Access to modern markets and the impacts of rural road rehabilitation: Evidence from Nicaragua*

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Abstract

The isolation of agricultural households in developing countries often leads smallholder farmers to face higher prices for consumer goods from opportunistic middlemen. A rural road rehabilitation project in western Nicaragua was designed to reduce transportation costs and improve the connections between rural areas and urban markets. The application of a spatial arbitrage model to one of these road upgrades determines improved market access benefitted rural communities moderately in the form of lower prices of consumer goods and contributes to the discussion on what the benefits and the relevant comparison group should be in the impact evaluation of a rural road rehabilitation project.

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1 Introduction

Rural roads are a vital foundation for rural development in developing countries. Due to the poor condition of rural roads, small family farmers are challenged by a multidimensional set of factors including increased travel times and transportation costs and isolation in terms of access to social and economic facilities. Dirt roads, in particular, can erode easily, sometimes making it even impossible to pass during the rainy season. The isolation of agricultural households can lead to lack of information regarding price, supply and demand, and quality standards, and often leads smallholder farmers to face higher prices for consumer goods from opportunistic middlemen.

The conceptual and empirical evidence suggests that interventions aimed at improving smallholders' participation in modern market channels are central to stimulating smallholder market access and escape from semi-subsistence poverty traps (Barrett, 2008; Khandker, Bakht, & Koolwal, 2009; Mu & Van de Walle, 2011; Gollin & Rogerson, 2014). Rural road rehabilitation projects are credited with facilitating farmers' participation in markets and increasing transportation of goods and services. This paper studies whether improved access to markets is reflected in changes in prices and availability of consumer goods in a small region of western Nicaragua where the main rural road was significantly rehabilitated as part of a program conducted by the Millennium Challenge Corporation (MCC).

In 2005, the MCC signed a five-year compact (MCA-N) with the Government of Nicaragua to invest in the western part of the country in the departments of Chinandega and León. As a part of this program, the MCA-N Transportation Project (2008-2009) had the goal of reducing transportation costs and improving rural communities' access to markets in this region, which has significant growth potential due to its fertile land and its connection to the Pan-American Highway that leads to markets in Honduras and El Salvador. This $57.9 million investment

allocated to the rehabilitation of 42 miles in two secondary roads and one secondary trunk road was expected to decrease transportation costs by $3.2 million annually and significantly reduce travel time, benefiting more than 97,000 people.

Benefits were expected to accrue to communities living within the zone of influence of the road upgrades in the form of lower prices and increased availability of consumer goods. An independent impact evaluation by Alevy (2014) concluded that the distribution of some perishable and fragile goods improved as a result of the program, but that the short-term overall effects of the project had been modest. This paper follows a different strategy by providing a model of spatial arbitrage between a big city and a rural area that focuses only on one of the roads that were rehabilitated as part of the MCA-N Transportation Project.

This particular road connects the city of León, which is the second largest in Nicaragua, with the fishing port of Poneloya and the coastal village of Las Peñitas and it is the only direct access to these coastal communities. Before the project its 12.2-mile surface was in very poor condition[1], as indicated by a baseline International Roughness Index (IRI) of 12.0, which fell to 1.84 after the rehabilitation.[2] The project included the improvement of pavement structures, minor and major drainage structures, sidewalks, shoulders, signage, and buses bays.

An impact evaluation determines what difference has a program made by comparing the observed outcomes with an estimate of what would have happened in the absence of the program. In this case, the goal is to compare the trend in prices in the area of influence of the rehabilitated road to what the trend in prices in the area would have been had the road not been rehabilitated. This opens a discussion on what the relevant comparison group should be in the impact evaluation of a rural road rehabilitation. This paper's strategy is to assume that, in the unobserved scenario, the level of prices in the rural area would be driven by the level of prices

[1]The average running speed of vehicles was about 35 miles/hr.

[2]IRI is the most commonly used road roughness index for evaluating and managing road systems.

in the big city. Prices in León can serve as an adequate counterfactual for the impact evaluation of the rehabilitated road because they should not be affected by improved access to smaller towns like Poneloya and Las Peñitas, except for those goods for which this rural area in particular is a major producer.

Most of the previous analyses of road improvements have focused on measuring the benefits from a direct reduction in transportation costs (Jacoby, 2000; Key, Sadoulet, & De Janvry, 2000; Stifel & Minten, 2008; Jacoby & Minten, 2009; Casaburi, Glennerster, & Suri, 2012). If we define transportation costs as a random variable, it could be said that all of these studies have analyzed the impact of a road improvement as a decrease in the mean transportation cost. However, improved road infrastructure may also reduce the uncertainty of transportation costs by reducing the probability of accidents and by allowing traders to coordinate their operations more efficiently. This paper contributes to this literature by allowing consumers to benefit not only from a reduction in transportation costs resulting in lower prices for consumer goods, but also to benefit from a reduction in the uncertainty of transportation costs resulting in lower variability of prices for consumer goods.

The estimated results show that improved market access benefitted rural communities moderately in the form of lower prices of consumer goods. However, they do not support Alevy's (2014) idea that the price of perishable and fragile items has been the most affected as a result of the intervention. In fact, storable consumer goods like cooking oil, toilet paper, matches, and toothpaste seem to be the ones that were affected the most by the intervention. The evidence on increased availability and lower variability of prices for consumer goods is not statistically significant. Still, setting up an empirical model that introduces these additional benefits of a rural road rehabilitation project contributes to a more complete impact evaluation methodology.

This paper is organized as follows. Section 2 provides a description of the

MCA-N Transportation Project and the dataset. Section 3 reviews Alevy's (2014) impact evaluation of the MCA-N Transportation Project and presents this paper's methodology for the impact evaluation of a rural road rehabilitation. The estimation results are presented in Section 4 and Section 5 discusses their interpretation. Section 6 concludes and suggests some extensions to this analysis.

2 Background

Nicaragua is the second poorest country in Latin America after Haiti. Over the last 25 years, Nicaragua endured a revolution, civil war, environmental disasters, and a president that embezzled over $100 million from his people. This chain of events left 50 percent of the country below the poverty line and without sufficient employment, infrastructure, health care, and education. Currently, almost half of its 6 million residents are living below the poverty line. Poverty is now largely a rural problem, although it can still be found in the capital, Managua, and in other urban areas. In poor and remote rural communities the access to basic services is a daily challenge.

A neglected rural road network can limit the exploitation of agricultural potential in a developing country such as Nicaragua. The improvement of rural roads and infrastructure could create opportunities for economic growth and poverty reduction, in particular, in western Nicaragua, a region where technical and financial assistance could potentially reduce farmers' technological constraints and increase agricultural productivity. The MCA-N Transportation Project focused on creating an engine for economic growth in this part of the country by substantially rehabilitating 42 miles of roads in 2008-2009: two secondary roads, Somotillo-Cinco Pinos in the north and León-Poneloya-Las Peñitas linking the urban center of León to oceanfront communities, and a secondary trunk road, Villanueva-Guasaule connecting the northern city of Villanueva to the Honduran border at El Guasaule.

The rehabilitation included resurfacing and extensive drainage and grading improvements. The road upgrades were expected to decrease vehicle operating costs and travel time. The communities within the zone of influence of the road upgrades were expected to benefit in the form of lower prices and increased availability of consumer goods.

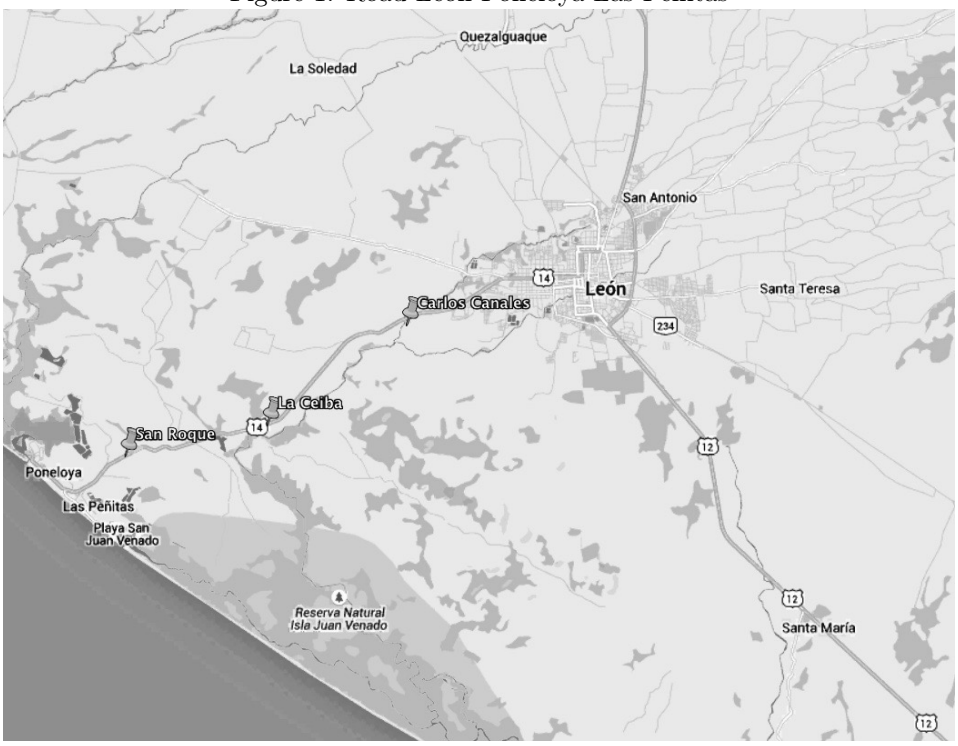
The MCC was specifically interested in being able to measure the project's impacts through data collection and analysis, including traffic counts, origin and destination surveys, and an establishment survey that provides data on the availability and prices of goods in the basic basket. The establishment survey collected information from establishments regarding availability and prices of goods that are part of the basic basket of goods that is used in Nicaragua to track consumer prices. Most of the surveyed establishments are small grocery stores. The rest are supermarkets or distributors. This basket contains 53 goods: 23 food items, 15 household items, and 15 clothing items. Four distinct rounds of data collection were conducted for the establishment survey, with two rounds both before and after the road rehabilitation.[3] This approach to data collection was meant to reduce concerns that some random shock such as bad weather or a temporary transportation difficulty would lead to an inaccurate conclusion about the conditions in specific establishments. All of the establishments in the survey are located in communities that are close to the roads that were originally considered for rehabilitation.

The establishment survey provides data on the availability and price of consumer goods around the area of influence of the road León-Poneloya-Las Peñitas shown in Figure 1. This road provides a clear scenario for the application of the model because it is the only direct access from the big city of León to Poneloya

[3]Two rounds of baseline surveys took place in August, 2008. The first round took place in August 11-16, 2008 and resulted in 209 completed surveys. The second round took place in August 25-30, 2008 and resulted in 200 surveys completed. Two rounds of surveys took place in the second half of 2010 after the road rehabilitation project was completed. The first round took place in August 30-September 3, 2010 and resulted in 224 completed surveys. The second round took place in September 27-October 1, 2010 and resulted in 209 surveys completed. Therefore, the final dataset of completed surveys contains 842 observations.

and Las Peñitas, which are not important ports for the exchange of goods. These coastal towns are mainly beach communities that are becoming popular tourist destinations.[4] The establishment survey was conducted in León, Poneloya, Las Peñitas, and in three additional communities directly served by the rehabilitated road: Carlos Canales, La Ceiba, and San Roque. Only four establishments were surveyed in La Ceiba and only two were surveyed in San Roque.[5] The number of observations for each community is described in detail in Table 1.

Figure 1: Road León-Poneloya-Las Peñitas



[4]The region of western Nicaragua has a lot to offer to visitors. Landscapes across the region include volcanoes, beaches, mangrove forests, estuaries, agricultural fields, and historic towns. Peanuts, sugar cane, salt, shrimp and rum are major contributors to the agricultural industry of the Chinandega department. The coastal towns of Poneloya and Las Peñitas offer tourists the opportunity to enjoy the Pacific Ocean. However, while poverty is low in the urban area of León, it is still either high or severe in this road's area of influence.

[5]For many of the consumer goods, the number of observations in these communities is too low to conduct any analysis.

Table 1: Observations in establishment survey

Community	Number of surveyed establishments	Observations				Total
		2008		2010		
		R1	R2	R1	R2	
León	35	27	26	23	24	100
Carlos Canales	14	8	8	12	11	39
La Ceiba	4	3	3	4	4	14
San Roque	2	1	2	2	2	7
Poneloya	17	10	10	14	12	46
Las Peñitas	15	10	10	13	11	44
Total	87	59	59	68	64	250

3 Impact evaluation methodology

Alevy's (2014) impact evaluation of the MCA-N Transportation Project follows three different empirical approaches. First, an economic rate of return analysis captures each road's flow of net benefits. This analysis shows that the rehabilitated roads' economic rate of return failed to meet a 10 percent hurdle rate. The average economic rate of return for the project as a whole was 2.1 percent. Actual capital costs were, on average, 2.2 times greater than those estimated in the feasibility studies. In particular, the economic rate of return for the road León-Poneloya-Las Peñitas was 0.95 percent or 4.5 percent if taken as an average across different methodologies.

Second, Alevy's (2014) analysis of the data collected by the establishment survey determines how prices and availability of consumer goods in the basic basket responded after the intervention. Difference in difference models are estimated for both the number of goods available and the prices of goods. The MCC had originally planned to rehabilitate several more roads. However, as a result to a series of actions taken by the government of Nicaragua, funding for the MCA-N Transportation Project was reduced. In his analysis of the data collected by the establishment survey, Alevy (2014) uses prices and availability of consumer goods

from the areas where the rehabilitation of a rural road was cancelled as a counterfactual to identify the impact of the road rehabilitation on the availability and prices of consumer goods in the treated areas. The underlying assumption is that the trends in price levels and availability for consumer goods in the areas where the road rehabilitation projects were cancelled serve as a counterfactual for the trends in price levels and availability for consumer goods in the areas where the road rehabilitation projects were conducted.

Alevy's (2014) identification strategy relies on the use of panel data, which requires surveying the same establishments before and after the road rehabilitation, and propensity score matching, which assigns heavier weights to control communities with similar characteristics to the treated communities. The matching is done using whether the community is urban or rural, the type of establishment, and whether the community is located directly on the road. Control communities were defined as all of the communities that were not located in the area of influence of the three rehabilitated roads. Alevy (2014) also tried expanding or reducing this definition of control communities by defining a broader area of influence of the roads or defining treated communities as only the communities that were directly located next to one of the three rehabilitated roads. This analysis provided evidence that the distribution of some perishable and fragile food items had improved as a result of the transportation project, but that the overall effects of the project had been modest. In particular, it was found that prices for cheese and eggs declined about 20% in the treated areas. Although there was a slightly larger increase in availability of consumer goods in project communities, it was not found to be statistically significant.

Alevy's (2014) third analysis relies on household survey data collected to evaluate the Rural Business Development[6] portion of the compact. Although this sur-

[6]The Rural Business Development (RBD) Program was designed to support farmers to develop and implement a business plan built around a high potential activity (Carter, Toledo, & Tjernström, 2012). Plans specified not only the type of activity that a farmer had to develop, but also the type of services that the RBD Program would provide during a 24-month period of

vey was not designed specifically to evaluate the MCA-N Transportation Project, Alevy's (2014) analysis also suggested that the upgraded roads had improved access to perishable and fragile items.

3.1 Spatial arbitrage model

This paper takes a different approach by providing a model of spatial arbitrage in support of the idea that the relevant comparison group for price changes in a rural area should be the price changes in the closest big city. Suppose there is a big city (C) and a rural area (T), which are connected by a low-quality road. Unless they can be produced locally, products are brought to the rural area from the big city. This allows establishments in the rural area to sell products at a markup, which is expected to be at least as high as the cost of transporting these products from the city, but could be higher than that depending on the establishment's market power. The risk and uncertainty that come from transporting products on a low-quality road could also be part of this markup. Under these conditions, average prices in the rural area are expected to be higher than in the big city for products that cannot be produced locally.

Define α as the difference in prices between the rural area and the big city, i.e. $\alpha = P_T - P_C$. Suppose the variance of prices for a product in the big city is $Var(P_C) = \sigma_c^2$ and suppose the variance of the difference in prices is $Var(\alpha) = \sigma_\alpha^2$. Then, the variance of prices in the rural area would be defined as:

$$Var(P_T) = Var(P_C + \alpha) = \sigma_c^2 + \sigma_\alpha^2 + 2Cov(P_C, \alpha)$$

The variance of prices in the rural area will be higher than the variance of prices in the big city as long as $\sigma_\alpha^2 + 2Cov(P_C, \alpha) > 0$. The covariance term, $Cov(P_C, \alpha)$,

intensive treatment and training. Business services included expert technical assistance, marketing support, materials and equipment, with the objective of improving farm productivity, and consequently, households' economic well-being.

represents the relationship between prices in the big city and the markup at which they are sold in the rural area. Sellers in the rural area could raise their markup or leave it unaffected if prices in the big city rise. Then, $Cov(P_C, \alpha) \geq 0$ and the condition above will be satisfied. $Cov(P_C, \alpha) < 0$ means establishments in the rural area lower their markup as a result of an increase in prices in the big city. If $Cov(P_C, \alpha) < 0$, the condition above could still be met if $\sigma_\alpha^2 > -2Cov(P_C, \alpha)$.

Suppose now a road rehabilitation takes place and significantly improves the quality of the road that links the rural area to the big city. Interpret this as a decrease in the first and second moments of the distribution of α. In this model, there are three possible effects of the intervention on the level and variance of the price of consumer goods. First, a decrease in the average level of markup, $E(\alpha)$, is expected to bring average prices in the rural area and in the big city closer together. Second, a decrease in the variance of transportation costs, σ_α^2, is expected to result in a decrease in the variance of prices in the rural area, $Var(P_T)$, if $\sigma_\alpha^2 > -2Cov(P_C, \alpha)$. Third, changes in the market structure of the rural area should also have an effect on prices. A reasonable scenario is that in which a better road improves competition in the rural area reducing the oligopolistic power of establishments.

The model predicts as a result of a rural road improvement the prices of consumer goods brought in from the big city to the rural area should behave as in Figure 2. First, the rural road improvement will reduce the markup at which establishments sell their products in the rural area. This means that after the intervention the average P_T should move closer to the average P_C. Second, a decrease in the variance of transportation costs could result in a decrease in the variance of prices in the rural area. This means that after the intervention the volatility of P_T should move closer to the volatility of P_C.

For goods that can be produced locally, but cannot be transported costlessly to the big city, there would be a negative markup and the price trend in the big

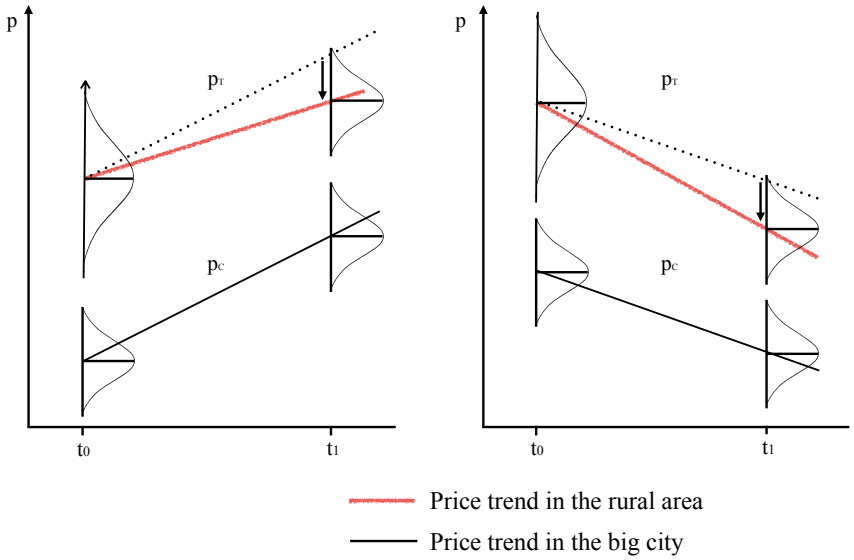


Figure 2: Model scenarios

city would be located above the price trend in the rural area in Figure 2. In that case, locally produced items would be cheaper in the rural communities, which is a detriment to the rural producers who would benefit from selling their product at a higher price in the big city.

3.2 Difference in differences

Difference-in-differences estimation can be used to deduce the impact of a policy change on the treated population (effect of the treatment on the treated). The structure implies that the treatment group and control group are trending in the same way over time. This means that the unobserved scenario is that had the treated group not received treatment, its mean value would be the same distance from the control group in the subsequent periods. The difference-in-differences

estimate is the measure of distance between this unobserved outcome and the actual outcome of a variable of interest.

3.2.1 Maximum likelihood (heteroscedastic)

This paper uses maximum likelihood estimation to calculate difference in differences of prices and standard deviations.[7] The log likelihood function for the heteroscedastic normal regression model is:

$$\ln L = \sum_{i=1}^{N} \left[\ln \phi \left\{ \left(y_i - x_i \beta \right) / \sigma_i \right\} - \ln \sigma_i \right]$$

where y_i is the dependent variable of interest, x_i is a vector of control variables, and ϕ is the probability density function of the standard normal distribution.

Define the dependent variable of interest, P_{igtr}, as the price at establishment i of consumer good g where t indicates year 2008 or 2010 and r indicates survey round one or two. Consider the following difference-in-differences model of prices where x_i is a vector of treatment and year dummies:

$$P_{igtr} = \beta_0 + \beta_1 D_i + \beta_2 \lambda_t + \beta_3 D_i \lambda_t + u_{igtr} \tag{1}$$

In this model, the treatment dummy, D_i, equals zero for León and is equal to one for the rest of the communities. The year dummy, λ_t, equals zero in 2008 and is equal to one in 2010. The error term u_{igtr} satisfies the assumptions of a linear regression model with $E\left[u_{igtr}\right] = 0$ and $Var\left[u_{igtr}\right] = \sigma^2_{igt}$. The difference in differ-

[7] As usual, standard errors are obtained by applying the Delta method. For a given $1 \times k$ vector of parameter estimates, $\hat{\theta} = \left(\hat{\theta}_1, \hat{\theta}_2, \ldots, \hat{\theta}_k\right)$, consider the estimated p-dimensional transformation $g(\hat{\theta}) = \left[g_1(\hat{\theta}), g_2(\hat{\theta}), \ldots, g_p(\hat{\theta})\right]$. The estimated variance-covariance of $g(\hat{\theta})$ is given by $Var\left\{g(\hat{\theta}) \right. = GVG'$ where V is the estimated variance-covariance matrix of $\hat{\theta}$ and G is the Jacobian of g, the $p \times k$ matrix of partial derivatives for which:

$$G_{ij} = \frac{\partial g_i(\theta)}{\partial \theta_j}|_{\theta=\hat{\theta}}$$

where $i = 1, \ldots, p$ and $j = 1, \ldots, k$. Standard errors are obtained as the squared roots of variances.

ences will be given by $\ _3$. If $E\left[P_{igtr}|D_i=0,t=2010\right]-E\left[P_{igtr}|D_i=0,t=2008\right]=\ _2$ and $E\left[P_{igtr}|D_i=1,t=2010\right]-E\left[P_{igtr}|D_i=1,t=2008\right]=\ _2+\ _3$, then:

$$E\left[P_{igtr}|D_i=1,t=2010\right]-E\left[P_{igtr}|D_i=1,t=2008\right]$$

$$-\left[E\left[P_{igtr}|D_i=0,t=2010\right]-E\left[P_{igtr}|D_i=0,t=2008\right]\right]=\ _3$$

In this model in particular, we are also interested in calculating the difference in differences of standard deviations to study what has happened to the volatility in prices after the intervention. Consider the following difference-in-differences model of standard deviations:

$$\sigma_{it}=\gamma_0+\gamma_1 D_i+\gamma_2\ _t+\gamma_3 D_i\ _t+\varepsilon_{it} \tag{2}$$

The difference in differences of the standard deviation of prices will be given by γ_3.

An alternate model would say there is no reason to expect the variation in prices in the rural area to be related to the variation in prices in the big city. In that case, we would only evaluate whether the standard deviation of prices in the treated communities has fallen after the rural road rehabilitation. Consider the model:

$$\sigma_{it}=\gamma_0^*\left(1-D_i\right)+\gamma_1^*\left(1-D_i\right)\ _t+\gamma_2^* D_i+\gamma_3^* D_i\ _t+\varepsilon_{it} \tag{3}$$

The interpretation of γ_3^* is different in this case. Its significance indicates whether the standard deviation of prices at the treated communities has changed from 2008 to 2010.

3.2.2 Squared deviation of prices over rounds

The structure of this dataset in particular allows to evaluate whether short-term variance in prices has been impacted by the project. Two rounds of data were

gathered before the intervention. This allows to obtain the squared deviation of prices over rounds, a measure of what the short-term price variation was at each establishment before the road rehabilitation. Then, this baseline measure can be compared to the same measure after the intervention to estimate whether there has been a significant change. The following measure of short-term variance, s_{gt}^2, is defined as the average squared deviation in prices over rounds across establishments for a consumer good g in year t:

$$s_{gt}^2 = \sum_i \}\frac{1}{N} \left(P_{igt2} - P_{igt1}\right)^2$$

Difference-in-differences estimation can be used to test whether there has been a significant change in squared deviation of prices over rounds (short-term variance) after the intervention. Consider the following model:

$$\left(P_{igt2} - P_{igt1}\right)^2 = \ _0 + \ _1 D_i + \ _2 \ _t + \ _3 D_i \ _t + u_{igt} \tag{4}$$

where $E\left[u_{igt}\right] = 0$. As before, D_i equals zero for León and is equal to one for the other communities. The difference in differences of the squared deviation of prices over rounds will be given by $_3$. It could also be argued that there is no reason to expect the short-term variation in prices in the rural area to be related to the short-term variation in prices in the big city. Then, we should also consider the following model:

$$\left(P_{igt2} - P_{igt1}\right)^2 = \ ^*_0 \left(1 - D_i\right) + \ ^*_1 \left(1 - D_i\right) \ _t + \ ^*_2 D_i + \ ^*_3 D_i \ _t + u_{igt} \tag{5}$$

4 Estimation results

This section estimates whether the level and variance of the price of consumer goods in the treated rural communities (Carlos Canales, La Ceiba, San Roque, Poneloya, and Las Peñitas) moved closer to the level and variance of the price of consumer goods in the big city, León, after the rural road rehabilitation. The model suggests prices in the treated communities could behave as in Figure 2. Not only are prices in the rural area expected to move closer to prices in the big city after the rural road rehabilitation, but also the variance of prices in the rural area is expected to fall and become more similar to the variance of prices in the big city.

Table 2 provides some baseline summary statistics. P_C indicates average prices in León (control) and P_T indicates average prices in the five communities connected to the big city by the road (treatment). Prices are given in córdobas, the official currency of Nicaragua (1 córdoba = 0.05 US dollars approximately). The average markup, α, is defined as the difference in price means, Mean(P_T)-Mean(P_C). In the baseline, most of the consumer goods are cheaper (22/37 goods) and less volatile (23/37 goods) in León. Thirteen of these goods are significantly cheaper in León. These include six food items: beans, sugar, cooking oil, chicken, eggs, and potatoes. They also include seven household items: detergent, toothpaste, matches, broom, toilet paper, sanitary towels, and toothbrush. On average, these thirteen products are 13.77% more expensive outside of León and range from 6% more expensive (chicken) to 21% more expensive (detergent). The only product that was found to be significantly more expensive in León was fish. Table 3 provides the same statistics for 2010. The difference from α in 2008 to α in 2010 equals the difference-in-differences estimates in Table 4. There seems to be a significant decrease in markup for cooking oil, toothpaste, matches, and toilet paper (markup did not increase significantly for any of these thirteen goods). Fish provides an example of how improving access in the big city to goods that are typically produced in the

rural area could also be a major benefit of a better road to consumers in the big city and producers in the rural area. Even though the price of fish in León has increased in 2010, it has moved closer to the price in the rural communities.

The maximum likelihood heteroscedastic estimation method provides the same estimates while also allowing to obtain the difference in differences of standard deviations. The results from this model, with standard deviations modeled as in Equation 2, are included in Tables 5 and 6. Clothes and a few other items are omitted from this analysis because of the low number of observations available. It is clear that a positive and significant $_1$ leads to identifying the same thirteen goods (twelve because there are not enough observations for chicken). The year trend, $_2$, is always positive for household items and does not follow a clear trend for the rest of the goods. The significance of the treatment effect on the treated, $_3$, changes in some cases from that in Table 4 because this method has introduced heteroscedasticity into the model.

Again, there seems to be a significant decrease in markup for cooking oil, toothpaste, and toilet paper. These three non-perishable goods were significantly more expensive in the rural area in the baseline. In the follow-up, their prices moved significantly closer to the price in León. Their behavior after the intervention resembles the model presented in Figure 2. The markup for cooking oil used to be 4.08 in 2008 and fell to 2.37 in 2010. However, the price of cooking oil in 2010 is still significantly higher (8.58%) in the rural area. The markup for toothpaste used to be 2.36 in 2008 and fell to -0.68 in 2010. This markup is no longer significant, which means the price of toothpaste in the rural area is no longer significantly different from the one in León. Similarly, the markup for toilet paper fell from 1.28 in 2008 to 0.22 in 2010 and it is no longer significant. The markup for matches used to be 0.11 in 2008 and fell to -0.45 in 2010. However, this fall is not significant in the heteroscedastic model. The relative interpretation of these results is presented in Table 7, which summarizes the results from the maximum likelihood

heteroscedastic estimation as percentile deviations from the constant. It suggests the falls in prices could be significant for the consumer. The percentile decreases in prices in the rural area are -5.4% for cooking oil, -12.1% for toothpaste and -9.7% for toilet paper.

The standard deviations of cooking oil, toothpaste, matches, and toilet paper also behave similar to the model presented in Figure 2. The standard deviation of the price of these four products in the baseline was higher in the rural area as shown by $\gamma_1 > 0$ (not significant for toilet paper). This difference in their volatility seems to fall or stay the same over time as shown by $\gamma_3 < 0$ (positive not significant for cooking oil and not significant for toothpaste). Table 7 also presents the results for standard deviations modeled as in Equation 3.

A different model allows to test whether there is any evidence of a change in squared deviation of prices over rounds, which is a measure of short-term variance. The estimation results from this model are shown in Table 8. It is clear that this model does not provide any clear evidence of a change in short-term variance of prices of consumer goods after the road rehabilitation. The parameters of interest, $_3$ and $^*_3$, are only significant in a few cases and do not seem to follow any pattern. However, it is worth noting that toilet paper again stands out as a good for which short-term variance fell significantly after the project.

One additional model is required to test whether the availability of consumer goods in the treated rural communities has increased after the rural road rehabilitation. The dependent variable for this part of the analysis is whether or not the consumer good was available for sale at the establishment at the time of the survey. A probit model is appropriate to analyze such a binary outcome, in this case, Yes=1 and No=0. The control variables are the same treatment and year dummies as in the difference-in-differences model. The results from these probit regressions presented in Table 9 show that availability at the establishments in the rural area has only increased significantly for white bread and yellow onion. Availability for

rice, sugar, cabbage, matches, toilet paper and bathroom soap has significantly decreased.

5 Discussion

5.1 Price levels and standard deviations

The vulnerability of poor isolated households to weather shocks suggests they would benefit, not only from a reduction in the transportation costs of purchasing inputs and selling outputs, but from a reduction in the uncertainty of these costs. Transportation costs may be extremely volatile, for example, when heavy rains during the monsoon season in some regions of the world might even make some villages inaccessible. The condition of the road León-Poneloya-Las Peñitas before its rehabilitation was similar to this scenario. An International Roughness Index (IRI) of 12.0 characterizes a rough unpaved road and a fall to 1.84 after the rehabilitation is that of a brand new highway.

Roads play a central role in rural development, but despite large amounts spent on them, little is known about the size and distribution of their benefits. Even though the evidence on increased availability and lower variability of prices for consumer goods is not statistically significant, introducing these additional benefits to the impact evaluation contributes to the general methodology for estimating the gains of a rural road rehabilitation project.

The definition of an appropriate counterfactual is critical because the rehabilitation of a rural road will hardly ever be randomized. Defining the urban area of León as the relevant control group, the estimation results provide some evidence of an impact in consumer prices. However, there are several factors that could be making these impacts so notoriously modest. The first one is the proximity of the follow-up survey. How long it takes for impacts to emerge is an issue that often arises in discussions of road impacts and planning for their evaluation (Mu &

Van de Walle, 2011). Good maintenance of the road is also critical for impacts to appear in the medium and long term. The improved condition of the road might simply not last long enough for a significant change to appear in the prices of consumer goods.

5.2 Availability and market structure

It is important for the assumptions of the difference in differences model to be explicitly stated and discussed in any impact evaluation that uses this methodology. The definition of a control group should never be taken lightly. Alevy (2014) examines whether the rehabilitation of the roads affected the number of goods available for sale at the establishments and the results from that analysis did not indicate that there were strong effects of the intervention on the availability of goods. In contrast, this paper takes advantage of the dichotomous nature of the answers to the availability question to analyze the impact of the road rehabilitation with a different methodology, but still did not find evidence of a significant change.

It is questionable whether changes in availability in any other areas can serve as an adequate counterfactual to the changes in availability of goods in the communities connected to a rehabilitated rural road. Comparing changes in availability to what has happened in other areas has not proved to be useful in this setting and there is no clear theoretical reason in this paper's model that would support it. Therefore, determining whether consumer goods have become more available was done analyzing availability of goods before and after the intervention within the treated areas.

With respect to market structure, it is an open question what the relevant model of market structure is for intermediaries in a rural community in a developing country. Different models of trader competition and intermediation generate different predictions about the price response to an improvement in rural road quality and how this response varies with market characteristics. The competition-enhancing

effect of an improved road may reduce the middlemen's market power. An improvement in transportation infrastructure that intensifies competition between traders and reduces transportation cost uncertainty could result in a reduction in the middleman's expected margin. In particular, the model this paper has adopted predicts that reduced markups should be associated with decreases in prices in rural markets and this could be due both to decreased transportation costs or to a fall in the establishments' market power.

6 Conclusion

This paper studies the changes in price levels, price volatilities, and availabilities of consumer goods in the area of influence of the rehabilitated road León-Poneloya-Las Peñitas. The remoteness of the coastal villages in this area makes this scenario ideal for a simple and clear application of a spatial arbitrage model. The direction of trade flows may not be as clear in a different area, for example, around Somotillo, a city located close to the border with Honduras that has several links to other communities surrounding it.

This paper contributes a different approach on how to construct an appropriate comparison or control group for communities receiving improved infrastructure. Alevy (2014) obtains the impact of the road rehabilitation by comparing areas where a rehabilitation took place and areas where it did not. By providing a model of spatial arbitrage and analyzing a single road's area of influence individually, the model presented in this paper suggests that the relevant comparison group is the urban area of León, which is located within the area of influence of the road.

Evaluating several projects as a whole can lead the impact evaluation to ignore a lot of what is happening within the area of influence of each project. Alevy's (2014) analysis supports the idea that the price of perishable and fragile items in the area of influence of the rehabilitated roads has decreased as a result of the

intervention. However, this paper has not found strong evidence that this has been the case in the area of influence of the road León-Poneloya-Las Peñitas. In fact, the results in this paper seem to support the opposite idea. Storable consumer goods like cooking oil, toilet paper, matches, and toothpaste seem to be the ones that were affected the most by the intervention.

The first logical extension to this paper is to analyze the two other roads that were rehabilitated by the MCA-N Transportation Project. A different extension would be to use data from the household-level survey conducted for the evaluation of the Rural Business Development program to study the impacts of rural road rehabilitation on farmers' market decisions instead.

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Table 2: Difference in means in 2008 (treated vs. control)

Price (Córdobas)	Mean P_C	S.D.	N	Mean P_T	S.D.	N	α	α/P_C%
Rice (lb)	10.71	1.29	12	10.25	0.69	36	-0.46	-4.28%
Beans (lb)	13.73	1.27	11	15.60	0.99	15	1.87***	13.64%
Sugar (lb)	5.38	0.32	10	5.95	0.24	30	0.58***	10.70%
Cooking oil (l)	34.42	1.24	12	38.50	2.18	36	4.08***	11.86%
Beef (lb)	37.00	1.18	11	38.50	4.95	2	1.5	4.05%
Pork (lb)	36.00	1.22	5	34.00	1.73	3	-2	-5.56%
Chicken (lb)	22.50	0.87	5	23.87	0.97	23	1.37**	6.09%
Fish (lb)	23.50	3.51	8	18.67	1.15	3	-4.83***	-20.57%
Eggs (dozen)	29.40	1.95	5	33.00	3.04	42	3.6***	12.24%
Tortilla	1.50	0.58	4	1.08	0.19	12	-0.42	-27.78%
Pinolillo	6.07	6.17	10	3.03	2.61	45	-3.04	-50.03%
Pasta (400 g)	7.05	0.96	11	7.38	1.36	29	0.33	4.74%
Tomato	1.60	0.49	12	1.70	0.98	32	0.1	6.17%
Yellow onion	1.79	0.58	12	2.06	0.88	26	0.27	14.85%
Potatoes	10.08	1.08	12	11.42	0.95	26	1.34***	13.29%
Chiltoma	1.17	0.44	12	1.02	0.31	30	-0.15	-12.86%
Green plantain	3.25	0.75	12	3.00	0.56	25	-0.25	-7.69%
Orange	1.78	0.38	10	1.67	0.52	6	-0.11	-6.10%
Cabbage	12.67	3.70	12	11.29	4.27	17	-1.37	-10.84%
Laundry Soap	11.41	1.07	11	12.25	2.07	24	0.84	7.37%
Detergent	1.58	0.38	6	1.92	0.44	26	0.34*	21.46%
Toothpaste	20.40	1.35	10	22.76	2.82	25	2.36***	11.57%
Matches	0.98	0.08	11	1.09	0.22	41	0.11**	11.06%
Broom	28.82	3.57	11	32.88	4.19	8	4.06**	14.08%
Toilet paper	7.05	1.17	10	8.33	1.25	46	1.28***	18.10%
Bathroom soap	10.50	0.67	12	10.37	1.07	41	-0.13	-1.28%
Sanitary towels	10.08	0.47	12	11.81	1.67	32	1.73***	17.15%
Deodorant	40.00	4.45	11	41.23	7.17	13	1.23	3.08%
Toothbrush	7.67	0.62	12	9.03	1.34	34	1.36***	17.77%
Short shirt (Men)	103.75	38.16	4	77.50	45.96	2	-26.25	-25.30%
Underpants (Men)	16.75	5.68	4	18.33	5.16	6	1.58	9.45%
Socks (Men)	11.25	2.50	4	12.29	2.06	7	1.04	9.21%
Short shirt (Women)	112.50	32.83	6	75.00		1	-37.5	-33.33%
Underpants (Women)	16.50	1.73	4	19.17	4.92	6	2.67	16.16%
Brassier (Women)	24.50	1.00	4	24.17	3.76	6	-0.33	-1.36%
Underpants (Kids)	10.80	4.02	5	9.71	0.76	7	-1.09	-10.05%
Socks (Kids)	11.40	2.19	5	10.17	0.41	6	-1.23	-10.82%

*** p<0.01, ** p<0.05, * p<0.1

Table 3: Difference in means in 2010 (treated vs. control)

Price (Córdobas)	Mean P_C	S.D.	N	Mean P_T	S.D.	N	α	α/P_C%
Rice (lb)	9.77	0.60	13	10.05	0.55	41	0.28	2.86%
Beans (lb)	13.17	3.97	9	13.84	3.17	19	0.68	5.13%
Sugar (lb)	7.61	4.12	14	6.95	1.53	42	-0.66	-8.69%
Cooking oil (l)	27.68	1.03	14	30.05	2.32	38	2.37***	8.58%
Beef (lb)	36.00	0.93	8	40.00		5	4	11.11%
Pork (lb)	39.00	1.10	6	34.50	2.12	2	-4.5	-11.54%
Chicken (lb)	20.00		1	22.32	1.54	31	2.32***	11.61%
Fish (lb)	25.00		2	26.60	13.79	5	1.6	6.40%
Eggs (dozen)	28.00	3.46	5	30.55	9.35	47	2.55	9.12%
Tortilla	1.00		4	1.07	0.26	15	0.07	6.67%
Pinolillo	11.79	16.62	12	2.93	0.21	48	-8.86*	-75.18%
Pasta (400 g)	7.71	1.19	14	9.18	1.23	37	1.46***	18.94%
Tomato	2.11	0.65	9	1.73	0.59	35	-0.38	-18.12%
Yellow onion	3.22	1.97	9	3.21	1.10	36	-0.01	-0.43%
Potatoes	8.89	1.05	9	10.28	1.05	32	1.39***	15.66%
Chiltoma	1.67	0.50	9	1.88	0.65	26	0.22	13.08%
Green plantain	2.61	0.65	9	2.99	0.81	34	0.37	14.33%
Orange	1.50	0.71	5	1.58	0.49	6	0.08	5.56%
Cabbage	24.44	6.35	9	15.13	4.73	8	-9.32***	-38.13%
Laundry Soap	12.95	1.26	13	13.51	2.18	42	0.56	4.36%
Detergent	1.96	0.43	14	2.50	1.71	44	0.54*	27.64%
Toothpaste	22.79	3.62	14	22.11	4.09	37	-0.68	-2.97%
Matches	1.60	1.94	13	1.15	0.28	43	-0.45	-27.98%
Broom	30.63	2.07	8	32.87	3.83	15	2.24*	7.32%
Toilet paper	9.55	1.87	14	9.78	0.77	45	0.22	2.35%
Bathroom soap	12.04	0.69	14	12.91	1.32	38	0.87***	7.25%
Sanitary towels	12.75	1.76	14	14.05	1.30	39	1.3**	10.21%
Deodorant	41.23	3.22	13	46.18	5.13	20	4.94***	11.99%
Toothbrush	8.12	1.36	13	9.57	1.09	35	1.46***	17.94%
Short shirt (Men)	160.00	21.60	4	165.00	7.07	2	5	3.13%
Underpants (Men)	19.75	10.96	2	22.00	6.71	5	2.25	11.39%
Socks (Men)	13.50	2.12	2	12.75	3.65	8	-0.75	-5.56%
Short shirt (Women)	161.25	34.73	4	137.00	38.99	5	-24.25	-15.04%
Underpants (Women)	17.50	2.50	3	19.38	7.86	12	1.88	10.71%
Brassier (Women)	25.00		3	26.00	3.16	10	1	4.00%
Underpants (Kids)	10.83	1.44	3	11.00	3.25	12	0.17	1.54%
Socks (Kids)	10.00		3	12.20	2.97	10	2.2**	22.00%

*** p<0.01, ** p<0.05, * p<0.1

Table 4: Difference-in-differences estimation results

	α =Mean(P_T)-Mean(P_C)		Diff-in-diff	Significant baseline	Change in
Price (Córdobas)	2008	2010		markup	markup
Rice (lb)	-0.46	0.28	0.74**		
Beans (lb)	1.87***	0.68	-1.20	+	↓
Sugar (lb)	0.58***	-0.66	-1.24	+	↓
Cooking oil (l)	4.08***	2.37***	-1.71*	+	↓
Beef (lb)	1.5	4.00	2.5*		
Pork (lb)	-2.0	-4.50	-2.50		
Chicken (lb)	1.37**	2.32***	0.95	+	↑
Fish (lb)	-4.83***	1.60	6.43	-	↓
Eggs (dozen)	3.6***	2.55	-1.05	+	↓
Tortilla	-0.42	0.07	0.48**		
Pinolillo	-3.04	-8.86*	-5.83**		
Pasta (400 g)	0.33	1.46***	1.13*		
Tomato	0.1	-0.38	-0.48		
Yellow onion	0.27	-0.01	-0.28		
Potatoes	1.34***	1.39***	0.05	+	↑
Chiltoma	-0.15	0.22	0.37		
Green plantain	-0.25	0.37	0.62*		
Orange	-0.11	0.08	0.19		
Cabbage	-1.37	-9.32***	-7.95**		
Laundry Soap	0.84	0.56	-0.28		
Detergent	0.34*	0.54*	0.20	+	↑
Toothpaste	2.36***	-0.68	-3.04*	+	↓
Matches	0.11**	-0.45	-0.56*	+	↓
Broom	4.06**	2.24*	-1.82	+	↓
Toilet paper	1.28***	0.22	-1.05*	+	↓
Bathroom soap	-0.13	0.87***	1.01**		
Sanitary towels	1.73***	1.3**	-0.43	+	↓
Deodorant	1.23	4.94***	3.71		
Toothbrush	1.36***	1.46***	0.09	+	↑
Short shirt (Men)	-26.25	5.00	31.25		
Underpants (Men)	1.58	2.25	0.67		
Socks (Men)	1.04	-0.75	-1.79		
Short shirt (Women)	-37.5	-24.25	13.25		
Underpants (Women)	2.67	1.88	-0.79		
Brassier (Women)	-0.33	1.00	1.33		
Underpants (Kids)	-1.09	0.17	1.25		
Socks (Kids)	-1.23	2.2**	3.43		

*** p<0.01, ** p<0.05, * p<0.1

Table 5: Maximum likelihood estimates (heteroscedastic)

Parameter	Rice (lb)	Beans (lb)	Sugar (lb)	Cooking oil (l)	Pork (lb)	Milk (l)	Eggs (dozen)
$_0$	10.7***	13.7***	5.38***	34.4***	36.0***	16.8***	29.4***
	(.356)	(.366)	(.095)	(.343)	(.490)	(.321)	(.780)
$_1$	-.458	1.87***	.575***	4.08***	-2.00**	.00000	3.60***
	(.374)	(.441)	(.105)	(.496)	(.952)	(.000)	(.907)
$_2$	-.939**	-.561	2.24**	-6.74***	3.00***	.830	-1.40
	(.390)	(1.30)	(1.07)	(.433)	(.638)	(.742)	(1.59)
$_3$	.738*	-1.20	-1.24	-1.71**	-2.50*	.00000	-1.05
	(.415)	(1.50)	(1.09)	(.675)	(1.48)	(.000)	(2.14)
γ_0	1.23***	1.21***	.301***	1.19***	1.10***	1.29***	1.74***
	(.252)	(.259)	(.067)	(.242)	(.346)	(.227)	(.551)
γ_1	-.550**	-.261	-.065	.966***	.319	.00000	1.26*
	(.264)	(.312)	(.074)	(.351)	(.673)	(.000)	(.641)
γ_2	-.657**	2.53***	3.67***	-.194	-.095	2.25***	1.35
	(.276)	(.919)	(.754)	(.307)	(.451)	(.525)	(1.12)
γ_3	.514*	-.399	-2.40***	.334	.181	.00000	4.90***
	(.293)	(1.06)	(.772)	(.477)	(1.05)	(.000)	(1.51)
N	102	54	96	100	16	44	99

Parameter	Pinolillo	Pasta (400 g)	Tomato	Yellow onion	Potatoes	Ayote	Chiltoma
$_0$	6.07***	7.05***	1.60***	1.79***	10.1***	9.40***	1.17***
	(1.85)	(.276)	(.136)	(.161)	(.299)	(1.44)	(.123)
$_1$	-3.04	.334	.099	.266	1.34***	.00000	-.150
	(1.89)	(.371)	(.218)	(.233)	(.350)	(.952)	(.135)
$_2$	5.72	.669	.507**	1.43**	-1.19***	-3.40**	.500**
	(4.95)	(.412)	(.246)	(.640)	(.447)	(1.58)	(.199)
$_3$	-5.83	1.13**	-.481	-.280	.053	.00000	.368
	(4.97)	(.521)	(.315)	(.686)	(.516)	(.000)	(.242)
γ_0	5.86***	.916***	.473***	.557***	1.04***	4.57***	.425***
	(1.31)	(.195)	(.097)	(.114)	(.212)	(1.02)	(.087)
γ_1	-3.28**	.421	.492***	.301*	-.110	-.803	-.123
	(1.34)	(.263)	(.154)	(.165)	(.248)	(.673)	(.095)
γ_2	10.1***	.229	.141	1.30***	-.044	-2.76**	.046
	(3.50)	(.291)	(.174)	(.452)	(.316)	(1.12)	(.141)
γ_3	-12.4***	-.357	-.528**	-1.07**	.154	.00000	.291*
	(3.51)	(.368)	(.223)	(.485)	(.365)	(.000)	(.171)
N	115	91	88	83	79	20	77

*** p<0.01, ** p<0.05, * p<0.1

Table 6: Maximum likelihood estimates (heteroscedastic) (cont.)

Parameter	Green plantain	Orange	Cabbage	Laundry Soap	Detergent	Toothpaste	Matches
$_0$	3.25***	1.77***	12.7***	11.4***	1.58***	20.4***	.977***
	(.208)	(.114)	(1.02)	(.307)	(.140)	(.405)	(.022)
$_1$	-.250	-.108	-1.37	.841	.340**	2.36***	.108***
	(.235)	(.224)	(1.43)	(.515)	(.164)	(.685)	(.040)
$_2$	-.639**	-.275	11.8***	1.54***	.377**	2.39**	.621
	(.292)	(.305)	(2.24)	(.456)	(.178)	(1.02)	(.516)
$_3$	.624*	.192	-7.95***	-.276	.202	-3.04**	-.555
	(.341)	(.405)	(2.91)	(.700)	(.322)	(1.33)	(.519)
γ_0	.722***	.361***	3.54***	1.02***	.344***	1.28***	.072***
	(.147)	(.081)	(.723)	(.217)	(.099)	(.286)	(.015)
γ_1	-.174	.110	.598	1.01***	.088	1.48***	.146***
	(.166)	(.158)	(1.01)	(.364)	(.116)	(.484)	(.029)
γ_2	-.108	.271	2.44	.197	.067	2.21***	1.79***
	(.206)	(.216)	(1.58)	(.322)	(.126)	(.719)	(.365)
γ_3	.360	-.294	-2.15	-.067	1.19***	-.936	-1.73***
	(.241)	(.286)	(2.06)	(.495)	(.228)	(.943)	(.367)
N	80	27	46	90	90	86	108

Parameter	Broom	Toilet paper	Bathroom soap	Sanitary towels	Deodorant	Toothbrush
$_0$	28.8***	7.05***	10.5***	10.1***	40.0***	7.67***
	(1.03)	(.350)	(.186)	(.130)	(1.28)	(.170)
$_1$	4.06**	1.28***	-.134	1.73***	1.23	1.36***
	(1.72)	(.394)	(.249)	(.319)	(2.30)	(.283)
$_2$	1.81	2.50***	1.54***	2.67***	1.23	.449
	(1.23)	(.595)	(.258)	(.472)	(1.54)	(.399)
$_3$	-1.82	-1.05*	1.01***	-.428	3.71	.093
	(2.09)	(.633)	(.372)	(.591)	(2.70)	(.494)
γ_0	3.41***	1.11***	.645***	.449***	4.24***	.589***
	(.726)	(.247)	(.132)	(.092)	(.905)	(.120)
γ_1	.513	.129	.408**	1.20***	2.64	.728***
	(1.22)	(.279)	(.176)	(.225)	(1.63)	(.200)
γ_2	-1.47*	.698*	.022	1.25***	-1.15	.714**
	(.872)	(.421)	(.182)	(.334)	(1.09)	(.282)
γ_3	1.26	-1.18***	.232	-1.62***	-.739	-.954***
	(1.48)	(.447)	(.263)	(.418)	(1.91)	(.349)
N	42	115	105	97	57	94

*** p<0.01, ** p<0.05, * p<0.1

Table 7: Changes in price levels and standard deviations

Product	Only shown if significant									
	0	$\frac{\beta_1}{\beta_0}$	$\frac{\beta_3}{\beta_0+\beta_1+\beta_2}$	γ_0	$\frac{\gamma_1}{\gamma_0}$	$\frac{\gamma_3}{\gamma_0+\gamma_1+\gamma_2}$	γ_0^*	$\frac{\gamma_1^*}{\gamma_0^*}$	γ_2^*	$\frac{\gamma_3^*}{\gamma_2^*}$
Rice (lb)	10.7***		.079*	1.23***	-.447***		1.23***	-.533***	.682***	-.210*
Beans (lb)	13.7***	.136***		1.21***			1.21***	2.08**	.952***	2.24***
Sugar (lb)	5.38***	.107***		.301***		-.615***	.301***	12.2***	.236***	5.38***
Cooking oil (l)	34.4***	.119***	-.054***	1.19***	.814*		1.19***		2.15***	
Pork (lb)	36.0***	-.056**	-.068*	1.10***			1.10***		1.41**	
Milk (l)	16.8***			1.29***					1.29***	1.75***
Eggs (dozen)	29.4***	.122***		1.74***		1.12*	1.74***		3.00***	2.08***
Pinolillo	6.07***	-.500***	-.666***	5.86***	-.559***	-.984***	5.86***	1.72**	2.58***	-.921***
Pasta (400 g)	7.05***		.140*	.916***			.916***		1.34***	
Tomato	1.60***		-.218*	.473***	1.04**	-.478***	.473***		.965***	-.402***
Yellow onion	1.79***			.557***		-.496***	.557***	2.33**	.859***	
Potatoes	10.1***	.133***		1.04***			1.04***		.927***	
Ayote	9.40***			4.57***			4.57***	-.605***	1.00**	
Chiltoma	1.17***			.425***	-.289*		.425***		.302***	1.12***
Green plantain	3.25***			.722***			.722***		.548***	.460*
Orange	1.77***			.361***			.361***		.471***	
Cabbage	12.7***		-.344***	3.54***			3.54***		4.14***	
Laundry Soap	11.4***			1.02***	.989*		1.02***		2.03***	
Detergent	1.58***	.215*		.344***		2.39**	.344***		.432***	2.91***
Toothpaste	20.4***	.116***	-.121**	1.28***	1.16**		1.28***	1.72**	2.76***	.460*
Matches	.977***	.111***		.072***	2.04***	-.863***	.072***	24.9***	.218***	
Broom	28.8***	.141**		3.41***			3.41***	-.433**	3.92***	
Toilet paper	7.05***	.181***	-.097*	1.11***		-.608***	1.11***		1.23***	-.387***
Bathroom soap	10.5***		.085**	.645***	.632*		.645***		1.05***	
Sanitary towels	10.1***	.171***		.449***	2.67***	-.558***	.449***	2.78***	1.65***	-.223*
Deodorant	40.0***			4.24***			4.24***		6.89***	
Toothbrush	7.67***	.178***		.589***	1.23**	-.470***	.589***	1.21*	1.32***	

*** p<0.01, ** p<0.05, * p<0.1

Table 8: Differences in s^2_{gt} (treated vs. control)

	s^2_{2008}			s^2_{2010}				
Product	León	Rural area	Δs^2_{2008}	León	Rural area	Δs^2_{2010}	$_3$	$^*_3$
Rice (lb)	1.71	0.20	-1.51	1.20	0.64	-0.56	0.951	0.443
Beans (lb)	5.00	1.33	-3.67**	52.42	42.50	-9.92	-6.25	41.2***
Sugar (lb)	0.06	0.13	0.06	47.68	6.82	-40.87	-40.9	6.69
Cooking oil (l)	1.50	5.73	4.23*	1.00	11.17	10.17**	5.93	5.43
Eggs (dozen)	14.50	7.58	-6.92	2.00	115.41	113.41	120	108
Pinolillo	44.53	15.35	-29.18	281.35	0.07	-281.28	-252*	-15.3
Pasta (400 g)	1.65	1.08	-0.57	1.65	1.00	-0.65	-0.083	-0.083
Tomato	0.09	0.24	0.15	0.50	0.68	0.18	0.028	.434**
Yellow onion	0.54	0.86	0.32	5.63	2.03	-3.60	-3.92	1.16
Potatoes	2.17	1.33	-0.83	2.00	0.82	-1.18	-0.348	-0.515
Chiltoma	0.25	0.02	-0.23	0.25	0.25	0	0.229	0.229
Green plantain	0.75	0.08	-0.68	1.31	0.55	-0.76	-0.087	0.475
Laundry Soap	3.05	1.57	-1.48	1.00	7.42	6.42*	7.9	5.85
Detergent	0.50	0.13	-0.38	0.28	7.52	7.24	7.61	7.4
Toothpaste	1.25	1.63	0.38	28.80	35.27	6.47	6.1	33.6
Matches	0.01	0.03	0.02	0	0.03	0.03	0.014	0.002
Broom	4.00	11.33	7.33	14.50	8.33	-6.17	-13.5	-3
Toilet paper	2.81	1.71	-1.10	0.05	0.35	0.30	1.4	-1.36*
Bathroom soap	0.67	1.00	0.33	0.20	1.14	0.94	0.61	0.143
Sanitary towels	0.42	1.54	1.12	0.40	0.42	0.02	-1.11	-1.12
Deodorant	7.60	73.20	65.60	6.50	16.13	9.63	-56	-57.1

*** p<0.01, ** p<0.05, * p<0.1

Table 9: Probit regression estimates on availability of product (Yes=1, No=0)

Product	Control	ControlxYear	Treat	TreatxYear
Rice (lb)	-.736***	0.264	.674***	-.378*
Beans (lb)	-.736***	0.132	-.445***	0.002
Sugar (lb)	-.736***	0.264	.776***	-.444*
Cooking oil (l)	-.736***	0.264	.533***	-0.201
Beef (lb)	-.801***	-0.107	-1.86***	0.376
Pork (lb)	-1.30***	0.207	-1.53***	-0.386
Chicken (lb)	-1.30***	-0.697	-0.078	-0.008
Fish (lb)	-1.02***	-.671*	-1.53***	0.047
Eggs (dozen)	-1.10***	-0.103	.626***	-0.257
Cheese (lb)	-5.85	3.85	-.724***	-0.05
Tortilla	-1.43***	0.091	-.887***	0.065
Pinolillo	-.801***	0.197	.579***	-0.173
Pasta (400 g)	-.801***	0.328	0.157	0.033
White bread	-1.77***	0	-.533***	.758***
Tomato	-.736***	-0.089	0.197	-0.077
Yellow onion	-.736***	-0.089	-.533***	.689***
Potatoes	-.736***	-0.089	0	-0.052
Ayote	-.801***	-0.024	-2.15***	0.233
Chiltoma	-.736***	-0.089	0.157	-0.174
Green plantain	-.736***	-0.089	-0.039	0.091
Orange	-.869***	-0.338	-1.01***	-0.219
Cabbage	-.736***	-0.089	-.402**	-.756***
Laundry Soap	-.736***	0.199	.445***	-0.255
Detergent	-.736***	0.264	.402**	-0.142
Toothpaste	-.801***	0.328	.319**	-0.233
Matches	-.736***	0.264	.674***	-.449**
Broom	-.801***	-0.107	-1.08***	0.348
Toilet paper	-.801***	0.328	.725***	-.392*
Bathroom soap	-.736***	0.264	.489***	-.368*
Sanitary towels	-.736***	0.264	.319**	-0.129
Deodorant	-.801***	0.264	-0.237	-0.323
Toothbrush	-.736***	0.199	0.237	-0.254
Long Pants (Men)	-1.20***	-0.137	-1.86***	0.125
Short sleeve shirt (Men)	-1.30***	-0.031	-1.53***	-0.204
Underpants (Men)	-1.43***	-0.265	-1.08***	-0.151
Socks (Men)	-1.43***	-0.265	-1.01***	-0.084
Short sleeve shirt (Women)	-1.20***	-0.137	-1.53***	0.047
Long Pants (Women)	-1.30***	-0.031	-1.86***	0.125
Full Dress (Women)	-2.07***	0.069	-2.15***	0
Underpants (Women)	-1.30***	-0.186	-1.01***	0.139
Brassier (Women)	-1.30***	-0.186	-1.08***	0.101
Synthetic Leather Sandals (Women)	-1.43***	0.091	-2.15***	0
Full suit (Kids)	-1.30***	-0.031	-2.15***	0.667
Underpants (Kids)	-1.30***	-0.186	-1.15***	0.279
Socks (Kids)	-1.30***	-0.186	-1.23***	0.196

*** p<0.01, ** p<0.05, * p<0.1