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Distance to market and farm-gate prices of staple beans in rural Nicaragua

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***Abstract**: While smallholder marketing is seen effective to reduce poverty, farmers in rural areas face a number of challenges in doing so. One of the most important factors is transaction costs related to transportation. Our study quantifies the benefits associated with improvement of rural road infrastructure by scrutinizing farm-gate prices of beans in rural Nicaragua. We find that the longer the distance and traveling time are to major commercial centers from farming communities, the less farm-gate prices producers receive. We find that a decrease in distance and traveling time by one unit is associated with an increase in farm-gate prices by 2-2.5 cents/qq. If infrastructure development can reduce travel time by 25%, an average farm household would increase its annual revenue from beans by between $24 and $110 (3% and 12% of annual revenue). Given that such infrastructure development affects all farmers and crops, our findings suggest a larger implication*.

Keywords: Producer prices, Central America, Transactions costs, transportation infrastructure

JEL codes: O13, O18, Q11

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1. Introduction

In today's changing agri-food system, smallholder participation in commercial markets has attracted attention as a potential catalyst for alleviation of poverty. Farmers who are included in the global procurement system are found to benefit from premium product prices (Gulati et al., 2007), reduced transactions costs in product marketing (Nagaraj et al., 2008; Vieira, 2008), and access to necessary assets (Minten et al., 2009; Nagaraj et al., 2008; Swinnen, 2007). As a result, participating farmers are able to improve productivity, household income and/or asset holdings (Minten et al., 2009; Miyata et al., 2009; Reardon et al., 2009). However, participation in global supply chains requires good access to roads and other transportation infrastructure, production assets (e.g. irrigation system), and thorough knowledge of farming techniques among others (Barrett et al., 2012; Donovan & Poole, 2008; Hernandez et al., 2012; Michelson, 2013; Murray, 1991; Rao & Qaim, 2011). For lack of these factors, small farmers in rural areas are often excluded from the global retail markets and therefore unable to enjoy benefits that the global procurement system can provide.

In response to the difficulties that small farmers face, empirical studies suggest mechanisms that assist small farmers' participation in the global supply chain. For instance, Hellin et al. (2009) and Narrod et al. (2009) show the importance of collective actions by looking at cases in Central America, and Kenya and India, respectively. By forming farmer organizations, individual smallholders can conduct product marketing as a group, enabling access to improved market information as well as sales of larger quantities which can reduce transaction costs. Minten et al. (2009) argue that intensive farm technical assistance allows farmers to meet complex quality requirements imposed by buyers. They find that participating farmers in Madagascar are provided with necessary inputs by the buyer to ensure the quality of final products. Based on a negative experience in the pineapple industry in Ghana, Whitfield (2012) also highlights the importance of updating production technology as well as trade-friendly policy environments.

In essence, such mechanisms aim to reduce the transactions costs that smallholders face when accessing markets. Transactions costs are seen as one of the key factors that influence market participation and welfare of small farmers (Pingali & Khwaja, 2005; Barrett, 2008). Poor infrastructure in rural areas in particular can prevent smallholders in developing countries from participating in market-based economic activities (Mabaya, 2003; Moser et al., 2009). At the macro-level, geographically isolated areas demonstrate less market integration than those that are well-connected (Ravallion, 1986; Barrett, 1996; Baulch, 1997; Fackler & Goodwin, 2001). Rapsomanikis et al. (2006) show that high transfer costs due to poor infrastructure and lack of communication can create large marketing margins. Renkow et al. (2004) estimate that fixed transaction costs are equivalent to a 15% ad valorem tax on maize farmers in Kenya, and Jacoby and Minten (2009) show that transportation cost can be up to 50% of final product price in the case of rice farmers in remote areas of Madagascar. As a result, high transportation costs encourage farmers in rural areas to stay in subsistence farming (Dillon & Barrett, 2013; Key et al., 2000).

When markets are isolated, local players such as traders can acquire regional monopsony or oligopsony power (Barrett, 2008; Faminow & Benson, 1990; Graubner et al., 2011). As a result, commodity prices in geographically segregated areas often respond less quickly to changes in macro-level prices and are less integrated than in markets that are well linked to national and international markets (Getnet et al., 2005; Goletti et al., 1995; Siqueira et al., 2010). In dealing with market participants who have market power, smallholders will tend to pay more for inputs and receive less for their products, thus exacerbating the problem of low margins and poverty traps.

All of these considerations underline the recognized importance of transportation infrastructure improvement (Jacoby, 2000). Given the potential for infrastructure development in rural areas to alleviate poverty, there is an increasing interest in developing rural infrastructure (World Bank, 2007). However, quantifying the optimal level of infrastructure investment is a difficult task.

If policy makers ignore the effect of market segregation due to transportation cost on low farm prices, the optimal level of investment can be underestimated (Mérel et al., 2009). In order to take appropriate investment decisions, policy makers require quantitative information on the potential effect of rural road improvement. In this paper we generate such information by studying how farm-gate prices are affected by physical distance and traveling time from farms to markets. Building up on the hedonic price model, we identify product-, producer- and marketing-attributes, including physical distance and traveling time, which influence producer prices.

As a case study, we select the bean sector in rural Nicaragua. Bean is one of the most important crops for food security in Nicaragua besides maize and rice (FAO, 2012; INIDE, 2011). In the recent years, Nicaraguan bean sector suffered from stagnation of productivity and restriction of agricultural land expansion (FAO, 2012). In addition, as a key staple crop, beans are subject to government policy interventions that have arbitrary effects on bean producers. During 2010 and 2011, export restrictions were put in place by the government. This interrupted trade flows to major importers in neighboring Central American countries (FAO, 2012; La Prensa, 2011). Moreover, transportation costs within Nicaragua are high: on average, transportation costs within Nicaragua to local seaports account for 50% of total freight rates to the U.S. (World Bank, 2012). As a result, bean producers face difficulty in participating in commercial sales, particularly marginalizing those in remote areas. Our paper analyzes factors that influence producer prices of beans in Nicaragua. We pay particular attention to the role played by infrastructure and geographical location.

The rest of the paper is organized as follows. The next section describes the bean sector in Nicaragua. In section 3, we then explain our conceptual framework, data set and econometric model. Descriptive statistics and regression results are presented in section 4, and we discuss the findings and conclude in section 5.

2. Background

Beans are important for Nicaraguans not only as a staple food crop but also as a major income source for the poor (FAO, 2012; INIDE, 2011). Beans are produced throughout the country and especially in the Northwest (FAO, 2012). More specifically, production of beans is prominent in the departments[1] of Jinotega, Matagalpa and Nueva Segovia (INIDE, 2011).

Nicaragua's bean production is predominantly conducted by small producers. Approximately 50% of bean producers in the country farm less than 7ha[2] of land (Table 1).

Insert Table 1 here.

These small bean producers account for 30% of the land used for bean production. Considering that at the national level only 6% of total agricultural land is farmed by those who own less than 7ha of land (INIDE, 2011), beans are more important to small producers than other commodities.

[1] Geographical unit goes from departments, municipalities, and communities with departments being the largest units.

[2] In Nicaragua, land area is measured using Manzanas (Mz). 1 Mz=0.704ha.

The bean sector has seen little improvement regarding production technology (FAO, 2012). As a result, yield growth has been stagnant over the last 20 years (FAO, n.d.).

The majority of beans produced in Nicaragua are sold domestically but the export market has grown in the last decade (Figure 1).

Insert Figure 1 here.

Between 2007 and 2010, on average 30% of total production was directed to the export markets (FAO, n.d.-a). Central American countries are the biggest importers of Nicaraguan beans (Table 2). Since 2007, Nicaraguan exports to El Salvador, Costa Rica and Honduras have increased. El Salvador is now the largest importer of beans produced in Nicaragua, while a relatively small share is directed to the U.S. The active exchange of the commodity in the Central American region may be due to the Dominican Republic-Central America Free Trade Agreement (DR-CAFTA) signed by the Dominican Republic, the U.S. and Central American nations including Nicaragua in 2004 (USTR, n.d.). Bean exports to Venezuela have also grown since 2008 (Table 2).

Insert Table 2 here.

Two types of beans are produced in Nicaragua: red and black. Red beans are a staple commodity not only in Nicaragua but also in many other Central American countries. Therefore, production of red beans is significantly more than black beans. Although black beans may be exchanged domestically and regionally, they are mostly targeted for export to Venezuela (FAO, 2012). However, the sustainability as well as the potential of the Venezuelan market is questioned. Nicaragua and Venezuela do not have an official trade agreement such as DR-CAFTA, and exports to Venezuela are coordinated exclusively by the Nicaraguan government as a part of an alliance called ALBA (Bolivarian Alliance for the Peoples of Our America, Spanish acronym) (FAO, 2012). As a result, the transactions lack transparency (COHA, 2010) and there are concerns that the recent surge in black bean export to Venezuela may be temporary and do not provide income-generating opportunity for all producers.

As a key food security crop, beans are subject to policy interventions in Nicaragua. In 2010 and 2011, an informal restriction was put on red bean export in order to protect consumers in Nicaragua (The Economist, 2011). However, this policy was criticized for reducing Nicaragua's share of the regional red bean market (FAO, 2012; La Prensa, 2011). As seen in Table 2, bean export to El Salvador, Costa Rica and Honduras decreased significantly in 2010 and 2011. The resulting shortage of red beans in these Central American markets has been replaced by competitors such as China (FAO, 2012), which could result in Nicaragua losing these markets permanently.

Transportation costs are considered as one of the key factors that hinder both international and domestic product exchange in Nicaragua. According to World Bank (2012), Nicaraguan domestic transportation costs can make up more than 50% of the total freight costs to the U.S. For instance, transportation costs incurred within Nicaragua from Matagalpa, Jinotega and Nueva Segovia to the port of Corinto are 59%, 62% and 64%, respectively, of the total freight costs from these locations to Miami.

In summary, beans are important for smallholders in Nicaragua, many of whom live in remote areas without satisfactory transportation infrastructure. Accessibility to commercial markets differs significantly based on location. Our study intends to understand the role of transportation infrastructure to reach commercial markets in determining producer prices of beans. The next section explains our estimation strategy and the data that we employ.

3. Empirical estimation strategy

3.1. Conceptual framework

Our model is based on the hedonic price model developed by Rosen (1974). The hedonic price model decomposes observed market prices based on implicit characteristics of the goods exchanged. This model enables us to isolate product attributes of interest and assess how they influence market prices.

In the context of agricultural commodities, the hedonic price model has been mainly used to analyze consumer preferences for product attributes. For instance, a number of hedonic analyses of coffee prices have been published (e.g. Donnet et al., 2007, 2008; Teuber & Herrmann, 2012). Faye et al. (2004) and Mishili et al. (2009) look at cowpea prices in Senegal and Nigeria, Ghana and Mali, respectively. These studies analyze consumer preferences for individual products attributes in order to understand the factors that influence consumer choices. Our study applies an analogous methodology to disentangle product characteristics that influence prices received at the farm level. To the best of our knowledge, this is the first study to employ the hedonic price model in the context of producer prices.

Mathematically, the model is written as:

$$P_{it} = f(X_{jt}) + \varepsilon_{it} \qquad (1)$$

where P_{it} is the prices received by producer *i* at time *t*; the X_{it} is a vector of covariates that explain producer prices; and ε_{it} is the error term. We present possible covariates below and econometric issues will be discussed in the econometric model section.

Based on findings from the literature and the empirical context of Nicaraguan bean sector, we identify several variables that are potentially important determinants of farm-gate bean prices. Product quality is one of the most well-documented factors that influence prices (Donnet et al., 2007; Faye et al., 2004; Mishili et al., 2009). Quality characteristics can be implicit (e.g. reputation, brand, preferred production practices) or explicit (e.g. color, shape, size, taste). Marketing practices are often found to be important as well. In their consumer price study, Donnet et al. (2007) show that a large quantity decreases product prices. This may be because sellers are willing to give discount for a larger quantity of sales. However, we note that producer prices may increase with an increase in quantity exchanged since a large seller may be able to take advantage of the leverage. Gender might also play a role as female farmers may have less negotiation power than men and can face disadvantages when marketing (Dolan, 2001; Zhang et al., 2006). As a result, they may receive lower prices than their male counterparts.

Distance and lack of access to markets can have negative effects on producer prices. For instance, Fafchamps and Hill (2005) show that coffee producers in Uganda are offered lower prices by traders in their villages than at commercial markets due to the cost of traveling to remote villages. In addition, remoteness can reduce competition and enable oligopsonistic traders to offer lower farm-gate prices (Graubner et al., 2011). Michelson et al. (2012) show that farm-gate prices are significantly lower than wholesale prices in the capital city in Nicaragua. This may result from the exploitation of market power by traders in farming communities when individual transportation to commercial markets is not easy due to poor transportation infrastructure.

Based on these considerations, we employ various measures of product quality, quantity exchanged and transfer costs to major ports as explanatory variables in our analysis. We use total distance and traveling time between farming communities and commercial markets as proxies for transfer costs. No matter who travels the distance, farm-gate prices are set lower if the overall transfer costs are high. Therefore, our analysis applies total distance and traveling time from communities to major commercial centers instead of markets where producers could sell their products.

3.2. Data

We analyze sales data recorded by a local NGO, the Catholic Relief Services (CRS). CRS implemented a development project in rural Nicaragua between September 2007 and October 2012. This project targeted small farmers in Nicaragua who own less than 10 hectares of land. Among the information that was collected are records of individual sales by farmers over the five-year project period. In total, there are 3,893 bean producers in the data. Each producer sold beans at least once during the five years and the average producer sold beans three times, which sums up to a total of 11,719 observations. We exploit the full unbalanced panel data set.

The farmers included in the data set were not chosen randomly. Instead, CRS applied several criteria in selecting individuals to participate in its project[3]. However, the project did not include any interventions that directly influence farm-gate prices. Moreover, the information provided by CRS is rich in the factors that may influence farm-gate prices. The credibility of the information is high since the information on sales was collected every three months, which is approximately one cultivation cycle of beans. Price data are available for each individual sales transaction and include information on the buyers, destination countries, and product quality.

The dependent variable, the farm-gate prices of beans, was originally recorded in the local currency, Nicaraguan Córdobas. We converted the values to USD to facilitate result interpretation, using the exchange rates recorded throughout the project period. Our explanatory variables are transfer cost, and both non-binary and binary variables which are categorized as marketing-, product-, and farmer-related variables.

The exact location of each farm is not coded in the dataset, but for each farm we do know in which municipality it is located. Our data represent 54 out of a total of 153 municipalities in Nicaragua. The 54 municipalities on average each extend over 571 km², and most do not extend over 40 km in the longest dimension, while the distance to commercial markets range between 156km and 690km. While we are confident that the municipality provides a good first

[3] The details of the selection criteria are explained in a supplementary document and can be provided by the authors upon request.

approximation of a farm's location, GPS data would clearly facilitate future research. For each farm we calculate distances and traveling time between three major commercial centers and the center of communities in each municipality in which it is located using Google Maps. Both measurements are used since using only distances may not capture the quality of roads.

The three commercial centers are identified in terms of national and international product exchange: namely, Managua international airport, the Port of Corinto and the Port of Limón. The Port of Limón is the major seaport in Costa Rica while the Port of Corinto is in Nicaragua. In terms of Nicaragua's total export values, 30%, 15% and 14% are exchanged annually from Port of Corinto, Port of Limón and Managua international airport, respectively (Figure 2). As the nation's capital, Managua is an important point of commercial exchange for domestic consumption of beans. Thus we include Managua even though it is unlikely that beans are exported by air.

Insert Figure 2 here.

For marketing-related variables, we use information about buyers and the intended destination of the beans exchanged. Buyers are divided into five categories: local markets, intermediaries, farmer organizations/cooperatives, private companies, and private export companies. In the analysis, we drop the dummy variable representing local markets as a point of comparison. We expect product prices to be higher when the buyer is a farmer organization/cooperative rather than the local market or a private company. This is because cooperatives' main objective is not profit but rather enhancing members' welfare (Giannakas & Fulton, 2005). The information regarding destination countries was obtained through cooperatives. Approximately 90% of farmers in the sample belong to a cooperative and these cooperatives are aware of all the buyers outside local wholesale markets. Therefore, the cooperatives provided information regarding product destination countries corresponding to each buyer. All of the beans sold are destined for the domestic Nicaraguan market or for export to Costa Rica, El Salvador or Venezuela. In order to test whether prices differ by destination, we apply one dummy variable for each of the export destinations. Hence, the default destination is the domestic market in Nicaragua. While it is possible beans destined for export markets fetch higher prices, in the case of Venezuela the prices may be lower due to an agreement between the governments. Therefore, the expected effect of these destination dummy variables is unclear a priori.

For product-related variables, we apply product quality and variety. The quality variable is recorded as 1 if the bean sold is of a high quality. According to the NGO, quality was determined mainly based on grain size[4]. The variety variable equals 1 if the bean sold is red bean and 0 if it is black bean. We expect that the higher the quality of the product, the higher its price (Donnet et al., 2007; Faye et al., 2004; Mishili et al., 2009). Therefore, the quality variable is expected to have a positive coefficient. In terms of bean variety, red beans may receive higher and more volatile prices than black beans because black bean prices may be regulated by the Nicaraguan and Venezuelan governments while red bean prices are determined freely in the market.

For farmer-related variables, we employ two farmer characteristics variables: gender and household head. Gender of the producer is recorded as 1 if female and 0 if male. The household head variable equals 1 if the producer is the head of the household. The gender variable will have a negative coefficient if females face disadvantage when marketing compared with males (Dolan, 2001; Zhang et al., 2006). The effect of being a household head on producer prices is ambiguous.

3.3. Econometric model

In order to quantify how physical distance affects farm-gate prices in our panel data, we estimate a double log random-effects model. We conclude that this model is appropriate based on several diagnostic tests. First, we test for omitted variables problem and heteroskedasticity following Ramsey (1969) and Breusch & Pagan (1979), respectively. We find that pooled OLS estimation yields omitted variable problems and our data demonstrate heteroskedasticity. To mitigate the heteroskedasticity problem, we report heteroskedasticity-robust variances throughout. The omitted variable problems can be solved by exploiting the panel nature of our data set (Wooldridge, 2010). We use the random-effects model as our main interest lies in the distance and travel time variables, which are time-invariant.

Second, we test whether our dependent variable, farm-gate prices, is normally distributed. In Figure 3, we see that the distribution is skewed to the left and has several kinks. Diagnostic

[4] Generally speaking, international markets only accept "first grade", or high quality, and the lowest quality (below third grade) goes to animal feed. Beans that are not sold to international markets or feed processors are processed for human consumption or sold at local markets where the food quality standard is low.

tests suggested by D'agostino et al. (1990) and Royston (1992) confirm that the distribution is skewed and displays non-normal kurtosis. Therefore, we transform the dependent variable by taking a logarithm, and by applying a theta value estimated by the Box-Cox method. Both of these transformations yield normality in terms of skewness. We select the logarithmic transformation because the double-log model allows us to interpret estimated coefficients as elasticities.

Insert Figure 3 here.

Hence, we estimate the following specification of the model outlined in equation (1):

$$\ln P_{it} = \alpha + \beta_1 \ln TC_i + \beta_2 \ln Q_{it} + \gamma_j \sum_{j=1}^{J} X_{jt} + \xi_t + u_{it} \qquad (2)$$

where P_{it} is the farm-gate prices received by farmer i at time t; TC_i is the transfer cost (distance or time traveled to markets) between the municipality that farmer i lives in and the commercial center; Q_{it} is the quantity of beans sold; the X_{jt} are other characteristics that influence farm-gate prices; ξ_t are year dummies; and u_{it} is the error term. The covariates in X_{jt} include buyers (intermediaries, farmer organizations/cooperatives, private companies, private export companies), countries to which products were sold to (Costa Rica, El Salvador, Venezuela), product characteristics (product quality, red beans), and farmer characteristics (gender and head of the household).

4. Estimation results

Table 3 presents descriptive statistics for our data set. On average, the price of a quintal (qq) of beans is 34.13USD over all observations (see also Figure 3). A farmer sells about 21qq in one sales transaction while incurring 32.23USD of production costs. This generates 689.68USD of profit on average per sales transaction. Annually, a representative farmer produces 28.51qq of beans and incurs 43.79USD of production cost. The mean annual profit of all producers in the sample is 937.01USD per year. The annual profit ranges between -261USD and 18,319USD.

Insert Table 3 here.

Few farmers sell their products at non-local markets: only about 7% of producers sell to intermediaries, farmer organizations, and private companies. 14% of the producers are female and about half are heads of a household. Nearly 80% of the products were of high quality and 92% of products were red beans. Small percentage of produce is exported: approximately 8% to Costa Rica, El Salvador and Venezuela altogether.

On average, producers are located at a distance of 156km, 213km and 690km from Managua airport, the Port of Corinto and the Port of Limón, respectively. This confirms that the error introduced by using municipality rather than exact location for each farm is comparatively small. The average traveling times are 133, 183 and 596 minutes for Managua airport, the Port of Corinto and the Port of Limón, respectively.

Table 4 shows the estimated coefficients for all models. Overall the regressions are able to explain roughly one-half of the variation in the observed farm-gate prices. Most of our expectations are met. A one percent increase in quantity exchanged reduces farm-gate prices by 0.01%. For an average farmer, it is equivalent to a decrease by 0.3 cents/qq. While the coefficients in all models are statistically significant and negative, the magnitude of the effect is relatively small.

Insert Table 4 here.

As expected, farmer organizations offer higher prices than local markets, while private companies offer less. Product quality is strongly and statistically significantly linked to higher farm-gate prices, which is consistent with the findings from the empirical literature. The magnitude of the effect highlights the importance of quality attribute in determination of bean prices compared with other variables. First quality products receive 0.54% higher prices than the rest, which is approximately 18 cents/qq for an average exchange. Female sellers tend to receive lower prices than males, and household heads are likely to receive higher prices than non-household heads. Red beans are associated with higher prices than black beans. Prices of beans for the Costa Rican market tend to be lower than those that stay in Nicaragua. This might be due to their preference for black beans (Rodríguez Lizano, 2014). While the Salvadorian market offers higher prices than in Nicaragua, the coefficient for Venezuela is not statistically significant[5].

Regarding the estimated coefficients of distances, our main interest, all coefficients are negative and statistically significant. This indicates that a longer distance to the points of commerce is associated with a decrease in farm-gate prices. A one-percent increase in the distance to Managua, Corinto and Limón is associated with a 0.07%, 0.13% and 0.32% decrease

[5] Since Venezuela imports only black beans, there may be multicolinearity between the variables “Venezuela”, “Private company”, “Export company”, and “Red bean”. We tried excluding “Venezuela” from all estimations but omitting the variable does not change the results in terms of both signs and statistical significance.

in farm-gate prices, respectively. Evaluated at mean values, these estimated distance effects are equivalent to price reductions of 2 cents per qq and km of distance.

How does the message change if time traveled is taken into account rather than physical distance? Overall the results are very similar in all important respects. The signs of the coefficients of the time variable are negative and statistically significant. The result indicates that a one-percent increase in time traveled to the three locations is associated with a decrease in farm-gate bean prices by 0.10%, 0.15% and 0.45% for Managua, Port of Corinto and Port of Limon, respectively. Hence, on average a one-minute reduction in time traveled is associated with an increase in the bean price by approximately 2.5 cents per qq.

5. Discussion

The magnitudes of the estimated distance/travel time effects reported above are reasonable. An interview with CRS staffs revealed that the cost of transporting beans is approximately 4 cents per qq and kilometer. How important are these effects for the participating farmers and the rural communities?

Suppose that the transportation infrastructure improves in the farming communities and as a result the time of transportation decreases by 25%. In other words, it takes 100, 137 and 447 minutes on average instead of 133, 183 and 596 minutes to go to Managua, Corinto and Limón, respectively. According to our estimates, this would increase revenues from bean sales by $0.84, $1.26 and $3.85 per qq for sales directed to Managua, Corinto and Limón, respectively[6]. The average farmer in our sample sells 28.51qq of beans yearly. Therefore, assuming that production costs do not change and transportation costs decrease due to road improvement, bean sales profit would increase by at least between $24 and $110 per year. This ranges between 3% and 12% of an average farming household's annual income from bean sales. For the total 11,718 sales transactions in our sample, this translates to an annual income increase of between $281,232 and $1,288,980.

At the sectorial level, our finding has a larger implication. Our analysis is limited to bean producers in selected regions. Needless to say, bean farmers in our data set produce other crops

[6] Since we employ log-log model, the relationship between time traveled and producer prices may not be linear throughout observations even if elasticities stay constant. To check this, we calculated the effects at the mean, median, 25% quantile and 75% quantile. The results suggest that the price increase corresponding to a 25% decrease in time traveled would be between $0.75 and $3.21 at the median, $0.71 and $2.63 at the 25% quantile, and $0.69 and $3.74 at the 75% quantile. Therefore, we conclude that non-linearity does not affect our results to a large extent.

such as fresh vegetables and fruits. In addition, there are a total of approximately 260,000 agricultural producers throughout Nicaragua according to the national census (INIDE, 2011). The distance effects estimated above will also apply to these other crops and producers. Hence, investments in improved infrastructure such as roads would have a significant effect on agricultural revenues as a whole. This effect should be taken into account when calculating the benefits of infrastructure investment programs.

Note as well that our analysis of benefits to farmers of reducing transport costs does not take externalities into account. Improving rural transportation networks can have both positive and negative effects on rural communities (Straub, 2008, 2011). However, quantifying these effects is challenging (Straub, 2008) and beyond the scope of our research.

We acknowledge that our measure of distance, which is based on the municipality that a farm is located in, is imperfect. Ideally we would use GPS data to locate each farm precisely. While this might increase the explanatory power of our regressions, there is no reason to believe that error in the measurement of distance biases our results in either direction. We assume that the measurement errors can be both positive and negative, which results in zero bias on average.

6. Conclusions

In the development literature, smallholders' market participation has attracted attention as a catalyst for alleviation of poverty. One of the most important factors to enable smallholder marketing is reduction of transaction costs that small producers face in rural areas. Particularly, costs related to transportation have been discussed as important. However, quantification of benefits from improving transportation infrastructure has not been achieved by the empirical literature despite the recognized importance. Our study intends to fill the gap by taking one of the first steps towards understanding the effect of physical distance on farm-gate prices.

Using the data set collected in rural Nicaragua over five years, we estimate a hedonic price model. It enables us to separate attributes of the commodity of interest, staple beans, and understand what characteristics are associated with change in producer prices. We estimate a double-log model, using the random effects panel approach. Our main interest lies in the variable capturing distance and travel time between farming communities and major commercial centers. We selected the airport of Managua and two seaports in Nicaragua and Costa Rica which are important for agricultural marketing and trade. In addition to the distance variable, we employ other characteristics such as product quality and destination countries.

The results indicate that an increase in physical distance is indeed correlated with a decrease in farm-gate prices of beans. More specifically, we find that an increase in distance by 1km and travel time by one minute are associated with a decrease in farm-gate prices by 2-2.5 cents. We conclude that annual agricultural income from bean sales would increase by between $24 and $110 per year if travel time to markets is reduced by 25%. Considering that improvement in public roads affects multiple sectors and dimensions of poverty alleviation, the seemingly small increase in farm-gate prices can have important effects on rural households' agricultural income.

We acknowledge the limitations of our study. Our findings are limited to road development and do not take other types of transaction costs into account. Moreover, it is beyond the scope of our research to address externalities from rural road development. Therefore, we are not able to provide a comprehensive quantification as to the monetary returns to investment in public roads in rural areas. While such a task is challenging, further research should address more holistic measure of the benefits associated with development of rural roads.

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8. Tables and figures

Table 1. Farm size and number of bean producers in Nicaragua: 2011

Size	Bean producers			Bean cultivation area		
(Ha)	Number	%	Cumulative %	Ha	%	Cumulative %
<0.4	1,583	1.1	1.1	279	0.1	0.1
0.4-0.7	5,176	3.8	4.9	1,796	0.8	0.9
0.7-1.8	19,749	14.3	19.2	12,658	5.6	6.5
1.8-3.5	20,934	15.2	34.4	21,411	9.5	16.0
3.5-7	20,978	15.2	49.6	29,056	12.9	28.9
7-14	19,558	14.2	63.8	33,696	14.9	43.8
14-35	25,060	18.2	82.0	51,558	22.8	66.6
35<	24,841	18.0	100.0	75,508	33.4	100.0
Total	137,879	100.0	---	225,962	100.0	---

Source: (INIDE, 2011)

Table 2. Destination of Nicaraguan bean export

Destination	2006	2007	2008	2009	2010	2011
North America						
USA	3,744	3,789	5,523	5,732	4,886	2,540
Canada				80		20
Central America						
Guatemala	225	496	259	832	472	683
El Salvador		21,710	27,253	25,149	18,306	9,713
Costa Rica		17,981	14,264	14,525	12,675	3,766
Honduras		9,231	6,682	13,522	4,654	536
Panama			0	20	0	0
Others						
Venezuela			660	2,460	14,040	9,806

Source: (FAO, n.d.-a)

Table 3. Descriptive statistics

	Mean	S.D.	Min	Max
Price of beans(USD/qq*)	34.13	11.21	5.3	93
Quantity(qq)	20.99	24.96	0.5	416
Total production cost(USD)	32.23	39.45	0.5	739
Profit/sale(USD)	689.68	890.16	-396.4	13,394
Annual quantity/producer(qq)	28.51	33.71	0.5	476
Annual production cost/producer(USD)	43.79	52.20	0.7	1,109
Annual profit/producer(USD)	937.01	1,212.21	-260.8	18,319
Intermediary	0.03	0.18	0.0	1
Organization	0.00	0.04	0.0	1
Private company	0.02	0.15	0.0	1
Private-export company	0.02	0.13	0.0	1
Quality: first	0.79	0.40	0.0	1
Gender	0.14	0.35	0.0	1
Head of family	0.53	0.50	0.0	1
Red bean	0.92	0.26	0.0	1
Costa Rica	0.02	0.13	0.0	1
El Salvador	0.03	0.17	0.0	1
Venezuela	0.03	0.16	0.0	1
Distance (km) from municipalities to				
Managua	156.28	48.66	82	284
Port of Corinto	212.63	44.81	157	418
Port of Limón	690.08	49.15	444	818
Travel time (minutes) by motor vehicle to				
Managua	133.17	41.60	68	242
Port of Corinto	183.24	41.78	127	362
Port of Limón	596.04	41.54	386	705
Observations	11,718			

*Nicaraguan quintales. 1 qq = 100lbs or approximately 45kg.

Source: Authors' calculation

Table4. Regression results (t-values in brackets)

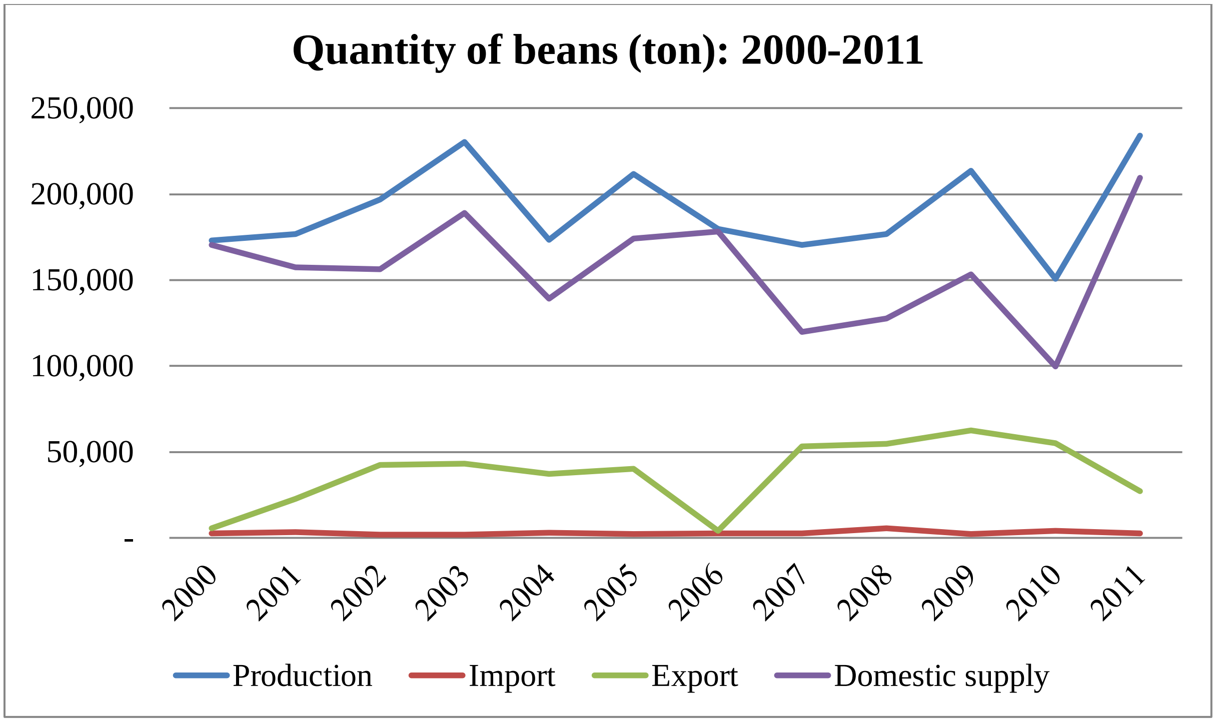
	Distance (km)			Travel time (minutes)		
	Managua	Corinto	Limón	Managua	Corinto	Limón
Quantity	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	(3.96)***	(4.69)***	(4.01)***	(4.59)***	(5.33)***	(4.68)***
Intermediary	-0.03	-0.02	-0.03	-0.02	-0.01	-0.02
	(4.49)***	(1.96)**	(4.21)***	(3.17)***	(1.34)	(3.02)***
Organization	0.12	0.13	0.12	0.14	0.16	0.13
	(7.77)***	(9.12)***	(7.77)***	(7.72)***	(9.39)***	(7.76)***
Private company	-0.10	-0.09	-0.10	-0.10	-0.09	-0.10
	(6.67)***	(6.00)***	(6.65)***	(6.16)***	(5.62)***	(6.21)***
Export company	-0.00	0.01	-0.00	0.00	0.02	0.00
	(0.03)	(0.50)	(0.02)	(0.07)	(0.96)	(0.18)
Quality: first	0.54	0.54	0.54	0.54	0.54	0.54
	(29.79)***	(29.50)***	(29.85)***	(29.53)***	(29.13)***	(29.57)***
Sex	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
	(4.09)***	(3.98)***	(3.98)***	(3.65)***	(3.61)***	(3.64)***
Head of family	0.04	0.04	0.04	0.04	0.04	0.04
	(8.31)***	(8.82)***	(8.59)***	(8.83)***	(9.12)***	(9.11)***
Red bean	0.13	0.13	0.13	0.13	0.12	0.13
	(13.56)***	(13.44)***	(13.64)***	(13.01)***	(12.84)***	(13.23)***
Costa Rica	-0.10	-0.09	-0.09	-0.09	-0.10	-0.09
	(6.50)***	(6.81)***	(6.57)***	(6.72)***	(7.32)***	(6.81)***
El Salvador	0.24	0.26	0.25	0.25	0.26	0.25
	(32.88)***	(31.38)***	(33.10)***	(33.13)***	(32.53)***	(33.44)***
Venezuela	-0.01	-0.01	-0.01	-0.01	-0.02	-0.01
	(0.70)	(0.73)	(0.65)	(0.63)	(0.98)	(0.62)
Transfer cost	-0.07	-0.13	-0.32	-0.10	-0.15	-0.45
	(7.85)***	(10.12)***	(8.72)***	(12.45)***	(13.56)***	(12.88)***
Constant	3.39	3.75	5.12	3.53	3.82	5.94
	(76.67)***	(54.21)***	(21.58)***	(87.34)***	(66.65)***	(26.55)***
R^2	0.49	0.50	0.50	0.50	0.50	0.50

* *p*<0.1; ** *p*<0.05; *** p<0.01.

Note: Regressions include time (year) fixed effects which are available from the author.

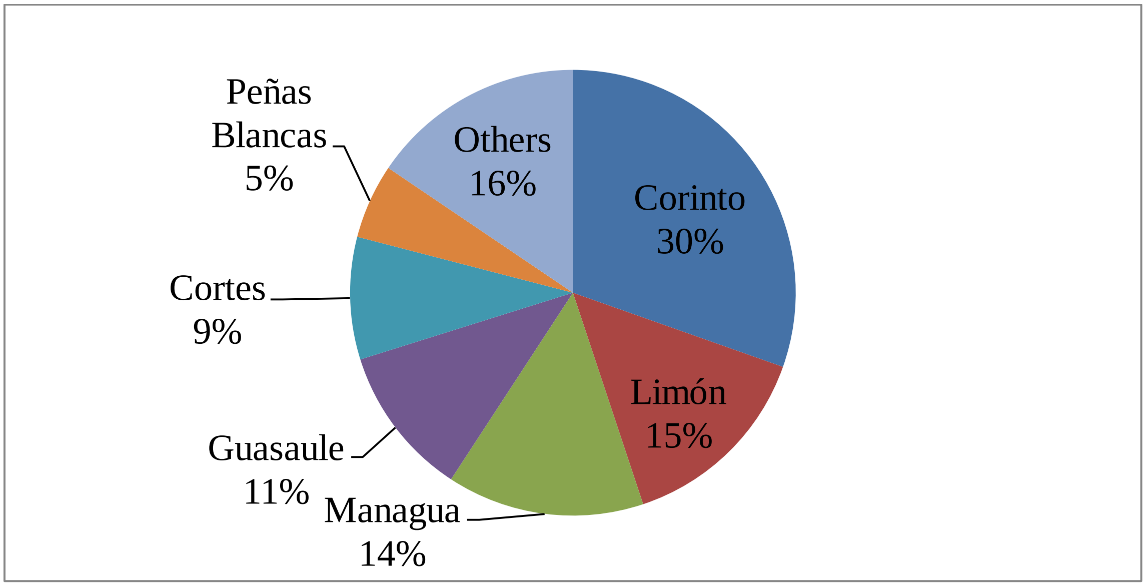
Source: Authors' calculation

Figure 1. Production, domestic supply and trade of beans in Nicaragua: 2000-2011



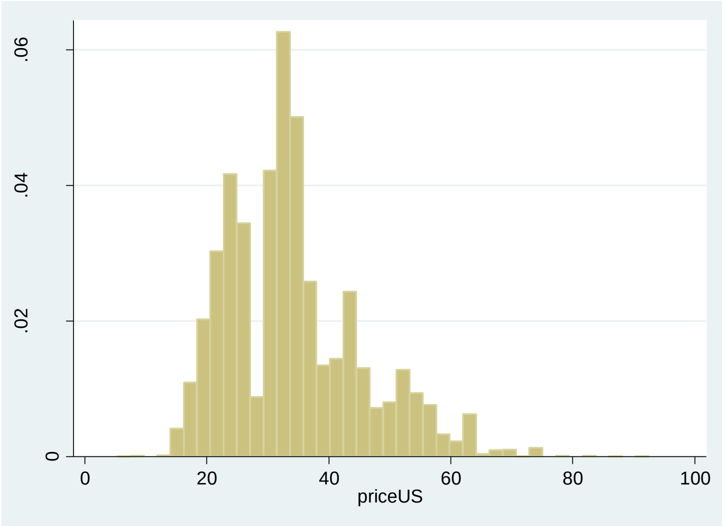
Source: (FAO, n.d.-a)

Figure 2. Share of value exported from various ports in Central America



Source: (CETREX, 2015)

Figure 3. Distribution of farm-gate prices



Source: Authors' calculation