported here for conciseness.) These results emphasize the differences in SDI by region shown in Figure 4 above. Etea et al. (2020) also show that different areas can result in diversification strategies.

After changing the dependent variable from the adjusted-inflation total income to the consumption

expenditure, the results from Table 4 show that in the case of pooled data, the lower-consumption households (0.10 and 0.25 quantiles) benefited from the income diversifications.² Precisely, the significantly positive SDI coefficients mean higher diversifications can lead to higher household consumption expenditure. These effects can still be observed from all levels of household consumption expenditure before 2010, except for the 0.95 expenditure quantile in 2008 that signalled the reverse trend of the effect from income diversification. After that, the negative effects of income diversification on total household consumption expenditure have been seen widely in most expenditure quantiles, especially in 2018. Interestingly, once we added the regional dummy variables into the model (Table 5), the effects of SDI became less significant after 2010 in all quantiles. This indicates the regional differences in diversification strategies that may not directly affect household consumption expenditures.

To assess the diversification effects at the regional level, we estimate the model using the data from the Mekong River Delta (MRD) where the average household farm income is highest. Table 6 shows the results from the case with inflation-adjusted household income being the dependent variable. We found mixed results where in the pooled data the effects from SDI are positively and statistically significant for the low to medium-income groups

Table 3. Effect of income diversification on inflation-adjusted household income with regional dummy variables.

	q05	q10	q25	q50	q75	q90	q95
Pooled Data	1,123*** (202.3)	69.94 (153.3)	66.20 (200.8)	-794.3*** (282.6)	-1,349*** (422.8)	-4,350*** (749.6)	-49,827*** (9,032)
2004	1,343** (681.6)	1,716** (675.2)	1,007** (489.7)	1,525*** (517.4)	66.04 (854.8)	-2,617 (1,851)	-7,625** (3,339)
2006	1,501** (694.2)	1,985*** (565.6)	1,378*** (476.1)	717.8 (1,051)	-1,294 (1,108)	-10,156*** (2,764)	-17,707*** (4,729)
2008	1,503 (1,186)	595.3 (1,003)	-154.0 (1,194)	-3,458** (1,615)	-13,177*** (2,166)	-17,601*** (3,700)	-22,381*** (5,803)
2010	-2,407* (1,427)	-2,408** (940.9)	-2,685** (1,102)	-8,157*** (1,892)	-14,726*** (3,165)	-13,129*** (4,727)	-21,986*** (7,692)
2012	2,015 (2,175)	1,797 (2,609)	-288.0 (2,226)	-10,727*** (1,591)	-26,985*** (3,672)	-50,101*** (4,757)	-50,781*** (10,173)
2014	7,719*** (2,036)	6,238** (2,706)	-1,715 (2,986)	-16,952*** (3,018)	-33,035*** (4,321)	-48,266*** (6,056)	-62,432*** (9,251)
2016	3,140 (2,994)	3,767 (3,154)	-5,812* (3,437)	-25,150*** (3,914)	-43,356*** (4,495)	-58,417*** (5,997)	-72,978*** (10,234)
2018	841.1 (3,245)	-4,570 (3,645)	-10,228*** (2,351)	-29,574*** (4,418)	-44,454*** (4,231)	-57,959*** (9,666)	-87,209*** (21,582)

***, ** and * indicate the statistical significance at 1%, 5%, and 10% level, respectively. Number in the parenthesis is the robust standard error.

²The results from 2010 are omitted from the table as the models cannot be estimated.

Table 4. Effect of income diversification on total household consumption expenditure.

	q05	q10	q25	q50	q75	q90	q95
Pooled Data	-94.91 (60.38)	267.3*** (97.57)	213.6** (92.98)	34.60 (113.2)	-212.5 (161.6)	-157.8 (308.0)	-24.15 (6,571)
2004	2,835*** (560.6)	4,117*** (556.1)	5,998*** (346.0)	9,322*** (610.7)	11,412*** (1,308)	13,661*** (1,803)	9,359 (5,720)
2006	2,137*** (552.6)	2,726*** (668.7)	3,757*** (670.3)	7,163*** (965.4)	7,618*** (783.7)	9,427*** (2,096)	7,315** (3,442)
2008	1,752** (884.0)	2,094** (828.6)	4,184*** (784.6)	6,408*** (906.7)	4,217*** (1,380)	2,849 (4,844)	-29,820** (14,711)
2010	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
2012	-855.4 (542.5)	-1,221*** (375.5)	-1,358*** (451.2)	-999.1 (745.9)	-725.0 (1,410)	-861.4 (2,215)	1,777 (4,752)
2014	-1,172 (883.8)	-1,157* (628.8)	-1,174 (766.3)	388.6 (942.4)	-679.0 (2,247)	-5,784 (4,933)	-9,055* (5,437)
2016	-1,379* (791.3)	-849.5 (943.3)	-1,501 (958.3)	-3,389** (1,363)	-3,979* (2,335)	1,288 (3,764)	3,798 (7,101)
2018	-2,598** (1,030)	-1,564* (839.5)	-1,686** (843.1)	-2,240* (1,296)	-862.8 (2,488)	-9,167* (4,966)	-10,641 (8,800)

***, ** and * indicate the statistical significance at 1%, 5%, and 10% level, respectively. Number in the parenthesis is the robust standard error. N.A. = not available.

Table 5. Effect of income diversification on total household consumption expenditure with regional dummy variables.

	q05	q10	q25	q50	q75	q90	q95
Pooled Data	-122.7** (61.36)	357.9*** (98.18)	289.6*** (94.28)	59.82 (114.3)	-134.3 (163.5)	-54.82 (310.7)	-47,540*** (7,889)
2004	2,868*** (241.0)	3,967*** (406.2)	5,606*** (539.8)	8,850*** (745.1)	11,326*** (1,077)	12,857*** (2,145)	9,243** (3,679)
2006	2,505*** (638.3)	2,998*** (627.6)	4,507*** (609.4)	8,381*** (742.9)	10,060*** (954.1)	11,504*** (2,999)	9,397* (5,154)
2008	1,589** (775.6)	2,335*** (617.3)	4,534*** (771.3)	6,972*** (996.9)	6,056*** (1,991)	3,014 (5,372)	-15,102 (17,903)
2010	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
2012	-526.0 (501.7)	-375.7 (668.1)	-875.7 (608.3)	-83.77 (705.5)	1,380 (1,238)	1,477 (2,369)	4,626 (3,301)
2014	-783.7 (745.6)	-707.0 (579.3)	-407.7 (468.2)	1,094* (562.9)	-210.2 (1,534)	-5,896* (3,097)	-7,286 (5,133)
2016	-474.4 (677.3)	-35.86 (930.5)	-795.6 (821.7)	-1,435 (1,149)	-2,041 (2,459)	5,786 (4,804)	7,212 (5,527)
2018	-996.6 (784.4)	-62.82 (904.4)	-1,758 (1,133)	-377.6 (1,781)	-802.2 (3,033)	-5,663 (4,634)	-10,552 (7,644)

***, ** and * indicate the statistical significance at 1%, 5%, and 10% level, respectively. Number in the parenthesis is the robust standard error. N.A. = not available.

Table 6. Effect of income diversification on inflation-adjusted household income in the Mekong River Delta.

	q05	q10	q25	q50	q75	q90	q95
Pooled Data	1,320 (1,260)	3,178* (1,651)	4,951*** (1,087)	3,360** (1,558)	854.3 (1,903)	-6,097* (3,232)	-11,451** (4,869)
2004	-964.6 (1,623)	-902.7 (1,537)	-218.7 (907.0)	1,481 (1,160)	-231.6 (1,820)	-3,926 (4,142)	-10,855 (6,766)
2006	-2,080 (1,328)	-1,432 (1,241)	-602.8 (1,295)	-868.2 (1,509)	-3,128 (2,267)	-11,080*** (3,475)	-15,727*** (5,630)
2008	252.4 (1,878)	-689.1 (2,239)	-3,371 (2,377)	-1,139 (1,829)	-4,767 (3,032)	-2,758 (9,151)	-1,885 (12,751)
2010	-4,682 (3,043)	-675.2 (2,978)	1,560 (2,532)	335.5 (2,968)	-5,013 (4,254)	957.2 (6,567)	1,933 (11,507)
2012	-2,182 (5,304)	-2,874 (5,010)	-5,368 (4,912)	-4,981 (4,744)	-4,453 (5,159)	-21,258* (11,827)	-27,880 (21,989)
2014	4,557 (4,493)	10,771*** (3,352)	9,266** (4,332)	1,644 (6,651)	-1,320 (7,162)	-14,331 (12,072)	-42,260** (17,094)
2016	4,933 (6,566)	8,041 (5,967)	-885.6 (7,425)	-4,017 (6,188)	-17,594 (11,614)	-24,044 (17,157)	-41,805 (28,117)
2018	12,536 (7,729)	15,556** (6,543)	16,926** (7,156)	9,895 (9,705)	-8,931 (13,448)	-17,669 (17,406)	-8,175 (44,666)

***, ** and * indicate the statistical significance at 1%, 5%, and 10% level, respectively. Number in the parenthesis is the robust standard error.

Table 7. Effect of income diversification on total household consumption expenditure in the Mekong River Delta.

	q05	q10	q25	q50	q75	q90	q95
Pooled Data	895.5** (385.6)	978.8** (393.5)	2,421*** (355.1)	3,846*** (604.9)	5,051*** (1,001)	8,042*** (2,411)	7,693* (4,059)
2004	2,016 (1,414)	3,339** (1,620)	5,350*** (1,918)	8,738*** (1,650)	12,544*** (2,168)	16,751*** (4,145)	3,415 (9,371)
2006	663.3 (1,242)	2,700** (1,327)	3,817*** (959.3)	7,211*** (2,210)	12,648*** (3,209)	15,410** (6,493)	13,071 (8,911)
2008	1,432 (2,166)	4,777*** (1,555)	7,063*** (1,943)	7,372*** (2,648)	10,337*** (3,255)	16,922* (8,937)	17,919 (22,132)
2010	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
2012	-576.3 (1,087)	210.8 (1,224)	2,492** (1,083)	3,329*** (1,190)	4,149* (2,257)	9,199 (5,893)	15,144* (7,811)
2014	682.2 (1,875)	1,051 (1,449)	2,356 (1,448)	5,849*** (1,956)	6,725** (3,156)	7,397 (5,676)	4,693 (8,088)
2016	1,376 (1,553)	850.6 (1,420)	1,356 (1,692)	-301.5 (3,117)	2,927 (3,435)	17,469** (7,362)	34,563*** (9,370)
2018	-1,185 (1,784)	489.9 (1,723)	1,411 (1,071)	3,038 (2,705)	4,954 (4,435)	-5,825 (10,537)	-6,754 (23,477)

***, ** and * indicate the statistical significance at 1%, 5%, and 10% level, respectively. Number in the parenthesis is the robust standard error. N.A. = not available.

(0.10, 0.25, and 0.50 quantiles) while the high-income groups (0.90 and 0.95 quantiles) have negative effects. Similar results but with less significant coefficients are still observed for the cross-sectional data by year and quantile. This implies that income diversification leads to an increase in household welfare for low and middle-income households. However, this is opposite for high-income households that might focus only on some sources, which generate better income for them. It is interesting to explore the diversification effects in high-income households, especially on its dynamics and how it is less diversified, but we leave this for future research. We also added the dummy variables for provinces in the MRD region but found similar results, not reported here, as those in Table 6. Minot et al. (2006) and Le and Le (2020) support our results in the sense that diversities in rural areas can affect income diversification. Note, however, that these two studies investigated the factors affecting income diversification while our study assesses how diversification affects household welfare.

Changing the welfare-dependent variable from the adjusted-inflation total income to the total household consumption expenditure for households in the MRD, we found in Table 7 that the effect of SDI on the welfare is significantly positive in all quantiles for the pooled data and most quantiles for the cross-sectional data before 2010. Though the effect is still positive after 2010 for some quantiles, the negative effects also exist but are not statistically significant. This indicates the

changing trend of income diversification in the region that becomes less diversified. A possible cause might be the structural change from the rapid economic growth in the region. This is an interesting matter that needs further investigation for future research. We also added the provincial dummy variables for the consumption expenditure model in the MRD but found no significant differences and chose not to report the results for conciseness. If we consider income diversification as a resilience-building strategy, our results are consistent with those of Do (2023).

With the SDI effects that differ across quantiles, we investigated further and attempted to find the underlying reasons. We found the majority of income for low-income households comes from the agricultural sector while it is the wage earnings for high-income households. When considering the average number of risks the households faced per year, we found that low-income households often get a higher number of risks than high-income households (Figure 7). There are two points to discuss here. First, the agricultural sector is known for its prone to risks, e.g. from climate and/or seasonal price uncertainties, low-income households need to diversify their sources of income as a risk management strategy. In addition, the only source of farm income may not help them to survive. That is also a reason why they need to have more income sources. Second, with the structural change from rapid economic growth, the agricultural sector has become less important, and many household members earn more income from

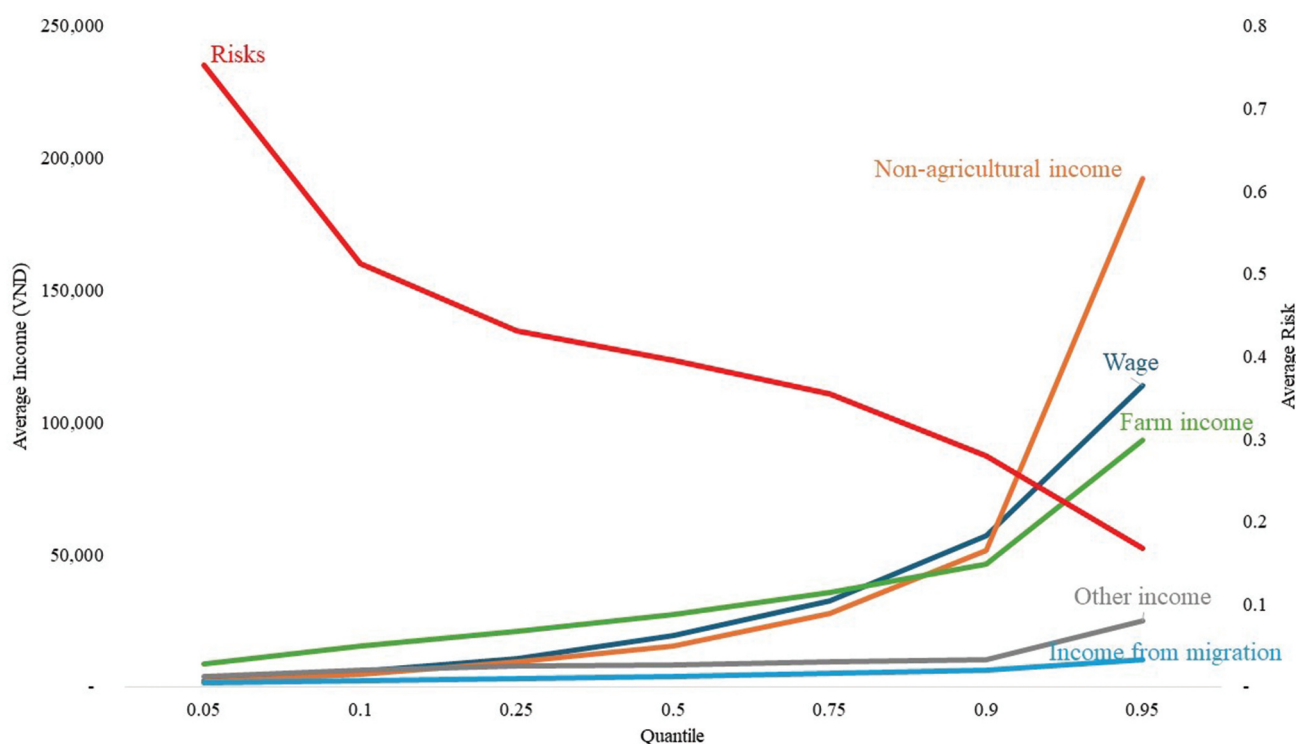


Figure 7. Relationship between average income from each source and average risk by Quantile.

wages, which might be sufficient for them to live without other sources of income. Hence, high-income households may choose not to diversify their income sources. However, these two points need to be investigated further in the future.

In the analysis, we also included other controlled variables such as the education of respondents, number of working members in the household, business owner household, agricultural income, number of working members in the household, total cultivated area, and urban household, and these positively affect the household welfare. In contrast, the number of risks and the poor household have negative effects on household welfare. In addition, we added the regional and provincial dummy variables that show the different effects on household welfare across the regions and provinces. However, due to the spaces, these results are not reported here, but some of them can be found in the supplementary material.

In summary, income diversification was proven to be an important risk management strategy to increase welfare (income or expenditure), especially for low-income Vietnamese households in the agricultural sector. However, the effect of

diversification seems reversed after 2010 but is not more prevalent and significant. While for higher-income households where non-farm income is a major source, diversification may not help them achieve welfare gain. The less diversification generates a concern, especially for those lower-income households, that fewer income sources might make them more vulnerable and limit risk management strategies.

V. Conclusions and recommendations

The agricultural sector has played an important role in Vietnam's economic development. Given the credible threats of climate change to the sector, income diversification would be key for agricultural households to reduce vulnerability and manage the relevant risk. This study assesses the heterogeneous and dynamic effects of income diversification on household welfare across the country. Before 2010, income diversification obviously increases household welfare either in terms of income or consumption expenditure, especially for low-income households. On the other hand, medium-to-high-income households

had the reverse effects on income. This is possibly due to the fact that these households focus only on a few economic activities, which are the main source of their income. After 2010, all households seem to have negative effects from income diversification. In other words, their sources of income become less diversified. This might be caused by the rapid economic growth that transforms the Vietnamese economy from agricultural-based to industrial-based and attracts workers out of the traditional sector. A major concern is the change might generate more vulnerabilities in low-income households.

Based on our findings, we have three recommendations. First, to acknowledge the importance of income diversification, this can be prioritized and made as a policy where appropriate incentives are used to encourage low and middle-income households to diversify their income sources. In the case that diversification cannot be done due to limited resources, e.g. poor irrigation system, relevant agencies need to provide sufficient support and solve all those hurdles. Second, to lessen all possible negative effects, the relevant agencies might promote skill development for low-income households such as providing training courses. Third, better infrastructure, both physical and non-physical such as road improvement and access to the internet and digital technology, can be a key to boosting income diversification.

There are some limitations in our study. One is the missing values of household consumption expenditure in 2010 and we are unsure whether it is caused by data entry errors or other reasons. This prevents us from obtaining the relevant results. The other is data on infrastructure as it can allow to make an in-depth analysis. There are also some issues that need further investigation in the future including less diversification and dynamics in high-income households, and the effect of rapid economic growth on income diversification.

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