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The effect of earthquakes on food consumption and prices: Evidence from a natural experiment design

El efecto de terremotos en el consumo y precios de alimentos: Evidencia de un diseño de experimento natural

Juan Enrique Huerta Wong
Coordinación General de Comunicación Social y Vocería del Gobierno de la República, México
jehuerta848@gmail.com
ORCID: https://orcid.org/0000-0003-3592-6578

Julieth Santamaría
University of Minnesota. Department of Applied Economics, Estados Unidos
juliethsa@iadb.org
ORCID: https://orcid.org/0000-0002-8487-106X

Adán Silverio Murillo
Instituto Tecnológico de Estudios Superiores de Monterrey ITESM, Campus Ciudad de México
adan.sm@tec.mx
ORCID: https://orcid.org/0000-0002-5966-8887,

Isidro Soloaga
Universidad Iberoamericana. Ciudad de México
isidro.soloaga@ibero.mx
ORCID: https://orcid.org/0000-0003-0854-5809,

Abstract

Do disasters reduce food consumption and increase prices? In recent years, many countries have faced a growing wave of disasters, alongside governments' growing interest in quantifying their impact. Given the difficulty of collecting data in disaster-hit areas, little is known about how a disaster affects households in the short term. In this study, we use an experimental design to study food consumption and prices collected following an earthquake. Using a difference-in-differences approach, we evaluate the effect of the earthquake and found: 1) strong decreases in food consumption at the intensive and extensive margin; 2) the distribution of food baskets helped to mitigate this effect, suggesting that disaster recovery

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funds are key to alleviate food insecurity after a disaster; 3) road disruptions, as hazard impacts, might exacerbate the reduction in food consumption.

Keywords: Disasters, Food consumption, Food prices, Food security.

Resumen

¿Los desastres reducen el consumo de alimentos e incrementan sus precios? En los años recientes, muchos países han enfrentado una ola creciente de desastres, al tiempo que los gobiernos aumentan su interés en cuantificar su impacto. Dada la dificultad de recoger datos en regiones impactadas por desastres, poco se sabe acerca de cómo un desastre afecta a los hogares en el corto tiempo. En este estudio, utilizamos un diseño experimental natural para estudiar consumo de alimentos, y también recolectamos precios después de un terremoto. Usando un enfoque de diferencia en diferencias para analizar los datos, evaluamos el efecto del terremoto y encontramos: 1) fuertes reducciones en el consumo de alimentos a un margen intensivo y extensivo, 2) la distribución de canastas de alimentos ayudaron a mitigar este efecto, sugiriendo que los fondos de recuperación del desastre son claves para aliviar la inseguridad alimentaria después de un desastre, 3) las afectaciones a caminos, así como los impactos de tormentas per se, pueden contribuir a la reducción en el consumo de alimentos. Una contribución adicional de este artículo de investigación es documentar cómo se realiza un diseño de investigación experimental natural.

Palabras clave: *Desastres, Consumo de alimentos, Precios de alimentos, Seguridad Alimentaria.*

JEL: I14, I24, Q546.

1. Introduction

Disasters worldwide have increased considerably since the 1970s, affecting on average over 200 million people every year (Leaning and Guha-Sapir, 2013). Alongside their greater occurrence, the need to estimate the consequences of disasters has also increased. The most visible effects of disasters are the loss of human lives and infrastructure. Existing literature has also suggested that disasters may affect human capital accumulation, wages, and employment by disturbing prices, assets, and the consumption of families (Baez *et al.*, 2010; Baird *et al.*, 2011; Crespo-Cuaresma, 2010; Fafchamps *et al.*, 1998; Noy and DuPont, 2016). The impact of disasters on consumption and prices is still an open debate. While classical economic theory predicts that individuals can maintain their levels of consumption against temporary income shocks, and that prices would rise due to the short-term contraction in the supply of staple goods, there is evidence that this is not always the case (Cavallo *et al.*, 2014; Kazianga and Udry, 2006). Moreover, it is unclear what happens inside households, i.e., if there are unequal impacts at the individual level depending on one's position within the family. This paper makes a contribution by addressing the question of hazards' impact on prices and consumption, as well as the question of heterogeneous effects inside families.

To explore the effects of natural disasters on consumption and prices, we exploit the impact of a series of powerful earthquakes that struck Mexico in September, 2017. These earthquakes caused hundreds of deaths and damages to thousands of buildings. One of these earthquakes was cataloged as the strongest one that had hit Mexico over the last hundred years. Thus, given the unpredictability of disasters, we use the occurrence of these earthquakes as a natural experiment to explore the causal effects on consumption and prices. With this in mind, two months after these earthquakes hit Mexico, we collected household-level data from two municipalities that were greatly affected (Juchitán, Oaxaca, and Jojutla, Morelos), and two municipalities that served as a comparison group (Martinez de la Torre, Veracruz, and Rincon de Romos, Aguascalientes). The data contains information previous to August 2017, and after (i.e., October 2017) the occurrence of the earthquakes in September 2017.[1]

Using a difference-in-differences estimation as the main identification strategy and Oster's bounding methodology as a robustness check, we evaluate the effect of the earthquakes on respondents' self-reported consumption and the prices of 14 items: beans, rice, milk, coffee, tuna, soup, lemons, chicken, tortillas, tomatoes, bananas, sugar, beef and eggs. It is worth mentioning that after the earthquakes, the Mexican government provided households in the affected municipalities with baskets of basic goods. Among other goods, these baskets contained beans, rice, milk, coffee, tuna, and soup.

We found that the consumption of most of the products analyzed fell following the earthquake, both at the intensive and extensive margins. Here, we refer to intensive as the probability of consuming or not consuming the good, in contrast to extensive as the chances in the quantity consumed of the good. The only exception to this trend was the consumption of canned tuna, for which there was a massive increase in the quantity demanded. A substitution effect between proteins explains this effect: in times of crisis, households tend to consume the cheapest protein they can afford – in this case, canned tuna – and will stop consuming more expensive proteins such as chicken and beef. Among the goods for which consumption decreased, the reduction was more pronounced for those that were not part of the basket provided by the Mexican government. This suggests that disaster relief funds do help to reduce levels of food insecurity. Oster's bounding methodology also suggests that these results were not driven by unobservable confounders.

Turning our attention to the effects on prices, we found weak evidence pointing to a reduction in prices after the earthquake. In particular, we found subtle drops in prices for four of the 14 goods analyzed. The fall in the demand for goods that are mostly inelastic explains the low movement in prices. With regard to the goods for which we did find effects, we suggest two possible explanations: on one hand, there was a massive decrease in the demand for beef, which is why prices could decrease for this item. On the other hand, in the case of inelastic goods such as beans, soup, and tortillas, an expansion in the supply caused by the distribution of government baskets may explain the fall in prices.

In an analysis of heterogeneous effects, we found that households with more debt suffered the greatest decreases in consumption. There was also a greater fall in consumption among those households that had experienced travel interruptions as a consequence of the earthquake. Moreover, we found that cooperating with neighbors did not generate differential effects.

Finally, we undertook an additional analysis to understand the mechanisms of the fall in consumption using a difference-in-differences model. We found that, as a result of the earthquake, households lost their savings, and their asset holdings decreased. This suggests that because of the decrease in assets, households may have decided to reduce con-

1 One of the selection criteria for these locations included that a disaster had not hit the municipalities in the four years prior to the data collection. Additionally, comparison municipalities, which were not hit by the earthquakes of September 2017, shared economic characteristics similar to those of the treatment group.

sumption to offset this loss. Other side effects of the earthquake also explain the fall in consumption: we found a large drop in the contribution to household income among the women interviewed, their partners, and their children. Additionally, children stopped going to school. These clues point to massive damages to the infrastructure of the affected localities, directly affecting household income flow. This contraction in income can, in turn, also explain the drop in consumption.

- Our contribution to the existing literature is threefold. First, in line with the neoclassical theory, we provide evidence of a reduction in the consumption of basic foods after a disaster, as well as a substitution effect acting on the consumption of less expensive goods. Second, to the best of our knowledge, we are the first to have evaluated and provided evidence that the provision of food baskets is an important and effective measure for guaranteeing food security in disaster zones. Finally, we are the first to explore the mechanisms by which a natural event affects consumption. Overall, this paper emphasizes the importance of disaster funds in post-disaster recovery and the alleviation of food insecurity. In this sense, we are then contributing to a growing corpus of literature on the economic consequences of earthquakes in Mexico (e.g., Banxico, 2017; Capraro *et al.*, 2018; Calderón Villareal y Hernández, 2012; León and Ordaz, 2021).

The remainder of this paper is organized as follows. Section 2 reviews the literature on the effect of disasters and describes the Mexican context before and after the earthquakes. Section 3 describes the data collection process and the variables used for the analysis. Section 4 describes our empirical strategy and robustness checks. Section 5 summarizes the results. Finally, Section 6 presents concluding remarks and policy implications.

2. Theory

2.1 Literature Review

A large body of literature has analyzed the effects of negative income shocks on households' behavior. This literature was initially motivated by the neoclassical life cycle model, also known as the permanent income hypothesis, which suggests that individuals tend to smooth their consumption over their lifetime by saving when they have income surpluses and dissaving during hard times (Modigliani & Brumberg, 1954). However, the literature has also found that precautionary saving is very rare, particularly among uneducated households and individuals at the lower tail of the income distribution (Bernheim & Scholz, 1993; Browning & Lusardi, 1996; Mullanaithan & Shafir, 2013). Moreover, the literature has also found that negative income shocks can have a variety of consequences in a wide range of aspects: they can increase mortality (Baird *et al.*, 2011; Adda et al., 2009), reduce adult height, worsen health and life expectancy, increase food insufficiency (Leete and Bania, 2010), increase education gender gaps (Bjorkman-Nyqvist, 2013), increase crime and civil conflict (Cortes *et al.*, 2016; Miguel *et al.*, 2004), and reduce inter-generational mobility (Skoufias, 2003).

Disasters often cause market disruptions due to asset and property destruction, death and injuries, and shortages of basic goods (Perry, 2017). In turn, households react in different ways to smooth their consumption and recover from the loss. On the one hand, households can choose to sell assets to maintain the same level of consumption. On the other hand, they can reduce their present consumption in order to keep their assets. Hoddinott (2006) finds evidence that poorer households tend to smooth their assets rather than smooth their consumption. Consistent with this finding, Fafchamps *et al.* (1998) suggest that households in West Africa do not sell assets after a severe drought. They hypothesize that households choose to protect their productive investment because the low market price prevailing at the time of the sale would not compensate for the loss. Auffret (2003) explains that the possible reduction in consumption might also be caused by production shocks and a decline in investment growth after a disaster.

As far as price effects are concerned, the classical theory suggests that there is at least a temporary increase in prices in the short run. Two forces can drive this effect: on one hand, a disaster increases the demand for critical goods; on the other hand, if businesses or roads are affected, the supply of basic goods might shrink (Perry, 2017). Conversely, the sticky price theory would suggest that prices will remain stable. Cavallo *et al.* (2014) studied supermarket prices in Chile and Japan after a disaster. On the demand side, they find that consumers demand more non-perishable products for fear that they will be lacking in the future. On the supply side, they found that product availability dropped after the disasters and that recovery was slow. They also found that prices remained relatively stable in the short term and started to increase after 4-6 months. Gagnon and Lopez-Salido (2015) analyze the effect of Hurricane Katrina and other weather-related shocks, also finding subtle price changes following large demand shocks.

2.2 The Mexican context and the 2017 disasters

Mexico is among the 30 countries most exposed to two types of disasters: hurricanes and earthquakes. In September 2017, two strong earthquakes and multiple aftershocks hit Mexico. The first, which occurred on September 7, had a magnitude of 8.2 on the Richter scale. It is now considered to be the deadliest earthquake to have occurred over the last hundred years in Mexico. This earthquake affected the south and southeast of the country, causing damage to 41,000 homes and affecting more than 1.5 million people (BBC News, 2017; Reuters, 2017). The most affected state was Oaxaca, which reported a death toll of 71 . Within this state, Juchitán, one of our "treatment" municipalities, was one of the most affected cities: around 400 houses were destroyed, and 1,700 were damaged as a consequence of the earthquake, representing the destruction of a third of the city's infrastructure

The second strongest earthquake on the list took place on September 19. The magnitude of this earthquake was 7.1 and is the strongest earthquake to hit Mexico City since 1985. It affected Mexico City, Morelos, and Puebla. USAID (2017) estimates that there were over 250 fatalities and 20,000 damaged buildings as a result of the earthquake. Jojutla (Morelos), one of the municipalities closest to the epicenter of the earthquake, had a death toll of 71 and was left with millions of damages in infrastructure.

3. Methodology and Data

Experimental designs constitute the golden standard in research to explain causality. A conventional experimental design identifies at least two homogeneous groups (intervention/ control) composed of randomly chosen individuals. After that, it is plausible to propose that the change is the result of that intervention because groups were similar in crucial variables before the intervention. When lacking experimental control, conducting non-experimental panel studies or using sophisticated analyses, including instrumental variables econometrics, is plausible to explain causality. The disaster literature has used a particular approach called natural experiments. Natural experiments use exposure to natural events as treatment variables because it is assumed that such exposure is random and lacks systematic bias. Exposure to natural events then constitutes an exogenous variable to which a broad number of people are exposed randomly (De Silva *et al.*, 2010; Kinney *et al.*, 2008; Kirk, 2009).

On September 2017, many earthquakes (>5000) happened in Mexico. Three of them had devastating consequences, happening on September 7th, 19th, and 23rd. Juchitán, Oaxaca (where more than 70 people died, and more than 2800 houses were destroyed completely), and Jojutla, Morelos were the most affected cities. Previous experimental research on hurricanes as disasters (Huerta *et al.*, 2022) reported a list of 14-18 consumption items valuable to assess households' economic impact in hurricanes aftermath. Based on Huerta *et al.* (2022), we conducted a natural experiment on 800 households, collecting data on consumption, prices, labor conditions, assets, credit, household features, trust, and mental health in November 2017.

To estimate the impact of disasters on consumption and prices, we tested a natural research design including information on two selected municipalities affected by the earthquakes: Juchitán (Oaxaca) and Jojutla (Morelos). We also collected data on two municipalities that served as a comparison group: Martinez de la Torre (Veracruz) and Rincon de Romos (Aguascalientes). We selected these four municipalities based on four parallel trends of development criteria: first, the affected municipalities had not been hit by a disaster in the four years before the data collection; second, these municipalities shared similar trajectories in terms of economic outcomes five years before the earthquakes; third, average labor income, and margination. In addition to that, fieldwork visits, second-hand data, and media reports made us decide that Jojutla, Morelos, and Juchitán, Oaxaca, were optimal localities for a natural experiment. We discard Mexico City, although also severely affected, for a number of reasons. First, Mexico's capital city received much more attention than small towns. As we conceived this research as basal in a longitudinal approach, recovery odds in Mexico City were probably more considerable, as it is more likely to bring media attention. Otherwise, Jojutla and Juchitán were ultimately affected, whereas Mexico City was partially affected. Media outlets reported that people in affected areas moved after the earthquakes, which is not ideal for a longitudinal study. In opposition, moving from Juchitán or Jojutla is possible just in the case a family decides to transform all members' lives, which is not frequently the case. The same criteria were applied to comparison localities. This means that in applying parallel trends for development and community size, a number of localities of Mexico State and Hidalgo also appeared, but they were discarded because of their proximity to Mexico City and other metropolitan areas, including Toluca, Pachuca, or even Tulancingo. That was how comparison communities were Martínez de la Torre, Veracruz (mirroring Juchitán), and Rincón de Romos (likewise mirroring Jojutla).

Regarding the data collection process, we randomly selected streets in each municipality. Likewise, in each street, we randomly selected five households that fulfilled three criteria:

1. The person who answered the questionnaire was the head of the household or the partner of the head of the household.
2. She was a woman.
3. There was someone in the household aged 21 or under.

The objective of this selection criteria was twofold: on the one hand, we aimed for a sample that was as homogeneous as possible while sharing the same economic vulnerabilities; on the other hand, we wanted to minimize gender perception biases. Based on these criteria, our dataset contained information on 399 households in the comparison group and 369 households in the treatment group.

After explaining to participants the indirect benefits they would provide by contributing to extending knowledge of earthquake policies in Mexico, they signed consent letters approving their informed participation and knowledge that they did not receive any direct or indirect harm. All procedures were carefully explained, including the possibility of going back after months or years to interview them again. To the best of our knowledge, there are no IRB [Institutional Review Board] offices at research institutions or universities in Mexico, nor any ethical procedures to reach research participants. However, the main correspondent followed IRB training from UT Arlington [University of Texas at Arlington] and ERB training from McGill University through his graduate studies[2]. We then opted for pulling an informed consent letter coming from broadly used letters in those institutions.

The questionnaire contained information on 14 items: beans, rice, milk, coffee, tuna, soup, lemons, chicken, tortillas, tomatoes, bananas, sugar, beef, and eggs. It is worth mentioning that after the earthquake, the Mexican government provided households in the affected municipalities with baskets of basic goods. Among other goods, these baskets contained beans, rice, milk, coffee, tuna, and soup. This fact is important to take into account when analyzing the results.

All households were asked whether they consumed a specific good at a specific point in time, i.e., before or after the disaster. If the individuals answered yes, they were then asked about the quantities of the good they consumed and the price they paid. With respect to the timeline, the research design was implemented in November 2017, and the respondents were asked to recall information regarding prices and consumption in January and August 2017. This could potentially have caused recall bias. However, we think this bias should not have affected the treatment and comparison groups differently. Additionally, the main models and robustness checks compared the information reported for August (before the earthquake) versus November (after the earthquake). We consider this time frame to be small enough to minimize the recall errors. Even so, it is possible that households in municipalities affected by the earthquake would have tended to think that the "old times were better". For this reason, we included additional robustness checks to test for this source of bias.

Table 1 contains descriptive statistics of the database. The table shows the three main outcomes: a consumption dummy that takes the value of 1 if the household consumed the

2 In some countries, research with human beings involves a series of steps that research projects must go through to ensure the rights and welfare of participants are protected. At the USA, universities have Institutional Review Boards with this objective. At Canada, universities have Ethical Review Boards. We do not know any ethical offices in Mexico with this purpose.

product analyzed, and 0 otherwise; a variable that contains the amount of consumption in a standardized measure depending on the particular product; and, finally, self-reported prices per household measured in Mexican pesos of 2017.

Despite carefully selecting the sample, Table 1 shows that the percentage of consumption of eight of the 14 products was higher for the treatment group before the earthquake occurred. The biggest difference lies in coffee, bananas, and beef consumption. At the intensive margin, it can also be seen that households in the treatment group consumed larger quantities of all the products analyzed. Likewise, the price level of these products was higher among the treatment group.

When the means of the consumption variables are compared in the period after the earthquake, there is a decrease in the size of the difference between the treatment and comparison groups. In some cases, this leads to a difference in means that is statistically equal to zero, or that reverts the sign of the difference. This pattern suggests that consumption in the treatment group decreased significantly after the earthquake. On the other hand, the treatment group still reported higher prices than the comparison group, suggesting that prices remained stable after the earthquake.

4. Empirical Application

We used a difference-in-differences (DID) approach as our main identification strategy to examine the effect of the Mexican earthquakes on household consumption and prices. The main specification was as follows:

$$Y_{it} = \beta_0 + \beta_1 After_t + \beta_2 T_i + \beta_3 (After_t * T_i) + X_i \theta + e_i$$

where Y_{it} is the outcome of interest for household *i* at time *t*; $After_t$ takes on the value one in the period after the shock and zero otherwise; T_i takes the value one for municipalities affected by the disaster and zero otherwise; X_i is a vector of a set of control variables, including family size, number of children in the household, type of family (nuclear vs extended family), dummies for whether the household *i* received any type of cash assistance, and fixed effects at the municipality level. It should be noted that the coefficient of interest is β_3 which estimates the effect that the disaster had in the treated municipalities compared to the comparison group.

The aforementioned difference-in-differences (DID) estimator needed to satisfy the *parallel-trends* assumption, *i.e.*, that the outcome variables of the treatment and comparison groups should have followed the same trend in the absence of the treatment. Our dataset shows three points in time for four of the 14 goods: January, August, and November. For these products, we ran a DID using only the observations before the earthquake. In other words, $After_t$ in the placebo test takes on the value of one in August and zero in January.

The results of this test can be found in Table 2. Two of the products evaluated are beans and rice, which formed part of the basket that the Mexican government distributed in the affected municipalities. The other two products that we included in the placebo test were lemon and chicken, which were not part of the basket distributed by the government. The results show that before the earthquake, the effect of the interaction is not significant for the intensive and extensive level of consumption. In other words, the placebo test seems to suggest that the assumption of parallel tendencies holds. Regarding prices, the placebo test suggests that the parallel trends assumption holds for three out of four products. We did not have the necessary information to test this assumption for the other products. However, we know that there was no structural change in the period before the earthquake that would have altered the households' consumption patterns. Therefore, we can ascertain that the assumption of parallel trends also holds for the other products we analyzed.

To evaluate the robustness of the results, we used Oster's bounding methodology. Oster developed a method to evaluate how the power of unobservable characteristics affects the stability of the coefficient. Additionally, we tested for heterogeneous effects on debt, road disruptions, and cooperation among neighbors. Finally, we explored the mechanisms of these effects. The following section presents the results and explains these robustness tests in greater detail.

5. Results

5.1 Difference in Differences

Table 3 presents the results of the difference-in-differences model. We show the coefficient associated with the interaction of the time and treatment dummies per product. The standard errors are clustered at the street level. All regressions include a set of control variables: family size, number of children in the household, type of family (nuclear vs extended family), a set of dummies on the type of cash assistance received by households, and fixed effects at the municipality level.

Columns (1) and (2) display the results for the consumption dummies. Consumption at the extensive margin decreased for nine out of the 14 products. The greatest decreases in consumption occurred in proteins: households affected by the earthquake decreased their consumption of beef by 20 percentage points and that of chicken by 18.7 percentage points after the earthquake. However, it would appear that the households did not stop eating protein. The results show an increase in canned tuna consumption by 15.6 percentage points after the earthquake. This suggests that the decrease in chicken and beef consumption is partly associated with a substitution effect of these with the consumption of tuna.

Columns (3) and (4) present the results for the logarithm of the quantity consumed. At the intensive margin, we find a decrease in consumption of eight out of the 14 products. In other words, households not only stopped consuming certain goods but also consumed less of them. The largest decrease in the intensive margin occurred for chicken (24.1 p.p.), meat (21.8 p.p.), and milk (21.6 p.p.). Again, in this case, there was an increase in the quantity of canned tuna consumed to 35.8 p.p. This lends further support to the hypothesis that households substituted more expensive proteins for canned tuna.

Looking at the combined effect of this set of regressions, there is a pattern worth highlighting: the consumption of all the products not included in the government-distributed basket decreased either to the intensive or extensive margins. This was not the case for the products that were included in the basket. There was a fall in the consumption of two out of six products, but that decrease was quite small. We did not find effects on the consumption of rice, coffee, and soup, which were also included in the basket. Additionally, there was an increase in canned tuna consumption. This indicates that recovery funds are key to guaranteeing households' food security after a disaster.

On the other hand, the prices of 10 of the 14 products analyzed remained stable after the earthquake. However, we found that four products had a price decrease of up to 7.4 percent. While this effect is statistically significant, it is not large. In conclusion, it seems that neither the earthquake nor the distribution of basic supplies by the government generated immediate changes in the majority of market prices. This provides support for the sticky-price theory.

We also analyzed the effects of the earthquake on other food groups. Columns (1)-(3) in Table 5 report the results of the difference-in-differences model, using dummies as outcomes for whether the household consumed salads, fruit or bread. We found a significant and large effect on these food groups. The reduction in the consumption of salads and fruits is 20.9 p.p. and 18.3 p.p., respectively. Although the reduction in bread consumption is smaller in size, it is not negligible (9.2 p.p.). This means that along with proteins, healthy foods such as salads and fruits are more likely to disappear from the diet of households that face income shocks.

Finally, given the consistent results suggesting a trend toward the reduction of consumption, we tested who in the household took on most of the burden. Columns (4)-(6) show a difference-in-differences model, using as the outcome a dummy indicating whether the member of the household ate fewer meals a day. Our results suggest that women were 23.7 p.p. more likely to eat fewer meals per day after the earthquake. Men were also 20.6 p.p. more likely to reduce their consumption per day. It seems that the reduction in consumption among men and women in households aimed at smoothing children's consumption. Children were 11.5 p.p. more likely to eat fewer meals a day after the earthquakes, which was about half the reduction in consumption of their parents.

5.2 Oster's bounding methodology

We applied Oster's bounding methodology as a robustness test. Oster proposes a method for testing the robustness of results under the assumption that the relationship between the observables and the treatment is informative of the relationship between the unobservables and the treatment. This assumption is called the proportional selection assumption. Oster also defines $R_{\max}$ as the R-squared resulting from a hypothetical regression of the outcome on the treatment, the observable and unobservables. Assuming a value for $R_{\max}$, this methodology allowed us to yield two sets of results: first, the true β_3, if we were able to control for the unobservables in the regression; and, second, the δ that would generate $\beta_3 = 0$ Following Oster, for the first exercise, we assumed $\delta = 1$. Additionally, for both exercises, we present the results assuming two possible values for $R_{\max}: (1) R_{\max} = 2\tilde{R} - R_o$; and $(2) R_{\max} = 2\tilde{R}$, where $\tilde{R}$ is the R-squared from a regression of the treatment outcome and the control variables, i.e., our difference-in-differences model and R_o is the R-squared from a regression of the treatment outcome.

Table 4 reports the results of this methodology. Column (1) presents a summary of the results from Table 3. Columns (2) and (4) display a unique solution for the coefficients that would have been obtained if we had assumed that the observables were at least as important as the unobservables $\delta = 1$ for the corresponding assumption on $R_{\max}$. In general, we find that the sign of the coefficients for the effects that were significant in the difference-in-differences model is stable. However, the coefficients are larger. We can also see that the most unstable coefficients are the ones for which we did not find a significant result in the first place.

Columns (3) and (5) show the coefficient of proportionality that should be assumed in the model for the true coefficient to be equal to zero. The larger the delta, the more the unobservables must weigh in order to bring the coefficient towards zero. For example, $\delta = 2$ means that the unobservables must be twice as important as the observables to cause $\beta_3 = 0$. A δ close to one or above one thus indicates that the coefficient is stable. The results of Table 4 show that, for the significant coefficients, the proportion that unobservables must have is most often close to one or larger than one. This helped us to validate our results.

5.3 Heterogeneous effects

In this section, we evaluate whether the effects of the earthquake were different for people with different types of vulnerability. In particular, we aimed to test the effect of the difference-in-differences model for (1) households with debt; (2) homes that suffered road interruptions as a result of the earthquake; and (3) households that cooperated with their neighbors in order to help each other.

Figure 1 presents the effects of consumption, quantity consumed, and prices on the occurrence of earthquakes. The dark blue dots and lines represent the coefficients and confidence intervals of households that had debt in November 2017, while the light blue dots and lines correspond to the equivalent measures for households without debt. On average, the effects are not very different, regardless of the type of household. This tells us that having debt makes no difference in changes to the food consumption patterns caused by earthquakes.

Figure 2 displays the results pertaining to road disruptions. The latter is an important indicator because, on one hand, it gives us the opportunity to assess the extent of earthquake infrastructure damage, giving us a potential indication of the intensity of the shock for the households analyzed. On the other hand, it allows us to approximate the extent to which the supply of products in the area may have been affected. The results show that road disruptions do generate differential effects. In particular, those households with road disruptions recorded the biggest drops in meat, chicken, and banana consumption. These households also seem to be the drivers of the fall in consumption of the other goods that had a significant effect in the DID model. In addition, these households also reported a smaller increase in canned tuna consumption.

These results suggest that households that experienced road interruptions were also those that experienced greater food insecurity after the earthquakes. This could have happened due to a combination of three scenarios: the government's food baskets did not reach these households; the supply of goods decreased due to the difficult access to markets near these households; and/or the demand for goods fell more in these places because the households suffered greater losses and had to sacrifice more consumption.

Finally, we analyzed the differential effects between households that cooperated with their neighbors after the earthquake and those that did not cooperate. Figure 3 displays the results for this set of regressions. We found that households that cooperated with their neighbors had slightly more reduced consumption. In other words, those households that decided to cooperate did so because the earthquake hit them harder. Thus, it seems that social capital increases when there are large negative income shocks.

The reduction in consumption can become a strategy as a consequence of the side effects caused by the earthquake. Figure 4 shows the changes in four outcomes after the earthquake. The figure suggests that there were not great differences between the treatment and control groups in terms of the movements in and out of the households. This figure also displays striking reductions in the number of asset holdings and amenities,[3] the number of children going to school, and the number of household members contributing to the household income.

Figure 5 displays the results comparing households that reduced their asset holdings after the earthquake with households that did not. The results suggest that households with greater losses had larger reductions in the consumption of beans, milk, lemon, chicken, tomatoes, bananas, sugar, beef, and eggs. Although these households also increased their consumption of tuna, households with greater asset loss had a more modest increase as compared with households that did not lose assets. This might suggest that the reduction in consumption can be partly mediated by asset loss.

Finally, as we saw in Figure 4, after the earthquakes there were fewer household members contributing to the household income. This can partly be explained by anecdotal evidence suggesting that the massive destruction of buildings after the earthquakes left people without access to their workplace given short-term rigidities in the job market, a strategy that households could have used was to reduce consumption. Figure 6 displays estimates of the DID model comparing households that reduced the number of members contributing to the household income with those that did not. The results indicate that having fewer members contributing to the household income lead to larger reductions in the consumption of proteins, accompanied by a greater increase in the consumption of canned tuna.

6. Concluding remarks

Throughout the paper, we examined how disasters affect consumption and prices in Mexico. We also explored the role of disaster public funds in smoothing income shocks after a disaster. More specifically, we explored whether people living in municipalities affected by the earthquakes: a) smoothed consumption and perceived changes in prices, b) used coping strategies to compensate for asset losses, and c) improved cooperation with neighbors in order to help each other. The results suggest that consumption decreased after earthquakes. The exception to this rule are those goods that the government distributed in disaster zones. We also found that households located in areas exposed to damages in public infrastructure (roads) were the most affected. Thus, our findings suggest that even if the public policy might be successful in preventing household-level damage regarding consumption, community-level impacts are more difficult to tackle.

We also explored how households cope with the challenge of recovery in the aftermath of an earthquake. First, we explored whether households acquire more debt and found no support for this hypothesis. We think that although more research is needed on this subject, a reason why people do not acquire debt is that debt is extremely expensive for the poor. The informal credit market, which is the one that most Mexicans have access to, offers high interest rates and makes this strategy unreasonable.

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3 Asset holdings and amenities include nine items: computer, boiler, cell phone, internet access, piped water, bathroom access, landline, cable tv, and cars.

A second strategy that households might use to cope with the losses is to reach out for family financial support. Further research may explore if women do not contribute to the household income because patriarchal-like depressed job markets preclude them from job opportunities or because they are busy enough with promoting mental resiliency among family members and staying at home to be interviewed by the many governments and non-governmental agencies aimed to deliver social services. Parity in the job market in terms of posts or income has been a historical fight in liberal societies. The stagnation in gender equality patterns might be explained by considering that families choose to maximize their welfare by leaving a member in the home (Torche, 2015). In the absence of clear rewards in depressed job markets, it seems plausible to hypothesize that idiosyncratic patterns act as incentives for women to stay at home. Figure 4 has shown that, indeed, women stop contributing to household income; however, the finding that other partners (in the case of men), even sons, also stopped contributing to household income may be interpreted not only as people losing jobs but also with regard to family decisions in the search for welfare. Apparently, families decided not to disperse and did not reduce their size. This is consistent with the previous finding that people helped each other. If neighbors decided to collaborate with others, the lack of reductions in family size may be hypothesized as people being busy helping each other as well. Again, as informative as Figure 4 is, we need more evidence to solidly establish this statement.

Medium-term outcomes: Beyond food security as a short-term outcome of disasters, the public policy failed to act as a safety net in the case of children attending school. One of the most significant losses in terms of development may be the case of children who stop attending school. We will need further research to observe how long the children did not attend school (short, long-term) and whether this pause challenged the children's opportunities to move up the socioeconomic ladder.

Representativeness is not a usual goal in experimental designs, but understanding causality can only be achieved when experimental control is performed in a particular study. Otherwise, although sample size requirements are minor in research designs compared to public opinion studies, they are not the same as referring to case studies, as shown in the conventional chart of scientific evidence levels.

Based on experimental research, this paper contributes to the existing knowledge and policymakers working in the field of natural hazards. We now have evidence that government public funds work to smooth the consumption of goods in the program's catalog. Now, knowing that those funds seem to be working, specifically in terms of consumption, it is time to ask if public funds operate in a cost-effective manner. It is also time to ask if the goods provided by the program are sufficient or if it would be possible to manage more goods at a similar budget. Particularly relevant is the question arising from the fact that children stopped attending school. It is possible that children did this because the earthquakes affected the public education infrastructure. It is also possible that children did not attend school because they were psychologically affected, so much so that they were not capable of paying attention to their duties or rights. This is relevant because hazards will continue to happen in Mexico, and it is worth increasing the institutional arrangements to prevent the ensuing economic and social disasters.

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6. Tables

Table1: Descriptive Statistics

	Before			After		
Variables	Treatment	Comparison	Difference	Treatment	Comparison	Difference
Consumption dummy						
Beans	98.1	98.0	0.1	94.7	98.2	–3.5***
Rice	94.8	93.2	1.6	94.2	90.5	3.7*
Milk	91.3	88.7	2.6	89.2	92.4	–3.2
Coffee	84.5	52.3	32.2***	91.6	62.5	29.1***
Tuna	58.6	50.3	8.3**	94.0	57.5	36.5***
Soup	89.9	91.7	–1.8	94.8	91.3	3.5*
Lemon	89.7	79.1	10.6***	84.2	80.0	4.2
Chicken	97.3	89.2	8.1***	84.5	95.6	–11.1***
Tortillas	99.2	100.0	–0.8*	98.9	99.7	–0.8
Tomatoes	98.9	99.0	–0.1	92.0	98.2	–6.2***
Bananas	91.6	74.4	17.2***	81.0	75.8	5.2*
Sugar	98.4	92.9	5.5***	93.6	93.7	–0.1
Beef	87.8	73.6	14.2***	74.2	78.7	–4.5
Eggs	97.6	92.4	5.2***	93.6	92.1	1.5
Consumption quantity						
Beans	1.8	1.7	0.1	1.6	1.6	0.0
Rice	1.4	1.2	0.2**	1.7	1.3	0.4
Milk	4.5	3.3	1.2***	3.8	3.5	0.3
Coffee	1.3	0.6	0.7***	1.4	0.7	0.7***
Tuna	2.5	1.4	1.1***	5.1	1.5	3.6***
Soup	3.3	2.8	0.5***	3.5	2.7	0.8***
Lemon	2.3	1.3	1.0**	1.9	1.2	0.7**
Chicken	2.3	1.3	1.0***	1.9	1.6	0.3*
Tortillas	7.9	7.4	0.5	7.1	7.1	0.0
Tomatoes	2.9	2.4	0.5***	2.4	2.3	0.1
Bananas	2.5	1.4	1.1***	2.0	1.4	0.6***
Sugar	1.9	1.7	0.2	1.7	1.5	0.2**
Beef	1.5	1.1	0.4***	1.2	1.1	0.1
Eggs	3.1	2.1	1.0**	2.8	2.0	0.8**
Price						
Beans	30.5	21.4	9.1***	30.6	23.0	7.6***
Rice	16.9	14.7	2.2***	18.8	15.9	2.9***
Milk	24.7	16.0	8.7***	23.6	16.4	7.2***

Coffee	34.2	27.8	6.4***	41.8	31.4	10.4***
Tuna	17.3	12.2	5.1***	18.8	13.0	5.8***
Soup	8.0	5.4	2.6***	7.5	5.6	1.9***
Lemon	16.6	11.9	4.7***	15.1	10.1	5.0***
Chicken	56.5	43.4	13.1***	56.8	46.2	10.6***
Tortillas	22.9	11.8	11.1***	25.8	12.7	13.1***
Tomatoes	21.1	14.3	6.8***	17	12	5.0***
Bananas	12.3	9.8	2.5***	12.4	10.1	2.3***
Sugar	19.5	20.8	–1.3	23.6	20.9	2.7*
Beef	95.0	69.7	25.3***	96.6	77.1	19.5***
Eggs	29.3	22.3	7.0***	32.5	24.5	8.0***

Note: The quantity consumed takes the value of zero if the individual reported not to have consumed the product. Prices are given in Mexican Pesos per unit of measurement. Items marked † formed part of the public funds basket.

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

Table 2: Placebo test

	(1)	(2)	(3)	(4)
VARIABLES	Beans†	Rice†	Lemon	Chicken
Consumption dummy				
After	−0.011*	−0.039**	−0.020	0.013
	(0.006)	(0.016)	(0.022)	(0.017)
Treatment	−0.005	0.008	0.120***	0.099***
	(0.009)	(0.012)	(0.026)	(0.023)
After × Treatment	0.011	0.012	−0.007	−0.018
	(0.008)	(0.019)	(0.026)	(0.021)
Constant	0.990***	0.971***	0.803***	0.877***
	(0.006)	(0.009)	(0.021)	(0.021)
Observations	1,416	1,413	1,416	1,414
Consumption quantities				
After	0.079	−0.120	0.301	−0.046
	(0.113)	(0.097)	(0.261)	(0.154)
Treatment	0.162	0.146	1.089***	1.278***
	(0.143)	(0.123)	(0.297)	(0.266)
After × Treatment	−0.162	0.092	−0.275	−0.265
	(0.158)	(0.116)	(0.34)	(0.251)
Constant	1.619***	1.337***	0.993***	1.357***
	(0.096)	(0.091)	(0.060)	(0.160)
Observations	1,411	1,409	1,406	1,405

Prices (in logs)				
After	−1.338**	0.912**	−1.152	1.919**
	(0.600)	(0.442)	(0.994)	(0.846)
Treatment	8.482***	2.637***	10.048***	15.753***
	(1.632)	(0.536)	(3.643)	(1.771)
After × Treatment	0.403	−0.249	−5.703	−2.653*
	(0.806)	(0.750)	(3.607)	(1.490)
Constant	22.890***	13.831***	13.096***	41.457***
	(0.624)	(0.334)	(1.170)	(0.992)
Observations	1,369	1,321	1,150	1,286

Note: Clustered standard errors at the street level are provided in parentheses. Items marked † formed part of the public funds basket. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Differences in Differences

	Consumption		Quantity		Price	
Variables	Estimate	Obs	Estimate	Obs	Estimate	Obs.
Beans	−0.037**	1505	−0.057**	1481	−0.061***	1408
	(0.017)		(0.028)		(0.022)	
Rice	0.006	1486	0.042	1464	−0.018	1335
	(0.019)		−0.027		(0.025)	
Milk	−0.066***	1457	−0.216***	1436	−0.024	1293
	(0.022)		(0.042)		(0028)	
Coffee	−0.037	1370	0.05	1327	−0.009	967
	(0.030)		(0.034)		(0.054)	
Tuna	0.156***	1271	0.358***	1252	−0.038	763
	(0.033)		(0.067)		(0.040)	
Soup	0.017	1455	0.002	1437	−0.064***	1282
	(0.021)		(0.032)		(0.024)	
Lemon	−0.076**	1455	−0.079**	1417	0.012	1148
	(0.035)		(0.039)		(0.044)	
Chicken	−0.187***	1468	−0.241***	1451	−0.005	1320
	(0.032)		(0.035)		(0.022)	

Tortillas	−0.002	1513	−0.105***	1502	−0.055***	1494
	(0.007)		(0.032)		(0.017)	
Tomatoes	−0.062***	1514	−0.118***	1492	−0.061	1437
	(−0.017)		(−0.028)		(0.038)	
Bananas	−0.134***	1460	−0.193***	1434	0.023	1133
	(0.034)		(0.047)		(0.035)	
Sugar	−0.045**	1492	−0.008	1474	0.008	1371
	(0.019)		(0.022)		(0.026)	
Beef	−0.204***	1432	−0.218***	1415	−0.074***	1110
	(0.029)		(0.030)		(0.023)	
Eggs	−0.036*	1493	−0.035	1467	−0.029	1367
	(0.021)		(0.033)		(0.034)	

Note: This table displays the interaction term of the DiD model and the number of observations in the regression for each outcome. Standard errors clustered at the street level are displayed in parentheses. Controls in the regression include family size, number of children in the household, type of family, and a dummy for whether the family received any cash or in-kind assistance.

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

Table 4: Oster bounding methodology

	DID model	$R_{max} = 2\tilde{R} - \mathring{R}$		$R_{max} = 2\tilde{R}$	
		β for $\delta = 1$	δ for $\beta = 0$	β for $\delta = 1$	δ for $\beta = 0$
Consumption dummy					
Beans	−0.037**	−0.772	0.669	−2.414	0.380
Rice	0.006	1.097	0.968	1.160	0.943
Milk	−0.066***	−0.153	−1.351	−0.159	−1.298
Coffee	–0.037	−0.708	−0.136	−1.045	−0.093
Tuna	0.156***	−0.187	0.749	−1.630	0.288
Soup	0.017	0.637	0.872	0.843	0.759
Lemon	−0.076**	−0.608	−0.563	−0.613	−0.560
Chicken	−0.187***	−0.431	0.925	−0.605	0.694

Tortillas	−0.002	0.055	0.015	0.069	0.013
Tomatoes	−0.062***	0.137	0.814	1.639	0.288
Bananas	−0.134***	−0.875	−0.815	−0.875	−0.815
Sugar	−0.045**	−0.258	−2.816	−0.266	−2.750
Beef	−0.204***	−0.671	−2.569	−0.701	−2.471
Eggs	−0.036*	−0.241	−1.320	−0.243	−1.315
Quantity demanded					
Beans	−0.057**	−3.247	0.713	−3.775	0.665
Rice	0.042	−1.164	0.282	−1.521	0.247
Milk	−0.216***	−0.881	−1.087	−0.885	−1.083
Coffee	0.050	−0.610	0.005	−0.968	0.004
Tuna	0.358***	−0.124	0.903	−3.185	0.293
Soup	0.002	−2.425	0.201	−2.769	0.189
Lemon	−0.079**	−1.069	−0.261	−1.140	−0.249
Chicken	−0.241***	−1.068	−0.849	−1.069	−0.848
Tortillas	−0.105***	32.542	0.427	33.760	0.420
Tomatoes	−0.118***	−5.317	1.027	−5.634	1.000
Bananas	−0.193***	−1.600	−0.499	−1.622	−0.494
Sugar	−0.008	−4.093	−0.758	−4.094	−0.758
Beef	−0.218***	−0.924	−1.040	−0.927	−1.037
Eggs	−0.035	−2.473	6.863	−2.496	6.833
Price					
Beans	−0.061***	−0.974	−0.136	−1.203	−0.114
Rice	−0.018	−0.961	−0.037	−1.134	−0.033
Milk	−0.024	−0.756	−0.080	−1.052	−0.060
Coffee	−0.009	−1.495	−0.049	−2.162	−0.036
Tuna	−0.038	−0.876	−0.069	−1.099	−0.058
Soup	−0.064***	−0.453	−0.228	−0.581	−0.175
Lemon	0.012	−2.681	−0.008	−3.119	−0.007
Chicken	−0.005	−0.939	−0.066	−1.170	−0.056
Tortillas	−0.055***	−0.936	−0.112	−1.329	−0.081
Tomatoes	−0.061	−1.366	−0.177	−1.486	−0.168
Bananas	0.023	−0.529	0.083	−0.839	0.059
Sugar	0.008	−0.118	0.173	−0.334	0.072
Beef	−0.074***	−1.291	−0.186	−1.460	−0.169
Eggs	−0.029	−0.947	−0.067	−1.355	−0.049

Note: Column (1) shows the difference in difference estimators displayed in table 3.

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

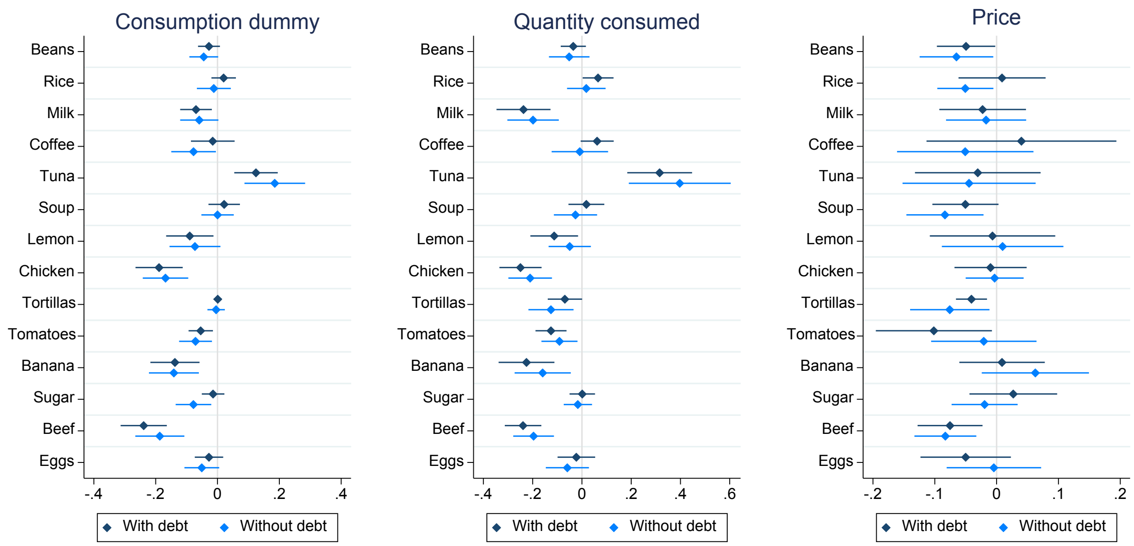
Table 5: DID - Effects on other consumption and allocation of the shock

	Other consumption			Who consumed less meals?		
VARIABLES	Salad	Fruits	Bread	Woman	Man	Their children
After	-0.020	-0.038**	-0.020	-0.013	-0.009	-0.002
	(0.025)	(0.019)	(0.020)	(0.012)	(0.013)	(0.011)
Treatment	0.171***	-0.002	0.007	0.090**	0.117***	0.097**
	(0.052)	(0.040)	(0.047)	(0.041)	(0.041)	(0.038)
After×Treatment	-0.209***	-0.183***	-0.092**	0.237***	0.206***	0.115***
	(0.043)	(0.041)	(0.037)	(0.034)	(0.038)	(0.023)
Controls	✓	✓	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓	✓	✓
Observations	1,522	1,519	1,524	1,505	1,247	1,501
Number of folios	767	766	768	768	643	768

Note: OLS regressions with dichotomous outcomes displayed. Standard errors clustered at the street level in parenthesis. Controls in the regressions include family size, number of children in the household, type of family and a dummy for whether the family received any cash or in-kind assistance.

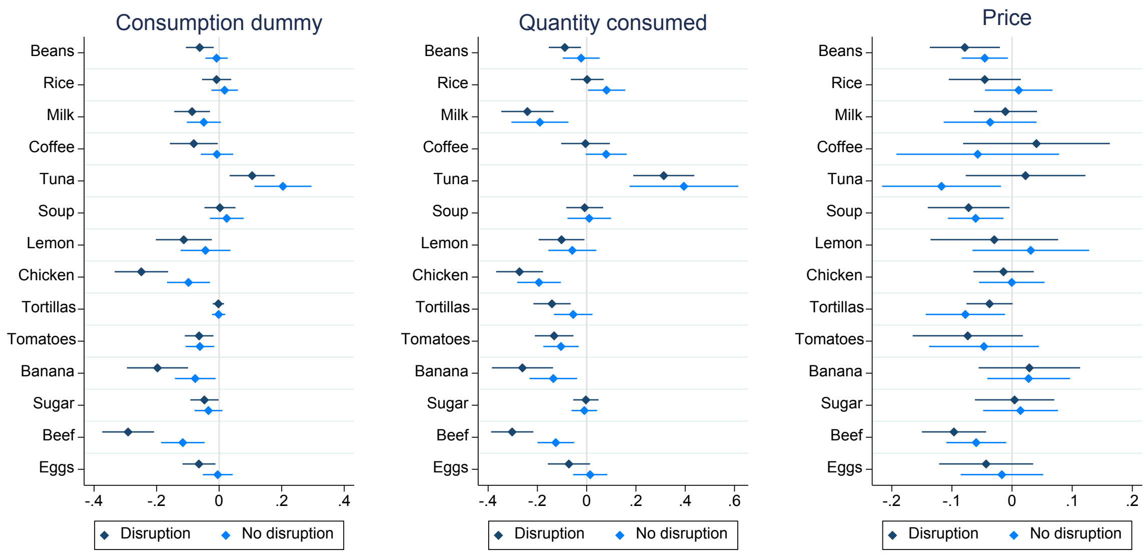
*** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Heterogeneous effects on debt holdings



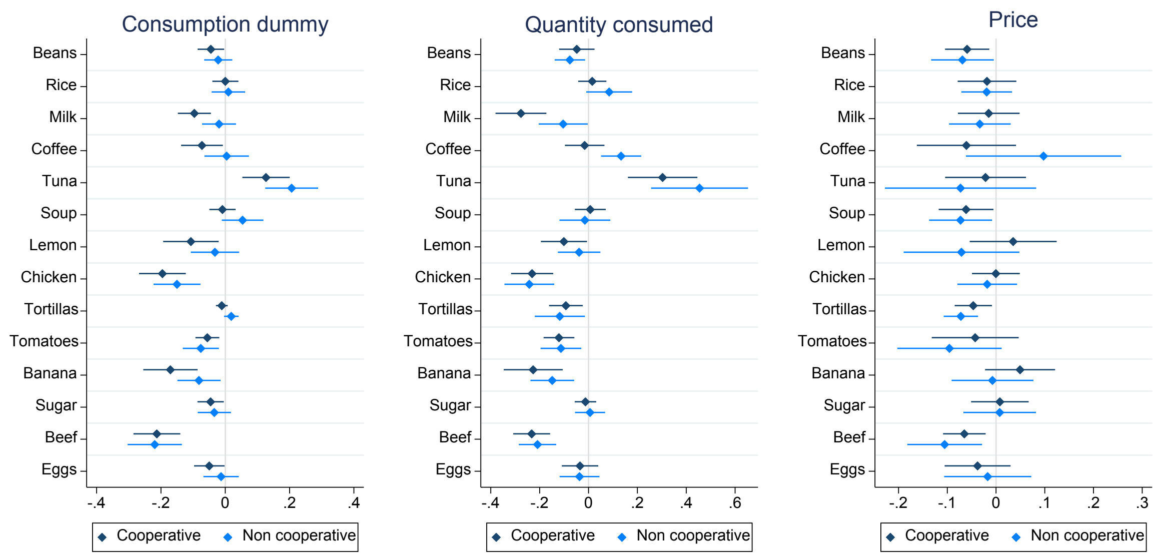
Note: This figure displays, for each outcome, the interaction term of the DID model and the number of observations in the regression. Standard errors clustered at the street level. Controls in each regression include family size, number of children in the household, type of family, a set of dummies for any cash or in-kind assistance the household received, and fixed effects at the municipality level. Outcomes are measured as follows: consumption corresponds to a dummy indicating whether the product was consumed; quantity corresponds to the logarithm of the quantity consumed if the household reports any consumption of the product and zero otherwise; and prices are measured as the logarithm of the value reported in Mexican pesos. *** p<0.01, ** p<0.05, * p<0.1

Figure 2: Heterogeneous effects on highway disruption



Note: This figure displays, for each outcome, the interaction term of the DID model and the number of observations in the regression. Standard errors clustered at the street level. Controls in each regression include family size, number of children in the household, type of family, a set of dummies for any cash or in-kind assistance the household received, and fixed effects at the municipality level. Outcomes are measured as follows: consumption corresponds to a dummy indicating whether the product was consumed; quantity corresponds to the logarithm of the quantity consumed if the household reports any consumption of the product and zero otherwise; and prices are measured as the logarithm of the value reported in Mexican pesos. *** p<0.01, ** p<0.05, * p<0.1

Figure 3: Heterogeneous effects on cooperative attitudes



Note: This figure displays, for each outcome, the interaction term of the DID model and the number of observations in the regression. Standard errors clustered at the street level. Controls in each regression include family size, number of children in the household, type of family, a set of dummies for any cash or in-kind assistance the household received and fixed effects at the municipality level. Outcomes are measured as follows: consumption corresponds to a dummy indicating whether the product was consumed; quantity corresponds to the logarithm of the quantity consumed if the household reports any consumption of the product and zero otherwise; and prices are measured as the logarithm of the value reported in Mexican pesos. *** p<0.01, **

Figure 4: Changes in family configurations

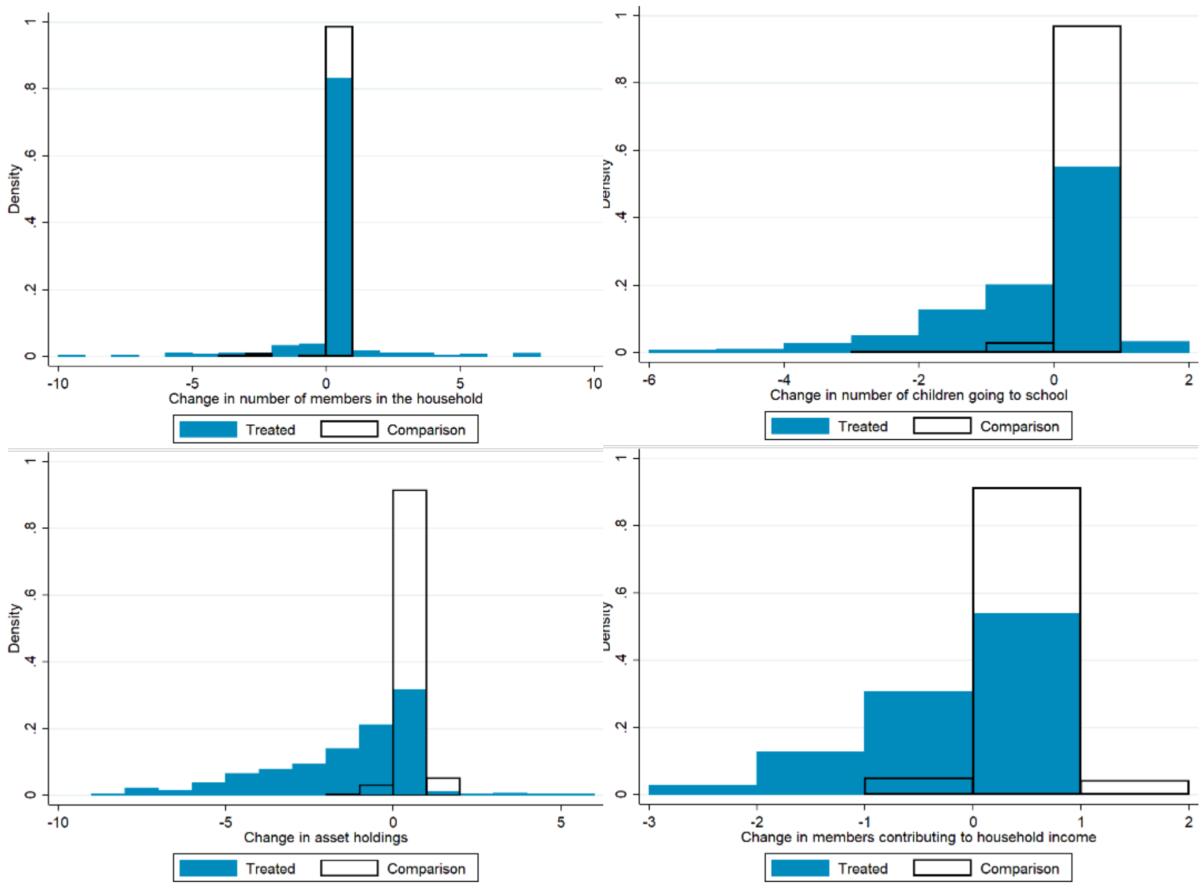
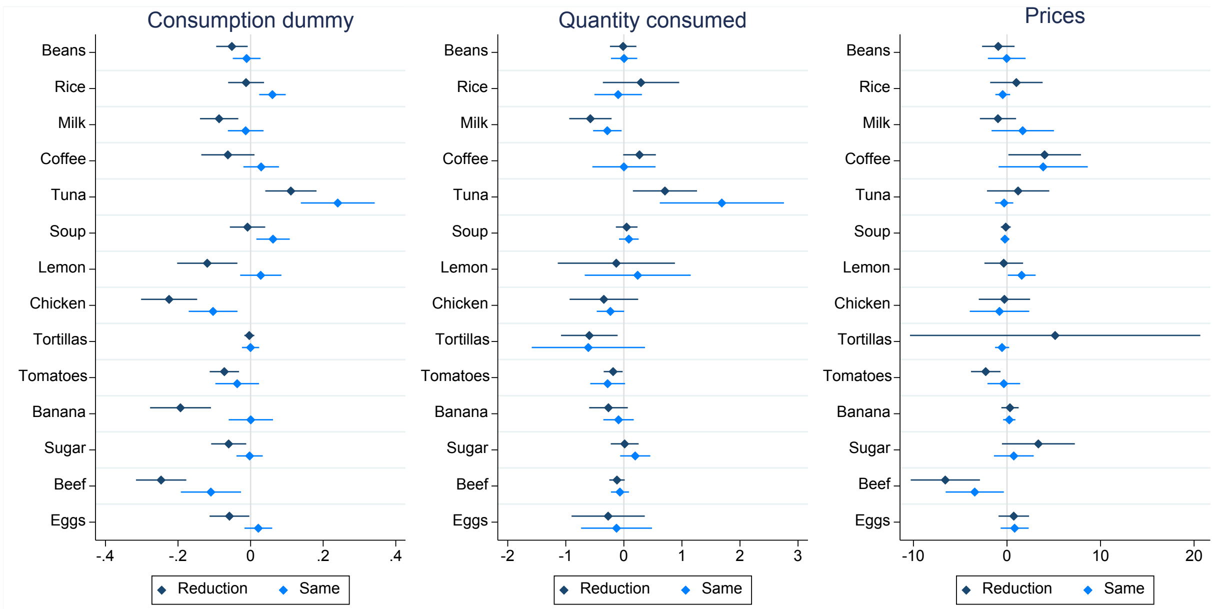


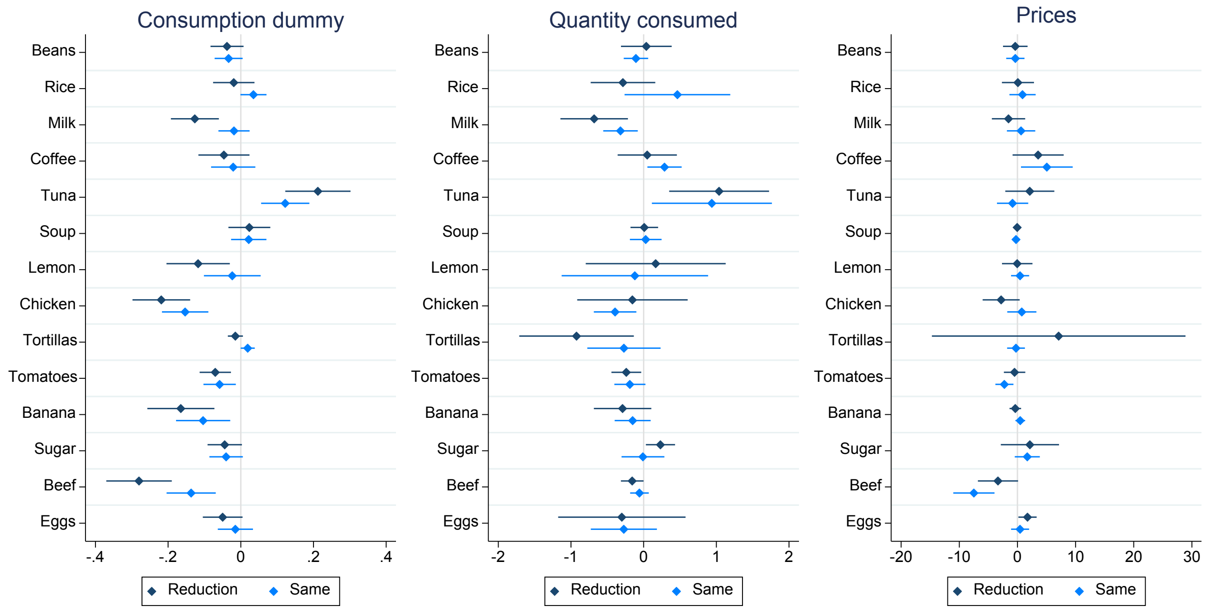
Figure 5: Heterogeneous effects on changes in asset holdings



Note: This figure displays the interaction terms from separate DID models for each product (row) and outcome (columns). The effects are shown in dark blue for households that experienced changes in asset holdings and in light blue for those that did not. Confidence intervals with clustered standard errors at the street level are shown. Controls in each regression include family size, number of children in the household, type of family, a set of dummies for any cash or in-kind assistance the household received, and fixed effects at the municipality level. Outcomes are measured as follows: consumption corresponds to a dummy indicating whether the product was consumed; quantity corresponds to the logarithm of the quantity consumed if the household reports any consumption of the product and zero otherwise; prices are measured as the logarithm of the value reported in Mexican pesos.

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

Figure 6: Heterogeneous effects on changes in the number of household income contributors



Note: This figure displays the interaction terms from separate DID models for each product (rows) and outcome (columns). The effects are shown in dark blue for households that experienced changes in the number of household income contributors and in light blue for those that did not. This figure displays, for each outcome, the interaction term of the DiD model and the number of observations in the regression. Standard errors clustered at the street level. Controls in each regression include family size, number of children in the household, type of family, a set of dummies for any cash or in-kind assistance the household received and fixed effects at the municipality level. Outcomes are measured as follows: consumption corresponds to a dummy indicating whether the product was consumed; quantity corresponds to the logarithm of the quantity consumed if the household reports any consumption of the product and zero otherwise; and prices are measured as the logarithm of the value reported in Mexican pesos. *** p<0.01, ** p<0.05, * p<0.1