Three Essays on the Welfare and Social Impacts of External Shocks and Public Policies in Mexico



Rita A. Motzigkeit Gonzalez Wirtschaftswissenschaftliche Fakultät Universität Passau

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Erstgutachter: Prof. Dr. Michael Grimm, Universität Passau

Zweitgutachter: Prof. Dr. Johannes Graf Lambsdorff, Universität Passau

Drittprüfer: Prof. Dr. Thomas Widjaja, Universität Passau

Everthing not saved will be lost

Abstract

In this thesis I examine the welfare and social consequences associated with one economic shock and two policy interventions in Mexico. I use non-experimental approaches that exploit increased data availability as well as in-depth knowledge of the institutional background and show how germane extensions in the methodology shed light on previously unaccounted consequences and help better identify affected households. In particular, I quantify the role of quantity substitution effects in the alleviation of welfare, I estimate the effect of quality substitution on the efficiency of a taxation policy, and I document the possible consequences of an aggressive policy intervention on organized and property crime.

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1 Introduction

There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know.

-Donald Rumsfeld

1.1 General motivation

The identification and measurement of the ramifications of economic shocks and policy interventions are an important topic in Economics¹ because of the considerable welfare and social consequences associated with them.

Additionally to the immediate loss, economic shocks can have persistent and pervasive long-term impacts through the compound responses of those affected. For example, selling productive capital as a way of generating income in face of a shock can hinder the engagement in productive activities in the future². Coincidentally, the reduced supply of goods can lead to price changes that can impact previously unaffected individuals.

As opposed to a shock, a policy intervention is a guided course of action with a specific aim. The changes elicited can have the desired behavioral effects, but can likewise lead to unexpected outcomes. The existence of so-called "unintended consequences" poses an additional challenge to the already intricate exercise of formulating successful economic policies, especially if these consequences have a

¹It was, for example, mentioned extensively in the World Development Report 2014 (World Bank, 2014).

 $^{^{2}}$ For example, Dercon (2005) offers a summary of possible shocks, coping strategies, and consequences of both.

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negative impact on the desired outcome³. However, their identification can lead to a better understanding of both the economic and social relationships at play. For example, taxing one good might lead to price increases in its close substitutes and affect the welfare of individuals not initially targeted by the policy. Yet, this development clarifies the preferences of the economic subjects and this insight can prove useful in future policies.

Policy makers will be able to respond appropriately to negative or unwanted welfare and social impacts if they can determine in time what the unintended consequences, the affected economic subjects and the changes along the income (or expenditure) distribution are. In each case, researchers will require nuanced and precise information in order to ameliorate any downfalls or modify any policies to achieve the desired efficacy and efficiency.

To obtain such granular information, welfare and social changes need to be measured along the corresponding distribution while paying special attention to relevant socioeconomic characteristics. Their choice has to be informed by in-depth knowledge of the setting and the institutional background to which the policy was introduced or the shock took place.

Yet, despite the need for detailed descriptions of the consequences and adaptation processes that occur in such cases, studies are often limited in the scope of their analysis. This limitations can arise because of data unavailability that impedes the inclusion of germane extensions to the methodology. This is more salient for some topics, like law enforcement and crime, and more so in countries where the necessary infrastructure for data gathering is still developing.

Furthermore, because economics is a social science, the study of casual relationships in certain areas is complicated by the reliance on "natural experiments", i.e. the unexpected onset of changes in the economic environment⁴. Nevertheless, the continuous digitization of information makes the analysis of topics that were difficult to address in the past possible, as it allows for data gathering in unconventional and non-experimental ways. One example, out of many, for analyses that use such data are found in Baker et al. (2016) and Nomura et al. (2017). This type of data is generally called "Big Data". Although the definition is still vague, one component is data acquired through web scrapping. In this method, internet searches for a particular item are automated and the relevant data is extracted from the results. While the opportunities and challenges of these data in Economics are still debated (Einav and Levin, 2014), these data can be an useful extension to the conventional ones.

Mexico provides an interesting study in the consequences of disruption, guided

 $^{^{3}}$ In their paper on arms races and conflict, Collier and Hoeffler (2007) define unintended consequences as previously unaccounted negative externalities.

⁴Laboratory experiments are not always feasible or ethical.

or not, in the economic landscape. It is a large transitioning country in an unique position. Not only it is geographically and culturally positioned between the United States of America and Latin America, it is also part of the North American Free Trade Agreement (NAFTA), which makes it susceptible to exogenously generated price changes, particularly of food prices, as it is a net importer of these. It also faces particular internal challenges. It is infamous for the presence of drug trafficking organizations on its soil and the violence they entail; in the decade between 2006 and 2016 alone, around 7000 individuals a year lost their lives to drug-related violence Shirk and Wallman (2015), for example. Moreover, it currently faces the epidemiological and nutrition transitions and needs to prepare accordingly to their fallout. The magnitude of the changes in health outcomes is exemplified in Rivera et al. (2004). They report an increase in the national prevalence of obesity 160% between 1988 and 1999.

While these three topics: food price changes, drug trafficking organizations and the epidemiological and nutrition transition are, as presented here, singular to Mexico, they are by no means unique.

Food prices spikes have affected the lives of many in developed and developing countries as have the repercussions of badly targeted offsetting policies (Wood et al., 2012; Ivanic and Martin, 2008; Akter and Basher, 2014; Ferreira et al., 2013; Jacoby, 2013), countries at different stages of development struggle with violent organized crime (Dorn et al., 2005; Draca and Machin, 2015; Bückner and Ciccone, 2010; Paloyo et al., 2010; Gaviria, 2000; Angrist and Kugler, 2008), and the epidemiological and nutrition transitions have been a topic in countries such as the United Kingdom and others (De Agostini, 2014; Popkin and Gordon-Larsen, 2004; Popkin, 1993; Allais et al., 2010).

1.2 Thesis outline

In this thesis I use non-experimental approaches that exploit increased data availability as well as in-depth knowledge of the institutional background to analyze the social and welfare impacts of shocks and policy interventions in Mexico. In particular I pinpoint possible unintended consequences, identify affected households and measure changes along the expenditure distribution.

1.2.1 Food price shock

Food price spikes have proven to be an increasingly challenging issue in the last 20 years (Swinnen and Squicciarini, 2012) rising concerns regarding food security (for example, Harttgen and Klasen (2012)), poverty (for example, Wood et al. (2012); Ivanic and Martin (2008); Campo et al. (2008); Vu and Glewwe (2011)), as well as

welfare (for example, Ferreira et al. (2013); Jacoby (2013)) and governments are quick to intervene in case food price changes threaten to destabilize the social and economic life.

One such price hike started 2006 and called several governments into action. In Vietnam the rises in the price of rice moved the government to prohibit exports of this items until price stability could be achieved (Heady and Fan, 2008). In Mexico, the price for the main staple, tortilla, doubled in less than 12 months and people took to the streets (Dyer and Taylor, 2011). Governments and aid agencies were eager to identify the "net-losers" to try and stop social and economic upheaval. Although welfare and development economists are well aware of the processes such shocks entail, in welfare analyses they have seldom included quantity substitution effects.

In the case of Mexico, a country with a varied diet, the inclusion of such effects, as well as accounting for changes in different types of income, provides a rich picture of the welfare changes that take place. The results show that substitution away from expensive food items serves as non-negligible coping strategy and that rural households can be as affected by a price spike as non-rural ones, albeit the latter ones are usually grouped into the "net-producers" of food who are expected to gain from such a price increase (Deaton, 1987; Deaton, 1988; Deaton, 1990).

1.2.2 Kingpin strategy and property crime

A special type of government intervention that aims at curtailing a certain behavior are armed interventions against organized crime (Calderón et al., 2015). In particular, Mexico has been increasingly struggling with organized drug trafficking organizations (DTO) in the last 20 years (Shirk and Wallman, 2015). While neither organized crime nor drug trafficking organizations are new to Mexico, the scope of their activities picked up after the Colombian Cartels started winding down their activities in the mid 1990s⁵. While the literature is clear that one direct consequence of the government intervention was to exacerbate the violent and deadly altercations between and within cartels in Mexico and thus racking up more than 60000 drug cartel related deaths in ten years, there is no literature that addresses other possible unintended consequences.

I provide an initial documentation of the link between a government intervention that disrupts the existing *status quo* of organized crime organizations and the effect this can have on property crime that is not typically associated with them. I find supportive evidence for a link between a violent intervention and the geographical expansion of DTO as well as a possible link between the presence of these DTO and

⁵The reasons for this do not lie in any Mexican activities but mostly in interventions from the Colombian government and fights between cartels for control Castillo et al. (2013).

a decline in property crimes not directly related to the business of drug trafficking.

1.2.3 Soda tax

Intentional price hikes, for example due to an excise tax, need to be tested for their explicit usefulness. Mexico introduced a tax on sugar-added beverages in January 2014 with the aim of curbing the consumption of this good that has been deemed harmful (Powell et al., 2013; Malik et al., 2006), especially as the obesity rates in Mexico have soared in the last 20 years (Rivera et al., 2002; Rivera et al., 2004).

The projections on the efficiency and efficacy of such a tax are based on price elasticity estimates that do not take into account a possible substitution along the quality margin (McKelvey, 2011; Andalon and Gibson, 2017). If quality substitution is large enough, a tax to damper consumption will not efficient and it might not be even effective. Although the issue of quality substitution has been mentioned in the literature (for example, Ferreira et al. (2013) note that this can be a concern.) and is handled implicitly, there is a lack of literature that does so explicitly.

Using large cross-sectional data as well as detailed price data from a secondary source, I am able to determine the extent of the quality and quantity substitution. I show that given the spread of the price bracket in soda, a tax on quantity will lead to quality substitution large enough to almost offset the effect of the tax. Furthermore, I present evidence that the tax affects the poor, who consume less soda, overproportionally.

1.3 Contribution

The results show how combining different data sources and the methodological extensions they allow, sheds light on previously unaccounted welfare and social effects.

In particular, I show how quantity substitution effects in the wake of a price increases help alleviate welfare losses to a larger extent than previously thought. Similarly, quality substitution effects are prominent in goods with a large quality margin, and they can diminish the efficiency and efficacy of a taxation policy intended to decrease their consumption. Finally, aggressive policy interventions aimed at reducing organized crime can have the negative unintended consequence of increasing the geographical presence of those organizations and the subsequent unintended consequence of reducing crime not related to them.

In each case I identify affected groups, be it households or geographical areas, and measure the extend of the elicited distributional changes, be it direct or indirect ones. When possible, I pay especial attention to the impacts on poorer households.

1. INTRODUCTION

The methodological extensions and the documented relationships in this thesis offer multiple possibilities for future research: the inclusion of quality as well as quantity substitution in future welfare analysis of price changes, the social consequences the retreat of organized crime from an area can have on certain types of crimes, and the possibility to limit quality substitution through other measures when trying to curb the consumption of certain goods.

Welfare effects of changed prices. The "Tortilla Crisis" revisited

2.1 Introduction

In the last 20 years the incidence and scope of temporary food prices shocks around the world has increased (Swinnen and Squicciarini, 2012; Wood et al., 2012; Hoyos and Medvedev, 2009). Between 2008 and 2010 Mexico experienced two tremendous increases of maize prices due to increased demand, population growth, low past investment, geopolitical concerns, droughts in other parts of the world as well an increased interest in biofuels (Wood et al., 2012; Baffes and Dennis, 2013; Piesse and Thirtle, 2009; Robles and Torero, 2010; Dyer and Taylor, 2011). People took the streets and protested against the governments' inability to control the loss of purchasing power, particularly among the urban poor¹. But Mexico (and maize), were not the only ones affected: world prices for milk powder, wheat and rice increased substantially (Ivanic and Martin, 2008) and countries like Vietnam and India tried to curb exports to ensure sufficient internal supply (Ferreira et al., 2013).

These price shocks raised policy concerns regarding poverty (Wood et al., 2012; Ferreira et al., 2013; Ivanic and Martin, 2008) as well as food security (Swinnen and Squicciarini, 2012; Cohen and Garrett, 2010; Harttgen and Klasen, 2012). Theoretically, such price shocks have important distributional effects to which governments may want to react through appropriate targeted interventions. Yet, teasing out these distributional consequences in detail is far from straightforward because price increases do not only affect the consumption side but also the income side whenever households' income directly or indirectly depends on the production of these goods. Moreover, households can react to price changes by adjusting their

¹For example: http://www.elmundo.es/mundodinero/2007/01/31/economia/1170261989. html

2. WELFARE EFFECTS OF CHANGED PRICES. THE "TORTILLA CRISIS" REVISITED

consumption, production and labor supply. Most of the existing literature ignores the complexity of such price changes and focuses solely on the consumption side and on first order effects, though there are some notable exceptions which will be discussed below.

In this paper I use a series of cross-sectional household surveys with detailed information about households' consumption patterns and income sources by product group in conjunction with detailed price data from 46 price stations distributed all over Mexico to calculate the net welfare effects associated with observed price shocks in general and food price changes in particular. Moreover, I decompose these net effects into its various contributing factors. This is the first study that analyses the welfare effects of food price inflation in Mexico in such detail and hence provides valuable insights regarding the design and targeting of policies to mitigate the distributional consequences of such shocks. In doing so, this paper contributes to the methodological discussion on how to account for differential inflation in welfare analyses.

A plethora of previous empirical studies have analyzed the distributional impact of food price changes. Besides methodological differences² these studies differ in their scope. Furthermore, the welfare effects of price changes are most likely highly context specific, depending on income and expenditure profiles in each country (Harttgen and Klasen, 2012; Akter and Basher, 2014).

The focus of some studies is on simulating the effects on welfare of a price change, for example because of a change in the taxation regime (Porto, 2006; Porto, 2008) or by imputing price changes and simulating the response (Ivanic and Martin, 2008; Hoyos and Medvedev, 2009; Vu and Glewwe, 2011). According to Akter and Basher (2014), results obtained in this manner should be interpreted carefully because they do not have data on, or ignore, adjustments in expenditures and income of the households. This can lead to overestimating the effects of price changes.

Other studies do not rely on simulation, but estimate only the first order expenditure effects, i.e. welfare effects that arise from unadjusted changes in expenditures. The advantages of this approach are twofold: first, household expenditure data is more readily available than income data and so the welfare assessment can be performed shortly after the price increase (Friedman and Levinsohn, 2002) and second, it is argued that a distinction between production and consumption is only necessary if both react to different price signals. For example Deaton (1989) reasons that Thai subsistence farmers posses large shares of auto-consumption in goods with low added value, thus observing equal pricing for consumption and production. Furthermore, urban households are not likely producers; income effects in this

 $^{^2\}mathrm{Araar}$ and Verme (2016) and Janvry and Sadoulet (2009) offer an excellent summary on this point.

case are most likely minimal and can be ignored for certain purposes (Hoyos and Medvedev, 2009). Nevertheless, these analyses are limited to a specific commodity group or a small number of commodity groups and do not offer comprehensive results.

Studies that include the adjustment of expenditures due to a change in prices, i.e. the second order expenditure effect, also known as substitution effects, are, for example, Robles and Torero (2010) for a set of four Latin American countries and Friedman and Levinsohn (2002) for Indonesia. Both studies conclude that the inclusion of substitution effects substantially influences the magnitude of the estimated welfare change by accounting for the expenditure adjustments of the households. Robles and Torero (2010) find that not including substitution effects would overestimate the welfare loss induced by a price increase by 7 to 12 percent, on average.

Finally, studies more akin to this are those that include first and second order effects, both in income and in expenditures. Examples are Jacoby (2013) for India and Ferreira et al. (2013) for Brazil³. Although these studies are limited to the analysis of food prices, they find that including income responses provides more differentiated welfare effects. Particularly, it appears that poor households seem to benefit from the price increase.

Several studies have looked into the welfare effects of price changes in Mexico. Valero-Gil and Valero (2008) concentrate on changes in consumption patterns due to increases in prices of staples and find a moderate poverty rate increase. They also identify certain food staples for which they argue price controls would achieve the largest welfare effects. Porto (2008) proposes a methodology that includes responses on the income and the expenditure sides. He simulates different price increase scenarios and for each computes "consumption" and "income" effects. The first is a compound of the first and second order responses in expenditure, the second refers to agricultural wages. He finds that an income effect *can* ameliorate the (negative) impact of a price increase but that this will depend on the size of the observed price changes and the goods for which the price increases. Dyer and Taylor (2011) also use a simulation to assess the effect of corn price increases on corn production and the respective labor supply and conclude that even in rural areas, there are large discrepancies in the distribution of gains and losses. Campo et al. (2008) simulate three different price increases for two types of commodity groups: cereals and all goods. They conclude that the expenditures of poor individuals, be it in rural or non-rural areas, are hit harder by price increases than non-poor ones because their food expenditure shares are relatively larger; thus food price increases have a

 $^{^{3}}$ Akter and Basher (2014) measure the effect on welfare of a price increase in Bangladesh and its subsequent economic consequence. This approach is not comparable as they assume that the economic response was not simultaneous

negative poverty effect, i.e. they increase and exacerbate poverty. Nonetheless, the authors also include the second order expenditure effect to account for substitution and found that the rural poor in particular are able to offset a part of the negative expenditure effect. In a further methodological step, Wood et al. (2012), found that including an income effect, i.e. computing the compensating variation, in necessary since the magnitude of the welfare effect changes significantly. According to their simulation results, the inclusion of the first order expenditure effects overestimates and that of second order expenditure effects, one that includes only the own-price elasticities, underestimates the welfare change.

These studies typically rely on simulations, unit values (ratio of expenditures for an item with respect to overall expenditures) instead of prices, or on a limited set of goods to estimate welfare impacts. I estimate the compensating variation for rural and non-rural households using official prices for food and non-food items as well as including wage and non-wage income.

I find that most of the positive welfare changes observed stem from a positive expenditure effect rooted in changes in the prices of non-food items. Furthermore, in times of high food inflation, as was 2008 - 2010 most of welfare losses can be attributed to changes in food prices. Moreover, the inclusion of both the income as well as the substitution effects considerably changes the magnitude of the welfare change. Finally, while the welfare losses appear to be similar in both rural and non-rural areas, the poverty impact in non-rural ones is larger.

2.2 Concept

I take the ""welfarist" approach" (Slesnick, 1998) to welfare here⁴: welfare is obtained from the consumption of goods and services and is thus roughly defined as the amount of money needed to sustain a given level of utility. Net welfare changes are the product of changes in income and expenditures. A higher (lower) income means gains (losses) in welfare and higher (lower) expenditures for a given utility level mean losses (gains) in welfare. Hence, changes in prices can cause changes in welfare by affecting both income and expenditures.

The size and direction of a change in expenditures due to a change in prices can be broken down into the income and the substitution effects. The income effect arises due to the changes in the purchasing power and the substitution effect due to changes in the relative prices between goods.

For example, a consumer facing an increased price for beef may purchase less beef than before (income effect). Simultaneously, and provided unchanged prices of other goods, the price of chicken meat relative the price of beef will be lower and

⁴A different approach to welfare measurement is for example Sen's capability approach.

the consumer may substitute beef with more chicken meat (substitution effect). The magnitude of the substitution will depend on the individual, relative valuation of each good. Hence, the empirical analysis of the substitution effect requires the corresponding direct and cross price-elasticities.

Moreover, the magnitude of the welfare effect will depend on the size of the relative expenditure share in total expenditures of the commodity in question. Price changes of goods whose relative expenditure shares are relatively small will have a comparatively small impact on welfare as opposed to price changes of goods whose relative expenditure share is large.

Changes in household income due to changes in the prices of goods will depend on the income source. If the households' income comes from wages, then income changes will depend on the pass-through rate from prices to wages, unlike a situation where the income comes from own-business sources. In this case, the changes in marginal returns to labor triggered by a price change can lead to changes in the hours worked or lead to new employment of previously unemployed members or both. That is, there can be changes on the intensive and on the extensive margin and, depending on the characteristics of the labor market, a price change in one good can also lead to changes in the production, and thus employment, in other goods (Jacoby, 2013).

In a second case, the position of the household as net consumer or net producer of the good has been discussed in the literature in the past (for example Deaton (1989)). If the analysis is restricted to one good, net consumers should lose from a price increase and net produces should gain. In an analysis with several goods this differentiation is difficult to achieve if not impossible.

Wage income constitutes a substantial part of non-rural total income, while business income plays a larger role in rural areas⁵. Second, I argue that the response time to a price change between both income types can vary. In both cases, a composite measure of income would conceal any particular effects.

A third income source that has to be considered in the Mexican context is transfer income. It does not have a direct link to a particular price change, but Governments may try to compensate households for a serious loss in purchasing power. Thus, the change in transfer income is attributed to the price changes, although the link is not as straightforward is with the other two types of income. For this reason I include changes in the transfer income without directly linking them to a price change.

As all possible goods are taken into account, there are two lines at which groups can be differentiated that are not producer or consumer. The first one is the aforementioned distinction between wage or business income, the second will be on the area of residence. Depending on the rural or urban status of the household

⁵Descriptive statistics to both can be found in Section 2.3

it will have different options regarding goods and income opportunities. This distinction is not only relevant as far as income is concerned, but is also interesting regarding any consumption or substitution possibilities available to the household.

Lastly, while the reaction of the labor market to price changes is outside the scope of this study, the relative changes in income that originate there are not. Empirically, these relative changes will amount to changes in income across time periods.

The impact a change in price p_i of a commodity, i on household welfare can be described by the overall (proportional) change in money-metric household welfare (Janvry and Sadoulet, 2008; Jacoby, 2013; Robles and Torero, 2010; Ferreira et al., 2013) that is composed of changes in income and changes in expenditure. Note that at first glance this appears as a profit equation but actually refers, as stated before, to the measure of money needed to maintain a certain utility level⁶.

$$\mathrm{d}b_h = \frac{\Delta y_h}{y_h} - \frac{\Delta E_h}{E_h} \tag{2.1}$$

Where db_h is the money-metric change in household welfare, $\frac{\Delta y_h}{y_h}$ stands for relative changes in income and $\frac{\Delta E_h}{E_h}$ for relative changes in expenditure in a household h.

These are the two main contributors to welfare, the next step consists in formulating expressions for both that can be estimated empirically.

The household minimum expenditure necessary to achieve an utility level U is defined as $E_h(\mathbf{p}, U)$ where \mathbf{p} is the vector of prices for goods: $i = 1 \dots n$. The compensating variation (CV) is a measure of the income change a household needs to realize the utility level achieved in the setting prior to a price change. The CV is approximated here with a second order Taylor expansion with respect to the initial price of the minimum expenditures $E_h(\mathbf{p}^0, U)$ where, \mathbf{p}^0 stands for the prices at time period 0. Additionally, such an expansion will allow to account for substitution behavior, as will be explained later⁷.

$$E_h(\mathbf{p}, U) \approx E_h(\mathbf{p}^0, U) + \left[\frac{\partial E(\mathbf{p}^0, U)}{\partial \mathbf{p}}\right]' d\mathbf{p} + \frac{1}{2} d\mathbf{p} \left[\frac{\partial^2 E(\mathbf{p}^0, U)}{\partial^2 \mathbf{p}}\right]' d\mathbf{p} \qquad (2.2)$$

Rearranging (2.2) yields:

 $^{^{6}\}mathrm{The}$ author thanks Johann Graf Lambsdorff for his comments on this point

⁷Friedman and Levinsohn (2002); Vu and Glewwe (2011); Robles and Torero (2010); Ferreira et al. (2013) develop similar expressions for the CV.

$$\Delta E_h(\mathbf{p}, U) \approx \left[\frac{\partial E(\mathbf{p}^0, U)}{\partial \mathbf{p}}\right]' d\mathbf{p} + \frac{1}{2} d\mathbf{p} \left[\frac{\partial^2 E(\mathbf{p}^0, U)}{\partial^2 \mathbf{p}}\right]' d\mathbf{p}$$
(2.3)

In (2.3) $\frac{\partial E(\mathbf{p}^{0},U)}{\partial \mathbf{p}}$ is a vector and $\frac{\partial^{2}E(\mathbf{p}^{0}),U}{\partial^{2}\mathbf{p}}$ is a matrix. Using Shepard's Lemma one can restate $\frac{\partial E(\mathbf{p}^{0},U)}{\partial p}$ as the Hicksian compensated demand, $h(\mathbf{p}^{0},U)$. Rewrite (2.3) as:

$$\Delta E_h(\mathbf{p}, U) \approx \left[h(\mathbf{p}^0, U)\right]' d\mathbf{p} + \frac{1}{2} d\mathbf{p} \left[\frac{\partial h(\mathbf{p}^0, U)}{\partial \mathbf{p}}\right]' d\mathbf{p}$$
(2.4)

Equation (2.4), the compensating variation, can be expressed as a fraction of total expenditures, E. By simultaneously using proportional price changes we achieve an expression with expenditure shares and elasticities. For this, define two square matrices $\mathbf{H} \equiv diag(h(\mathbf{p}, U))$ and $\mathbf{P} \equiv diag(\mathbf{p})$ such that:

$$\mathbf{H} = \begin{bmatrix} h(p_1, U) & \dots & \dots & 0 \\ 0 & h(p_2, U) & \dots & 0 \\ \vdots & \dots & \ddots & \vdots \\ 0 & 0 & \dots & h(p_n, U) \end{bmatrix} \text{ and } \mathbf{P} = \begin{bmatrix} p_1 & \dots & \dots & 0 \\ 0 & p_2 & \dots & 0 \\ \vdots & \dots & \ddots & \vdots \\ 0 & 0 & \dots & p_n \end{bmatrix}$$

Using these matrices, rewrite (2.4) as:

$$\begin{split} \frac{\Delta E_h(\mathbf{p}, U)}{E_h} &\approx \frac{1}{E_h} \left[h(\mathbf{p}^0, U) \right]' d\mathbf{p} \ \mathbf{P} \mathbf{P}^{-1} \\ &+ \frac{1}{E_h} \frac{1}{2} d\mathbf{p} \mathbf{P} \mathbf{P}^{-1} \left[\frac{\partial h(\mathbf{p}^0, U)}{\partial \mathbf{p}} \mathbf{H} \mathbf{H}^{-1} \right]' d\mathbf{p} \ \mathbf{P} \mathbf{P}^{-1} \end{split}$$

Rearrange to obtain an expression with expenditure shares and elasticities:

$$\frac{\Delta E_h}{E_h} \approx \left[\omega\right]' \left[\frac{d\mathbf{p}}{\mathbf{p}}\right] + \frac{1}{2} \left[\frac{d\mathbf{p}}{\mathbf{p}}\right]' \left[\mathbf{\Omega}\mathbf{\Gamma}\right]' \left[\frac{d\mathbf{p}}{\mathbf{p}}\right]$$
(2.5)

In Equation (2.5) $\begin{bmatrix} d\mathbf{p} \\ \mathbf{p} \end{bmatrix}$ is a vector of proportional price changes,

 $\omega = \begin{bmatrix} \frac{h(p_1, U)p_1}{E} \\ \frac{h(p_2, U)p_2}{E} \\ \vdots \\ \frac{h(p_n, U)p_n}{E} \end{bmatrix}$

is the vector of expenditure shares, $\mathbf{\Omega} \equiv diag(\omega)$ and

$$\boldsymbol{\Gamma} = \begin{bmatrix} \frac{\partial h_1}{\partial p_1} \frac{p_1}{h_1} & \cdots & \frac{\partial h_1}{\partial p_n} \frac{p_n}{h_1} \\ \vdots & \ddots & \vdots \\ \frac{\partial h_n}{\partial p_1} \frac{p_1}{h_n} & \cdots & \frac{\partial h_n}{\partial p_n} \frac{p_1}{h_n} \end{bmatrix} = \begin{bmatrix} \epsilon_{11} & \cdots & \epsilon_{1n} \\ \vdots & \ddots & \vdots \\ \epsilon_{n1} & \cdots & \epsilon_{nn} \end{bmatrix}$$

is the elasticity matrix where the elements of the main diagonal are the own-price elasticities and those of the off-diagonal the cross-price elasticities.

The following expression restates the CV as a sum:

$$\frac{\Delta E_h}{E_h} \approx \sum_{i=1}^n \omega_i \frac{\Delta p_i}{p_i} + \frac{1}{2} \sum_{i=1}^n \sum_{j=1}^n \omega_i \epsilon_{ij} \frac{\Delta p_i}{p_i} \frac{\Delta p_j}{p_j}$$

$$\approx \sum_{i=1}^n \omega_i \frac{\Delta p_i}{p_i} + \frac{1}{2} \sum_{i=1}^n \omega_i \sum_{j=1}^n \epsilon_{ij} \frac{\Delta p_i}{p_i} \frac{\Delta p_j}{p_j}$$
(2.6)

The first term includes expenditure shares for goods i, ω_i . It measures the direct change in expenditures caused by a proportional price change in good i. The second term accounts for substitution by including the own and cross-price elasticities, ϵ_{ij} . Thus, the expression for the CV developed here accounts for the income and the substitution effects introduced earlier.

The first term on the right of (2.1), $\frac{\Delta y_h}{y_h}$, is the proportional change in in income, which can be split up into wage income, business income and transfers.

The term $\frac{\Delta y_h}{y_h}$ in (2.1) becomes:

$$\frac{\Delta y_h}{y_h} = \sum_{i=1}^n \sum_{q=1}^Q \frac{\Delta v_{q,i}}{y_h} \frac{\Delta p_i}{p_i} + \sum_{i=1}^n \frac{\Delta \theta_i}{y_h} \frac{\Delta p_i}{p_i} + \frac{\Delta \tau}{y_h}$$
(2.7)

The first term corresponds to the change in wage income v of an individual q earned in the production of a good i in the household h that has Q members. The second one corresponds to the total business income θ earned in the household in the production of good i. The third and final term represents state transfers, τ .

Using the decomposed proportional changes in income, (2.7), and expenditures, (2.6), we can rewrite (2.1):

$$db_{h} = \sum_{i=1}^{n} \sum_{q=1}^{Q} \frac{\Delta v_{q,i}}{y_{h}} \frac{\Delta p_{i}}{p_{i}} + \sum_{i=1}^{n} \frac{\Delta \theta_{i}}{y_{h}} \frac{\Delta p_{i}}{p_{i}} + \frac{\Delta \tau}{y_{h}}$$
$$- \sum_{i=1}^{n} \omega_{i} \frac{\Delta p_{i}}{p_{i}} - \frac{1}{2} \sum_{i=1}^{n} \omega_{i} \sum_{j=1}^{n} \epsilon_{ij} \frac{\Delta p_{i}}{p_{i}} \frac{\Delta p_{j}}{p_{j}}$$
(2.8)

As in Ferreira et al. (2013) and Porto (2008), Equation (2.8) captures different effects of changes in prices on household welfare:

- 1. A wage income effect: $\rho_v = \sum_{i=1}^n \sum_{q=1}^Q \frac{\Delta v_{q,i}}{y_h} \frac{\Delta p_i}{p_i}$
- 2. A business income effect: $\rho_{\theta} = \sum_{i=1}^{n} \frac{\Delta \theta_i}{y_h} \frac{\Delta p_i}{p_i}$
- 3. A transfer effect: $\rho_t = \frac{\Delta \tau}{y_h}$
- 4. An expenditure effect: $\rho_e = \sum_{i=1}^n \omega_i \frac{\Delta p_i}{p_i}$
- 5. A substitution effect: $\rho_s = \frac{1}{2} \sum_{i=1}^n \omega_i \sum_{j=1}^n \epsilon_{ij} \frac{\Delta p_i}{p_i} \frac{\Delta p_j}{p_j}$
- The net effect is then: $db_h = \rho_v + \rho_\theta + \rho_t \rho_e \rho_s$

In practice, each income effect can be further decomposed into commodity group components, for example food and non-food items.

The first four components can be estimated using expenditure and income information extracted from several waves of the ENIGH and official price data. To estimate the fifth component one needs to estimate first the corresponding price elasticities.

Before I describe the details to the estimation procedures below in Section 2.3, I start with a short description of the data.

2.3 Data and empirical strategy

This study relies on three waves of a nationally representative household survey on income and expenditures and on an extensive and detailed set of officially levied monthly prices.

2.3.1 Prices

Unit values, the ratio of expenditure to quantity of a good, are commonly used instead of prices when the latter are not available. Yet, the use of prices in welfare analysis has two distinct benefits.

Unlike prices, unit values generated from household data contain in themselves the quality decisions made by the consumers. If higher income households are willing to pay more for a given good than lower income ones for that same good, then unit value for a good will increase with increasing income. The positive association between unit values and income can bias a welfare analysis because increases in unit values will not accurately represent changes in quantity demanded (McKelvey, 2011; Deaton, 1988)⁸.

On the other hand, unit values cannot be produced if the household does not report the consumption of a good or if the amount consumed is not reported. This implies that the unit values have to be imputed, usually by making assumptions about the consumption level of household (Dybczak et al., 2010). The use of prices foregoes any assumptions regarding consumption pattern and so of any assumptions regarding the separability of preferences (Vu and Glewwe, 2011).

Prices were obtained from the DOF⁹ for different geographical points, so called *price stations*. A Consumer Price Index (CPI) was computed for every point using the official weights for the various items that constitute the underlying consumption basket. Lastly, to each municipality prices are assigned according to its geographical location. These procedures are described next.

Prices for 314¹⁰ items are levied monthly by the Banco de México (Banxico)¹¹ in 46 different municipalities. These *price stations* were selected to be nationally representative by the responsible organization. Table 2.B.1 lists these price stations. Municipalities are second level administrative divisions, the next one being the locality. In Figure 2.2 municipalities are delimited by black lines.

Using these prices and the weights from the consumer basket from June 2002, I calculate the CPI for every price station using January 2004 as a base. With this CPI I deflate income and prices into real values (Janvry and Sadoulet, 2008) and simultaneously maintain regional variation.

⁸An affect that is unacounted here is quality substitution, i.e. when a price increase leads to consumption of lower quality, and thus cheaper, items of one commodity group.

⁹Spanish for Diario Oficial de la Federación

 $^{^{10}\}mathrm{In}$ three cities (México D.F., Guadalajara, and Monterrey) a 315th price is levied, that for the subway or the electric transportation system

 $^{^{11}\}mathrm{In}$ June 2011 this task was reassigned to the INEGI

Figure 2.1 relates the mean CPI level and its standard deviation. The largest increase as well as the highest decline both occurred in mid-2008. The large variation in CPI illustrates the divergence in prices for the various commodities at different price stations.



Figure 2.1: CPI

Every municipality in the country was unambiguously assigned to the closest price station by geodesic distance between the centroids of the municipality that is the price station and the municipality where the household resided at the time of the interview.

Figure 2.2 visualizes this procedure for three selected price stations. The prices and CPI from the price station are imputed on the assigned municipalities. None of the price stations is in a "rural" municipality, therefore, it is not possible to assign municipalities to rural or non-rural price stations. Welfare effects in rural areas have to be interpreted with this shortcoming in mind. An alternative assignment of prices is conceivable: price stations and municipalities across the country could be matched based on particular characteristics. The challenge would lie in choosing those characteristics to appropriately reflect the consumption patterns. Furthermore, a matching across the country would imply that the geographical component, which greatly influences tastes and availability, would be lost.



Figure 2.2: Selected price stations and municipality assignment

Notes: Shown here for selected price stations: Juárez (in the North), Heroica Matomoros (in the East) and Acapulco de Juárez (in the West)

Prices and households' income and expenditures are reported at different aggregation levels. On the expenditure side, prices levied and expenditure items in the household surveys match according to an official key (Banco de México, 2011), though at a higher level of aggregation than the orginal price data. On the income side prices and income sources can be matched using the industrial classification¹² of the workplace of each individual as well as the Mexican Classification of Occupations¹³ and the National System of Classification of Occupations¹⁴, though again at a higher level of aggregation the the original price data. Aggregation levels for the income and the expenditure side are different and thus subsequently combined into a harmonized aggregation level which yields 20 commodity groups which can be grouped into food and non-food groups as is shown in Table 2.1.

Food	Non-food
Tortillas, bread, cereals and similar	Clothing, shoes and accessories
Maize and beans	Housing
Meats and fish	Furniture and household appliances
Milk and milk products	Health and personal care
Eggs	Transportation
Fruits	Education
Vegetables and greens	Leisure
Bottled fruits and legumes	Other services
Seasonings, sugar, oils and fats	
Beverages, incl. coffee	
Candy, chocolates and tobacco	
Food cooked outside of home	

 Table 2.1: Food and non-food groups

Figure 2.3 reports country-wide monthly mean percentage changes in relative real prices for food and non-food groups with their respective standard deviations for the years 2006 - 2008. This figure exemplifies why the term "Tortilla Crisis" is actually a misnomer, as it refers to only one item. The situation was more of unequally volatile food price growth rates.

There are two spikes in food prices on the left panel in Figure 2.3: one at the end of 2007 and one in the middle of 2008. Although the average growth rate is roughly positive, the standard deviation around the spikes is sizeable, a reflection of regional differences in price changes among food groups.

 $^{^{12}\}mathrm{Given}$ by the North American Industrial Classification System, 'SCIAN' by its initials in Spanish

¹³Clasificación Méxicana de Ocupaciones, 'CMO' by its initials in Spanish

¹⁴Sistema Nacional de Clasificación de Ocupaciones, 'SINCO' by its initials in Spanish



Figure 2.3: 12-month growth rates in real prices

The INEGI divides the country into eight different regions¹⁵. Each graph in Figure 2.4 shows the food price growth rates for food for each region.

The regions appear to be affected by large food price growth rate the most. There are the northwest, northeast and the southeast

Table 2.2 reports mean 12-month growth rates of real food prices as well as their mean standard deviations. Unlike cereals and other grains, growth rates for meat declined.

	2006	-2007	2007	-2008	2008	-2009	2009	-2010
Commodity group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Tortilla, bread, cereal and similar	3.6	10.1	3.1	15.8	8.7	28.8	2.7	18.4
Maize and beans	3.8	17.1	7.0	21.2	25.5	35.9	-0.8	24.2
Meat and fish	-1.4	21.8	-5.5	14.9	8.5	31.1	$2 \cdot 4$	19.9
Milk and milk products	9.3	133.9	3.7	18.3	3.6	28.1	1.9	19.0
Eggs	14.1	17.9	8.8	30.9	8.6	28.9	-7.2	18.6
Fruits	2.7	8.9	-5.2	15.7	4.5	28.8	4.6	18.4
Vegetables and greens	0.7	11.1	-6.0	15.8	6.4	30.2	9.2	22.4
Bottled fruits and legumes	-0.1	15.7	11.3	144.1	32.6	197.8	$2 \cdot 1$	24.0
Seasonings, sugar, oils and fats	-6.7	21.0	$4 \cdot 8$	92.2	5.3	44.7	1.6	21.6
Beverages, incl. coffee	-3.5	10.2	-3.5	14.3	$2 \cdot 1$	15.2	5.4	11.2
Candy, chocolates and tobacco	0.3	15.5	-1.4	20.0	$3 \cdot 1$	29.9	7.0	21.4
Food cooked outside of home	-1.0	9.8	-3.8	14.9	4.5	29.1	$2 \cdot 3$	19.1

Table 2.2: 12-months growth rates in real food prices

Source: Banxico, author's calculations

The most drastic price increases are found between the years of 2007 - 2008 and 2008 - 2009, with 12-month growth rates between 20% and 60%. The large standard deviations in Figure 2.3 are partly explained by very large standard deviations in

¹⁵The regions are Northwest (Baja California, Baja California Sur, Chihuahua, Durango, Sinaloa and Sonora), Northeast (Coahuila, Nuevo Leon, Tamaulipas), West (Colima, Jalisco, Michoacan, Nayarit), East (Hidalgo, Puebla, Tlaxcala, Veracruz), North-center (Aguascalientes, Guanajuato, Queretaro, San Luis Potosi, Zacatecas), South-center (Mexico City, Mexico, Morales), Southwest (Chiapas, Guerrero, Oaxaca), Southeast (Campeche, Quintana Roo, Tabasco, Yucatan)



Figure 2.4: Food price growth rates by region

single commodity groups, which are a result of price differences among the price stations and reflect regional disparities.

Because the welfare effect will depend on the relative change in prices as well as on the relative change in income and expenditures for each commodity group¹⁶, welfare will evolve differently for households that experienced the same price changes but differ in their income and expenditure patterns. Thus, for the analysis changes between points in time of the variables of interest need to be observed.

Whereas the assessment relies on relative changes between points in time the household data consists of repeated cross-section. Hence, it is not possible to perform the analysis at the household level.

2.3.2 Unit of analysis

Approximately 60% of all municipalities surveyed appear in subsequent waves, with 199 municipalities being surveyed in every wave over the time period considered. The analysis is performed for changes in the same municipality between two survey waves. Specifically, the comparison is made at per capita municipality changes in income and expenditure at every centile and decile of per capita expenditure. Using per capita expenditures ensures comparability with the relevant literature mentioned above (e.g.: Ferreira et al. (2013); Robles and Torero (2010)).

One concern that arises when analyzing municipality level changes is alterations in the composition of the municipality that might drive the results, for example a changed migration pattern. In Mexico, internal and external migration are relatively low. According to the National Council for Population¹⁷ between the years of 2005 and 2010 only around 1% of the population emigrated abroad and around 6% migrated to a different municipality¹⁸. A large share of migration occurs to municipalities at the borders and touristic areas Anzaldo et al. (2008); Sobrino (2010). Nonetheless, I do not observe households across time and so, cannot observe migration patterns. To limit the effect that migration could have over time on the income and expenditure profiles, the analysis occurs between subsequent survey waves and not, for example, between the years before and after the price change. First, because price changes occur as a continuum and the setting of a precise date for the beginning of the price increase would be arbitrary by any means, and second, by observing such a short time period the changes for influences of migration on the municipality income and expenditure characteristics are hopefully minimized.

Another important dimension is the rural/non-rural divide. According to the INEGI, a locality is rural if it has 2500 inhabitants or fewer. Each municipality is

 $^{17}\mathrm{CONAPO}$ by its initials in Spanish

 $^{^{16}}$ as outlined in Section 4.2

 $^{^{18}3\%}$ out of the federal state and 3% within the federal state

composed of a number of localities. Using the information on the rural status of the locality I can determine the median rural status of a municipality. In the years 2006 - 2008 there were 220 rural and 309 non-rural municipalities and in the years 2008 - 2010 245 rural and 381 non-rural ones.

Price stations are by choice of the incumbent agency municipalities with at least 20000 inhabitants (Banco de México, 2013), thus no price station accurately reflects the price dynamics in rural areas. Nevertheless, the differentiation between rural and non-rural municipalities is relevant as income and expenditure profiles are clearly different.

2.3.3 Household data

2.3.3.1 Income

Household data come from a biannual survey, the National Household Survey on Income and Expenditures¹⁹ provided by the Mexican Statistical Office²⁰ for the years 2006, 2008, and 2010. This is a nationally representative cross-sectional household survey that interviews between 20875 and 27665 households in over 900 different municipalities in each wave and contains information on the socio-demographic characteristics of households and its members, as well as detailed income and expenditure information.

Estimation of the wage, business and transfer income effects along the lines shown in Section 4.2 requires that household income is reported by types and source. Using information on the sector of activity and the occupation of the individual²¹, income earned by any member of the household can be classified as either wage income, business income or transfer income. The last one refers to the widespread and ample governmental transfer programs in Mexico. The first two income types can be further assigned to the commodity group in which they were earned. The final steps involve deflating the income with the CPI (see Section 2.3.1) and trimming the data by eliminating households in the first and last percentiles in the total income and total expenditure distributions. Then we generate municipality level weighted means as well as real relative changes in income.

Figure 2.5 shows the mean per capita income levels pooled for all years by income category. Overall income levels are higher in non-rural areas, although the speed at which income increases across deciles is higher in rural ones.

To further illustrate the differences between rural and non-rural municipalities and to further motivate our use of wage and business income, Figure 2.6 presents

¹⁹ENIGH by its initials in Spanish.

 $^{^{20}\}mathrm{INEGI}$ by its initials in Spanish.

²¹Using the SCIAN, CMO, and SINCO detailed before



Figure 2.5: Mean per capita income levels

Notes: A locality has a rural status if it has 2500 inhabitants or less. Mean values for the years 2006, 2008, and 2010.

the mean income share for each income type. In addition we disaggregate the income types by their source: food and non-food. The role of agricultural businesses is larger in rural than in non-rural areas, therefore, food business income plays a larger role in rural areas. Furthermore, transfer income is particularly important at lower deciles, but much more so in rural areas. Because transfer income is awarded in part due to economic status, these higher shares in the income constitution are exemplary of the poverty situation in rural areas.

Income composition differs markedly between rural areas and their counterparts. Whereas the major component of income in non-rural areas are wages, with more than 65% in all deciles, in rural areas the components appear more balanced. Nonetheless, we observe the save trend with respect to the income composition in both areas: at higher deciles, most income is wage income, particularly of the non-food kind.

Figure 2.7 illustrates the mean per capita income level across deciles for every survey wave. To put these reported income levels into perspective, the mean rural


Figure 2.6: Income composition by food and non-food

Notes: Income shares computed for the ENIGH 2006, 2008 and 2010 waves. A locality has a rural status if it has 2500 inhabitants or less.

and non-rural poverty lines in 2004 were 1004.3 MXN per capita and 1637.1 MXN per capita respectively²². In the rural setting this translates into an average poverty headcount of approximately 40 %, while in non-rural areas this figure reaches around 20 %.

Despite, it is clear that in both settings average per capita income *increased* in all deciles between 2006 and 2008 and between 2008 and 2010.

2.3.3.2 Expenditures

Per capita food and non-food expenditure shares (Figures 2.8 and 2.9) display the expected behavior: food (non-food) expenditure shares decline (increase) with increasing deciles.

The increases in the expenditure share for food in the years 2008 and 2010, which are mirrored by declines in the non-food shares, follows from the decline in

 $^{^{22}\}mathrm{Official}$ SEDESOL values for July 2004, deflated with the CPI presented in this section.



Figure 2.7: Decile mean per capita income levels

Notes: A locality has a rural status if it has 2500 inhabitants or less.

overall expenditures caused by the decline in non-food expenditures in that same time period. Particularly interesting is that real food expenditures remained largely unchanged during the observed time period indicating that food expenditures are largely unresponsive to inflation. To sustain unchanged expenditure levels despite the inflation, households either spend less on other goods, which would explain the lower levels of expenditures in non-food items, or sustain the consumption through a higher income, or both. This last argument is consistent with the higher income presented in Figure 2.7 above.

A cursory analysis would imply a positive effect of the price changes on welfare: incomes increased while total expenditures decreased. Nonetheless, it is not clear if the income increases are sufficient to compensate the for the price increases or how the decline in non-food expenditures affects welfare. Furthermore, the changes in income and expenditure presented above vary for each decile and by rural and non-rural setting.

Overall, the net welfare effect will depend on the changes in prices, income and expenditures. To further account for possible substitution effects, we compute the



Figure 2.8: Food expenditure shares

Notes: Deciles were computed separately for rural and non-rural municipalities.

price and cross-price elasticities of the 20 commodity groups.

2.3.4 Elasticities

The compensated own- and cross-price elasticities which are needed to estimate the substitution effect $-\rho_{s}$ - are derived from Hicksian demand functions which are in turn obtained from the estimation of a quadratic almost ideal demand system (QUAIDS). This system, proposed by Banks et al. (1997), allows for non linearities in the Engel curves by including a quadratic term in the expenditure share equation²³. The reason for choosing this demand system lies in following similar studies and generating comparable results, albeit, according to Araar and Verme (2016), the choice of demand system appears to be of minor relevance for the results.

I estimated a QUAIDS controlling for rural status of the household and number

 $^{^{23}\}mathrm{See}$ Section 2.A for the estimated system.



Figure 2.9: Non-food expenditure shares

Notes: Deciles were computed separately for rural and non-rural municipalities.

of residents and obtained a full set of compensated own- and cross-price elasticities for every single commodity group in every household in every wave. These elasticities were aggregated at the municipality level in the same fashion as the income and expenditure data detailed before.

Table 2.3 summarizes the compensated own- and cross-price elasticities for all years without distinction between rural and non-rural households. The commodity groups are listed both vertically and horizontally. Row elements react to a change in the price in the column elements (Poi, 2012). Thus the diagonal elements correspond to the own-price elasticities. For example, the own-price elasticity of the group "Tortilla, bread, and cereals" is -1.09: the demand for this group will recede by 1.09% when the price for the same increases by 1%. Similarly, if the price for "Maize and beans" increases by 1% the demand for "Tortilla, bread, and cereals" will increase by 0.17%.

Overall the estimated elasticities are within a reasonable range, with no overly large values, and possess no unexpected signs. For example, own-price elasticities are always negative. As for the cross-price elasticities, the signs vary depending on

Commodity group	Tortilla, bread, and cereals	Maize and beans	Meat and fish	Milk and milk prod- ucts	Eggs	Fruits	Vege- tables and greens	Bottled fruits and legumes	Spices, sugar, and oil
Tortilla, bread, and cereals	-1.09	0.17	-0.03	0.26	-0.03	0.39	0.35	0.04	0.19
Maize and beans	0.53	-1.61	-0.51	1.30	-0.01	-0.11	-0.15	-0.00	-0.30
Meat and fish	-0.02	-0.10	-1.29	0.21	-0.03	-0.01	-0.25	-0.03	0.16
Milk and milk products	0.42	0.63	0.48	-0.30	0.01	0.33	0.37	0.02	0.11
Eggs	-0.08	-0.00	-0.11	0.00	-0.66	-0.32	-0.71	0.11	-0.01
Fruits	1.29	-0.11	-0.03	0.74	-0.33	-0.08	-0.22	-0.11	-0.09
Vegetables and greens	0.65	-0.10	-0.66	0.44	-0.41	-0.12	-1.90	0.38	-0.03
Bottled fruits and legumes	0.19	0.01	-0.18	0.08	0.18	-0.14	1.06	-0.93	0.03
Spices, sugar, and oil	0.63	-0.32	0.83	0.24	-0.01	-0.09	-0.05	0.01	-1.29
Beverage, incl. coffee	0.48	0.11	0.79	-0.23	0.22	-0.46	0.46	-0.05	-0.28
Sweets and tob.	0.08	-0.24	0.47	-0.00	0.47	0.09	0.98	0.15	-0.29
Food cooked outside of home	-0.24	0.06	1.19	-0.63	0.05	0.04	0.54	-0.13	0.25
Clothing	0.03	-0.05	-0.19	0.38	-0.03	0.10	-0.01	-0.00	-0.02
Housing	-0.19	-0.05	0.15	0.07	-0.00	0.05	0.02	0.02	-0.02
Furniture and household appl.	0.22	0.10	-0.01	-0.43	0.23	-0.15	0.04	0.04	0.06
Health and personal care	-0.08	-0.01	0.11	-0.01	-0.01	-0.00	-0.02	-0.00	0.03
Transportation	-0.06	0.13	0.19	-0.44	0.07	-0.14	0.08	-0.06	0.08
Education	-0.00	0.11	0.47	-0.37	0.07	0.10	0.30	-0.07	-0.06
Leisure	-0.01	-0.26	-0.25	0.54	-0.32	-0.35	-0.75	0.10	-0.33
Other services	0.52	-0.16	-1.82	0.23	-0.17	0.22	0.12	0.16	-0.01

 Table 2.3:
 Compensated price elasticities

Notes: Calculated using ENIGH 2006, 2008, and 2010.

whether in the data those goods are complements or substitutes.

I estimate the substitution effect, ρ_s described in Section 4.2, using such an elasticity matrix for every municipality for those years at the beginning of an inter-wave comparison. the year 2010.

The next section presents the results of an estimation of the five effects described in Section 4.2.

Commodity group	Beve rages	Sweets and tob.	Food cooked out.	Clothing	g Hou- sing	Furni- ture and house. app.	Health and per- sonal care	Trans- por- ta- tion	Educa- tion	Leisure	Other ser- vices
Tortilla, bread, and cereals	0.28	0.01	-0.18	0.02	-0.37	0.23	-0.18	-0.09	-0.04	-0.03	0.08
Maize and beans	0.16	-0.15	0.11	-0.10	-0.31	0.34	-0.04	0.73	0.33	-0.13	-0.06
Meat and fish	0.29	0.06	0.50	-0.12	0.20	-0.01	0.13	0.24	0.30	-0.05	-0.18
Milk and milk products	-0.19	-0.00	-0.64	0.59	0.21	-0.67	-0.02	-1.02	-0.54	0.19	0.06
Eggs	0.37	0.28	0.13	-0.07	0.04	0.69	-0.02	0.41	0.22	-0.21	-0.07
Fruits	-0.81	0.04	0.08	0.35	0.32	-0.48	0.02	-0.70	0.30	-0.27	0.11
Vegetables and greens	0.42	0.31	0.58	-0.02	0.03	0.06	-0.06	0.22	0.48	-0.32	0.04
Bottled fruits and legumes	-0.12	0.14	-0.42	0.01	0.29	0.23	0.04	-0.38	-0.32	0.10	0.12
Spices, sugar, and oil	-0.52	-0.19	0.53	-0.02	-0.12	0.24	0.18	0.43	-0.20	-0.26	-0.01
Beverages, incl. coffee	-1.04	-0.07	-0.33	-0.03	-0.07	0.23	0.31	0.40	-0.61	0.23	-0.08
Sweets and tob.	-0.18	-1.23	-0.09	-0.06	0.17	0.05	0.12	-0.49	-0.43	0.21	0.21
Food cooked out.	-0.25	-0.03	-1.13	0.32	-0.49	0.13	0.29	0.06	0.14	-0.04	-0.12
Clothing	-0.03	-0.02	0.17	-1.04	0.21	-0.00	0.10	0.17	0.10	0.13	0.01
Housing	-0.03	0.01	-0.22	0.13	-0.33	-0.12	0.21	0.11	0.07	0.10	0.04
Furniture and house. app.	0.12	0.00	0.07	0.01	-0.18	-0.93	0.05	0.59	-0.05	0.09	0.14
Health and personal care	0.10	0.01	0.09	0.08	0.26	0.03	-1.06	0.37	0.02	0.08	0.01
Transportation	0.12	-0.06	-0.01	0.12	0.11	0.37	0.35	-1.15	0.17	0.08	0.06
Education	-0.34	-0.09	0.08	0.15	0.13	-0.05	0.03	0.34	-0.81	-0.03	0.06
Leisure	0.56	0.17	-0.07	0.58	0.68	0.27	0.51	0.57	-0.21	-1.33	-0.10
Other services	-0.31	0.27	-0.60	0.09	0.47	0.94	0.14	0.64	0.35	-0.15	-0.92

Table 2.3: Compensated price elasticities (continued)

Notes: See above.

2.4 Results

The five effects identified in Section 4.2 are estimated using local polynomial regressions (Friedman and Levinsohn, 2002; Porto, 2006)²⁴ at every percentile of real per capita expenditure. Results are presented at the decile mean and for two different situations: overall price changes and changes in food prices, first as nationwide changes and then disaggregated for rural and non-rural areas.

2.4.1 Effects on welfare of changed overall prices

2.4.1.1 General effects

The estimated effects are reported as percentages of initial per capita expenditures for all municipalities, without distinguishing between rural and urban ones. For the first two years these are the subsequent years, afterwards the comparison occurs biennially. Results for the for periods 2006 - 2008 and 2008 - 2010, i.e. those with the sharpest price changes, are reported in Figures 2.10 and 2.11.

Percentage changes in initial income due to the price increase are reported on the vertical axis. Negative (positive) values convey the percentage of income in the initial period that should be added (subtracted) in that percentile to income in the comparison period to achieve the initial welfare level. For example, a household in the first decile in 2006 would need on average 101.25% of its 2006 income

 $^{^{24}\}mathrm{Ferreira}$ et al. (2013) use a similar approach



Figure 2.10: Net effect due to overall price changes, 2006-2008



Figure 2.11: Net effect due to overall price changes, 2008-2010

to achieve in 2008 the same level of welfare as in 2006 because this percentile's percentage changes in initial income is of about -1.25%. A welfare change of zero percent means that negative and positive changes balance themselves out and not necessarily that there was no change at all.

Figure 2.10 plots the mean changes between 2006 and 2008 as well as its standard deviation. The mean line in Figure 2.10 lies above the zero line for all deciles, indicating that, on average, there were no net losses, with the fourth decile having the largest mean gains. Yet, the plot of the standard deviation shows that at least within the first seven deciles there were some losses. As opposed to that, the Figure 2.11 shows net mean losses across all deciles for the time between 2008 and 2010 except for the three richest deciles that display an an average net change of zero. Losses, indicted by the spread of the standard deviation into the negatives, are larger and more predominant that any gains during this time period. The spread of the welfare changes tightens around zero at the upper end of the expenditure distribution but is very wide at its lower end. For example, in the first decile a household would need on average approximately 115% of its 2008 income to achieve in 2010 the same level of utility as in 2008; but the welfare changes in that same decile stretches from positive 5% to negative 40%. An explanation for this very wide spread might be the pooling of rural and non-rural municipalities.

Because both types have different income compositions as well as average income levels, results might be counterintuitive. Particularly in the first deciles do average income per capita differ markedly. For the year 2010 average income per capita in the first decile in rural areas amounted to 1000 Mexican Pesos, in non-rural areas 1500; a 50% difference.

Before exploring rural and non-rural differences in the next Section, I turn to the composition of the welfare change. Tables 2.4 and 2.5 present the composition of the mean net effects depicted in Figures 2.10 and 2.11 above. In the columns are those effects outlined in Section 4.2. The first three columns relate changes in welfare to changes in the following income sources: wages income, business income and transfer income. Next are welfare changes due to changes in expenditures and substitution followed by the net effect. Tables for the periods 2004 - 2005 and 20005 - 2006 can be found in Section 2.B.

Decile			Ef	fect		
	Wage income	Business income	Transfers	Expenditures	Substitution	Overall
	(ho_w)	$(ho_{ heta})$	(ho_t)	$(-\rho_e)$	$(-\rho_s)$	(db)
1	-2.05	-2.23	-0.51	2.42	0.65	-1.72
2	-1.43	-2.88	2.78	5.73	0.67	4.87
3	-0.86	-1.48	1.59	4.54	0.70	4.50
4	-2.03	0.40	0.41	10.09	0.47	9.30
5	-1.54	-1.63	0.34	6.25	0.59	3.97
6	-1.81	-0.51	-0.32	5.40	0.48	3.24
7	-0.09	-2.12	-0.06	6.68	0.47	4.87
8	-2.01	-0.58	-0.13	8.23	0.55	6.06
9	-1.48	-0.61	-0.02	5.39	0.49	3.77
10	-1.78	0.02	0.05	8.00	0.38	6.66

Table 2.4: Breakdown of the overall effect for 2006 – 2008

Source: ENIGH, Banxico, author's calculations

Both the expenditure and the substitution effects enter Equation 2.8 with a negative sign. Welfare is defined as the monetary amount needed to maintain a certain utility level; an estimated positive expenditure or substitution effect relates to us the percentage of initial income that would be needed to be spend in order to maintain a given level of utility, thus a positive expenditure or substitution effect diminishes welfare. A positive substitution effect though, would only happen if the own- or cross-price elasticities were positive, and that is never the case in the data. Hence, the substitution effect always affects welfare positively. In the Tables that report the breakdown of each effect both the expenditure and the substitution effects are accounted for with the sign with which they contribute to the welfare change.

Decile			Ef	fect		
	Wage income	Business income	Transfers	Expenditures	Substitution	Overall
	(ho_w)	$(ho_{ heta})$	(ho_t)	$(- ho_e)$	$(-\rho_s)$	(db)
1	-0.79	-4.17	3.06	-16.19	1.70	-16.40
2	-1.00	-2.71	-0.85	-4.39	1.09	-7.77
3	-0.05	0.09	-0.01	-8.01	0.87	-7.08
4	0.46	-1.08	1.27	-7.25	0.74	-5.87
5	-1.45	-0.40	-1.21	-2.34	0.70	-4.69
6	-0.71	0.31	-0.75	0.29	0.69	-0.17
7	-1.30	0.04	0.60	-2.91	0.53	-3.03
8	-0.85	-0.10	0.13	0.62	0.70	0.50
9	-0.94	-0.60	0.07	0.67	0.48	-0.33
10	0.08	0.00	0.06	0.65	0.32	1.11

Table 2.5: Breakdown of the overall effect for 2008 - 2010

Source: ENIGH, Banxico, author's calculations

Between 2006 - 2008 most deciles experienced small average net gains, which are in part due to welfare gains because of the expenditure and the substitution effects offsetting the losses incurred due to negative changes in both wage and business income. Thus, in this first time period, changes in welfare came from modest negative changes in income and large enough changes in expenditures.

This is not at all the case in the next period, where the losses, specially in the lower deciles. Both the substitution and the transfer effects, although substantial, are too small to offset the combined negative effects of the negative income effects and large expenditure effects. The expenditure effect is large, regressive and dominates the evolution of the net effect.

2.4.1.2 Rural and non-rural effects

The distinction between rural and non-rural areas is important beyond determining the size of a community. As Ferreira et al. (2013) state, different labor markets and accessibility to commodity groups can lead to different welfare effects. An indication that both income and expenditure profiles are different was provided above.

Figures 2.12 and 2.13 depict the welfare changes for the years 2006 - 2008 and 2008 - 2010 separately for rural and non-rural areas.

Splitting the analysis into rural and non-rural areas reveals differences that were not visible before. In the 2006 - 2008 period, non-rural areas experienced no negative welfare changes on average: the mean line is always in the positive range. While this is also the case for rural areas, the effects in this case are lower



Figure 2.12: Net effect due to overall price changes, 2006-2008

for middle income deciles. It becomes clear that the lumping together the two different areas actually overstates the losses, particularly in the lower deciles.

In contrast in the 2008 - 2010 period, welfare changes turn into the negatives and the behavior of the mean as well as the standard deviation is less smooth than in the pooled analysis.

Tables 2.6 and 2.7 provide the breakdown of the net effect into its components for the period 2006 - 2008 and allow us to pinpoint the effect driving the behavior of the mean curve.

In line with the results obtained for whole country, both rural and non-rural areas display positive welfare changes that stem from the expenditure effect, although, on average, these are larger in non-rural areas. This effect is the driver of the positive welfare changes in the non-rural setting because it is large enough to offset the negative wage and business income effects. This is only partly the case in rural areas, where the expenditure effect is not always large enough to offset the (mostly) negative income. In both cases the net effect is driven by the expenditure effect.

The mean welfare change during 2008 - 2010 for both settings is negative: there are almost no positive effects of wage or business income, and only minor positive effects stemming from the transfers. Unlike the previous two-year period where expenditures actually had a positive effect, in this period expenditures



Figure 2.13: Net effect due to overall price changes, 2008-2010

had a principally negative effect on welfare that is never fully counteracted by the substitution effects. Nonetheless, the inclusion of other effects besides the expenditure effect matters for the magnitude of the net welfare affect and provides a more nuanced picture of the components of welfare change.

As reported in Section 2.3.1, the largest price increase observed during the crisis was for foodstuff. The next section presents a welfare analysis that concentrates on changes of foodstuff prices alone.

2.4.2 Effects on welfare of changed foodstuff prices

2.4.2.1 General effects

The aim in this section is to compute the welfare changes accounting for changes in food prices alone.

The main advantage of considering changes in food prices separately from changes in all prices is that it allows us to see how close, or far, both measures are to one another. Because complete data on consumption and expenditures profiles as well as on the respective prices is rarely available, it is common to use only food prices. In a high (food)-inflation environment, as are some of the time periods

Decile			Ef	fect		
	Wage	Business	Transfers	Expenditures	Substitution	Overall
	income	income				
	(ho_w)	$(ho_{ heta})$	(ho_t)	$(- ho_e)$	$(-\rho_s)$	(db)
1	-1.55	-3.62	2.33	7.92	0.61	5.48
2	-0.73	-0.24	1.34	7.21	0.53	8.05
3	-1.64	-1.44	1.13	6.24	0.84	4.90
4	-0.89	-0.66	0.43	3.55	0.55	2.98
5	-0.79	-1.63	0.09	6.50	0.33	4.50
6	-0.31	-1.41	0.29	8.04	0.61	7.18
7	-1.75	0.06	-0.47	7.70	0.44	5.98
8	-2.39	-1.62	-0.04	8.89	0.54	5.38
9	-1.23	-0.46	0.17	5.58	0.65	4.70
10	-1.47	0.28	-0.04	8.88	0.29	7.94

Table 2.6: Breakdown of net effect in the non-rural setting 2006 - 2008

Source: ENIGH, Banxico, author's calculations

considered in this study , measures of welfare change could be decisively different when food prices are used as opposed to when all prices are considered because expenditure and income shares associated with food items vary across deciles and between rural and non-rural areas. This feature of any welfare analysis and its consequences has to be considered, particularly if the aim is to device efficient and well-targeted interventions.

For the welfare analysis which only considers food price changes, price changes in non-foodstuff commodity groups²⁵ are set to zero and Equation (2.8) is estimated again, thus replicating the approach taken in the literature by studies that concentrate solely on the impact of foodstuff prices (e.g. Ferreira et al. (2013); Friedman and Levinsohn (2002)).

Any income source that is not related to a food item as well as any expenditures in non-food and substitution between food and non-food items is not taken into account. Thus the only effect that remains unchanged from the previous Section is the transfer effect, which enters the welfare equation without any relationship to a price change.

As in Section above, results for the years 2006 - 2008 and 2008 - 2010 are presented below, both overall and disaggregated for non-rural and rural areas. Results for the years 2004 - 2005 and 2005 - 2006 can be found in Section 2.B.

The overall results for both time periods show a smaller mean welfare change with a decisively tighter spread compared to the scenario where I consider price changes in all goods.

 $^{^{25}}$ See Table 2.1

Decile			Ef	fect		
	Wage income	Business income	Transfers	Expenditures	Substitution	Overall
	(ρ_w)	(ρ_{θ})	(ho_t)	$(-\rho_e)$	$(-\rho_s)$	(db)
1	-2.68	-3.40	5.29	2.03	0.66	1.18
2	0.01	0.01	-4.46	6.84	0.69	3.93
3	-0.64	0.17	4.04	1.86	1.09	5.10
4	-1.41	-2.31	-1.37	4.88	0.71	1.16
5	-3.38	-0.27	0.18	$2 \cdot 24$	1.00	-0.02
6	-0.22	-0.08	1.45	10.44	0.63	11.58
7	-0.46	0.09	-0.63	7.22	0.40	7.15
8	-2.24	-0.13	-1.57	4.96	0.49	2.76
9	-1.35	-0.88	-2.46	5.03	0.66	1.79
10	-1.18	-0.02	0.15	6.33	0.71	5.85

Table 2.7: Breakdown of net effect in the rural setting 2006 - 2008

Source: ENIGH, Banxico, author's calculations

Food price changes contributed minimally to any welfare gains during the years 2006 - 2008; most gains present in the analysis with all prices are gone as can be seen in Figure 2.14. While the mean gains reached a maximum of approximately 7% in the analysis with all prices, here it barely extends to 2%, none of the gains identified in the initial analysis are longer present: none of them are directly associated with changes in food prices.

In comparison, the mean losses identified for the 2008 - 2010 period are still present for only food items and display a very similar behavior across deciles. Furthermore, the spread is, again, very small.

Particularly for this last period, one that was marred by high food price inflation, concentrating only on food price changes does not change much of the computed mean welfare losses. It appears that in this particular case the losses were induced almost exclusively by the high food prices.

The decomposition of the net welfare effect for the years 2006 - 2008 and 2008 - 2010 in Tables 2.10 and 2.11 substantiates these observations: in 2006 - 2008 the expenditure effects that contributed largely to the positive net welfare effects observed in the previous section are absent while in 2008 - 2010 the expenditure effects that made up a large part of the negative welfare changes remained in place, although they are largely regressive over the deciles. Of important interest appear the substitution effects in the second two-year period. As Janvry and Sadoulet (2008) speculated, during the food price surge these effects are, in some cases, large enough to offset the negative income effects, and in some cases, larger. Moreover unlike the previous two-year period, the effect is strongest in the lower deciles and regressive, indicating that substitution is used mostly by the poor as a

Decile			Eff	ect		
	Wage	Business	Transfers	Expend.	Subst.	Overall
	income	income				
$(ho_{ heta})$	(ho_t)	$(-\rho_e)$	$(-\rho_s)$	(db)		
1	1.91	-2.52	-0.15	-20.65	1.81	-18.33
2	2.86	-0.94	-0.11	-0.32	0.26	1.57
3	-0.68	-0.63	0.09	-11.66	0.69	-12.19
4	-1.57	-1.27	-0.61	-0.31	0.99	-2.73
5	-1.16	-0.01	0.47	-0.38	0.55	-0.54
6	-1.21	0.23	0.17	-1.45	0.62	-1.66
7	-1.46	-0.05	0.12	-0.45	0.74	-1.10
8	-0.93	-0.53	0.03	2.45	0.54	1.56
9	-0.21	0.00	-0.12	-1.32	0.27	-1.38
10	-0.01	-0.05	0.17	1.74	0.36	$2 \cdot 24$

Table 2.8: Breakdown of net effect in the non-rural setting 2008 - 2010

Source: ENIGH, author's calculations

way of maintaining a given utility level.

Overall losses at the lower end of the distribution appear highly connected to food prices, more so during high food price inflation, a logical implication of their higher expenditure shares in foodstuff as depicted above in Figure 2.8.

The next section explores the differences in welfare effects between rural and non-rural status.

2.4.2.2 Rural and non-rural effects

Results for rural and non-rural areas for both time periods permit to account for the different income and expenditure profiles, although I do not expect these results to vary widely from the pooled results as most of the gains appear to stem from non-food items. Thus I would expect to see mean welfare change curves for both settings that are a downward shifted version of those where all prices are taken into account.

And so it is that welfare changes due to food price changes in this disaggregated setting (Figures 2.16 and 2.17) do not differ substantially from the non-disaggregated ones (Figures 2.14 and 2.15), but there are differences with respect to an analysis that includes the non-food items.

In the first period, 2006 - 2008, municipalities experience almost none of the positive expenditure effects that were reported when the non-food items were included and thus much of the positive welfare change is absent. Again, this indicates that welfare gains can be attributed to changes in non-food items. This is true for both rural and non-rural municipalities (Tables 2.B.2 and 2.B.3). Although

Decile			Eff	ect		
	Wage	Business	Transfers	Expend.	Subst.	Overall
	income	income				
$(ho_{ heta})$	(ho_t)	$(-\rho_e)$	$(-\rho_s)$	(db)		
1	0.78	-6.64	1.22	-20.58	2.06	-24.08
2	-1.83	-1.07	1.04	-4.10	0.28	-5.41
3	-1.74	-1.40	0.15	1.31	0.86	-0.87
4	-2.14	-1.29	-0.78	-10.68	0.96	-12.45
5	1.53	0.14	0.55	-6.99	1.24	-3.78
6	-1.68	-0.55	-2.88	-1.76	0.86	-3.97
7	-1.54	0.48	-1.74	1.20	0.66	-0.21
8	-1.38	-0.76	-2.31	1.06	0.86	-1.47
9	-0.20	-0.02	-0.20	-0.16	0.45	-0.02
10	1.21	-0.21	0.77	-1.55	0.60	0.46

Table 2.9: Breakdown of net effect in the rural setting 2008 - 2010

Source: ENIGH, author's calculations

the positive expenditure effect is lost, non-rural municipalities experience smaller negative and even positive income effects, both from wages and business, which helps to achieve the modest welfare gains. These effects originate most likely in the lower share of income generated in food related activities in non-rural areas.

During the high food inflation years, 2008 - 2010, non-rural households appear to be more severely affected than rural ones, particularly in the lower expenditure deciles: the differences in the welfare change between deciles are smaller in the non-rural setting. This behavior is not observed in the analysis that includes non-food items, although it is difficult to estimate its economic relevance just from these Figures. An exercise on the extent of changes in poverty rates due to changes in welfare later on will provide some insight.

A comparison of the composition of the welfare effects with and with-out nonfood items provides insight on the source of the differences in the welfare estimate between both.

As stated above, (negative) mean welfare changes for rural and non-rural municipalities are smaller when only food items are taken into account in the analysis. In the years of high food inflation, the expenditure effect is as large as its counterpart when non-food items are included, as can be seen from comparing Tables 2.12 and 2.13 with their analogs in the section above. This is particularly striking for the lower deciles in both the rural and non-rural setting, because there the effects are the largest.

Finally, the average substitution effects are particularly large in the first deciles and there is little difference between rural and non-rural. For example in the non-rural setting, the substitution effect alone can off-set the negative income



Figure 2.14: Net effect due to food price changes, 2006-2008

(wage and business) effect in the first five and in the non-rural in at least the first three deciles. It is also relatively large, with a relative size of approximately a fourth of the expenditure effect and significantly contributes to ameliorating the welfare change in several cases.

During high inflation times, the welfare of the poor is hit the strongest, be it solely food items or not. A separate analysis of non-rural and rural municipalities indicates that there is not much difference between both, with the negative welfare effect stemming principally from a large expenditure, low business income and negative wage income effects. This is consistent with the large media and social attention that was devoted to the so-called "Tortilla Crisis" ²⁶.

The results also indicate that rural and non-rural areas are no different when it comes to substitution. It has been argued that rural areas would have better opportunities to substitute away from expensive food items, but this does not seem to be the case in this context.

A comparison of the welfare changes elicited by changes in all prices and one that takes into account only food prices concludes that non-food goods played an

 $^{^{26} {\}rm For\ example:\ http://www.elmundo.es/mundodinero/2007/01/31/economia/1170261989.}$ html



Figure 2.15: Net effect due to food price changes, 2008-2010

important role in generating welfare gains, but this appears to be the case only when inflation was not so high, or only at early stages of an inflation period. During a low inflation period, a welfare analysis limited to food prices overstates the losses incurred, but during a high food inflation period, such an analysis will provide quite precise measures, at least on the mean.

The results presented here only show the gains and losses at certain levels of per capita expenditure but not how the welfare changes impacted the position of each municipality in the expenditure distribution. The next section analyses the effects of price changes on poverty.

2.4.3 Impacts on poverty

Mexico's CONEVAL²⁷ reports two different monthly per capita poverty lines: the minimum nutritional line and the minimum well-being line. Both are reported for rural and non-rural areas. Using these lines and the CPI at the price station level introduced in Section 2.3.1, I construct real poverty lines and use them in this section to conduct a poverty assessment. Hence,I work with 92 poverty lines,

²⁷National Council for the Evaluation of Social Policy, by its initials in English

Decile			Ef	fect		
	Wage	Business	Transfers	Expenditures	Substitution	Overall
	income (ρ_w)	$\operatorname{income}(ho_{ heta})$	(ρ_t)	$(-\rho_e)$	$(-\rho_s)$	(db)
1	-1.52	-1.56	3.63	-0.19	0.52	0.88
2	-0.24	-0.59	1.29	0.03	0.49	0.99
3	0.05	-0.43	1.95	-0.26	0.40	1.71
4	-0.57	-0.75	0.52	0.52	0.35	0.07
5	-0.34	-0.83	0.41	0.56	0.27	0.06
6	-0.16	-0.12	-0.40	0.14	0.25	-0.32
7	-0.11	-0.65	0.70	0.07	0.17	0.17
8	0.04	-0.24	0.28	0.02	0.11	0.21
9	0.10	-0.23	0.03	-0.09	0.14	-0.05
10	-0.04	-0.10	0.28	0.11	0.11	0.37

Table 2.10: Breakdown of net effect (food prices) 2006 – 2008

Source: ENIGH, Banxico, author's calculations

46 for rural areas and 46 for non-rural areas in accordance to the number of price stations and thus of computed CPI. Mean values on these lines can be found in Table 2.B.4 28 .

The summary measures of poverty used here are the Foster-Greer-Thorbecke (FGT) measures, i.e. the poverty headcount (FGT0), the poverty gap (FGT1) and the poverty severity (FGT2) indexes (Foster et al., 1984; Foster et al., 2010).

To compute the impact of welfare change on poverty I adjusted the municipality level real per capita expenditures by the calculated welfare change for the case when changes in all prices are considered and alternatively for the case where only changes in food prices are considered and computed the difference to the unadjusted case. That is, I computed each poverty measure with the survey data. Then I adjusted the expenditures in each case by the amount needed to achieve the utility level of the first period in the second one. For example if the welfare change was -14.48 as computed for the first decile in the analysis for the years 2008 - 2010 for changes in food prices (Table 2.12), to achieve the same level as utility in 2010 as in 2008, municipalities in this decile would need on average 114.48 of the expenditures per capita they had in 2008 in 2010. We computed the poverty measures anew with the adjusted measures and subsequently calculated the difference between the unadjusted and the adjusted ones. This was done by adjusting for the welfare change estimated when all prices are taken into account and when only food prices are allowed to changed as well as for rural and non-rural areas. The results is the comparison of poverty measures between two alternative scenarios: one with

²⁸To compute changes in the poverty changes for 2006, I used data from the ENIGH 2005

Decile			Ef	fect		
	Wage	Business	Transfers	Expenditures	Substitution	Overall
	(ho_w)	$\stackrel{ m income}{(ho_{ heta})}$	(ho_t)	$(- ho_e)$	$(- ho_s)$	(db)
1	-1.78	-0.53	0.67	-15.89	4.52	-13.01
2	-1.35	-0.07	1.17	-8.92	2.41	-6.76
3	-0.01	-0.12	1.46	-6.83	1.66	-3.84
4	0.03	-0.62	0.26	-5.92	1.76	-4.50
5	0.02	-1.07	-0.67	-3.24	0.55	-4.42
6	0.22	-0.44	-0.35	-2.25	0.48	-2.33
7	0.13	-0.11	0.38	-1.75	0.34	-1.01
8	-0.07	-0.30	0.28	-1.13	0.21	-1.02
9	-0.02	-0.34	0.21	-0.70	0.14	-0.70
10	0.03	0.04	0.12	-0.28	0.08	-0.00

Table 2.11: Breakdown of the net effect (food prices) 2008 – 2010

Source: ENIGH, Banxico, author's calculations

and one without the welfare consequences of the price changes. Results for the well-being lines are reported in Table 2.14 and those for the nutritional lines in Table 2.B.5.

Because of how the difference between poverty measures is computed, a negative difference means that the price change had a positive effect on poverty alleviation: the poverty measure after adjusting the expenditures is higher. This is only possible if the per capita expenditure after the adjustment is lower than before, i.e. to reach the utility level of the previous period less expenditure per capita is needed, and this is the case when the net welfare effect is positive. Conversely, a positive difference in the poverty measures means that the price change had a negative effect on welfare: once I compensate for the changes incurred due to the price change the poverty measure decreases.

The differences reported in Tables 2.14 and 2.B.5 have to be interpreted differently for each poverty measure. The poverty headcount index, FGT0, is the share of individuals whose per capita expenditure lies below the poverty line in the total population. Hence, the reported values can be interpreted as percentage point differences in the share of poor between the two alternative scenarios. The poverty gap index, FGT1, is a measure of the distance between the expenditure per capita and the poverty line and so reports how far on average the poor are from the poverty line. An increase in this measure amounts to a deepening of the poverty, with poor individuals falling even lower below the poverty line. This measure reports the average distance from the poverty line. Because every distance is weighted equally, this measure does not provide any information regarding the expenditure distribution of the poor, that is, a transfer of income from a poor



Figure 2.16: Net effect due to food price changes, 2006-2008

household to another that is richer (but below the poverty line) will not necessarily lead to an increase of the FGT1. A decrease in this measure can be achieved by bringing those close to the poverty line even closer without changing the position of the extreme poor. A decrease in this poverty measure can be interpreted as the change in the monetary amount needed to bring every poor individual to the poverty line, with this monetary amount being a share of the poverty line.he poverty line needed to bring every poor individual to the poverty line. The poverty severity index, FGT2, is the square of the poverty gap and so it is the sum of the weighted poverty gaps for each individual, with the weights being in proportion to the gap itself, i.e. individuals further away from the poverty line have larger weights.

Changes in the poverty measures for the well-being line are larger than those for the nutritional line, an expected result considering that the nutritional line is about 2/3 of the well-being line. During the crisis time periods of 2006 - 2008 and 2008 - 2010 changes in the poverty measures due to food price changes follow those due to changes in all prices more closely in rural than in non-rural areas, although this is only valid for the well-being poverty line and not for the nutritional line.

Furthermore, poverty measures for the well-being line in non-rural areas are affected to a greater extent by changes in food prices than by changes in all prices. For example, the poverty headcount between 2008 - 2010 increased by 0.34



Figure 2.17: Net effect due to food price changes, 2008-2010

percentage points due to changes in all prices. For changes in food prices alone that figures amounts to 0.72. With a population share of 81% and a headcount ratio fo 67% for the well-being line, an increase in one percentage point in the headcount ratio in this demographic translates into approximately 9 million individuals more in poverty. The changes in food prices also increased the average distance the poor are from the poverty well-being line as well as deepened the poverty. While the results for the FGT1 and FGT2 are small, they are considerable larger than their counterparts in rural areas.

The values in Table 2.14 provide valuable insight into the consequences of the unchecked price changes, particularly in the discrepancy that exists between rural and non-rural areas.

Decile			Eff	ect		
	Wage	Business	Transfers	Expend.	Subst.	Overall
	income	income				
$(ho_{ heta})$	(ho_t)	$(-\rho_e)$	$(-\rho_s)$	(db)		
1	-2.78	2.57	1.25	-20.84	5.11	-14.68
2	0.37	-0.29	0.44	-10.64	3.24	-6.88
3	0.22	-1.49	-0.23	-6.12	1.34	-6.28
4	0.46	-1.18	-0.34	-3.71	0.38	-4.40
5	0.26	-0.01	0.51	-1.95	0.49	-0.70
6	0.11	-0.09	0.31	-1.72	0.30	-1.09
7	-0.13	-0.38	0.28	-1.05	0.21	-1.07
8	-0.05	-0.32	0.16	-0.70	0.16	-0.74
9	0.03	0.06	0.10	-0.80	0.11	-0.50
10	0.05	0.09	0.11	-0.09	0.08	0.24

Table 2.12: Breakdown of net effect in the non-rural setting 2008 - 2010

 $Source:\ {\rm ENIGH},$ author's calculations

Decile	Effect								
	Wage	Business	Transfers	Expend.	Subst.	Overall			
	income	income							
$(ho_{ heta})$	(ho_t)	$(-\rho_e)$	$(-\rho_s)$	(db)					
1	-1.18	-1.76	-0.65	-16.08	$4 \cdot 44$	-15.22			
2	-1.40	-1.33	1.88	-10.37	3.74	-7.49			
3	-0.86	-0.80	1.15	-2.82	1.30	-2.03			
4	-0.39	-0.59	2.02	-6.54	1.50	-4.00			
5	0.39	-0.22	1.61	-5.81	$1 \cdot 10$	-3.27			
6	-0.36	-0.52	1.24	-1.91	0.50	-1.05			
7	-0.46	-0.33	0.16	-0.66	0.27	-1.02			
8	-0.33	-0.16	-1.04	-0.91	0.43	-2.02			
9	-0.03	-0.21	-0.60	-1.31	0.35	-1.80			
10	-0.07	-0.84	0.56	-0.70	0.12	-0.94			

Table 2.13: Breakdown of net effect in the rural setting 2008 - 2010

Source: ENIGH, author's calculations

Poverty line	Net impact of		2005	2006	2008	2010
	A 11	FGT0	0.07	-0.11	0.34	0.24
Non-rural	All prices	FGT1	0.05	-0.04	0.10	0.12
		FGT2	0.02	-0.01	0.04	0.05
		DOM		0.40		
	Foodstuff prices	FGT0	0.62	0.48	0.72	0.93
	rooustun prices	FGT1	0.17	0.11	0.18	0.27
		FGT2	0.07	0.04	0.06	0.10
Rural	All prices	FGT0	0.15	-0.07	0.06	0.15
		FGT1	0.03	-0.02	-0.03	0.09
		FGT2	0.01	-0.02	-0.02	0.04
		FGT0	0.13	0.02	0.08	0.13
	Foodstuff prices	FGT1	0.03	-0.00	-0.00	0.07
		FGT2	0.01	-0.01	-0.00	0.04

 Table 2.14:
 Poverty changes (well-being line)

Source: CONEVAL, author's calculations

2.5 Conclusion

There is almost no evidence regarding the welfare effects of the food price hikes that affected Mexico over the period 2006 to 2010. The evidence that is available typically focuses just on few channels by which such price hikes can affect welfare and they typically focus only on food and neglect other goods that experienced significant price changes.

This study presented a comprehensive framework to analyze the welfare effects of prices changes. The analysis considers income and expenditure effects and decomposes the total welfare effects in its various contributors. The study accounts for all prices but also offers a detailed analysis of what was called in the media the 'Tortilla crisis'.

The results show that changes in the prices of non-food items make up a large part of the total welfare change and more so in high inflation years, i.e. in the period 2008 - 2010. The inclusion of non-food items in the analysis changes the results by introducing welfare gains that are unaccounted for when only food items are considered.

The comparison of an analysis with and without changes in the prices of nonfood items reveals that non-rural areas, as most households there are net buyers of food, experienced larger welfare losses when only food items are considered. These results may explain the social unrest evoked by the increased tortilla prices that peaked at the beginning of 2007. Non-rural areas were the most vocal about the strain the increased prices in this staple of the Mexican diet was exerting on them, and rightly so. This study shows that the inclusion of changes in prices in non-food items contributed to welfare gains, i.e. a focus on food price changes alone clearly leads to an over estimation of the losses.

Unlike other studies, this study highlights the importance of including differentiated income as well as substitution effects. The results show that the income effects implied substantial welfare losses, particularly for the poorest deciles. Both the business as well as the wage income effect are mostly negative and when they are positive, they are relatively small. During the years 2006 – 2008 when food price inflation was not salient, the negative contribution of the income effects to welfare significantly off-sets part of the positive effects associate with pure price effects. This is particularly visible in the first deciles and in rural areas more generally: the pure expenditure effect leads to positive welfare changes while the total effect, i.e. including income effects leads to negative welfare changes. Such an overturning of the direction of the welfare change becomes less likely when the negative expenditure effect is relatively large, as it was the case during the high food price inflation years. Nonetheless, the estimates of the welfare changes are definitely more accurate if it is accounted for all possible channels. Particularly in lower deciles the business income effect can amount to a fourth of the expenditure

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effect. In fact, the income effects are negative in almost all years.

The contribution of the substitution effects are also substantial. In some cases these effects are as large as a fourth of the net welfare effect. They can even completely offset negative income effects and contribute positively to the welfare change. As expected, these effects play a larger role when only food items are considered, but their relevance is only slightly reduced when prices for other items are included. These effects are also reportedly larger in the first half of the expenditure distribution and more so during the years of high food price inflation and contribute to a large extent to counter negative expenditure effects when only food prices are taken into account.

The welfare changes were contextualized with a poverty assessment. The mean welfare changes in rural and non-rural areas during times of high food inflation are very similar, with the poorest having the largest losses and the losses being larger in non-rural areas, but the poverty impact is larger in rural areas.

Although the "Tortilla Crisis" was a national phenomenon, and the reporting focused on larger urban areas, losses were almost as large for the poorest decile in the non-rural areas as in the rural ones, with the added aggravation that the poorest decile in rural areas is closer to the poverty line than the poorest decile in non-rural areas. Thus the 'Tortilla Crisis' had a larger poverty impact in rural areas.

In sum, the inclusion of differentiated effects provides a deeper understanding of the contributors to welfare changes as well as more precise estimates of the effects associated with the 'Tortilla crisis'. This study shows that a focus on expenditure effects alone can be very misleading; although accounting for income effects may not imply a reversal of the expenditure effect but it may at least reduce it substantially.

An important extension of this work would be the inclusion and differentiation of consumer and producer prices (Janvry and Sadoulet, 2009), because the consumer prices will most likely skew the effects of the producers and the overall effect depending on the relative distribution of consumers and producers in the rural and non-rural areas.

Moreover, substitution between food commodities appears to play an important role in the survival strategies of the poor. A valuable extension would be the analysis of the unintended consequences of such substitution effects. It is for example possible that significant changes in the diet of the poor can have long lasting negative health effects. For instance Juarez Torres (2015) shows that the nutritional patterns of food and non-food poor individuals are different, as are their nutrient elasticities for certain products. She concludes that rising food prices in certain food commodities (cereals and vegetables) could aggravate the nutritional condition of the the most vulnerable population segments as they substitute away into items with less nutritional content.

2.A The Quadratic Almost Ideal Demand System (QUAIDS)

The QUAIDS (Banks et al., 1997) is based on an indirect utility function of the form:

$$\ln V(\mathbf{p}, m) = \left[\left\{ \frac{\ln m - \ln a(\mathbf{p})}{b(\mathbf{p})} \right\}^{-1} + \lambda(\mathbf{p}) \right]^{-1}$$

Where $\ln a(\mathbf{p})$ is a translog of the form:

$$\ln a(\mathbf{p}) = \alpha_0 + \sum_{i=1}^k \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^k \sum_{j=1}^k \gamma_{ij} \ln p_i \ln p_j$$
(2.A.1)

In (2.A.1) p_i is the price for a good *i* for $i = 1 \dots k$ and $b(\mathbf{p})$ is the simple Cobb-Douglas price aggregator:

$$b(\mathbf{p}) = \prod_{i=1}^{k} p_i^{\beta_i}$$

and

$$\lambda(\mathbf{p}) = \sum_{i=1}^k \ln p_i$$

Homogeneity, symmetry and adding-up imply the following restrictions:

$$\sum_{i=1}^{k} \alpha_i = 1, \qquad \sum_{i=1}^{k} \beta_i = 0, \qquad \sum_{i=1}^{k} \gamma_i j = 0 \qquad \text{and} \qquad \gamma_{ij} = \gamma_j (2.A.2)$$

Applying Roy's Identity to 2.A and defining the expenditure share of a household as $w_i = p_i q_i/m$ we obtain the corresponding expenditure share equations system:

$$w_i = \alpha_i + \sum_{i=1}^k \gamma_{ij} \ln p_j + \beta_i \ln \left\{ \frac{m}{a(\mathbf{p})} \right\} + \frac{\lambda_i}{b(\mathbf{p})} \left[\ln \left\{ \frac{m}{a(\mathbf{p})} \right\} \right]^2$$

For the construction of the Slutsky matrix we are interested in the compensated price elasticites. The estimation of these occurs with use of the user written command 'quaids' for Stata[©] from Poi (2012), that also allows us to include

demographic variables²⁹ and that imposes the restrictions in (2.A.2) automatically.

2.B Supplementary Tables

A-L	M-V
Acapulco de Juárez	Mérida
Aguascalientes	Mexicali
Benito Juárez	Monclova
Chetumal	Monterrey
Chihuahua	Morelia
Ciudad Acuña	Oaxaca de Juárez
Colima	San Andrés Tuxtla
Córdoba	San Francisco de Campeche
Cortázar	San Luis Potosí
Cuernavaca	Santiago de Querétaro
Culiacán Rosales	Santo Domingo Tehuantepec
Fresnillo	Tampico
Guadalajara	Tapachula de Cordova y Ordoñez
Hermosillo	Tepatitlán de Morelos
Heroica Matamoros	Tepic
Heroica Puebla de Zaragoza	Tijuana
Huatabampo	Tlaxcala de Xicohtencatl
Iguala de la Independencia	Toluca de Lerdo
Jacona de Plancarte	Torreón
Jose Mariano Jiménez	Tulancingo
Juárez	Veracruz
La Paz	Victoria de Durango
Leon de los Aldama	Villahermosa

Table 2.B.1: List of price stations

²⁹Folowing Ray (1983)

2.B.0.1 Net welfare effect (foodstuff)

Decile	Effect							
	Wage	Business	Transfers	Expenditures	Substitution	Overall		
	(ho_w)	$(ho_{ heta})$	(ho_t)	$(-\rho_e)$	$(-\rho_s)$	(db)		
1	0.34	-1.29	2.27	0.59	0.45	2.36		
2	0.18	-1.01	1.54	0.78	0.39	1.88		
3	-0.34	-1.44	0.99	0.05	0.34	-0.40		
4	-0.27	-0.32	0.68	-0.40	0.25	-0.07		
5	-0.20	-0.37	0.20	-0.26	0.24	-0.39		
6	0.28	0.06	0.52	0.31	0.07	1.24		
7	-0.04	-0.18	0.06	0.12	0.07	0.04		
8	0.14	-0.33	-0.05	-0.11	0.18	-0.18		
9	0.10	-0.15	0.06	0.01	0.13	0.15		
10	-0.10	-0.11	0.33	0.08	0.12	0.31		

Table 2.B.2: Breakdown of net effect in the non-rural setting 2006 – 2008

Source: ENIGH, Banxico, author's calculations

Decile	Effect							
	Wage income	Business income	Transfers	Expenditures	Substitution	Overall		
	(ho_w)	$(ho_{ heta})$	(ho_t)	$(-\rho_e)$	$(-\rho_s)$	(db)		
1	-2.15	-2.75	6.51	-0.05	0.60	2.18		
2	-1.17	-0.81	-1.98	0.68	0.55	-2.73		
3	-1.19	0.83	0.98	-0.28	0.50	0.84		
4	-0.28	-0.53	0.82	-1.36	0.43	-0.93		
5	-0.31	0.09	1.98	-1.89	0.41	0.28		
6	-1.02	-0.33	-0.39	0.65	0.36	-0.73		
7	-0.42	-0.45	0.69	1.60	0.25	1.67		
8	-0.21	0.04	-1.54	1.11	0.22	-0.39		
9	-0.24	-1.08	0.16	0.56	0.24	-0.36		
10	-0.13	-0.46	0.94	-0.37	0.14	0.12		

Table 2.B.3: Breakdown of net effect in the rural setting 2006 - 2008

Source: ENIGH, Banxico, author's calculations

2.B.0.2 Poverty lines and poverty dynamics

Year	Rural				Non-rural			
	Nutritional	SD	Well-	SD	Nutritional SD We		Well-	SD
			being				being	
2006	623.2	47.4	$1,\!279.5$	97.3	904.4	68.8	2,080.0	158.1
2008	929.6	269.3	1,819.6	527.1	1,324.2	383.6	$2,\!908.1$	842.4
2010	1,066.8	133.0	2,076.9	258.9	1,527.0	190.3	$3,\!310.0$	412.6

Table 2.B.4: Real monthly per capita poverty lines

Source: CONEVAL (National Council for the Evaluation of Social Policy), author's calculations

Poverty line	Net impact of		2005	2006	2008	2010
		FGT0	0.03	0.00	0.02	0.03
Non-rural	All prices	FGT1	0.00	-0.00	0.00	0.00
		FGT2	0.00	-0.00	0.00	0.00
		FGT0	0.02	-0.00	0.02	0.04
	Foodstuff prices	FGT1	0.00	-0.00	0.00	0.01
		FGT2	0.00	-0.00	0.00	0.00
	All prices	FGT0	0.02	-0.03	0.02	0.08
Rural		FGT1	-0.00	-0.01	-0.01	0.02
		FGT2	-0.01	-0.01	-0.00	0.01
	Foodstuff missa	FGT0	0.02	-0.01	0.03	0.07
	Foodstuff prices	FGT1	0.00	-0.00	0.00	0.02
		FGT2	-0.00	-0.00	-0.00	0.01

Table 2.B.5: Poverty changes (nutritional line)

Source: CONEVAL, author's calculations

3

The Geographical Expansion of Drug Cartels and Property Crime in Mexico

3.1 Introduction

Between 60000 and 70000 drug-related murders were committed in Mexico (Shirk and Wallman, 2015; Calderón et al., 2015) in the decade between 2006 and 2016, or around 7000 a year. This surge in violence coincides with the introduction of aggressive actions in the "War against Drugs" by then President Felipe Calderón to curb the activities of Drug Trafficking Organizations (henceforth DTO).

In this study I seek to evaluate if DTO presence had any effect on property crime. To do so first, I outline the historic and ongoing relationship between DTO and property crime and argue that by its nature, the DTO is interested in suppressing activities not related to their core business and that is presence will negatively influence the property crime rate. I then provide supportive evidence for this argumentation through an empirical analysis conducted in three steps: first, I analyze the effect that the state intervention had on DTO presence and thus, on its geographical expansion. Then I use available crime data to investigate how the DTO presence influences property crime. Finally, I use the variation in DTO presence that stems from the state intervention to examine changes in property crime. This multi-step approach allows me to document the possible relationship between the government policy, the DTO presence, and changes in crime.

There are three predominant explanations for the role of the government in the surge of violence: it is either the unintended consequence of democratization or of the "kingpin" strategies that aim at incapacitating the heads of the DTO, or both. Proponents of the first explanation argue that the democratization process

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disturbed a long standing political and economical status-quo between the ruling political party and the DTO. The intermission of other political parties led to uncoordinated geographical areas where the DTO resorted to violence to secure themselves against competitors as well as against representatives from the newly empowered political opposition. Proponents of the second explanation, that of "kingpin" strategies, purport that an intervention aimed at eliminating the heads of the DTO in an effort to curb its activities was at the root of the increase in violence. This unintended consequence originates in the destabilization of the DTO, causing intra- as well as inter-DTO violence besides eliciting a backlash from the DTO against the state (Calderón et al., 2015; Osorio, 2015). Finally, a combination of both is also conceivable, although difficult to assess empirically.

With regard to violence and territorial presence of the DTO, the "War against Drugs" of the Calderón presidency is largely regarded as a failure. Nonetheless, seizures of cocaine in the USA, the main staple of Mexican DTO, have declined from shy under 200 tons in 2005 to 37 tons in 2013. If this is due to lower or better trafficking or lower demand remains an open question (United Nations Office on Drugs and Crime, 2016).

Because trade routes and geographical control are priorities in the business of drug trafficking, any disruption in the control and defense capacities of any DTO will attract contending DTO to settle, if not in the targeted municipality, in neighboring areas. As for the effect on crime, a DTO that settles in a previously not controlled area is both interested in the revenues that can be accrued from other types of crime besides drug trafficking as well as in limiting the expansion of any resident criminals; either because they are a threat or because the attract negative attention. Hence, the DTO can have an interest in taxing the criminal cell for a part of their revenue or to coax away individuals involved in property crime into the ranks of the DTO. In some cases, the DTO have been documented to be taking over criminal activities not related to drug trafficking. Examples include the taxing of transporters of agricultural products under the threat of violence¹. Extortion is a property crime under the Mexican law and it is included in the analysis presented here but the recorded values are most likely not representative of the actual incidence of this type of crime.

Parallel to the exacerbation of the violent conflict came an increase in the total number of municipalities where any given DTO showed presence. According to data provided by Coscia and Rios (2012), the share of municipalities with presence of at least one DTO went from 10 % to 30 % between 2005 and 2010, as can be seen in Table 3.1. A fracture of several DTO into contending groups occurred at the same time. Osorio (2015) argues that the spatial diffusion of DTO action and interaction stems from the disruptive nature of the state intervention: The

¹http://www.jornada.unam.mx/2013/07/20/opinion/017a2pol

intervention destabilizes the military force of a given DTO and makes it more appealing for their competitors to intrude into the territory of the weakened DTO as well as to expand into further unoccupied ones without fear of competition. This line of argumentation is complementary to that of the unintended consequences of "kingpin" strategies. While the expansion as well as the fractionalization of DTO had started before the all-out "War on Drugs", it is conceivable that it accelerated the process by ways of disruption. The intervention can also foster the geographical diffusion by means of inciting infighting in any given DTO. As the "immobilization" of the any leaders creates a power vacuum within the organization, hopeful successors try to reach for power. To do so, they need to demonstrate that they can contribute to maintaining and possibly expanding the power of the DTO, hence some individuals will branch out into neighboring areas to try and bring these under DTO control.

Calderón et al. (2015) argue that kingpin strategies disrupt the chain of command allowing local criminal cells to switch from drug trafficking to (other) criminal activities to increase their revenue. The authors propose that this will only be the case if the head of the organization wants to limit predation against the general population during the time they are undisturbed. A similar line of argumentation comes from Schelling (1984). He argues that a criminal organization is not a cohesive entity but one that is comprised of a head or a core and a set of cells or individuals that work for the organization in a controlled area. A cell working in an area controlled by an organization is taxed for part of its proceedings under the guise of, for example, so-called protection. The cell's participation in the taxation scheme will be enforced by the superior organization as a way of signaling its strength and competence to outside competitors as well as other cells; this includes punishing stray or recalcitrant cells either financially or physically.

In dealing with the criminal cells the organization has two main interests: first, to keep the cells small enough that they do not threaten its hegemony or interfere with their own business and second, to treat every cell equally. The former interest aims at increasing its revenues and criminal standing, the latter at avoiding internal conflict. Consequently, the cell will try to extract as much income as possible from those it predates upon while simultaneously cowering away from the larger organization so as to not be punished or eliminated.

An intervention focused at incapacitating or eliminating the leaders of an organization, if successful, disturbs the status quo and with it the geographic control the respective DTO might have. Once the loss of leaderships puts a DTO into a vulnerable position, other DTO have an increased incentive to spread into areas as close to the fringes of the sphere of influence of the affected DTO as possible. A new DTO regime in an area without any former DTO presence will establish its order by subduing any criminal cells soon as possible. Alternatively,

Year	Mean	St. dev.	Max.	Obs.	Share
1991	1.0	0.0	1.0	6	0.00244
1992	1.2	0.4	2.0	5	0.00203
1993	1.1	0.3	2.0	22	0.00895
1994	1.1	0.3	2.0	29	0.01180
1995	1.1	0.4	2.0	20	0.00814
1996	1.2	0.4	2.0	31	0.01261
1997	1.1	0.2	2.0	48	0.01953
1998	1.1	0.4	2.0	43	0.01750
1999	1.1	0.3	2.0	28	0.01139
2000	1.1	0.4	3.0	53	0.02157
2001	1.3	0.7	4.0	55	0.02238
2002	1.1	0.4	3.0	49	0.01994
2003	1.4	0.6	4.0	77	0.03133
2004	1.5	0.7	4.0	116	0.04721
2005	1.6	0.7	4.0	225	0.09157
2006	1.6	0.9	6.0	297	0.12087
2007	1.7	0.9	5.0	402	0.16361
2008	1.9	1.1	8.0	588	0.23931
2009	2.1	1.2	8.0	655	0.26658
2010	2.1	1.3	9.0	$70 \ 9$	0.28868

Table 3.1: DTO presence

Source: Coscia and Rios (2012), author's calculations. Statistics over all municipalities with at least one DTO present (Obs.). Share refers to the share of municipalities in the country with at least one DTO present. Max. is the maximum number of DTO active, mean is the average number of DTO active in that year in all municipalities where at least one DTO was active (thus the minimum is at least one). The maximum number of DTO active in a year is also the number of existing DTO in the sample. The number is capped at 9 as of 2010. there are reports of (forced) recruitment by the DTO in Mexico, and by organized crime in general in other countries (e.g.: Dorn et al. (2005)). Both the taxation and the recruitment can lead to a reduction in property crime.

One such intervention was started by the then Mexican Presidency in 2006. It explicitly focused state and particularly military attention to detaining or eliminating the leaders of any DTO in an attempt to curb their activities. The state sanctioned offensive began the 11th of December 2006 with two operations: "Operación Michoacán" and "Operación Baja California" meant to apprehend or incapacitate the heads of two cartels. These operations were followed by other in almost all parts of the country (Espinal-Enríquez and Larralde, 2015).

Coincidently, starting with the intervention, national levels of property crimes (dispossession and ouster, property damage) started dropping. Figure 3.1 depicts this decline, with a marker for January 2007.



Figure 3.1: Evolution of property crime over time

Notes: Source is SEBOG, depicted data is national mean levels for every month using Federal State reported crime data. There are five totals in each month, one for each type of property crime: breach of faith, damages to private property, dispossesion, extortion and fraud.

Despite the wealth of studies examining the effects of the presence of DTO on homicides as well as of studies the dynamics of crime and its determinants (for example: Bazzi and Blattman (2014); Benson et al. (1992); Bückner and Ciccone (2010); Calderón et al. (2015); Castillo et al. (2013); Corona Juárez (2014); Dell (2015); Diaz-Cayeros et al. (2015); Draca and Machin (2015); Enamorado

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et al. (2016); Espinosa and Rubin (2015); Guerrero Gutiérrez (2011); Lessing (2015); Lindo and Padilla-Romo (2015); Osorio (2015); Phillips (2015)), to my knowledge there is no study that directly assesses the influence of the DTO on property crime, even though there are reports linking both (Calderón et al., 2015; Guerrero Gutiérrez, 2011)². This lack of studies is in part because of the methodological challenges such an assessment poses. As far as high crime rates in a municipality are a product of weak law enforcement, DTO can be more likely to show presence because the costs of fighting and bribing the respective law enforcers are lower than doing so in municipalities with low crime rates and probably stronger law enforcement. Conversely a DTO intruding into a municipality with high crime rates will incur costs from establishing its dominance over the criminal cells, hence making it more appealing to show presence in those municipalities with low crime rates. Thus, it is important to account for the possible selection process of the DTO in their quest for geographical dominance in order to control for possible simultaneities that will bias the estimates of the relationship between the presence of the DTO and the municipality level property crime rates.

Although the exact welfare costs of crime are difficult to assess, there is an understanding of their general magnitude and burden to society. R. Soares (2015) cites material costs in Latin America and the Caribbean of 5 percent of GDP besides the intangible associated with crime: behavioral changes and impacts on the labor market being just two.

I use data on killed or immobilized DTO bosses from Calderón et al. $(2015)^3$ between 2006 and 2010 and DTO presence generated by Coscia and Rios $(2012)^4$ to illustrate the channel between the intervention and the geographical expansion and fractionalization as well as judicial crime reports at the municipality level from the INEGI, night time lights and other controls to explore the relationship between DTO presence and property crime.

I find that past successful interventions in neighboring municipalities help explain the presence and the number of DTO in any given municipality. Furthermore, there is a negative relationship between measures of DTO presence and criminal activity.

In the next section I put forward in detail the argument for the negative relationship between the DTO and property crime. Next I present the data and provide results and discussions from the empirical exercise. The last section concludes.

 $^{^{2}}$ A study that tackles a similar question is the one in Jones (2013), where the author explores the side effects of the kingpin strategies on kidnappings perpetrated by a specific DTO

³The authors generously allowed the use of their data

⁴The authors generously allowed the use of their data
3.2 Concept

3.2.1 Influence of the kingpin strategy on the geographical spread of DTO

The geographical expansion of the DTO (González, 2015) reported after 2006 is driven by several factors.

One is the contagion and displacement explanation. For Mexico, Corona Juárez (2014) shows that increases in drug crime in a region lead to increases of drug crimes in neighboring regions. Furthermore, drug enforcement in a region leads to more drug crimes in neighboring regions. Thus, there is a transmission of criminality and it would seem, a displacement of the illegal activities. In neither case are the causes completely explored. In the first instance a know-how transmission appears to be at work, whereas the second one appears to be a consequences of the redistribution of law enforcement. If police where to move from low crime areas into neighboring high-crime areas, crime could increase in those areas left without sufficient law enforcement. In a study of the US state of Florida, Benson et al. (1992), shows that there is an important effect of drug enforcement policy on property crimes through the changed allocation of police resources away from property crimes and towards drug enforcement. Nevertheless, if this was the case in Mexico we would observe an increase in property crimes and that is not the case. Furthermore, there appears to have been no redistribution of law enforcement in Mexico: the strategy of the Mexican government, i.e., to incapacitate or eliminate those individuals in the upper echelons of the DTO, was performed with the help of the state military and counter-insurgency forces.

Another explanation is the destabilization of the chain of command and the subsequent internal restructuring processes of the DTO. As Diaz-Cayeros et al. (2015) detail, while the precise internal structure of any DTO is not known accurately the basic structure is: an inner circle controls several semi autonomous subsidiaries. If argue in line with Calderón et al. (2015) and Osorio (2015) that the neutralization of leadership members destabilizes the chain of command and creates incentives for other DTO to push into challenged territory in a bid to expand the number of trading routes controlled (Dell, 2015) and simultaneously advertise their provess as new commanders of the organization.

By threatening the use of violence, e.g. through protection rackets, the DTO limits the income earning abilities of the criminal cell making crime less profitable. At the same time the DTO might recruit individuals out of the criminal cells for its own purposes⁵. Furthermore, if a DTO is confronted with several cells under its control, one of its main concerns is to treat every single one it deals with equally,

⁵The recruiting is not always voluntary.

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so as to avoid any confrontations and to maintain the cost of controlling as low as possible, so we expect every cell to be treated equally.

Thus, by destabilizing different areas and different DTO, the kingpin strategy has two unintended consequences: one direct and one indirect. It directly increases the presence of DTO in the country and it indirectly decreases the level of property crime.

I argue that in an area where a DTO suffers the state intervention, i.e. loses one of its leaders, it will become weak enough for its neighboring areas to become liable to the presence of rival DTO. This is because the costs of taking control are unlike lower than before the state intervention. This effect will be more pronounced for those municipalities with no presence of any DTO before the state intervention. If a municipality without previous DTO presence is taken over, the new DTO will establish itself as soon as possible and part of this, will be quickly subduing the existing criminal cells.

One caveat remains: It is also feasible that crime *reporting* decreases because of the use of intimidation tactics by the cell or the DTO itself. Intimidation to abstain from reporting crimes to the authorities has been reported in the past as well as lack of reporting due to distrust in the local authorities (INEGI, 2015). To analyze the reasons for the lack of reporting is beyond the scope of this study, nonetheless it is worth mentioning that probably not all crimes are affected by underreporting due to intimidation in the same manner.

3.2.2 The relationship between the DTO and the criminal cell

The term "cartel", which is used widely to refer to the DTO, is misleading as in the DTO is not a cartel in the economic science sense. The DTO do not collude to fix prices, in fact, conflict within and between DTO is common (Dell, 2015) and is usually resolved either through the use of violence or bribery (Guerrero Gutiérrez, 2011).

A DTO is a business engaged in illegal activities (Diaz-Cayeros et al., 2015; Dell, 2015; Guerrero Gutiérrez, 2011; Schelling, 1984), the main one being the transportation of illicit substances; for this it competes with other DTO in developing and securing trade routes with the aim of minimizing the transportation costs. It simultaneously has to fend off attacks of law enforcement representatives that want to stop DTO activities. For this reasons, geographical control is paramount in the business of the DTO, and most of the violence between DTO and between DTO and law enforcement representatives arises from the struggle for control, particularly of crucial areas, so called *plazas* (Lessing, 2015; Dell, 2015).

In addition, DTO have been linked to a host of other criminal activities like

kidnapping, extortion, prostitution, auto theft, money laundering and protection rackets (Guerrero Gutiérrez, 2011; Jones, 2013). This secondary operations are typically controlled by local cells (Dell, 2015) that are accountable to the DTO that controls the area ⁶. While the precise internal structure of the DTO is not known⁷, an increasing number of criminal cells have been linked to collaborate with the DTO for protection from the police, drug supply and financial gain (Guerrero Gutiérrez, 2011). For the DTO, the cell offers territorial know-how as well as other efficiency gains by providing a source of muscle force that is not part of the core business and as such presents no danger in case of an apprehension by the authorities or by any rivals (Dell, 2015).

Standard theory states that a criminal will commit a crime on the basis of a cost-benefit analysis (e.g. Becker (1968); Draca and Machin (2015)). In this framework the criminal, or what I call the cell, obtains income from a crime and faces certain costs if he is unsuccessful (e.g. fines, forgone income due to jail time (Becker, 1968)) When the DTO arrives and subdues the cell it can tax the cell or (forcefully) recruit its members away, or both. The taxation lowers the income that is obtained from the criminal act while simultaneously giving the cell access to the services of the DTO. These services include the bribing or intimidating of law enforcement officials as well as law representatives⁸; both are actions that lower the apprehension probability and the fine: a bribed official will not file a report, an intimidated judge will pronounce a more lenient sentence. The DTO can simultaneously recruit members away from the cell and engage them in illicit activities of a different nature. In that case property crime would also fall, but it is unclear if the effect would be long-lasting as other individuals could fill up empty spots.

In sum, if a DTO controls an area, it influences the number of activities that the criminal cells perform by taxing them or recruiting them away. Thus when a DTO captures an area, I expect the crime rates to decrease with respect to areas where no DTO is in control, all other things being equal.

⁶A type of forced "franchising", where single individuals as well as local criminal cells have been forced to take part in criminal activities has been anecdotally documented, for example in Saviano (2014). Guerrero Gutiérrez (2011) report that the Zetas Cartel is known to force illegal migrants to work for them, killing them if they refuse

⁷The secretive inner working of organized crime have spawned a series of books that range from "McMafia" (Glenny, 2009) to "Narconomics" (Wainwright, 2016)

⁸Or both; the tactic of offering individuals the choice between the money or their life (know as *plata o ploto*, i.e. *the silver or the lead*) is widespread (Shirk and Wallman, 2015)

3.3 Data and variables of interest

3.3.1 Crime data

The crime data used here is the judicial (processed) crime data available from Mexico's National Institute of Statistics and Geography⁹ and comprises monthly crimes at the municipality level for the years 2006 - 2010. There are a few benefits to these data: the occurrence of the crime has been confirmed, it does not contain duplicates of crimes, as a crime can be reported more than once by more than one affected individual, and the data of occurrence of the crime has been confirmed. The judicial crime data is available until 2012, after which it is no longer reported. Every year published contains crimes for almost all past years, as the data is published once the crime is processed and not when the alleged crime is reported. Thus the data for the years 2006 - 2010 was extracted from the information reported in the years 2006 to 2012 in an effort to obtain a database as complete as possible.

Criminal activities of interest are property crimes. In Mexico property crimes include theft, dispossession, property damage, and fraud. In general, with the possible exception of fraud, these crimes do not lie in the general field of interest of the DTO whose explicit interest lies in the geographical control of trade routes for drug trafficking. Nonetheless, there is a growing body of literature that links DTO activity and crimes only tangentially interesting for the drug trade, for example the theft of crude oil and its reselling.

The focus lies on property crime as violent crimes in the DTO turf war, such as rape and homicide, contain an element of demonstration and submission very much linked to the DTO and not precisely to a criminal cell submissive to it¹⁰

Figure 3.2 visualizes the change in property crime in every municipality between 2006 and 2010. In this time period the rate of property crime declined generally and particularly in the center, the pacific coast and the Yucatán peninsula. At the same time, property crime increased in certain areas, particularly in the north east.

3.3.2 DTO presence data

I use DTO presence data compiled by Coscia and Rios (2012) from different internet resources. It provides yearly muncipality level observations for a total of 10 different DTO for the years of 1990 - 2010. Of interest for the analysis are only the observations from 2006 onward.

⁹INEGI by its name in Spanish

¹⁰The SNSP has developed six different characteristics to consider a homicide a DTO related one. These include signs of torture or severe lesions; bodies that are taped or gagged; and others (Enamorado et al., 2016).



Figure 3.2: Growth rate property crime 2006 -2010

While the dataset contains municipality level observations for different DTO, I do not analyze any differences the DTO may exhibit with respect to crime, only the possible effect of the presence of any DTO.

3.3.3 State intervention

Data of the successful state interventions, this are the month and municipality of the death or capture of a general or a lieutenant of a given DTO, is the one assembled and used in Calderón et al. $(2015)^{11}$. It contains municipality monthly observations on the capture of a leader or a lieutenant between 2006 and 2010 compiled for official government sources.

Figure 3.4 visualizes the municipalities where a DTO head (leader or lieutenant) was either detained or eliminated between the years of 2006 and 2010. There were a total of 76 successful intervened municipalities with 97 confirmed immobilized

 $^{^{11}\}mathrm{I}$ thank the authors for allowing me to use their dataset.





DTO heads.

3.3.4 Descriptive statistics

Besides data on property crime, the state intervention and the DTO presence, I include variables to control for sociodemographic characteristics. The main descriptive statistics are presented in Table 3.2.

Figure 3.4: Municipalities with a successful government intervention 2006 - 2010



	Mean	St. dev.	Min.	Max.
Crime category				
Theft	24.16	41.63	0	639
Other property crime	13.90	29.37	0	954
DTO presence				
DTO $(=1)$	0.212	0.409	0	1
Nr. of DTO	0.411	0.946	0	9
State intervention				
Any capture $(=1)$	0.045	0.207	0	1
Nr. of captures	0.010	0.134	0	4
Other characteristics				
$\ln(\text{tot. population})$	9.317	1.535	4.62	14.37
Per capita night lights	0.096	0.084	0.00	1.43
Male population 15-39 years old $\%$	0.184	0.025	0.10	0.34
Male population 15-39 years old (absolute)	8364.670	27135.722	13	414495
Unemployment rate	3.389	1.524	1.18	8.17

Table 3.2: Descriptive statistics

Notes: There are 12200 observations (2440 municipalities for 5 years). Crime is reported crime per 100 thousand population. Source: INEGI. DTO presence was compiled by Coscia and Rios (2012), one municipality in 2010 is missing DTO information, thus the total number is 12199. Total population, male population and measures of state intervention were compiled by Calderón et al. (2015). There were successful interventions in 76 municipalities with a total of 97 captures between 2006 and 2010. Per capita night lights is the municipality-pixel year mean, source: NOAA. Unemployment rate the yearly average at the federal state level, source: BIE.

3.4 Empirical strategy

3.4.1 State intervention and DTO expansion

I use data on DTO leaders and lieutenants captured or eliminated between 2006 and 2010 for each municipality¹² to estimate the effect it had on the presence of DTO in its neighboring municipalities¹³. While the data on the captures is a monthly municipality panel, the presence data is a yearly municipality panel. Thus, the unit of analysis is municipality year. For this I aggregated the yearly number of reported leader or lieutenant captures in each municipality and created a dummy variable called *Capture* for any capture or elimination in a neighboring municipality. Neighboring municipalities are those that share a border with the municipality in question.

One major concern is the extent to which the choice of the government to intervene in a municipality is independent of the explanatory variables used. The policy was aimed at curbing the actions of all DTO, but it is unrealistic that the governments actions were not opportunistic and beset with political maneuvering. Did the government intervene in municipalities with a larger number of deaths to assuage public concerns, or was it less costly to intervene in poorer municipalities? It the policy was placed endogenously it will bias the subsequent results.

The first two colums of Table 3.3 show results of a linear probability model where the dependent variable is a successful government intervention in the municipality, i.e. the capture or elimination of a head of any DTO. Columns 3 and 4 report results of an OLS on the number of successful captures.

The only variable that appears to be correlated with the intervention is the male population. As the male population is encoded as a z-core, thus an increase of one standard deviation in the number of males would lead to an increase of 0.24 (0.64) standard deviations in the probability of an intervention. As can be seen above in Table 3.2, the standard deviation of male population in the aggregate is very large, thus while the coefficient on male population is significant, but it very small. In all, none of the municipality level variables available appear to explain the intervention satisfactorily. Nonetheless, this exercise does not rule out other factors that might have influenced the decision of the government to intervene in a particular municipality at a particular time, it merely shows that none of the variables used here do.

I am interested in the effect that the capture of a DTO head in a neighboring municipality has on the DTO presence in a municipality with no previous DTO presence, that is I want to estimate the following:

 $^{^{12}}$ The author thanks Calderón et al. (2015) for allowing the use of the data

 $^{^{13}\}mathrm{The}$ author thanks Coscia and Rios (2012) for allowing the use of the data

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	Any c	apture	Nr. of	captures
	(1)	(2)	(3)	(4)
Ln (property crime)	-0.00	-0.00*	-0.00	-0.01*
	(0.00)	(0.00)	(0.00)	(0.00)
Male population 15-39 yo	0.24^{*}	0.24^{*}	0.64^{**}	0.64^{**}
	(0.10)	(0.10)	(0.20)	(0.20)
Per capita night lights	-0.02	-0.02	-0.03	-0.03
	(0.03)	(0.02)	(0.04)	(0.04)
Ln (tot. population)	0.00	0.00	-0.07	-0.07
	(0.03)	(0.03)	(0.06)	(0.06)
Constant	-0.03	-0.00	0.63	0.67
	(0.32)	(0.32)	(0.53)	(0.54)
Year fixed effects	Yes	Yes	Yes	Yes
Municipality fixed effects	Yes	Yes	Yes	Yes
N	12199	12199	12199	12199
r2	0.02	0.02	0.03	0.03
F	8.64	8.66	7.23	7.33

Table 3.3: What explains the intervention?

Notes: Standard errors in parentheses. Observations clustered at the municipality level. Year and municipality fixed effects. The crime in columns 1 and 3 is theft, the crime in columns 2 and 4 is other property crime. One municipality in 2010 is missing information on DTO presence, thus the total number of observations is 12199 instead of 12200. The male population was normalized to a z-score.

* p < 0.10, ** p < 0.05, *** p < 0.01

$$DTO_{it} = \beta_1 Capture_{j,t-1} + \gamma \mathbf{X}'_{\mathbf{i}} + \nu_i + \phi_t + \eta_{it}$$
(3.1)

Equation (3.1) includes municipality fixed effects ϕ_t and year fixed effects ν_i . Neighboring municipalities are indexed by j.

The dependent variables in Table 3.4 are the presence of any DTO in a municipality in a given year (columns 1-3) and the number of DTO present in a municipality in a given year (columns 4-6). Explanatory variables are different measures of the state intervention: any capture, capture of a leader or a lieutenant, or number of captures. To illustrate the relationship between the intervention and the geographical expansion of the DTO, the sample is limited to municipalities that had no DTO presence in the previous period. The results suggest that the capture of any DTO head in the immediate vicinity of a municipality with no previous reported DTO presence will increase the probability that a DTO is reported in that municipality in the next period by 8%. There were a total of 76 successful interventions (i.e. intervened municipalities) in the 5 years between 2006 and 2010. A total of 332 municipalities neighboring a municipality with an intervention in the past period and with no previous DTO presence displayed DTO presence in the year following the intervention. Thus, on average, the state intervention is associated with 27 municipalities with DTO presence. If one considers the capture of a DTO leader this number increases to 67. Nonetheless, the issue of endogeneity remains unaddressed.

The results are also consistent with the argument that the kingpin strategy led to a fractionalization of the DTO, as the capture of a leader in the vicinity of a municipality is significantly and positively associated with an increase in the number of DTO active in a municipality, as opposed as the capture of a lieutenant, which has no statistical significance. The male population is significantly associated with the presence and number of DTO in a municipality; as the variable is coded as a z-score, an increase in one standard deviation in the number of males would lead to an increase of approximately 3 to 5.4 standard deviations in either the presence or the number of DTO in a municipality. A standard deviation increase of the male population amounts to an increase three times the mean absolute value and is thus practically unfeasible. Nonetheless, the results are consistent with the literature on gender and crime (e.g.: Schwartz et al. (2009)).

3.4.2 DTO presence and crime

The potential effect of DTO on crime can be expressed by the following equation:

$$Crime_{it} = \alpha + \beta DTO_{it} + \mathbf{X}'_{it}\gamma + \nu_i + \phi_t + \nu_{it}$$
(3.2)

In Equation (3.2) the crime rate $(Crime_{it})$ is a function of the presence of a DTO (β_i) , controlling for a vector of area attributes (\mathbf{X}) such night light intensity and gender composition of the population. Again, I include all possible and relevant controls, as well as municipality and year fixed effects.

There are two subcategories of property crime: theft and other property crime. The last one includes dispossession or illegal use of immobile property and damages to third party property.

In Table 3.5 both measures of DTO presence, any DTO presence and the total number of DTO active in a municipality, are associated with a negative change in crime; although the coefficient on the DTO presence is not significant for theft. This might be a problem if the already mentioned endogeneity between the DTO presence and levels of crime.

3.4.3 State intervention and crime

To document the relationship between the state intervention, the DTO presence and changes in property crime, I now use a two step approach where I use the variation in DTO presence that can be attributed to the state intervention as an explanatory variable in a regression of the log of crime for each type of property crime. This is functionally equivalent to an instrumental variables estimation but here it is only used to explore the channel from the state intervention via the DTO presence to property crime without any ambition that this channel is purely causal. Although the instrument can be shown to be relevant it is obviously not possible to defend its exogeneity. The state intervention may affect property crime in neighboring municipalities directly, if for instance it withdraws police forces from the neighboring municipality to the municipality of the intervention. While the state intervention is reported to be mostly a military one¹⁴, I am not aware of any available data that would allow to control for police presence.

Both Tables, 3.6 and 3.7 use in their columns 1 and 2 the number of captures in the past period in the immediate neighborhood of a municipality to instrument for either the presence of any DTO or the number of DTO present in any given municipality. Columns 3 and 4 of each Table report results where any capture in the neighborhood of a municipality is used as an instrument for either the presence of a DTO or the number of DTO active.

The results for other property crime, reported in Table 3.6, are partly in line with the expectations: the coefficient on any measure of DTO presence is negatively associated with property crime as well as statistically significant. As opposed to Table 3.5, the variation in DTO presence exploited here is not the one directly observed, but the one that can be statistically explained by the state intervention, this means that while the coefficients reported here are much larger (ten or 30 times larger) and thus imply larger decreases in crime than the earlier reported results, they do so only for that change in DTO presence than can be traced back to the state intervention. The large size of the coefficients raises concerns about the relevance of the used instrument, yet the F-statistic is well above the critical value of 10.

Contrasting are the results of Table 3.7 which are not in line with the expectations: none of the coefficients of interest is statistically significant and they partly have an unexpected sign. As in Table 3.5, there appears to be no relationship between the DTO presence and theft. These results will be discussed later on.

A possible explanation for the lack of the statistical significance of the coefficients

¹⁴drug offenses in Mexico are a federal crime

on theft as opposed to other property crime, provided the estimation is correct, lies in the difference in the nature of both crimes. In contrast to theft, property crime is an activity that mostly generates no income. Individuals engaged in property crime could possible be absorbed (recruited) more easily by the DTO than those engaged in theft, as they are probably easier to incentivize to join the DTO¹⁵ than those who already have a source of income.

Regarding the magnitude of the coefficients in Table 3.6: the presence of any DTO that can be explained though a successful intervention in the vicinity in the past, is associated with $-72.2\%^{16}$ less property crime than in similar municipality with no comparable DTO presence. This values is -84.3% in the case where the DTO presence is explained through the number of captures instead of any successful capture. The extent to which the number of DTO active in a municipality affects crime can be gathered from columns (2) and (4). Here the number of DTO active in a municipality in a period is explained by the number of capture or any capture in a municipality in the neighborhood in the past period. Municipalities with an increase of one DTO because of a successful intervention in the past will display between 38% and 43% less property crime than similar municipalities without an analogous increase in DTO presence. Unfortunately, this difference is difficult to quantify in monetary terms as there is no information on the value of the property lost or damaged in the data. The mean number of property crime per 100k population is 13.9 with a relatively large standard deviation more than double the mean value. The decrease on the mean would be of between 5 to 11 property crime cases per 100k population.

 $^{^{15}{\}rm This}$ argumentation obviates any form of forced recruitment that most certainly goes on $^{16}(\exp(\text{-}1.28)\text{-}1)*100$

	DTO p	oresence ($=1)_{(i,t)}$	Nr.	of DTO	(i,t)
	(1)	(2)	(3)	(4)	(5)	(6)
L.Any capture $(=1)$	0.08***			0.12***		
	(0.03)			(0.05)		
L.Leader's capture $(=1)$		0.19^{**}			0.32^{**}	
		(0.08)			(0.15)	
L.Lieutenant's capture		0.04			0.05	
		(0.03)			(0.03)	
L.Number of captures			0.06^{**}			0.08^{**}
			(0.02)			(0.03)
Pop. males 15-39 yo	2.95^{***}	2.98^{***}	2.94^{***}	5.40^{***}	5.45^{***}	5.39^{***}
	(0.83)	(0.82)	(0.84)	(1.67)	(1.65)	(1.67)
Per capita night lights	0.11	0.12	0.12	0.30	0.32	0.31
	(0.10)	(0.10)	(0.10)	(0.19)	(0.19)	(0.19)
$\ln(\text{tot. population})$	-0.27**	-0.27**	-0.27**	-0.41**	-0.42^{**}	-0.41**
	(0.11)	(0.11)	(0.11)	(0.19)	(0.18)	(0.19)
Constant	2.92^{***}	2.96^{***}	2.92^{***}	4.65^{**}	4.71^{**}	4.64^{**}
	(1.07)	(1.06)	(1.08)	(1.89)	(1.87)	(1.90)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Municipality fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Ν	7865	7865	7865	7865	7865	7865
r2	0.06	0.07	0.06	0.06	0.06	0.06
F	42.18	37.12	42.07	35.49	31.15	35.42

Table 3.4: DTO presence and state intervention

Notes: Standard errors in parentheses. Observations clustered at the municipality level. Year and municipality fixed effects. Sample has been limited to municipalities that had no DTO presence in the previous period. One municipality is missing DTO presence information for the year 2010.

* p < 0.10, ** p < 0.05, *** p < 0.01

	(1)	(2)	(3)	(4)
	Theft	Theft	Other	Other
DTO (=1)	-0.04		-0.06**	
	(0.03)		(0.02)	
Nr. of DTO active		-0.03**		-0.05***
		(0.01)		(0.01)
Pop. males 15-39 yo	0.09	0.14	-0.03	0.06
	(0.20)	(0.20)	(0.19)	(0.18)
Population density (per $km2$)	0.00^{*}	0.00^{*}	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Per capita night lights	9.94^{*}	9.40^{*}	30.06***	29.09***
	(5.66)	(5.64)	(6.29)	(6.21)
Unemployment rate (yearly average)	-0.02^{*}	-0.02	-0.03***	-0.02**
	(0.01)	(0.01)	(0.01)	(0.01)
Constant	1.26^{***}	1.25^{***}	1.23^{***}	1.22^{***}
	(0.06)	(0.06)	(0.06)	(0.06)
Year fixed effects	Yes	Yes	Yes	Yes
Municipality fixed effects	Yes	Yes	Yes	Yes
N	12199	12199	12199	12199
F	3.47	3.81	18.45	19.23
р	0.00	0.00	0.00	0.00
R-sq.	0.146	0.176	0.151	0.079

Table 3.5: DTO presence and property crime

Notes: Dependent variable is ln(crime). Standard errors in parentheses. Observations clustered at the municipality level. Year and municipality fixed effects. One municipality is missing DTO presence information for the year 2010. The unemployment rate is for the federal state.

* p < 0.10, ** p < 0.05, *** p < 0.01

Table 3.6:Instrume	ntal variable regi	ession: other pr	operty crime	
	(1) Nr. captures	(2) Nr. captures	(3) Any capture	(4) Any capture
DTO (=1)	-1.85***		-1.28***	
	(0.67)		(0.46)	
Nr. of DTO active		-0.43***		-0.38***
		(0.14)		(0.13)
Pop. males 15-39 yo	-0.30	0.69^{*}	-0.21	0.60^{*}
	(0.29)	(0.36)	(0.25)	(0.32)
Population density (per km2)	0.00	-0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Per capita night lights	1.54	13.70^{*}	10.68	15.79^{**}
	(11.96)	(7.65)	(8.97)	(7.30)
Unemployment rate (yearly average)	0.04	0.03	0.02	0.02
	(0.03)	(0.02)	(0.02)	(0.02)
Year fixed effects	Yes	Yes	Yes	Yes
Municipality fixed effects	Yes	Yes	Yes	Yes
Ν	12199	12199	12199	12199
н	11.42	19.57	19.84	28.23
Notes: Dependent variable is $\ln(\text{crime})$ of clustered at the municipality level. Year and information for the year 2010. The unemploy * $n < 0.10$. ** $n < 0.05$. *** $n < 0.01$	other property crimunicipality fixed ment rate is for th	ime. Standard er l effects. One mur le federal state.	rors in parenthes nicipality is missir	es. Observations 1g DTO presence
* $p < 0.10, ** p < 0.05, *** p < 0.01$				

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	(1)	(2)	(3)	(4)
	Nr. captures	Nr. captures	Any capture	Any capture
DTO (=1)	-0.04		0.45	
~	(0.51)		(0.41)	
Nr. of DTO active	~	-0.01	~	0.13
		(0.12)		(0.12)
Pop. males 15-39 yo	0.09	0.11	0.16	-0.12
	(0.21)	(0.29)	(0.21)	(0.30)
Population density (per km2)	0.00	0.00^{*}	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Per capita night lights	9.90	10.17	17.69^{**}	15.89^{**}
	(9.76)	(7.29)	(8.73)	(7.49)
Unemployment rate (yearly average)	-0.02	-0.02	-0.04**	-0.04^{**}
	(0.02)	(0.02)	(0.02)	(0.02)
Year fixed effects	Yes	Yes	Yes	$\mathbf{Y}_{\mathbf{es}}$
Municipality fixed effects	Yes	\mathbf{Yes}	\mathbf{Yes}	Yes
Ν	12199	12199	12199	12199
Ъ	11.42	19.57	19.84	28.23

3.4 Empirical strategy

3.5 Conclusion

In an effort to successfully curb the drug trafficking activity in Mexico, the government implemented a so-called kingpin strategy that aimed at the elimination or capture of a the heads and lieutenants of the resident drug trafficking organizations, the DTO. There is ample literature showing that this policy had disastrous unintended consequences as it generated an outburst of violence that left around 60000 death in 10 years.

This study concentrates on that same government intervention but aims to analyze the relationship between the presence of drug trafficking organizations and property crime. I argue that a DTO that arrives at a new geographical location will aim to control that area as best as possible. To do so, it will subdue any existing criminal cells, be it by coercing or coaxing. This will effectively reduce the amount of property crime.

I use data on the number and the location of deaths and captures of DTO leadears, as well as data on the presence of DTO and judicial crime data as well as varios controls to analyze if the government intervention fostered the geographical expansion of the DTO and if this expansion helps explain changes in theft and other types of property crime.

I find that the a successful state intervention in a neighboring municipality increases the probability of a municipality displaying DTO presence in the next period. The state intervention also increases the number of DTO present. To better document the relationship between the intervention, the DTO and property crime I use the variation in DTO presence that can be attributed to the state intervention to estimate changes in the two types of property crime.

The results suggest that DTO presence is negatively associated with changes in property crime to the extent that property crime could be almost halved by the presence of the DTO. The relationship does not hold for theft.

This analysis provides tentative evidence for another set of unintended consequences, besides the violent ones, that can arise due to an aggressive government intervention: changes in property crime. Such declines in property crime could be misatributed or instrumentalized by a government and could so divert resources away from deterrence and prevention of crime. This study put forth the argument and supplied suggestive evidence, for the involvement of criminal organizations in crime modalities that are not directly connected to their business. If the DTO tax or even prohibit the exercise of certain, illegal, activities, they are de facto substituting the state presence and undermining its monopoly on regulations.

It is unclear if once the DTO "leaves" an area, be it because it moves on or because it ceases to exist, the existing criminals, no longer subdued, will retake their previous activities, particularly if the state presence is not active fast enough. A case where the cessation of activities of an organized crime organization coincided with an increase in property and other crimes can be seen in Colombia. After the United Self-Defenses of Colombia demobilized in 2006 reports of band of criminals spiked. As is the case with non-experimental settings, the successful estimation of a causal relationship is very difficult and requires a great deal of data and ingenuity.

The nature of organized crime and drug trafficking organizations itself makes it very difficult to have accurate measures of their presence. An organization might have been active in a given municipality or area for an unknown amount of time before it appears in the data. Furthermore the limited availability and quality of committed crime data continues to be a concern as is the involvement of the police itself in reporting or the presence of gangs, for which I cannot account.

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4

Nutritional Impacts of Price Changes: Quality and Quantity Substitution in Mexico

4.1 Introduction

Both the epidemiological transition (the replacement of infectious disease morbidity by non-communicable chronic diseases (NC-CD) in a society) and the nutrition transition (the shift in dietary preferences from cereals and fiber to animal products and fat in a society) are currently underway in Mexico although not at similar speeds; the nutrition transition appears to be faster (Rivera et al., 2004; Popkin, 1993) as it goes faster through its different stages. Both have been linked to changes in the food consumption patterns and dietary intake as well as with reduced physical activity. The long term costs if this development continues can be high: as of 2013, an estimated 75% of deaths in Mexico are caused by NC-CD, with projected healthcare costs of more than US\$1 billion in 2021 (Barquera et al., 2013).

An added complication to the situation is that both shifts are not homogeneous throughout the country, with the north having a higher incidence of NC-CD and the nutritional patterns of a developed country, as opposed to the south (Romieu et al., 1997; Rivera et al., 2002). Moreover, the different stages of the nutrition and epidemiological transition can appear at the same time, for example, Romieu et al. (1997) reports the concomitant existence of obesity in women and stunting in children in certain southern Mexican states, with newer studies, such as Barquera et al. (2013) , confirming that undernutrition and obesity coexist, even in the same individual (e.g.: obesity and iron deficiency). Moreover, Rivera et al. (2004) note that the sum of overweight and obesity appear to decline as socioeconomic conditions improve, suggesting that poor individuals are, and will be, bearing the

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medical and economic brunt of these transitions. The evolution of changes in dietary intake, medical conditions and of disease can be worsened by other risk factors, namely the low levels of leisure time dedicated to physical activity reported in the low socioeconomic categories in Mexico. Furthermore, obesity appears to be increasing faster in children than in adults (Barquera et al., 2013).

The aim of this paper is to assess the impact of the "sugar tax" on household food consumption and their nutrition patterns with a particular focus on quantity and quality substitution effects in Mexico. To do so I extend the approach of McKelvey (2011); Andalon and Gibson (2017) to compute quality adjusted nutrient elasticities in the manner of Ecker and Qaim (2011).

In particular I use household food expenditure data from two waves of a representative household survey as well a official prices in a pseudo-panel approach to calculate the corresponding elasticities and thus assert the caloric and macronutrient intake change that is possible with an increase in the prices of sugar-added beverages.

There appears to be a very strong link between the nutritional and the epidemiological transitions: Rivera et al. (2004) report that between the years of 1988 and 1999 in Mexico the amount of food quantities purchased declined but also that the composition of the food bought changed: the purchase of refined carbohydrates and soda increased by 6.3% and 37.2% respectively while the purchases of fruits and vegetables declined by approximately 30%. For the same 11-year time span, the authors report on the increase in the prevalence of overweight and obesity¹ in Mexico. The national prevalence of overweight increased by almost 47% and that of obesity by 160%. Colchero et al. (2016) report a prevalence of overweight and obesity of more than 33% for individuals between the ages of 2 and 18 and of 70% for adults. Despite efforts to control the incidence of both medical conditions, as of 2013 no decline was observed (Barquera et al., 2013).

Changes in NC-CD mirror the evolution in dietary preferences and that of overweight and obesity. The increases in age-adjusted mortality rates for diabetes, acute myocardial infarction and hypertension for the same 11-year span reported by Rivera et al. (2004) amount to 62%, 53% and 55% respectively. Colchero et al. (2016) report that the prevalence of diabetes in Mexico is the highest of the OECD countries.

Studies (Powell et al. (2013); Malik et al. (2006)) suggests that added sugar in beverages is linked with overweight, obesity, and derived heart and metabolic diseases such as diabetes, as the caloric intake from liquids does not appear to cause satiation in humans and thus leads to an overconsumption². Caloric intake

¹The WHO defines an adult as overweight if its BMI is larger than or equal to 25 and as obese if its BMI is larger than or equal to 30. The BMI is defines as a persones weight in kilograms devided by the square of the height im meters (http://www.who.int/mediacentre/factsheets/fs311/en/ last accessed May 5, 2017).

²The reason appears to be that in humans the sugars or the calories from liquid beverages

from beverages accounts for about 20% in Mexico, one of the highest in the world. Also, the consumption of caloric beverages increased more than 200% between 1990 and 2006 (Barquera et al., 2013). Any reduction in the consumption of beverages with added sugar would probably go a long way in reducing overweight and obesity and so its associated NC-CD, provided, the reduction in the consumption of those beverages does lead to a reduction in calorie intake and does not have any adverse nutritional effects.

An idea (Fletcher et al., 2010) of reducing the consumption of sugar, fat, and refined carbohydrates are excise taxes. These "obesity taxes" mirror in its aim and implementation other taxes for controlled substances, for example tobacco. In the case of the latter it has been implemented with small but non-negligible success in curbing consumption and even more success in increasing tax revenues. In the case of soft drink taxes, there is limited evidence, at least for adults (Fletcher et al., 2010), that such a tax reduces the amount of consumed calories from soft drinks. A concern that arises with the proposal of such a tax are possible substitution effects: it is unclear if a tax that reduces the consumption of soda will also reduce the calorie intake or whether individuals will increase the consumption of non-taxed items of a similar caloric content in response to the tax. In a study with data from the United States, Fletcher et al. (2010) show that a soft drink tax does reduce the amount (but no the probability) of soft drinks consumed, but that the reduction in caloric intake is completely offset by the consumption of other drinks with similar caloric content, for example juices.

Mexico introduced a "sugar tax" the 1st of January 2014 of 1 MXN/L on nondiary, non-alcoholic beverages with added sugar, the so called sodas or "refrescos" (approximately a 10% price increase to the previous year) as well as an addvalorem tax increase from 5% to 8% on a pre-defined list of non-essential food items with high energy density³ (Colchero et al., 2016). This tax is one of several steps undertaken by the government to combat obesity, overweight, and NC-CD (Barquera et al., 2013).

In an effort to explain the rapid rise of non-communicable chronic diseases (NC-CD) and obesity in Mexico between 1980 and 1998, Rivera et al. (2002) characterize the epidemiological and nutritional transitions, but are unsuccessful in establishing a link between the NC-CD and dietary changes. They posit that: "although unlikely, it could be that people spent less money but purchased larger amounts of cheaper food [...]." Other studies, such as Fletcher et al. (2010), provide first evidence of

do not limit the intake from calories from non-liquid foods, i.e. caloric beverages do not cause satiation in a human the way solid food does. Thus *drinking* calories leads to an energy surplus. The mechanism is unknown but it is theorized that humans lack genetic markers that would triggers a satiation response (Wolf et al., 2008).

 $^{^{3}\}mathrm{High}$ energy dense are those foods that contain more than 275 calories (1151kJ) per 100 gram.

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substitution effects *between* goods in the case of a price increase (e.g.: through "obesity taxes"), a so-called *quantity* substitution. But there is little evidence regarding the substitution along the same type of goods. In a observational study of the Mexican "sugar tax", Colchero et al. (2016) report that there was a reduction in purchases of sweetened beverages, but that the reductions were larger for noncarbonated beverages than for carbonated ones. The authors hypothesize that the comparably low decreases in the consumption of carbonated beverages after the tax could be due to consumers substituting to lower priced versions, i.e. that the consumers would be engaging in quality substitution. McKelvey (2011) sets up a framework to identify quantity and quality substitution using unit values and prices to obtain price elasticities of quantity and quality. Unit values (the ratio of expenditures to quantity) are extracted from a household survey, while prices are obtained from official government sources. The author analyses rice consumption in Indonesia and finds that quality substitution is prevalent. Similarly, Gibson and Kim (2013) analyze the effect of increased prices on calorie intake from rice in VietNam and find that ignoring quality substitution would lead to a gross overestimation of the reductions in calorie intake from rice. For Mexico, Andalon and Gibson (2017) provide suggestive evidence on the biases in the price elasticity of quantity that arise from computations using solely the unit values. Their estimates show that a quality corrected price elasticities of quantity for sugared beverages in Mexico is actually up to a third smaller than expected and that the associated reduction in quantity would not be nearly enough to produce large enough changes in weight. Nonetheless, the estimates they obtained were computed with a household survey from 2014 that was conducted months after the introduction of the tax and after the individuals have had time to adapt their consumption patterns. I improve on that study by providing a pseudo-panel estimate where time invariant parameters have been taking into account using data from before the introduction of the tax, and by providing estimates of nutritional changes.

The contribution of this study is manifold: it provides for the first time estimates on the quality corrected price elasticity of quantity for various nutrients. Furthermore, this study also contextualizes the findings by providing an assessment of changes in the nutritional patterns in a country with a varied diet: Mexico.

I find that in the case of soda the use of prices as opposed to unit values leads to biased estimates of the price elasticity of quantity. In particular, quality substitution can offset almost completely any price effects. Furthermore, households at lower levels of food expenditure, and with lower levels of soda consumption, are those that will bear most of the tax, as they do not have much room to engage in quality substitution. Conversely, households with higher levels of food expenditure and also higher levels of soda consumption will be less affected. I compare prices, quantities and unit values of soda between 2012 and 2014 and find that prices increased overproportionally, quantity consumed showed almost no change and unit values increased overproportionally for those households that appear to be unable to engage in quality substitution.

4.2 Concept

I begin by highlighting the implications of using unit values to assess price elasticities drawing from McKelvey (2011) and then I describe the computation of nutritional elasticities from quality adjusted price elasticities of quantity.

Total expenditure x_i for a commodity group i is the product of price p_i and quantity q_i :

$$x_i = \boldsymbol{p}_i \cdot \boldsymbol{q}_i \tag{4.1}$$

where p_i and q_i are vectors for the price and quantity of each element of the group *i*. For example a commodity group could be "beef" and its components would then be steak, brisket, sirloin, and any other cuts.

The price vector (\mathbf{p}_i) can be decomposed in to a scalar λ_i that captures a component that is common to all prices in that price vector and a vector for the relative prices withing the group \mathbf{p}_i^* . By expanding the RHS of Equation (4.1) by $\frac{Q_i}{Q_i}$ with Q_i being the sum of each component of q_i in a group, the total expenditures can be written as

$$x_i = \lambda_i \frac{\boldsymbol{p}_i^* \cdot \boldsymbol{q}_i}{Q_i} Q_i \tag{4.2}$$

In Equation (4.2) the element $v_i = \frac{p_i^* \cdot q_i}{Q_i}$ is the measure of quality for the consumption of of group *i* because if the relative prices p_i^* are constant, but the level of v_i for a consumer is larger than for another it must be because the first one has chosen q_i in a manner in which he is spending more per unit than the second consumer. Thus, higher expenditures for one and the same item indicate higher quality ⁴.

The usually used unit value of a group is a ratio of expenditures to quantity:

 $^{^{4}}$ As in McKelvey (2011) the assumption of constant relative prices is paramount to the estimation and inference of the elasticities and I will not deviate from it here.

$$V_i = \frac{x_i}{Q_i} \tag{4.3}$$

Thus, using Equation (4.2) one can rewrite Equation (4.3) as:

 $V_i = \lambda_i \cdot v_i$

Changes in the unit value can not only occur due to changes in the common component of the price λ_i but also due to changes in the quality v_i chosen by the consumer.

The assessment of changes in quantity due to a changes in prices occurs through the price elasticities of quantity. A standard method for estimating the price elasticity involves the regression of expenditure shares for each commodity group in a demand system on the corresponding unit value.

This method implies that once a price changes, the consumer will change the quantity of the good consumed, for example by switching to the consumption of a substitute. This might be the case for very narrowly defined consumption goods, for example a single brand of a food staple, but is unlikely to be the case for broader groups of items, for example sugared beverages, as the consumer might as well change to cheaper varieties of the same good.

As a possible solution to account for quality substitution between items in a group in the absence of market prices, Deaton (1988) proposes to exploit the assumption of weak separability of commodity groups; but as McKelvey (2011) and Andalon and Gibson (2017) show, this assumption does not appear to hold.

To be able to account for quality substitution in the case where market prices and unit values are available one needs two different equations.

$$w_{hit} = \alpha_1 + \beta_1 ln x_{ht} + \gamma_1 \boldsymbol{z}_{ht} + \boldsymbol{\theta}_1 ln \boldsymbol{\lambda}_{ht} + u_{1hit}$$

$$(4.4)$$

In Equation (4.4) the expenditure share w for a household h for a commodity group i at time t is regressed on the total expenditures of the household for all the goods in the demand system lnx_{ht} , a vector of household characteristics z_{ht} and a vector of all the prices in the demand system λ_t . The inclusion of all prices in the demand system is to account for possible cross-price substitution.

In what follows I suppress the time index t for legibility. Deriving the expression in Equation (4.4) with respect to the price of good i, accounting for the quantities $Q_i = \frac{w_{hi}x_h}{V_i}$, and noting that $\frac{\partial lnx}{\partial ln\lambda_i} = 0$ yields:

$$\frac{\partial lnQ_i}{\partial ln\lambda_i} = \frac{\partial ln(w_{hi})}{\partial ln\lambda_i} - \frac{\partial lnV_i}{\partial ln\lambda_i}$$
(4.5)

Equation (4.5) allows for the estimation of the quality adjusted price elasticity of quantity. It adjusts the elasticity in the expenditure share changes in unit values that occur through changes in prices. The regression (4.4) accounts for all other items in the demand systems besides i as they are included in the price vector λ_t , but cross-price effects are not shown in Equation (4.5). They are derived analogously and will be of interest later on.

To see the quality substitution note that:

$$\frac{\partial lnQ_i}{\partial ln\lambda_i} = \frac{\partial ln(w_{hi})}{\partial ln\lambda_i} - \frac{\partial \lambda_i}{\partial \lambda_i} - \frac{\partial lnv_i}{\partial \lambda_i}$$
(4.6)

If the elasticity of quality to price is zero $\left(\frac{\partial lnv_i}{\partial \lambda_i} = 0\right)$ then Equation (4.8) turns into:

$$\epsilon_{1i} = \frac{\partial lnQ_i}{\partial ln\lambda_i} = \frac{\partial ln(w_{hi,t})}{\partial ln\lambda_i} - 1$$

The elasticity of quantity to price can be then be obtained from a regression of Equation (4.4), where θ_{1i} is the coefficient of interest⁵.

If one allows for quality substitution, then the second term on the LHS of Equation (4.5) can be obtained from a regression of unit values on the prices:

$$lnV_{hi} = \alpha_2 + \beta_2 lnx_h + \gamma_2 \boldsymbol{z}_h + \boldsymbol{\theta}_2 ln\boldsymbol{\lambda}_t + u_{2hi}$$

$$\tag{4.7}$$

As does Equation (4.5), Equation (4.7) includes controls for the prices of all goods present in the demand system. Of initial interest are only the direct elasticities, and the coefficient of interest will be θ_{2i} .

Two further points need to be mentioned concerning the estimation of quality adjusted price elasticities of quantity. The price elasticity of quantity can be obtained without having to account for any quality substitution effects if both quantities consumed and prices are observed, as I do. In that case, one would only need to replace expenditure share $w_{hi,t}$ with quantities consumed in Equation (4.4).

 $^{^5{\}rm This}$ would be the direct elasticity, elasticities of substitution can be computed analogously (McKelvey, 2011).

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But as one of the main aims of the study is to compute, show and contextualize the quantity of substitution, I will compute the unadjusted and the unadjusted price elasticities. The second point refers to the comparability of the results with previous analyses. The two studies that are the closest to this one are McKelvey (2011), for the methodology, and Andalon and Gibson (2017) as they study the same price change as is done in this study. In both cases the authors implement a measurement error correction in the method presented here that aims a reducing the differences to other methods presented there.

$$\epsilon_{2i} = \frac{\partial lnQ_i}{\partial ln\lambda_i} = \frac{\frac{\partial w}{\partial \lambda_i}}{w} - \frac{\partial lnV_i}{\partial ln\lambda_i}$$
(4.8)

In those previous studies, the first term in Equation (4.8) $\left(\frac{\partial w}{\partial \lambda_i}\right)$ has been modified to control for a possible spurious correlation in a regression of the expenditure shares on the unit values as the total expenditures appear in the denominators of both the dependent variable and the independent variable of interest (Andalon and Gibson, 2017; McKelvey, 2011). This correction is not needed in cases when there is no comparison across methods and will therefore not be implemented here⁶.

The adjusted and the unadjusted price elasticities of quantity will only differ if $\frac{\partial lnv_i}{\partial ln\lambda_i} = 0$, that is, in cases where there is no quality substitution. This might be the case for very narrownly defined commodity groups or those that are comprised of a single item, for example maize tortillas.

As for the nutritional elasticities I employ the approach taken by Ecker and Qaim (2011)⁷, Huang (1996) and Huang and Lin (2000) in their studies of price and income changes and nutritional impacts. Especially in the case of a single price change this approach allows to derive changes in the nutritional impacts associated with it. The approach is not very well suited to analyze simultaneous changes in prices for different items.

The nutrient elasticities to food prices are calculated as follows:

$$e_{iN} = \frac{\sum_j c_{jN} q_j e_{ij}}{\sum_j c_{jN} q_j},$$

where c_{jN} is the quantity of nutrient N present in one unit of food item j, q_j is

 $^{^{6}\}mathrm{The}$ correction was first introduced by Deaton (1988) in a setting were only unit values were available.

⁷Which in turn has its roots in Pitt (1983) and Sahn (1988).

the quantity of food item j consumed, and e_{ij} is the price elasticity of food item i due to price changes in j. Thus the e_{jN} are the weighted average of all price elasticities e_{ij} , where each weight is the share of the nutritional content of each food to the overall nutrient consumption.

Empirically, I use a pseudo panel approach (Verbeek, 2008; Verbeek and Vella, 2005; Deaton, 1985) using two subsequent waves of the Mexican National Income and Expenditure Household Survey⁸. A pseudo-panel is less likely to suffer from attrition and the computation of cohort means diminishes the measurement error in the variables of interest (Gardes et al., 2005). To obtain the best results cohorts have to be carefully constructed. Ideally, the choice of cohort will be so that the heterogeneity within cohort is minimized and the heterogeneity between cohorts is maximized. Additionally, the usage of cohorts in pseudo-panels is an application of instrumental variables and as such requires that the standard instrumental variables approach conditions are met, i.e., relevance and exogeneity (Verbeek and Vella, 2005). Furthermore, the aggregation process through which the cohorts are created produces systematic heteroscedasticity that needs to be corrected without eliminating the invariance of the cohort over time (Gardes et al., 2005).

With this approach, and based on Equations (4.4) and (4.7), the estimated model is then given by:

$$\bar{w}_{cti} = \alpha_{1ct} + \beta_1 ln\bar{x}_{ct} + \gamma_1 \boldsymbol{z}_{ct} + \boldsymbol{\theta}_1 ln\bar{\boldsymbol{\lambda}}_{ct} + u_{cti}, c = 1, \dots, C; t = 1, \dots, T,$$

For cohort c, commodity group i and time period t, and cohort average expenditure shares(\bar{w}_c), food expenditures (\bar{x}_c) and a vector of food prices ($\bar{\lambda}_c$). z_c is a vector of cohort level controls. Contingent on a sufficiently large number of observations per cohort, α_{ct} can be viewed as a time invariant fixed unobserved parameter. In that case the θ_1 are the within estimator on the pseudo panel.

The next regression is estimated to compute the quality adjusted elasticities of quantity:

$$ln\bar{V}_{cit} = \alpha_{2ct} + \beta_2 ln\bar{x}_{ct} + \gamma_2 \boldsymbol{z}_{ct} + \boldsymbol{\theta}_2 ln\bar{\boldsymbol{\lambda}}_{ct} + v_{cit}, c = 1, \dots, C; t = 1, \dots, T,$$

The unadjusted price elasticity for a good i given changes in the price of good j is then:

$$\epsilon_{1i} = \frac{\theta_{1i}}{\bar{w}_{cti}} - 1,$$

⁸ENIGH by its initials in Spanish.

and the quality adjusted price elasticity for good i is:

$$\epsilon_{2i} = \frac{\theta_{1i}}{\bar{w}_{cti}} - \theta_{2i}.$$

The data sources and descriptive statistics thereof are detailed as follows in Section 4.3.

4.3 Data

4.3.1 Food expenditures and quantities

Food expenditure data comes from the Mexican Income and Expenditure Survey⁹ for the years 2010 and 2012. These surveys were selected because they were conducted before the tax was introduced. This ensures that the computed elasticities are not affected by any adaptation of the consumers to the new \tan^{10} .

To account for the household size I use adult equivalence scales to compute per capita food expenditures. The individual adult equivalence scales used here are those developed by Teruel et al. (2005)¹¹ for Mexico using the ENIGH 2002¹². Adult equivalents are used to computed adjusted per capita total expenditures for each household.

A point of concern regarding the use of a household survey to identify food consumption patterns is the seasonal availability of certain products, particularly if these products are predominantly consumed by a specific socio-economic group. The 2012 household survey was levied between the 27 August and the 24 November. The items of consideration here are available all year, as they are not seasonal products. As for seasonal preferences, Mexico has no clearly defined seasons but a "rainy" and a "dry" seasons, the onset of which varies according to the area.

Another point of concern if that quantities purchased are not necessary quantities consumed and that the nutritional content of food will change due to cooking. In the first case, the FAO (2015); FAO (2014) estimates that the average national food waste in Mexico amounts to 37,26% of total production. Out of the total number of calories wasted, 30% of losses occur at the consumption stage of the

⁹ENIGH by its name in Spanish

¹⁰Andalon and Gibson (2017) in a study with a similar focus use data levied *after* the introduction of the tax.

¹¹Note that the scales were developed with different methods. I use here the one developed with the method of Engel and then only the values obtained at the median of the distribution which diverge slightly at the third decimal place from those at the mean.

 $^{^{12}}$ The equivalence scales are as follows: for ages 0 to 5: 0.64, for ages 6 to 12: 0.67, for ages 13 to 18: 0.63, for ages 19 to 65: 0.84. Individuals aged 66 and older are weighted with one.

food supply chain¹³ as much as in the production stage. Not all products produced in Mexico are wasted in the same proportion, with guava (57,73%), cow milk (57,14%), mango (54,54%) and fish and sardines (54,07%) taking up the first four spots. Another issue with food waste, is that is probably most salient in higher income brackets than in lower ones. As the household surveys offer no measure of control for actually consumed food, the interpretation of results should bear this in mind. Nonetheless, soda, which is the commodity of interest here, does not appear in any account of food waste that I was able to revise.

With regards to the nutritional content, the items of interest in this study are not usually cooked¹⁴. Nonetheless, there can be differences in macronutrient or energetic content between brands of the same commodity goods. In the case of sugar-added beverages this difference is negligible. For example, the difference between 368ml of Coca Cola and 368ml of Jarritos Mexican Cola is just one calorie. This difference might be more salient for close substitutes of soda beverages, for example milk. In the household surveys it is not reported if the milk bought had lowered fat content. This is an issue regarding the amount of final calories, but not regarding the final amount of sugar. For example, skimmed milk (with a fat content of 1,5%) has around 1970 kilo calories per 1 liter, while whole milk (with a fat content of 3,5%) has approximately 2720 kilo calories per liter. Both types of milk have the same amount of sugar though, around 48 grams per liter.

4.3.2 Cohorts

The households are grouped into cohorts which are determined by the region¹⁵, the rural status¹⁶ of the municipality in which the household is located, as well as the economic sector in which the household head is active¹⁷.

Verbeek (2008) puts forward the argument that estimation techniques that are based on the grouping of individual observations into cohorts are equal to those used in instrumental variable approaches. In particular this means that the cohorts

¹³This is an average for all Latin America

¹⁴Boiling milk does not alter its nutritional content.

¹⁵There are four different regions: The North includes Baja California, Sonora, Chihuahua, Coahuila, Nuevo Leon and Tamaulipas. The North-Center region includes Aguascalientes, Baja California Sur, Colima, Durango, Jalisco Michoacán, Nayarit, San Luis Potosí, Sinaloa y Zacatecas. The Center includes Distrito Federal, Estado de México, Guanajuato, Hidalgo, Morelos, Puebla, Querétaro and Tlaxcala. The South region includes Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz and Yucatán.

¹⁶According to the Mexican National Institute of Statistics and Geography a municipality is labeled as rural if the number of inhabitants lies below 2500 indivuals.

¹⁷In case the household head engaged in more than one activity, the primary activity was chosen. Economic sectors are: agriculture, mining, energy and construction, industry, commerce, services, government and other. Also, unemployed household heads have an own category.

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should be relevant with regards to the main explanatory variable(s).

In the case discussed in this study, the explanatory variables of interest are the unit values and the prices of soda. Table 4.1 reports the correlations between the cohorts and these variables of interest. As will be discussed below, there is no statistical association between unit values and prices. In contrast the correlation between the cohorts and the aforementioned unit values and prices is significant and negative. With these results I go forward and present summary statistics for the cohorts.

	Cohort	Price (soda)	Unit value (soda)
Cohort	1.0000		
Price (soda)	-0.4118*	1.0000	
	(0.0000)		
Unit value (soda)	-0.4401*	-0.0794	1.0000
	(0.0000)	(0.4055)	

Table 4.1: Correlations

Notes: This table reports Pearson's correlations calculated with analytical weights to control for the number of households in each cohort. Significance levels are in parentheses. (*) indicates a significance level at the 5%.

Table 4.2 summarizes some key characteristics of the cohorts and the consumption profiles of the commodity groups used in the main analysis. Notable are the strong differences in household numbers that are present in each cohort. To avoid any distortion of the results, appropriate weights are used in the statistical analysis. Means are build over the years 2010 and 2012, in the case of consumption variabes the means refers to weekly consumption. The food expenditure shares of soda in the data lie between 5% and 17%, with a total amount of soda bought that lies between 3 and 7 liters, closely followed by water. For comparison, the average food expenditure share of tortillas, a main food staple, lies between 7% and 21% of the food expenditure in a week. This goes to show that soda is a prominent food item.

4.3.3 Unit prices & unit values

Prices used here are those levied for several items representative of a set of products each month in 46 different municipalities, called price stations, and published by the INEGI¹⁸. I match each municipality in the country to a price station by the shortest geodesic distance between the municipality centroids and match each household to a price by the month in which the household was interviewed. If the

¹⁸Until 2011, the prices were levied and published by the Mexican Central Bank.

	Mean	SD	Min.	Max.
Cohort characteristics				
Households (Nr. in cohort)	814.489	633.515	11	2108
Food expenditures (MXN)	449.154	72.228	290.269	596.504
Share of males (%)	0.752	0.171	0.430	1
Share of indigenous households (%)	0.302	0.173	0.056	0.781
Nr. adult equivalents	3.047	1.446	0.630	15.330
Nr. household individuals	3.886	1.972	1	21
Weekly expenditure shares $(\%)$				
Soda	0.088	0.018	0.050	0.176
Water	0.059	0.010	0.031	0.161
Milk	0.097	0.014	0.057	0.154
Chips and similar	0.029	0.006	0.011	0.064
Weekly quantities (liter or kilogram)				
Soda	5.144	0.597	3.262	7.249
Water	31.402	5.867	12.250	91.200
Milk	3.920	0.835	1.872	5.686
Chips and similar	0.323	0.227	0.125	3.220

Table 4.2: Summary statistics

Notes: Summary statistics for 56 cohorts in each of two waves of the ENIGH, with a total of 36074 households. Consumption variables are weekly means. Expenditures shares are shares of total food expenditures. Quantities and shares are reported for one week (7 days). Quantities are in liter or kilogram. Share of males includes underage individuals. A household is reported as indigenous if the household head ascribes to an indigenous community or if their mother language is an indigenous one. Adult equivalents were computed using the scales from Teruel et al. (2005). The food expenditures of each household were deflated with the corresponding CPI of the month and year in which the household was interviewed. The base is the the second quarter of 2010.

interview took place in a week in which one month ended and another started I take the average of the prices of both months.

Unit values are extracted from expenditure and quantity information. Unlike prices, not all households observe an unit value as not all households consume all available goods. To be able to account for unit values in the same manner as I account for prices, the missing unit values have been imputed. To do so I look for the median of the unit value in question at the same expenditure decile in either the same municipality, neighboring municipalities, or finally, the federal state. Having a complete set of prices and unit values allows me to create a complete matrix of own- and cross-price elasticities.

To motivate the emphasis put on the difference between unit values and prices

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and thus, on quality substitution, I explore the extent of quality substitution. If unit values accurately reflected price changes, then a doubling of prices would result in a doubling of unit values.

Figure 4.1 plots the unit values against the prices of soda, the commodity group of interest.



Figure 4.1: Prices and unit values are natural logarithms of cohort means

The prices lie below the 45 degree reference line and the linear fit shows a miniscule positive association between prices and unit values. In this particular case, using unit values as a proxy for prices in a regression meant to identify the price elasticites would lead to biased estimates.

The reasons for the difference between unit values and prices remains. The official prices are the average of the prices levied by the government. Included are several instances of major brand such as Coca-Cola as well as beverages from the same "brand family": Fanta, Sprite and Lift. Underrepresented brands in the official list include Peñafiel, Jarritos, Sidral Mundet, Manzanita Sol and Mirinda. Although only one of these (Jarritos) is owned by a Mexican company, three of them (Peñafiel, Sidral Mundet and Manzanita Sol) were originally of Mexican ownership, now owned by international conglomerates. The difference in prices between brands in this particular commodity group can be considerable. For example, in February

2011, in the price station of Acapulco, a liter of Jarritos had a price of 3.84 MXN and one of Coca Cola one of 13 MXN¹⁹. The difference between prices and unit values illustrated in Figure 4.1 can be explained if the officially levied prices do not accurately mirror the average composition of the soda basket of each household. To corroborate such claim, I would need access to the detailed entries of the household surveys, which are not reported. Nevertheless, the distance in prices for such close substitutes, which are also reported in the same commodity group in the household surveys, offers ample room for substitution.

4.3.4 Commodity groups & nutritional content

The household surveys report information on commodity groups which in turn are comprised of commodity items. For example the commodity group soda is comprised of different brands of soda. The INEGI²⁰ report prices for different commodity items²¹ and also a key to match items to groups. Thus, there is an unequivocal assignment between both sources of data.

To obtain nutritional values for each commodity group, nutritional data for each was compiled from the United States Department of Agriculture (USDA)²². Please note that the nutritional content reported here does not refer solely to macronutrients as calories are not a nutrient per se but a measure of energy and that humans derive their energy from lipids, carbohydrates and proteins. Furthermore, carbohydrates are compounds of complex and simple sugars but simple sugar is reported separately. For simplicity, going forward I refer to "nutritional content" to the compendium of elements presented here.

Table 4.3 reports the nutritional content of sodas as well as two possible substitutes and chips. The nutritional elements of interest are presented in the first four columns with a selection of chemical elements in the last four.

Reported nutritional content can vary widely between official tables even for the same good, and this is surely the case for cooked food and for agricultural produce. As discussed above, in the case of industrially produced food, and particularly for soda, this is not the case. Nonetheless, this is the case for chips and similar, particularly with regards to the caloric content. This is a result of the wide variety of what in Mexico is called *botanas*, i.e. snacks and which can include potato chips as well as fried belly pork or maize treats. To avoid a distortion of the nutritional elasticities, the values reported here constitute a lower bound²³.

¹⁹This information was gathered from the indivual entries published the fourth of March 2011 in the DOF (Diario Oficial de la Nacion or Official Journal of the Nation).

 $^{^{20}\}mathrm{Or}$ the Mexican Central Bank, depending on the year

²¹The aforementioned different brands.

²²https://www.usda.gov/

 $^{^{23}\}mathrm{A}$ kilogram of potato chips can have up to 4000 kilo calories.

Commodity group	Calories	Protein	Lipids	Carbohydrates	Sugar	Na	Fe	Mg	Κ
Milk	640	32.8	36.6	46.5	48	490	.5	130	1510
Soda	480	0	0	120	120	30	0	0	0
Bottled water	0	0	0	0	0	10	0	20	0
Chips and similar	1330	21.9	33.9	235.1	2	3170	6.5	210	4000

 Table 4.3:
 Nutritional values

Notes: Values for a liter or kilogram. Calories are kilo calories. Proteins, lipids, carbohydrates, and sugar are reported in grams. Na (sodium), Fe (iron), Mg (magnesium) and K (potassium) are reported in milligrams.

4.3.5 Consumption of sodas

Soda intake has been an increasing concern in Mexico. In the last 20 years, the intake per capita has trippled and the number of households that report consuming soda regularly increased in the same time span, by circa 20 percentage points to around 70%. This increase in the consumption of soda does not appear to follow a regular trend as the overall energy intake from non-beverages does not appear to have changed (Barquera et al., 2008).

Figure 4.2 shows the mean quantity of liters and calories consumed per week across the food expenditure distribution.

At the upper end of the food expenditures the soda consumption alone accounts for 3500 kcal. Replacing that amount of soda with a non-caloric alternative, for example water, would lead to a weight loss of about 500 grams of fat in a person in a week. It is clear that achieving meaningful a reduction in calorie intake from sodas will be much easier at the higher levels of consumption that at lower levels, as a percentual reduction at lower levels translates to much smaller absolute values.

A concern going forward can be the possible relationship betwen unit values and quantity or total food expenditures. Households could buy in bulk because it is cheaper. Then unit value would not correctly reflect a quality decision but an economic one. Simultaneously, poorer households, those with lower absolute expenditures for food, might not be able to afford to buy in bulk. Unit values in that case will not reflect a quality decision, either.

As Figure 4.3 shows, there is no apparent relationship between unit value and quantity bought or unit value and food expenditures.


Figure 4.2: Quantity, calorie intake, and food expenditures



Figure 4.3: Unit values, soda quantity, and food expenditures

Notes: In the box at the bottom of each graph are the corresponding regression coefficients for the linear fit with their t-values in parentheses

4.4 Results

The price elasticities in Figure 4.4 were obtained by weighting each cohort with the square root of the number of households of which it is comprised and by including the prices for bottled water, milk, and chips as controls. The share of male individuals and the share of indigenous population in each cohort were included as further controls. The quality elasticity is computed as an average for all cohorts, for that reason the slope of both graphs is the same.





Notes: Note that the vertical axes are of the same length but are not in the same range.

The unadjusted elasticity lies just beneath -1 which is consistent with the literature on elasticities of sugar-added beverages (Andreyeva et al., 2010). Cohorts with higher food expenditures have larger (negative) elasticities. This price sensitivity might arise from larger substitution possibilities. The magnitude of the difference does not appear to be very large: the smallest value is -1.33 and the largest -1.093^{24} . With an average consumption of 5 liters of soda, a price increase of 1% would lead to decreases in consumption of 66.5 and 54.65 milliliter, respectively.

 $^{^{24}}$ Rounded to the third decimal.

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As expected, price increases are negatively associated with changes in unit value. In the case of soda (Figure 4.4), these changes are large enough to offset any changes in expenditure share associated with the price changes. The quality substitution is large enough to yield positive price elasticities of quantity, albeit the resulting elasticity is smaller than one. This undeproportional quantity increase associated with price increases grows smaller the larger the mean food expenditure of the cohort ist. While the quality elasticity is the same for all cohorts, cohort at the upper end of the spectrum appear so to be less affected, or less inclined, to substitute out of their prefered quality, as opposed to those at the lower end of the spectrum. Again, this might be a reflection of the available substitution posibilities.

Cohorts with lower food expenditures are less prone to engage in quality substitution. As indicated before, unit values and food expenditures are not related but as can be seen in Figure 4.5, cohorts with lower unit values, i.e. those that already consume at lower quality levels, have the lowest quality adjusted elasticities. If quality is a ladder, those that consume at very low quality levels figuratively cannot step any lower. Hence, a tax on sodas will record the largest impact in these households, as they are unable to quality-substitute away.



Figure 4.5: Quality adjusted elasticity and unit value

The large extent of quality substitution presented here has implications for

the efficiency and efficacy of the sugar tax in Mexico. This tax meant an average increase of around 10% per liter of soda. As Figures 4.6 and 4.7 show, the projected effect would be a modest change in sugar and calorie intake. As expected, the reduction is larger at higher levels of expenditure, as these are the cohorts with the largest consumption. The tax would lead to a reduction in the calorie intake between 200 and 400 calories on average in a cohort in a week.

Figure 4.6: Calorie intake change with a 10% tax on soda



Sugar intake would be reduced by around 50 grams on average in a cohort in a week. That is a reduction of about two table spoons of sugar.

These results are not particularly large, and it is doubtful that they alone would lead to meaningful changes in the prevalence of NC-CD. Not discussed are possible changes in consumption patterns and preferences that could lead to a long term reduction of sugar and calorie intake.

The results that take into account the quality substitution, presented in the right panel of each Figure, show a reversal of the modest results of a sugar tax. In both cases, calorie and sugar intake, the results are positive across the food expenditure distribution. Furthermore, due to the low magnitude of the quality corrected price elasticities, the absolute changes in calories and sugar intake turn out very small and the relationship between the magnitude of the absolute changes and food expenditures is no longer present.



Figure 4.7: Sugar intake changes with a 10% tax on suda

Average nutritional price elasticities of soda are presented in Table 4.4. Because these elasticities are based on the price elasticities discussed above, these nutritional elasticities include cross-price effects. Regarding their magnitude, we observe the same behaviour as before. Nutritional elasticities differ greatly between quality adjusted and unadjusted. With quality correction, the nutritional elasticities are reduced to a third of the unadjusted values and in the case of sugar, are positive, albeit very small.

		Calories	Proteins	Lipids	Carbohydrates	Sugar	Na	Fe	Mg	Κ
Adjusted	Mean SD	$-0.346 \\ 0.094$	-0.401 0.246	-0.402 0.271	$0.156 \\ 0.922$	$0.279 \\ 0.627$	-0.374 0.645	-0.407 0.076	-0.239 0.583	-0.403 0.040
Unadjusted	Mean SD	$-1.171 \\ 0.046$	-1.107 0.033	-1.118 0.038	-1.202 0.054	-1.171 0.037	-1.246 0.082	-1.331 0.094	-1.154 0.041	-1.174 0.063

Table 4.4: Adjusted and unadjusted nutritional elasticities

Notes: The elements presented in the last four rows are: Na (sodium), Fe (iron), MG (magnesium) and K (potassium).

Particularly the low price elasticity of calories as well as the positive elasticity of sugar might prove problematic in reaching any substantial changes in NC-CD, as they indicate low efficiency of any price increase in sodas in reducing calorie and sugar intake as would be needed to achieve positive health outcomes.

I use the ENIGH 2014 to compare the mean cohort level consumption and unit values for soda to those in the ENIGH 2012. The ENIGH 2014 was levied around seven months after the introduction of the tax.

The first step consists in comparing mean prices before and after the price increase. This is to see if there was actually a pass-throug of prices. While the literature on this particular tax (for example, Andalon and Gibson (2017)) mentions that there was an almost 100% pass-through rate, I want to visualize the magnitude of the increase for different cohorts and see if there is any relationship between the price increases and the food expenditure distribution. I achieve this by comparing the mean prices at the cohort level, in particular by visualizing the difference in mean values²⁵ (Figure 4.8). The prices reported thrughout this study are liter prices for which the tax was 1 MXN increase. As shown in the Figure below, the actual price increases lied well above that, with a mean price increase of just above 2 MXN per liter. It is worth mentioning that the prices reported here are not prices from January 2014 (i.e. at the moment the tax was introduced) but that the prices were matched to each household at the time the household was interviewed. This might account in some part for the overproportional price increase observed.

With regards to quantity of soda consumed, the unadjusted price elasticity predicts that an increase in the prices of 1% should lead to a decline of approximately 1% in quantity. The average price in 2012 for a liter of soda was of around 10 MXN, with an average price increase of a little over 2 MXN, the average decline in quantity should be of around 20%, that is an average decline in the consumption of soda with respect to 2012 of around one liter per week.

As shown in Figure 4.2 quantities consumed are the lowest at the low end of the food expenditure distibution with approximately four liters and the highest at the upper end of the distribution with almost 7 liters. Hence, one would expect the decline in absolute values to be the largest at higher levels of food expenditure. On the other hand, quality adjusted elasticities suggest a modest increase in consumption across the board.

Figure 4.9 shows the mean difference in quantities between both years for each cohort along the food expenditure distribution. The mean difference across cohorts is just below -0.47 liters. This differences are not consistent with a price elasticity of -1, but neither are they completely consistent with a quality adjusted price elasticity. Nevertheless, a comparison of the cohort mean levels between years yields that only eight cohorts display statistically different mean consumptions. The differences in quantities stemming from those cohorts are indicated by a black diamond in Figure 4.9.

²⁵All prices have been deflated with the corresponding monthly price index and are thus comparable.



Figure 4.8: Price differences 2012-2014

Notes: Differences are computed at the cohort mean. The mean difference in quantity across all cohorts (2.273836 pesos) is depicted by the solid horizontal line. A comparison of means yields that all differences are statistically significant. There is no statistical relationship between the difference in prices and food expenditure (not reported.).

While there is a significant price increase, there does not appear to be a corresponding decline in the consumption of soda. The argument put forward in the text is that the lack of an effect of the tax on consumption is due to quality substitution. That is, households will move towards goods in the same commodity group with lower quality and thus, lower unit value. Furthermore, this effect should be more salient in those households that are able to move to lower quality items. In the data this was the case for households at the upper end of the food expenditure distribution.

Figure 4.10 illustrates the differences in mean unit value for each cohort along the food expenditure distribution between 2012 and 2014. Again, statistically significant differences between means for each cohort are indicated by black diamonds while insignificant ones are clear circles. Moreover, the dotted line represents the relationship between the difference in unit values and the food expenditure. This relationship is statistically significant at the 1%.

Differences of zero or not significant differences mean that although prices per



Figure 4.9: Quantity differences 2012 - 2014

Notes: Differences are computed at the cohort mean. The mean difference in quantity across all cohorts (-.4617876 liters) is depicted by the solid horizontal line. Statistically simificant differences are depicted by solid diamonds. Not statistically significant differences are empty circles. There is no statistically significant relationship between the difference in quantities and the food expenditures (not reported.).

liter increased, on average, those cohorts are paying the same unit value as before the tax. But for this to be the case, they have to be most likely consuming lower quality items.

In conclusion, while prices for soda increase, there is not a corresponding decline in the quantities consumed. The data also suggests that those at low levels of food expenditure are unable to switch to a lower quality and bear the tax increase to a larger extent.



Figure 4.10: Unit value differences 2012-2014

Notes: Differences are computed at the cohort mean. The mean difference in quantity across all cohorts (1.149383 pesos) is depicted by the solid horizontal line. Statistically sinificant differences are depicted by solid diamonds. Not statistically significant differences are empty circles.

4.5 Conclusion

I estimate price elasticities of quantity for soda beverages in Mexico and differentiate between quality adjusted and unadjusted elasticities.

I find that quality substitution in this particular commodity group is large enough to offset any negative demand effects that could arise from a price increase, for example a tax. Particularly individuals with high food expenditures and high consumption of soda present a high tendency to substitute into lower quality items in the same commodity group. Conversely, quality substitution is less likely to occur at low food expenditure levels. A probable cause is that there is no room for quality substitution. One indication for this claim lies in the low unit values reported at low food expenditure levels. This would also mean that the brunt of any taxation scheme would be born by households with low food expenditures, which already display low levels of consumption. I show that after the tax is introduced in 2014 prices for soda increase overproportionally but quantities do not change as expected. Furthermore, unit values increase more strongly at lower levels of food expenditure. To better see the reason for this, note that the mean price for Coca-Cola in 2014 was 15 MXN while the prices for all other types of soda, including national brands, were just above 12 MXN²⁶. A taxation scheme that taxes all brands by the same amount per liter maintains this distance in prices. Households that consumed brands with higher prices before the tax is introduced will inevitable choose brands with relatively lower prices after the tax is introduced and thus will not necessarily change their consumption behaviour. In a situation were households with higher expenditures are also those with a higher consumption of the taxed good it is unlikely that such a tax will have any significant effect on the quantity consumed. Conversely, the tax will disproportionally fall on those households that consume those goods that display low prices, and thus low quality, and for which there is not a lower quality to choose. This means, that if those households able to pay a higher unit value are simultaneously those with the highest consumption, then the efficacy of such a tax has to be called into question.

The policy implications that can be drawn form this study point toward more complex solutions to the high soda consumption present in many countries. Amongst others, the existence of low quality substitutes appears to be the most problematic in achieving a significant quantity reduction. Individuals that already consume low quality items appear to respond more strongly to the tax, as the have less possibilities to engage in quality substitution.

The soda tax was implemented the 1st of January 2014. A study by Colchero et al. (2017) reports sustained decrease in soda purchases, up to 9% in 2015. In their study, they use store purchase data for more than 6000 households. Furthermore, they report that the largest decreases in purchases of soda were found at the lowest socioeconomic levels. Particularly this last finding is in line with low quality adjusted elasticities found in this study. As for the magnitude of their findings, they argue that the large, sustained decline in soda purchases could be attributed to an increased awareness of the negative effects of soda on health.

The main driver of the results in this study is the discrepancy between unit values gathered from a household expenditures survey and the prices levied by an official government source. Going forward, it would certainly be of interest to revise changes in purchases as well as in consumption along the quality spectrum. For example data on store purchases, in the likes of Colchero et al. (2017), could be used to determine if there is shift in the brands consumed, especially towards those with lower prices. Alternatively, albeit difficult, data on sales from the different companies that offer these brands could be analysed to determined the existence of a shift.

²⁶The price data per item is provided by the INEGI. The mean was computed over the months of September until November 2014. That is the same time frame during which the survey used in this study was levied.

4. NUTRITIONAL IMPACTS OF PRICE CHANGES: QUALITY AND QUANTITY SUBSTITUTION IN MEXICO

This question appears to be of importance in the discussion regarding consumption of goods that are easily over-consumed and for which there are a variety of qualities available, for example alcohol. In the last months of 2017, Scotland discussed and agreed on the implementation of a minimum price for alcohol to decrease over-consumption.

An interesting extension would be to consider information on physical activity and changes thereof. It is well known that the lack of physical activity plays an important part in maintaining and increasing physical as well as mental health (Rivera et al., 2002). In the past, Mexico has attracted attention with ingenious campaings to increase physical activity, for example offering free metro tickets in exchange for sit-ups. The efficacy and effectivenes of both types of both pecuaniary and non-pecuniary strategies should be weighted against one another. Finally, it would be interesting to consider the effect of zero sugar items as a substitute for sugar-added ones. Although Colchero et al. (2017) report that the share of this last beverages on total purchases is negligible, representative data on their consumption is not readily available. Beverages without sugar or with sugar substitutes could become a valuable alternative in the fight against NC-CD in the future.

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