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FOOD SECURITY NORTHERN UPLANDS

Discussion Paper 3

An empirical study of market integration for seven food markets in Lao PDR

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Abstract

Market integration is an important factor in ensuring that price changes in one market are transferred to another market. If markets are integrated, then those markets with no food scarcity will be able to respond to the price signals of the markets where there is local food scarcity, thus reducing price volatility and reducing the incidence of hunger. In this study we investigate the extent to which seven provincial food markets in Lao PDR are integrated, and which factors influence the degree of integration. We find that meat markets are more likely to be integrated than rice markets, and that the major factors which influence the degree of integration differ between commodities.

Introduction

Market integration concerns the flow of goods and information, and thus prices, over space, form and time, and can be defined as tradability between markets, including a market clearance process in which demand, supply and transaction costs in distinct markets jointly determine prices trade flows, and transmission of price shocks from one market to another (Sanogo and Maliki Amadou 2010). Barrett (2008) defines tradability as the fact that a good is traded between two economies or that market intermediaries are indifferent between exporting from one location to another or not doing so. The concept of market integration is closely related to concepts of efficiency, since analysis of spatial market integration provides an indication of competitiveness, effective arbitrage, and efficient pricing (Sexton, Kling and Carman 1991). For these reasons, integration of markets is often considered a precondition for their effective reform (Baulch 1997).

There are a number of probable consequences when markets are not spatially integrated. Price signals will not be transmitted from food deficit to food surplus areas, making food prices more volatile (Baulch 1997) and price information less accurate. With incomplete price information, marketing decisions of producers will be distorted, product movement will be inefficient (Goodwin and Schroeder 1991), cross sectional aggregation of demand and supply is not logical, and equilibrium prices that are related to aggregate supply and demand cannot be identified (Barrett 1996). Where markets are integrated, the producer faces a new market demand schedule for his crop and average price, price elasticity, price

variance and correlation between prices and revenues will be affected. For example, price elasticity of demand could be expected to be higher, since more diverse markets offer more substitution possibilities, and variance of price is likely to drop, since price variability is related to yield variability, and variability due to local weather is likely to be less over a wider area (Fafchamps 1992).

In this analysis the main focus is on spatial market integration, which may be evaluated in terms of a relationship between prices of a commodity in spatially separated markets, where prices move together and price signals and information are transmitted smoothly. Two regions are in the same economic market for a homogeneous good if the prices for that good differ by exactly the interregional transfer cost (Sexton, Kling and Carman 1991). If linkages exist, price shocks in individual markets should evoke responses in others. Regions may not be linked because of an absence of arbitrage (autarkic markets); or because of impediments such as poor access, trade barriers, imperfect information or risk aversion; or because of imperfect competition in one or more markets. In this analysis of market integration we aim to determine the extent to which provincial markets are integrated, and then, as a second step, to investigate which provincial characteristics are important in explaining the extent or otherwise of market integration.

Market integration in developing countries

The extent of market integration is of particular concern in developing countries where integrated markets play an important part in the optimisation of resource use, increased farm incomes, wider commodity markets, growth of agro based industries, promotion of value adding and creation of employment (Acquah and Owusu 2012). While food markets exist in villages in most of the developing world, these rural food markets are thin and isolated for a variety of reasons, and prices are often poorly transmitted between central and regional markets or surplus in one market will be transmitted to other markets (Ghosh 2011).

A well-integrated market system is essential to household food security, is associated with the escape of households from poverty (Fafchamps 1992), contributes to the rise in importance of non-food cash cropping, and is seen to be key to extension of new food

production technologies which could otherwise flood local markets with unusable surpluses (Delgado 1986). Food insecurity is easier to avoid in a well-integrated market system where distant markets with no scarcity will be able to respond to the price signals of the isolated markets where there is local food scarcity, thus reducing price volatility (Delgado 1986; Hossain and Verbeke 2010). As agricultural productivity increases, and transport costs fall, rural food markets depend less critically on local conditions. The impact of food scarcity is particularly linked to the lack of market integration (Van Campenhout 2007) since the persistence of a localised scarcity in regional food markets depends on how well the region is connected by arbitrage to other regions (Ravallion 1986) and, hence, how easily a deficit. Because of food price volatility, and given that basic staples make up a large share of total consumption and have low income elasticity, farmers avoid food price risk by aiming for food self-sufficiency (Fafchamps 1992). As a result, only wealthier farmers grow cash crops.

The responses of agricultural producers to changes in policies depend on the extent to which regional markets respond to changes in central market prices (Dercon 1995; Badiane and Shively 1998). Information about market integration, provides basic data for understanding how specific markets work, having implications for the costs and the possibilities of government intervention, since integration could make costs of some types of intervention lower (Varela, Aldaz-Carroll and Iacovone 2012; Akpan et al. 2014). The gains from market liberalisation, for example, will accrue to producers/sellers and consumers only if markets are integrated, so that correct price signals are transmitted through marketing channels and farmers are able to specialise according to long term comparative advantage, and to take advantage of economies of scale.

Problems with measurement of market integration

A major problem for analysis of market integration is the lack of suitable data. Tests for market integration usually consider the extent to which shocks are transmitted among spatially separate markets. Neither prices nor trade flows can, on their own, indicate whether actual trading behaviour is efficient. Studies using only price data do not give a complete picture of the condition of agricultural markets, and provide little or no information about actual trading behaviour, while analysis based on trade volumes cannot

establish whether spatial equilibrium conditions hold, and thus whether trade exhausts all rents to arbitrage so as to ensure efficiency.

Time series data for food prices are usually available, and are generally the most reliable type of information in developing countries. It is difficult to obtain regional trade flows data, and if these data are available, their time period, and/or frequency, often do not match that of the food price data (Baulch 1997). As a result, market integration studies in these countries have largely been restricted to the analysis of the interdependence of prices of spatially segregated markets (Ghosh 2011), using time series techniques such as cointegration and VAR. These are the approaches that Van Campenhout (2007) labels "Level I" methods, and it is assumed that if markets are integrated, price differences between markets are equal to transaction costs as long as the markets trade with each other.

LOP studies assume that parity should hold contemporaneously, and that price changes in one market will be transmitted on a one-to-one basis to the other market instantaneously (short-run integration) or over a number of lags (long run integration), (Sanogo and Maliki Amadou 2010). These assumptions may not be realistic, and conventional tests may reject perfect price correlation when in fact markets are efficiently linked most of the time. Price linkages may not be contemporaneous where there are lags in deliveries of commodities from exporting to importing regions, where trade is discontinuous or bidirectional, or when transactions costs are nonstationary. Transaction costs will also vary with the quality of physical and facilitating marketing structure (Fafchamps 1992 in Abdulai (2000), and if transactions costs are non-stationary, and prices drift apart, then an arbitrage opportunity may not exist. Interseasonal flow reversals are common where infrastructure is poor, and in those situations price spread observations may be unreliable indicators of market integration or competition since the spreads will vary seasonally. Fixed costs of adjustment may mean economic agents don't adjust continuously (Abdulai 2000).

Finally, the use of price data in isolation leads to problems such as spurious integration (resulting from the existence of common exogenous trends (for example, general inflation, population growth or climate patterns), agricultural seasonality or autocorrelation), and heteroskedasticity in price data of high frequency.

Analytical framework

There have been advances in methodology to deal with some of the problems mentioned in the previous two paragraphs, but while it would be advantageous to be able to use more sophisticated methods that explore the information contained in trade flow data, we are limited by the fact that we have only price data over time, that is, monthly price data by province capital city in Laos for up to 48 months from January 2011 to December 2014 for 38 food groups. We follow the general methods used by Goodwin and Schroeder (1991) for livestock in the US, over four different periods; Goletti, Ahmed and Farid (1995) for rice in Bangladesh; Varela, Aldaz-Carroll and Iacovone (2012; 2013) of food markets in Indonesia, and Ismet, Barkley and Llewelyn (1998) for rice in different regions of Indonesia. These studies proceed in two stages. In the first stage, spatial market integration in relevant geographical settings is measured, and in the second stage the measure of market integration is regressed on a number of explanatory variables, including marketing infrastructure, volatility of policy, and production.

More specifically we follow Ismet, Barkley, and Llewelyn (1998), who use weekly provincial level data on retail rice prices for Java and off-Java rice prices during the period 1982-1993, and Varela, Aldaz-Carroll and Iacovone (2012; 2013) who measure spatial integration among Indonesian provinces in the markets for rice, soybeans, maize, sugar and cooking oil using monthly price time series. Both start by performing Johansen co-integration tests, on all possible pairs of provincial prices for the period of analysis, to test for co-integration of the regional price series. They then use the values of the trace statistic, the measure of market integration, as the dependent variable in the analysis of the determinants of integration, regressing the trace statistic on measures of regional characteristics such as infrastructure (measured by road density), and market development (measured by income per capita of the region).

In this study, we test for a common stochastic long run trend by performing Johansen-Juselius cointegration rank tests (Johansen 1988; Johansen and Juselius 1990) on all pairs of provincial prices for the commodities under consideration (paddy sticky rice, paddy steam rice, and first quality Lao sticky rice, Lao steam rice, beef, buffalo, and pork). Johansen's co-integration test (Johansen 1988), suggests cointegration when the trace statistic (Johansen's

co-integration test statistic) is higher than a critical value. The two series are then said to share a common stochastic long-run trend. The higher the trace statistic for a pair of provincial prices, the more strongly co-integrated the series.

The Johansen procedure is a sequence of tests. The null hypothesis of no cointegrating relationship is first tested and, if rejected, subsequent null hypotheses are tested until a null can no longer be rejected. The trace statistic tests the null hypothesis against the alternative that there are at most p cointegrating relations (where is p is always equal to the number of variables). Two price series are "co-integrated" if they are both integrated of the same order, say *I* (1), and there exists a linear combination, $\beta_1 p_{it} + \beta_2 p_{2t}$, which is stationary. The tests for co-integration basically check if that stationary linear combination exists.

The method is used to calculate the trace statistics for the defined VAR. In our analysis we are testing pairs of markets and so have only two variables. Assumptions about intercepts and trend terms will determine which critical values should be used. The appropriate Osterwald-Lenum (Osterwald-Lenum 1992) critical value depends on the assumptions regarding the presence of intercept or trend terms and whether such terms appear within or outside the cointegrating equation(s) (CE). By outside it is meant that a deterministic term lies in the remainder of the VAR, that is, that portion of the VAR other than the CE. The possible assumptions or cases are no intercept, no trend, intercept in CE only, intercept in VAR, intercept in VAR, trend in CE only, intercept in VAR, trend in VAR. The last two cases are rare and only consistent with explosive series. We assume that there is an intercept in the VAR, since Dickey and Rossana (1994) note that if a model forces a zero intercept under both the null and alternative hypotheses, and if the true data have a non-zero mean, the test statistic accepts the null hypothesis because of the mean not because of the coefficient ρ. The appropriate lag was tested for each series and a one period lag was found to be the optimum. We assume no trend. Since we estimate this for pairs there are only two cointegrating vectors. The Osterwald-Lenum critical value (at a 95% LOS) for the trace statistic is then 15.41.

Price Data

We have monthly price data by province capital city for up to 48 months from January 2011 to December 2014 for 38 food groups. In this analysis we focus on the markets for paddy sticky rice, paddy steam rice, and first quality Lao sticky rice, Lao steam rice, beef, buffalo meat and pork. Data for some of these series are incomplete. For the majority of provinces the prices from January to April 2011 are not reported. We used imputation to fill missing values. Summary statistics for the selected commodities for both the reported data, and the data including imputed values are given in table A1.

Using the imputed data we perform Johansen co-integration tests to determine whether the markets in the city pairs are cointegrated. We obtain a trace statistic for each pair, that is, 136 trace statistics for each product for 136 market pairs. The exception is pork, where there are 120 trace statistics. Because the price for pork in Luang Prabang is reported as 3000 kip for each of the 48 months, there is no variation in price, and therefore no trace statistic can be obtained for any of the 16 pairs which include Luang Prabang.

The trace statistics for the 136 pairs are provided in table A2 in the appendix. The critical value to determine whether two markets are cointegrated is 15.41 (Osterwald-Lenum 1992), given the assumption that the VAR has an intercept. The number of markets found to be cointegrated for the seven commodity groups analysed is given in table 1. The markets for the three livestock products tend to be integrated, 86.03 per cent of pairs are integrated for beef, 74.17 Per cent for pork, and 84.56 per cent for buffalo meat. The percentage of integrated pairs is lower for rice: 52.2 per cent for paddy sticky rice, 31.62 per cent for paddy steam rice, 44.1 per cent for domestic sticky rice, and only 30.6 per cent for domestic steam rice. While the differences between commodities are consistent with Varela, Aldaz-Carroll and Iacovone (2013), who find that the degree of market integration varies across different commodities, the results differ in that Varela, Aldaz-Carroll and Iacovone (2013) find that the degree of integration for rice markets in Indonesia is greater for rice and sugar than for non-staple products such as soybeans and maize. On the other hand they also found some limited evidence that, for rice, self-sufficiency was associated with a lower degree of integration.

Determinants of market integration

Once we have the measure of the strength of cointegration, we are interested in determining the factors which influence the extent of market integration. We use the trace statistics for pairs of provincial capitals (generated in the first step, above), and regress the trace statistic on a number of provincial variables. Because there are two provinces in each pair we include the characteristics of both provinces in the regression. We then estimate the joint effect of the province characteristic on the dependent variable.

The empirical model takes the form:

$$lnTraceStatistic_{ij} = \beta_0 + \beta_1 TransactionCosts_i + \beta_2 TransactionCosts_j + \beta_3 MarketInfrastructure_i + \beta_4 MarketInfrastructure_j + \beta_5 TechnologyAdoption_i + \beta_6 TechnologyAdoption_j + \beta_7 Population_i + \beta_8 Population_j + \beta_9 Productionpercapita_i + \beta_{10} Productionpercapita_j + e_{ij}$$

In addition to OLS, we also estimate this model using a Seemingly Unrelated Regression model for the different forms of rice to determine whether the four included rice markets are correlated.

Dependent variable

The dependent variable is the trace statistic, interpreted as a measure of the degree of market integration. The larger the trace statistic between markets *i* and *j*, the more strongly the markets are integrated. We estimate the relation between our measure of market integration and the province characteristics as a semi-log equation, hence our estimates measure the percentage change in the trace statistic for a one unit change in the independent variables. We also estimate robust standard errors, to address the problem that since the test statistic of cointegration is a generated variable, and follows a non-standard (non-normal) distribution, the OLS estimator is not normally distributed. Therefore, OLS cannot directly be utilised as standard errors will not be correct (Goodwin and Schroeder 1990; Brester and Goodwin 1993).

Province characteristics

The location characteristics used in similar studies can be broadly classified into several categories: 1) determinants of market flow and marketing infrastructure, including physical access, access to communications and credit, and whether some kind of market exists; 2) degree of modernisation; 2) demand, measured by population; 3) supply, measured by output per capita; 4) geographical characteristics and, finally, 5) other unobserved transactions costs.

Several of these categories have been extensively discussed in Lao PDR. The intra-provincial differences in access to food, particularly rice, in Laos can be attributed to geography (eg uplands vs plain), poor transport infrastructure and high transport costs: for example, 48% of roads (as measured by length) were still earthen in 2012 (Eliste and Santos 2012). Other problems include weak market institutions, formal and informal barriers to national and regional trade, and lack of supporting urban infrastructure and services (FAO 1989; International Development Association, International Monetary Fund and Lao People's Democratic Republic 2008). Production constraints include agriculture-related problems such as poor soil fertility, weeds, rodents, insect pests, and erratic climatic conditions, and socioeconomic issues, such as labour shortage, lack of access to credit, and poor post-harvest handling. More remote areas, particularly those in the north, are characterised by inadequate access to transport and road links, slow implementation of land tenure arrangement and lack of irrigation infrastructure (Lao PDR Strategy Team). The problems in the south mainly relate to insufficient market information and linkages, absence of commodity grades and standards, inadequate commercial credit facilities and lack of new technologies in more isolated areas. We can include proxies for most of these categories using data on provincial values from the 2010/11 Agricultural Census and other Lao government sources. A wide range of information about the 17 provinces in Lao PDR can be extracted for the results of the Lao Agricultural Census 2010/11 (Agricultural Census Office: Steering Committee for the Agricultural Census 2012). Other statistics can be found at the Lao Statistics Bureau. They can be grouped as follows.

Transactions costs

The variables used to account for transaction costs, and determinants of trade flows, are, overall, similar across different studies. They include transportation costs, transport

hindrances, changes in policy, and security. We do not have transportation costs, but do have road distance between markets (distance between each of the pairs of provincial capitals). Because in Laos there is a problem not only of distance, but also of road quality, we use time in hours required to travel between capitals. The information was obtained from Google maps in a one hour window on 23 March 2016, thus avoiding discrepancies caused by Google allowing for different traffic conditions on different days.

Geographic factors

Geographic factors will also affect the degree of market integration. Mountainous terrain, lack of supporting urban infrastructure and services (FAO 1989; International Development Association, International Monetary Fund and Lao People's Democratic Republic 2008), and likelihood of natural disasters may be such factors. We therefore include the proportion of households that are upland, the percentage of villages that are urban, and the percentage of villages prone to natural disasters in our analysis.

Marketing infrastructure

One of the constraints to market operation identified for Laos is poor transport infrastructure and high transport costs (Eliste and Santos 2012). We use paved road density because that should reflect the degree of wet season access to proxy for this set of variables. Road access (in dry and wet seasons) could also be included. Other problems include weak market institutions, so we also include the percentage of villages in a province where agricultural output is sold in a market to reflect the existence of markets. To address concerns about insufficient market information and linkages, absence of commodity grades and standards and inadequate commercial credit facilities, we include variables such as the percentage of the population which has access to all three of television, radio and newspapers, and the percentage of villages where credit facilities are available. While some studies include remoteness or centrality, which for a given distance to a city centrality depends on the size of the closest city (captured by weighting distance in km by inverse of

population of the closest city), we have considered that this effect should be captured by the time taken to travel between the pairs of provincial capitals.

Adoption of technology

Another limitation may be the lack of new technologies in more isolated areas. Varela, Aldaz-Carroll and Iacovone (2013) and Ismet, Barkley and Llewelyn (1998) use per capita income as a proxy for economic development. However, we have a large number of provincial measures that could be used to measure dispersion of technology. The main problem is to choose between them since we must be conscious of the number of degrees of freedom available to us. As examples of the spread of new technologies, we have included the percentage of households which use a rice mill, the percentage of area planted to modern, improved rice varieties, and the percentage of villages which have electricity.

Demand and supply

Other specific determinants of transfer costs are demand aspects, for example, purchasing power, competition/collusion and insecurity. Low purchasing power potential in an area may explain lack of incentives for traders to move food there. This can be included as population per province, population density per kilometre squared, and PCI (real per capita income), output PC (annual average output of commodity (in kg) divided by population), and productivity (average yield per ha in tons over the period). We include total population per province, and output per capita for rice (for the rice markets) and number of livestock per head for each of the specific meats. Per capita income by province is not available.

Results

A summary of the results of the estimations for the seven food groups is shown in table 2, and more detailed results by product in the appendix in tables A3-A9. The results have been obtained by estimating regressions including data for both provinces in the respective pairs, and then estimating the joint effects for each characteristic, with the exception of time taken to travel between the provincial capitals. The reported values are the joint effects. Because we have considered that there may be correlation between the four different rice markets we have also included estimates using Seemingly Unrelated Regressions. The

degree of correlation between these markets can be seen in the correlation matrix of residuals given in table A10 in the appendix. While we can reject the null hypothesis that the markets are independent, the degree of correlation is minor, and has a minimal effect on results.

Varela, Aldaz-Carroll and Iacovone (2013) find that integration across provinces is explained by the remoteness and quality of transport infrastructure of a province, and, for rice, self-sufficiency. We have used, instead, travel time between markets and the percentage access to paved roads. Ismet, Barkley and Llewelyn (1998) find that integration is explained by self-sufficiency and per capita income. Per capita income in the latter study is used to account for the level of economic development apart from roads. Since we do not have per capita income by province, we have used other measures of development to represent adoption of technology, and thus economic development. Therefore, our results are not directly comparable with those of these two studies.

The factors that have a statistically significant effect on market integration differ across food products, and are summarised in terms of whether they are significant, and whether they have a positive or negative effect, in table 2. The detailed results by food product are shown in tables A3-A9. The models for the four rice markets are better in terms of overall significance and goodness of fit than those for meat.

Travel time between provincial capitals is statistically significant only for Lao sticky rice and for pork, and has the expected negative sign. Some variables have no statistical significance in explaining market integration, or have surprising signs, and this may relate to the fact that we are using prices in provincial capitals, not disaggregated price data from villages, and also that our independent variables are average provincial data. This problem applies particularly to the geographic factors. For example, the percentage of villages in a province that are urban has no statistically significant effect on market integration. The percentage of villages in a province that are upland has a positive statistically significant effect for both types of paddy rice, and for beef, and the percentage of villages prone to natural disasters has a positive statistically significant effect for paddy and Lao steam rice, and for beef.

Results for the market infrastructure variables are also mixed. The paved road density has, as expected, a statistically significant and positive effect on market integration for all rice categories, but no effect for meat markets. The percentage of the provincial population with good exposure to the media has surprisingly a negative effect, and the percentage of villages with credit facilities has an effect (positive) only for paddy steam rice. The percentage of villages with a market (that is, where agricultural produce is sold) has a negative effect for paddy rice, and positive effect for Lao sticky rice and for beef.

For the variables included as an indicator of technological progress, the results are again mixed. The percentage of houses using a rice mill is significant and positive for both categories of paddy rice, and for Lao sticky rice. The percentage of an area planted to improved varieties of rice has a negative effect on market integration, possibly because this contributes to self-sufficiency which both Varela, Aldaz-Carroll and Iacovone (2013) and Ismet, Barkley and Llewelyn (1998) find reduces the level of integration in rice markets.

Results for the demand and supply variables are again mixed. Population of the province either has no statistically significant effect, or is significant for both categories of sticky rice, but has an economic effect which is close to zero. Commodity production per capita has a significant but negative effect for paddy sticky rice, a significant and positive effect for Lao sticky rice, and a negative effect for beef. Possibly for paddy rice and beef, an increase in productivity means a reduced need to trade, and therefore a reduction in the level of market integration.

Conclusion and further work

Traditionally economists looked at bivariate correlation coefficients between distinct markets and at the difference in estimated transfer costs, to determine the extent of market integration. This is also the approach we follow here. However, there have been important advances in methodology since the mid-1980s in terms of controlling for seasonality (Delgado 1986), and allowing for autocorrelation, distinct short run and long run dynamics and common inflation and seasonal components, testing for short run versus long run integration by correlating the price in one region with lagged own prices and contemporaneous and lagged prices in another region (Ravallion 1986). Further advances

include the threshold switching model which allows for regime switching when shocks result in price differences that are greater than transactions costs (Goodwin and Piggott 2001) and the Parity Bounds Model which explicitly recognises the influences of transactions costs on spatial market linkages, and which estimates the probability of being in spatial price regimes that are consistent with the equilibrium notion that all spatial arbitrage opportunities are being exploited (Spiller and Huang 1986; Sexton, Kling and Carman 1991; Baulch 1997; Barrett and Li 2002).

These improved models require more detailed data than those available to us at the moment. The data required include the volume and direction of trade flows, and whether or not the trade goes to central markets. An understanding of trade flows also depends on the availability of disaggregated data. In this analysis we have use monthly price data for provincial capitals. While our results provide an indication of the extent of market integration for seven food markets in Lao PDR, and of the factors which affect the level of market integration, the results are limited by the non-availability of disaggregated data.

In addition, the analysis is based on provincial capital price data, which do not necessarily reflect price conditions at the village level. There is substantial, rich data available for village characteristics, but because our price data are at the province level we use average provincial data for our explanatory variables. Ideally it would be desirable to use the disaggregated village data, combined with frequent time series price and trade flow data at village level, to obtain a clearer understanding of the way in which village characteristics affect their integration into a food market.

Table 1 Number and percentage share of integrated market pairs in Lao PDR

Food type	Number of market pairs integrated (out of 136)	Percentage of market pairs integrated
Paddy sticky rice	71	52.21
Paddy steam rice	43	31.62
Lao sticky rice 1	60	44.12
Lao steam rice 1	28	20.59
Beef 1	117	86.03
Pork 1	89*	74.17
Buffalo 1	115	84.56

*There are 120 market pairs for Pork

Table 2 Summary of OLS regression results

	Paddy sticky rice	Lao sticky rice	Paddy steam rice	Lao steam rice	Beef	Buffalo	Pork
	Whether or not statistically significant						
Transaction costs							
Travel time between provincial capitals	No	Yes (-ve)	No	No	No	No	Yes (-ve)
Geographic factors							
% villages urban	No	No	No	No	No	No	No
% HH upland	Yes (+ve)	No	Yes (+ve)	No	Yes (+ve)	No	No
% rural villages prone to natural disasters	No	No	Yes (+ve)	Yes (+ve)	Yes (+ve)	No	No
Market infrastructure							
Paved road density percent	Yes (+ve)	Yes (+ve)	Yes (+ve)	Yes (+ve)	No	No	No
% of popn exposure to all three media	Yes (-ve)	No	Yes (-ve)	No	Yes (-ve)	No	No
% villages with Credit facilities	No	No	Yes (+ve)	No	No	No	No
% of villages in which ag produce sold	Yes (-ve)	Yes (+ve)	Yes (-ve)	No	Yes (+ve)	No	No
Adoption of technology							
% HH using rice mill	Yes (+ve)	Yes (+ve)	Yes (+ve)	No	Yes (-ve)	No	No
% area planted to improved rice varieties	Yes (-ve)	No	Yes (-ve)	Yes (-ve)	Yes (+ve)	Yes (+ve)	No
% of villages with electricity	No	Yes (-ve)	No	Yes (+ve)	Yes (+ve)	Yes (-ve)	Yes (+ve)
Demand							
Total population of province	Yes (0)	Yes (0)	No	No	No	No	No
Supply							
Commodity production per capita	Yes (-ve)	Yes (+ve)	No	No	Yes (-ve)	No	No
Commodity production per capita squared	Yes (0)	No	Yes (0)	No	Yes (+ve)	No	No
F Stat of regression	20.450	15.320	18.620	14.470	6.160	7.480	3.430
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R squared	0.743	0.720	0.613	0.590	0.550	0.602	0.446

Notes: Yes/No stand for statistically significant/insignificant effect, respectively. (+ve), (-ve) and (0) stand for economical positive, negative or insignificant effects, respectively.

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Table A1 Comparison of reported and imputed prices

Paddy sticky rice										
	Reported					Missing values imputed				
Price	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Viangchan	48	3063.06	176.15	2700	3500	48	3063.06	176.15	2700	3500
Phongsali	43	3272.09	79.66	3000	3500	48	3271.56	81.53	3000	3500
Luang Namtha	43	3172.09	260.34	3000	4000	48	3163.47	258.25	2849	4000
Oudomxai	43	3106.40	397.58	2600	3800	48	3094.20	382.42	2600	3800
Bokeo	43	2435.12	313.35	2040	2900	48	2433.22	304.75	2040	2900
Luang Prabang	48	2985.42	232.46	2800	3500	48	2985.42	232.46	2800	3500
Houaphan	44	4004.55	415.38	3200	5000	48	3990.79	410.93	3200	5000
Xaignabouri	44	2661.36	459.63	2000	3500	48	2624.55	467.68	1619.8	3500
Xiengkhouang	44	3441.48	332.89	2500	4000	48	3464.22	335.10	2500	4121
Viangchan Province	44	2689.66	264.45	2200	3210	48	2692.07	254.33	2200	3210
Borikhamxai	44	2419.64	363.90	1800	2950	48	2398.97	356.98	1800	2950
Khammouane	48	2522.92	396.92	2100	3800	48	2522.92	396.92	2100	3800
Savannakheth	48	2595.83	390.15	1800	3300	48	2595.83	390.15	1800	3300
Salavan	44	2328.68	414.76	1500	3033	48	2366.83	418.70	1500	3033
Xekong	43	2283.72	681.71	1500	3400	48	2363.84	688.61	1500	3400
Champasack	48	2323.06	465.07	1600	2975	48	2323.06	465.07	1600	2975
Attapeu	43	2465.12	966.06	1500	3500	48	2648.91	1083.95	1500	4936
Lao sticky rice										
	Reported					Missing values imputed				
Price	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Viangchan	48	7872.98	215.14	7389	8000	48	7872.98	215.14	7389	8000
Phongsali	43	6232.56	438.46	5800	7000	48	6213.19	425.58	5754.9	7000
Luang Namtha	43	8046.51	154.84	7800	8500	48	8043.49	147.38	7800	8500
Oudomxai	43	6233.14	1224.20	5000	9000	48	6311.87	1198.65	5000	9000
Bokeo	43	5799.42	908.43	5000	7500	48	5750.28	886.59	4617.4	7500
Luang Prabang	44	7227.27	677.33	6000	9000	48	7202.84	672.76	6000	9000
Houaphan	44	6143.18	986.98	4000	7500	48	6141.96	954.45	4000	7500
Xaignabouri	44	5363.64	917.30	4500	7000	48	5302.97	901.53	4411.9	7000
Xiengkhouang	48	6831.25	770.51	6000	8000	48	6831.25	770.51	6000	8000
Viangchan Province	44	6183.34	657.71	5000	7250	48	6153.36	645.06	5000	7250
Borikhamxai	44	6287.34	892.14	5000	7375	48	6327.63	867.09	5000	7375
Khammouane	48	5862.50	223.49	5500	6000	48	5862.50	223.49	5500	6000
Savannakheth	48	5791.67	866.54	4250	7000	48	5791.67	866.54	4250	7000
Salavan	44	5406.82	778.60	3800	7166	48	5414.25	766.50	3800	7166
Xekong	48	6261.27	856.58	5000	8000	48	6261.27	856.58	5000	8000
Champasack	43	6534.88	1202.20	5000	8000	48	6508.77	1140.62	5000	8000
Attapeu	43	6790.70	411.63	6000	7000	48	6822.52	434.55	6000	7683

Paddy steam rice										
	Reported					Missing values imputed				
Price	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Viangchan	48	3450.23	112.09	3000	3600	48	3450.23	112.09	3000	3600
Phongsali	43	3258.14	73.14	3000	3500	48	3259.59	76.17	3000	3500
Luang Namtha	43	2467.09	184.56	2280	2800	48	2482.39	188.61	2280	2838
Oudomxai	43	3869.77	547.09	2700	4500	48	3825.09	546.56	2700	4500
Bokeo	43	2978.49	453.97	2500	3800	48	2976.56	432.07	2500	3800
Luang Prabang	44	3495.46	367.24	2800	4200	48	3518.92	362.13	2800	4200
Houaphan	44	3774.43	537.69	2500	5000	48	3814.62	542.83	2500	5000
Xaignabouri	38	3065.79	388.54	2500	4000	48	3059.85	374.10	2500	4000
Xiengkhouang	48	2912.50	95.93	2800	3000	48	2912.50	95.93	2800	3000
Viangchan Province	44	3076.14	340.81	2500	3750	48	3073.90	327.41	2500	3750
Borikhamxai	44	3320.89	233.20	2950	3800	48	3332.52	229.39	2950	3800
Khammouane	47	2553.19	393.34	2100	3500	48	2559.89	391.89	2100	3500
Savannakheth	48	2854.17	327.44	2200	3200	48	2854.17	327.44	2200	3200
Salavan	44	3181.82	602.81	2500	4750	48	3168.39	581.37	2500	4750
Xekong	48	2909.65	287.32	2500	3200	48	2909.65	287.32	2500	3200
Champasack	43	3055.81	326.82	2500	3500	48	3028.71	324.36	2500	3500
Attapeu	43	2416.28	538.49	1700	3000	48	2433.84	519.02	1700	3079

Lao steam rice1										
	Reported					Missing values imputed				
Price	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Viangchan	48	8558.73	514.10	8000	9250	48	8558.73	514.10	8000	9250
Phongsali	43	6372.09	486.64	5800	7000	48	6406.74	475.54	5800	7000
Luang Namtha	43	7796.51	424.88	7000	8500	48	7803.76	409.28	7000	8500
Oudomxai	43	5825.58	486.53	5000	6500	48	5793.47	482.95	5000	6500
Bokeo	43	6276.16	528.61	6000	8000	48	6299.02	513.43	6000	8000
Luang Prabang	43	6279.07	503.59	6000	8000	48	6276.94	488.43	6000	8000
Houaphan	44	6647.73	931.24	5000	9000	48	6730.44	934.64	5000	9000
Xaignabouri	44	7363.64	408.68	7000	8000	48	7368.49	393.21	7000	8000
Xiengkhouang	48	6529.17	481.12	6000	7000	48	6529.17	481.12	6000	7000
Viangchan Province	44	6574.71	877.74	5500	9000	48	6608.27	849.14	5500	9000
Borikhamxai	44	7716.21	763.09	6800	9000	48	7721.69	730.46	6800	9000
Khammouane	48	6314.06	790.85	5500	8000	48	6314.06	790.85	5500	8000
Savannakheth	48	7291.67	682.87	6000	8000	48	7291.67	682.87	6000	8000
Salavan	44	7933.98	1421.70	6000	10000	48	7901.93	1369.31	6000	10000
Xekong	48	8763.88	1336.40	6500	10000	48	8763.88	1336.36	6500	10000
Champasack	43	9255.81	928.21	7000	10000	48	9138.27	961.30	7000	10000
Attapeu	43	7348.84	686.04	6000	8000	48	7397.48	685.10	6000	8384

Beef 1										
	Reported					Missing values imputed				
Price	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Viangchan	48	57704.29	13012.00	38500	73750	48	57704.29	13012.28	38500	73750
Phongsali	43	43162.79	10941.00	28000	60000	48	41583.20	11380.81	25564	60000
Luang Namtha	43	42813.95	9919.30	28000	60000	48	41391.16	10285.23	27968	60000
Oudomxai	43	44860.47	9083.20	35000	60000	48	43298.44	9909.34	24825	60000
Bokeo	43	47790.70	10818.00	30000	60000	48	46013.96	11515.52	29013	60000
Luang Prabang	44	42613.64	9553.30	30000	60000	48	41627.71	9794.51	26784	60000
Houaphan	44	50738.64	10952.00	30000	60000	48	49260.45	11600.03	30000	60000
Xaignabouri	44	42727.27	10968.00	30000	60000	48	41167.07	11744.08	20376	60000
Xiengkhouang	48	51411.46	13041.00	32000	75000	48	51411.46	13040.80	32000	75000
Viangchan Province	44	53835.23	11903.00	36750	70000	48	52139.45	12757.82	28832	70000
Borikhamxai	43	52360.47	10010.00	40000	65000	48	50985.08	10574.86	33340	65000
Khammouane	48	57588.54	11961.00	37000	75000	48	57588.54	11961.32	37000	75000
Savannakheth	48	57161.46	12244.00	35000	70000	48	57161.46	12244.03	35000	70000
Salavan	44	45151.59	10923.00	35000	65000	48	43606.16	11768.51	21180	65000
Xekong	48	52819.65	12632.00	35000	70000	48	52819.65	12632.06	35000	70000
Champasack	43	47813.95	15549.00	29000	70000	48	45149.81	16696.06	19781	70000
Attapeu	43	58023.26	12962.00	40000	80000	48	56052.94	13750.15	32463	80000

Buffalo 1										
	Reported					Missing values imputed				
Price	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Viangchan	48	57393.23	13179.00	35500	73750	48	57393.23	13179.23	35500	73750
Phongsali	43	43162.79	10941.00	28000	60000	48	41227.08	11869.16	20895	60000
Luang Namtha	43	42767.44	9961.40	28000	60000	48	41541.47	10142.91	25501	60000
Oudomxai	43	44860.47	9083.20	35000	60000	48	42782.64	10729.34	20456	60000
Bokeo	43	48023.26	10473.00	30000	60000	48	46256.73	11226.56	28268	60000
Luang Prabang	44	42613.64	9553.30	30000	60000	48	41733.73	9628.92	29339	60000
Houaphan	44	50738.64	10952.00	30000	60000	48	49723.86	11063.92	30000	60000
Xaignabouri	44	42727.27	10968.00	30000	60000	48	40916.53	12146.68	16784	60000
Xiengkhouang	48	52244.79	14026.00	32000	75000	48	52244.79	14026.33	32000	75000
Viangchan Province	44	53948.86	11791.00	36750	70000	48	52422.51	12397.71	33572	70000
Borikhamxai	43	52197.67	10023.00	40000	65000	48	50750.01	10790.70	30270	65000
Khammouane	48	54078.13	13016.00	35000	70000	48	54078.13	13015.76	35000	70000
Savannakheth	48	55166.67	11815.00	33000	70000	48	55166.67	11814.76	33000	70000
Salavan	44	45151.59	10923.00	35000	65000	48	43648.99	11634.71	22956	65000
Xekong	48	48187.50	12209.00	34000	70000	48	48187.50	12208.57	34000	70000
Champasack	43	47348.84	16040.00	28000	70000	48	44011.77	18210.56	9367.5	70000
Attapeu	43	54302.33	11881.00	40000	75000	48	51980.62	13404.30	24093	75000

Pork 1										
	Reported					Missing values imputed				
Price	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Viangchan	48	35960.54	2372.00	32000	41250	48	35960.54	2371.99	32000	41250
Phongsali	43	35023.26	3391.10	28000	40000	48	34721.34	3456.50	28000	40000
Luang Namtha	43	33209.30	3783.20	24000	35000	48	33258.59	3624.91	24000	36166
Oudomxai	43	36069.77	3283.40	28000	40000	48	35664.85	3358.62	28000	40000
Bokeo	43	39767.44	2169.50	30000	45000	48	39720.74	2236.75	30000	45000
Luang Prabang	44	30000.00	0.00	30000	30000	48	30000.00	0.00	30000	30000
Houaphan	43	33720.93	2207.40	30000	35000	48	33506.59	2382.46	26665	35000
Xaignabouri	44	31613.64	2544.60	28000	35000	48	31214.01	2826.67	24597	35000
Xiengkhouang	48	36901.04	3858.10	30000	45000	48	36901.04	3858.10	30000	45000
Viangchan Province	31	39040.32	3114.50	35000	45000	48	38154.90	3578.57	28708	45000
Borikhamxai	32	35187.50	1999.00	31000	38000	48	35677.93	2639.51	28556	41553
Khammouane	48	36557.29	2342.50	30000	40000	48	36557.29	2342.51	30000	40000
Savannakheth	48	39729.17	5096.90	28000	50000	48	39729.17	5096.89	28000	50000
Salavan	44	31988.64	2373.50	25000	38000	48	32026.96	2426.03	25000	38000
Xekong	48	37673.60	2401.20	33000	40000	48	37673.60	2401.24	33000	40000
Champasack	43	33790.70	4166.50	27000	40000	48	33014.10	4670.08	21125	40000
Attapeu	43	41279.07	2207.40	40000	45000	48	40802.63	2792.20	32166	45000

Table A2 Trace statistics

Market pairs	Paddy sticky rice	Paddy steam rice	Lao sticky rice1	Lao steam rice 1	Beef 1	Buffalo 1	Pork 1
Attapeu - Houayxai_Bokeo	13.42	9.7	27.05	12.8	29.9	27.14	24.33
Attapeu - Luangnamtha	19.34	11.12	29.14	6.77	24.81	27.18	17.22
Attapeu - Luangprabang	12.12	13.17	25.83	12.7	20.8	16.63	
Attapeu - Oudomxai	10.74	8.18	28.74	17.84	26.01	41.35	16.87
Attapeu - Pakxan_Bolikhamxai	9.27	7.21	28.62	10.25	27.78	30.61	20.54
Attapeu - Pakxe_ Champasak	6.51	11.96	28.78	8.74	20.48	36.36	26.02
Attapeu - Phongsali	27.87	33.96	24.71	15.99	26.08	32.58	20.85
Attapeu - Phonhong_Viangchan	12.05	12.85	23.83	12.02	19.45	23.49	48.8
Attapeu - Phonsavan_Xiangkhoang	13.24	4.86	26.17	9.29	26.63	22.85	27.09
Attapeu - Saravan	8.52	13.46	36.34	10	28.82	35.85	22.62
Attapeu - Savannakhet	9.22	9.02	25.44	5.46	26.41	43.37	27.64
Attapeu - Thakhek_Khammouan	10.52	7.16	36.14	9.86	30.6	25.02	43.99
Attapeu - Viangchan	35.81	14.17	25.77	12.61	26.18	26.61	25.22
Attapeu - Xaignabouri	11.4	11.62	27.92	11.27	32.56	40.17	16.21
Attapeu - XamNua_Houaphan	18.9	11.44	29.41	27.43	22.91	13.43	26.93
Attapeu - Xekong	6.06	16.65	31.45	8.03	22.26	20.4	29.42
Houayxai_Bokeo - Pakxe_ Champasak	8.24	9.72	13.18	9.48	28.44	36.92	22.89
Houayxai_Bokeo - Pakxan_Bolikhamxai	7.3	9.36	12.32	10.42	30.18	28.22	23.71
Houayxai_Bokeo- Luangnamtha	22.17	6.55	18.89	8.22	22.19	30.03	29.35
Houayxai_Bokeo- Luangprabang	10.16	21.07	9.11	12.11	17.87	13.91	
Houayxai_Bokeo- Oudomxai	10.99	8.12	19.45	11.17	20.45	25.92	18.59
Houayxai_Bokeo- Phongsali	27.31	32.58	27.62	10.87	9.05	26.31	25.63
Houayxai_Bokeo- Phonhong_Viangchan	13.3	12.5	21.69	15.01	12.73	17.69	23.32
Houayxai_Bokeo- Phonsavan_Xiangkhoang	16.06	20.78	32.33	13.83	34.05	28.26	13.43
Houayxai_Bokeo- Saravan	11.74	17.56	15.43	9.67	19.51	9.8	20.19
Houayxai_Bokeo- Savannakhet	13.35	14.06	7.3	9.62	36	37.96	20.53
Houayxai_Bokeo- Thakhek_Khammouan	16.57	7.66	8.99	9.48	26.49	23.56	23.22
Houayxai_Bokeo- Viangchan	13.8	15.77	12.31	12.64	37.11	40.73	13.52
Houayxai_Bokeo- Xaignabouri	9.12	11.89	34.45	12.46	31.94	29.18	15.06
Houayxai_Bokeo- XamNua_Houaphan	20.96	13.84	26.19	20.8	18.16	16.27	19.46
Houayxai_Bokeo- Xekong	9.01	10.16	10.42	12.23	20.81	18.41	17.23
Luangnamtha- Luangprabang	19.12	12.35	13.05	17.74	30.92	37.06	
Luangnamtha- Oudomxai	17.84	14.07	22.84	4.9	34.18	28.76	13.71
Luangnamtha- Phongsali	34.78	25.24	20.04	5.62	16.01	25.54	17.19
Luangnamtha- Phonhong_Viangchan	18.28	9.16	16.95	3.84	20.34	24.94	15.89
Luangnamtha- Phonsavan_Xiangkhoang	21.65	4.53	17.74	3.47	23.51	26.14	4.84
Luangnamtha- Saravan	16.54	5.89	21.76	5.18	23.97	16.46	13.22
Luangnamtha- Savannakhet	16.78	8.19	13.51	4.11	26.26	27.85	10.57
Luangnamtha- Viangchan	20.98	16.1	17.54	4.26	27.25	32.77	2.71
Luangnamtha- Xaignabouri	14.35	9.3	17.09	3.85	35.49	28.98	9.57
Luangnamtha- Xekong	15.88	3.76	18.1	5.52	23.15	30.71	8.16
Luangprabang- Oudomxai	16.57	14.43	9.07	20.64	25.62	20.76	
Luangprabang- Phongsali	27.42	32.61	10.93	14.07	14.08	16.42	
Luangprabang- Phonhong_Viangchan	13.73	15.62	6.63	7.43	14.73	13.27	
Luangprabang- Phonsavan_Xiangkhoang	15.01	14.35	6.62	7.04	21.84	17.57	
Luangprabang- Saravan	10.08	16.14	6.17	7.78	26.23	13.53	
Luangprabang- Savannakhet	8.77	20.57	5.89	8.29	18.49	16.13	
Luangprabang- Viangchan	16.57	21.34	8.93	7.47	18.96	17.9	
Luangprabang- Xaignabouri	7.41	18.59	8.02	6.87	29.97	22.79	
Luangprabang- Xekong	6.14	13.32	9.11	8.04	21.98	15	
Oudomxai- Phongsali	30.03	22.49	28.71	18.66	17.68	26.27	46.72
Oudomxai- Phonhong_Viangchan	17.8	19.08	11.3	11.37	25.37	30.24	5.03
Oudomxai- Phonsavan_Xiangkhoang	16.67	7.78	16.49	11.45	23.11	23.84	8.61
Oudomxai- Saravan	18.67	7.88	15.7	12.54	29.76	26.64	16.49
Oudomxai- Savannakhet	12.6	12.49	8.74	8.38	40.2	46.57	12.13
Oudomxai- Xaignabouri	12.15	13.41	22.37	10.9	36.1	33.68	16.83
Oudomxai- Xekong	10.44	6.48	11.43	15.21	21.8	23.24	6.41

Pakxan_Bolikhamxai- Luangnamtha	15.79	6.99	14.82	2.18	32.85	28.31	10.44
Pakxan_Bolikhamxai- Luangprabang	12.6	16.67	4.32	6.01	19.92	14.81	
Pakxan_Bolikhamxai- Oudomxai	17.13	9.18	13.22	11.2	47.84	51.67	11.9
Pakxan_Bolikhamxai- Pakxe_ Champasak	5.25	7.89	11.69	4.31	67.5	74	24.67
Pakxan_Bolikhamxai- Phongsali	25.12	21.07	9.06	5.55	16.67	20.45	12.68
Pakxan_Bolikhamxai- Phonhong_Viangchan	18.24	17.8	13.16	10.51	25.96	21.8	21.35
Pakxan_Bolikhamxai- Phonsavan_Xiangkhoang	15.1	7.22	17.74	6.07	37.16	25.96	10.84
Pakxan_Bolikhamxai- Saravan	9.85	7.86	21.67	10.77	19.73	12.27	17
Pakxan_Bolikhamxai- Savannakhet	8.24	11.49	5.59	3.78	64.22	44.68	20.93
Pakxan_Bolikhamxai- Thakhek_Khammouan	7.68	9.05	9.64	3.98	29.7	18.92	17.85
Pakxan_Bolikhamxai- Viangchan	18.82	16.31	8.86	18.73	33.45	29.48	10.02
Pakxan_Bolikhamxai- Xaignabouri	7.51	10.76	16.3	25.82	28.09	26.76	14.65
Pakxan_Bolikhamxai- XamNua_Houaphan	15.54	12.48	35.65	18.07	23.28	16.53	18.02
Pakxan_Bolikhamxai- Xekong	4.75	5.31	11.04	4.75	27.19	15.71	18.44
Pakxe_ Champasak - Luangnamtha	15.68	6.34	12.15	4.14	30.49	32.39	14.91
Pakxe_ Champasak - Luangprabang	6	13.97	7.89	7.78	21.11	21.68	
Pakxe_ Champasak - Oudomxai	9.5	8.04	8.78	16.29	37.16	52.49	18.41
Pakxe_ Champasak - Phongsali	27.75	30.87	9.53	5.74	13.25	28.95	22.69
Pakxe_ Champasak - Phonhong_Viangchan	17.06	8.04	8.29	5.97	24.77	32.09	25.13
Pakxe_ Champasak - Phonsavan_Xiangkhoang	19.03	9.88	8.41	4.94	28.99	33.93	18.57
Pakxe_ Champasak - Saravan	10.95	11.2	17.57	11.65	21.14	21.36	34.29
Pakxe_ Champasak - Savannakhet	15.06	10	5.03	4.43	61.58	74.5	21.7
Pakxe_ Champasak - Thakhek_Khammouan	9.23	6.59	9.1	7.11	29.15	31.04	23.06
Pakxe_ Champasak - Viangchan	11.74	14.63	7.87	6.35	32.31	39.47	17.3
Pakxe_ Champasak - Xaignabouri	11.67	11.86	13.91	5.66	33.13	40.2	38.52
Pakxe_ Champasak - XamNua_Houaphan	16.46	14.75	21.8	19.06	17.56	21.16	22.28
Pakxe_ Champasak - Xekong	12.56	6.67	8.39	17.26	22.48	22.64	16.34
Phongsali Phonhong_Viangchan	31.1	26.87	22.52	10.29	19.51	29.01	18.62
Phongsali Phonsavan_Xiangkhoang	29.83	27.33	15.77	13.05	10.29	23.56	14.88
Phongsali Saravan	26.03	30.76	13.74	6.05	16.79	18.09	12.18
Phongsali Savannakhet	26.44	28.74	7.3	8.32	13.77	33.08	15.19
Phongsali Xaignabouri	31.37	35.21	27.47	5.68	31.82	41.61	15.61
Phongsali Xekong	25.74	32.23	9.63	6.37	9.9	23.4	7.49
Phonhong_Viangchan - Phonsavan_Xiangkhoang	21.58	10.06	24.02	16.12	21.35	23.01	24.06
Phonhong_Viangchan - Xaignabouri	13.3	12.5	20.79	11.99	36.04	31.59	18.07
Phonhong_Viangchan - Xekong	12.09	13.35	9.88	6.68	14.63	42.06	27.34
Saravan- Phonhong_Viangchan	22.81	14.29	16.25	7.78	19.63	7.9	23.49
Saravan- Phonsavan_Xiangkhoang	25.88	7.45	16.71	5.52	17.56	8.82	8.18
Saravan- Savannakhet	20.14	9.24	9.59	3.57	23.91	25.25	15.65
Saravan- Xaignabouri	8.75	11.87	22.59	12.87	46.2	34.65	23.48
Saravan- Xekong	20.17	9.92	12.47	8.47	15.16	5.78	8.68
Savannakhet- Phonhong_Viangchan	18.98	12.12	7.14	5.92	23.56	31.82	26.26
Savannakhet- Phonsavan_Xiangkhoang	25.94	12.47	6.35	9.29	35.06	29.44	13.81
Savannakhet- Xaignabouri	7.24	16.02	7.87	4.94	34.18	61.82	13.23
Savannakhet- Xekong	11.95	8.26	10.97	5.08	30.19	21.32	16.27
Thakhek_Khammouan- Luangnamtha	20.73	9.05	16.06	5.46	25.23	31.1	12.45
Thakhek_Khammouan- Luangprabang	9.8	12.25	11.36	16.72	22.26	20.12	
Thakhek_Khammouan- Oudomxai	11.87	16.05	11.43	31.54	25.99	22.72	13.08
Thakhek_Khammouan- Phongsali	27.02	21.84	8.29	8.96	9.01	16.25	17.35
Thakhek_Khammouan- Phonhong_Viangchan	13.16	10.42	9.13	6	18.09	14.68	48.05
Thakhek_Khammouan- Phonsavan_Xiangkhoang	19.37	6.64	8.98	4.87	28.31	19.37	25.83
Thakhek_Khammouan- Saravan	17.94	5.76	13.66	6.93	27.99	19.98	21.31
Thakhek_Khammouan- Savannakhet	14.54	13.21	9.29	4.09	44.06	29.31	24.84
Thakhek_Khammouan- Viangchan	13.53	19.38	12.84	5.51	37.39	38.48	30.12
Thakhek_Khammouan- Xaignabouri	10.88	12.89	10.59	5.08	28.42	26.48	15.26
Thakhek_Khammouan- Xekong	15.98	3.17	21.06	7.58	27.43	14.23	32.17
Viangchan - Oudomxai	17.8	19.08	11.3	11.37	25.37	30.24	5.03
Viangchan - Phongsali	35.16	29.81	10.61	8.19	11.09	25.76	7.19
Viangchan - Phonhong_Viangchan	16.67	16.71	12.79	17.67	18.51	21.58	20.65
Viangchan - Phonsavan_Xiangkhoang	19.89	16.31	13.39	8.42	27.8	29.05	22.62

Viangchan - Saravan	12.2	13	13.13	11.19	23.13	17.28	12.75
Viangchan - Savannakhet	12.62	18.38	13	6.44	46.33	51.82	12.98
Viangchan - Xaignabouri	21.93	24.44	11.15	24.2	39.4	42.09	7.69
Viangchan - Xekong	10.67	11.56	14.75	6.71	26.83	16.6	9.12
Xaignabouri- Phonsavan_Xiangkhoang	14.39	10.88	20.78	6.7	23.89	26.37	9.99
Xaignabouri- Xekong	9.75	10.53	10.17	6.18	21.66	25.6	8.02
XamNua_Houaphan- Luangnamtha	29.34	9.9	18.76	16.99	13.56	19.96	11.1
XamNua_Houaphan- Luangprabang	18.96	18.72	10.23	22.92	14.6	14.42	
XamNua_Houaphan- Oudomxai	20.88	12.04	21.61	27.68	13.13	13.44	13.18
XamNua_Houaphan- Phongsali	35.94	29.28	22.28	26.19	8.88	13.98	15.15
XamNua_Houaphan- Phonhong_Viangchan	21.97	13.12	27.27	24.19	11.21	10.56	23.83
XamNua_Houaphan- Phonsavan_Xiangkhoang	22.65	12.51	27.95	13.92	26.94	18.23	13.44
XamNua_Houaphan- Saravan	17.17	12.32	22.38	17.79	11.5	6.79	16.24
XamNua_Houaphan- Savannakhet	16.24	18.14	9.61	14.2	24.36	15.07	30.24
XamNua_Houaphan- Thakhek_Khammouan	19.39	11.62	11.81	16.26	25.69	18.59	22.96
XamNua_Houaphan- Viangchan	21.68	18.68	13.85	22.1	20.12	21.79	14.63
XamNua_Houaphan- Xaignabouri	19.94	19.39	26.84	17.98	14.91	12.37	12.07
XamNua_Houaphan- Xekong	15.18	11.44	13.6	16.56	35.92	8.42	19.91
Xekong- Phonsavan_Xiangkhoang	22.39	7.04	10.68	5.56	32.32	16.76	8.02

Table A3 Results for first quality paddy sticky rice

	Semi-log robust standard errors				SUR for rice equations (semilog)		
	Paddy sticky rice				Paddy sticky rice		
	Coefficient	t stat	P>t		Coefficient	t stat	P>t
Transaction costs							
Travel time between provincial capitals	-0.002	-0.610	0.542		-0.002	-0.660	0.512
Geographic factors							
% villages urban	-0.001	-0.050	0.959		-0.001	-0.040	0.965
% HH upland	0.027	4.730	0.000		0.027	4.540	0.000
% rural villages prone to natural disasters	-0.006	-0.990	0.322		-0.006	-0.950	0.342
Market infrastructure							
Paved road density percent	0.181	6.160	0.000		0.181	6.580	0.000
% of popn exposure to all three media	-0.133	-3.810	0.000		-0.133	-3.850	0.000
% villages with Credit facilities	-0.019	-1.600	0.113		-0.019	-1.420	0.156
% of villages in which ag produce sold	-0.032	-2.790	0.006		-0.032	-2.680	0.008
Adoption of technology							
% HH using rice mill	0.020	3.020	0.003		0.020	2.800	0.005
% area planted to improved rice varieties	-0.024	-2.790	0.006		-0.024	-2.650	0.008
% of villages with electricity	0.000	0.020	0.983		0.000	0.020	0.981
Demand							
Total population of province	0.000	-3.420	0.001		0.000	-3.970	0.000
Supply							
Rice production per capita	-0.004	-2.280	0.025		-0.004	-2.580	0.010
Rice production per capita squared	0.000	3.480	0.001		0.000	4.310	0.000
F Stat of regression	20.450				14.560		
Prob > F	0.000				0.000		
R squared	0.743				0.743		

Table A4 Results for first quality Lao sticky rice

	Semi-log robust standard errors				SUR for rice equations (semilog)		
	Lao sticky rice				Lao sticky rice		
	Coefficient	t stat	P>t		Coefficient	t stat	P>t
Transaction costs							
Travel time between provincial capitals	-0.015	-3.910	0.000		-0.015	-3.830	0.000
Geographic factors							
% villages urban	-0.012	-0.360	0.717		-0.012	-0.380	0.702
% HH upland	0.009	1.140	0.256		0.009	1.300	0.196
% rural villages prone to natural disasters	0.010	1.550	0.124		0.010	1.360	0.174
Market infrastructure							
Paved road density percent	0.138	3.730	0.000		0.138	4.270	0.000
% of popn exposure to all three media	-0.069	-1.590	0.115		-0.069	-1.700	0.090
% villages with Credit facilities	-0.031	-1.840	0.068		-0.031	-2.010	0.045
% of villages in which ag produce sold	0.026	2.020	0.046		0.026	1.870	0.062
Adoption of technology							
% HH using rice mill	0.027	3.030	0.003		0.027	3.270	0.001
% area planted to improved rice varieties	-0.003	-0.270	0.790		-0.003	-0.260	0.792
% of villages with electricity	-0.015	-2.260	0.026		-0.015	-2.630	0.009
Demand							
Total population of province	0.000	-3.850	0.000		0.000	-4.320	0.000
Supply							
Rice production per capita	0.005	2.380	0.019		0.005	2.560	0.011
Rice production per capita squared	0.000	-1.110	0.271		0.000	-1.040	0.300
F Stat of regression	15.32				12.92		
Prob > F	0				0		
R squared	0.72				0.72		

Table A5 Results for first quality paddy steam rice

	Semi-log robust standard errors				SUR for rice equations (semilog)		
	Paddy steam rice				Paddy steam rice		
	Coefficient	t stat	P>t		Coefficient	t stat	P>t
Transaction costs							
Travel time between provincial capitals	0.002	0.290	0.775		0.002	0.400	0.686
Geographic factors							
% villages urban	0.011	0.310	0.755		0.011	0.300	0.763
% HH upland	0.033	3.780	0.000		0.033	4.060	0.000
% rural villages prone to natural disasters	0.037	2.970	0.004		0.037	4.430	0.000
Market infrastructure							
Paved road density percent	0.182	4.400	0.000		0.182	4.950	0.000
% of popn exposure to all three media	-0.248	-4.460	0.000		-0.248	-5.350	0.000
% villages with Credit facilities	0.034	1.980	0.051		0.034	1.890	0.059
% of villages in which ag produce sold	-0.059	-2.590	0.011		-0.059	-3.700	0.000
Adoption of technology							
% HH using rice mill	0.017	2.350	0.021		0.017	1.830	0.067
% area planted to improved rice varieties	-0.044	-4.200	0.000		-0.044	-3.660	0.000
% of villages with electricity	-0.004	-0.490	0.624		-0.004	-0.600	0.550
Demand							
Total population of province	0.000	-0.780	0.435		0.000	-0.730	0.469
Supply							
Rice production per capita	-0.003	-1.370	0.173		-0.003	-1.640	0.102
Rice production per capita squared	0.000	2.350	0.021		0.000	3.150	0.002
F Stat of regression	18.620				7.980		
Prob > F	0.000				0.000		
R squared	0.613				0.613		

Table A6 Results for first quality Lao steam rice

	Semilog Robust standard errors				SUR for rice equations (semilog)		
.	Lao steam rice				Lao steam rice		
	Coefficient	t stat	P>t		Coefficient	t stat	P>t
Transaction costs							
Travel time between provincial capitals	0.001	0.200	0.840		0.001	0.230	0.822
Geographic factors							
% villages urban	-0.023	-0.700	0.485		-0.023	-0.570	0.568
% HH upland	0.008	0.780	0.438		0.008	0.830	0.405
% rural villages prone to natural disasters	0.052	4.470	0.000		0.052	5.320	0.000
Market infrastructure							
Paved road density percent	0.089	2.300	0.023		0.089	2.050	0.041
% of popn exposure to all three media	-0.043	-0.850	0.397		-0.043	-0.780	0.433
% villages with Credit facilities	-0.019	-1.030	0.305		-0.019	-0.910	0.365
% of villages in which ag produce sold	0.023	1.030	0.305		0.023	1.220	0.223
Adoption of technology							
% HH using rice mill	-0.003	-0.410	0.684		-0.003	-0.260	0.796
% area planted to improved rice varieties	-0.031	-2.330	0.022		-0.031	-2.200	0.028
% of villages with electricity	0.024	3.340	0.001		0.024	3.050	0.002
Demand							
Total population of province	0.000	-0.500	0.620		0.000	-0.430	0.666
Supply							
Rice production per capita	0.001	0.560	0.575		0.001	0.590	0.557
Rice production per capita squared	0.000	0.030	0.974		0.000	0.030	0.972
F Stat of regression	14.47				7.25		
Prob > F	0				0		
R squared	0.59				0.59		

Table A7 Results for first quality beef

Semi-log robust standard errors			
Beef			
	Coefficient	t stat	P>t
Transaction costs			
Travel time betw een provincial capitals	0.001	0.25	0.8
Geographic factors			
% villages urban	0.02	0.84	0.404
% HH upland	0.018	2.8	0.006
% rural villages prone to natural disasters	0.024	2.38	0.019
Market infrastructure			
Paved road density percent	-0.008	-0.2	0.84
% of popn exposure to all three media	-0.105	-1.94	0.055
% villages w ith Credit facilities	0.016	1	0.322
% of villages in w hich ag produce sold	0.033	2.2	0.03
Adoption of technology			
% HH using rice mill	-0.035	-4.78	0
% area planted to improved rice varieties	0.02	2.68	0.008
% of villages w ith electricity	0.038	3.67	0
Demand			
Total population of province	0	-1.43	0.155
Supply			
Cattle per capita	-40.517	-4.95	0
Cattle per capita squared	75.955	5.06	0
F Stat of regression	6.16		
Prob > F	0		
R squared	0.55		

Table A8 Results for first quality buffalo meat

Semi-log robust standard errors			
Buffalo meat			
	Coefficient	t stat	P>t
Transaction costs			
Travel time between provincial capitals	0.001	0.18	0.861
Geographic factors			
% villages urban	0.001	0.04	0.97
% HH upland	0.003	0.35	0.725
% rural villages prone to natural disasters	-0.011	-1.22	0.225
Market infrastructure			
Paved road density percent	-0.009	-0.16	0.874
% of popn exposure to all three media	0.083	1.44	0.154
% villages with Credit facilities	0.004	0.22	0.83
% of villages in which ag produce sold	0.004	0.16	0.873
Adoption of technology			
% HH using rice mill	-0.001	-0.07	0.946
% area planted to improved rice varieties	0.026	2.21	0.029
% of villages with electricity	-0.042	-2.86	0.005
Demand			
Total population of province	0	0.49	0.622
Supply			
Buffalo per capita	12.899	1.26	0.211
Buffalo per capita squared	-45.063	-1.79	0.077
F Stat of regression	7.84		
Prob > F	0		
R squared	0.602		

Table A9 Results for first quality pork

Semi-log robust standard errors			
Pork			
	Coefficient	t stat	P>t
Transaction costs			
Travel time between provincial capitals	-0.015	-2.24	0.028
Geographic factors			
% villages urban	0.01	0.15	0.878
% HH upland	-0.01	-0.39	0.699
% rural villages prone to natural disasters	0.001	0.06	0.954
Market infrastructure			
Paved road density percent	-0.081	-0.67	0.502
% of popn exposure to all three media	0.062	0.51	0.613
% villages with Credit facilities	-0.009	-0.32	0.752
% of villages in which ag produce sold	0.023	0.46	0.645
Adoption of technology			
% HH using rice mill	-0.003	-0.23	0.822
% area planted to improved rice varieties	0.008	0.56	0.574
% of villages with electricity	0.023	2.26	0.026
Demand			
Total population of province	0	0.17	0.866
Supply			
Pigs per capita	2.142	0.59	0.56
Pigs per capita squared	-1.015	-0.67	0.504
F Stat of regression	3.43		
Prob > F	0		
R squared	0.446		

Table A10 Correlation matrix of residuals for SUR estimation

	ln paddy sticky rice	ln Lao sticky rice	ln paddy steam rice	ln Lao steam rice
ln paddy sticky rice	1			
ln Lao sticky rice	-0.0639	1		
ln paddy steam rice	0.0851	-0.0262	1	
ln Lao steam rice	0.199	0.1526	0.2083	1
Breusch-Pagan test of independence	chi2(6)	16.09		
	p value	0.0133		