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Abstract

In developing countries, when markets are incomplete migration can have multiple effects on agricultural production. In this paper, I use instrumental variables techniques to explore the effects of seasonal migration on agricultural production in rural Vietnam during the 1990s. Instrumenting migration with network variables specific to Vietnam, I find that migration shapes agricultural production is several ways. Although there are no effects of migration on aggregate production, there is weak evidence that migrant households move somewhat out of rice production and into the production of other crops. Inputs used by migrant households also decrease relative to similar non-migrant households. In exploring the mechanisms by which these changes occur, I find evidence consistent with a move from labor intensive into land intensive crops, rather than productivity changes or a shift from using labor to capital as an input.

Key Words: Migration, Vietnam, instrumental variables, agriculture, factor demands.

JEL: 013, O15, Q12, J62.

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Seasonal Migration and Agriculture in Vietnam

Although the migration of labor out of agriculture is a primary feature of the economic development process (de Haan, 1999; Taylor and Martin, 2001), the effects that migration can potentially have on the rural economy can be quite complex. Migrants typically continue to have economic interactions with the source households and communities they leave behind (Stark and Bloom, 1985), and these interactions are particularly important when markets do not function well. The literature on the effects of migration on source communities has studied migration as part of a household risk coping strategy (Rosenzweig and Stark, 1989; Paulson, 2000; Giles, 2006), as affecting different sources of income (Taylor, Rozelle, and de Brauw, 2003); and as affecting poverty and inequality within the villages or communities that migrants leave (Du, Park, and Wang, 2005; McKenzie and Rapoport, 2007).

Migration may also have direct effects on agricultural production in source communities. If rural markets function well, the effects of migration on agricultural production should be minimal. Households that send out migrants would be able to hire labor to substitute for the labor that migrants would have provided on the farm, and if necessary households could borrow money for inputs prior to production. However, if land, labor, or credit markets are incomplete, migration could have either positive or negative effects on household production. For example, if households cannot substitute for migrant labor, the loss of that labor could cause agricultural production to decrease. Alternatively, households might use less labor intensive technologies, or they might substitute land intensive for labor intensive crops. If households lack access to liquidity or credit, migrant remittances may help relax other constraints on agricultural production; as a result, household production or productivity may rise with migration. Therefore, the possible effects of migration on agricultural production are theoretically indeterminate and likely depend upon constraints and the relative values of specific inputs.

Although the theoretical justification that migration could affect agricultural production is well understood, little econometric research has examined at the direct relationship between migration and agricultural output or productivity. Lucas (1987) showed that temporary migration from several countries to South African mines led to decreased agricultural production in the short run, but enhanced agricultural productivity in the long run. Taylor and Wyatt (1996) find that remittances sent home to Mexico by migrants in the United States relieve constraints on household farm production. Rozelle, Taylor, and de Brauw (1999) find that in northeast China, migration is negatively associated with maize yields, but migrant remittances more than make up for the presumed lost labor effect. As a result, maize yields are higher for migrant households than for non-migrant households. More recently, Mendola (2005) found that international migration from Bangladesh leads to the use of better agricultural technology, but domestic migration does not have the same effect.

One reason that the literature is somewhat small may be that migration is not a randomprocess, and so unobservables that affect the migration decision almost certainly affect decisions regarding other household level outcomes as well. Therefore, it is difficult to convincingly identify the effects of migration on household level outcomes in source communities. Recently, authors have begun to use identification strategies for migration based on two sources of plausibly exogenous variation. To identify the size of migrant networks among Mexican laborers in the United States, Munshi (2003) used lagged weather shocks to villages in Mexico. Hildebrandt and McKenzie (2005), Woodruff and Zenteno (2007), and McKenzie and Rapoport (2007) all use variation in the time to completion of rail lines from the United States into Mexican states in the early 1900s to identify migration to the United States on various outcomes. They all argue that rail lines facilitated the creation of networks to the United States use varying time to completion of rail lines in the early 1900s, and the quality of the network was affected by the arrival of these rail lines.

In this study, I will use historical trends in conjunction with institutional features unique to Vietnam in order to identify the effects of seasonal migration on agricultural production. In Vietnam, many people were relocated after the War ended in 1975, and migration was severely restricted. People born in either Hanoi or Ho Chi Minh City prior to the restricted period may have contacts in those cities that became useful again once restrictions on migration were lifted. Therefore, people who live in communes that have more members born in the city may have advantages in migration over members of other communes.

Vietnam is a particularly good place to study the effects of migration on agricultural production. Vietnam's economy has grown rapidly since the late 1980s, which has translated to significant improvements in living standards. One apparent strategy among households to improve their living standards has been to increase seasonal migration (de Brauw and Harigaya, 2007). Benjamin and Brandt (2004) show that rural income growth can be traced in general to agricultural growth and specifically growth in rice production. Most rural households are engaged in agricultural production, as they have access to land through the communes. However, rural labor markets are thin in Vietnam, and households primarily depend upon their own labor for farming. Although land rental markets began to develop during the 1990s (Ravallion and van de Walle, 2006), land rental was not terribly frequent by the late 1990s. Furthermore, most land rights development took place in1998, after the data used in this study were collected (Do and Iyer, 2005). In sum, Vietnam's agricultural sector is characterized by small household producers facing significant constraints on production, which is exactly the setting in which migration could have effects on agricultural production.

The objective of this paper is to understand the effects of seasonal migration on agricultural production in Vietnam. Empirically, I initially explore how migration has affected rice and other types of agricultural production. To understand how and whether migration has affected production technology, I also explore the effects of migration on agricultural factor demands. To meet the objective, the paper will be organized as follows. The first section introduces and discusses the data set used in the analysis. The second section introduces the empirical methodology and the instrumentation strategy for migration. The third section presents the econometric results and discusses the findings, and the fourth section concludes.

1. Data

For this study, I use data obtained from the Vietnam Living Standards Survey (VLSS), conducted in 1992-93 and in 1997-98 by the World Bank in collaboration with the Vietnam State Planning Committee and the General Statistical Office. The VLSS is a comprehensive nationwide survey consisting of two main parts: a household survey and a commune level survey. The household survey collected information on multiple aspects of living conditions, including individual-level education, off-farm employment, on-farm labor, migration, and household demographics. To learn about participation in migration by households, I use a specific module asked in both surveys about whether any household members left the household for some period of time to work. The module also asked whether people were born outside of the commune they were living in.

To learn about agricultural production, both surveys included detailed sections on agricultural production and inputs. Much of the enumeration of inputs did not occur at the crop level, so many of the variables must be aggregated to the farm level. These inputs include family labor, hired labor, pesticides, insecticides, the rental of machinery or custom services, and seeds. Other inputs can be measured at the crop level, such as fertilizer and land area.

Although the two survey forms were generally quite consistent with one another, they had a few important differences for my purposes. One primary difference is that the land section of the form changed significantly between rounds of the survey, as the 1997-98 survey asked more detailed questions about specific land uses. For example, it asked about the area and irrigation status of each specific plot, whereas the 1992-93 survey asked about the total area and irrigation status of each broad type of land (e.g. annuals, perennials). Because of the format of the 1992-93 form, it is not possible to estimate a yield response function; as a result, I must either estimate agricultural production functions (e.g. output on inputs) or reduced form agricultural production functions (e.g. output on prices). The forms also did not differentiate about the land rights for specific plots, so one might argue that farmers are making choices about the amount of land to farm, through rentals. Although possible, land transactions are small relative to the total land holdings of households (Deininger and Jin, 2004; Ravallion and van der Walle, 2006). I use two different measures of land holdings; the total amount of land planted in annual crops, and as the total amount of land farmed by the household.[1]

The commune-level survey provided further information on local living conditions and prices. For this paper, I used several parts of the commune-level survey, including information on the proportion of the commune workforce that was migrating in 1992, the price of rice in commune-level markets, the distance of the commune from market centers and roads, and measures of general commune economic characteristics.

The 1992-93 and 1997-98 surveys have quite different sample sizes and geographic compositions.[2] The sample of 4799 households in the 1993 survey was chosen to be nationally representative and self-weighting, but the 6000 households in the 1997 survey include over 1500 households that were added from another survey to replace households that were not tracked from the 1993 survey (World Bank, 2001). In total, 3492 rural households were included in both surveys, and for this analysis I construct a panel of 3109 rural households that reported farm income in both surveys. Of those households, 2602 produced rice, by far the most households reporting producing a specific crop.

[1] The results in the paper are robust to using alternative definitions of the land area under cultivation.

[2] Both rounds of the VLSS took place over the course of a calendar year. To avoid labeling confusion, from this point on I will use the year 1993 to refer to the 1992-3 survey and 1998 to refer to the 1997-8 survey.

Although the 1993 sample could be considered self-weighting if attrition could be considered random, summary statistics on various agricultural variables measured in panel and non-panel households in 1993 indicate significant differences. Households that left the sample were somewhat less involved in agricultural production than the panel households (Table 1). Revenues and input use appeared to be somewhat lower in the households that left the sample than those that were re-interviewed in 1998. As a robustness check, I implement a procedure that correcting for potential attrition bias in the basic output functions (Wooldridge, 2002).

Agricultural Growth in Vietnam

Vietnam's agricultural sector, led by increases in rice production, experienced dramatic gains between the two rounds of the VLSS survey (Table 2). Average household production of rice increased from 2268 kg in 1993 to 2927 kg in 1998, and prices increased overall as well (Benjamin and Brandt, 2004). As a result, expressed in January 1998 Vietnamese dong average total household farm revenue increased by 38%, from 5.73 million to 7.89 million dong per annum, on average. When rice is removed from revenues, the remainder rose somewhat more slowly, by 31%, but the number of households growing crops other than rice increased. Rice accounted for an average of 70% of agricultural revenue in both surveys, and so rice is clearly the most important crop for farm households in Vietnam.

Without providing a complete growth accounting for agricultural output, it is still clear that some inputs increased dramatically while others did not. As discussed by Benjamin and Brandt (2004), fertilizer use increased dramatically in Vietnam during the 1990s, catalyzed by liberalized fertilizer trade between north and south Vietnam. Among households in the VLSS, the total amount of fertilizer used increased from 308 to 514 kg on average, or by over 66%. Meanwhile, the amount of labor days reported worked decreased slightly among both men and women. Among men, the average decreased by about 60 days, whereas it declined by 50 days among women. Therefore farmers appear to have increased output by using more fertilizer while using their labor more effectively. The share of land holdings that was irrigated also increased, from just under half to six-tenths of the land, on average, implying that additional water inputs may help account for agricultural output growth.

Seasonal Migration in Vietnam

I follow de Brauw and Harigaya (2007) and define seasonal migrants as members of the household who left for part of the year to work, but are still considered household members.[3] Seasonal migrants typically indicated that they were away between busy

[3] I analyze seasonal rather than long-term migration for pragmatic reasons. The surveys explicitly included questions about migration by household members during the past 12 months, where household members were defined as individuals who normally live and eat their meals in this household (World Bank, 2001). To consider permanent migration, I would have had to infer additional information about individuals who were not considered household members by the survey protocol. Since I cannot discern whether migrants who were away from the household at the time of the survey will return, a few permanent migrants may be included as seasonal migrants.

seasons on the farm; in the 1998 survey data, they were away for an average of 4.6 months. As found in much of the literature on rural-urban migration in the world, seasonal migrants in Vietnam tend to be younger, well-educated men when compared with other household members (Table 3). Over half of the seasonal migrants in the sample were between the ages of 20 and 40. Furthermore, the average seasonal migrant in the 1998 sample has 6.8 years of schooling, while non-migrants have an average of 5.9 years of schooling.[4] Migrants are also twice as likely as others to have some vocational training.

The number of households in the full panel sending out seasonal migrants increased from 65 to 369 between 1993 and 1998. Migrant households are measurably poorer than the average household in the sample; average per capita expenditures in 1998 for migrant households were lower than the sample mean (1740 thousand dong, versus 2360 thousand dong). In general, migrant households have lower per-capita expenditure levels than the sample mean (1740 thousand dong in 1993). Migrant households are generally from communes in specific geographic areas. In 1998, over 20% of households in coastal areas and "hills/midlands" had at least one seasonal migrant (rows 4 and 6). In contrast, few migrants left high mountainous areas; only 2.4% of rural households had a migrant in 1998. The lack of mobility in high mountainous areas is likely due to underdeveloped transportation networks and limited off-farm employment opportunities. This point is somewhat corroborated by the fact that migrants tend to go to Hanoi or Ho Chi Minh (HCM) City; over one-third of migrants in the 1998 survey reported going to one of the two major cities. Thus, the typical migrant household can be characterized as a relatively poor household residing in lower lying areas, which may have more developed social networks through which to migrate.

When I compare the change in agricultural production and input use between surveys in households that increased their participation in migration (migrant households) with other households, I find small but noticeable differences in summary statistics (Table 4). In general, migrant households appear to have grown their agricultural output somewhat more slowly that non-migrant households. For example, the change in the value of total farm output is approximately one million dong lower in migrant households than non-migrant households (rows 4-6). Migrant households also appear to have added less fertilizer than non-migrant households, have decreased the labor input in farming more than non-migrant households, and used slightly less land in 1998 and than in 1993, while non-migrant households appear to have increased the amount of land they are using on average. However, these summary statistics do not account for many of the differences between migrant and non-migrant households discussed above, nor others. Outliers could also affect the means. In the empirical section, I control for regional differences and all input and output variables are expressed in logarithms to minimize the effect of outliers.

[4] This difference can wholly be accounted for by differences in the average ages of the two groups.

2. Methodology

Agricultural production in Vietnam is difficult to summarize in a succinct manner. The VLSS collected information on over 60 different crops grown in Vietnam, detailed information on the use and cost of several different types of fertilizer, and comprehensive information on other costs incurred by households while farming. Since rice accounts for the majority of agricultural production by value, it is sensible to disaggregate total production into rice and all other crops. Total agricultural revenue is simply calculated by aggregating the production of all crops, weighted by their respective prices.[5]

One can think of agricultural production generally as $Q = f(\mathbf{L}, A, F, \mathbf{X}, \gamma)$, where Q is the amount produced; **L** represents different types of labor; A represents land area; F represents fertilizer, and **X** represents other inputs, such as seed, fertilizer, pesticides, herbicides, and machinery rental. The variable γ represents any other factors that are either unobservable to the analyst or are random. Assuming that unobservable factors are orthogonal to the random shocks farmers face, one can write $\gamma = \theta + \varepsilon$, where θ represents unobservable factors and ε is a random error term.[6] Assuming that farmers maximize profits, one typically learns about the production process by first choosing a functional form for the production function, and then an estimation procedure. One method would be to estimate the production function directly; an alternative is to appeal to duality theory and estimate output or inputs as a function of reduced form prices.

From the perspective of the farm production problem, an increase in the availability of employment in distant markets acts like a price faced by the households, rather than as a production input. Essentially, a measure of migration reflects the net wages in distant markets. Therefore it is sensible to test for the effect of migration on production in what would be the reduced form of the agricultural production function, derived from the cost minimization problem. To choose a functional form, I initially plot changes in the logarithm of rice production against changes in the logarithm of four inputs: male labor days, female labor days, total chemical fertilizer used (in kg), and annual land (Figure 1). The functional form implicit in these figures is a Cobb-Douglas production function, and many of the lowess plots are essentially linear, implying that the assumption of a Cobb-Douglas production function may not be a bad one.[7] The land variable exhibits what could be systematic curvature, but the other variables appear approximately linear for most of their range.[8]

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[5] As a significant portion of agricultural output is self-consumed in Vietnam, I use unit values as the price weights for aggregating agricultural production. When a household did not sell a particular crop, the median unit value for the commune was used, and when that was not available, the median regional or national price was used instead. All values and prices in this article have been adjusted for differences in both spatial price differences and differences in the timing of the survey.

[6] It is easy to think of unobservables that affect the farm production process, such as farmer ability and soil fertility.

[7] A similar figure, not shown here, was also produced for changes in levels rather than logs, and it exhibited a great deal of curvature.

[8] Although using a more flexible functional form might seem desirable, price data is not available for many of the inputs and so I cannot derive the budget shares I would need to use as dependent variables in the factor demand equations.

Although one could in theory try to estimate a more flexible functional form such as a translog (Christensen, Jorgensen, and Lau, 1973), the primary difficulty is that prices for many of the inputs cannot be estimated or simply are not available. Solving the cost minimization problem using the translog functional form results in regressing expenditure shares for various inputs on prices, and budget shares are impossible to compute if some inputs lack prices. Since the Cobb-Douglas form seems reasonable for most of the inputs and budget shares cannot be computed, I choose to work with the Cobb-Douglas form in the remainder of the paper.[9]

Reduced Form Estimation of Production and Factor Demands

Since the availability of work as migrants is best considered as a price facing the household, I use the reduced form equations derived from the dual cost minimization framework. Consider that farm production uses **N** inputs and prices *w* are available for all of the inputs. To remove the unobservable farmer effects, one could simply estimate the effect of prices on output in differences, and the estimating equation can be written:

$$\Delta \ln Q_{ivr} = \beta_{vr} + \sum_{j=1}^{N} \beta_j \Delta \ln w_{ivr}^{j} + \beta_p \Delta \ln p_{ivr}^{j} + \Delta \varepsilon_{ivr} \quad (1)$$

where *i* indexes households, *v* indexes communes, and *r* indexes regions. As two periods of data are available in the context of this paper, all time related effects are removed by differencing. The intercept, β_{vr}, is for now assumed to vary at the commune level, and *p* represents the output price. For rice production, I will use the median price recorded in the commune level market survey, and I omit the output price in regressions on the value of farm output.

Of the major farm inputs used in Vietnam (labor, land, and fertilizer), only fertilizer has a well-defined price; here, I use the household level unit value as a price for fertilizer. Household labor inputs into farming may vary by the human capital of the resident doing the farming; therefore I proxy for wages using the demographic composition of the household, omitting children under 5 who do not work on the farm.[10] The categories I use are men over 60 years of age, women over 55, men aged 18 to 59, women aged 18 to 54, and children aged 6 to 17.[11] I simply continue to include a variable

[9] I estimated the production function using both a Cobb-Douglas and a translog production function for the primary inputs, using a differenced estimator to control for unobserved heterogeneity at the household level and commune level effects to control for differences in productivity growth. I could not reject the hypothesis that the additional coefficients suggested by the translog functional form were jointly significant, and moreover the additional coefficients violated curvature assumptions, as the literature suggests is often the case (e.g. Westbrook and Buckley, 1990).

[10] It might also be sensible to use the educational background of the household as another proxy for the human capital endowed to the household; however, the education of the adults in the household is absorbed into the household level unobserved variable that is removed through differencing. A differenced schooling variable would only measure schooling among new adults or schooling accruing to children, depending upon the variable definition, and would have a murky relationship with agricultural production. Since the clear effect of schooling or other training is therefore largely accounted for through differencing, it is sensible to omit a further measure.

[11] I use these categories as results with more categories did not differ qualitatively. It is important to account for children as child labor is employed in agriculture in Vietnam, although its prevalence decreased

measuring the amount of land used to proxy for its value. When I include variables on other farm expenditures, they are also simply measured as values.

Accounting for these changes to equation (1), one can write:

$$\Delta \ln Q_{ivr} = \beta_{vr} + \beta_M \Delta M_{ivr} + \sum_{j=1}^{M} \beta_j \Delta X_{ivr} + \beta_f \Delta \ln w_{ivr}^{f} + \phi \bullet \Delta Z_{ivr} + \Delta \varepsilon_{ivr} \qquad (2)$$

where *M* represents migration, *X* represents demographic groups within the household, and **Z** represents other factors that affect output, such as the share of land irrigated or other farm costs. Our parameter of interest here is β_M, or the effect of migration on agricultural production.

If equation (2) is estimated using OLS, the coefficient estimate $\hat{\beta}_M$ would almost certainly be biased, since unobservables at the household level are likely correlated with both decisions the household makes about migration and agricultural production. Conceptually, the sign of the bias is indeterminate. If migrants leave in response to unobserved negative production shocks, then one might expect a negative bias on the coefficient on migration. Alternatively, if migration is correlated with unobservables related to improved transportation network access over time, then the estimate will exhibit positive bias. Therefore, to consistently estimate β_M, I must use an instrumental variables framework, and find instruments **W** that are correlated with migration but are not related to agricultural inputs or outputs, except through their influence on migration.

Instrumenting for Migration

To instrument for migration, I use a strategy based on migration networks similar to the one employed by de Brauw and Harigaya (2007). Migration networks increase the amount of information about migrant opportunities that households with access to migration have, lowering the costs of migration (Stark, 1991; Carrington et al, 1996). My first measure of networks is the percentage of the commune that was seasonally migrating in 1992 from the commune level survey. Restrictions on movement were removed just before 1992, and migrants who left soon after restrictions were lifted may have given members of those communes an advantage in subsequent migration.[12] We complement this measure of the network with a variable more unique to Vietnam. Prior to the end of Vietnam's independence war, people moved around a great deal (e.g. Ngo, 2006), but movement became restricted immediately thereafter. As a result, many people live in communes in which they were not born; in the 1997-98 VLSS, 23% of residents were born outside of their home commune (Lucas, 2000). People who were born or had lived in either Hanoi or Ho Chi Minh City before the war ended might be more likely to have either contacts or family in the city, making them or members of their households particularly good candidates to move to one of those cities. Therefore, as an additional instrument we use the share of household members who were born or had lived in either

over the 1990s (Edmonds and Turk, 2004).

[12] This variable is similar to one that has been used elsewhere in the literature to identify migration (e.g. Rozelle, Taylor, and de Brauw, 1999; Taylor, Rozelle, and de Brauw, 2003). It is particularly useful in this context because the network is a new one and would not have been affected by factors that might influence the quality of an established migration network, as argued by Munshi (2003).

Hanoi or HCM City in each household, prior to 1975. Both variables are measured in the 1992-93 VLSS.

Since neither instrument is randomly distributed across communes, one might be concerned that one of the instruments might affect agricultural output or input decisions more directly. For example, villages with early migrant networks could have had better access to markets at the beginning of the 1990s, and therefore agricultural production or input use might be related to the migrant networks in those communities. We might further be concerned that individuals who were born in Hanoi or HCM City might have had access to better schools, therefore affecting decisions made about agricultural production or input use. To attempt to address these concerns, I regress the instruments on a number of observable variables that proxy for variation in levels of market development. All of these variables are measured at the commune level in 1993 (Table 5). There appear to be no significant correlations between any of the commune level observables and the share of out-migrants in 1993 (column 1). The *p*-value for the *F* statistic testing the null hypothesis that the estimated coefficients on the commune characteristics are jointly zero is 0.498, which implies that these variables are jointly uncorrelated with the network instrument.

The share of the household born in either Hanoi or HCM City is negatively correlated with the distance of the commune from Hanoi or HCM City, but there are only a few weak correlations between other variables in the model and the instrument (column 2). The finding about the distance variables is sensible, as people likely did not move that far out of the cities when they moved. Almost all of the other variables, however, have estimated coefficients that are not statistically different than zero. The only exception is the presence of electricity in the commune in 1993, which has a positive correlation (significant at the 10 percent level) with the born in Hanoi/HCM City variable. However, once again I cannot reject the hypothesis that coefficients on all of the variables other than the distance from Hanoi/HCM City variables are zero; in this regression, the *p*-value on the *F* statistic is 0.292. Therefore I test whether the results in the paper are robust to including the electricity dummy variable as well as the distance variables. These variables would represent the effect of each variable on growth in the dependent variable being used in a specific regression rather than the level effect. Since both of the instruments appear not to be correlated in general with specific observable commune level variables related to market development, they remain good instrument candidates.

The next important characteristic of good instruments is that they must be strongly correlated with the endogenous variable they will instrument. To learn whether or not the instrument candidates have a strong relationship with migration from the household, I regress the change in the number of migrants on the two instrument candidates (Table 6). In all five specifications shown, the two instruments both have a positive relationship with the change in the number of migrants from the household, and the estimated coefficients are both individually significant at the 5 percent level. Furthermore, the cluster corrected *F* statistic testing the hypothesis that the coefficients on both instruments is zero ranges between 9.4 and 12, all of which are near or exceed Stock and Yogo (2002)'s critical values for weak instruments. In all four cases, the results do not depend upon whether or not I use the full sample in estimation (columns 1 and 2) or the subsample of households that grew rice (columns 3 through 5). Therefore we can be reasonably sure that the instruments are strong and the estimated coefficients from an instrumental variables regression will only be minimally biased towards the OLS estimates. Before I can estimate the effect of migration on agricultural production, I have a final concern. One of the instruments is measured at the commune level, so actually estimating equation (2) would be impossible as the commune level intercepts, which measure differences in agricultural growth across communes, would be collinear with the instrument.

Therefore I adopt the following strategy. I use regional dummies in all specifications, and in some specifications to account for differences in agricultural growth across regions.[13] Additionally, in some specifications I add a vector of commune level variables measured in 1993 to control for potentially important commune level differences, including those that were correlated with the Hanoi/HCM City instrument. The variables used include the distance to Hanoi and HCM City, respectively, an indicator variable for electricity in the village, and whether or not rice grown in the commune was sold at markets in 1993. Mathematically, I replace $\beta_{vr} = \beta_r + \theta \bullet \mathbf{C}_{vr}$, where **C** is the vector of commune level characteristics that may affect changes in agricultural growth, and I will estimate:

$$\Delta \ln Q_{ivr} = \beta_r + \beta_M \Delta M_{ivr} + \sum_{j=1}^{M} \beta_j \Delta X_{ivr} + \beta_f \Delta \ln w_{ivr}^{f} + \phi \bullet \Delta Z_{ivr} + \theta \bullet \mathbf{C}_{vr} + \Delta \varepsilon_{ivr} \qquad (3)$$

3. Econometric Results

To learn about the effects of migration on agricultural production, I estimate equation (3) using an instrumental variables, Generalized Method of Moments (IV-GMM) estimator. The weighting matrix used in the GMM estimator accounts for arbitrary heteroscedasticity and intracluster correlation, and it is asymptotically efficient in the presence of heteroscedasticity (Wooldridge, 2002; Baum, Schaffer, and Stillman, 2003). For all specifications, I report the cluster corrected *F* statistic for the excluded instruments in the first stage, and the Hansen *J* statistic, which tests whether the overidentification restrictions are valid.

The Effect of Migration on Agricultural Output

Since the most important agricultural product in Vietnam is rice, I first use total rice production as the dependent variable in equation (3) (Table 7). As I cannot correct for selection into rice production, the results presented here should be considered conditional on producing rice.[14] In general, the estimator performs well as covariates are added; the estimated coefficients on the control variables have the expected sign and are almost all statistically significant (columns 2-4). Additional members of all demographic groups other than elderly women are associated with increases in rice production. Variables related to prices and inputs have sensible estimated coefficients. Higher fertilizer unit values are associated with decreases in rice production, indicating that household

[13] I also include terrain dummies in all specifications.

[14] There is not an obvious candidate for an instrument that would be correlated with the decision to produce rice but would not affect the amount of rice actually produced.

production responds to price increases on inputs. On the other hand, additional land and specifically the share of land that is irrigated both have strong, positive effects on production. Finally, higher expenditures on seeds, insecticides and pesticides, hired labor, and machinery rental have a positive association with rice produced, indicating that the amounts used dominate any price effects in the variable.

Variables related to prices and inputs have sensible estimated coefficients. Higher fertilizer unit values are associated with decreases in rice production, indicating that household production responds to price increases on inputs. On the other hand, additional land and specifically the share of land that is irrigated both have strong, positive effects on production. Finally, higher expenditures on seeds, insecticides and pesticides, hired labor, and machinery rental have a positive association with rice produced, indicating that the amounts used dominate any price effects in the variable.

Although the point estimates for the effect of migration on rice production are negative and large in all four specifications, they are only marginally statistically significant in two of the specifications (columns 1-4).[15] The point estimates imply that among households likely to respond to migrant networks, an additional migrant is associated with between 24% and 39% less rice production. Although these estimates may seem large, it is probably best to interpret them in one of two ways. One could interpret the estimates as local average treatment effects (Angrist and Krueger, 2001), which implies they only apply to those households likely to respond to changes in the intensity of migrant networks. The effects are quite large among such households. Alternatively, one could interpret the coefficients as elasticities. The elasticities implied by the top and bottom of the range are −0.029 and −0.046 at the mean level of migration in the sample. At the mean, rice production is relatively inelastic to migration.

As rice production grew rapidly on average between the two surveys (Benjamin and Brandt, 2004), these results at least suggest that holding other factors constant, migrant households may have had less incentives to boost rice production than non-migrant households. The estimated coefficient is statistically significant at the 10 percent when controlling for demographics and prices (column 2) and when the irrigation and "other expenditures" variables are added (column 3), but lose their significance when the commune characteristics are added (column 4). This result highlights the need to continue to control for additional commune characteristics, since some of them are correlated with at least one of the instruments.

If we assume that the above results are suggestive of a decrease in rice production among households likely to respond to migrant networks, households could be responding to migrant opportunity in several different ways. An initial question one might ask is whether or not aggregate production or revenue is changing. Although 70% of farm revenue is from rice (Table 2), aggregate farm revenue may respond differently than rice production or revenue to changes in migration. If aggregate farm revenue

[15] I include the OLS coefficients in Appendix Table 1. In general, it seems that OLS coefficients on rice and fertilizer exhibit positive bias, whereas they exhibit negative bias for total production and non-rice production. Although the difference between the coefficient estimates in several cases is quite large, to some extent this difference reflects the difference between the average effect of migration on the entire sample (the OLS coefficient, which is biased) and the effect on those likely to respond to migrant networks (the IV coefficient, which is unbiased).

decreases with migration, households may be moving completely out of agriculture as they begin to participate in migration. On the other hand, if revenue is the same or increasing with migration, it would suggest that households change their crop mix in response to migration.

To examine the effects of migration on aggregate production, I regress the logarithm of total agricultural revenue on migration and covariates (Table 8, columns 1-3). Whether I include only demographic characteristics (column 1), demographic characteristics and variables reflecting prices (column 2), or all of the variables included in column 4 of Table 7, I find no evidence of a statistically significant relationship between migration and total agricultural revenue. However, the point estimates are all positive, which would suggest that some households are changing their crop mix in response to migration if they are decreasing rice production.[16]

To test whether households change their crop mix in response to migration, I separate out the value of rice production and regress the logarithm of the value of all other production on migration (Table 8, columns 4-6). Conditional on growing crops other than rice, I find a positive, statistically significant effect on the value of all other production, regardless of the covariates used. The point estimates are all between 1.6 and 1.75, corresponding to elasticities with respect to migration between 0.19 and 0.21. Although the statistical evidence that migrant households reduce rice production is not strong, conditional on growing other crops migrant households appear to increase their output of other crops. Interpreted as a local average treatment effect, the effect of migration on the crop mix is quite strong, and one can conclude that households participating in migration begin to grow more of crops other than rice.

There are several possible explanations for the positive effect of migration on the value of non-rice crop production. First, it could be that households are able to overcome constraints faced in producing higher valued crops, and they use migration to facilitate investment in those crops. This hypothesis would be indicated by a shift towards purchasing additional inputs for crops other than rice. Households could be overcoming constraints they faced in producing higher value crops, and use migration to facilitate investment in those crops. Alternatively, due to the decreased amount of available labor, households may choose to leave the production of a relatively labor intensive crop, rice, to produce more relatively land intensive crops. One would then expect to see less inputs used by migrant households than similar non-migrant households. In the next subsection, I examine these explanations.

Before beginning to examine changes in input demand, it is important to understand whether potential attrition bias has affected the results. As noted previously, households dropping out of the sample after the 1993 survey appeared systematically less involved in farming than households remaining in the sample. To test whether attrition bias affects the results, I implement a procedure detailed in Wooldridge (2002) (Table 9). I first regress a number of characteristics about the households in the 1993 sample on an indicator variable that denotes panel households, and then I predict probabilities that each household stays in the sample. These probabilities are used as probability weights in estimation. The point estimates for the effect of migration on production are virtually the

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[16] Note that there is no need to drop households in these regressions, since all farm households are included. Therefore these results are not conditional on first participating in any specific type of production.

same as those found in Tables 7 and 8, indicating that the results are robust to potential attrition bias.

In summary, migration appears to have affected on agricultural production in Vietnam during the 1990s. This finding is only clear when examining crudely disaggregated statistics on production, as migration appeared to have no statistical effect on the total value of farm production, at least among households likely to respond to migrant networks. Among these households, I find weak evidence that migration decreased rice production, while revenues from other crops rose sharply.

Effects of Migration on Agricultural Inputs

The results explaining the determinants of agricultural production do not consider how households may have changed the relative intensities of agricultural inputs in response to migration. To learn about whether migration has affected input demands, I simply use various inputs as the dependent variable in equation (3), as the unconstrained solution to the cost minimization problem implies the same functional form for factor demands as for the supply response equation. Again recognizing that rice is the most important crop grown by revenue, I attempt to explain the variation in both fertilizer used on rice and the total amount of fertilizer. I also attempt to explain variation in the labor days worked by men and women.

Among households likely to respond to migrant networks, fertilizer use responds negatively to migration both for rice production (Table 10, column 1) and for all crops (column 2). As with the value of non-rice production, the point estimates are quite large, indicating a large effect among households likely to respond to networks. The estimated coefficients are both statistically significant and correspond to rice and total fertilizer demand elasticities of –0.12 and –0.10 with respect to migration at the mean amount of migration in the sample, respectively. As a result, it does not seem that migration is helping households overcome constraints on high value production; if so, we would have presumably found a positive coefficient on fertilizer demand for crops other than rice.

Other estimated coefficients in the fertilizer regressions are reasonable in sign, magnitude, and significance. For example, the price elasticity of demand is –0.7 and –0.8, respectively, and both are quite precisely estimated. Finally, the difference between the estimated coefficient on migration in the rice fertilizer equation (–0.98) and the estimated coefficient in the all fertilizer equation (–0.78) is consistent with the findings for output. If households are substituting out of rice production in response to migrant networks, then their total fertilizer purchases should not respond as much as their fertilizer purchases for rice.

Households likely to respond to migrant networks also decreased their labor involvement in agriculture more significantly than other households (Table 10, columns 3 and 4). The estimated coefficient is somewhat larger in absolute value for men (–1.11) than for women (–0.66), though both are statistically significant at the 5% level. Other estimated coefficients have quite sensible magnitudes; for example, the presence of additional men either over 60 years of age or between 18 and 59 years of age have larger effects on the number of days worked by men than by women, whereas the exact opposite is true for labor days worked by women. Therefore, migrant households likely to respond to migrant networks appear to put less labor into farming than comparable non-migrant households, ceteris paribus. There are two potential explanations for this finding. First, the shadow value of time rises for households with migrants who have left, and therefore they are likely to have substituted more away from labor. As many of the tasks in rice production are traditionally labor intensive, household rice production may have dropped slightly as a result of the decreased labor intensity of farming in those households, as weakly suggested by the results in Table 7. Alternatively, it could be that the shadow value of time has increased among migrant households relative to non-migrant households, and so they report time spent farming more accurately, as it is the default activity for many rural residents. Households with more valuable time might have answered questions about time spent farming more precisely than households with less time pressure on their activities. It is impossible to disentangle these two explanations.

Migration and Effects on Agricultural Production: Mechanisms

Results in Tables 7, 8, and 9 suggest that the use of several inputs is lower among migrant households, while the value of crop production for crops other than rice is increasing. Furthermore, migrant households do not appear to be using migration in order to overcome constraints on production. There are three good explanations for these findings that merit further consideration. First, migrant households could be using other labor saving technologies by substituting capital for labor, specifically by renting more machine services. Second, households could be shifting from relatively labor intensive crops (such as rice) into relatively land intensive crops. Third, it could be that migrant households have inherently had a larger increase in total factor productivity that other households. Although all three hypotheses are difficult to test cleanly, I can provide suggestive evidence about all three.[17]

A primary way that households might take advantage of labor saving technologies is by renting machinery to accomplish tasks formerly done with labor. However, only a third of households in the sample rented machinery or machine services in 1993, so the base is quite small, and regressions conditional on using machine services in both years (or at all) may not be terribly meaningful.

However, the number of households using machine services did increase to approximately two thirds of the sample by 1998. To measure whether or not this increase was related to migration, I constructed a dummy variable that is one for any households that increased machine rental expenditures between 1993 and 1998, and was zero otherwise. I then used the dummy variable as the dependent variable in equation (3) and the specification in column 4 of Table 7. The coefficient on the migration variable was 0.05, and it was not statistically different from zero, so it does not appear that migrant households increased their machine rentals relative to non-migrant households.

Second, households may have shifted from rice into more land intensive crops. I test this hypothesis by separating the land intensive crops, including grains other than rice

[17] Another possible hypothesis is that migrant households shift from crop production in general into livestock production. I computed the number of tropical livestock units owned by each household at the time of the survey, and regressed the change in tropical livestock units owned by the household on the instrumented migration variable. The estimated coefficient on migration was positive, small, and statistically no different than zero, indicating that migration does not affect livestock production.

and legumes, from labor intensive crops, such as perennials and others.[18] Although it is simple to estimate this relationship, I cannot control for selection into farming these crops, so the results are conditional on growing land intensive crops. When I regress the change in the logarithm of the value of land intensive crops grown on the set of explanatory variables in column 4 of Table 7, the point estimate of the effect of migration on annual crop value is 1.75, with a standard error of 0.58. This coefficient estimate is quite similar to the one estimated when the total-value of non-rice crops was used as a dependent variable, and the two results together are broadly consistent with a shift into land intensive crops.

Third, it could be that migration leads to greater total factor productivity. I cannot directly test whether total factor productivity at the household level has increased. However, I can test whether total factor productivity at the commune level increased faster in communes with access to migrant networks than those that did not. To test this hypothesis, I first regressed the logarithm of rice production on fertilizer, land, male labor, female labor, and other expenditures, in a Cobb-Douglas framework, differencing out household fixed effects and allowing the constant in the model to vary at the commune level. In this regression, the constant represents the change in total factor productivity at the commune level. I next saved the constants and regressed them on the two migration instruments (using the mean share of the household born in Hanoi or HCM City at the commune level as the second instrument), a vector of commune characteristics, and regional dummy variables. Neither of the two migration instruments had an estimated coefficient that was statistically significant, so it is safe to conclude that there is no evidence total factor productivity increased any faster in communes with access to migrant networks than in communes without access.

Taking these three tests in combination with the earlier results, it is now possible to trace out the effects of migration on agricultural production. Migrant households have decreased inputs relative to non-migrant households, and appear to have shifted at least on the margin from growing more labor intensive to more land intensive crops. These changes have not affected the total revenues of migrant households relative to non-migrant households, holding other factors constant. There is no evidence that migration has led to capital substituting for labor or to total factor productivity increases in agriculture.

4. Discussion and Conclusion

In this paper, I have explored the relationship between migration and agricultural production using a panel of households in Vietnam. To instrument for migration, I used two variables to measure the strength of migrant networks to which households in rural Vietnam are exposed: the share of migrants from their communes in 1992, and the share of the household born in either Hanoi or HCM City. Although the instruments are not randomly distributed, I could not find observable variables that measured market development and hence might have rendered the instruments poor ones.

In general, migration had complex, subtle effects on agricultural production.

[18] I use all "annual" crops other than rice as my definition of land intensive crops.

When
I disaggregate the total value of production, I find weak evidence that migrant households decrease rice production, and strong evidence that they shift into more land intensive crops, ceteris paribus. Migration also affected farming inputs. Households with access to migrant networks put less fertilizer on their crops, and used less labor days in farming than households without. These changes did not preclude migrant households from participating in the large income gains experienced in the agricultural sector during the 1990s (Benjamin and Brandt, 2004), which is consistent with findings that migration helped households improve their living standards (de Brauw and Harigaya, 2007). All of the effects of migration described in this paper are probably quite subtle in the aggregate. Between 1993 and 1998, migration increased approximately sixfold, but only 10 percent of rural households in the VLSS were sending out seasonal migrants. As migration has increased since then, it is likely that effects on agricultural production have also increased and potentially changed.

These findings do not exhaust the possible effects of migration on productive activities in rural Vietnam during the 1990s. Although evidence presented in this paper does not suggest that migration helped households overcome credit constraints in agriculture, migration could have helped households overcome other types of credit constraints, such as constraints on starting or expanding non-farm enterprises. Vijverberg and Haughton (2004) shows that some households used non-farm enterprises to increase their living standards; migration may have acted as a catalyst for these non-farm enterprises. Exploring this hypothesis could be a productive avenue for further research.

Finally, land laws have also been liberalized since 1998 (Do and Iyer, 2005). If households are responding to migration by acquiring more land to shift into land intensive crops, in high migration areas one might observe more land rentals and potentially sales of land. Understanding this hypothesis and others related to the interaction between migration and land use are a fruitful area for further research.

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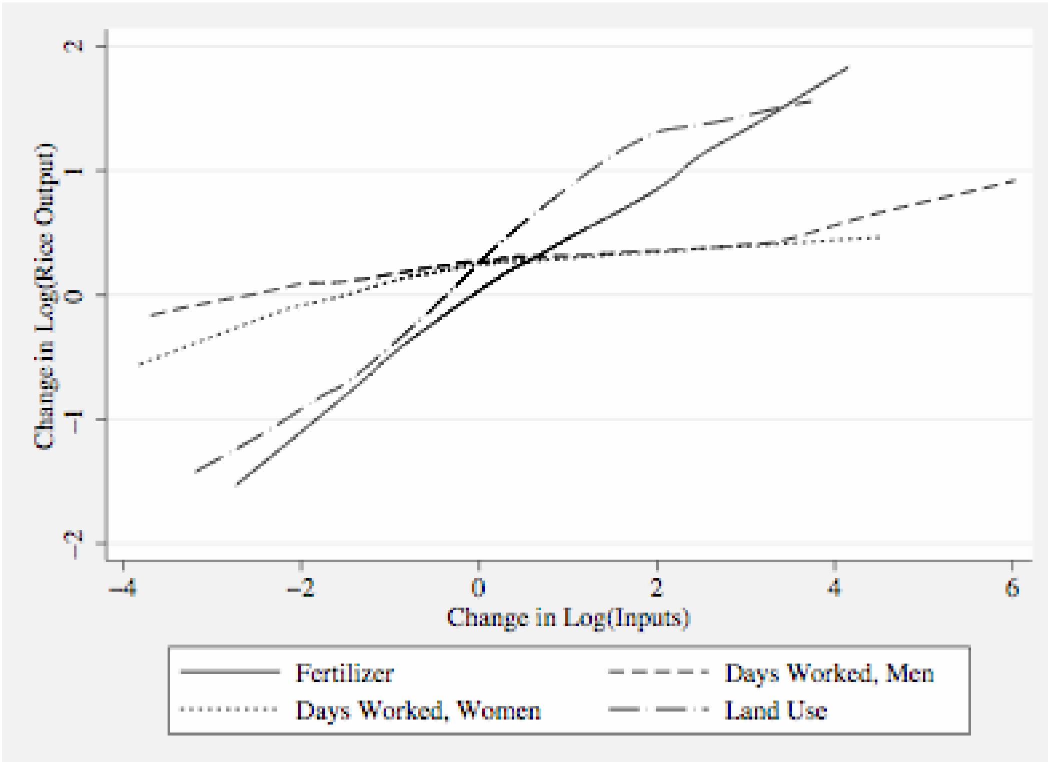

Figure 1. Lowess Plot of Change in Rice Production against Major Inputs, Vietnam, 1993 to 1998.

Table 1. Agricultural Production, Vietnam, 1993 and 1998, by Panel Status

	Panel Households	Only Surveyed in 1993/1998
Summary Statistics for 1992-3		
Share Producing Rice	*0.863*	*0.756*
Avg. Rice Production	2253	1730
(kg)	3162	1867
Share with Agricultural Revenue	*0.935*	*0.878*
Avg. Value of Farm	5650	4439
Production (thousand dong)	6465	5060
Average Household Farm Days	593.1	419
Worked	436.6	352.8
Summary Statistics for 1997-8		
Share Producing Rice	*0.733*	*0.704*
Avg. Rice Production	2905	2900
(kg)	4467	4252
Share with Agricultural Revenue	*0.941*	*0.945*
Avg. Value of Farm	7630	10231
Production (thousand dong)	11210	13520
Average Household Farm Days	493.9	522.6
Worked	522.6	313.8

Note: All averages are conditional on either rice being produced or household participating in farming. There are 3492 households in the panel; 345 only appeared in 1992-3 and 873 appeared in 1997-8.

Source: VLSS.

Table 2. Descriptive Statistics on Agricultural Production Measures, Vietnam, 1993 and 1998

Variable	**1992-3** Number of Observations	Mean	St. Dev.	**1997-8** Number of Observations	Mean	St. Dev.
Measures of Output						
Rice Production (kg)	2841	2268	3186	2676	2937	4491
Total Farm Revenue	3061	5735	6517	3047	7896	11340
Total Revenue, without rice	2630	1920	3255	2527	2704	6706
Share of Rice in Revenue	2841	0.702	0.251	2676	0.696	0.243
Farm Inputs						
Fertilizer used on Rice (kg)	2655	254.3	344.9	2645	353.2	514.9
Total Fertilizer used (kg)	2862	308.1	456.3	2952	513.4	946.2
Male Labor Days, Farming	2787	320.1	258.5	2444	263.5	182.5
Female Labor Days, Farming	2953	336.7	256.8	2667	286.6	188.9
Total Land, Annuals (m^2)	2964	4611	5537	2786	4568	6040
Total Land (m^2)	3070	6719	8420	3061	7322	10690
Share of Land, Irrigated	3065	0.475	0.414	3061	0.601	0.382

Notes: Summary Statistics are all conditional on positive values, except for the share of land that is irrigated.
Source: VLSS.

Table 3. Characteristics of Individuals in Rural Vietnam, by Migration Status, VLSS, 1998

	Migrants	Non-Migrants
Proportion who are Male	0.705	0.453
	(0.456)	(0.498)
Age	29.9	38.4
	(11.9)	(18.0)
Years of Education	6.81	5.87
	(3.21)	(3.65)
Skill Training? (1=yes)	0.103	0.050
	(0.304)	(0.218)
Married? (1=yes)	0.488	0.620
	(0.500)	(0.485)
Number of Observations	486	10.360

Note: Standard deviations in parentheses.

Table 4. Changes in Farm Outputs and Inputs between 1993 and 1998, Vietnam

Variable	Non-Migrant Households	Migrant Households	All Households
Change in Rice Production (kg)	613	451	596
	(3212)	(2787)	(3170)
	2350	*270*	*2620*
Change in Value, Farm Output	2196	1174	2092
	(9272)	(6338)	(9020)
	2791	*318*	*3109*
Change in Fertilizer, Rice (kg)	86.3	57.7	83.3
	(376.1)	(243.9)	(364.8)
	2494	*293*	*2787*
Change in Total Fertilizer (kg)	236.5	94.0	221.5
	(861.8)	(325.0)	(823.2)
	2791	*318*	*3109*
Change in Male Labor Days	-59.0	-83.1	-61.4
	(248.9)	(275.1)	(251.6)
	2123	*234*	*2357*
Change in Female Labor Days	-51.4	-71.3	-53.4
	(251.3)	(263.4)	(252.6)
	2316	*268*	*2584*
Change in Total Land (m^2)	782	-553	647
	(9184)	(8196)	(9097)
	2721	*306*	*3027*

Notes: Standard deviations in parentheses. Number of observations in italics. All means are conditional on the mean being larger than zero.
Source: VLSS.

Table 5. Relationship between Commune Variables and Instrument Candidates

Dependent Variable:	Share of Village, Migrants in 1993	Share of Household, born in Hanoi/HCM City
Average Education Level, Commune	0.086	0.001
	(0.488)	(0.003)
Log, Commune Population	1.455	0.001
	(0.921)	(0.011)
Public Transport Available? (1=yes)	0.327	0.005
	(1.090)	(0.008)
Distance to Paved Road (km)	-0.124	-0.001
	(0.142)	(0.001)
Electricity in commune? (1=yes)	-0.282	0.021
	(1.121)	(0.013)*
Factory Present in 1989? (1=yes)	1.558	0.007
	(1.350)	(0.008)
Log, average expenditures, 1993	2.425	-0.016
	(2.538)	(0.014)
Total Land, Commune, 1993 (Hectares)	-0.573	-0.001
	(0.484)	(0.005)
Secondary School present in commune (1=yes)	-0.348	0.004
	(1.113)	(0.008)
Presence of Rice Market in 1992? (1=yes)	1.326	0.011
	(1.184)	(0.010)
Commune in majority kinh (1=yes)	-0.336	0.014
	(1.294)	(0.012)
Village Located in River Delta (1=yes)	-0.579	-0.016
	(1.534)	(0.013)
Distance to Hanoi (km/100)	0.618	-0.011
	(0.742)	(0.005)**
Distance to HCMC (km/100)	0.552	-0.016
	(0.874)	(0.006)**
Regional Dummies?	yes	yes
N	114	3109
R^2	0.1612	0.0456
F statistic	0.95	1.2
p-value, F statistic	0.4979	0.2922

Notes: *-indicates significance at the 10 percent level; **- indicates significance at the 5 percent level. Column 1 regression is at the commune level; column 2 is at the household level. Standard errors in column 1 are robust and column 2 standard errors are clustered at the commune level. The *F* statistic tests the null hypothesis that all of the estimated coefficients are jointly zero, except the two coefficients on the distance variables.
Source: VLSS.

Table 6. Determinants of Change in Number of Seasonal Migrants between 1993 and 1998, Vietnam

Explanatory Variable	(1)	(2)	(3)	(4)	(5)
Instruments (in levels)					
Share of Migrants in	0.017	0.017	0.017	0.016	0.016
Village Workforce, 1993	(0.005)**	(0.005)**	(0.007)**	(0.007)**	(0.007)**
Share of Household born	0.199	0.213	0.214	0.211	0.220
in Hanoi/HCM City	(0.077)**	(0.078)**	(0.082)**	(0.082)**	(0.084)
Demographic Composition (Differenced)					
Number of Women		0.007	0.013	0.013	0.012
over 55		(0.025)	(0.026)	(0.027)	(0.027)
Number of Men		0.053	0.068	0.070	0.071
over 60		(0.022)**	(0.026)**	(0.026)**	(0.027)**
Number of Women,		0.034	0.037	0.038	0.038
aged 18 to 55		(0.013)**	(0.015)**	(0.015)**	(0.015)**
Number of Men,		0.054	0.054	0.055	0.055
aged 18 to 60		(0.014)**	(0.016)**	(0.016)**	(0.016)**
Number of Children,		-0.015	-0.017	-0.018	-0.018
aged 6 to 17		(0.006)**	(0.007)**	(0.008)**	(0.008)**
Agricultural Prices and Other Variables (Differenced)					
Unit Value,			0.008	0.012	0.008
Rice Fertilizer			(0.017)	(0.018)	(0.018)
Logarithm, Land			-0.030	-0.026	-0.027
in Annuals (m^2)			(0.017)*	(0.017)	(0.017)
Logarithm, Commune			-0.092	-0.096	-0.082
Price of Rice			(0.134)	(0.136)	(0.123)
Share of Land				0.003	0.004
Irrigated				(0.035)	(0.031)
Logarithm, Other				-0.009	-0.008
Farm Expenditures				(0.010)	(0.011)
Commune Characteristics (in levels)					
Distance to Hanoi					-0.003
(km)					(0.022)
Distance to HCM City					-0.005
(km)					(0.026)
Rice Marketed in Village,					0.016
1993					(0.029)
Electricity Present in					-0.054
Village, 1993					(0.047)
Regional and Terrain Dummies?	yes	yes	yes	yes	yes
Number of Obs.	3109	3109	2435	2383	2383
R^2	0.049	0.065	0.063	0.063	0.066
F statistic, instruments	11.75	12.03	9.56	9.42	10
p-value, instruments	<0.0001	<0.0001	0.0002	0.0002	0.0001

Notes: *- indicates significance at the 10 percent level; **- indicates significance at the 5 percent level. Standard errors clustered at the commune level in parentheses. Groups of variables are measured in either levels or are differenced, as noted. Sample size is lower in columns (3) to (5) as they refer to rice production.
Source: VLSS.

Table 7. Determinants of Rice Production in Rural Vietnam, 1993 and 1998

Explanatory Variable	(1)	(2)	(3)	(4)
Number of Migrants,	-0.317	-0.397	-0.350	-0.243
Household	(0.246)	(0.212)*	(0.203)	(0.196)
Number of Women		0.043	0.039	0.041
over 55		(0.030)	(0.029)	(0.028)
Number of Men		0.108	0.106	0.099
over 60		(0.038)**	(0.038)**	(0.039)**
Number of Women,		0.092	0.082	0.076
aged 18 to 55		(0.018)**	(0.018)**	(0.019)**
Number of Men,		0.102	0.096	0.091
aged 18 to 60		(0.023)**	(0.022)**	(0.022)**
Number of Children,		0.034	0.028	0.029
aged 6 to 17		(0.011)**	(0.011)**	(0.010)**
Unit Value,		-0.076	-0.072	-0.071
Rice Fertilizer		(0.049)	(0.040)*	(0.039)*
Logarithm, Land		0.594	0.565	0.568
in Annuals (m^2)		(0.043)**	(0.043)**	(0.045)**
Logarithm, Commune		-0.147	-0.126	-0.116
Price of Rice		(0.126)	(0.130)	(0.140)
Share of Land			0.207	0.180
Irrigated			(0.054)**	(0.048)**
Logarithm, Other			0.070	0.068
Farm Expenditures			(0.020)**	(0.020)**
Distance to Hanoi				0.045
(km)				(0.035)
Distance to HCM City				0.063
(km)				(0.041)
Rice Marketed in Village,				-0.023
1993				(0.046)
Electricity Present in				-0.073
Village, 1993				(0.059)
Regional dummies?	yes	yes	yes	yes
Number of Obs.	2602	2422	2371	2371
F stat., instruments	9.59	9.96	9.81	10.30
Hansen J Statistic	0.2818	0.9546	0.9499	0.3518
p-value, J statistic	0.5955	0.3285	0.3298	0.5531

Notes: *- indicates significance at the 10 percent level; **- indicates significance at the 5 percent level. Dependent variable is logarithm of rice production, expressed in kilograms. All equations differenced to remove household fixed effects, and are estimated using an instrumental variables, Generalized Method of Moments (IV-GMM) procedure. Standard errors are clustered at the commune level. All equations include a vector of regional and geographic variables.
Source: VLSS.

Table 8. Effect of Migration on Agricultural Revenue, Vietnam, 1993-1998

Dependent Variable:	Log, Total Agricultural Revenue			Log, Non-Rice Ag. Revenue		
	1	2	3	4	5	6
Number of Migrants,	0.184	0.130	0.116	1.725	1.747	1.600
Household	(0.261)	(0.199)	(0.201)	(0.748)**	(0.692)**	(0.770)**
Number of Women	0.048	0.021	0.018	0.047	0.046	0.044
over 55	(0.038)	(0.030)	(0.029)	(0.078)	(0.078)	(0.075)
Number of Men	0.201	0.099	0.099	0.179	0.082	0.084
over 60	(0.046)**	(0.041)**	(0.041)**	(0.098)*	(0.097)	(0.103)
Number of Women,	0.113	0.050	0.052	-0.019	-0.074	-0.070
aged 18 to 55	(0.027)**	(0.018)	(0.018)	(0.046)	(0.050)	(0.050)
Number of Men,	0.192	0.104	0.104	0.096	0.034	0.040
aged 18 to 60	(0.023)**	(0.021)	(0.020)	(0.062)	(0.066)	(0.066)
Number of Children,	0.086	0.043	0.043	0.134	0.105	0.102
aged 6 to 17	(0.013)**	(0.010)**	(0.009)**	(0.028)**	(0.028)**	(0.030)**
Unit Value,		-0.001	-0.005		-0.049	-0.026
All Fertilizer		(0.038)	(0.037)		(0.083)	(0.077)
Logarithm, Total Land		0.411	0.405		0.445	0.445
(m^2)		(0.032)**	(0.033)**		(0.082)**	(0.080)**
Share of Land		0.258	0.249		-0.051	-0.089
Irrigated		(0.056)**	(0.060)**		(0.167)	(0.157)
Logarithm, Other		0.153	0.156		0.078	0.073
Farm Expenditures		(0.021)**	(0.020)**		(0.047)	(0.045)
Distance to Hanoi			0.017			0.102
(km)			(0.035)			(0.116)
Distance to HCM City			-0.004			0.071
(km)			(0.042)			(0.132)
Rice Marketed in Village,			0.024			0.111
1993			(0.051)			(0.142)
Electricity Present in			-0.067			0.132
Village, 1993			(0.056)			(0.155)
Regional dummies?	yes	yes	yes	yes	yes	yes
Number of Obs.	3010	2680	2680	2302	2157	2157
F stat., instruments	12.13	12.98	13.77	11.50	12.16	11.93
Hansen J Statistic	0.325	0.217	0.593	0.529	0.497	0.609
p-value, J statistic	0.569	0.642	0.441	0.467	0.481	0.435

Notes: *- indicates significance at the 10 percent level; **- indicates significance at the 5 percent level. All equations differenced to remove household fixed effects, and are estimated using an instrumental variables, Generalized Method of Moments (IV-GMM) procedure. Standard errors are clustered at the commune level. All equations include a vector of regional and geographic variables.
Source: VLSS.

Table 9. Effect of Migration on Sources of Agricultural Revenue, Vietnam, 1993 and 1998, Correcting for Attrition Bias

Dependent Variable: Explanatory	Rice Production (kg) (1)	All Production (value) 2	Non-Rice Production (value) 3
Variable			
Number of Migrants, Household	-0.251	0.117	1.569
	(0.198)	(0.201)	(0.752)
Number of Women over 55	0.042	0.019	0.048
	(0.028)	(0.029)	(0.074)
Number of Men over 60	0.100	0.099	0.084
	(0.039)**	(0.042)	(0.102)
Number of Women, aged 18 to 55	0.077	0.053	-0.071
	(0.018)**	(0.018)	(0.050)
Number of Men, aged 18 to 60	0.092	0.104	0.037
	(0.022)**	(0.021)	(0.067)
Number of Children, aged 6 to 17	0.029	0.044	0.102
	(0.010)**	(0.009)	(0.029)
Share of Land Irrigated	0.184	0.249	-0.086
	(0.047)**	(0.058)	(0.153)
Logarithm, Other Farm Expenditures	0.067	0.152	0.073
	(0.020)**	(0.020)	(0.044)
Distance to Hanoi (km)	0.045	0.019	0.107
	(0.035)	(0.035)	(0.114)
Distance to HCM City (km)	0.061	-0.002	0.074
	(0.041)	(0.041)	(0.129)
Rice Marketed in Village, 1993	-0.019	0.026	0.108
	(0.046)	(0.050)	(0.141)
Electricity Present in Village, 1993	-0.071	-0.067	0.129
	(0.059)	(0.056)	(0.154)
Regional dummies?	Yes	yes	yes
Number of Obs.	2371	2680	2157
Hansen J Statistic	0.282	0.565	0.499
p-value, J statistic	0.596	0.452	0.480

Notes: *- indicates significance at the 10 percent level; **- indicates significance at the 5 percent level. All equations differenced to remove household fixed effects, and are estimated using an instrumental variables, Generalized Method of Moments (IV-GMM) procedure. Standard errors are clustered at the commune level. All equations include a vector of regional and geographic variables, as well as appropriate price and land variables included in Tables 7 and 8. Observations are weighted by the predicted probability of staying in the sample, based on explanatory variables in the model.
Source: VLSS.

Table 10. Effect of Migration on Agricultural Factor Demands, Vietnam, 1993 and 1998

Dependent Variable:	Fertilizer, Rice (1)	All Fertilizer (2)	Days Worked, Men (3)	Days Worked, Women (4)
Number of Migrants,	-0.984	-0.775	-1.108	-0.663
Household	(0.393)**	(0.286)**	(0.523)**	(0.383)*
Number of Women	0.035	-0.023	-0.046	0.210
over 55	(0.050)	(0.048)	(0.057)	(0.050)**
Number of Men	0.090	0.042	0.333	0.167
over 60	(0.051)*	(0.041)	(0.072)**	(0.068)**
Number of Women,	0.061	0.073	0.117	0.295
aged 18 to 55	(0.029)**	(0.026)**	(0.031)**	(0.031)**
Number of Men,	0.115	0.136	0.301	0.153
aged 18 to 60	(0.032)**	(0.026)**	(0.042)**	(0.033)**
Number of Children,	-0.008	0.026	0.083	0.118
aged 6 to 17	(0.014)	(0.013)**	(0.017)**	(0.015)**
Unit Value,	-0.834			
Rice Fertilizer	(0.065)**			
Logarithm, Land	0.496			
in Annuals (m2)	(0.042)**			
Logarithm, Commune	-0.228			
Price of Rice	(0.219)			
Unit Value,		-0.700	-0.030	0.002
All Fertilizer		(0.098)**	(0.053)	(0.048)
Logarithm, Total Land		0.305	0.069	0.072
(\$m^2\$)		(0.040)**	(0.056)	(0.043)
Share of Land	0.237	0.304	0.112	-0.034
Irrigated	(0.071)**	(0.074)**	(0.090)	(0.081)
Logarithm, Other	0.127	0.211	-0.033	-0.023
Farm Expenditures	(0.022)**	(0.024)**	(0.027)	(0.023)
Commune Controls	Included	Included	Included	Included
Regional Dummies?	yes	yes	yes	yes
Number of Obs.	2383	2690	2140	2361
F stat., instruments	10	13.09	9.33	10.09
Hansen J Statistic	0.6796	0.2767	1.1236	0.0098
p-value, J statistic	0.4097	0.5989	0.2891	0.9212

Notes: *- indicates significance at the 10 percent level; **- indicates significance at the 5 percent level. All equations differenced to remove household fixed effects, and are estimated using an instrumental variables, Generalized Method of Moments (IV-GMM) procedure. Standard errors are clustered at the commune level. All equations include a vector of regional and geographic variables. *Source:* VLSS.

Appendix Table 1. OLS Results for Effect of Migration on Agricultural Production and Factor Demands

Dependent Variable:	Est. Coefficient on Migration (Standard Error)	Number of Obs.	R^2
Rice Production	-0.018 (0.030)	2602	0.037
Total Ag. Production	-0.010 (0.033)	3010	0.075
Total Non-Rice Production	0.067 (0.131)	2302	0.037
Fertilizer, Rice	-0.092 (0.032)**	2485	0.091
All Fertilizer	-0.099 (0.033)**	2787	0.153
Male Labor Days	-0.003 (0.050)	2357	0.022
Female Labor Days	-0.031 (0.037)	2584	0.022
Total Other Costs	-0.055 (0.049)	2822	0.090

Notes: **- indicates significance at the 5 percent level. Each row represents a separate regression; regional and geographic dummies are included in all regressions. The dependent variable is expressed in logarithms in all regressions, and all equations are differenced to remove household fixed effects.
Source: VLSS.

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