# The Effect of an Agricultural Input on Nonfarm and Farm Participation of Households in Rural Vietnam

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**Ausgust 2015**

**Abstract**

This paper examines the impact of an increase in volume of chemical fertilizer on the allocation of labor between nonfarm and farm sectors in rural Vietnam during the period 1993-1998. We use instrumental variables approach applied on a panel dataset. The study shows that higher volume of chemical fertilizer reduces the employment of rural households in nonfarm sector and increases the participation in farm activities. Meanwhile, we find that larger volume of chemical fertilizer creates the incentives for households with small agricultural land to work more in farm activities compared to those with large agricultural land.

**Key words:** Instrumental variable, rural Vietnam, farm and nonfarm activities.

**JEL:** F16, H31, J01

## 1. Introduction

Recently, researchers have focused on the impact of imported intermediate goods on enterprise performances. Clearly, trade liberalization has been characterized by the increase in world imports. Reduction in tariff and non-tariff barriers has produced a significant rise in the trade of intermediate goods, especially for developing countries, which depend on foreign technology. Access to new imported intermediated goods allows domestic firms to expand productions, increase productivity and reduce production costs. Using firm-level data from India to examine the impact of imports of intermediate inputs on domestic product scope, Goldberg et al (2010) find that lower input tariffs lead to an increase in new products introduced by domestic firms. Smeets and Warzynski (2010), using firm-product level dataset from Denmark, indicate that imported inputs of different origins improve total factor productivity of firms. Halpern et al. (2011) use firm-level data for Hungary and show that most of the positive effect of importing intermediate goods on firm productivity comes from greater imported input variety. Similarly, Amiti and Kinings (2007) show that lower tariffs on intermediate inputs raise productivity via learning, variety and quality effects in Indonesia. All these studies point out that imported immediate goods play a vital role in firm performances through reduction in production costs, access to new imported input varieties and access to better quality inputs. However, there is little known about the impact of intermediate agricultural inputs on the allocation of labor between farm and non-farm sectors at household level.

Early agricultural reforms of Vietnam started in 1981. The first step towards market economy occurred in 1988 when Vietnam recognized the family as the basic unit of the agrarian economy and cooperative lands were allocated to individual households. State subsidies to agricultural production were removed. Farmers were free to purchase input and sell output in the market. The decollectivization of agricultural land increased rice productivity in rural Vietnam (Pingali and Xuan, 1992). Poverty rate declined fast from 58.1 percent in 1993 to 37.4 percent in 1998 (Glewwe et al, 2002). In addition, the 1990s witnessed gradual liberalization of government controls over trade. Much of the trade restriction on chemical fertilizer was relaxed in 1990s. This allowed Vietnam to increase the volume of imported chemical fertilizer. Therefore, a 23% decline in fertilizer price between 1993 and 1998 might be clearly attributed to the policy-driven

trade liberalization (Niimi, Y et al, 2004; Benjamin and Brandt, 2002). While fertilizer represents the largest component of farm input expenses (Minot and Goletti, 1998). This provides us an excellent case to study the relationship between imported intermediate goods and the allocation of labor between nonfarm and farm sector at households in rural Vietnam.

Although Edmonds and Pavcnik (2006) use the rice price as a proxy for trade liberalization in rural Vietnam and find that higher rice prices lead to re-allocation of labour from farms to nonfarm jobs, they keep silent on the impact of trade liberalization through price of intermediate agricultural input, particularly chemical fertilizer, on non-farm and farm employment. This study attempts to investigate the impact of trade liberalization through price of intermediate goods on non-farm and farm employment in rural Vietnam. The key objective of this study is to explore the impact of the usage of volume of chemical fertilizer on the allocation of labor between farm and non-farm sectors. Obviously, there is endogeneity issue between volume of chemical fertilizer and employment of a household in farm and nonfarm sectors. This would lead to spurious relationship if we may not control the confounding variables or omitted variables. Given these issues, we take advantage of exogenous variation in chemical fertilizer price in 1990s as instrumental variable for the usage of volume of chemical fertilizer when Vietnam removed import quota on chemical fertilizer. Another source of exogenous variation that can be used as instrumental variable is the interaction between price of chemical fertilizer and initial annual agricultural land.

Our findings show that higher volume of chemical fertilizer decreases the nonfarm employment of rural households. Specifically, a 10% increase in volume of chemical fertilizer decreases by 0.019 household member participating in nonfarm activity or reduces the number of nonfarm-working hours per week by 0.98. Further, we find that an increase in volume of chemical fertilizer increases the number of household members working on farm. Meanwhile, volume of chemical fertilizer has positive impact on volume of organic fertilizer, ratio of expense of hired labor, cultivated area with the usage of chemical fertilizer and number of crops with the usage of chemical fertilizer. Finally, the impact of volume of chemical fertilizer on farm participation for households with small landholdings is greater than that for those with large landholdings.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 describes data and presents descriptive statistics. Section 4 details the econometric approach. Section 5 reports the empirical results. Section 6 does robustness checks. Section 7 provides discussions. Finally, section 8 concludes.

## 2. Literature review

The linkage between agricultural and manufacturing sectors has been hotly debated. Based on the experiences of the Industrial Revolution in Britain, several economists think that agricultural productivity has a positive impact on industrialization. First, higher agricultural productivity provides enough food to feed the growing population in the industrialization sector, meanwhile, releases labor for industrialized sector. Second, an increase in agricultural income results in higher demand for industrial products. Gollin et al (2002) indicates that an increase in agricultural productivity may release agricultural labor into other sectors, leading to higher average productivity. So, higher agricultural productivity promotes the industrialization or the development of nonagricultural activities. Similarly, Jonhson (2000) finds that in the eighteenth and nineteenth century, agricultural productivity is one of the three factors that drive the remarkable economic growth. Another finding is that at the global level, agricultural productivity gain and the growth of the non-farm sector are complements. In detail, productivity of labor in agriculture has to increase enough to release labor out of agriculture and move to the city. In contrast, Matsuyama (1992) shows that improvement in agricultural productivity does not result in industrialization in a small open economy because the development of agricultural sector prevents the growth of the manufacturing sector, however in closed economy agricultural productivity is positively associated with economic growth. Chang et al. (2006) extend Matsuyama's model by adding the revenue-generating effect and find that higher agricultural productivity leads to a transition in labor from the agricultural sector to the manufacturing sector. Hazell and Haggblade (1990) have the similar finding as Gollin et al (2002), Jonhson (2000) and Chang et.al (2006). They use cross-sectional data on states and district and semi-input-output model to investigate the relationship between agricultural growth and nonfarm income and employment. They conclude that agricultural growth has positive impact on nonfarm income and employment in rural area. Using variation in high-yielding variety crop yield in India to analyse the impact of improvement in agricultural sector on growth of nonfarm activity, Foster and

Rosenzweig (2004) show the mixed results mostly because of the data limitation. When they use the data of major states in India over 30 years, the result is suitable with the hypothesis that nonfarm and agricultural development are complements. However, when using time series of over 240 villages in India, they conclude that within the country agricultural development is negatively associated with non-agricultural activity. Kilkenny (1993) and Mishra and Goodwin (1997) study the effect of farm subsidies on the nonfarm employment, but their findings are contrasting. Kilkenny (1993) points out that ending farm subsidies would lead to a reduction in rural nonfarm employment and household income while Mishra and Goodwin (1997) indicate that higher income support through government farm programs declines the probability of working off the farm.

Obviously theoretical and empirical studies have provided mixed results about the relationship between agricultural and non-agricultural sectors. Some researchers argue that agricultural development is an essential condition for non-agricultural sector. Others contend that the development of the non-agricultural sector promotes agricultural sector. In this paper, we will use Vietnamese context to provide empirical evidences to resolve the debate about the role of agriculture in development. In particular, we will examine whether the development of agricultural sector would promote or hinder the development of nonfarm sector in rural Vietnam. Meanwhile, there is also a debate about the role of nonfarm sector. There is labor surplus in rural area, so expansion of nonfarm sector would attract a lot of labor surplus from agricultural sector. However, others argue that subsidy for farming activities would increase the demand for agricultural labor and address the issues on labor surplus in agricultural sector.

## 3. Data and descriptive statistics

This study uses two Vietnam Living Standards Surveys (VLSSs) of 1993 and 1998, which were implemented by the Vietnamese General Statistics Office, with technical assistance from the World Bank, and funded by the United Nations Development Programme (UNDP) and the Swedish International Development Agency (SIDA). These surveys are nationally representative, and include questionnaires at both household and commune levels. The household survey contains detailed information on education, health, employment, housing, food and non-food expenses, consumer durables, and credit. The commune survey provides

information on infrastructure and price of commodity at the commune level. Price questionnaire contains information on price of food and nonfood products, services and fertilizer. VLSS 1993 includes 4,800 households and 120 communes. VLSS 1998 contains 6,000 households and 150 communes.[1] These surveys can establish a panel dataset of 4,303 rural and urban households which were revisited in both years. Because issues on relationship between farm and nonfarm sector are rural phenomenon, this study uses a panel dataset of 3258 rural households.[2] We calculate farm and nonfarm participation of household members for only adults aged 20–64 living in rural households and work on the main job for the past 7 days. In 1993, the sample is self-weighted, implying that households have the same probabilities of being selected. For data from 1998, we use the sample weights as provided with these data.

Table 1 presents the percentage of participation of rural households in farm and nonfarm sectors, which indicates that percentage of rural households engaged only in farm activities decreased over time, down to 52.82% in 1998 from 62.22% in 1993. This suggests that economic transition, in addition to urbanization and industrialization, led to the contraction of the agricultural sector and expansion of nonfarm sector. Further, percentage of rural households engaged both farm and non-farm activities seems to increase from 19.64% in 1993 to 22.9% in 1998, implying that rural households tend to diversify to increase their income.

Table 1: Percentage of rural households participating in farm and nonfarm sectors

| | Percentage of rural households engaged only in farm activities | Percentage of rural households engaged only in nonfarm activities | Percentage of rural households engaged both farm and non-farm activities |
|---|---|---|---|
| 1993 | 62.22 | 11.94 | 19.64 |
| 1998 | 52.82 | 16.54 | 22.90 |

Table 2 shows that real chemical fertilizer price decreased by 24%, from 2.79 thousand

[1] Haughton et al (2001) shows that the panel dataset of two VLSS 1993 and 1998 is not representative of the rural population. However, this is a common issue of panel dataset in developing countries (see Deaton, 1997 for discussion). And socio-economic characteristics of households are similar between two surveys (Justino and Litchfield, 2003; Benjamin and Brandt, 2002). Further, Justino et al (2008) confirm that the results of panel dataset 1993-98 provide good inferences for the population in rural Vietnam. Therefore, we are confident in using the panel dataset 1993-1998 to interpret the results of our study.

[2] Note that there was urbanization in Vietnam, therefore households in rural area in 1993 would become urban households. Further, the VLSSs 1993 and 1998 have only information on characteristics of commune in rural area. Therefore, we only use panel dataset covering households in rural area in both 1993 and 1998.

VND per kg in 1993 to 2.12 thousand VND per kg in 1998.[3] Meanwhile, on average, the volume of chemical fertilizer used by households increased from 158.5 kg in 1993 to 186.3 kg in 1998.

Regarding the absolute value of farm and nonfarm participation, Table 2 indicates that the number of household members participating in nonfarm activities increased from 0.46 person in 1993 to 0.65 person in 1998. Similarly, number of nonfarm-working hours of a household in the past 7 days and hours worked in wage job[4] in the past week also increased. Although the number of household members working on farm decreased slightly from 1.66 persons in 1993 to 1.56 persons in 1998, the number of farm-working hours of households per week increased significantly from 62.7 hours in 1993 to 184.8 hours in 1998. It is noteworthy that the questionnaire on farm hours of rural households between 1993 and 1998 is different, so the results on number of farm-working hours of a household per week should be interpreted with some caution.[5]

In terms of relative values of farm and nonfarm participation, we find that ratio of members working in nonfarm activities to household size increased from 46 percent in 1993 to 65 percent in 1998. However, ratio of nonfarm-working hours to total working hours and ratio of hours worked in wage work to total working hours decreased. Similar to the trend of absolute value of farm participation, ratio of members working on farm nearly remains unchanged between 1993 and 1998 and ratio of farm-working hours increased significantly up to 81% in 1998 from 74% in 1993.

Finally, ratio of expense for hired labor to total farm costs decreased. Annual agricultural land per household tends to decrease, this may be because of urbanization. And the volume of organic fertilizer declined over time, down to 1961 kg in 1998, from 1812 kg in 1993.

[3] Chemical fertilizer price is deflated to price of January 1998. Our calculation on variation in price of chemical fertilizer between 1993 and 1998 is a bit different from other papers (Niimi, Y et al, 2004; Benjamin and Brandt, 2002) because we use weights.

[4] Hours worked in wage job only include wage job in nonfarm sector.

[5] The 1993 questionnaire asks how many hours on average the respondent works in self-employed agriculture in the last 7 days. However, no such question of the 1998 questionnaire is asked for self-employed agricultural work. Instead, the 1998 questionnaire disaggregates the within the household agricultural work into 4 different tasks (planting and harvesting, livestock maintenance, processing, marketing) and 3 different categories of agricultural production (crop and fruit production, aquatic cultivation, and forestry), asking hours worked in peak and non-peak seasons over the last 12 months in each of these categories.

**Table 2: Descriptive statistics**

| Variables | 1993 | | 1998 | |
|---|---|---|---|---|
| | Mean | Std | Mean | Std |
| Fertilizer price (thousand VND) | 2.79 | 0.40 | 2.12 | 0.24 |
| Volume of chemical fertilizer (kg per year) | 158.46 | 246.08 | 186.32 | 380.27 |
| Number of members working in nonfarm activities | 0.46 | 0.76 | 0.65 | 0.93 |
| Number of nonfarm-working hours per week | 19.52 | 36.20 | 26.75 | 43.93 |
| Hours worked in wage nonfarm per week | 8.69 | 21.93 | 13.89 | 31.24 |
| Number of members working on farm | 1.66 | 1.19 | 1.56 | 1.11 |
| Number of farm-working hours per week | 62.7 | 54.15 | 184.8 | 110.67 |
| Ratio of members working in nonfarm activities to household size | 0.085 | 0.15 | 0.12 | 0.18 |
| Ratio of nonfarm-working hours to total working hours | 0.22 | 0.36 | 0.15 | 0.26 |
| Ratio of hours worked in wage work to total working hours | 0.11 | 0.25 | 0.08 | 0.19 |
| Ratio of members working on farm to household size | 0.29 | 0.20 | 0.30 | 0.21 |
| Ratio of farm-working hours to total working hours | 0.74 | 0.38 | 0.81 | 0.29 |
| Ratio of expense for hired labor to total farm costs | 0.06 | 0.12 | 0.04 | 0.08 |
| Annual Agricultural land (m2) | 4902.50 | 6528.38 | 4322.71 | 6221.85 |
| Volume of organic fertilizer (kg per year) | 1961.44 | 2683.73 | 1936.90 | 2746.30 |
| Observations | 3258 | | 3258 | |

Notes: All monetary variables are adjusted for inflation.

## 4. Methodology

To estimate the impact of volume of chemical fertilizer on non-farm and farm participation, we use the following regression model as follows:

$$Y_{ijt} = \beta_0 + \beta_1 V_{ijt} + \beta_2 T_t + \beta_3 X_{ijt} + \beta_4 M_{jt} + \mu_j + \varepsilon_{ijt} \quad (1)$$

where $Y_{ijt}$ are measures of non-farm and farm participation of household i in commune j at time t. Nonfarm or farm employment of a household member is defined as a main job in nonfarm or

farm activities during the past 7 days, respectively.[6] We use different measures of nonfarm participation at household level to check the robustness of our results. The first measure of nonfarm participation is number of household members working in nonfarm sector. This measure allows us to examine the participation of household members in nonfarm sector over the past 7 days, however this measure does not distinguish a household member working full time or part-time in nonfarm sector. Therefore, we use second measure of nonfarm participation to take into account the limitation of the first measure. The second measure is number of household's nonfarm-working hours. In rural area, people may work in nonfarm sector but they work for themselves, therefore we do not have information on wage for those. To address this issue and look at another aspect of nonfarm activities, we use the third measure of nonfarm participation, which is total working hours of household members in wage jobs.[7] Although the absolute values are good to measure the change of nonfarm participation, it does not take the demographic change of rural households into account. To address this issue, we use relative measures of nonfarm participation including ratio of number of household members working in nonfarm sector to household size, ratio of number of nonfarm-working hours of a household to total working hours, ratio of hours worked in wage jobs to total working hours. The use of different measures of nonfarm activity – absolute and relative values - enables us to look at the different aspect of nonfarm activity and do robustness checks to see whether our results are strong and robust. Similarly, we also utilize both absolute and relative measures of farm participation, particularly they are number of household members participating in farm sector, number of farm-working hours per week, ratio of number of household members working on farm to household size and ratio of farm-working hours to working hours.

$V_{ijt}$ is the volume of chemical fertilizer which is used by household i in commune j at time t. $T_t$ represents the time dummy (equal to one for 1998 and zero for 1993). $X_{ijt}$ are characteristics of household i in commune j at time t such as education of household head and his/her spouse, age of household head. These variables may affect the farm and nonfarm participation of rural households. $M_{jt}$ are characteristics of commune j at time t such as having car way to village, having electricity in village, having post office in village, having market in village. $\mu_j$ is commune fixed-effects. Better infrastructure at commune level also provides

[6] Our definition of nonfarm participation includes the rural-urban migration.
[7] Note that farming wage of an individual is not reported in the surveys.

incentives for the development of farm and nonfarm activities, this might affect the choice of rural households in farm and nonfarm participation. Therefore, controlling the commune-level fixed-effects can remove commune-level time-invariant factors which can affect the interest outcomes. When we run regressions we also cluster all standard errors at commune level.

The OLS estimation of equation (1) tends to suffer from omitted variables and reverse causality problems. First, households participating in nonfarm activity would have higher income (Hoang et al, 2014), these households would use this additional income from nonfarm employment to purchase more chemical fertilizer to invest in their agricultural activities. This implies that nonfarm activity of households may affect the volume of chemical fertilizer which households use. On the other hand, households using large amount of chemical fertilizer would have higher agricultural profit due to higher agricultural productivity, so they may use the additional income to invest or work in the nonfarm sector. Obviously, this is the reverse causality. In a similar vein, the reverse causality also happens for the interest outcome on farm participation. Second, confounding factors such as history, culture and entrepreneurship can affect volume of chemical fertilizer and nonfarm employment or farm involvement simultaneously. Ignoring these issues would lead to biased results. In other words, using OLS would provide inconsistent estimation results. The direction of endogeneity bias would be ambiguous. If the inability of a farmer increases the abuse of chemical fertilizer, then the OLS estimates will be larger than the IV ones. In other case, farmer entrepreneurship may use less chemical fertilizer to produce agricultural products with good quality and sell at high price, this suggests that OLS estimates will be smaller than the IV ones.

Thus, this study uses panel dataset and the instrumental variables method to address the issue of endogeneity. We choose the chemical fertilizer price and the interaction between chemical fertilizer price and the annual land that a household owned in 1993 as instrumental variables for the usage of volume of chemical fertilizer of households. The 1990s witnessed the gradual liberalization of Vietnamese government of the control over chemical fertilizer. Using price data at commune level of VLSSs 1993 and 1998, we find that the real price of chemical fertilizer decreased 24% between 1993 and 1998. This significant decrease in chemical fertilizer price is widely acknowledged to be due to trade liberalization (Niimi, Y et al, 2004; Dwayne and Loren, 2002). And the fertilizer price affected equally across the communes. In fact, the quantity

of imported chemical fertilizer (urea) increased by 27%, from 1.3 in 1994 to 1.65 million tons in 1998 (Niimi, 2004). This percentage increase is consistent with the data of VLSS 1993 and 1998 at household level. Specifically, the average volume of chemical fertilizer per household also increased by 27.8%, up to 179.8 kilograms in 1998 from 140.7 kilograms in 1993. This suggests that the change in quantity of chemical fertilizer at national level transferred to households. Those factors point out that variation in chemical fertilizer price is exogenous in our study. Recently, Seshan (2013) also uses VLSSs of 1993 and 1998, and fertilizer price as exogenous variable to analyse its impact on household welfare in rural Vietnam.

Meanwhile, in 1988 cooperative lands were decollectivized. The land was allocated to individual households in relatively equal way (Ravallion and Van De, 2004). As of 1993 transferring the assigned land could not be done among households under the 1988 land redistribution (Edmonds and Pavcnik, 2005). This implies that households may not influence household land assignments under the Land Law. Although the 1993 Land Law gave the farmers the right to choose what to grow, in practice it was very difficult for farmers to shift to other crops. Crop choice was administered by commune authorities based on the commune land use plan and the plan had to be approved at district level (Markussen et al, 2011). Further, district-level governments are also granted authority on wide range of activities relating to economic development, so districts applying land plans can not differ systematically from those districts not applying (or applying only partially). This suggests that agricultural annual land of households of 1993 is exogenous in our study. In addition, landholdings vary across regions in rural Vietnam. Therefore, the interaction between chemical fertilizer price and the annual land of households of 1993 provides another excellent candidate to become an instrumental variable for volume of chemical fertilizer. We argue that lower fertilizer price would have larger impacts on volume of chemical fertilizer of households with larger annual land compared to those with smaller one. Our first-stage regression of nonfarm participation in equation (1) will be as follows:

$$V_{ijt} = \alpha_0 + \alpha_1 P_{jt} + \alpha_2 P_{jt} L_{ij\_1993} + \alpha_3 X_{ijt} + \beta_4 M_{jt+} \mu_j + \varepsilon_{ijt} \qquad (2)$$

where $P_{jt}$ is the price of chemical fertilizer in commune j at time t. $L_{ij\_1993}$ is log of area of annual

agricultural land of household i in commune j in 1993.[8]

Table A1 of Appendix reports the results of the first-stage regressions. We find that log of real chemical fertilizer price and the interaction between log of real chemical fertilizer price and log of annual agricultural land are highly statistically significant. The results remain unchanged even when we control or do not control for commune characteristics. F-test of excluded instruments are greater than 10, this implies that our instruments are relevant.

As discussed above, we look at the impact of volume of chemical fertilizer on nonfarm and farm participation, simultaneously. In other words, we consider "participation in farm activities" and "participation in non-farm activities" as independent choices of a rural household. However, participation in farm activities" and "participation in non-farm activities" may be correlated, for example better infrastructure at commune level would increase the agricultural performance and the probability of seeking jobs in nonfarm sector. Labour participation in farm and non-farm activities might be jointly determined; in such a case, the error terms of the farm and non-farm equations could be correlated. Meanwhile, the sample selection bias might occur because unobservable factors can affect the decision of farm and nonfarm participation. If this is true, our results might be inconsistent due to sample selection bias. To correct for the selectivity, we would estimate an extended Heckman model and add the selectivity terms (λ) into the output equations for farm and non-farm sectors in the following way[9]. First, we estimate the choice of working in farm activities or non-farm activities. We use a bivariate probit model, where the error terms of the two equations are supposed to be correlated, i.e. the two choices are interrelated. The equations can be expressed as follows:

$$\begin{cases} P_h^{F^*} = \gamma^F z^F + \varepsilon^F \\ P_h^{NF^*} = \gamma^{NF} z^{NF} + \varepsilon^{NF} \end{cases}$$

With $P^{F^*} > 0$ if the number of household members working in farm sector is greater than zero (binary variable $P^F(0,1)$; $P^{NF^*} > 0$ if number of household members working in nonfarm sector is greater than zero (binary variable $P^{NF}(0,1)$). To make the extended Heckman model work well,

[8] Specifically, we take log of (1+area of annual agricultural land). All households who do not have annual agricultural land will be assigned to zero.

[9] See Henning and Henningsen (2007) for their application.

$Z^F$ and $Z^{NF}$ must have one or more independent variables than those in equation (1). Therefore, $Z^F$ and $Z^{NF}$ include all independent variables as discussed in the equation (1) and dummy variables for interview months.

Then, we run the second-stage regression of equation (1) for nonfarm and farm participation by adding the selectivity term $\lambda^{NF} = \frac{\phi(\gamma^{NF} z^{NF})}{\Phi(\gamma^{NF} z^{NF})}$ and $\lambda^{F} = \frac{\phi(\gamma^{F} z^{F})}{\Phi(\gamma^{F} z^{F})}$, respectively.

**5. Empirical results**

Table 3 presents the results of equation (1) on the impact of volume of chemical fertilizer on nonfarm participation of rural households with and without IV using different measures of nonfarm participation. The Sargan test confirms that p-values of all measures of nonfarm participation are not significant, this suggests that our instruments are free from exclusion restriction concern. Meanwhile, p-values of Hausman test for endogeneity are highly statistically significant, it implies that volume of chemical fertilizer is endogenous variable and we need to use instruments to address the endogeneity issue.

We find that log of volume of chemical fertilizer is negatively associated with the number of household members taking part in nonfarm sector. Using IV regressions, the magnitude of the coefficient of log of volume of chemical fertilizer is larger than that of OLS regressions. In particular, a 10% increase in volume of chemical fertilizer reduces 0.012 and 0.019 additional household member working in nonfarm sector for OLS and IV regressions, respectively (Columns 1 and 2). Obviously, ignoring the endogeneity issue, the result would be downward biased.

Regarding the number of nonfarm-working hours of households, the result using OLS regression shows that a 10% increase in the volume of chemical fertilizer reduces number of weekly nonfarm-working hours of households by 0.6 (Column 3). Using IV regression, the effect is again larger. A 10% increase in the volume of chemical fertilizer decreases number of weakly nonfarm-working hours of households by 0.99 (Column 4).

In a similar vein, Columns (5) and (6) present the estimation results using number of nonfarm-working hours per week in wage jobs as a measure of nonfarm participation. Ignoring the endogeneity issue, the result indicates that a 10% increase in the volume of chemical

fertilizer reduces number of nonfarm-working hours per week in wage jobs by 0.3. When we use IV regression, the result shows that a 10% increase in the volume of chemical fertilizer reduces number of nonfarm-working hours per week in wage jobs by 0.5.

To corroborate the results of the impact of volume of chemical fertilizer on nonfarm participation, we use relative measures of nonfarm participation as dependent variables. Particularly, we normalize number of household members working in nonfarm sector by household size, number of nonfarm-working hours and number of hours worked in wage jobs by total working hours of a household. These adjustments have the advantage of taking into account eventual significant structural demographic changes in households between 1993 and 1998. Columns 7-12 of Table 3 provide similar results, which show that volume of chemical fertilizer is highly statistically significant and has negative impacts on ratio of number of household members working in nonfarm sector to household size, ratio of number of nonfarm-working hours of a household to total working hours and ratio of hours worked in wage jobs to total working hours. Meanwhile, the magnitude of coefficient of log of volume of chemical fertilizer using IV estimation is greater than that using OLS estimation.

Taking all the results together, we find that estimation coefficients would be downward biased if we do not take endogeneity issue into account. And the results show that volume of chemical fertilizer has negative impacts on nonfarm participation of rural households. This also means that an increase in volume of chemical fertilizer reduces the participation of rural households in nonfarm sector.

## Table 3: The Impact of volume of chemical fertilizer on nonfarm participation of rural households

| | Number of household members participating in nonfarm sector | | Number of working hours of household in nonfarm sector | | Number of hours worked in wage jobs | | Ratio of number of household members working in nonfarm sector to household size | | Ratio of number of nonfarm-working hours of a household to total working hours | | Ratio of hours worked in wage jobs to total working hours | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VARIABLES | OLS | IV | OLS | IV | OLS | IV | OLS | IV | OLS | IV | OLS | IV |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| Log of volume of chemical fertilizer | -0.116*** | -0.189*** | -5.959*** | -9.867*** | -2.905*** | -5.087*** | -0.025*** | -0.038*** | -0.077*** | -0.124*** | -0.043*** | -0.069*** |
| | (0.017) | (0.026) | (0.803) | (1.481) | (0.608) | (1.257) | (0.003) | (0.005) | (0.006) | (0.008) | (0.005) | (0.010) |
| Year dummy | 0.206*** | 0.221*** | 8.252*** | 9.050*** | 5.622*** | 6.067*** | 0.042*** | 0.045*** | -0.054*** | -0.045*** | -0.016* | -0.011 |
| | (0.034) | (0.034) | (1.182) | (1.304) | (0.840) | (0.906) | (0.006) | (0.006) | (0.012) | (0.014) | (0.009) | (0.010) |
| Sargan test (p-value) | | 0.323 | | 0.263 | | 0.395 | | 0.254 | | 0.871 | | 0.206 |
| Hausman test for endogeneity (p-value) | | 0.00 | | 0.00 | | 0.02 | | 0.00 | | 0.00 | | 0.01 |
| Observations | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 |
| R-squared | 0.355 | 0.056 | 0.301 | 0.046 | 0.186 | 0.020 | 0.332 | 0.063 | 0.484 | 0.172 | 0.273 | 0.084 |

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Year dummy equals to 1 for 1998 and 0 for 1993. The independent variables of OLS and IV estimations include education of household head and his/her spouse, age of household head, characteristics of commune such as having car way to village, having electricity in village, having post office in village, having market in village. All regressions control for commune fixed-effects. Standard errors are clustered at commune level.

Table 4 presents the results on the impact of chemical fertilizer on farm activities using OLS and IV regressions. P-values of Sargan test are insignificant for all IV regressions. P-values of Hausman test for endogeneity are significant for all cases, this suggests that the results would be biased if we do not apply instrumental variables method to estimate.

We find a positive impact of volume of chemical fertilizer on farm participation. Ignoring the endogeneity issue, the OLS result shows that a 10% increase in chemical fertilizer increases 0.023 additional household members participating in farm sector (Column 1). The IV estimation indicates that the estimation effect is greater, specifically a 10% increase in chemical fertilizer increases 0.037 additional household members participating in farm sector (Column 2). Columns (3) and (4) also show the positive impact of volume of chemical fertilizer on number of farm-working hours of a household. Again, the estimate of coefficient of IV regression is greater than that of OLS regression. When we use relative measures of farm activity, log of volume of chemical fertilizer is positively related to ratio of number of household members working on farm to household size and ratio of farm-working hours to total working hours (Columns 5-8). Also, the magnitudes of estimation coefficient using IV regressions are larger than those using OLS regressions.

Obviously, using the different measures of farm activity we find that log of volume of chemical fertilizer has significant and positive impacts on participation in farm activity of rural households. In other words, a rise in volume of chemical fertilizer leads to an increase in farm activity of rural households.

As discussed above, the decision of working in farm or nonfarm sectors may be correlated. Therefore, the results on the impact of volume of chemical fertilizer on farm or nonfarm employment might be biased. Table 5 provides the second-stage regressions of equation (1) for Tables 3 and 4 by adding the selectivity term (as mentioned in Section 4). The results remain unchanged, suggesting that our IV results of Tables 3 and 4 are consistent.

## Table 4: The impact of chemical fertilizer on farm activities

| | Number of household members participating in farm sector | | Number of farm-working hours per week | | Ratio of number of household members working on farm to household size | | Ratio of farm-working hours to working hours | |
|---|---|---|---|---|---|---|---|---|
| | OLS | IV | OLS | IV | OLS | IV | OLS | IV |
| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Log of volume of chemical fertilizer | 0.234*** | 0.374*** | 30.433*** | 44.083*** | 0.033*** | 0.057*** | 0.107*** | 0.155*** |
| | (0.018) | (0.045) | (1.719) | (2.995) | (0.003) | (0.006) | (0.006) | (0.007) |
| Year dummy | -0.143*** | -0.171*** | 109.578*** | 106.792*** | -0.005 | -0.010 | 0.053*** | 0.043*** |
| | (0.045) | (0.049) | (5.066) | (5.203) | (0.007) | (0.008) | (0.014) | (0.016) |
| Sargan test (p-value) | | 0.924 | | 0.773 | | 0.433 | | 0.763 |
| Hausman test for endogeneity (p-value) | | 0.00 | | 0.00 | | 0.00 | | 0.00 |
| Observations | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 |
| R-squared | 0.339 | 0.096 | 0.418 | 0.180 | 0.275 | 0.040 | 0.548 | 0.308 |

See the notes of Table 3.

Table 5: Extended Heckman model (IV regressions)

| VARIABLES | Number of household members participating in nonfarm sector | Number of working hours of household in nonfarm sector | Number of hours worked in wage jobs | Ratio of number of household members working in nonfarm sector to household size | Ratio of number of nonfarm working hours of a household to total working hours | Ratio of hours worked in wage jobs to total working hours | Number of household members participating in farm sector | Number of farm-working hours per week | Ratio of number of household members working on farm to household size | Ratio of farm working hours to working hours |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Log of volume of chemical fertilizer | -0.189*** | -9.874*** | -5.069*** | -0.038*** | -0.124*** | -0.069*** | 0.373*** | 44.054*** | 0.058*** | 0.155*** |
| | (0.026) | (1.485) | (1.283) | (0.005) | (0.008) | (0.010) | (0.042) | (2.987) | (0.006) | (0.007) |
| Year dummy | 0.235*** | 9.209*** | 7.019*** | 0.047*** | -0.031* | -0.001 | -0.101 | 112.017*** | -0.000 | 0.048*** |
| | (0.065) | (2.959) | (1.988) | (0.011) | (0.019) | (0.012) | (0.062) | (5.957) | (0.010) | (0.017) |
| Control for selectivity term | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Sargan test (p-value) | 0.299 | 0.260 | 0.354 | 0.231 | 0.707 | 0.556 | 0.783 | 0.593 | 0.365 | 0.836 |
| Hausman test for endogeneity (p-value) | 0.00 | 0.001 | 0.016 | 0.002 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Observations | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 | 6,516 |
| R-squared | 0.056 | 0.046 | 0.020 | 0.063 | 0.029 | 0.010 | 0.101 | 0.181 | 0.053 | 0.308 |

See the notes of Table 3.

## 6. Robustness checks

We might be concerned that the results of Tables 3 and 4 are not robust because number of working hours in nonfarm or farm activities are censored at zero. It means that absolute and relative values of nonfarm and farm participation may be equal to zero. We re-run regressions for all dependent variables of Tables 3 and 4 using Tobit model with and without instrumental variables. The results suggest that log of volume of chemical fertilizer is negatively associated with nonfarm participation and it is positively associated with farm involvement of rural households. Besides, the magnitude of the impact using instrumental variables Tobit regressions is greater than that using Tobit regressions (unreported). We also worry that the standard errors of explanatory variables for "number of working hours" outcomes are large, this can lead to biased results. We take log of "number of working hours" outcomes[10] and re-run regressions, results are similar (unreported).

We revisit the exclusion-restrictions assumption when we use IV estimation. The month of interview may affect our results because the farm activities happen seasonally. The survey was conducted in all months of a year. To control for seasonal trend, we create dummy variables for interview months. We add dummy variables to all IV regressions of Tables 3 and 4, our IV results remain unchanged (unreported). Further, change in price of nonfood goods at the commune level might be correlated with change in commune-level price of chemical fertilizer and impact the usage of volume of chemical fertilizer and nonfarm (farm) activities of rural households simultaneously. Therefore, our results may be driven by price of nonfood goods, which are mostly used by rural households, such as: laundry detergent, toothpaste, cotton netting, mosquito net, shirts, trousers and reed mat. We control price of those goods at commune level in all IV estimations of Tables 3 and 4, the results remain robust to this exercise (unreported). Finally, we remove all variables at commune level in IV regressions of Tables 3 and 4, the results remain similar.

## 7. Additional investigations

### 7.1. Relationship between volume of chemical fertilizer and other agricultural

[10] We include all households with and without hours worked on farm or in nonfarm sector in our sample. We take log of (hours + 1), so the households without hours worked on farm or in nonfarm sector will have the value of zero when we take log.

**performances**

We hypothesize that an increase in agricultural income due to a decrease in chemical fertilizer price may lead to higher demand for non-food products; this would imply that non-food production might be expanded and labor demand in non-food sector would increase. Rural households would allocate their labor from agricultural to nonfarm sectors. To test this hypothesis, we add agricultural income of rural households in IV regressions of Tables 3 and 4. We found that the magnitudes of the coefficient of log of volume of chemical fertilizer remain much unchanged. Similarly, we control directly for nonfood expenditure into those regressions, the results are also much the same. Given these results, we can conclude that the results of Tables 3 and 4 are not driven by higher demand for non-food products.

Meanwhile, to corroborate those findings of Tables 3 and 4, we will explore the impacts of volume of chemical fertilizer on other agricultural activities of rural households. Obviously, organic fertilizer is usually made by rural households from plant or animal waste, so it takes a lot of time of rural households to make and deliver it to the field, while rural households can not make chemical fertilizer and they buy it. In fact, rural households might utilize both chemical and organic fertilizer simultaneously because organic fertilizer would increase agricultural productivity in the long term and chemical fertilizer increases agricultural productivity in the short term. In other words, chemical fertilizer will bring the higher productivity but soil will be exhausted very quickly so they have to use organic fertilizer to make land fertile in the long term. Therefore, farmers may increase usage of chemical fertilizer and organic fertilizer at the same time. In this case, higher usage of volume of chemical fertilizer leads to higher usage of volume of organic fertilizer, rural households would spend more time on farm activities due to an increase in volume of organic fertilizer. To justify this hypothesis, we run second-stage regressions of equation (1) with interest outcomes: volume of organic fertilizer and volume of organic fertilizer per square meter. Columns 1-2 of Table 6 shows a positive impact of log of volume of chemical fertilizer on log of volume of organic fertilizer. For example, a 10% increase in chemical fertilizer leads to 5.98% increase in volume of organic fertilizer. Similarly, a 10% rise in volume of chemical fertilizer is positively associated with 0.14% increase in volume of organic fertilizer per square meter. The results suggest that rural households need to take more time or labor on farm activities.

We also expect that when the agricultural activity expands due to greater chemical fertilizer usage, farmers are likely to hire more laborers to meet the demand of the expansion of their agricultural activities. Indeed, Column 3 shows that volume of chemical fertilizer is positively and highly statistically significant for share of expense for hired labor to total farm cost. In particular, a 10% increase in volume of chemical fertilizer leads to 0.15% increase in share of expense for hired labor to total farm costs.

Higher volume of chemical fertilizer may not increase agricultural labor if farmers intensify the additional volume of chemical fertilizer for a given cultivated area. On the other hand, agricultural labor would be added when farmers expand cultivated area, which is applied chemical fertilizer.[11] Therefore, we also want to examine whether higher volume of chemical fertilizer increases the cultivated area with the usage of chemical fertilizer. The results of Column 4 indicate that log of volume of chemical fertilizer has positive and significant impact on cultivated area with the usage of chemical fertilizer. Similarly, log of volume of chemical fertilizer is statistically and positively significant for number of crops with the usage of chemical fertilizer (column 5). Given those results, we infer that an increase in volume of chemical fertilizer rises the cultivated area, where was applied chemical fertilizer. Those results support the findings that farmers increase their labor in farm sector due to a rise in volume of chemical fertilizer.

**Table 6: The Impact of volume of chemical fertilizer on the other factors of rural households (IV regressions)**

| Independent variables | Log of volume of organic fertilizer | Log of volume of organic fertilizer per square meter | Ratio of expense of hired labor over total farm costs | Cultivated area with the usage of chemical fertilizer (ha) | Number of crops with the usage of chemical fertilizer |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Log of volume of chemical fertilizer | 0.598*** | 0.014* | 0.015*** | 4.520*** | 0.628*** |
| | (-0.111) | (-0.009) | (-0.004) | (-0.5) | (-0.038) |
| Year dummy | -0.366*** | -0.026** | -0.024*** | 1.106** | 0.525*** |
| | (-0.088) | (-0.012) | (-0.006) | (-0.523) | (-0.088) |

[11] Farmers do not have enough chemical fertilizer to apply for all their crops in rural Vietnam, so they just apply chemical fertilizer for necessary crops.

| | | | | | |
|---|---|---|---|---|---|
| Sargan test (p-value) | 0.992 | 0.991 | 0.326 | 0.754 | 0.339 |
| Hausman test for endogeneity (p-value) | 0.023 | 0.678 | 0.435 | 0.00 | 0.00 |
| Observations | 6516 | 6516 | 6516 | 6516 | 6516 |
| R-squared | 0.122 | 0.015 | 0.058 | 0.209 | 0.298 |

See the notes of Table 3.

### 7.2. The bifurcation effect of volume of chemical fertilizer

To clarify whether there is a difference in the allocation of labor between nonfarm and farm activities for rural households already worked in farm and those did not in farm in initial year (in 1993) and for those with annual agricultural land greater and less than 5550 m2. This is useful to understand which the most affected households are and how rigid or constrained is the labor market in Vietnam.

We divide the sample into two sub-samples: households with farming in 1993 and those without farming in 1993 and consider the impact of volume of chemical fertilizer on nonfarm and farm participation. This time we only report the results using instrumental variables method. The results are presented in Table 7, which shows that log of volume of chemical fertilizer is negatively associated with nonfarm involvement for households farming in 1993, given any absolute or relative measures of nonfarm participation. However, we find little evidence on the impact of volume of chemical fertilizer on nonfarm involvement for households not farming in 1993. In particular, the findings are that log of volume of chemical fertilizer is not statistically significant for number of working hours in nonfarm sector and number of working hours in wage jobs (Columns 4 and 6), but, the results are statistically significant for number of household members working in nonfarm sector, ratio of number of household members, ratio of number of nonfarm-working hours and ratio of hours worked in wage job per week to total working hours (Columns 2, 8, 10 and 12). It is worth noting that the magnitude of coefficients of log of volume of chemical fertilizer for those farming in 1993 is larger than that for those without farming in 1993. VLSS 1993 shows that on average, the number of nonfarm hours of a household with and without farming is 11.6 and 47.1 hours per week, respectively. This suggests that households without farming in 1993 would specialize in nonfarm sector, those households may not have

agricultural land. Therefore, an increase in volume of chemical fertilizer does not change much the nonfarm participation of household without farming in 1993, but it has significant impact on households farming in 1993..

Table 8 also divides sample into households with farming and without farming in 1993, but it considers the impact of volume of chemical fertilizer on farm participation. We find that the impact of volume of chemical fertilizer on farm participation for households without farming in 1993 is greater than that for those with farming in 1993, except for number of farm-working hours per week. This is relevant because households with farming in 1993 are less sensitive to the change in volume of chemical fertilizer than those without farming in 1993.

We argue that households with larger landholdings would specialize in farming activities more than those with smaller landholdings. In other words, farmers with larger landholdings have higher probability of being more strongly attached to their land compared to those with smaller landholdings. Further, labor surplus would be more common in households with smaller landholding than those with larger landholdings when land constraints are prevalent in Vietnam. This suggests that rural households with smaller landholdings would diversify more into nonfarm sector than those with larger landholdings. Therefore, an increase in agricultural input goods provides more incentives for farmers with small landholdings to work on their farm. To test this hypothesis, we divide our sample into two sub-samples: households with annual land greater than 5,550 square meters and those with annual land less than 5,550 square meters in 1993.[12]

Table 9 runs regressions of equation (1) using IV estimation with interest outcome – nonfarm participation for households with annual land less than 5,550 square meters and those with annual land greater than 5,550 square meters. We find that log of volume of chemical fertilizer is negatively and statistically significant for nonfarm participation for both sub-samples with annual land less and greater than 5,550 square meters. Meanwhile, we find no evidence that volume of chemical fertilizer has systematically different impact on nonfarm participation between households with annual land less than 5550 square meters and those greater than 5550 square meters.

[12] We divide annual land of rural households in 1993 into five quintiles. The minimum value of annual land of fifth quintile is 5550 square meters. We base on this threshold to separate the sample into households with small and large landholdings.

In a similar vein, Table 10 reports the results on farm activities of rural households using IV estimation. We find that log of volume of chemical fertilizer is positively and statistically significant for farm participation of both households with annual land less than 5,550 square meters and those greater than 5,550 square meters. The results are robust for different measures of farm participation of rural households. It is interesting that the impact of volume of chemical fertilizer on farm involvement for households with annual land less than 5,550 square meters is larger than that for those greater than 5,550 square meters. Given fixed agricultural land, labor surplus is prevalent in households with small landholdings. Therefore, an increase in volume of chemical fertilizer would induce farmers with labor surplus or small landholdings to work more in farm activities. Smallholders seem to engage proportionately more in the farm sector than non-smallholders, but they do not reduce nonfarm participation proportionately. This suggests that a rise in volume of chemical fertilizer provides more opportunity in farm sector for smallholders than large holders. Our findings do not contrast with those of Edmonds and Pavcnik (2006), which show that higher rice price would encourage inefficient farmers to specialize in other sectors, while farmers who stay in rice production would specialize in rice production and sell more rice for sale.

**Table 7: The Impact of volume of chemical fertilizer on nonfarm participation with and without farming in 1993 (IV regressions)**

| | Number of household members participating in nonfarm sector | | Number of working hours of household in nonfarm sector | | Number of working hours of household in wage jobs | | Ratio of number of household members working on nonfarm to household size | | Ratio of number of nonfarm-working hours of a household to working hours | | Ratio of hours worked in wage jobs per week to working hours | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | farming in 1993 | not farming in 1993 | farming in 1993 | not farming in 1993 | farming in 1993 | not farming in 1993 | farming in 1993 | not farming in 1993 | farming in 1993 | not farming in 1993 | farming in 1993 | not farming in 1993 |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| Log of volume of chemical fertilizer | -0.197*** | -0.164* | -11.338*** | -5.353 | -8.023*** | 1.418 | -0.037*** | -0.034** | -0.113*** | -0.129*** | -0.080*** | -0.050** |
| | (0.031) | (0.093) | (1.785) | (4.545) | (1.421) | (5.177) | (0.005) | (0.015) | (0.011) | (0.025) | (0.012) | (0.024) |
| Year dummy | 0.284*** | -0.136* | 11.844*** | -5.279* | 7.442*** | 0.914 | 0.058*** | -0.031** | 0.008 | -0.361*** | 0.012 | -0.132*** |
| | (0.034) | (0.078) | (1.473) | (3.156) | (1.077) | (2.104) | (0.006) | (0.016) | (0.013) | (0.024) | (0.010) | (0.027) |
| Sargan test (p-value) | 0.468 | 0.542 | 0.329 | 0.436 | 0.491 | 0.619 | 0.333 | 0.723 | 0.995 | 0.883 | 0.781 | 0.891 |
| Hausman test for endogeneity (p-value) | 0.00 | 0.395 | 0.00 | 0.746 | 0.00 | 0.732 | 0.004 | 0.465 | 0.00 | 0.053 | 0.00 | 0.556 |
| Observations | 5,334 | 1,182 | 5,334 | 1,182 | 5,334 | 1,182 | 5,334 | 1,182 | 5,334 | 1,182 | 5,334 | 1,182 |
| R-squared | 0.027 | 0.088 | 0.014 | 0.076 | -0.007 | -0.004 | 0.036 | 0.102 | 0.082 | 0.256 | 0.037 | 0.077 |

See the notes of Table 3.

**Table 8: The Impact of chemical fertilizer on farm activities with and without farming in 1993 (IV regressions)**

| VARIABLES | Number of household members participating in farm sector | | Number of farm-working hours per week | | Ratio of number of household members working on farm to household size | | Ratio of farm-working hours to working hours | |
|---|---|---|---|---|---|---|---|---|
| | farming in 1993 | not farming in 1993 | farming in 1993 | not farming in 1993 | farming in 1993 | not farming in 1993 | farming in 1993 | not farming in 1993 |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Log of volume of chemical fertilizer | 0.356*** | 0.402*** | 43.308*** | 41.448*** | 0.047*** | 0.071*** | 0.144*** | 0.155*** |
| | (0.064) | (0.080) | (4.032) | (7.530) | (0.008) | (0.013) | (0.008) | (0.023) |
| Year dummy | -0.367*** | 0.765*** | 108.515*** | 104.581*** | -0.044*** | 0.153*** | -0.038*** | 0.522*** |
| | (0.053) | (0.077) | (5.386) | (8.409) | (0.007) | (0.014) | (0.014) | (0.030) |
| Sargan test (p-value) | 0.739 | 0.769 | 0.963 | 0.705 | 0.169 | 0.913 | 0.988 | 0.669 |
| Hausman test for endogeneity (p-value) | 0.004 | 0.004 | 0.00 | 0.029 | 0.006 | 0.001 | 0.00 | 0.034 |
| Observations | 5,334 | 1,182 | 5,334 | 1,182 | 5,334 | 1,182 | 5,334 | 1,182 |
| R-squared | 0.079 | 0.036 | 0.131 | 0.274 | 0.036 | 0.031 | 0.194 | 0.407 |

See the notes of Table 3.

**Table 9: The Impact on nonfarm participation of households with different landholdings (IV regressions)**

| VARIABLES | Number of household members participating in nonfarm sector | | Number of working hours of household in nonfarm sector | | Number of working hours of household in wage jobs | | Ratio of household members working in nonfarm sector to household size | | Ratio of nonfarm-working hours of a household to working hours | | Ratio of hours worked in wage jobs per week to working hours | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <5550 square meters | >=5550 square meters | <5550 square meters | >=5550 square meters | <5550 square meters | >=5550 square meters | <5550 square meters | >=5550 square meters | <5550 square meters | >=5550 square meters | <5550 square meters | >=5550 square meters |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| Log of volume of chemical fertilizer | -0.120** | -0.174*** | -4.559* | -9.692*** | -6.390*** | -5.697*** | -0.040*** | -0.035*** | -0.088*** | -0.112*** | -0.068*** | -0.066*** |
| | (0.047) | (0.024) | (2.368) | (1.412) | (1.864) | (1.385) | (0.008) | (0.004) | (0.013) | (0.008) | (0.011) | (0.010) |
| Year dummy | 0.160*** | 0.307*** | 6.040*** | 13.240*** | 4.273*** | 9.436*** | 0.037*** | 0.057*** | -0.090*** | 0.022 | -0.042*** | 0.040*** |
| | (0.032) | (0.052) | (1.490) | (1.877) | (0.992) | (1.407) | (0.007) | (0.008) | (0.015) | (0.016) | (0.011) | (0.012) |
| Sargan test (p-value) | 0.546 | 0.368 | 0.715 | 0.189 | 0.568 | 0.472 | 0.328 | 0.658 | 0.992 | 0.794 | 0.631 | 0.825 |
| Hausman test for endogeneity (p-value) | 0.261 | 0.034 | 0.870 | 0.014 | 0.019 | 0.012 | 0.040 | 0.010 | 0.032 | 0.00 | 0.0130 | 0.0017 |
| Observations | 4,358 | 2,158 | 4,358 | 2,158 | 4,358 | 2,158 | 4,358 | 2,158 | 4,358 | 2,158 | 4,358 | 2,158 |
| R-squared | 0.042 | 0.099 | 0.041 | 0.069 | 0.009 | 0.012 | 0.030 | 0.104 | 0.112 | 0.333 | 0.035 | 0.129 |

See the notes of Table 3.

**Table 10: The Impact on farm activities of households with different landholdings (IV regressions)**

| VARIABLES | Number of household members participating in farm sector | | Number of farm-working hours per week | | Ratio of number of household members working on farm to household size | | Ratio of farm-working hours to working hours | |
|---|---|---|---|---|---|---|---|---|
| | <5550 square meters | >=5550 square meters | <5550 square meters | >=5550 square meters | <5550 square meters | >=5550 square meters | <5550 square meters | >=5550 square meters |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Log of volume of chemical fertilizer | 0.601*** | 0.352*** | 75.826*** | 41.650*** | 0.083*** | 0.049*** | 0.180*** | 0.137*** |
| | (0.076) | (0.049) | (7.313) | (3.475) | (0.012) | (0.007) | (0.018) | (0.007) |
| Year dummy | -0.125** | -0.329*** | 111.541*** | 95.979*** | -0.013 | -0.020** | 0.089*** | -0.029 |
| | (0.052) | (0.093) | (6.767) | (8.218) | (0.009) | (0.010) | (0.020) | (0.019) |
| Sargan test (p-value) | 0.976 | 0.943 | 0.280 | 0.878 | 0.379 | 0.647 | 0.808 | 0.865 |
| Hausman test for endogeneity (p-value) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.005 | 0.00 | 0.00 |
| Observations | 4,358 | 2,158 | 4,358 | 2,158 | 4,358 | 2,158 | 4,358 | 2,158 |
| R-squared | -0.140 | 0.135 | -0.131 | 0.207 | -0.050 | 0.127 | 0.143 | 0.449 |

See the notes of Table 3.

## 8. Conclusions

This paper uses VLSS of 1993 and 1998 to examine the impact of volume of chemical fertilizer on the allocation of labour from farm to nonfarm sectors. A lot of studies look at this relationship, however both theoretical and empirical studies have provided mixed findings about the relationship between agricultural and non-agricultural sectors. In this study, we try to provide in-depth insights about the impact of agricultural input on farm and nonfarm participation. We use rigorous methodology - instrumental variable approach - to address the endogeneity issue.

Vietnam in 1990s provides us a unique case to consider the effect of volume of agricultural input – chemical fertilizer on nonfarm and farm participation. The gradual liberalization of trade of Vietnam in 1990s relaxed the import quota of chemical fertilizer, this led to a decline in chemical fertilizer price. It means that the variation of chemical fertilizer price is exogenous. Meanwhile, the collective land allocation to individual households in rural area also provides us another exogenous variable. Given these, we use chemical fertilizer price and the interaction between chemical fertilizer price and the annual agricultural land of 1993 as instruments for volume of chemical fertilizer. We find that higher volume of chemical fertilizer leads to lower nonfarm participation and higher involvement of rural households in farm sector. Further, higher volume of chemical fertilizer increases the usage of volume of organic fertilizer, ratio of expense of hired labor, cultivated area with the usage of chemical fertilizer and number of crops with the usage of chemical fertilizer. Finally, we show that the impact of volume of chemical fertilizer on farm employment for households with small landholding is greater than that for those with larger landholdings.

Our findings provide several policy implications. First, trade liberalization of intermediate goods allows farmers to benefit from agricultural inputs with lower price, this helps farmers to increase their farm activities, especially for farmers with small land. Second, our paper shows that agricultural development would decrease the off-farm employment. This may suggest that policy changes supporting agricultural input would encourage farmers to work in agricultural sector and reduce incentives to work off farm.

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## APPENDIX

Table A1: first-stage regressions

| Dependent variable: log of volume of chemical fertilizer | | |
|---|---|---|
| | (1) | (2) |
| Log of price of chemical fertilizer | -2.690*** | -2.699*** |
| Log of price of chemical fertilizer * log of annual land | 0.396*** | 0.397*** |
| Control for commune characteristics | No | Yes |
| F test of excluded instruments: | 67.51 | 67.93 |
| Number of Observations | 6170 | 6170 |

See the notes of Table 3.