Heliyon 9 (2023) e13789

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Does domestic migration adversely affect food security? Evidence from Vietnam

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ARTICLE INFO

Keywords:
Domestic migration
Food security
The difference-in-difference estimation technique with instruments
Vietnam

ABSTRACT

With a population of more than 100 million as of December 2022, food security remains a persistent challenge in Vietnam despite achieving a miracle of economic growth and social transformation in recent decades. Vietnam has also experienced a significant migration from rural areas into urban cities such as Ho Chi Minh City, Binh Duong, Dong Nai and Ba Ria - Vung Tau. The effects of domestic migration on food security have largely been neglected in the existing literature, particularly in Vietnam. This study investigates the impacts of domestic migration on food security using data from the Vietnam Household Living Standard Surveys. Food security is proxied by three dimensions: food expenditure, calorie consumption, and food diversity. The difference-in-difference and instrumental variable estimation techniques are used in this study to address endogeneity and selection bias. The empirical results reveal that domestic migration in Vietnam increases food expenditure and calorie consumption. We also find significant effects of wage, land and family characteristics such as education level and the number of family members on food security when different food groups are considered. Regional income, household headship and the number of children in a family mediate the relationship between domestic migration and food security in Vietnam.

1. Introduction

Migration has long been considered an effective strategy for improving their livelihood. Migration can increase a household's income through remittances, encourage engagement in more productive activities and act as a coping mechanism for economic shocks. Since 1975, the number of individuals living outside their countries of origin has nearly tripled to almost 272 million, approximately 3.5% of the global population. Annual international remittances of more than 680 million dollars overshadow worldwide aid [1]. Remittances are also considered to benefit the poor more than any form of financial assistance because remittances can evade the often-stagnant bureaucracies and be spent instantly by the family in need [2].

Vietnam is no exception. The nation has achieved a miracle of economic growth in the past three decades. Vietnam is a country with a significant rate of domestic migration and urbanization [3]. estimates that Vietnam has 6.4 million migrants aged five and older, accounting for approximately 7.3% of the total population. The Red River Delta and the Southeast areas are the two largest immigration regions in Vietnam. The Southeast area, the country's economic hub with many major industrial zones, continues to be the most attractive destination, with 1.3 million immigrants from other regions of Vietnam. Its migration rate doubled from 10.3‰ in 2005 to 20.4‰ in 2020. This figure means that about 20.4 people from 1000 people from other regions moved to the Southeast area in 2020.

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https://doi.org/10.1016/j.heliyon.2023.e13789
Received 3 March 2022; Received in revised form 2 February 2023; Accepted 9 February 2023
Available online 16 February 2023

The immigration rate is negligible for the Red River Delta, meaning that people from other regions in Vietnam do not migrate to the Red River Delta. Meanwhile, concerning emigration, people leave their area of origin to move to other regions to live and work. The Mekong River Delta, Central Highlands, and Northcentral & Southcentral coast have experienced high emigration rates of 11.8, 7.9, and 7.2‰. With the rise of migration, the improvement of qualifications for labour is also noted. The technical and professional capabilities of migrants have constantly improved over a decade and even outweighed those of non-migrants. However, new social issues can also arise from increased migration, such as those regarding food security. Thus, the impacts of migration on socio-economic development are potentially emerging problems for Vietnam in the near future.

With significant migration across provinces in Vietnam, food security has become a key concern for the governments. Vietnam has generally been considered an agriculture-based economy. Agriculture affirms its pivotal role in the economy of Vietnam in all circumstances. In the context that several economic sectors were disrupted and suffered heavy damage, such as the current pandemic, agricultural production is maintained to ensure social security and national food security and contribute to export growth. Such importance of agriculture is illustrated in Fig. 1. The gross domestic product (GDP) in 2021 increased by 2.58% over the previous year. The agriculture, forestry and fishery rose by 2.9%, contributing 13.97% to the growth rate of total value added to the entire Vietnamese economy.

More specifically, in 2021, the land area for rice growing for the entire year will decrease by 38.3 thousand hectares compared to 2020. Reduced land area for rice growing is associated with the change in the production structure and land use purpose. The production of livestock products increases to meet consumption needs. The size of newly concentrated planted forests in Vietnam increased by 2.8% compared to the 2020 level. Captured fishery output increased by 0.9% over the previous year. Such achievements in agriculture, forestry and fishery have significantly contributed to economic growth and development in Vietnam. The agriculture sector has played an essential role in ensuring people's income and social security and contributing to implementing the national strategy concerning hunger eradication and poverty reduction in Vietnam [4].

While it is generally agreed that migration brings many benefits to human development and poverty reduction, its effect on the food security status of the households left behind remains in contention. On the one hand, migration can improve food expenditure through remittances, and migrants can also bring nutrition knowledge. However, on the other hand, the loss of labour can cause a reduction in productivity, disruption in family life, poor diets and increased psychological problems [5,6].

Previous empirical analyses have investigated the effects of migration on food security ([7] for countries in Sub-Saharan Africa [8], for Africa [9], for Ghana). Findings from these studies are mixed. Results from selected studies indicate that migration positively affects households' food consumption because of direct income effects. For instance Ref. [7], examine the growth effects of remittances and the governance quality on food and nutrition security in Sub-Saharan African countries. The authors conclude that the interaction of remittances and governance quality, proxied by a composite index, positively and significantly affects the average value of food production. Other studies fail to provide empirical evidence supporting the impact of migration on food security. For example [8], explore this critical linkage in African countries. Their findings confirm the negative effect of migration on food security [9]. examine the between migration and food security in Ghana. Their results indicate that migration in Ghana does not affect the total food expenditures per capita and provides a minimal effect on food expenditure patterns. For Vietnam, various scholars have also investigated the impact of economic–social issues on food security. For example [10], examine the link between Vietnam's income shock and food insecurity prediction. Another study on Vietnam's food security has also been conducted by Ref. [11]. However, their analysis focuses on the link between the informal employment penalty and food security in Vietnam.

As discussed in the following section, our literature review indicates that many studies have investigated the effects of various social and economic aspects on food security. However, the impact of domestic migration on food security has largely been ignored in the existing literature, particularly in Vietnam. This study examines the effects of domestic migration on food security using data from the Vietnam Household Living Standard Survey (VHLSS) for the 2016–2018 period. Vietnam presents a suitable setting for analyzing the linkage between domestic migration and households' food security for two key reasons. *First*, the decades of the fast-growing

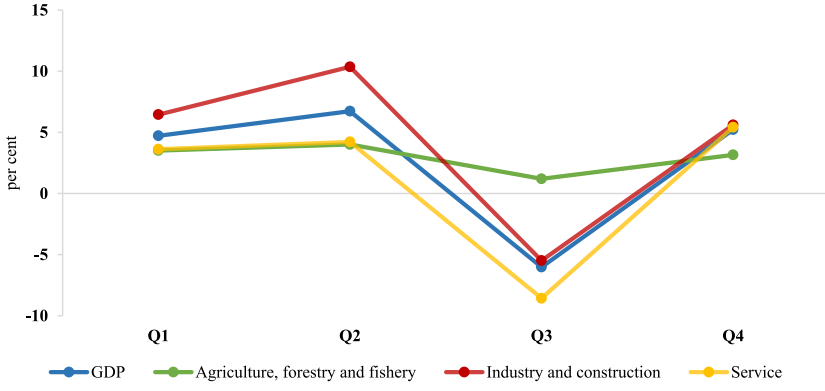

Fig. 1. GDP growth rate in the quarters of 2021 in Vietnam (%)
Source: General Statistics Office.

Vietnamese economy have widened the disparity in economic growth and development and social transformation between different regions in the country. This disparity pushes domestic migration to increase over time. In 2014, there were almost 7 million migrants in Vietnam, a 50% increase from 1999, with the rural-to-urban migration flow accounting for most of them [12].

From 2005 to 2020, the immigration rate in Vietnam doubled. If ten people out of 1000 local population migrated to the country's other regions in 2005, this figure doubled to more than 20 people in 2020. *Second*, despite making great strides in economic and social development in the last few decades, nutrition remains a persistent challenge in Vietnam. In 2019, there were 1.4 million food-insecure households in the country. The undernourishment rate among children of, 38.6%, while significantly improved, remains considerably higher than the threshold set by the World Trade Organization (WTO). The issue appears substantially more severe in rural areas, with over 20% of high schoolers suffering from malnutrition compared to 3% in urban areas [13].

This study contributes to the existing literature in two main dimensions. *First*, we apply the difference-in-difference with the instrumental variable (DID-IV) technique, which has yet to be used in migration and food security studies. Endogeneity is one of the prominent issues in such studies because domestic migration and food security can be affected by the same unobserved factors. Previous studies have used many estimation techniques to address this problem, such as propensity score matching, the fixed-effects model and instrumental variables. However, these methods have flaws, and none has gained universal concession. The DID-IV has combined the advantages of incorporating changes due to different factors from the treatment and accounting for both observed and unobserved compounding effects [14]. *Second*, this study examines the effects of domestic migration on food security using the DID-IV estimation technique. We note a study from Ref. [15]. However, the dataset used in their paper is from 2006, which may not be able to reflect Vietnam's economic milestones in the following years, such as the WTO accession or the 2008/2009 global financial crisis. This study uses the more updated VHLSS surveys in 2016 and 2018. Our results using a more updated dataset are expected to provide policymakers in Vietnam with a more current and comprehensive understanding of the effects of domestic migration on the food security of Vietnamese households in the country.

Following this introduction, the remainder of the paper is structured as follows. Section 2 reviews theoretical contentions and related empirical studies. Research methodology and data are then discussed in section 3. Finally, empirical results are presented in section 4, followed by the conclusion and policy implications in section 5 of the paper.

2. Literature review

Theories about the relationship between migration and food security can be traced back to the new economics of labour migration, which states that remittances are crucial for household welfare in overcoming liquidity constraints and unbinding insurance [16]. Specifically, migration can positively impact consumption expenditure through spending remittances on basic needs products like food. Migration might also expose migrants to new-found knowledge about nutrition and dietary diversity [17]. The loss of a family member to migration can improve the food security conditions of other members by reducing the demand for precautionary savings and lessening the mouths to feed. On the flip side, however, migration may endanger a household's food security status if the family's loss of labour is inadequately replaced by remittances [18]. In such cases, the net impact of migration includes loss of employment, reduced income, and decreased spending on food and nutrition products.

Empirical studies about domestic migration have only emerged recently and scantly, especially with food security. Few studies use cross-sectional data to examine this linkage [19]. studied the relationship between residential remittances and food security in Ghana. Using multivariate ordered logistic regression on survey data from 1438 households, the authors failed to discover positive impacts from migration and remittances on food security [20]. examined the role of internal migration in influencing food security among rural households in India, focusing specifically on the access dimension. Using a case study approach to survey data from 392 households, the authors claimed that remittances contributed positively to household food security through improved purchasing power and enabling investments in land and agriculture.

Other studies have addressed the relationship between issues other than migration and agriculture or food security. For example [21], examines the impacts of global agriculture commodity price volatility and food price volatility on economic integration from 1970 to 2012. For 133 countries, increased volatility of agricultural commodity prices and food prices is found to reduce economic integration in which middle- and high-income countries experience the most significant impact.

Some studies have attempted to use the propensity score matching (PSM) method to address this problem. In Eastern Indonesia [22], examined the relationship between migration and food expenditure. The study exploited the availability of the recent Indonesia Family Life Survey East dataset. Using PSM to address the non-random selection of migration, the findings revealed that having a migrant member improved the composite index of food consumption score and the family's food security [23]. used PSM to examine the impact of remittances on expenditure patterns in Tajikistan. The author found no evidence of internal or external remittances positively impacting household expenditures.

[8] turned to the fixed-effects model and investigated the linkage between food security and international remittances using panel data from 1990 to 2013 in African countries. The results showed positive links for access, stability and utilization dimensions but negative ones for availability dimensions. However, the method is only helpful if the omitted variable is considered constant at the family or individual level. For example, a positive economic shock might help migrant-sending households finance migration and increase expenditure on food. In such cases, the improvement in household income might not be observable, and the researcher could falsely claim that migration improves the food consumption status of the family.

Separately [16], investigated the effect of rural outmigration on household food security using two-round panel data from 573 households in Ethiopia. Difference-in-difference model and inverse-probability of the treatment weighting approach were utilized to address selection bias and endogeneity. The authors focused on food security's stability and access components, measured by hunger

incidence and the absolute amount of food consumed over seven days. The study found that rural outmigration improved adult calorie consumption by 22% while reducing calorie deprivation and the food poverty gap.

[24] assess the effects of economic globalization indicators (exchange rates, FDI inflows, total agricultural exports, agricultural import duties, and fertilizer imports) on agricultural value added in developing countries. Using the conventional panel data models (OLS, fixed effects, random effects), FDI inflows and agriculture export values improve the agricultural value-added [25]. [26] review relevant literature to address the four myths regarding the feminization of agriculture. More and more women become involved in an activity with traditionally more men. These myths include (i) whether feminization of agriculture is predominant on the current global scale; (ii) whether women who are left behind are passive victims and not farmers; (iii) whether feminization reduces productivity in the agriculture sector, and (iv) whether all women experience identical challenges as men do in agriculture. The study presents the complexities of gendered power relations in feminization trends and explores the ramifications for global food security.

Other studies have chosen an instrumental variable approach to estimate the relationship between migration and food security [27]. examined the impact of international migration and remittances on poverty in developing countries. Using a new dataset from 71 low-income and middle-income countries, they found that a 10% increase in remittances would lead to a 3.5% decline in the share of people living in poverty [15]. explored the relationship between internal migration and food consumption patterns in Vietnam between 2004 and 2006. Using an instrumental variable approach to control endogeneity, the authors discovered that short-term migration positively affected per capita food expenditures, calorie consumption and food diversity. Meanwhile, long-term migration was found to be an insignificant determinant. Finally [9], investigated the link between migration and food consumption using the 2005–2006 Ghana Living Standards Survey. The results indicated that migration did not substantially affect total food expenditures per capita and had a minimal noticeable effect on food expenditure patterns.

For Vietnam [10], use a two-step approach to predict the changes in insecurity risk due to income shocks at a regional level in Vietnam. The study first indicates that a 10% decrease in income is associated with a 3.5% increase in food insecurity. Second, results from their analysis imply that the income shock during the pandemic in Vietnam may have an average minor effect on food insecurity. However, some areas of Vietnam appear to be affected more significantly than others. In a recent study [11], examine the effects of formal and informal non-farm wage employment on food security for rural areas in Vietnam. Their empirical results indicate that informal employment reduces the consumption of vegetables and fruits under both the expenditure- and calorie-based categories. Informal employment also mitigates households' consumption of nutritious food, while no evidence supports this reduction in formal employment. While an increase in formal and informal non-farm wage employment reduces the consumption of cereals and starches, consuming food away from home is more significant for formal employment. In addition, formal work increases food expenditures and also improves sanitation and hygiene among households.

Our literature review indicates that the effects of domestic migration on food security have largely been ignored in the existing literature, particularly in emerging countries such as Vietnam. Vietnam is an interesting case study for investigating this relationship because the country has experienced tremendous pressure from migration and urbanization, which is associated with the fundamental issue of food security. This lack of empirical evidence on the important link between domestic migration and food security warrants this study to be conducted.

3. Research methodology

3.1. Measuring food security

Food security is when people have "physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" [28]. Food security is commonly associated with availability, access, utilization, and stability. Past studies about food security at the household level have used many different proxy measures to encompass the determinants of each dimension. Some widely used measures include food costs and nutrient requirement, food and energy consumption, nutrient poverty, and dietary diversity. However, as [29] noted, there needs to be more consistency in how measures have been studied, and no single measure can incorporate all dimensions of food security. Therefore, the choice of food security measures largely depends upon the available data from each country's household expenditure survey and the objectives of the studies.

Our study follows [15,30] in measuring food security through nutrition and food consumption. Food security is measured in three dimensions: food expenditure, calorie consumption, and dietary diversity. First, food expenditure is calculated as total household expenditures on food items in the past 30 days divided by the number of household members. Next, the values are collected for 43 food items, divided into seven groups: (i) Starch, (ii) Protein, (iii) Fat, (iv) Vegetables, (v) Fruits, (vi) Milk, and (vii) Sugar. Per capita, total food expenditures and per capita expenditures across seven food groups are then calculated by dividing expenditures by the number of household members.

Calorie consumption is computed as the total calorie consumed in a household in the past 30 days divided by the number of household members. Total calorie consumption is the sum of a calorie of all food items consumed by the household during the period. The quantity of food items consumed is converted into calories using the calorie conversion table from the Vietnam National Institute of Nutrition. The use of the national conversion table from Vietnam differs from other food security studies, which adopt the calorie conversion table from the Food and Agriculture Organization. However, Vietnam's conversion table appears to be more reflective of the food condition in Vietnam [15].

The Simpson and Shannon indices are used as proxies for dietary diversity. Traditionally, past studies often use the number of food groups or food items consumed in the household to proxy dietary diversity. However, this method needs to consider the weights of food groups, which can produce incorrect measures since the nutrient level varies among different food groups. Both indexes can deal with

this problem by accounting for nutrient weighting using monetary or calorie shares of food groups. Simpson index and Shannon index are calculated as follows:

$$\text{Simpson index} = 1 - \sum_i w_i^2$$

$$\text{Shannon index} = -\sum_i w_i \log(w_i)$$

where w_i is the expenditure share of food group i. The Simpson index ranges from 0 to 1, while the Shannon index ranges from 0 to the logarithm of the highest number of food groups. It is noted that the higher the index, the more diversified the diet is.

3.2. Estimation technique

Two main challenges are associated with estimating the impact of domestic migration on the food security of migrant-sending households. The first challenge is the self-selection of migrant families. If households are self-selected, they might be systematically different from non-migrant families. Therefore, estimations in such cases will be biased if the incentives for migration are not considered.

We apply the difference-in-difference (DID) estimation technique to address this challenge. The DID model estimates the effects of migration on households by comparing the average change in food security dimensions among migrant-sending households and non-migrant households. The approach assumes that both groups of Vietnamese households have parallel trends in the outcome, and the composition is stable for repeated cross-sectional design. Thus, the DID model can help control time-invariant changes in factors other than migration.

The regression model is as follows:

$$Y_i = \alpha_0 + \alpha_1 \text{Mig}_i + \alpha_2 \text{Year}_i + \alpha_3 \text{Inter}_i + \alpha X_i + \varepsilon_i \quad (1)$$

where.

- i denotes the households.
- Y_i represents food security.
- Mig_i is a binary variable coded as one if the household has a migrant member and zero otherwise.
- Year_i is a time dummy variable. Inter_i is the interaction term between Mig_i and Year_i.
- X_i is the vector of household characteristics to control for the effects of internal migration on a household's food security status, and
- ε_i is the error term.

The second challenge is endogeneity. Endogeneity stems from unobservable characteristics, which affect migrating decisions and food consumption patterns. For instance, parents with a high degree of education are more likely to migrate to seek better job opportunities while devoting more time and income to dietary nutrition for their children. Another possible cause of endogeneity is reverse causation, where malnutrition induces migration. In such cases, the single use of DID may not be optimal because the DID estimation technique tends to underestimate the impact of the treatment because of crossover or selection bias [14].

As a result, we use the instrumental variable (IV) estimation technique and the DID estimations to address this problem. This estimation strategy has been employed by Ref. [14] to investigate the impact of the Nepal Poverty Alleviation Fund program. This World Bank initiative covers 400 most impoverished districts in Nepal on rural household welfare. The DID-IV strategy effectively overcomes poor compliance between the actual intervention and randomized assignment. Undoubtedly, one major obstacle is identifying the appropriate IV, which only affects migrating decisions, not food consumption patterns. This task is challenging. Therefore, it is no surprise that most studies have focused on a small number of instruments, such as the historical migration rates [9,23] and the economic conditions of the destinations [31].

This study uses the migration network and the interaction between household size and networks as instrumental variables. The network is calculated as the percentage of adult labourers over migrants at the district levels. This variable has been established as a good IV in numerous studies about migration [9,32]. Having migration networks can raise the possibility that one migrates since it lowers the cost of migration and increases the prospect of finding a job. However, the migration networks are unlikely to impact a household's food consumption directly. The interaction between networks and household size is included in our analysis to increase the variability of the instruments and strengthen the approach.

Using this estimation strategy, the relationship between domestic migration and food security can be estimated with a two-stage least square. In the first stage, the link between domestic migration and the instrument variables is examined to separate the trouble-free element of the domestic migration variable. Because the interaction between an endogenous variable and an exogenous variable is considered endogenous, this interaction variable is also instrumented. The first-stage regressions are presented as follows:

$$\text{Mig}_i = \beta_0 + \beta_1 \text{Net}_i + \beta_2 (\text{Net}_i * \text{Size}_i) + \beta X_i + \nu_i \quad (2)$$

$$\text{Inter}_i = \delta_0 + \delta_1 \text{Net}_i * \text{Year}_i + \delta_2 (\text{Net}_i * \text{Size}_i * \text{Year}_i) + \delta X_i + \zeta_i \quad (3)$$

where.

- Net_i represents the migration networks.

- Net_i*$Size_i$ denotes the interaction between migration networks and household size.

In the second stage, the predicted values of domestic migration and the interaction variables from equations (2) and (3) are then used in equation (1). The new DID model is as follows:

$$Y_i = \lambda_0 + \lambda_1 \widehat{Mig} + \lambda_2 Year_i + \lambda_3 \widehat{Inter} + \lambda X_i + \pi i \quad (4)$$

where.

- Y_i represents the different dimensions of food security.
- $\widehat{Mig}_i$ is the predicted value of Mig_i
- $\widehat{Inter}_i$ is the predicted value of $Inter_i$, and
- X_i is the vector of control variables.

λ_3 is our estimated coefficient of interest. When λ_3 is positive, implying that migration through remittances contributes to improved food consumption. When λ_3 is negative, the loss of labour outweighs remittances received, reducing a household's income and ability to spend on food.

The control variables include demographic variables that may impact the household's food consumption pattern. They possess characteristics of the household heads, such as gender and age, because the household head is usually the person in charge of household expenditure. The number of members and adults in the household can affect food consumption because food is shared among family members and adults consume more food than children. Third, higher education can lead to more awareness of a healthy diet. As such, the education level of the member is included in our analysis. Finally, income and assets of the household, proxied by total wage and land owned, are essential factors because they determine whether households might or might not have to rely on remittances for essential expenditures like food.

4. Data

The study uses the 2016 and 2018 Vietnam Household Living Standard Surveys (VHLSS) surveys. The VHLSS has been administered biennially since 2002 by the General Statistics Office of Vietnam in collaboration with the World Bank. The VHLSS systematically monitors the living standards of the Vietnamese population and evaluates Vietnam's socio-economic development goals. The surveys are carried out in all 63 provinces in Vietnam, focusing on households and communes. Sample selection is randomly chosen from the enumeration process of the Census. The surveys are designed to ensure that 50% of the sample in the previous VHLSS survey is included in the following survey. The surveys cover migration, education, healthcare, employment, expenditure, durables, housing, aid and land.

Descriptive statistics of domestic migration are presented in Table 1. Compared to the 2004–2006 period, the domestic migration rate declined. Individual migrants accounted for 3.2–3.3% of the sample in 2016 and 2018, a sizable drop from the previous 2004–2006 period. Meanwhile, in 2016, about 10% of the surveyed households had migrant members. The figure climbed to 11% in 2018, but still significantly lower than the 17.2% rate in the 2004–2006 period. Table 2 also presents the descriptive statistics for variables used in our analysis.

5. Empirical results

5.1. The first-stage analysis of the effects of domestic migration on food security

As previously discussed, two distinct stages of our empirical analyses are considered. Table 3 reports the empirical findings of our analysis of the relationship between domestic migration and food security for the first stage.

The under-identification test using Kleibergen-Paap LM statistics strongly rejects the null hypothesis at a 1% level, indicating that the model is appropriately identified. For the weak identification test, both Cragg-Donald Wald F-statistic and Kleibergen-Paap Wald F-statistic tests are reported. Because the independent and identically distributed random variables assumptions are dropped, and robust standard errors are used, the Kleibergen-Paap-based test is more appropriate. Results from this test reject the null hypothesis at a 5%

Table 1
Domestic migration statistics in Vietnam.

	2004–2006	2016	2018
Individual			
Migrant	4.7	3.2	3.3
Non-migrant	95.3	96.8	96.7
Household			
Migrant	17.2	10.0	11.0
Non-migrant	82.8	90.0	89.0

Table 2
Descriptive statistics of variables used in our analysis.

	N	Min	Max	Mean	Std. Dev.
Food expenditure	8355	0	5521	838	427
Calorie consumption	8355	0	9723	703	336
Diet diversity	8346	0	0.83	0.64	0.07
Migration	8356	0	1	0.10	0.30
Gender	8356	0	1	0.75	0.43
Age	8356	14	105	52	13.97
Age_square	8356	196	11,025	2853	1555
Adult	8356	0	8	2.46	1.30
Member	8356	1	13	3.81	1.57
Wage	8356	0	900,000	41,665	62,567
Land	6925	10	606,134	7727	17,334

Table 3
Empirical results from the first-stage regression of the analysis on the effects of domestic migration on food security.

	(1)	(2)
	Migration	Interaction
Network	0.573**	−0.0317
	(0.253)	(0.0230)
Network*Member	0.199**	0.00772
	(0.0841)	(0.00752)
Network*Year	0.104	0.755***
	(0.278)	(0.133)
Network*Member*Year	−0.0998	0.0793*
	(0.0924)	(0.0415)
Year	0.0112	0.0421***
	(0.00739)	(0.00516)
Gender	−0.00840	−0.00799
	(0.0107)	(0.00876)
Age	0.0136***	0.00890***
	(0.00201)	(0.00158)
Age_square	−0.000124***	−8.10e-05***
	(1.86e-05)	(1.48e-05)
Adult	0.0116**	0.0108**
	(0.00514)	(0.00433)
Wage	−1.67e-07**	−1.61e-07**
	(7.53e-08)	(6.43e-08)
Land	1.08e-08	−1.03e-07
	(1.47e-07)	(1.28e-07)
Member	−0.0217***	−0.0143***
	(0.00374)	(0.00326)
Education	0.00109*	0.000986*
	(0.000649)	(0.000532)
Constant	−0.266***	−0.203***
	(0.0496)	(0.0398)
F-test	97.36***	63.39***
Sanderson-Windmeijer Chi-sq	196.94***	401.64***
Sanderson-Windmeijer F-test	65.43***	133.43***
Kleibergen-Paap rk LM	226.16***	
Cragg_Donald Wald test	443.40**	
Anderson-Rubin Wald test	2.20*	
Stock-Wright LM S	66.47***	
Observations	4150	4150
R-squared	0.330	0.345

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

level, indicating that the excluded instruments are not correlated with the endogenous regressors. In addition, results from the Sargan-Hansen test of overidentifying restrictions fail to reject the null hypothesis at the conventional significance levels. Therefore, the instruments are uncorrelated with the error terms, and the instruments are correctly excluded from the empirical analysis.

5.2. The second-stage empirical results on the effects of domestic migration on food security in Vietnam

Table 4 presents empirical findings concerning the effects of domestic migration on food security in Vietnam using the DID-IV models for each food security dimension. The interaction between migration and the time dummy variable for food expenditure is positive and statistically significant. This finding suggests that migration induces increased spending on food for migrant-sending households. This finding is consistent with the results from previous studies for other countries. For example [33], conclude that households with remittances in Indonesia spent 8.5% more on food than those without remittances. Similarly [34], found that monthly food expenditure per capita is doubled for families receiving remittances in Moldova.

Our analysis is then extended to examine the effects of domestic migration on the expenditure for individual food groups. Our study covers seven food groups: starch, protein, fat, vegetables, fruits, milk and sugar. Table 5 reports empirical results on the effects of domestic migration on food expenditures, an important proxy for food security, across seven food groups in Vietnam. In addition, the effects of domestic migration on calorie consumption, another proxy for food security, are presented in Table 5.

As presented in Table 5, our results indicate that migration is only found to increase expenditure on protein and fruits – two of seven food groups examined in this analysis. This analysis cannot confirm the effects of migration on food expenditure for the other food groups. This finding is consistent with results from Ref. [15] study, which confirms the positive impacts of the short-term migration to food expenditure on cereals and other starches, fats and oils, and sugar and beverages. We note that [15]'s study uses a very early VHLSS survey, and back in 2011, the Vietnamese economy was still considered heavily agriculture-based economy. Migration is generally considered for survival when provinces with many large-scale industrial zones, such as Binh Duong, Dong Nai and Ba Ria – Vung Tau from the Southern region of Vietnam, attract millions of migrants from other regions of the country.

In addition, we also find significant effects of wage, land and family characteristics such as education level and the number of family members on food expenditure. Our results indicate that increased wage is associated with increased food expenditure. Owning assets such as land also contributes to an increase in food expenditure. Interestingly, our empirical evidence confirms that improved education level positively affects food expenditure across five food groups, whereas it will reduce food expenditure on starch and sugar. In our analysis, many family members are associated with food expenditure across various food groups, except for milk only.

The effects of domestic migration and other variables such as wage, land and family characteristics on calorie consumption are presented in Table 6. The findings concerning the effects of calorie consumption are consistent with those on food expenditure. Domestic migration positively affects Vietnam's overall per capita calorie consumption levels (as presented in Table 4). When various food groups are considered, the effects on calorie consumption (as presented in Table 6) are very similar to those on food expenditure (Table 5). The significant level is, however, considerably lower than food expenditure. This result concerning calorie consumption is similar to findings from other studies, including [19,20]. Moreover, migration is linked to increased vegetable and fruit calorie intake.

Table 4
The effects of domestic migration on food expenditure, calorie consumption, and dietary diversity.

	Food Expenditure (1)	Calorie Consumption (2)	Simpson (3)	Shannon (4)
Migration	−77.22	80.14*	0.00200	−0.0204
	(50.59)	(47.58)	(0.0120)	(0.0395)
Interaction	194.2***	208.0*	0.00283	0.0119
	(73.26)	(112.0)	(0.0139)	(0.0451)
Year	−44.73***	−23.35	−0.00518*	−0.0213**
	(16.89)	(18.69)	(0.00298)	(0.00865)
Gender	−31.69*	2.516	0.00377	0.00274
	(16.65)	(17.85)	(0.00273)	(0.00790)
Age	23.63***	10.83***	0.000442	0.000978
	(2.839)	(2.293)	(0.000568)	(0.00160)
Age_square	−0.197***	−0.0937***	−2.86e-06	−5.99e-06
	(0.0264)	(0.0205)	(5.11e-06)	(1.45e-05)
Adult	−17.70**	17.82**	−0.00728***	−0.0123***
	(7.251)	(7.318)	(0.00147)	(0.00411)
Wage	0.00123***	−0.000203	2.27e-07***	2.00e-07***
	(0.000150)	(0.000155)	(2.64e-08)	(6.11e-08)
Land	0.00120***	0.00102***	−9.15e-08*	4.83e-08
	(0.000467)	(0.000339)	(5.26e-08)	(2.67e-07)
Member	−70.49***	−43.60***	0.00554***	0.00619*
	(6.858)	(12.89)	(0.00121)	(0.00321)
Education	2.562**	−2.449	0.000869***	0.000241
	(1.077)	(1.518)	(0.000220)	(0.000685)
Constant	425.1***	574.7***	0.606***	1.380***
	(72.60)	(57.65)	(0.0159)	(0.0434)
Kleibergen-Paap rk LM	226.157***	226.157***	226.173***	102.472***
Kleibergen-Paap rk Wald	63.363**	63.363**	63.363**	25.773**
Hansen J	3.275	3.157	6.584**	6.197**
Observations	4150	4150	4146	1842
R-squared	0.122	0.037	0.036	0.016

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

Table 5
The effects of domestic migration and other indicators on food expenditures across seven food groups in Vietnam.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Starch	Protein	Fat	Vegetables	Fruits	Milk	Sugar
Migration	1.325	−30.43	−1.811	−9.331	−22.39***	−9.797	−4.784
	(15.89)	(30.37)	(3.099)	(7.363)	(4.333)	(15.92)	(6.466)
Interaction	51.59	81.93**	1.593	11.78	20.00***	15.44	11.91
	(32.59)	(38.11)	(4.045)	(8.617)	(5.289)	(19.89)	(8.159)
Year	−11.63**	−4.217	−0.0867	−1.813	−8.906***	−16.00***	−2.072
	(5.515)	(9.379)	(1.076)	(1.530)	(1.718)	(5.610)	(2.138)
Gender	−8.430*	−31.30***	1.524	−0.138	2.815*	19.00***	−15.16***
	(5.045)	(9.279)	(1.077)	(1.419)	(1.673)	(5.766)	(1.881)
Age	4.161***	15.18***	0.367*	1.666***	1.303***	−0.891	1.848***
	(0.737)	(1.555)	(0.187)	(0.263)	(0.317)	(1.251)	(0.315)
Age_square	−0.0354***	−0.130***	−0.00302*	−0.0147***	−0.0109***	0.0125	−0.0163***
	(0.00662)	(0.0143)	(0.00167)	(0.00242)	(0.00303)	(0.0121)	(0.00284)
Adult	11.80***	−4.609	0.376	−0.504	−1.578**	−23.93***	0.748
	(2.268)	(3.995)	(0.391)	(0.622)	(0.705)	(2.548)	(0.924)
Wage	−0.000186***	0.000688***	−1.64e-07	4.85e-05***	0.000107***	0.000464***	0.000109***
	(4.72e-05)	(7.31e-05)	(7.84e-06)	(1.30e-05)	(1.41e-05)	(5.44e-05)	(2.04e-05)
Land	0.000376***	0.000544**	9.55e-05***	6.23e-05*	−8.77e-06	1.48e-05	0.000118**
	(9.43e-05)	(0.000277)	(2.57e-05)	(3.46e-05)	(2.06e-05)	(7.93e-05)	(5.25e-05)
Member	−14.48***	−49.41***	−4.831***	−6.695***	−4.176***	15.15***	−6.047***
	(3.664)	(3.008)	(0.406)	(0.536)	(0.509)	(1.725)	(0.662)
Education	−0.649	1.881***	0.199***	0.238***	0.278***	0.623**	−0.00618
	(0.440)	(0.585)	(0.0680)	(0.0901)	(0.0846)	(0.299)	(0.106)
Constant	183.8***	118.6***	33.30***	24.10***	7.548	28.02	29.74***
	(19.27)	(39.44)	(5.045)	(6.675)	(7.635)	(32.06)	(8.041)
Observations	4150	4150	4150	4150	4150	4150	4150
R-squared	0.050	0.135	0.083	0.105	0.063	0.064	0.049

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

Table 6
The effects of domestic migration and other indicators on calorie consumption across seven food groups in Vietnam.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Starch	Protein	Fat	Vegetables	Fruits	Milk	Sugar
Migration	53.26*	15.41	3.099	−1.607	−1.458*	9.224	2.206
	(27.88)	(12.76)	(5.716)	(1.180)	(0.759)	(5.750)	(29.37)
Interaction	154.9	23.69	1.877	2.687*	1.924*	1.185	21.72
	(98.02)	(15.84)	(7.318)	(1.372)	(1.053)	(7.536)	(34.00)
Year	−4.667	3.765	−0.827	−0.867***	−0.501*	−1.650	−18.61**
	(15.27)	(3.061)	(1.703)	(0.282)	(0.257)	(1.174)	(7.702)
Gender	1.662	−3.307	3.406**	0.106	0.0969	3.043***	−2.490
	(13.85)	(3.147)	(1.733)	(0.286)	(0.282)	(1.052)	(7.603)
Age	4.184***	3.794***	0.977***	0.338***	0.110**	−0.271	1.694
	(1.499)	(0.582)	(0.296)	(0.0544)	(0.0439)	(0.228)	(1.275)
Age_square	−0.0344**	−0.0308***	−0.00782***	−0.00284***	−0.000756*	0.00174	−0.0188*
	(0.0134)	(0.00542)	(0.00271)	(0.000505)	(0.000409)	(0.00203)	(0.0114)
Adult	23.28***	−2.252*	0.730	−0.0407	−0.195*	−6.119***	2.415
	(5.791)	(1.324)	(0.679)	(0.121)	(0.108)	(0.506)	(3.038)
Wage	−0.000642***	0.000122***	−1.12e-05	6.62e-06***	5.33e-06***	9.22e-05***	0.000224***
	(0.000128)	(2.36e-05)	(1.22e-05)	(1.99e-06)	(1.73e-06)	(1.04e-05)	(6.22e-05)
Land	0.000603***	7.28e-05	0.000115***	−6.06e-06	6.77e-06	−1.18e-05	0.000242*
	(0.000187)	(6.70e-05)	(3.66e-05)	(4.96e-06)	(4.49e-06)	(1.74e-05)	(0.000124)
Member	−7.848	−18.65***	−9.306***	−1.298***	−0.485***	4.725***	−10.74***
	(11.89)	(1.031)	(0.620)	(0.0986)	(0.0787)	(0.417)	(2.785)
Education	−2.478*	0.805***	0.107	0.106***	0.0305**	0.224***	−1.243***
	(1.306)	(0.201)	(0.109)	(0.0177)	(0.0152)	(0.0635)	(0.461)
Constant	295.0***	84.38***	64.30***	2.019	2.232**	10.74*	116.1***
	(33.87)	(15.49)	(8.043)	(1.391)	(1.080)	(6.254)	(35.50)
Observations	4150	4150	4150	4150	4150	4150	4150
R-squared	0.023	0.170	0.127	0.113	0.031	0.064	0.013

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

This finding is consistent with increased expenditures in individual food groups (see Table 6).

For dietary diversity, the impact of domestic migration is examined using the Simpson and Shannon indices as the proxies. We note that the effects of domestic migration on dietary diversity are positive but statistically insignificant (see Table 4). This finding is consistent with [22] analysis. Domestic migration does not affect food diversity significantly.

5.3. The impacts of regional income, household headship and children on food security

Previous studies have shown that the impacts of domestic migration on migrant-sending households can be heterogeneous, and the effects are contingent on the characteristics of the family [17,20,21,33]. This section extends our analysis by examining the effects of regional income, household headship, and the number of children on food security. Empirical results are presented in Table 7 below.

Households are divided into six regional subgroups, representing six socio-economic regions in Vietnam. There are significant differences in economic growth between regions in Vietnam. For example, per capita income in the most developed region (the Southeast region) is more than 2.5 times higher than the least developed one (the Northwest region) [4]. Examining how income across regions meditates the effects of domestic migration on the households' food security is important and exciting. Sub-sample analyses demonstrate that domestic migration has a more significant impact on food security in low-income regions than high-income regions. In particular, for the two poorest regions in Vietnam, the Northwest and Central regions, domestic migration increases household food expenditure significantly. Estimated coefficients for per capita calorie consumption and food diversity are also statistically significant in the Northwest region. These findings suggest that domestic migration positively affects food security (including food expenditure, calorie consumption and dietary diversity) for households in this low-income region.

Household headship has important implications for household food security because, in many countries, female-headed households (FHHs) are restricted by gender norms that hinder their capacities to partake in economic activities and access economic assets [35]. This issue is especially more pressing in Vietnam because the land distribution procedures under "Doi Moi" (the 1986 Economic Reform in Vietnam) tend to favour male-headed households (MHHs), which motivates men to be the household heads. Our empirical results show that domestic migration benefits FHH more than MHH regarding food security. The magnitude of the estimated coefficients from all proxies of food security for FHHs is more than three times higher than those for the MHHs. In addition, estimated coefficients for per capita food expenditure and food diversity (Simpson index) are statistically significant.

Nutrition is essential for children [17]. As such, we examine the difference in the effects of migration on Vietnamese households with and without children. Our results confirm that domestic migration positively and significantly affects per capita food expenditure

Table 7
The impacts of regional income, household headship and children on food security (including food expenditure, calorie consumption and dietary diversity).

	(1)	(2)	(3)	(4)
	Food Expenditure	Calorie Consumption	Simpson	Shannon
Region (low → high income)				
North West	582.8**	1130**	0.0301	0.162*
	(255.7)	(551.4)	(0.0255)	(0.0917)
Central	164.9*	93.18	0.00941	0.0629
	(99.00)	(86.76)	(0.0277)	(0.0827)
Central Highlands	110.1	176.3	0.00182	0.0565
	(240.0)	(192.7)	(0.0622)	(0.0904)
Mekong River Delta	2.065	−141.8	−0.0359	−0.0798
	(136.0)	(125.2)	(0.0263)	(0.0834)
Red River Delta	76.26	−37.00	−0.00158	−0.0702
	(136.7)	(92.79)	(0.0204)	(0.0564)
South East	−705.9	−406.7	−0.522	0.587
	(1396)	(1156)	(0.725)	(0.484)
Headship				
Male	133.9*	115.8	−0.0113	−0.0325
	(74.18)	(89.25)	(0.0157)	(0.0451)
Female	410.3**	475.9	0.0479*	0.0639
	(204.0)	(377.8)	(0.0253)	(0.0837)
Children				
0	260.7***	231.1***	0.022	0.087
	(99.47)	(76.18)	(0.017)	(0.087)
1	225.4	147.8	−0.026	−0.019
	(140.3)	(255.9)	(0.018)	(0.065)
2	−149.2	−122.9	−0.012	−0.210
	(186.8)	(147.2)	(0.059)	(0.149)
3 or above	141.4	457.2	−0.010	0.038
	(159.7)	(366.4)	(0.028)	(0.056)

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

and calorie consumption for households without children. This finding implies that domestic migration across regions in Vietnam results in increased food expenditure and calorie consumption. However, the results are not statistically significant for families with children in Vietnam.

6. Conclusion and policy implications

Migration has long been a survival strategy for people in developing countries. Theoretical and empirical studies have provided empirical evidence on the effects of migration on human development and poverty reduction. However, the effects of domestic migration on food security remain unsolved, especially with the worsening food security situation in recent years. The important effects of domestic migration on food security have largely been underexamined in the existing literature, particularly for emerging markets such as Vietnam. This study is conducted to examine this important effect in Vietnam using appropriate estimation techniques to ensure the robustness of the empirical findings. Vietnam has been considered one of the fastest-growing economies globally for decades, largely because of labour transformation from rural to urban. Migration has been a challenging socio-economical issue for the country. Vietnam remains perplexed by the malnutrition and food insecurity problems in certain regions in Vietnam. Understanding the effects of domestic migration on food security appears important for policy implications.

This study uses data from the 2016 and 2018 VHLSS surveys to examine the effects of domestic migration on food security. In this paper, food security is proxied by three distinct indicators: (i) food expenditure, (ii) calorie consumption, and (iii) dietary diversity. The effects of domestic migration and other indicators such as wage, land, education and the number of family members on food security across seven different food groups are also considered. The analysis is also extended to examine the effects of regional income and family characteristics such as the family headship and the number of children on food security. The difference-in-difference estimation technique, together with instrumental variables, is used. Key findings can be summarized as follows.

First, domestic migration positively affects food security on two fundamental dimensions: food expenditure and calorie consumption. *Second*, households with migrants spend more on protein, vegetables and fruits when food expenditure and calorie consumption are used as the proxies for food security. Our findings also confirm the significant effects of wage, land and family characteristics such as education level and the number of family members on food security when both proxies, including food expenditure and calorie consumption, are used. *Third,* expanding our analysis to households with differing characteristics, we also find that migration has a very significant impact on the food security status of households in lower-income regions in the country. Household headship can play a mediating role as migration benefits female-headed households more than male-headed households. In addition, households without children spend more from remittances on food expenditure and calorie consumption than households with children.

Policy implications for the Vietnamese government have emerged based on these important findings. *First*, evidence of the positive impact of domestic migration on food security supports the importance of formulating policies to reduce costs and expand opportunities for migration. We note that Vietnam's household registration system, or *Ho Khau* in Vietnamese, has been a continuing barrier to domestic migration. As such, this registration needs major reform. *Ho Khau* was an instrument for food rationing, job allocation, and a means to limit domestic migration implemented in the 1980s. The system restricts migrants' access to healthcare, public schooling and financial assistance in the past. Reform to this registration system is needed to allow migrants seamless transitions across regions, so remittances are quickly sent back to their families. We note that current Vietnam's National Assembly – the country's lawmakers, has been discussing this issue for years. However, no firm decision with more explicit guidance has been reached in 2022. Detailed implications of reforming this registration system should be urgently considered, and the transition to a well-suited system supporting domestic migration is considered urgent in the Vietnamese context.

Second, migration networks should be developed to help potential migrants overcome migration costs across regions. Migrants from the same commune can use their income to lend money to new migrants, supporting them in overcoming liquidity constraints. Migration networks can also help relax mental and financial burdens for their members by providing accommodation and assisting in job finding upon their arrival to the new regions. *Third*, remittance costs should be reduced. Remittances are the most tangible and direct way to benefit migrant-sending households. However, associated costs, such as transfer fees and bureaucracy, might limit their benefits. Many policies can lower these costs, including alleviating heavy governance on money transfers and improving financial inclusion by encouraging people's access to formal banking services.

Fourth, the social security system needs to expand its coverage to migrants. The system should ensure a minimum income for migrants through credit support activities in employment. This type of information is connected to the labour market and career change. Health and social insurance coverage targeting migrants should also be strengthened to proactively respond to income loss or job loss due to unpredictable risks. *Fifth*, market prices should be stabilized, especially for essential commodities such as food and petroleum. Stabilizing food prices would further sustain the positive impact of domestic migration on food security in lower-income regions. Therefore, it is necessary to monitor food supply and demand closely, prices and markets to promptly adjust to ensure supply and meet people's needs. Moreover, stable gasoline prices may also create conditions to promote domestic migration more significantly.

However, migration should be strictly regulated to minimize potential migration boom problems. Investment in infrastructure for remote provinces and reconsideration of the relevant economic structure for different regions should be implemented. Both unskilled or semi-skilled and high-skilled occupations should be invested in developed regions to minimize the mechanical population growth. Furthermore, communication and education for migrants should be strengthened to avoid social conflicts and reduce the burden of complex housing and social problems in urban areas. The Vietnamese government should implement policies focusing on supporting financially rural and disadvantaged areas. Policies supporting agriculture sectors, farmers and the rural regions, especially the

construction of new rural houses, should be considered and implemented. The government should carefully manage agricultural land areas and minimize the excessive construction of urban areas and industrial zones on land with good cultivation and farming capability to ensure national food security.

This study exhibits limitations. There are several types of migration, such as work, marriage, education, and others. While migration for economic reasons can be linked to food security, other types of migration are less likely to impact food security. Future studies should aim to define and separate migrants into various groups. Findings from such analyses will provide significant and insightful implications for policies in Vietnam. In addition, future studies may also need to exploit policy changes in Vietnam that may affect the treatment group (migrants) but not the control group (non-migrants).

Author contribution statement

Duc Hong Vo: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Data will be made available on request.

Declaration of interest's statement

The author declares no competing interests.

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