The Effect of Price of Intermediate Imported Product on Nonfarm Participation of Households in Rural Vietnam

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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 rigorous method – instrumental variables approach to document the evidence. The study shows that higher volume of chemical fertilizer due to lower price of chemical fertilizer reduces the employment of rural households in nonfarm sector and increases the participation in farm activities. We document that larger volume of chemical fertilizer creates the incentives for households with small agricultural land to work more in farm activities.

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 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 firm total factor productivity. Halpern et al. (2011) use firm-level data for Hungary and indicate 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.

Since the transition of Vietnam from centrally planned to market economy started in 1989, Vietnam has achieved a great success on poverty reduction. During the 1990s, GDP per capita growth increased significantly. Poverty rate reduced fast from 58.1 percent in 1993 to 37.4 percent in 1998 (Glewwe et al, 2002). Trade liberalization also contributes significantly to poverty reduction in 1990s (Justino et al, 2008; Niimi et al, 2004). Decollectivization increased rice productivity (Pingali and Xuan, 1992). Trade liberalization lifted the restriction on intermediate goods, this allowed Vietnam to import to produce. Therefore, Vietnam provides us an excellent case to study the relationship between intermediate goods and the allocation of labor within rural households. 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 1990s also witnessed gradual liberalization of government controls over trade. Much of the trade restriction on fertilizer was relaxed in 1990s. Therefore, 23 percent 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). Therefore, we expect that trade liberalization of Vietnam through relaxation of controls over the fertilizer in 1990s would affect non-farm employment. 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 fertilizer price, on non-farm employment. Therefore, does trade liberalization through price of intermediate goods affect non-farm employment? This question is still open and has not been answered. 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.

Our findings show that a reduction in chemical fertilizer price increases the volume of chemical fertilizer of rural households. And higher volume of chemical fertilizer decreases the nonfarm employment of households. Specifically, 10 percent increase in volume of chemical fertilizer decreases the 0.019 additional household member participating in nonfarm activity or reduces the number of nonfarm-working hours per week by 0.98. Meanwhile, we find that an increase in volume of chemical fertilizer increases the number of household members working on farm, leads to higher agricultural income, higher payment for hired labor and higher volume of organic fertilizer. The impact of volume of chemical fertilizer on farm participation is greater for households with small landholdings compared with 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 leads to higher demand for industrial products. Gollin et al (2002) indicates that an increase in agricultural productivity may release agricultural labor into other sectors, this leads 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, agriculture productivity is one of the three factors that are responsible for 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 prevent the development of the manufacturing sector however in closed economy agricultural productivity and economic growth have a positive link. Chang et al. (2006) extend Matsuyama's model by adding the revenue-generating effect and his finding is 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, the findings of Foster and Rosenzweig (2004) is mixed 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 agriculture and nonfarm development are complements. However, when using time series of over 240 villages in India, they conclude that within the country agricultural development are 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 terminating farm subsidies would lead to the reduction in rural nonfarm employment and household income while Mishra and Goodwin (1997) indicate that higher income support through government farm programs reduces the probability of farmers to work off the farm.

Obviously theoretical and empirical studies have provided mixed results and sometimes contrasting evidence 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 role of nonfarm sector. There is labor surplus in rural area, so expansion of nonfarm sector would attract a lot of labor surplus of agricultural sector and increase the agricultural productivity. However, others argue that subsidy for farming activities would address the issues on labor surplus.

3. Data and descriptive statistics

Using price data at commune level of VLSSs 1993 and 1998, we find that the real price of chemical fertilizer decreased 24 percent between 1993 and 1998. This significant decrease in fertilizer price is widely acknowledged to be due to trade liberalization (Niimi, Y et al, 2004; Dwayne and Loren, 2002). Import of fertilizer increased steadily during the 1990s, from 0.8 million tons to 1.9 million tons between 1990 and 1999 (Niimi, Y et al, 2004). We link this exogenous variation in fertilizer price at commune level to variation in farm and non-farm employment at household level. Therefore, Vietnam Living Standards Surveys in 1993 and 1998 are ideal datasets to answer the question because these datasets span the period of the

liberalization of fertilizer trade.

Vietnam Living Standards Surveys (VLSSs) of 1993 and 1998 were implemented by the Vietnamese General Statistics Office, with technical assistance from the World Bank, and funded by UNDP. These surveys are nationally representative, and include questionnaires at both the 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 price of commodity, infrastructure and institutions 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. Haughton et al (2001) shows that the panel dataset of two VLSS 1993 and 1998 is not representative of the rural population.[1] However, 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.

These surveys can establish a panel dataset of 4,303 rural and urban households which were revisited in both years. The issues on relationship between farm and nonfarm sector are rural phenomenon. So, this study uses a panel dataset of 3258 rural households.[2] In this study, we calculate farm and nonfarm participation of household members for only adults aged 20–64 living in rural households. In 1993, the sample is self-weighted, implying that households have the same probabilities of being selected, so we can assign 1 as weight of all households. To make inference to the total population (and not total households), our individual weight in 1993 will be 1 multiplied by household size. To avoid bias in results due to deliberate over- or under-sampling, VLSS 1998 provides sample weight for individuals, so we also use sample weight of individuals in 1998. Therefore, all the results below will be provided with sample weights.

Table 1 presents the percentage of participation of rural households in farm and nonfarm sectors,

[1] This is a common issue of panel dataset in developing countries (see Deaton, 1997 for discussion).
[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

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 urbanisation and industrialisation, has 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 fertilizer price decreased by 24 percent, from 2.79 thousand 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 household increased from 158.5 kg in 1993 to 186.3 kg in 1998, but volume of chemical fertilizer per square meter remains unchanged over time. It suggests that intensification of chemical fertilizer per square meter achieves optimal level in order to maximize agricultural productivity. However, the volume of organic fertilizer decreased over time, to 1961 kg in 1998, from 1812 kg in 1937. Besides, 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. In contrast, the number of household member working on farm decreased slightly from 1.77 people in 1993 to 1.72 people in 1998. In addition, Table 2 also indicates that total farm-working hours of households per week increased from 66 hours in 1993 to 164 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 cautious in interpretation.[5] It is not surprising that real

[3] Chemical fertilizer price is deflated to price of January 1998.
[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

expense for hired labour in the past 12 months increased up to 217 in 1998 from 185 thousand VND in 1993. Annual agricultural land per household tends to decrease, this may be because of urbanization. However, agricultural income of a household increased.

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
Volume of chemical fertilizer per m2 (kg per m2)	0.02	0.07	0.02	0.07
Volume of organic fertilizer (kg per year)	1961.44	2683.73	1936.90	2746.30
Number of household members participating in nonfarm activities	0.46	0.76	0.65	0.93
Number of nonfarm-working hours of a household 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 household members working on farm	1.77	1.19	1.72	1.11
Number of farm-working hours of a household per week	65.77	54.15	163.98	55.23
Expense for hired labour in the past 12 months (thousand VND)	185.27	596.22	217.24	832.06
Annual Agricultural land (m2)	4902.50	6528.38	4322.71	6221.85
Agricultural Income per year (thousand VND)	3791	3791	5470	5470
Ratio of number of household members participating in nonfarm activities to household size	0.09	0.15	0.12	0.18
Ratio of nonfarm-working hours of a household to total working hours	0.22	0.36	0.38	0.48
Ratio of hours worked in wage work to total working hours	0.11	0.25	0.21	0.39
Ratio of number of household members working on farm to household size	0.29	0.20	0.30	0.21
Ratio of number of farm-working hours of a household to total working hours	0.74	0.38	0.54	1.72
Ratio of expense for hired labor to total farm costs	0.04	0.09	0.02	0.05
Real agricultural income per capita	650	722	1005	1369
Observations	3258		3258	

Notes: all monetary variables are adjusted for inflation.

Similarly, Table 2 also reports the relative values. The results show that ratio of number of household members participating in nonfarm activities to household size increased from 9% in

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.

1993 to 12% in 1998 in the sample. The result is similar to ratio of number of nonfarm-working hours of a household to total working hours and ratio of hours worked in wage work to total working hours, which increased over time. In contrast, the ratio of number of household members working on farm to household size nearly remains unchanged. The ratio of number of farm-working hours of a household to total working hours declined from 74% in 1993 to 54% in 1998. The real agricultural income per capita[6] increased from 650 thousand VND in 1993 to 1005 thousand VND in 1998.

4. Methodology

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

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

where Y_{ijt} are measures of non-farm participation of household i in commune j at time t. Nonfarm employment of a household member is defined as a main job in nonfarm activities during the past 7 days.[7] 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.[8] In summary, the use of three measures of nonfarm activity enables us to look at the different aspect of nonfarm activity and do robustness checks to see whether our results are strong and robust.

[6] Agricultural income of households equals total revenue minus expenditure of all agricultural products.
[7] Our definition of nonfarm participation includes the rural-urban migration.
[8] Note that farming wage of an individual is not reported in the surveys.

V_{ijt} is the volume of chemical fertilizer which is used by household i in commune j at time t. T_t represents for 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. μ_j is commune fixed-effects. Better infrastructure at commune level also provide 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 variables at commune level can remove commune time-variant 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 have more endowments to work off the farm. Obviously, this is the reverse causality. Second, confounding factors such as history, culture and entrepreneurship can affect volume of chemical fertilizer and nonfarm employment simultaneously. Ignoring these issues would lead to biased results. In other words, using OLS would provide inconsistent estimation results. Thus, this study uses panel dataset and the instrumental variable method to address the issue of endogeneity. Meanwhile, we also control for commune fixed effects to cancel out unobservable time-invariant factors at commune level which can impact our results.

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. We expect that lower price of chemical fertilizer would have greater impact on households with larger landholding. The 1990s witnessed the gradual liberalization of government of the control over fertilizer trade. The quantity of fertilizer

import increased by 27 percent, from 1.3 to 1.65 million tons (Niimi, 2004). This increase is also consistent with the data of VLSS 1993 and 1998 on volume of chemical fertilizer which households use. Specifically, the average volume of chemical fertilizer per household also increased by 27.8 percent, up to 179.8 kilograms in 1998 from 140.7 kilograms in 1993. This suggests that the change in quantity of fertilizer at national level transferred to households. According to VLSSs 1993 and 1998, the price of chemical fertilizer price decreased by 23 percent at the commune level between 1993 and 1998. Therefore, we can confirm that fertilizer price is exogenous in our study. Recently, Seshan (2013) also uses fertilizer price in 1990s as exogenous variable to analyse its impact on household welfare in rural Vietnam using VLSSs 1993 and 1998.

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. Meanwhile, 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, 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. Figure 1 of Appendix confirms this. 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 area of annual agricultural land of household i in commune j in 1993.

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.

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 percent 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 total nonfarm-working hours of households, the result using OLS regression shows that a 10 percent increase in the volume of chemical fertilizer decreases number of weekly nonfarm-working hours of households by 0.6 (Column 3). Using IV regression, the effect is again larger. A 10 percent 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 percent 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 percent 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 values 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. 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 chemical fertilizer has negative impacts on nonfarm participation of rural households. This also means that a decline in chemical fertilizer price 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***	-0.050***	-0.088***	-0.029***	-0.057***
	(0.017)	(0.026)	(0.803)	(1.481)	(0.608)	(1.257)	(0.003)	(0.005)	(0.007)	(0.012)	(0.007)	(0.015)
Year dummy	0.206***	0.221***	8.252***	9.050***	5.622***	6.067***	0.042***	0.045***	0.168***	0.176***	0.108***	0.114***
	(0.034)	(0.034)	(1.182)	(1.304)	(0.840)	(0.906)	(0.006)	(0.006)	(0.015)	(0.015)	(0.011)	(0.011)
Sargan test (p-value)		0.323		0.263		0.395		0.254		0.154		0.206
Hausman test for endogeneity (p-value)		0.00		0.00		0.02		0.00		0.00		0.0111
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	0.250	0.029	0.135	0.010

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 use instrumental variables 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 percent 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 percent 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 on 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 magnitude of estimation coefficient using IV regressions are larger than those using OLS regressions.

Obviously, given the different measures of nonfarm 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 decrease in chemical fertilizer price leads to an increase in farm activity of rural households.

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***	28.629***	41.157***	0.033***	0.057***	0.240***	0.518***
	(0.018)	(0.045)	(1.618)	(2.798)	(0.003)	(0.006)	(0.040)	(0.129)
Year dummy	-0.143***	-0.171***	87.260***	84.702***	-0.005	-0.010	0.467***	0.410***
	(0.045)	(0.049)	(5.376)	(5.434)	(0.007)	(0.008)	(0.108)	(0.117)
Sargan test (p-value)		0.924		0.905		0.433		0.448
Hausman test for endogeneity (p-value)		0.00		0.00		0.00		0.01
Observations	6,516	6,516	6,516	6,516	6,516	6,516	6,516	6,516
R-squared	0.339	0.096	0.412	0.175	0.275	0.040	0.065	0.000

See the notes of Table 3.

6. Robustness checks

We might be concerned that the results of Tables 2 and 3 are not robust because number of working hours are censored at zero. We re-run regressions of Tables 2 and 3 using Tobit model with 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 (the results are reported in Tables 2 and 3 of Appendix). We also worry that the standard errors of explanatory variables for "number of working hours" outcomes are large, we take log of "number of working hours" outcomes[9] 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 2 and 3, our IV results remain unchanged (unreported). Further, 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. Price of those nonfood goods might correlate with chemical fertilizer price or impact the usage of volume of chemical fertilizer and nonfarm (farm) activities of rural households simultaneously. We control price of those goods at commune level in all IV estimations of Tables 2 and 3, the results remain robust to this exercise (unreported). In addition, we remove all variables at commune level in IV regressions of Tables 2 and 3, the results remain similar.

Up to now, we considered "participation in farm activities" and "participation in non-farm activities" as independent choices. However, participation in farm activities" and "participation in non-farm activities may be correlated. If this is true, our results might be biased. In order to further corroborate our findings, 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

[9] 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.

way:[10]

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 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 $P^{NF}(0,1)$). In addition to dummy variables for interview months, Z^F and Z^{NF} include the variables as discussed in the equation (1).

Then, we run second-stage regressions of equation (1) for Tables 2 and 3 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. However, the results are still robust (see Table 4 of Appendix).

7. Discussions

Our results suggest that a decline in fertilizer price due to trade liberalization in national and international market leads to higher usage of volume of chemical fertilizer, which results in an increase in farm employment of rural households and has negative impact on nonfarm activity. What may explain this relationship?

7.1. Relationship between volume of chemical fertilizer and other agricultural 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 implies 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 2 and 3, the magnitudes of the coefficient of log of volume of chemical fertilizer remain much unchanged.

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

Similarly, we control directly nonfood expenditure into those regressions, the results are also much the same. Given these results, we can conclude that the results of Tables 2 and 3 is not driven by higher demand for non-food products.

Meanwhile, to corroborate those findings of Tables 2 and 3, we will explore the impacts of chemical fertilizer on other agricultural activities of rural households. We find that it takes a lot of time to make and deliver organic fertilizer to the field compared with chemical fertilizer. If higher usage of volume of chemical fertilizer due to lower chemical fertilizer price leads to higher usage of volume of organic fertilizer, rural households would spend more time on farm activities. When price of chemical fertilizer reduces, rural households may use more chemical fertilizer and less organic fertilizer. In this case, chemical and organic fertilizers are substitutes. In contrast, 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. Therefore, rural farmers may use more organic fertilizer in addition to chemical fertilizer. 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 long term. 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 1-4 of Table 5 shows a positive impact of log of volume of chemical fertilizer on log of volume of organic fertilizer. Again, the impact of IV estimation is greater than that of OLS estimation. For example, a 10 percent increase in chemical fertilizer leads to 4.57 percent and 5.98 percent increase in organic fertilizer in IV and OLS regressions, respectively. Similarly, a 10 percent rise in chemical fertilizer is positively associated with 0.12 and 0.14 percent increase in organic fertilizer per square meter when we use IV and OLS regressions, respectively.[11] Given these results, we find that larger usage of volume of chemical fertilizer would lead to an increase in usage of volume of organic fertilizer, this implies 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

[11] P-values of Sargan test are not statistically significant, this suggests that the instrumental variables do not correlate with error terms.

usage, rural farmers are likely to hire more laborers to meet the demand of the expansion of their agricultural activities. In fact, Columns (5) and (6) suggest that volume of chemical fertilizer is positively and highly statistically significant for share of expense for hired labor to total farm cost. Again, the IV estimation effect is greater than OLS one. In particular, a 10 percent increase in volume of chemical fertilizer leads to 0.07 percent and 0.09 percent increase in share of expense for hired labor to total farm costs in OLS and IV regressions, respectively.

In similar vein, we want to investigate the relationship between volume of chemical fertilizer and real agricultural income of rural households. The results of Columns 7-10 confirm that higher volume of chemical fertilizer is positively correlated with real agricultural income and real agricultural income per capita of rural households. Both the results using OLS and IV regressions are highly statistically significant, however, the estimation effect is larger for IV regression than OLS regression. For example, a 10 percent increase in chemical fertilizer rises real agricultural income of rural households by 9.9 percent and 14.3 percent for OLS and IV regressions (Columns 7 and 8), respectively. This finding justifies our expectation that lower fertilizer price leads to higher volume of chemical fertilizer and a decrease in cost of agricultural activities. This implies that the real agricultural income would increase. Labor allocation would has more incentives to move to farm sector from nonfarm sector.

Finally, we expect that a decline in nonfarm participation due to an increase in chemical fertilizer would decrease the real nonfarm income of households. The results in Columns (11) and (12) confirm this. In particular, we find that a higher usage of chemical fertilizer decreases real nonfarm income of rural households and the estimate of coefficient of IV regression is greater than that of OLS regression. For example, 10 percent increase in volume of chemical fertilizer increases the real nonfarm income by 2.84 percent and 5.2 percent for OLS and IV regressions, respectively.

Table 5: The Impact of volume of chemical fertilizer on the other factors of rural households.

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		Log of real agricultural income of households		Log of real agricultural income per capita		Log of real income of households from nonfarm jobs	
	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	0.457***	0.598***	0.012**	0.014*	0.013***	0.015***	0.990***	1.427***	0.794***	1.149***	-0.284***	-0.520***
	(0.076)	(0.111)	(0.005)	(0.009)	(0.002)	(0.004)	(0.054)	(0.081)	(0.044)	(0.064)	(0.044)	(0.092)
Year dummy	-0.337***	-0.366***	-0.025**	-0.026**	-0.024***	-0.024***	0.002	-0.087	0.116	0.043	0.270***	0.318***
	(0.082)	(0.088)	(0.012)	(0.012)	(0.006)	(0.006)	(0.102)	(0.125)	(0.086)	(0.104)	(0.082)	(0.088)
Sargan test (p-value)		0.992		0.991		0.326		0.184		0.181		0.104
Hausman test for endogeneity (p-value)		0.023		0.678		0.435		0.00		0.00		0.001
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	0.760	0.122	0.450	0.015	0.262	0.058	0.368	0.059	0.371	0.056	0.193	0.021

See the notes of Table 3.

We argue that larger usages of volume of chemical fertilizer would increase volume of organic fertilizer of rural households. It means that farmers need to spend more time on making organic fertilizer and transporting it to the field. Further, larger usage of chemical fertilizer increases real agricultural income due to lower price of chemical fertilizer. Besides, greater usage of chemical fertilizer decreases the real income of rural households from nonfarm sectors. All these factors point out that households would allocate labor from nonfarm to farm sectors due to higher usage of chemical fertilizer.

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.[12]Therefore, we also want to examine whether higher volume of chemical fertilizer increases the cultivated area with the usage of chemical fertilizer. The results are reported in Table 6, which indicates that log of volume of chemical fertilizer has positive and significant impact on cultivated area with the usage of chemical fertilizer (Column 1). As a robustness check, the result also shows positive impact of log of volume of chemical fertilizer, even when we take log of cultivated area with the usage of chemical fertilizer (column 2). Similarly, log of volume of chemical fertilizer is statistically and positively significant for number of crops with the usage of chemical fertilizer (column 3. The result is not statistically significant for volume of chemical fertilizer per square meter (Column 4). Given those results, we infer that an increase in volume of chemical fertilizer rises the cultivated area, which was applied chemical fertilizer, however, it did not increase the intensification of usages of chemical fertilizer per square meter. 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 cultivated area with the usage of chemical fertilizer (IV regressions)

VARIABLES	Cultivated Area with the usage of chemical fertilizer (ha)	Log of cultivated area with the usage of chemical fertilizer	Number of crops with the usage of chemical fertilizer	Volume of chemical fertilizer per square meter
	(1)	(2)	(3)	(4)
Log of volume of chemical fertilizer	4.520***	0.582***	0.628***	0.001

[12] 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.

	(0.500)	(0.022)	(0.038)	(0.002)
Year dummy	1.106**	0.218***	0.525***	-0.002
	(0.523)	(0.073)	(0.088)	(0.003)
Sargan test (p-value)	0.754	0.934	0.339	0.213
Hausman test for endogeneity (p-value)	0.000796	1.72e-06	0.000223	0.0491
Observations	6,516	6,516	6,516	6,516
R-squared	0.209	0.396	0.298	0.005

See the notes of Table 3.

7.2. The impact of volume of chemical fertilizer on different kinds of rural households

To clarify whether the increase in labourers working in farm and a decrease in labourers participating in nonfarm sector concerns only households that already worked in a farm in the initial year (in 1993) or every households irrespective of their previous activities? 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.

Table 7 reports the results on the impact of volume of chemical fertilizer on nonfarm participation with and without farming in 1993. It shows that log of volume of 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, number of working hours in wage jobs and ratio of hours worked in wage job per week to total working hours (Columns 4, 6 and 12), but, the results are statistically significant for number of household members working in nonfarm sector, ratio of number of household members and ratio of number of nonfarm-working hours (Columns 2, 8 and 10). In addition, the magnitude of coefficients of log of volume of chemical fertilizer is larger for those farming in 1993 than those not farming in 1993. VLSS 1993 shows that on average, the number of nonfarm hours of a household farming and not farming is 11.6 and 47.1 hours per week, respectively. This suggests that households farming in 1993 attach much more to agricultural sector than those not farming in 1993. Therefore, an

increase in volume of chemical fertilizer would have greater impact on nonfarm involvement for those farming in 1993 than those not farming in 1993.

Table 8 also divides sample into households farming and those not farming in 1993 and considers the impact of volume of chemical fertilizer on farm activities. Regarding the absolute measure of farm activities, we find that greater volume of chemical fertilizer increases household members participating in farm sector or farm-working hours per week and the impact is larger for those farming in 1993 than those not farming in 1993. However, the results are mixed when we use relative measures of nonfarm participation.

Given the results above, 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, lower price 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.[13]

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 consistently different impact on nonfarm participation between households with annual land less than 5550 square meters and those greater than 5550 square meters.

[13] 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 the impact 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 is larger for households with annual land less than 5,550 square meters than those greater than 5,550 square meters. These results are consistent with the hypothesis that labor surplus is prevalent in households with small landholdings. Therefore, an increase in volume of chemical fertilizer due to a decline in fertilizer price would induce farmers with labor surplus or small landholdings 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 largeholders. 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	-0.203***	-0.161	-11.091***	-4.797	-6.655***	4.373	-0.039***	-0.041*	-0.089***	-0.096**	-0.066***	-0.007
	(0.027)	(0.140)	(1.625)	(7.378)	(1.311)	(8.009)	(0.005)	(0.021)	(0.014)	(0.045)	(0.016)	(0.055)
Year dummy	0.248***	0.010	10.556***	-1.535	6.775***	0.729	0.050***	0.006	0.199***	-0.013	0.124***	0.032
	(0.033)	(0.092)	(1.373)	(3.986)	(1.000)	(2.515)	(0.006)	(0.018)	(0.016)	(0.034)	(0.012)	(0.031)
Sargan test (p-value)	0.301	0.893	0.228	0.975	0.443	0.908	0.204	0.661	0.169	0.663	0.309	0.807
Hausman test for endogeneity (p-value)	0.00	0.480	0.00	0.76	0.00	0.35	0.00	0.37	0.00	0.04	0.014	0.95
Observations	5,602	914	5,602	914	5,602	914	5,602	914	5,602	914	5,602	914
R-squared	0.042	0.051	0.036	0.054	0.016	-0.046	0.049	0.063	0.024	-0.005	0.014	0.014

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	0.342***	0.494***	39.788***	41.071***	0.047***	0.073***	0.545***	0.347**
	(0.057)	(0.118)	(3.099)	(10.711)	(0.008)	(0.017)	(0.186)	(0.144)
Year dummy	-0.297***	0.841***	85.594***	84.249***	-0.031***	0.170***	0.296**	1.300***
	(0.052)	(0.110)	(5.719)	(9.516)	(0.008)	(0.021)	(0.127)	(0.327)
Sargan test (p-value)	0.998	0.991	0.997	0.913	0.346	0.494	0.345	0.138
Hausman test for endogeneity (p-value)	0.00234	0.0113	3.67e-06	0.0719	0.00196	0.00836	0.0384	0.169
Observations	5,602	914	5,602	914	5,602	914	5,602	914
R-squared	0.079	0.001	0.138	0.277	0.025	0.073	-0.004	0.010

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***	-0.048*	-0.071***	-0.069***	-0.051***
	(0.047)	(0.024)	(2.368)	(1.412)	(1.864)	(1.385)	(0.008)	(0.004)	(0.027)	(0.013)	(0.021)	(0.017)
Year dummy	0.160***	0.307***	6.040***	13.240***	4.273***	9.436***	0.037***	0.057***	0.163***	0.186***	0.098***	0.141***
	(0.032)	(0.052)	(1.490)	(1.877)	(0.992)	(1.407)	(0.007)	(0.008)	(0.019)	(0.018)	(0.014)	(0.016)
Sargan test (p-value)	0.546	0.368	0.715	0.189	0.568	0.472	0.328	0.658	0.487	0.244	0.233	0.706
Hausman test for endogeneity (p-value)	0.261	0.0341	0.870	0.0139	0.0199	0.0122	0.0407	0.0101	0.453	0.130	0.0169	0.0393
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	0.030	0.063	0.007	0.012

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	0.559***	0.357***	67.370***	38.569***	0.069***	0.049***	0.660***	0.532***
	(0.070)	(0.052)	(6.420)	(3.359)	(0.011)	(0.007)	(0.201)	(0.169)
Year dummy	-0.080	-0.328***	89.954***	73.823***	-0.004	-0.019*	0.609***	0.018
	(0.051)	(0.093)	(6.968)	(8.255)	(0.009)	(0.010)	(0.148)	(0.146)
Sargan test (p-value)	0.772	0.704	0.181	0.411	0.622	0.849	0.112	0.589
Hausman test for endogeneity (p-value)	0.00	0.00	0.00	0.00	0.00	0.00	0.091	0.028
Observations	4,358	2,158	4,358	2,158	4,358	2,158	4,358	2,158
R-squared	-0.096	0.125	-0.072	0.209	-0.025	0.116	-0.000	-0.006

See the notes of Table 3.

8. Conclusions

This paper uses VLSS of 1993 and 1998 to examine the impact of a decline in chemical fertilizer price 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 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 chemical fertilizer price is exogenous variable. Meanwhile, the collective land allocation to individual households in rural area also provide 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 a decline in chemical fertilizer price increases the volume of chemical fertilizer. And 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 and the real agricultural profit of households and share of costs for hired labor to total farm costs. Finally, we show that the impact of chemical fertilizer on farm employment is greater for households with small landholding than 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 agricultural profit. Second, off-farm jobs would generate the burden in the urban area. 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

Figure 1: The relationship between log of volume of chemical fertilizer and annual agricultural land in 1993

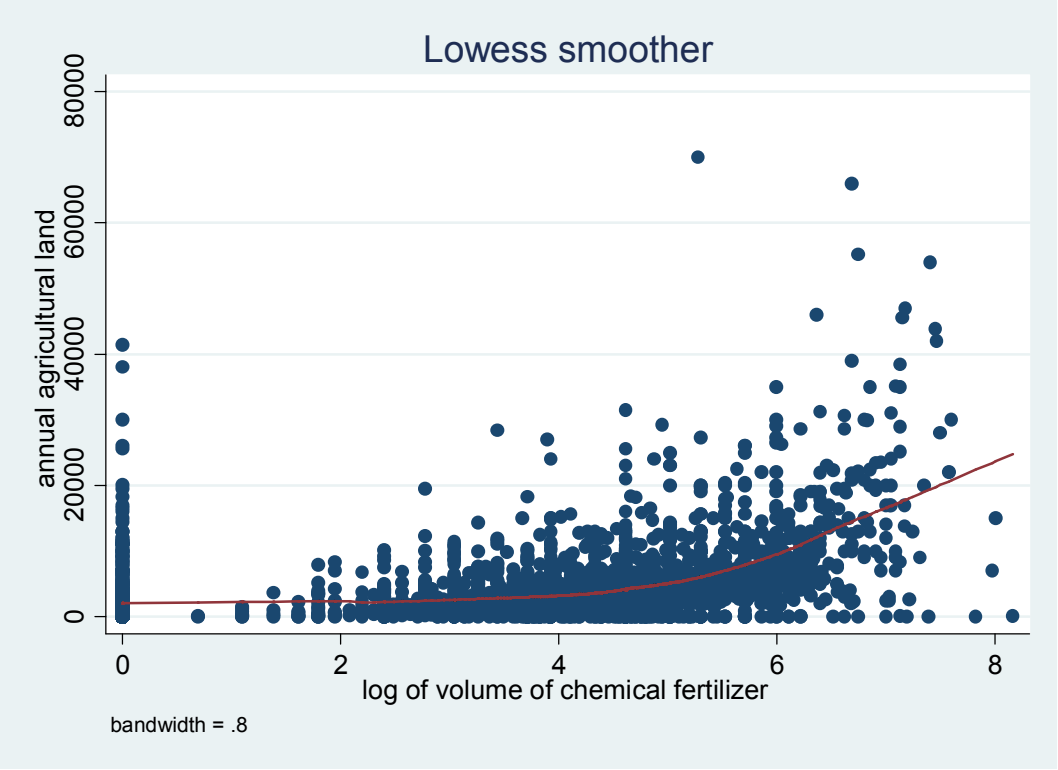

Table A1: first-stage regressions

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.

Table 2: The Impact on nonfarm participation of rural households (TOBIT model)

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	
	TOBIT	IVTOBIT	TOBIT	IVTOBIT	TOBIT	IVTOBIT	TOBIT	IVTOBIT	TOBIT	IVTOBIT	TOBIT	IVTOBIT
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log of volume of chemical fertilizer	-0.141***	-0.221***	-7.043***	-11.151***	-4.791***	-8.839***	-0.039***	-0.057***	-0.079***	-0.133***	-0.063***	-0.120***
	(0.019)	(0.034)	(0.951)	(1.691)	(1.022)	(1.625)	(0.004)	(0.007)	(0.010)	(0.018)	(0.014)	(0.024)
Year dummy	0.390***	0.410***	15.448***	16.456***	17.049***	18.062***	0.088***	0.093***	0.283***	0.296***	0.300***	0.314***
	(0.070)	(0.070)	(2.899)	(2.913)	(3.351)	(3.322)	(0.015)	(0.015)	(0.037)	(0.037)	(0.046)	(0.046)
Constant	-1.945***	-1.620***	-97.257***	-80.638***	-129.365***	-112.982***	-0.334***	-0.260***	-1.162***	-0.943***	-1.870***	-1.637***
	(0.442)	(0.441)	(17.847)	(17.359)	(15.240)	(14.857)	(0.097)	(0.095)	(0.214)	(0.211)	(0.203)	(0.198)
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

See the notes of Table 3.

Table 3: The impact of chemical fertilizer on farm activities (TOBIT model)

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	
	TOBIT	IVTOBIT	TOBIT	IVTOBIT	TOBIT	IVTOBIT	TOBIT	IVTOBIT
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log of volume of chemical fertilizer	0.273***	0.406***	24.643***	30.274***	0.042***	0.063***	0.450***	0.754***
	(0.019)	(0.034)	(1.627)	(2.245)	(0.004)	(0.007)	(0.084)	(0.131)
Year dummy	-0.162***	-0.180***	82.641***	82.000***	-0.023**	-0.026**	-2.062***	-2.099***
	(0.047)	(0.050)	(5.595)	(5.589)	(0.011)	(0.011)	(0.470)	(0.480)
Constant	0.703**	0.171	0.987	-21.506	0.290***	0.206***	-4.138***	-5.390***
	(0.298)	(0.304)	(21.412)	(23.098)	(0.066)	(0.067)	(1.099)	(1.227)

Observations	6,516	6,516	6,516	6,516	6,516	6,516	6,516	6,516		

See the notes of Table 3.

Table 4: Extended Heckman model

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***	-0.089***	-0.057***	0.372***	41.020***	0.057***	0.519***
	(0.026)	(1.485)	(1.283)	(0.005)	(0.012)	(0.015)	(0.045)	(2.794)	(0.007)	(0.129)
Year dummy	0.235***	9.209***	7.019***	0.047***	0.135***	0.091***	-0.070	90.740***	0.003	0.411***
	(0.065)	(2.959)	(1.988)	(0.011)	(0.029)	(0.021)	(0.059)	(6.035)	(0.009)	(0.154)
Sargan test (p-value)	0.306	0.262	0.359	0.234	0.262	0.292	0.541	0.640	0.591	0.452
Hausman test for endogeneity (p-value)	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.012
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	0.105	0.178	0.044	0.000

See the notes of Table 3.