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## ► To cite this version:

Osea Giuntella, Matthias Rieger, Lorenzo Rotunno. Weight gains from trade in foods: Evidence from Mexico. Journal of International Economics, 2020, 122, pp.103277. 10.1016/j.jinteco.2019.103277 . hal-02499475

**HAL Id: hal-02499475**

**<https://amu.hal.science/hal-02499475>**

Submitted on 21 Dec 2021

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# Weight gains from trade in foods: Evidence from Mexico\*

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This draft: October 3, 2019

## Abstract

In this paper, we investigate the effects of trade in foods on obesity in Mexico. To do so, we match data on Mexican food imports from the U.S. with anthropometric and food expenditure data. Our findings suggest that exposure to food imports from the U.S. can explain up to twenty percent of the rise in obesity prevalence among Mexican women between 1988 and 2012. Pro-obesity effects are driven by areas more exposed to unhealthy food imports. We also find evidence in favour of a price mechanism. By linking trade flows to obesity, the paper sheds light on an important channel through which globalisation may affect health.

Keywords: Trade, obesity, nutrition transition, Mexico

JEL codes: F60, F61, I10, I12

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\*We thank the editor and two anonymous referees for their constructive comments and advice. We are grateful to Nicolas Berman, John Cawley, Amitabh Chandra, Eleonora Fichera, Jessie Handbury, Sergi Jimenez, Fabrizio Mazzonna, Janneke Pieters, Brandon Restrepo and participants at the 2019 Food Trade and IO Workshop at INRA, 2019 CSAE Conference, 2018 FIW International Economics Conference, 2018 ISS-Wageningen Health Economics Workshop, IFPRI Workshop on Food Industries, Trade and Agriculture NBER Conference, 2018 ASSA meetings, 2017 HCHE Workshop on Risky Healthy Behaviors, 2017 ETSG Conference, 2017 FREIT Sardinia Conference, 2017 American-European Health Study Group Workshop, 2017 DIAL Conference, 2017 IRDES Workshop, 2017 Policy Evaluation in Health Workshop, and seminars at ARE Berkeley, UBC, Simon Fraser, IMT Lucca, Göttingen, Bocconi, PSE, TSE, and International Institute of Social Studies (ISS), Erasmus University, for their comments and suggestions. We thank Sarah Elven and Alessia Mortara for their able research assistance. Lorenzo Rotunno acknowledges support from the French National Research Agency Grant ANR-17-EURE-0020, the John Fell Fund (Oxford University Press, project LED0938), and the France-Stanford Collaborative Research project “A Nutritional Account of Global Trade”.

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# 1 Introduction

The prevalence of obesity, overweight and other diet-related chronic diseases has increased rapidly in the global south. Today, an estimated 62 percent of obese individuals live in developing countries (Ng and et al., 2014). And the number of overweight or obese people living in the developing world has tripled between 1980 and 2008 (Keats and Wiggins, 2014). Over the same period many emerging economies have opened up their food markets to international competition. In response, policy makers have paid more attention to the implications of globalisation and international trade for population health and diets. The World Health Organization (WHO, 2015), for instance, has adopted a clear mandate to help member states better align trade and health policies. Despite the perceived association between trade liberalisation and diet-related health outcomes (see the review by Barlow et al. (2017b)), the causal effects of trade in foods on obesity and their quantitative importance are not well established.<sup>1</sup>

The rise in obesity observed in emerging economies has been associated with a “nutrition transition” whereby diets become richer in animal fats, sugars, and processed foods as average income increases (Popkin and Gordon-Larsen, 2004). These nutritional changes are intertwined with an epidemiological transition in which populations suffer more from obesity, diabetes and cardiovascular diseases rather than infectious diseases and undernutrition (Omran, 1971).

Greater openness to trade in foods can affect the nutrition transition and hence obesity prevalence through changes in prices, income, norms, and tastes. Lower relative prices of imported and import-competing foods can raise food consumption and the incidence of obesity, especially if such price effects are concentrated in more unhealthy, ‘obesity-prone’ foods. By affecting individuals’ income, trade liberalisation can shape the nutrition transition and obesity prevalence. Finally, globalisation and trade openness can induce changes in food tastes and consumption, resulting in persistent and self-reinforcing effects on nutritional outcomes (Atkin, 2013; Dragone and Ziebarth, 2017).

In this paper, we examine the effects of U.S. exports of foods and beverages (F&B or ‘food’ for short) on obesity in Mexico. Over the last decades, Mexico has recorded spectacular increases in diabetes and obesity rates, becoming a prime example of a country in the nutrition transition (Popkin et al., 2012). According to the latest WHO data from 2016, it ranks among the thirty most obese countries in the world, with an estimated 28.9

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<sup>1</sup>A recent literature in public health has studied the association between trade liberalisation and availability of calories (Barlow et al., 2018), supply of products containing high-fructose corn syrup (Barlow et al., 2017a), and sugar-sweetened beverages (Lopez et al., 2017).

percent of the adult population being obese. Trade flows between the U.S. and Mexico have also boomed since the 1980s and in particular following the North American Free Trade Agreement (NAFTA) in 1994.<sup>2</sup> This is especially true for the F&B industry, where U.S. products represent around 75 percent of total Mexican imports and 8 percent of Mexican households' food expenditure in 2012 (see section 4.1 for details). These concurrent trends beg the question: has the U.S. 'exported' its high obesity prevalence (the highest among OECD countries (OECD, 2017)) to Mexico through trade in foods?

To identify the effect of U.S. food exports within Mexico, we allocate trade flows across Mexican states – i.e., the lowest spatial unit at which data are representative. We measure each state's 'exposure' with its historical expenditure by food product. The general idea is that national trade shocks affect regions and individuals differentially; depending on, for instance, their access to trade routes (Atkin and Donaldson, 2015) and their sectors of employment (Topalova, 2007, 2010; Autor et al., 2013; Dix-Carneiro and Kovak, 2017). In our paper, the share of total national expenditure of a given food product in each state at the start of the period measures exposure to trade shocks. In a shift-share design, this pre-determined and time-invariant measure of food consumption is used to predict changes in state-level food imports over time. The empirical approach implies that a Mexican state where expenditure in, say, processed foods, was higher at the beginning of the period will receive a larger share of a given increase in U.S. exports of processed foods. Reassuringly, the *imputed* changes in state-level food imports from the U.S. correlate strongly with *actual* changes in state food imports from the U.S., for which data are available only starting from 2006.

We focus on the import side of food trade between Mexico and the U.S. because of its immediate link with food consumption. While Mexican food exports to the U.S. and elsewhere also increased dramatically (a ten-fold increase in exports to the U.S.), lack of detailed production and employment data by product at the regional level hinders proper identification of their possible influences on obesity. Our analysis nonetheless checks for effects of increased Mexican food exports operating through relative food prices.

We document a positive and robust effect of U.S. food exports on changes in obesity prevalence across Mexican states.<sup>3</sup> Our analysis is based on anthropometric data for adult women collected through four surveys in 1988, 1999, 2006 and 2012, as data for men were

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<sup>2</sup>A large literature has examined the implications of Mexican economic liberalisation for economic growth (Hanson, 2010), labour markets and wage inequality (e.g. Hanson, 2007; Verhoogen, 2008), as well as retail prices and household welfare (Atkin et al., 2018).

<sup>3</sup>Obesity status is derived from the Body-Mass Index (BMI, equal to weight (in kg) over height squared (in meters)), commonly used as a measure of body fat.

only collected in later surveys (2006 and 2012).<sup>4</sup> The pro-obesity effect is confirmed in both long-difference and stacked first-difference specifications. The relationship between rising exposure to U.S. foods and obesity prevalence is statistically significant, also when controlling for state-level trends in obesity, exposure to foods from other countries (negatively and less strongly associated with obesity changes), and other state-level characteristics.

To bolster a causal interpretation of our findings, we follow [Autor et al. \(2013\)](#) and implement an instrumental variable (IV) strategy that aims at identifying supply-side shifters of U.S. food exports. Changes in U.S. food exports to other destinations than Mexico are used as instrument in order to isolate variation in U.S. food exports stemming from U.S. comparative advantage and market access to third countries across food products. Similar to the ordinary least squares (OLS) estimates, the IV results point to a sizeable causal effect of exposure to U.S. foods on the rise of obesity prevalence in Mexico. The supply-driven rise in U.S. food exports to Mexico can explain around ten percent of the spectacular increase in obesity prevalence among Mexican adult women observed between 1988 and 2012. The findings are confirmed when we use as instrument U.S. food exports to other countries as predicted by the residuals from regressions of U.S. food exports on product and destination fixed effects, which explicitly net out demand-side influences (see also [Autor et al. \(2013\)](#) for a similar strategy).

Counterfactual calculations using IV estimates illustrate that in the absence of food imports from the U.S. between 1988 and 2012, there would have been two millions fewer obese women in Mexico. While suggestive, these numbers point to a quantitatively important impact of food imports on obesity in Mexico, which is comparable to the effects of other changes in the local food environment found in the U.S. (see [Courtemanche and Carden \(2011\)](#) on obesity and Walmart supercenters expansions).

The strong obesity effect of American foods (relative to the lower and downward influence of those from other sources) hints at their unhealthiness, so we further categorize foods using the USDA Dietary Guidelines for Americans ([DGA \(2010\)](#); see also [Allcott et al. \(2019\)](#); and [Volpe et al. \(2013\)](#) for recent applications). While U.S. food exports to Mexico increased ten-fold between 1989 and 2012, exports of unhealthy foods featured the highest increases (e.g., exports of “food preparations” are 23 times higher in 2012 than in 1989). Similar patterns emerge when we group vegetables, fruits, fish and poultry into one category aggregating ‘healthy’ products, and pool other foods and drinks in an ‘unhealthy’ one. In the empirical analysis, this unhealthy component of changes in U.S. food exports drives our

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<sup>4</sup>We do confirm our baseline results using obesity data for men in the 2012 - 2006 difference (see footnote no. 30).

baseline findings. Moreover, the obesity effect of trade in unhealthy foods is amplified by low levels of education, potentially widening the already large disparities in obesity risk between women with different levels of education.

We submit our baseline findings to several robustness checks and extensions. In a temporal placebo test, we find that current changes in obesity prevalence are not related to future changes in food imports. Another falsification test using imports of apparel as an alternative measure of states' exposure to trade dismisses spuriousness due to overall trade with the U.S. The findings are also robust to controlling for Mexican food exports, the use of food imports statistics for final demand only, dropping specific states, and employing alternative dependent variables (BMI, overweight).

We explore mechanisms behind our baseline findings guided by standard neoclassical models of obesity (e.g., [Philipson and Posner \(2003\)](#); [Cutler et al. \(2003\)](#); [Lakdawalla and Philipson \(2009\)](#)). In these settings, individuals' utility increases with food consumption and with body weight up to a target weight level above which utility decreases with weight. Holding the ideal weight and the level of physical activity fixed, the reduction in relative food prices and the higher income potentially associated with greater trade integration might (at least initially) increase food consumption and body weight.

Greater import penetration in final goods can lower consumer prices through various theoretical channels – e.g., lower prices of imported goods, pro-competitive pressure on domestic producers, and elimination of policy distortions. As [Goldberg and Pavcnik \(2016\)](#) argue, the quantitative importance of the price-reducing effect of import liberalisation is however less clear and hinges on the specific market conditions. Using Mexican consumer price micro data (1995-2010) from [Gagnon \(2009\)](#) and [Gagnon et al. \(2013\)](#), we test for this mechanism in reduced-form by regressing national food prices on U.S. food exports to other countries – i.e., our instrument for foreign supply shocks. The results point to a negative and significant effect of U.S. export supply shocks on consumer food prices, whose magnitudes are in line with those found in previous studies ([Topalova, 2010](#); [De Loecker et al., 2016](#)). While prices of foods (and of other consumer products) went up in Mexico during the sample period ([Gagnon, 2009](#)), the evidence suggests that greater exposure to U.S. foods curbed food inflation – an effect that is concentrated in unhealthy food products. Mexican food prices did not respond to U.S. demand-driven shocks to Mexican food exports (as proxied by U.S. food imports from other countries than Mexico), suggesting that the rise of Mexican food exports did not have a significant effect on relative consumer prices. The price effects are strongly confirmed in regressions at the state level – greater exposure to U.S. food supply led to lower food prices, with no effect on local prices of other products.

Greater trade openness could affect food consumption and body weight by changing average income through increased competitiveness and market opportunities. This income channel should however pertain to overall trade rather than food imports only. On the import side, greater import competition can lead to reductions in wages (e.g., [Topalova \(2010\)](#); and [Dix-Carneiro and Kovak \(2017\)](#)), which could be partly mitigated by productivity increases through greater access to cheaper inputs (e.g., [Kis-Katos and Sparrow \(2015\)](#)). Our empirical strategy, exploiting differential exposure across food products (and hence within a single industry), is geared towards identification of consumption channels and cannot capture exposure through industry employment, which is normally adopted to identify income effects. In our empirical analysis at the state-level, we find no strong support for a systematic relationship between obesity rates and average income changes, providing little evidence that the obesity-inducing effect of greater penetration of U.S. foods is operating through changes in income.

Increased availability of U.S. foods over time can shift tastes for different types of foods. Consumers’ preferences exhibit taste formation when the marginal utility of current consumption increases with past consumption ([Dragone and Ziebarth \(2017\)](#); similar to what [Atkin \(2013\)](#) refers to as “habit” formation). Since higher U.S. food exports are significantly correlated with lower food prices, Mexican households could develop a stronger taste for foods that were relatively cheaper in the past because of exposure to U.S. supply. We test for this channel by regressing household budget shares on lags of U.S. food exports, while controlling for current state-level prices and household characteristics (including real expenditure). Results are overall consistent with habit formation, but the evidence is rather weak.

This paper provides the first causal evidence on trade in foods and obesity. It expands recent conceptual studies ([WHO, 2015](#); [Thow, 2009](#)) linking trade liberalisation to the nutrition transition and to the related rise in obesity, diabetes and other cardiovascular diseases in the global south. Existing cross-country studies provide mixed evidence – [Miljkovic et al. \(2015\)](#) and [Vogli et al. \(2014\)](#) report a positive and significant effect of trade openness on obesity and BMI, whereas the findings in [Oberlander et al. \(2017\)](#) and [Costa-Font and Mas \(2016\)](#) suggest that social (rather than economic) globalisation matters. We use detailed data from a single country, Mexico, and contribute to this nascent line of empirical work by identifying the impact of trade in foods (rather than total trade flows).

Our study also complements recent work on the adverse effects of trade liberalisation on health through income and labour market channels ([Colantone et al., 2019](#); [Adda and Fawaz, 2017](#); [Pierce and Schott, 2018](#); [Hummels et al., 2016](#); [Lang et al., 2019](#); [McManus](#)



and Schaur, 2016). Our paper applies a comparable shift-share identification strategy, but it is the first one to focus on obesity and on a demand-side channel operating through food consumption (Popkin and Gordon-Larsen, 2004; Rivera et al., 2004). In a similar vein, a recent study by Gracner (2015) leverages variation within Mexican states to document that reductions in the price of sugar-rich foods raise the prevalence of obesity, type 2 diabetes and hypertension. In this paper, we estimate the causal effect of food imports from the U.S. on obesity prevalence in Mexico, and then show empirically that the increasing penetration of U.S. foods has lowered the real price of foods. In line with the price effects of Gracner (2015), we find that the obesity impact of food imports is driven by unhealthy product groups

More broadly, we add to a large body of work on the economic determinants of obesity and dietary habits (Cawley, 2015). Courtemanche et al. (2016) find that the local economic environment (e.g., retailers and restaurants) explains a significant portion of the observed rise in obesity in the U.S.<sup>5</sup> Allcott et al. (2019), however, find that spatial differences in access to healthy foods explain only a small fraction of the differences in nutritional intake across people from different socioeconomic groups (e.g., with different levels of education). In our analysis, we find no evidence of a significant association between changes in obesity prevalence and the local food retail environment, as measured by food expenditure by place of purchase and consumption, and by state penetration of Walmart in Mexico. When controlling for these additional factors, the pro-obesity effect of U.S. foods remains unaltered. Our paper therefore highlights the role of international trade in foods as an independent economic driver of obesity.

The rest of the paper proceeds as follows. Sections 2 and 3 describe the empirical strategy and the data used in the analysis. Section 4 discusses the results, focusing on a descriptive analysis first (subsection 4.1), and then delving into the econometric results and extensions thereof (subsection 4.2). Section 5 discusses findings and some evidence of mechanisms. Section 6 concludes.

## 2 Empirical strategy

The empirical analysis follows three steps. First, we present some descriptive patterns in obesity and U.S. food exports to Mexico. Second, we estimate the effect of greater exposure to food imports from the U.S. on obesity prevalence. Third, we investigate possible mechanisms.

Our baseline specification relates obesity prevalence to exposure to U.S. food exports allocated to the 32 Mexican states – the lowest level of aggregation at which the health

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<sup>5</sup>See also Currie et al. (2010) on the effects of fast food restaurants on obesity.



surveys are representative –, controlling for state-level characteristics. In particular, we estimate the following regression:

$$(1) \quad \Delta Obesity_{s,t} = \beta_1 \Delta USimp_{s,t} + \beta_2 \Delta ROWimp_{s,t} + \beta_3 X_{s,t-1} + \beta_4 \Delta W_{s,t} + \theta_t + \epsilon_{s,t}$$

The ‘ $\Delta$ ’ operator denotes the difference between the value of the variable at time  $t$  and its value at  $t - 1$ . The empirical specification in differences attenuates concerns of serial correlation in the error term and is standard in shift-share designs used to study the local labour market impact of import competition (e.g., [Autor et al. \(2013\)](#)). Our data spans four periods (1988, 1999, 2006, and 2012), which correspond to the years of the health survey containing anthropometric information (individuals are not followed over time). We estimate regression (1) in a long-difference specification, where the  $\Delta$  operator indicates state-level differences between 2012 and 1988, and in a specification pooling the first differences in the sample (1999 - 1988, 2006 - 1999, and 2012 - 2006).

The  $\Delta Obesity$  variable equals the change in the share of adult women living in state  $s$  who have a BMI greater than or equal to 30 between  $t$  and  $t - 1$ . The main covariate of interest is  $\Delta USimp$  – imputed changes in food imports (PPP-adjusted) coming from the U.S. at the state level between  $t$  and  $t - 1$ .

The coefficient  $\beta_1$  identifies the effect of food imports from the U.S. on obesity in ‘reduced-form’. The variable  $\Delta USimp$  measures variation in states’ exposure to food imports as predicted by expenditure specialisation in different food products at  $t - 1$ . Specifically, differences in imputed food imports from the U.S. of state  $s$  over time are defined as:

$$(2) \quad \Delta USimp_{s,t} = \sum_g \frac{E_{g,s,t-1}}{E_{g,t-1}} \frac{\Delta M_{g,t}^{US}}{E_{s,t-1}}$$

where the subscript  $g$  identifies a food product. Changes in imports from the U.S. for each Mexican state at the product level are imputed from national trade statistics – imports at the state level are available only starting from 2006.<sup>6</sup>

In practice, we first convert U.S. food exports to Mexico from nominal US\$ to local Mexican consumer prices by multiplying the export values by the yearly PPP conversion factor for private consumption – in changes, this gives the variable  $\Delta M_{g,t}^{US}$  in equation (2). We then use the state’s expenditure share for a given product at  $t - 1$  (i.e., the state expenditure for a product relative to total national expenditure for the same product,

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<sup>6</sup>We show below that there is a strong correlation between our imputed and actual changes in Mexican state imports.

$\frac{E_{g,s,t-1}}{E_{g,t-1}}$ ) to allocate changes in (PPP-adjusted) imports across states. Imputed changes in state-level food imports from the U.S. ( $\sum_g \frac{E_{g,s,t-1}}{E_{g,t-1}} \Delta M_{g,t}$ ) are finally normalized by state food expenditures at  $t - 1$  ( $E_{s,t-1}$ ). The resulting variable,  $\Delta USimp_{s,t}$  measures changes in exposure to U.S. foods over time relative to household food expenditure (on both domestic and foreign foods) at baseline.

Variation in expenditure shares across states and products, as well as changes in trade flows over time identify our coefficient of interest,  $\beta_1$ , in the regression equation (1). If the food expenditure on each product is equally distributed across states, the  $\Delta USimp$  variable does not vary across states as well, and the  $\beta_1$  coefficient cannot be identified separately from period dummies  $\theta_t$  (or a constant term in the long-difference specification). More generally, time dummies absorb the influence of variation in national food imports from the U.S. as well as of other national shocks.

Our empirical design is borrowed from the literature on the local labour market impact of import competition (see, e.g., [Autor et al., 2013](#)), which has recently been applied to investigate the effects of imports on workers' health ([Colantone et al., 2019](#)). In this line of work, the objective is to investigate trade effects in the labour market and hence imports are allocated within countries according to sub-national and sectoral employment shares. In our analysis, we focus on a nutrition channel – expenditure shares are thus the relevant measure of trade exposure at the local level.<sup>7</sup>

The imputed import variable  $\Delta USimp$  can be thought of as an instrument for variation in the actual consumption of foods from the U.S. – which is unobserved until 2006 and likely to be endogenous to obesity prevalence. However, a causal interpretation of the  $\beta_1$  coefficient further requires that U.S. exports to Mexico vary across food categories and over time ( $\Delta M_{g,t}^{US}$  in equation (2)) with supply-side determinants of U.S. food production that are not affected by Mexican demand. We thus follow [Autor et al. \(2013\)](#) and exploit variation in U.S. food exports to other countries (except Mexico) in order to generate plausibly exogenous variation.<sup>8</sup> Our instrument is constructed as in equation (2) with changes in U.S. food exports to other destinations replacing U.S. food exports to Mexico. As a further

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<sup>7</sup>The coefficient  $\beta_1$  in equation (1) could still capture the influence of labour market channels (e.g., changing physical activity due to import competition) if the pre-determined expenditure shares correlate with initial employment shares.

<sup>8</sup>In previous versions of the paper, we considered U.S. food exports to the ten largest upper middle-income destination countries (UMIC) other than Mexico: China, Colombia, Costa Rica, Dominican Republic, Algeria, Malaysia, Russia, Thailand, Turkey and Venezuela. Using food exports to all other destinations, including countries at different stages of economic development and hence of the nutrition transition, alleviates concerns of cross-country correlation in food demand patterns. Results available upon request are nonetheless similar when using U.S. food exports to the ten major UMIC destinations to build the instrument.

check on our identification assumption, we also compute changes in the residuals from panel regressions of U.S. food exports on product and destination dummies (other than Mexico), and multiply these by U.S. food exports to Mexico in the initial period to construct our instrument.<sup>9</sup> Variation in these residuals should only come from changes in the patterns of U.S. comparative advantage in the food sector, and from any changes in market access. In particular, the product and destination fixed effects in the auxiliary regressions control for dietary shifts during the nutrition transition that are common to Mexico and other countries.<sup>10</sup>

The  $X$  term in equation (1) includes controls at the beginning of the period: lagged obesity changes and the food share of states' expenditure. By using initial expenditure shares to project variation in food imports over time, we are assigning more imports to states that were already on an upward trend in food consumption, and possibly in obesity prevalence. To control for such pre-existing patterns, the specification in (1) includes the changes in obesity prevalence during the previous period ( $\Delta Obesity_{s,t-1}$ ). For the long-difference specification and for the first time window in our sample (1999 - 1988), we set the value of  $\Delta Obesity_{s,t-1}$  equal to obesity prevalence in 1988 because of lack of data on obesity before then. Since the addition of the lagged obesity changes as a control in (1) can introduce endogeneity bias, in our baseline analysis we also present results without this regressor. With this pre-trend control though, our coefficient of interest  $\beta_1$  is identified off deviations in imputed food imports from states' trends in obesity. Its sign and size help assessing the role of exposure to U.S. foods in shaping the underlying and upward obesity trends observed in Mexico (and similar to those observed in other countries going through a nutrition transition). To make sure that the identifying variation in our variable of interest,  $\Delta USimp$ , comes from variation in food imports, we also control for the food share of states' expenditure at  $t - 1$ .<sup>11</sup>

Our preferred empirical specification controls for changes in exposure to food imports from countries other than the U.S. ( $\Delta ROWimp_{s,t}$ ) and for contemporaneous changes in other states' characteristics (collected in  $\Delta W_{s,t}$ ) that can shape obesity patterns and correlate

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<sup>9</sup>The residuals are differenced over the time periods in our estimation sample, averaged across destinations by product, and then exponentiated (see Dauth et al. (2014) for a similar approach).

<sup>10</sup>Time-varying demand shifters (from countries other than Mexico) could still affect the residuals. To net these out, we also constructed an alternative instrument by taking the residuals of regressions with the difference between U.S. food exports and Mexican food exports as dependent variable – to take into account the many zeros in the Mexican flows, we approximate the log difference by the difference in the inverse hyperbolic sine of the two export variables. This measure can proxy bilateral comparative advantage, and hence also reflect changes in Mexican productivity. Results (available upon request) are very similar to the baseline ones.

<sup>11</sup>This is equivalent to controlling for initial manufacturing share of local employment in the similar shift-share design of Autor et al. (2013).

with exposure to U.S. foods. State-level food imports from other countries are computed as for imports from the U.S. (see equation (2)), with  $\Delta M^{US}$  being replaced with changes in aggregate product-level imports from countries other than the U.S. (in PPP). The associated coefficient  $\beta_2$  is however likely to be biased for the same reasons that can bias the OLS coefficient on the U.S. food imports variable. Lack of a credible exclusion restriction that can identify global exogenous variation in food supply leads us to treat this variable as a control in our empirical analysis, in order to isolate the contribution of U.S. supply shocks to obesity in Mexico.

The matrix  $W$  controls for socio-demographic characteristics, namely the share of women in our sample with at least a high school diploma (a signal of high education attainment in our empirical setting), and for a measure of returning migration from the U.S. normalized the state’s population. We further control for more ‘economic’ variables that may be correlated with food imports from the U.S.: economic development as proxied by GDP per capita, the state’s stock of inward Foreign Direct Investments (FDI) (relative to the state’s GDP) and the unemployment share of adult women in our sample.<sup>12</sup> The state shares of total female population in the initial period (1990) are used as weights in the regressions to correct for sampling error in computing state-level variables and to ensure that our results are nationally representative. Standard errors in (1) are clustered at the state level.

### 3 Data

We use data on anthropometrics, expenditure and trade. The former are drawn from the Encuesta Nacional de Nutricion (ENN, 1988 and 1999) which then became the Encuesta Nacional de Salud y Nutricion (ENSA, 2006 and 2012).<sup>13</sup> The survey changed structure and expanded its content over time. However and importantly for our study, the surveys are representative at the state level. The ENN collected anthropometrics data only for children and women between 20 and 49 years of age. For this reason, we restrict our baseline analysis to this sample of adult women, and check the robustness of our results using men and other age groups surveyed in the ENSA (2006 and 2012). In each survey year, we compute obesity prevalence as the share of surveyed women between 20 and 49 years of age who are classified

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<sup>12</sup>GDP per capita and the returning migrants’ share in the state’s population are both in logs. The log of the FDI over GDP variable (equal to  $\ln(FDI) - \ln(GDP)$ ) is approximated by the difference between the inverse hyperbolic sine transformations of FDI and GDP in the presence of zeros in the FDI variable.

<sup>13</sup>We use these data rather than the individual panel data of the [Mexican Family Life Survey](#) (MXFLS) because the MXFLS is not representative at the state level (the smallest spatial unit at which the expenditure data are representative) and because it goes back only to 2002. Hence, using it would miss the major changes in U.S. food exports to Mexico that occurred in the 1990’s.

as obese. Due to lack of anthropometric data for five states in 1999,<sup>14</sup> we linearly interpolate (by state) using the preceding (1988) and subsequent observation (2006) to impute obesity prevalence for those observations.<sup>15</sup> It should be noted that this data issue does not affect the 2012 - 1988 changes in obesity prevalence or our results as we control for the added noise with an indicator for those five states with missing data in the relevant time periods.

The health surveys contain information on individual socioeconomic risk factors (education, employment status, household type) linked to obesity. We aggregate the education and employment variable at the state-level to control for the share of women in our sample with at least a high school diploma (measure of high education) and for the unemployed share of women. In individual-level extensions of our baseline model (equation (1)), we add a broader set of individual controls, including an index for the position of each household in the sample wealth distribution.<sup>16</sup>

Data on household expenditure are drawn from waves of the Encuesta Nacional de Ingresos y Gastos de los Hogares (ENIGH), the Mexican household-level survey on expenditure by detailed product categories, covering the period of the obesity data (from 1989 to 2012). State expenditures in 1989, 1998 and 2006 are used to compute changes in exposure to food imports (e.g.,  $\Delta USimp$  in (2)) over the 1988 - 1999, 2006 - 1999, and 2012 - 2006 periods, respectively.

Mexican imports from the U.S. and other trade variables starting from 1989 (all in current US\$) are sourced from UN COMTRADE. After harmonizing the product classification of the trade (SITC, revision 3) and expenditure data, we obtain a sample of 152 foods and beverages with a full time series of expenditures and imports.<sup>17</sup> Trade values in current US\$ are converted into local Mexican consumer prices by using the yearly PPP conversion factor for private consumption from the World Development Indicators.

Variation in  $\Delta USimp$  across states and over time comes from the interaction of pre-determined expenditures shares and time-varying U.S. food exports to Mexico (see

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<sup>14</sup> The 1999 wave of the ENN survey does not include four states and the state of Chihuahua has very few anthropometric measurements.

<sup>15</sup> As an alternative solution, we assign the average change in obesity prevalence across states in 1999 - 1988 and in 2006 - 1999 to those five states with missing data. Results (available upon request) are virtually identical to those presented here.

<sup>16</sup> We perform a principal component analysis of different household asset variables for each year (e.g., whether the house has walls made of concrete, a TV, a fridge) and use the first component as an index of household wealth. We then allocate households to quintiles of the index in order to mitigate sampling error.

<sup>17</sup> We exclude 16 products for which the matching with the trade or health (USDA) classifications was highly problematic, because of imprecise definitions (e.g. "loose seeds", "packaged seeds", "packed chillis") or because there was no clear international (e.g., "Pueblan chillis for stuffing", "unpasteurized milk") or health (e.g., "Cinnamon") category. They represent, on average, 3.5 percent of state imputed imports from the U.S. and 2 percent of state household expenditure.

equation 2). In order to identify the demand channel going from exposure to U.S. foods to obesity, these imputed imports should correlate with actual values. To verify this, we use data from the TransBorder Freight Database, reporting U.S. exports by broad sector to each Mexican state starting from 2006. A different sector classification and the inclusion of both final and intermediate goods in the TransBorder Database make it difficult to ensure a good match between imputed and actual food imports.<sup>18</sup> In spite of these data shortcomings, Figure A1 in the Appendix shows a strong correlation between actual and imputed food imports. Partialling out year fixed effects in Panel (a) delivers a positive and significant slope coefficient on imputed imports, whose variation can explain 71% of the residual variance in actual imports, as denoted by the partial  $R^2$ . In Panel (b), we control for both state and year fixed effects, exploiting the within-state variation in imports over time that also helps identifying the obesity empirical model. The estimates imply that, after netting out the influence of year dummies, changes in imputed imports over time can explain up to 38% of the within-state variation in actual imports. These results suggest that our allocation of national food imports to states can explain a substantial part of the variation over time in actual states' food imports from the U.S..<sup>19</sup>

When investigating plausible mechanisms underlying our main findings, we make extensive use of the micro data on Mexican prices that form the official Consumer Price Index (CPI).<sup>20</sup> These data, made available by Gagnon (2009), provide monthly price quotes identified by store, city and product category, between 1993 and 2010 (see Atkin et al. (2018), and Gracner (2015) for applications using similar price data). Although the time series do not cover the full set of health surveys with obesity data (seven Mexican states had no prices collected before 1995)<sup>21</sup>, the CPI microdata are representative of Mexican households' consumption basket, and the monthly quotes provide an accurate measure of annual food prices.<sup>22</sup> For these reasons, we adopt the CPI data to test for the price effects of exposure to

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<sup>18</sup>We define food imports in the TransBorder Freight Database as the sum of the product codes 16 to 22 in the classification available here: <https://www.bts.gov/sites/bts.dot.gov/files/docs/browse-statistical-products-and-data/transborder-freight-data/220171/codes-north-american-transborder-freight-raw-data.pdf>.

<sup>19</sup>If deviations from actual state food imports in our imputed import variable  $\Delta U Simp$  are correlated with obesity prevalence, they would lead to non-classical measurement error and bias our estimates. Univariate regressions of the difference between  $\Delta U Simp$  and the 2012 - 2006 change in actual food imports (normalized by the state's food expenditure, as for  $\Delta U Simp$ ) on obesity changes over the 2012 - 2006 period or on obesity prevalence in 2006 yield insignificant coefficients (point estimate=-0.03, std. error=0.13; and point estimate=-0.004; std. error=0.15), thus going against endogeneity due to non-classical measurement error.

<sup>20</sup>We thank an anonymous referee for pointing us to these data.

<sup>21</sup>Eleven Mexican states (out of 32) have more than one city (at most three) where prices are recorded. In our aggregation procedure, we average (log) prices of the same product across cities in the same state.

<sup>22</sup>The CPI microdata are of better quality than the self-reported unit values from the ENIGH expenditure surveys. ENIGH unit values at the household level do not capture the price of new and different varieties of



U.S. foods starting from 1995, when all Mexican states were included in the sample. Most of the food product categories can be easily matched with the ENIGH products – we could find the prices of 125 out of the 152 food products considered in the obesity regressions. The set of product categories is roughly constant over time, while product varieties (defined at the level of price quotes) changed substantially after 2002, which makes it impossible to track the price of the same variety throughout the sample. We follow [Gagnon \(2009\)](#) and drop implausible prices quotes and prices of products for which quantity units changed over time. Annual prices are obtained as averages of monthly price quotes (in logs). These are further averaged at the ENIGH product level, thus providing our measure of (log) prices of foods (and non-food products), aggregated at the country or state level. Importantly, we have no information on purchases at the level of price quotes (equivalent to varieties of the same food product).<sup>23,24</sup>

Part of the analysis tries to distinguish expenditure and trade in healthy and unhealthy foods. To identify these categories, we follow [Volpe et al. \(2013\)](#) (see also [Oster \(2018\)](#), and [Allcott et al. \(2019\)](#) for recent applications) and aggregate food products in the 52 groups used by the Quarterly Food-at-Home Price Database (QFAHDP). We classify these as healthful or unhealthful following USDA Dietary Guidelines for Americans ([DGA \(2010\)](#); also in [Volpe et al., 2013](#)). Healthy foods are those recommended for increased consumption (e.g., “dark green vegetables”), whereas unhealthy foods are those recommended for limited consumption (e.g., “refined flour and mixes”). We assign the food items from the trade and expenditure data to the 52 USDA food categories on the basis of their text description. Table A1 in the Appendix lists the food products and their USDA category. In the last column, we report a more conservative classification that restricts the healthy category to vegetables, fruits, fish and poultry.

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a food product, and are recorded by monitoring households’ purchases for one week only.

<sup>23</sup>This type of information is normally available in consumer panel microdata collected by market research companies (see [Atkin et al. \(2018\)](#)). Moreover, the price microdata cannot be used to construct store-specific price indexes because the store identifier changes with the product category.

<sup>24</sup>Data for state-level GDP and FDI stock are drawn from [INEGI](#). State population data is aggregated from the [Mexican censuses](#) in 1990, 1995, 2000, 2005, 2010, and interpolated in the years in between. We use data from the [EMIF](#), an annual survey starting from 1995, to obtain the number of Mexicans living in the U.S. who came back to Mexico in a given year, by Mexican state of birth. This flow is normalized by the state’s population. For the first period of our sample (1988), we use the Mexico census in 1990 and compute the share of people living in a state who reported having lived in the U.S. during the preceding five years.



## 4 Results

Before discussing the results of the econometric analysis, we provide some descriptive evidence on the evolution of obesity and U.S. food exports to Mexico in our sample, running from 1988 to 2012 and with data on obesity available at four points in time.

### 4.1 Descriptive evidence

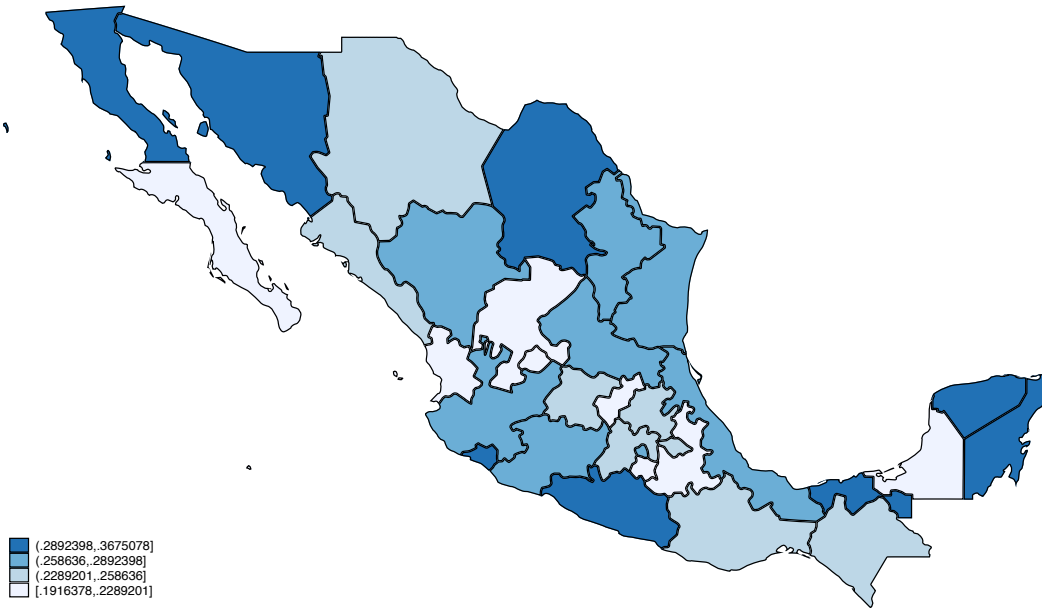
Our anthropometric data replicate the spectacular rise in obesity that is documented in other work on Mexico (Rtveladze et al., 2014). Average BMI of women is 19 percent higher in 2012 than in 1988, and the rate of obesity prevalence dramatically increased during the same period, going from 10 to 35 percent.<sup>25</sup> The share of women who are overweight or obese (i.e. with a BMI of at least 25) doubled from 35 to 70 percent.

Obesity among adult women increased nationally, yet the rate of change varies across Mexican states as shown in Figure 1 (showing the variable  $\Delta Obesity$  used in the long-difference specification). The state of Nayarit experienced the smallest increase (19 percentage points), while the biggest increase (37 percentage points) is recorded in Quintana Roo.

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<sup>25</sup>Survey weights are used for the 1999, 2006 and 2012 waves to compute these statistics. We use state-level weights equal to the number of adult women respondents divided by the relevant state population in 1990 for the 1988 survey, where survey weights are missing or have implausible values. Using an alternative measure of obesity based on the waist-to-height (WTH) ratio (women with a WTH over 0.58 are normally classified as obese), we find that obesity prevalence went from 18 to 42 percent between 1999 and 2012. We do not have data on waist in 1988.

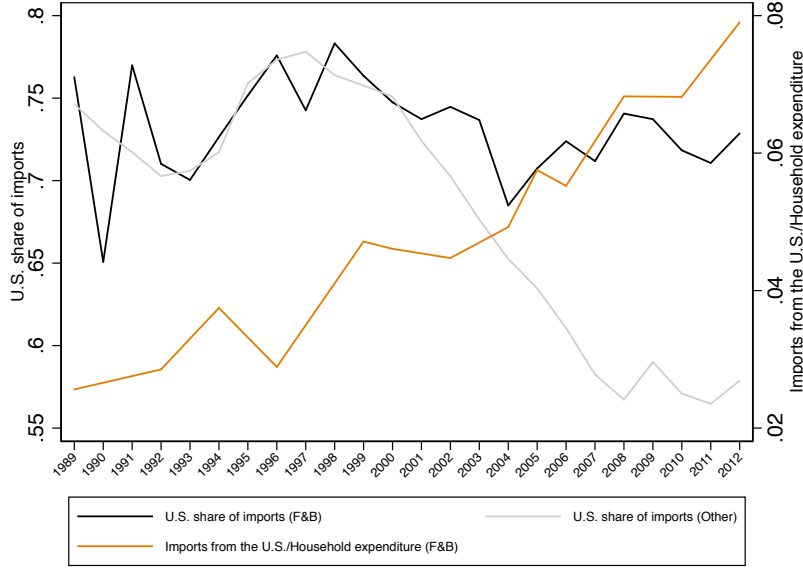
Figure 1: Changes in obesity prevalence across Mexican states between 1988 and 2012



At the same time, trade flows between Mexico and the U.S. have been rising steadily, following economic liberalisation policies adopted by the Mexican government and the formation of NAFTA in 1994. This trend is particularly visible in the F&B sector. Figure 2 shows that the U.S. are by far Mexico’s largest source of imports of F&B, whereas their importance in Mexican imports of other manufacturing goods has declined during the 2000s mainly because of heightened competition from emerging economies like China (Mendez, 2015). Figure 2 also portrays how the share of imports from the U.S. in total Mexican household expenditure in F&B (‘import penetration’) tripled between 1989 and 2012, going from 2.5 to 8 percent.<sup>26</sup> In comparison, food imports from other countries (ROW) have played a smaller role in Mexican food consumption over the same period – their share in total food expenditure went from 1.9 to 3 percent.

<sup>26</sup>These shares are lower if we consider only imports classified for final consumption (see section 4). Under this alternative definition, import penetration in household food expenditure went from 2 to 5.6 percent between 1989 and 2012. In the graph, import penetration is computed taking only imports and total expenditures on the 152 foods that have been successfully matched in the trade data and expenditure survey – the same set of products used in the regressions. Adopting the full set of SITC food products and the total household food expenditures computed from ENIGH, import penetration goes from 6 to 12 percent between 1989 and 2012.

Figure 2: U.S. share of Mexican imports and U.S. import penetration in Mexican food expenditure



Note: Mexican food imports are those under the one-digit categories 0 and 4, and the two-digit categories 11 and 22 of the SITC Revision 3 classification. Import values in current US\$ are converted in Mexican consumer prices using the annual PPP conversion factor for private consumption. Mexican household food expenditures are imputed from the ENIGH surveys using the households' sampling weights.

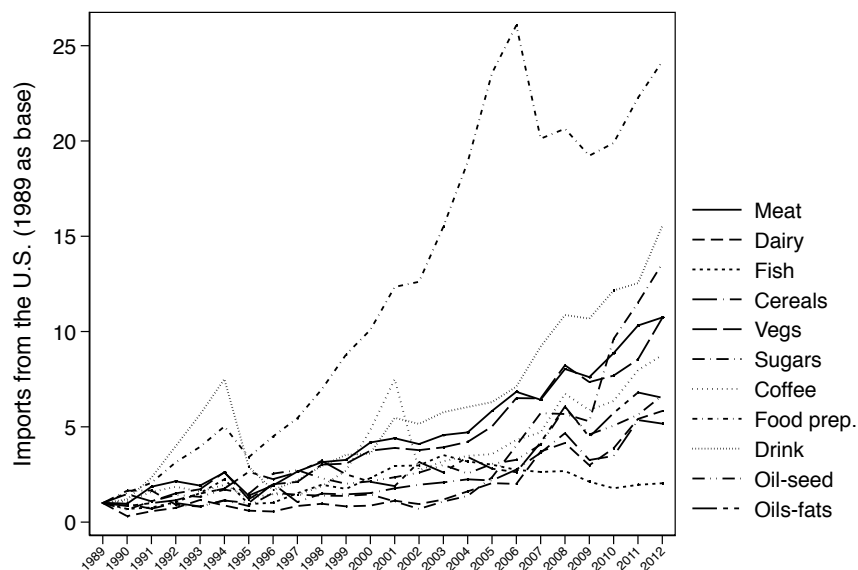
Our empirical strategy allocates U.S. food exports to Mexican states using expenditure shares by food product in the initial period. The map in Figure A2 in the Appendix illustrates the geography of changes in imputed food imports between 1989 and 2012, normalized by state's food expenditure in 1989 – the variable  $\Delta USimp$  in (2) for the long-difference specification. While exposure to U.S. foods increased everywhere, states were exposed differentially so. The increase in imputed imports was 2.9 times higher than total food expenditure in 1989 in the state of Tabasco (the largest relative increase), while the state of Durango reported the smallest relative increase in imports of U.S. foods (92% of the initial level of food expenditure). States on the Gulf of Mexico experienced higher increases in the penetration of U.S. foods than other states, while states on the U.S. border, whose labour markets and production structure have been affected the most by greater market access to the U.S. (i.e., via exports – see Hanson (2003); and Chiquiar et al. (2017)), have received relatively modest inflows of U.S. foods.<sup>27</sup>

The evolution of aggregate U.S. food exports to Mexico can mask important variation across different types of products. In Figure 3, we plot U.S. food exports by main F&B categories over time relative to their values in 1989 (in current US\$). Products

<sup>27</sup>Table A2 dissects this variation further and tabulates values for each state and time period used in the regression analysis.

that are generally associated with an unhealthy and obese-prone diet have been driving the overall increase in Mexican food imports from the U.S. More specifically, imports of “Food preparations” (including preparations of fats, sauces, soups, and homogenised foods) exhibited the highest relative increase among all food categories, going from 35.5 to 859 millions US\$.<sup>28</sup> “Drinks” and “sugars” also displayed large rates of change, recording fifteen-fold and fourteen-fold increases, respectively. While purely illustrative, these patterns suggest that the surge of Mexican imports from the U.S. was concentrated in generally ‘bad’ foods, which might have accelerated the spread of the obesity epidemic.

Figure 3: Mexican imports of F&B from the U.S. over time



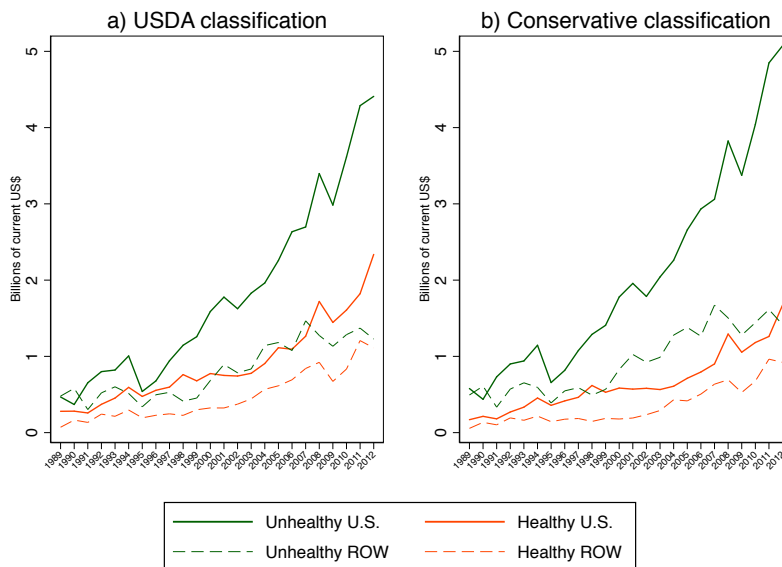
Note: U.S. exports in current US\$. Food categories are defined following the SITC Rev. 3 product classification: ‘Meat’ is category “01 – Meat and meat preparations”; ‘Dairy’ is category “02 – Dairy products and birds’ eggs”; ‘Fish’ is category “03 – Fish (not marine mammals), crustaceans, molluscs and aquatic invertebrates, and preparations thereof”; ‘Cereals’ is category “04 – Cereals and cereal preparations”; ‘Vegs’ is category “05 – Vegetables and fruit”; ‘Sugars’ is category “06 – Sugars, sugar preparations and honey”; ‘Coffee’ is category “07 – Coffee, tea, cocoa, spices, and manufactures thereof”; ‘Food prep.’ is category “09 – Miscellaneous edible products and preparations”; ‘Drink’ is category “11 – Beverages”; ‘Oil-seed’ is category “22 – Oil-seeds and oleaginous fruits”; and ‘Oils-fats’ is category “4 – Animal and vegetable oils, fats and waxes”.

This bias towards unhealthy American foods is even clearer after we classify the SITC products according to the ‘healthy’ and ‘unhealthy’ categories of the USDA. As shown in panel (a) of Figure 4, the latter increased faster than the former, especially starting from the mid-1990’s. Trends are similar when we use a more conservative classification that restricts the healthy category to vegetables, fruits, fish and poultry (see panel (b)). Starkly different patterns are instead observed for imports of foreign non-American foods – see the dashed

<sup>28</sup>Within the corresponding chapter “09 – Miscellaneous edible products and preparations”, the product category “09893 – Food preparations for infant use” recorded the largest increase in imports relative to the base level in 1989 (a ninety-three-fold increase). “09899 – Miscellaneous food preparations” experienced the second largest relative increase (and the largest absolute one), followed by “09843 – Mustard preparations”.

lines in Figure 4. According to the USDA classification, the value of unhealthy foods from ROW went from 0.5 to 1.2 billions US\$ between 1989 and 2012 – a much milder rise than the almost ten-fold increase in imports of unhealthy foods from the U.S. Overall, total Mexican food imports have become increasingly unhealthy, mainly because of U.S. foods.

Figure 4: Unhealthy and healthy Mexican F&B imports from the U.S. and ROW



Note: The “conservative” classification considers only vegetables, fruits, fish and poultry (the ‘Vegs+’ group, see Table A1).

## 4.2 Effects of food imports on obesity

Our benchmark specification allows us to assess the effect of changes in exposure to food imports from the U.S. – computed using pre-determined expenditure shares at the product level – on changes in obesity prevalence of adult women at the state level. We first show results using long differences (2012 - 1988), and then exploit all four survey rounds in the form of stacked first differences. The results from these baseline specifications are submitted to a number of checks – falsification tests, alternative measures of trade exposure, changes in the local retail environment, and other anthropometric outcome variables.

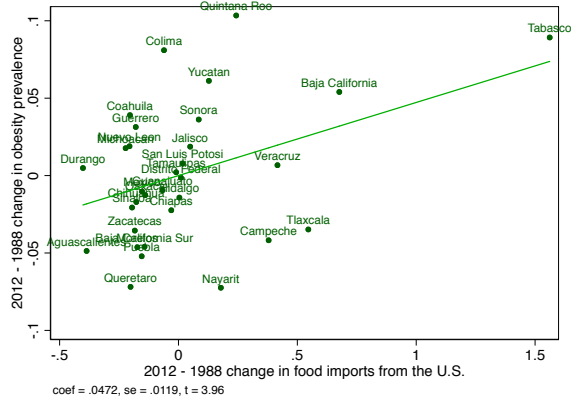
### (a) Baseline results

We document a positive relationship between long-run changes in exposure to foods coming from the U.S. and changes in obesity between 2012 and 1988. Figure 5 shows the

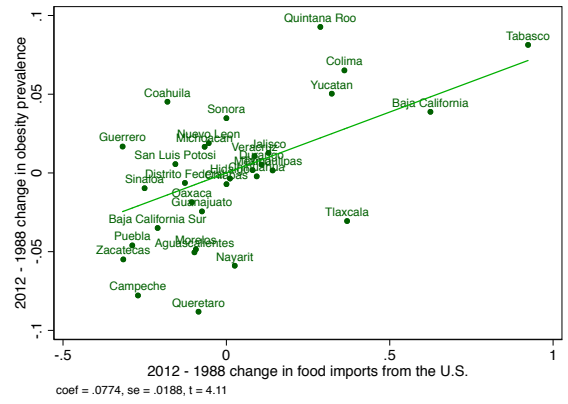
univariate relationship between the two changes (Panel (a)), which is robust to the inclusion of the full set of control variables and the lagged obesity trend (Panel (b)).

Figure 5: Long differences in obesity prevalence and in food imports from the U.S.

Panel (a): 2012 - 1988 changes, unconditional



Panel (b): 2012 - 1988 changes, with covariates



Note: Variables on the vertical and horizontal axis are ‘partialled out’ of the constant term and controls. Panel (a) is from estimates in Table 1, column (1), Panel (a.i). Panel (b) is from estimates from Table 1, column (1), Panel (d.i).

The long difference results are reported in Table 1, columns (1) to (3). One may be concerned that some of the covariates are potentially endogenous, and thus introduce bias in our estimations. To evaluate the sensitivity of our results to the inclusion of controls, we move from an unconditional to the fully-specified model in equation (1) through four panels: no covariates in Panel (a); adding relatively more exogenous sociodemographic controls ( $\Delta$  High educ. share and  $\Delta$  Ln(Migrant/Pop)) in Panel (b); including all the controls ( $\Delta$  High educ. share,  $\Delta$  Ln(Migrant/Pop), as well as Food expenditure share<sub>*t*-1</sub>,  $\Delta$  Ln(GDP per cap.),  $\Delta$  Ln(FDI/GDP),  $\Delta$  Unemp. share, and  $\Delta$  Food imports from ROW) in Panel (c); employing all controls plus the lagged obesity trend in Panel (d). In particular, the last step of adding lagged obesity changes (equal to the 1988 levels in the long difference specification) to the set of covariates permits to gauge the influence of the Nickell (1981) bias in the stacked first-difference model.

Consider first the OLS estimates in column (1). The unconditional point estimate of 0.0472 in Panel (a.i) implies that a one standard deviation increase in trade exposure (0.30, see Table A3 for summary statistics on our main variables) is associated with a 1.4%-points increase in the change in obesity prevalence (as reported in the bottom part of the panel). This amounts to 5.4% of the mean change in obesity. Including demographic variables in Panel (b.i) does not change the point estimate substantially. The coefficient on changes in food imports from the U.S. increases to 0.0761 when all controls are included (Panel c.i), and remains stable when we further add lagged obesity in Panel (d.i).

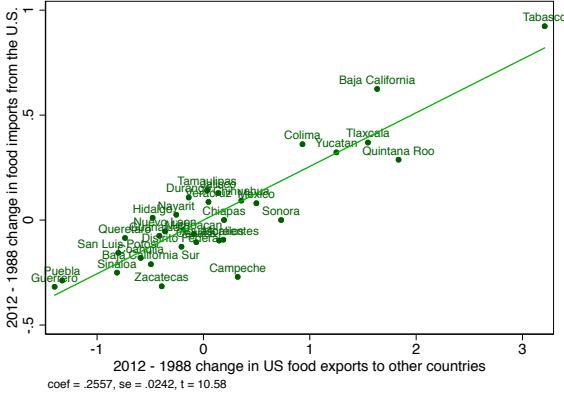
In the full model, a one standard deviation increase in exposure to U.S. foods is associated with a 2.3%-points increase in the change in obesity prevalence (equivalent to about one tenth of its mean change). The estimated coefficients on the control variables are given in Table A4. Changes in food imports from the ROW are negatively correlated with obesity (a finding that we discuss in more detail at the end of this sub-section), whereas the coefficients on the other state-level covariates are not significant.

A positive association between obesity prevalence and exposure to U.S. foods can be driven by Mexican demand-side determinants that co-shape changes in obesity. Using expenditure shares at the beginning of the period to allocate changes in national food imports can alleviate this threat, but proper identification of causal effects requires isolating U.S. food exports due to supply-side factors. To this end, we instrument Mexico’s imports from the U.S. with U.S. exports to other countries (Table 1, column (2)). As before, we provide unconditional and conditional point estimates in the four Panels (a.i-d.i). The IV coefficients are similar to their OLS counterparts in each panel and are always statistically significant. The unconditional causal estimate implies that if a state experienced a 0.3 higher change in penetration of U.S. foods, obesity prevalence among adult women would have risen by additional 1.5%-points. The same effect increases to 2.4%-points in the full baseline model (Panel d.i), with no changes with the respect to the specification excluding the lagged obesity variable (Panel c.i). Figure 6 summarizes our IV strategy, controlling for lagged obesity, concurrent changes in food imports from other countries, and changes in other covariates. Panel (a) of this figure reveals that U.S. exports to other countries are a strong predictor of U.S. food exports to Mexico. Panel (b) of the same figure displays the reduced form relationship: a significant and positive link between changes in U.S. food exports and changes in obesity in Mexico.

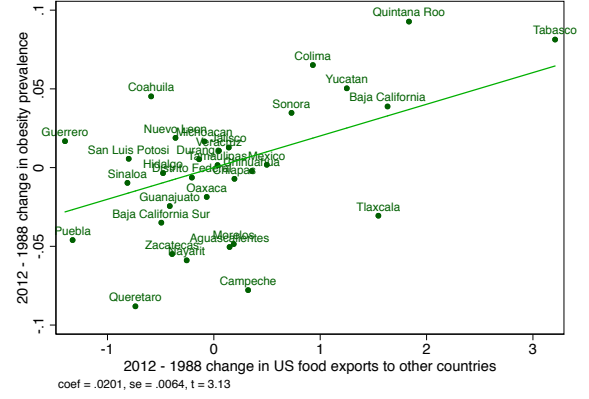


Figure 6: Instrumental Variable strategy

Panel (a): 1st stage 2012 - 1988 changes, with covariates



Panel (b): Reduced form 2012 - 1988 changes, with covariates



Note: Variables on the vertical and horizontal axis are ‘partialled out’ of the constant term and controls. Panel (a) is from estimates in Table 1, column (2), Panel (d.i).

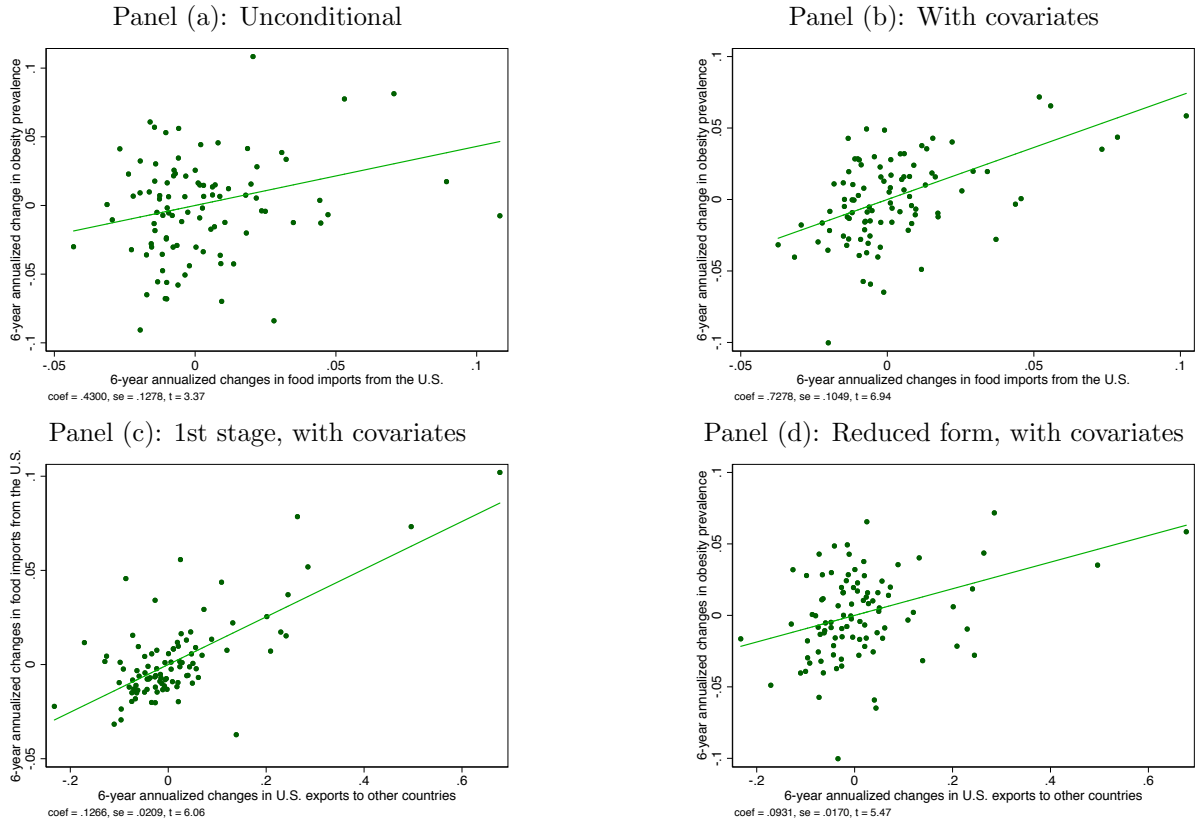
Identification can however remain problematic because variation in U.S. food exports to other countries may be correlated with food preferences in these destinations – which could be similar to the ones observed in Mexico. To alleviate such concerns, we use the changes in residuals from regressions of U.S. food exports on product and destination fixed effects to project U.S. food exports to Mexico from the initial period. These constructed changes in U.S. food exports are then used to build our instrument, as per equation (2). The variation in the residuals should stem from changes in comparative advantage and market access for U.S. products. Column (3) of Table 1 shows that these gravity-based IV estimates are similar to the OLS ones (column 1) and nearly identical to the other IV ones (column 2) within each panel.

Qualitatively similar patterns emerge when we exploit all four survey rounds and estimate stacked first differences (2012 - 2006, 2006 - 1999, 1999 - 1988). To make the periods comparable, changes in obesity prevalence and foods imports are annualized over a six-year period. Compared to the long-difference specification, pooling first differences enlarges our sample and attenuates the influence of single observations. A limitation of this specification is that obesity data are missing for five states in the health survey of 1999 (see section 3 and footnote 14). We assign the linearly interpolated obesity prevalence by state to fill these gaps. As this adds noise to our outcome variable, we include a dummy variable for those five states in the imputed periods (1999 - 1988 and 2006 - 1999).

Figure 7 displays the main obesity-U.S. imports relationship with stacked first differences in the top row. The pooled plots point to a robust, positive link with and without covariates. In Figure 8, we investigate the stability of findings in the three sub-periods. We find sizeable

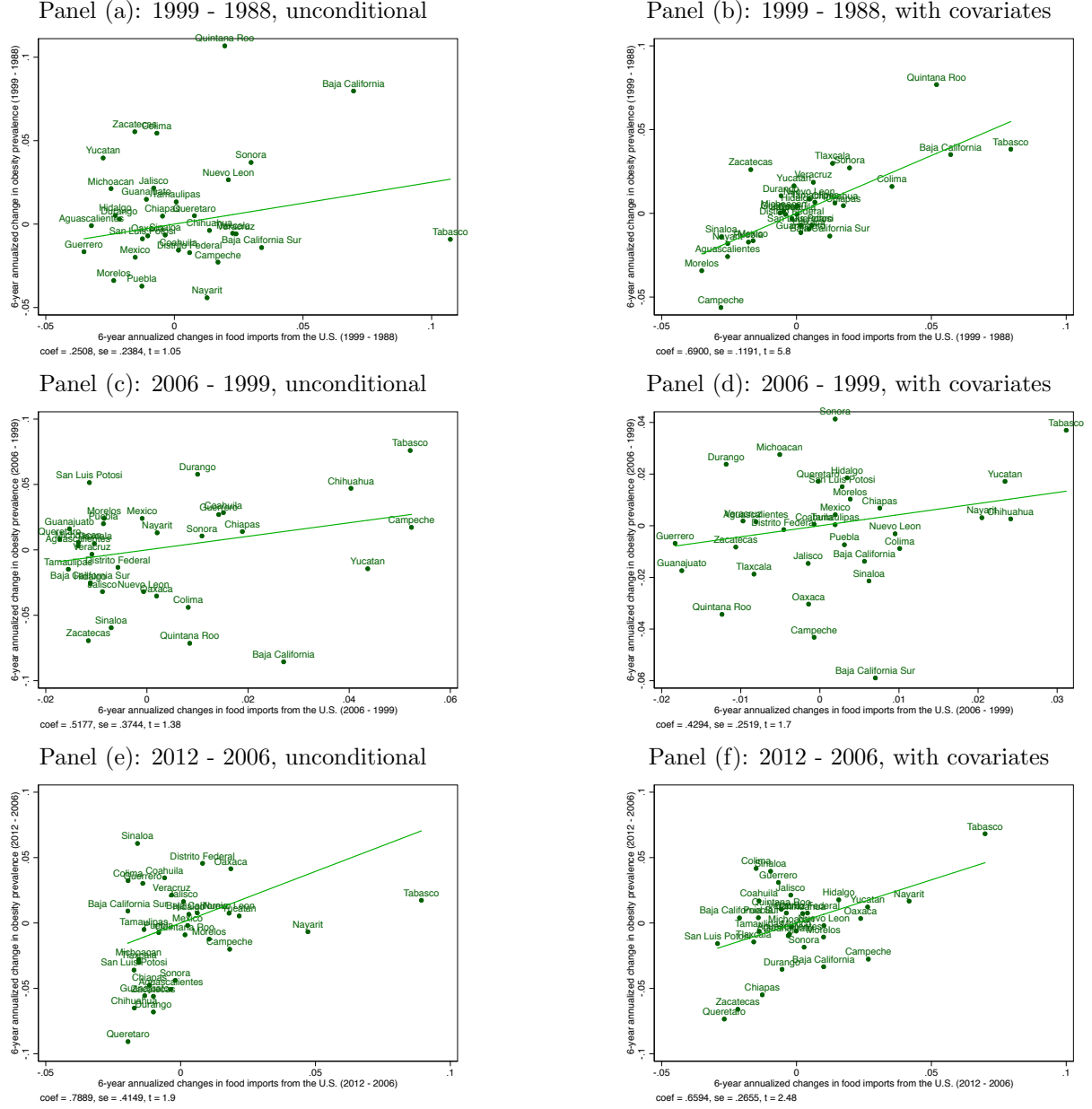
but statistically weaker unconditional correlations between variations in obesity prevalence and changes in normalized U.S. imports in 1999 and 2006 (Panels (a) and (c)), which however gain in strength once other state-level characteristics are controlled for (Panels (b) and (d)). Among the control variables, accounting for lagged obesity trends and changes in food imports from ROW disciplines the correlation between obesity and exposure to U.S. foods. All conditional plots display significant and positive correlations of similar size.

Figure 7: Pooled first differences in obesity prevalence and food imports from the U.S. – OLS and IV strategy



Note: Variables on the vertical and horizontal axis are ‘partialled out’ of the constant term, year dummies, and controls (except Panel (a), where only year dummies and the missing obesity dummy are partialled out). The set of covariates is as in Panel (d.ii) of Table 1. The state share of national female population between 18 and 59 years of age in 1990 is used as weight.

Figure 8: First differences in obesity prevalence and food imports from the U.S. (2012 - 2006, 2006 - 1999, 1999 - 1988)



Note: Variables on the vertical and horizontal axis are ‘partialled out’ of the constant term (Panels (a), (c), (e)), and controls (Panels (b), (d), (f)). The set of covariates is as in Panel (d.ii) of Table 1. The state share of national female population between 18 and 59 years of age in 1990 is used as weight.

Columns (4)-(6) of Table 1 report the OLS, IV and gravity-based IV estimates of the stacked differences model. Again we provide results in four panels, expanding the set of covariates as we move down through the Table. The unconditional OLS estimate of 0.430 (column (4), Panel a.ii) implies that a one standard deviation (0.038) increase in U.S. food penetration correlates with a non-negligible 1.7%-points increase in obesity

changes. As for the long-difference model, the point estimate of interest increases with the inclusion of covariates (compare estimates in column (4), Panels a.ii-d.ii). When all controls are included (Panel c.ii), the one standard deviation effect increases to 2.3%-points. Additionally controlling for the lagged obesity trend in Panel (d.ii) slightly increases the effect to 2.8%-points.

Given some of the changes in magnitudes across panels, it is worth highlighting the role of non-trade covariates in our OLS model (see the associated point estimates in Table A4). Unlike in the long difference model, some of these are significant and of the expected signs. States that devoted a larger share of household expenditure to foods tend to grow more obese. There is also a strong negative link between obesity changes and changes in the importance of return migration from the U.S.. Similarly, states where women became relatively more educated experience lower increases in obesity rates (echoing a large literature on obesity and education – e.g., [Cawley \(2015\)](#)). These two socio-demographic variables also increase the predictive power of our model in terms of  $R^2$  (by 18%-points). Conversely, income per capita, exposure to FDI, and the unemployment rate among the surveyed women within the state have no discernible effect on obesity rates.

Next consider the IV estimates in columns (5) and (6) of Table 1. Unlike in the long difference model, the unconditional IV estimates are smaller and less precisely estimated than their OLS counterpart (Panel a.ii, columns (5)-(6) vs. column (4)).<sup>29</sup> However, the inclusion of demographic covariates (with considerable predictive power) aids in this respect. When we control for these state characteristics, which may explain part of the variation in food demand across states, the IV effect of exposure to U.S. food supply becomes significant and hovers around its OLS counterpart (Panel b.ii). A one standard-deviation trade increase applied to the IV (or gravity-based IV) estimates translates to 1.3%-points (or 1.6%-points) increase in obesity changes. Concomitantly, while both IVs display good first stages (see reported F-Statistics), the gravity-based one is always stronger.

In sum, the first-stage relationship between U.S. food exports to other countries and U.S. food exports to Mexico remains robust in first differences when we control for state-level covariates, as shown in Figure 7, Panel (c). The IV estimate from column (5), Panel (d.ii) means that a one standard-deviation increase in trade adds 2.8%-points to the change in obesity prevalence among adult women. The pro-obesity effect of exposure to U.S. food supply also emerges in the corresponding reduced-form plot shown in Figure 7, panel (d).

In their totality, our baseline results based on first differences and long differences are

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<sup>29</sup>This is particularly true for the 2006 - 1999 and 2012 - 2006 differences, where the first-stage displays weak results (available upon request).

very comparable. When all controls and the lagged obesity trend are included, the one standard-deviation increase in food imports translates to significant increases in obesity ranging from 2.1%-points to 2.8%-points (compare the two sets of OLS, IV and gravity-based IV estimates in Panel (d)). When we drop the lagged obesity trend, effects range from 1.8%-points to 2.5%-points (Panel (c)). And when we restrict ourselves to plausibly more exogenous socio-demographic variables, they range from 1.3%-points to 2%-points (Panel (b)). The rest of the analysis will thus focus on our baseline specification (equation (1)) with controls and the lagged obesity trend.

Among the estimates on control variables, the one on food imports from other countries ( $\Delta ROWimp$ ) suggests that these are associated with a *lower* rise in obesity prevalence among adult women. If we exclude this variable, the causal impact of exposure to U.S. food imports on obesity is indeed lower (results available upon request), implying that some of the variation in our variable of interest,  $\Delta USimp$ , may be picking up exposure to the relatively healthy foods coming from other countries (see Figure 4). The lack of a viable empirical strategy to identify the causal effect of Mexico’s food imports from the rest of the world hinders the interpretation of the total (U.S. plus ROW) impact of food imports on obesity prevalence in Mexico. With these caveats in mind, estimates from Table A4 indicate that the robust pro-obesity effect of food imports from the U.S. quantitatively dominates that linked to ROW. According to the baseline long difference IV model in column (6), Panel (a), a one-standard-deviation higher exposure to ROW foods between 1988 and 2012 (equal to 0.08 – see Table A3 in the Appendix) is associated with 1.3%-points reduction in obesity changes over the same period, which remains significantly lower in absolute value than the 2.4%-points increase in obesity changes led by greater penetration of U.S. foods. In the pooled first difference model, the negative association between obesity prevalence and imports from ROW could potentially ‘erase’ 1%-points of the 2.8%-points increase in obesity changes due to exposure to U.S. foods. Overall, exposure to foreign foods has accentuated the rise in obesity, an effect stemming from the dominating role of American foods.<sup>30</sup>

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<sup>30</sup> Findings are confirmed when we consider changes in obesity prevalence among men (available only between 2006 and 2012) of the same age as women in the baseline analysis (20-49 years old). The coefficient on the 2012 - 2006  $\Delta USimp$  variable equals 0.61 in an univariate regression (std. error=0.34; compared to the 0.79 coefficient estimated for the same period on adult women – see panel (e) of Figure 8); and goes up to 0.87 (std. error=0.36) with controls and lagged obesity (compared to 0.66 obtained on adult women – see panel (f) of Figure 8). We also find similar pro-obesity effects of exposure to U.S. foods when we expand the demographic group to women and men up to 60 years old – a change that affects only obesity prevalence in 2006 and 2012. In this case, the OLS long-difference coefficient on  $\Delta USimp$  equals 0.068 (std. error=0.014), and the pooled first-difference one equals 0.60 (std. error=0.09) – both are slightly lower than their counterparts in columns (1) and (4), Panel (d), Table 1.

Table 1: Obesity prevalence and food imports from the U.S.

|   | (1)                                 | (2)                   | (3)                   | (4)                                   | (5)                   | (6)                   |
|---|-------------------------------------|-----------------------|-----------------------|---------------------------------------|-----------------------|-----------------------|
|   | OLS                                 | IV                    | IV res.               | OLS                                   | IV                    | IV res.               |
| Panel (a): <b>Unconditional</b>                 |                                     |                       |                       |                                       |                       |                       |
|   | Panel (a.i): <b>Long difference</b> |                       |                       | Panel (a.ii): <b>First difference</b> |                       |                       |
| $\Delta$ Food imports from U.S.                 | 0.0472***<br>(0.0119)               | 0.0509***<br>(0.0147) | 0.0480***<br>(0.0155) | 0.430***<br>(0.128)                   | 0.155<br>(0.293)      | 0.266<br>(0.238)      |
| <i>First-stage results:</i>                     |                                     |                       |                       |                                       |                       |                       |
| $\Delta$ U.S. food exports                      |                                     | 0.197***<br>(0.0492)  | 1.376***<br>(0.2287)  |                                       | 0.117***<br>(0.0254)  | 0.271***<br>(0.0273)  |
| F-stat excluded instr.                          |                                     | 15.99                 | 36.22                 |                                       | 21.18                 | 98.69                 |
| <i>Effect of one standard-deviation change:</i> |                                     |                       |                       |                                       |                       |                       |
| $\Delta$ Food imports from U.S.                 | 0.0142***<br>(0.0036)               | 0.0154***<br>(0.0044) | 0.0145***<br>(0.0047) | 0.0165***<br>(0.0049)                 | 0.00595<br>(0.0113)   | 0.0102<br>(0.0092)    |
| Obs   | 32                                  | 32                    | 32                    | 96                                    | 96                    | 96                    |
| R <sup>2</sup>                                  | 0.214                               | 0.212                 | 0.214                 | 0.438                                 | 0.421                 | 0.432                 |
| Panel (b): <b>Demog. controls</b>               |                                     |                       |                       |                                       |                       |                       |
|   | Panel (b.i): <b>Long difference</b> |                       |                       | Panel (b.ii): <b>First difference</b> |                       |                       |
| $\Delta$ Food imports from U.S.                 | 0.0529***<br>(0.0140)               | 0.0455***<br>(0.0170) | 0.0533***<br>(0.0167) | 0.530***<br>(0.122)                   | 0.348**<br>(0.173)    | 0.418**<br>(0.180)    |
| <i>First-stage results:</i>                     |                                     |                       |                       |                                       |                       |                       |
| $\Delta$ U.S. food exports                      |                                     | 0.218***<br>(0.0313)  | 1.363***<br>(0.2302)  |                                       | 0.122***<br>(0.0252)  | 0.268***<br>(0.0279)  |
| F-stat excluded instr.                          |                                     | 48.82                 | 35.08                 |                                       | 23.24                 | 92.60                 |
| <i>Effect of one standard-deviation change:</i> |                                     |                       |                       |                                       |                       |                       |
| $\Delta$ Food imports from U.S.                 | 0.0159***<br>(0.0042)               | 0.0137***<br>(0.0051) | 0.0161***<br>(0.0050) | 0.0204***<br>(0.0047)                 | 0.0134**<br>(0.0067)  | 0.0161**<br>(0.0069)  |
| Obs   | 32                                  | 32                    | 32                    | 96                                    | 96                    | 96                    |
| R <sup>2</sup>                                  | 0.273                               | 0.268                 | 0.273                 | 0.613                                 | 0.606                 | 0.610                 |
| Panel (c): <b>Controls</b>                      |                                     |                       |                       |                                       |                       |                       |
|   | Panel (c.i): <b>Long difference</b> |                       |                       | Panel (c.ii): <b>First difference</b> |                       |                       |
| $\Delta$ Food imports from U.S.                 | 0.0761***<br>(0.0199)               | 0.0756***<br>(0.0229) | 0.0666***<br>(0.0211) | 0.608***<br>(0.119)                   | 0.556***<br>(0.131)   | 0.478***<br>(0.165)   |
| <i>First-stage results:</i>                     |                                     |                       |                       |                                       |                       |                       |
| $\Delta$ U.S. food exports                      |                                     | 0.252***<br>(0.0247)  | 1.226***<br>(0.2337)  |                                       | 0.129***<br>(0.0220)  | 0.258***<br>(0.0317)  |
| F-stat excluded instr.                          |                                     | 104.1                 | 23.37                 |                                       | 34.50                 | 66.24                 |
| <i>Effect of one standard-deviation change:</i> |                                     |                       |                       |                                       |                       |                       |
| $\Delta$ Food imports from U.S.                 | 0.0230***<br>(0.0060)               | 0.0228***<br>(0.0069) | 0.0201***<br>(0.0064) | 0.0234***<br>(0.0046)                 | 0.0214***<br>(0.0050) | 0.0184***<br>(0.0064) |
| Obs   | 32                                  | 32                    | 32                    | 96                                    | 96                    | 96                    |
| R <sup>2</sup>                                  | 0.386                               | 0.386                 | 0.382                 | 0.645                                 | 0.644                 | 0.641                 |
| Panel (d): <b>Controls + obesity trend</b>      |                                     |                       |                       |                                       |                       |                       |
|   | Panel (d.i): <b>Long difference</b> |                       |                       | Panel (d.ii): <b>First difference</b> |                       |                       |
| $\Delta$ Food imports from U.S.                 | 0.0774***<br>(0.0188)               | 0.0787***<br>(0.0208) | 0.0708***<br>(0.0211) | 0.728***<br>(0.105)                   | 0.735***<br>(0.120)   | 0.556***<br>(0.137)   |
| <i>First-stage results:</i>                     |                                     |                       |                       |                                       |                       |                       |
| $\Delta$ U.S. food exports                      |                                     | 0.256***<br>(0.0242)  | 1.255***<br>(0.2594)  |                                       | 0.127***<br>(0.0209)  | 0.252***<br>(0.0283)  |
| F-stat excluded instr.                          |                                     | 112                   | 23.42                 |                                       | 36.74                 | 79.42                 |
| <i>Effect of one standard-deviation change:</i> |                                     |                       |                       |                                       |                       |                       |
| $\Delta$ Food imports from U.S.                 | 0.0233***<br>(0.0057)               | 0.0237***<br>(0.0063) | 0.0213***<br>(0.0064) | 0.0280***<br>(0.0040)                 | 0.0283***<br>(0.0046) | 0.0214***<br>(0.0053) |
| Obs   | 32                                  | 32                    | 32                    | 96                                    | 96                    | 96                    |
| R <sup>2</sup>                                  | 0.402                               | 0.402                 | 0.400                 | 0.714                                 | 0.714                 | 0.708                 |

Note: All regressions include a constant term. Regressions in Panels (a.ii), (b.ii), (c.ii), and (d.ii) include year dummies (for 2006 and 2012) and a dummy for states with imputed obesity prevalence in 1999 (for 1999 - 1988, and 2012 - 2006). Coefficients on the controls variables are in Table A4. The state share of national female population between 18 and 59 years of age in 1990 is used as weight. Robust standard errors clustered at the state level are in parentheses. Significant at: \*10%, \*\*5%, \*\*\*1% level.

(b) Benchmarking the impact of U.S. food exports on obesity in Mexico

The causal effect of food imports from the U.S. can be assessed against the average observed increase of 26 percentage points in obesity prevalence across states between 1988 and 2012 (see Table A3). The positive and significant IV coefficients from the long-difference and pooled first-difference specifications with demographic controls in columns (2) and (5), Panel (b), Table 1, imply that a one-standard-deviation higher penetration of U.S. food imports could account for about 5 percent of the rise in obesity observed during our sample period. Controlling for imports from ROW and the lagged obesity trend raises the quantitative importance of this impact to approximately 10 percent of the average change in obesity prevalence. These magnitudes are comparable to the obesity effects found in other studies examining the role of changes in the food environment. Courtemanche and Carden (2011), for instance, find that the local penetration of Walmart Supercenters is responsible for 10.5 percent of the rise in obesity rates in the U.S. since the late 1980s.

Another way to interpret the estimated effects is to construct counterfactual changes in nation-wide obesity prevalence among adult women that would have occurred in the absence of increased penetration of U.S. food imports. To this end, we use the IV estimates from column (2) in Table 1 to generate the changes in obesity rates mandated by the observed variation in instrumented food imports for each state over the sample period, 1988 - 2012. While informative about the size of the estimated effects, this counterfactual exercise relies on a number of important assumptions. It applies estimates obtained from relative changes in obesity prevalence across Mexican states to quantify effects on national obesity rates. This would, for instance, under-estimate the aggregate effects if higher exposure of one state raises obesity (e.g., through greater food consumption) also in a neighbouring state that was less exposed. Moreover, our exercise implicitly assumes that all other covariates and the error term in equation (1) are unaffected by the exogenous changes in U.S. food exports to Mexico. Because of the restrictiveness of these assumptions, we view these simulations as purely suggestive of economic magnitudes.

Using the baseline estimates from Panel (d) of Table 1, the changes in obesity prevalence implied by greater penetration of U.S. foods ( $\Delta \widehat{Obesity}_{s,2012-1988} \equiv \hat{\beta}_1 \Delta USimp_{s,2012-1988}$ ; with  $\hat{\beta}_1 = 0.079$ ) are multiplied by the number of women between 18 and 59 years of age (the closest demographic group to the 20-49 age range used in the estimations) at the beginning of the period for each state. Summing these numbers across states, we impute that 2 million women became obese as a result of changes in food imports from the U.S. relative to the state's food expenditure between 1988 and 2012. To put these numbers



into perspective, we divide them by the observed increases in the number of Mexican obese women. Changes in U.S. food penetration in Mexican markets can account for as much as 21.7 percent of the observed rise in obesity prevalence among Mexican women between 1988 and 2012. Employing the more conservative IV coefficient on  $\Delta USimp$  that we obtain without controlling for food imports from ROW ( $\hat{\beta}_1=0.045$ ) would lower the influence of increasing penetration of U.S. foods to 12.3 percent of the observed rise in the number of obese women between 1988 and 2012.<sup>31</sup>

Overall, the results from this exercise indicate that the statistically significant impact of food imports from the U.S. may account for up to 22 percent of the observed increase in obesity prevalence among Mexican adult women. These magnitudes, like the ones implied by the one standard-deviation changes in U.S. food exports, are comparable to the effects of other determinants of obesity found in the literature.<sup>32</sup>

### (c) Unhealthy imports and obesity prevalence

The strong pro-obesity effect of U.S. foods – in stark contrast with the negative association between obesity prevalence and food imports from other countries – hints at the presence of ‘obesity-prone’ characteristics specific to U.S. food imports. We know from Figure 4 that U.S. food exports to Mexico have increasingly been specialised in unhealthy foods, and this also relative to exports from ROW. We now test whether the pro-obesity effect of increasing exposure to U.S. foods is driven by its unhealthy component. We distinguish between healthy and unhealthy foods by applying the USDA classification, and additionally, our more conservative classification that includes vegetables, fruits, fish and poultry in the ‘vegs+’, healthy category, and fats, drinks and foods rich in carbohydrates in the ‘non-vegs’, unhealthy category (see section 3 and Table A1). The  $\Delta USimp$  variable is split into its unhealthy and healthy components (changes in food imports from the U.S. –  $\Delta M^{US}$  in equation (2) – are divided between the two categories), which are both included

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<sup>31</sup>These numbers, being based on the *total* variation in normalised U.S. food imports, can overstate the causal impact of U.S. food supply shocks if the endogenous demand component of import exposure correlates with obesity prevalence. To isolate the supply-driven variation in our  $\Delta USimp$  variable, we adopt the method proposed by Autor et al. (2013) and Acemoglu et al. (2016), which amounts to multiplying the observed  $\Delta USimp_{s,2012-1988}$  values by the partial  $R^2$  from the first-stage regression (equal to 0.82 in the baseline IV specification of column (2), Panel (d)). With this alternative approach, the simulated increase in the number of obese women due to changes in U.S. food supply amounts to 17.8 percent (or 10.7 percent when using estimates without controlling for  $\Delta ROWimp$ ) of the overall change in obese cases.

<sup>32</sup>Courtemanche et al. (2016) find that variables affecting the local cost of calories can explain up to 39 percent of the rise in obesity rates observed in the U.S. between 1990 and 2010. Single determinants of obesity such as the presence of supercenters and restaurants explain 16 and 14 percent, respectively.

in our baseline specification. In the IV regressions, U.S. exports of unhealthy and healthy foods to other countries are used as instruments. Possible collinearity between the two broad categories of food imports and between the two instruments lead us to interpret these ‘horse-race’ regressions with a grain of salt.

Table 2: Obesity prevalence and unhealthy food imports from U.S.

|   | (1)                   | (2)                   | (3)                   | (4)                                  | (5)                   | (6)                   |
|---|-----------------------|-----------------------|-----------------------|--------------------------------------|-----------------------|-----------------------|
|   | USDA classification   |                       |                       | Conservative classification (Vegs.+) |                       |                       |
| Panel (a): <b>Long-difference</b> (2012 - 1988) |                       |                       |                       |                                      |                       |                       |
| $\Delta$ Unhealthy imports from U.S.            | 0.0770***<br>(0.0278) | 0.118***<br>(0.0364)  | 0.132***<br>(0.0364)  | 0.0562***<br>(0.00987)               | 0.0732***<br>(0.0206) | 0.0791***<br>(0.0203) |
| $\Delta$ Healthy imports from U.S.              | 0.0309<br>(0.0202)    | 0.0576**<br>(0.0228)  | 0.0531**<br>(0.0207)  | -0.0857*<br>(0.0483)                 | -0.0979<br>(0.110)    | -0.0861<br>(0.0927)   |
| <i>Effect of one standard-deviation change:</i> |                       |                       |                       |                                      |                       |                       |
| $\Delta$ Unhealthy imports from U.S.            | 0.0130***<br>(0.0047) | 0.0200***<br>(0.0062) | 0.0224***<br>(0.0062) | 0.0164***<br>(0.0029)                | 0.0214***<br>(0.0060) | 0.0231***<br>(0.0059) |
| $\Delta$ Healthy imports from U.S.              | 0.00727<br>(0.0048)   | 0.0135**<br>(0.0054)  | 0.0125**<br>(0.0049)  | -0.00658*<br>(0.0037)                | -0.00751<br>(0.0085)  | -0.00661<br>(0.0071)  |
| Controls  | N                     | Y                     | Y                     | N                                    | Y                     | Y                     |
| IV  | N                     | N                     | Y                     | N                                    | N                     | Y                     |
| K-P F-stat.                                     |                       |                       | 48.60                 |                                      |                       | 164.8                 |
| Obs   | 32                    | 32                    | 32                    | 32                                   | 32                    | 32                    |
| R <sup>2</sup>                                  | 0.253                 | 0.437                 | 0.434                 | 0.331                                | 0.462                 | 0.460                 |

|  |                       |                       |                       |                       |                       |                       |
|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Panel (b): <b>Stacked first-difference</b> (2012 - 2006, 2006 - 1999, 1999 - 1988) |                       |                       |                       |                       |                       |                       |
| $\Delta$ Unhealthy imports from U.S.   | 0.556***<br>(0.124)   | 0.760***<br>(0.180)   | 0.860***<br>(0.223)   | 0.444***<br>(0.119)   | 0.739***<br>(0.111)   | 0.736***<br>(0.124)   |
| $\Delta$ Healthy imports from U.S.   | 0.273**<br>(0.113)    | 0.689***<br>(0.106)   | 0.620***<br>(0.134)   | -0.0662<br>(0.536)    | 0.349<br>(0.460)      | -0.124<br>(0.594)     |
| <i>Effect of one standard-deviation change:</i>                                    |                       |                       |                       |                       |                       |                       |
| $\Delta$ Unhealthy imports from U.S.   | 0.0144***<br>(0.0032) | 0.0197***<br>(0.0048) | 0.0223***<br>(0.0058) | 0.0132***<br>(0.0036) | 0.0221***<br>(0.0033) | 0.0220***<br>(0.0037) |
| $\Delta$ Healthy imports from U.S.   | 0.00515**<br>(0.0021) | 0.0130***<br>(0.0020) | 0.0117***<br>(0.0025) | -0.000828<br>(0.0067) | 0.00436<br>(0.0058)   | -0.00156<br>(0.0074)  |
| Controls   | N                     | Y                     | Y                     | N                     | Y                     | Y                     |
| IV   | N                     | N                     | Y                     | N                     | N                     | Y                     |
| K-P F-stat.  |                       |                       | 8.391                 |                       |                       | 21.77                 |
| Obs  | 96                    | 96                    | 96                    | 96                    | 96                    | 96                    |
| R <sup>2</sup>   | 0.444                 | 0.715                 | 0.713                 | 0.443                 | 0.716                 | 0.713                 |

Note: All regressions include a constant term. Regressions in Panel (b) include period dummies and a dummy for states with missing obesity prevalence in 1999, for 1999 - 1988 and 2006 - 1999. The state share of national female population between 18 and 59 years of age in 1990 is used as weight. Standard errors clustered at the state level are in parentheses. Significant at: \*10%, \*\*5%, \*\*\*1% level.

The estimates from the long-difference and stacked-difference models in Table 2 yield a stronger effect of unhealthy compared to healthy American foods. With the USDA classification (columns (1) to (3)), both unhealthy and healthy foods seem to foster obesity increases (consistent with a theoretical model where both healthy and unhealthy calorie

consumption leads to weight gains – see section 5); that said, the effects of the unhealthy component are always larger. The patterns are even more pronounced with our conservative classification (columns (4) to (6)), where greater exposure to unhealthy foods has a large and positive impact on obesity changes, while exposure to healthy foods is weakly and even negatively associated with lower obesity. IV estimates in columns (3) and (6) imply that a one standard-deviation increase in exposure to unhealthy foods augments obesity prevalence by roughly 2%-points – the same effect of a one standard-deviation increase in exposure to *total* food imports from the U.S. We interpret these findings in terms of a nutritional mechanism: the U.S. has contributed to the obesity epidemic in Mexico by specializing in producing and exporting unhealthy foods to Mexico.

#### (d) Robustness checks and extensions

This section investigates the robustness of our results to lead tests, to the exclusion of single states, to alternative definitions of trade exposure, to the role of the local food environment and to other anthropometric outcome variables. Finally, we test for heterogeneous effects by socio-economic status.

*Placebo tests using future changes.* To support the causal interpretation of our results, we run falsification tests where current changes in obesity prevalence are regressed on future changes in food imports from the U.S.. Results are reported in Table 3. Leads in the  $\Delta USimp$  variable are neither significantly nor systematically linked to current changes in obesity. In columns (1) and (2), the marginal effects of changes in U.S. food imports between 2017 and 2012 on variations in obesity prevalence between 2012 and 1988 are positive but highly insignificant. When we enter non-overlapping leads in the first difference models (columns (3) and (4)), the coefficient turns negative but remains insignificant, suggesting that, if anything, states that have higher future increases in penetration of U.S. foods experience lower rises in obesity prevalence. Stacked differences with and without controls yield mixed and insignificant point estimates (columns (5) and (6)). These patterns alleviate concerns that we may be picking up spurious correlations in food consumption and secular changes in body weight.

Table 3: Obesity prevalence and future changes in food imports from the U.S.

|   | (1)   | (2)              | (3)   | (4)   | (5)                 | (6)              |
|---|---|------------------|---|---|---------------------|------------------|
|   | 2012 - 1988 obesity on<br>2017 - 2012 U.S. imp. |                  | 1999 - 1988 obesity on<br>2012 - 2006 U.S. imp. | 2006 - 1999 obesity on<br>2017 - 2012 U.S. imp. | Stacked first-diff. |                  |
| $\Delta$ Food imports from U.S. <sub><math>t+1</math></sub> | 0.683<br>(1.265)                                | 1.123<br>(1.168) | -0.120<br>(0.168)                               | -0.583<br>(1.246)                               | -0.151<br>(0.163)   | 0.302<br>(0.288) |
| Controls  | N   | Y                | N   | N   | N                   | Y                |
| Obs   | 32  | 32               | 32  | 32  | 64                  | 64               |
| R <sup>2</sup>  | 0.015   | 0.132            | 0.006   | 0.007   | 0.016               | 0.375            |

Note: All regressions include a constant term. See Table A4 for the list of controls. Columns (5) and (6) include a dummy for the 2006 period and a dummy for states with imputed obesity prevalence in 1999. The state share of national female population between 18 and 59 years of age in 1990 is used as weight. Robust standard errors clustered at the state level are in parentheses. Significant at: \*10%, \*\*5%, \*\*\*1% level.

*Exclusion of single states.* Given the small sample size, outliers may influence our key results. To counter this concern, we drop one state at a time in the estimation. Panels (a) and (b) in Figure A3 in the Appendix plot the OLS coefficient on the  $\Delta USimp$  in the baseline long-difference and stacked-difference specifications (corresponding to columns (1) and (4), Panel (d), in Table 1). The limited sample size leads to some loss of precision especially in the long-difference model (e.g., when the state of Tabasco is dropped), but the coefficient is always significantly larger than zero and close in size to the one obtained in the full sample.

*Alternative measures of trade exposure.* Our baseline findings are equally robust to different definitions of the trade exposure variable. In columns (1) to (3) of Table 4, we single out U.S. food imports for final demand – and exclude imports for further industrial use that should not directly affect obesity. We use the Broad Economic Categories (BEC) classification for trade flows (matched with the more detailed SITC classification) to identify food products that are “mainly for household consumption” (BEC categories 112 and 122) and “other consumer goods” (BEC category 6). The matching between these BEC final demand categories and the SITC products is however not unique – some SITC products have multiple BEC categories –, we thus take this exercise as a robustness test of the baseline results obtained using all SITC food products.<sup>33</sup> Using this revised food imports variable leaves us with qualitatively similar findings.

Another possible concern with the baseline specification (1) is that the effect of food imports might capture the influence of overall exposure to imports from the U.S.. To check for this, we regress obesity prevalence on apparel imports (applying equation (2) to data on apparel imports and expenditures). This important tradable product should have no direct influence on diet and nutrition. The estimated coefficients in columns (4) to (6) suggest that,

<sup>33</sup>SITC products are classified for final demand if more than half of the entries fall into the BEC categories for final use.

if anything, exposure to American apparel is correlated with lower obesity rates, at least in long-run changes. Importantly, the coefficient on the  $\Delta USimp$  variable remains positive and significant when controlling for this variable.

Columns (7) to (9) assess the influence of exposure to Mexican food exports to the U.S. as dictated by pre-determined expenditure specialization.<sup>34</sup> We replace the import flow variable  $M$  in equation (2) with the value of Mexican exports to the U.S.. Mexican exports can correlate with Mexican imports from the U.S. in the presence of intra-product trade related, for instance, to export processing (*maquiladora*) in the food sector (Utar and Ruiz, 2013). Results however do not reveal any robust correlation between demand-based exposure to food exports and obesity prevalence, while exposure to food imports is consistently associated with higher obesity.<sup>35</sup>

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<sup>34</sup>As further discussed in section 2, this exercise does not aim to assess the impact of market access on obesity, for instance through an income channel. Greater overall export opportunities (not necessarily confined to the food sector) should matter, and industry employment is the relevant link between changes in aggregate exports and local income (McCaig, 2011).

<sup>35</sup>Similar results are obtained if we use exposure to Mexican food exports to all countries rather than exports to the U.S. only.

Table 4: Obesity prevalence and food imports from the U.S. – Alternative trade exposure

|  | (1)                   | (2)                   | (3)                   | (4)                   | (5)                   | (6)                | (7)                   | (8)                   | (9)                  |
|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------|-----------------------|-----------------------|----------------------|
|  | Final use imports     |                       |                       | Apparel imports       |                       |                    | Mex. exports          |                       |                      |
| Panel (a): <b>Long-difference</b> (2012 - 1988)                                    |                       |                       |                       |                       |                       |                    |                       |                       |                      |
| Δ Food imports from U.S.   | 0.0619***<br>(0.0135) | 0.0819***<br>(0.0190) | 0.0824***<br>(0.0209) | 0.0763***<br>(0.0169) | 0.0806***<br>(0.0187) |                    | 0.0807***<br>(0.0185) | 0.0834***<br>(0.0208) |                      |
| Δ Apparel imports from U.S.  |                       |                       |                       | -0.255<br>(0.388)     | -0.857<br>(0.554)     | -0.853*<br>(0.459) |                       |                       |                      |
| Δ Mex. food exports to U.S.  |                       |                       |                       |                       |                       |                    | 0.00710<br>(0.0183)   | -0.0118<br>(0.0184)   | -0.0122<br>(0.0149)  |
| <i>Effect of one standard-deviation change:</i>                                    |                       |                       |                       |                       |                       |                    |                       |                       |                      |
| Δ Food imports from U.S.   | 0.0147***<br>(0.0032) | 0.0195***<br>(0.0045) | 0.0196***<br>(0.0050) | 0.0230***<br>(0.0051) | 0.0243***<br>(0.0056) |                    | 0.0243***<br>(0.0056) | 0.0251***<br>(0.0063) |                      |
| Controls   | N                     | Y                     | Y                     | N                     | Y                     | Y                  | N                     | Y                     | Y                    |
| IV   | N                     | N                     | Y                     | N                     | N                     | Y                  | N                     | N                     | Y                    |
| F-stat excluded instr.   |                       |                       | 99.71                 |                       |                       | 124.4              |                       |                       | 116.6                |
| Obs  | 32                    | 32                    | 32                    | 32                    | 32                    | 32                 | 32                    | 32                    | 32                   |
| R <sup>2</sup>   | 0.229                 | 0.370                 | 0.370                 | 0.015                 | 0.453                 | 0.452              | 0.008                 | 0.413                 | 0.412                |
| Panel (b): <b>Stacked first-difference</b> (2012 - 2006, 2006 - 1999, 1999 - 1988) |                       |                       |                       |                       |                       |                    |                       |                       |                      |
| Δ Food imports from U.S.   | 0.419***<br>(0.0980)  | 0.797***<br>(0.110)   | 0.878***<br>(0.188)   | 0.707***<br>(0.113)   | 0.676***<br>(0.108)   |                    | 0.767***<br>(0.100)   | 0.819***<br>(0.166)   |                      |
| Δ Apparel imports from U.S.  |                       |                       |                       | 0.0640<br>(0.153)     | 0.162<br>(0.109)      | 0.166*<br>(0.101)  |                       |                       |                      |
| Δ Mex. food exports to U.S.  |                       |                       |                       |                       |                       |                    | 0.0277<br>(0.128)     | -0.186*<br>(0.102)    | -0.191**<br>(0.0947) |
| <i>Effect of one standard-deviation change:</i>                                    |                       |                       |                       |                       |                       |                    |                       |                       |                      |
| Δ Food imports from U.S.   | 0.0133***<br>(0.0031) | 0.0254***<br>(0.0035) | 0.0280***<br>(0.0060) | 0.0272***<br>(0.0043) | 0.0260***<br>(0.0041) |                    | 0.0295***<br>(0.0039) | 0.0315***<br>(0.0064) |                      |
| Controls   | N                     | Y                     | Y                     | N                     | Y                     | Y                  | N                     | Y                     | Y                    |
| IV   | N                     | N                     | Y                     | N                     | N                     | Y                  | N                     | N                     | Y                    |
| F-stat excluded instr.   |                       |                       | 24.78                 |                       |                       | 32.68              |                       |                       | 31.72                |
| Obs  | 96                    | 96                    | 96                    | 96                    | 96                    | 96                 | 96                    | 96                    | 96                   |
| R <sup>2</sup>   | 0.433                 | 0.703                 | 0.702                 | 0.387                 | 0.719                 | 0.719              | 0.386                 | 0.728                 | 0.727                |

Note: All regressions include a constant term. In Panel (b), all regressions include year dummies for 2006 and 2012, and a dummy for states with imputed obesity prevalence in 1999 (for 1999 - 1988, and 2012 - 2006). The state share of national female population between 18 and 59 years of age in 1990 is used as weight. Columns (1) to (3) use trade data only on food products classified for final consumption according to the BEC classification. Robust standard errors clustered at the state level are in parentheses. Significant at: \*10%, \*\*5%, \*\*\*1% level.

*Changes in the food environment and food purchases.* Changes in the local food environment (other than in penetration of food imports from the U.S.) and in purchase habits can shape obesity trends and at the same time coincide with those in our import variable.

American FDI in the retail and food sector can confound the pro-obesity effect of food imports. While our baseline results are robust to controlling for changes in overall FDI, Walmart expanded throughout Mexico during our sample period and has become one of the biggest retailers in Latin America. This development can weaken the interpretation of our results, if Walmart expansion in Mexico is correlated with growing obesity (see [Courtemanche and Carden \(2011\)](#) for evidence on the pro-obesity effect of Walmart in the U.S.) and if states where Walmart expanded more aggressively also saw greater penetration of food imports from the U.S.. To check for this possibility, we exploit data on the number of Walmart

stores by Mexican state as of 2007 from [Iacovone et al. \(2015\)](#). Since Walmart entered the Mexican market in the early 90's and spread mainly in the 2000's ([Atkin et al., 2018](#)), the stock of Walmart stores in 2007 (per thousands of people) equates to the change in Walmart presence since the beginning of our sample in 1988. Using the Walmart variable, we can provide two pieces of evidence. First, we find that it correlates negatively with 2006 - 1988 changes in obesity rates, indicating that, if at all, obesity prevalence has increased less rapidly in Mexican states that received more Walmart stores (see top row of Figure A4 in the Appendix). Moreover, there is no clear relationship between the changes in  $\Delta USimp$  over the 2006 - 1988 period and Walmart penetration (see the bottom row of Figure A4). Second, in Table 5, columns (1) to (4), we augment our regression model with the Walmart variable and the effect of U.S. food imports remains positive and significant. The coefficient on the Walmart variable is still negative but becomes weaker when considering changes in obesity rates over the long window (2012 - 1988). Taken together, these results suggest that Walmart penetration has no strong influence on the robust pro-obesity impact of food imports from the U.S..

That said, Walmart is not the only retailer active in the Mexican market and households more generally may buy American and other foreign foods in supermarkets and malls (rather than small markets and traditional stores, which are more likely to offer local foods), or consume them outside home (e.g., in fast food restaurants). The supermarket share in total food expenditure by state increased by a mere 3%-points over the period 1988 - 2012. Meanwhile, the share of food expenditure that went to restaurants increased from about 13 in 1988 to 22 percent in 2012. In the remaining columns of Table 5, we thus control for these shares. In both long and stacked differences models, these proxies for changing purchasing habits are not significantly correlated with obesity (at least at this level of aggregation), and more crucially have no bearing on our coefficient of interest.<sup>36</sup>

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<sup>36</sup>The aggregate measures might mask heterogeneous obesity effects depending on the type of food that is purchased in supermarkets or that is consumed away from home, which could shape obesity dynamics (see U.S.-based evidence in [Todd et al. \(2010\)](#)).



Table 5: Obesity prevalence and food imports from the U.S. – controlling for Walmart and place of food purchase

|   | (1)                    | (2)                     | (3)                   | (4)                   | (5)                   | (6)                   | (7)                   | (8)                   |
|---|------------------------|-------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
|   | 2006 - 1988            |                         | 2012 - 1988           |                       |                       |                       | Pooled first-diff.    |                       |
| $\Delta$ Food imports from U.S.                 | 0.247***<br>(0.0404)   | 0.196***<br>(0.0445)    | 0.0781***<br>(0.0201) | 0.0782***<br>(0.0200) | 0.0759***<br>(0.0206) | 0.0776***<br>(0.0211) | 0.726***<br>(0.107)   | 0.746***<br>(0.118)   |
| Walmart stores per 100k persons (2007)          | -0.0169**<br>(0.00699) | -0.0176***<br>(0.00586) | 0.00236<br>(0.0116)   | 0.00237<br>(0.00946)  |                       |                       |                       |                       |
| $\Delta$ Malls share food expen.                |                        |                         |                       |                       | 0.00480<br>(0.0588)   | 0.00422<br>(0.0465)   | -0.0256<br>(0.0428)   | -0.0255<br>(0.0387)   |
| $\Delta$ Restaurant share food expen.           |                        |                         |                       |                       | 0.0449<br>(0.130)     | 0.0431<br>(0.102)     | 0.0227<br>(0.0607)    | 0.0226<br>(0.0549)    |
| <i>Effect of one standard-deviation change:</i> |                        |                         |                       |                       |                       |                       |                       |                       |
| $\Delta$ Food imports from U.S.                 | 0.0323***<br>(0.0053)  | 0.0256***<br>(0.0058)   | 0.0236***<br>(0.0061) | 0.0236***<br>(0.0060) | 0.0229***<br>(0.0062) | 0.0234***<br>(0.0064) | 0.0279***<br>(0.0041) | 0.0286***<br>(0.0045) |
| IV  | N                      | Y                       | N                     | Y                     | N                     | Y                     | N                     | Y                     |
| F-stat excluded instr.                          |                        | 12.24                   |                       | 146.9                 |                       | 108.4                 |                       | 40.43                 |
| Obs   | 32                     | 32                      | 32                    | 32                    | 32                    | 32                    | 96                    | 96                    |
| R <sup>2</sup>                                  | 0.735                  | 0.721                   | 0.404                 | 0.404                 | 0.406                 | 0.406                 | 0.716                 | 0.716                 |

Note: All regressions include a constant term and state-level controls. Columns (7) and (8) include period dummies and a dummy for states with imputed obesity prevalence in 1999 (for 1999 - 1988, and 2012 - 2006). The state share of national female population between 18 and 59 years of age in 1990 is used as weight. Robust standard errors clustered at the state level are in parentheses. Significant at: \*10%, \*\*5%, \*\*\*1% level.

*Alternative measures of excess weight.* As a further check on our baseline findings, we replace obesity with overweight prevalence (defined as a BMI greater or equal to 25) and additionally with the average BMI among surveyed women. Results for the long-difference and pooled first-difference models are reported in Table 6. States that are more exposed to U.S. food imports over time experience also stronger overweight rates and higher average BMI.

The positive and significant long-difference IV point estimate in column (3), Panel (a), implies that a one standard deviation higher penetration of U.S. foods leads to a 1.2%-point increase in overweight changes, or 3 percent of the average increase in overweight prevalence observed between 1988 and 2012. In comparison, our baseline obesity effect (column (2), Panel (d), Table 1) is three times as large. The stacked first-difference estimate delivers a higher effect of exposure to American foods on overweight rates (6 percent of the average change in overweight between 1988 and 2012).

The share of overweight women in our sample coincides with the share of women above the average level of BMI. Therefore, it is not surprising that the positive and statistically significant effect of U.S. food imports on average BMI (columns (4) to (6) of Table 6) is of similar size as the one on overweight rates. The causal estimates in column (6) indicate that a one standard deviation increase in normalized U.S. food imports raises average BMI by 0.3 points between 1988 and 2012 (or 6 percent of the average increase in BMI over the period). Taken together, these anthropometric trends indicate that while imports of U.S. foods have shifted the entire BMI distribution, their effect is more pronounced in its right, obese tail.

Table 6: Overweight prevalence, average BMI, and food imports from the U.S.

|  | (1)                          | (2)                   | (3)                   | (4)                    | (5)                  | (6)                   |
|--|------------------------------|-----------------------|-----------------------|------------------------|----------------------|-----------------------|
|  | Dep. var.: Overw. prevalence |                       |                       | Dep. var.: Average BMI |                      |                       |
| Panel (a): <b>Long difference</b> (2012 - 1988)                                    |                              |                       |                       |                        |                      |                       |
| $\Delta$ Food imports from U.S.  | 0.0268<br>(0.0270)           | 0.0377**<br>(0.0176)  | 0.0383**<br>(0.0161)  | 0.391*<br>(0.205)      | 1.055***<br>(0.269)  | 0.977***<br>(0.260)   |
| $Overw_{t-1}$  |                              | -0.706***<br>(0.0973) | -0.706***<br>(0.0798) |                        |                      |                       |
| $BMI_{t-1}$  |                              |                       |                       |                        | -0.510***<br>(0.119) | -0.502***<br>(0.0971) |
| <i>Effect of one standard-deviation change:</i>                                    |                              |                       |                       |                        |                      |                       |
| $\Delta$ Food imports from U.S.  | 0.00808<br>(0.0082)          | 0.0114**<br>(0.0053)  | 0.0115**<br>(0.0049)  | 0.118*<br>(0.0617)     | 0.318***<br>(0.0811) | 0.295***<br>(0.0784)  |
| Controls   | N                            | Y                     | Y                     | N                      | Y                    | Y                     |
| IV   | N                            | N                     | Y                     | N                      | N                    | Y                     |
| F-stat excluded instr.   |                              |                       | 98.03                 |                        |                      | 105.7                 |
| Obs  | 32                           | 32                    | 32                    | 32                     | 32                   | 32                    |
| R <sup>2</sup>   | 0.017                        | 0.873                 | 0.873                 | 0.041                  | 0.663                | 0.662                 |
| Panel (b): <b>Stacked first difference</b> (2012 - 2006, 2006 - 1999, 1999 - 1988) |                              |                       |                       |                        |                      |                       |
| $\Delta$ Food imports from U.S.  | 0.218*<br>(0.127)            | 0.541***<br>(0.166)   | 0.613***<br>(0.189)   | 4.042***<br>(1.177)    | 7.933***<br>(1.481)  | 7.780***<br>(1.536)   |
| $\Delta$ $Overw_{t-1}$   |                              | -0.259***<br>(0.0894) | -0.264***<br>(0.0837) |                        |                      |                       |
| $\Delta$ $BMI_{t-1}$   |                              |                       |                       |                        | -0.204**<br>(0.0841) | -0.203**<br>(0.0807)  |
| <i>Effect of one standard-deviation change:</i>                                    |                              |                       |                       |                        |                      |                       |
| $\Delta$ Food imports from U.S.  | 0.0084*<br>(0.0049)          | 0.0208***<br>(0.0064) | 0.0235***<br>(0.0073) | 0.155***<br>(0.0452)   | 0.305***<br>(0.0569) | 0.299***<br>(0.0590)  |
| Controls   | N                            | Y                     | Y                     | N                      | Y                    | Y                     |
| IV   | N                            | N                     | Y                     | N                      | N                    | Y                     |
| F-stat excluded instr.   |                              |                       | 32.71                 |                        |                      | 35.08                 |
| Obs  | 96                           | 96                    | 96                    | 96                     | 96                   | 96                    |
| R <sup>2</sup>   | 0.599                        | 0.713                 | 0.712                 | 0.635                  | 0.762                | 0.762                 |

Note: All regressions include a constant term. Stacked difference models include period dummies and a dummy for states with imputed obesity prevalence in 1999 (for 1999 - 1988, and 2012 - 2006). Full set of controls is as in baseline model (see Table A4), but without lagged obesity (trend). The state share of national female population between 18 and 59 years of age in 1990 is used as weight. Robust standard errors clustered at the state level are in parentheses. Significant at: \*10%, \*\*5%, \*\*\*1% level.

*Effects of food imports on inequalities in obesity prevalence.* Local food environments and in our case exposure to U.S. foods can interact with socio-economic determinants of obesity, thereby exacerbating health inequalities (Allcott et al., 2019; Cawley, 2015). In what follows, we estimate regressions at the individual level where the outcome variable is an obesity dummy and investigate how the average effects of U.S. food penetration at the state level vary with education and employment status. Specifically, we estimate the following model at the individual level:

$$(3) \quad Obese_{i,s,t} = \beta_1 USimp_{s,t} \times Indiv_{i,s,t} + \beta_2 H_{i,s,t} + \gamma_{s,t} + \epsilon_{i,s,t}$$

The health surveys in 1988, 1999, 2006 and 2012 provide a repeated cross-section of adult women. The variable  $USimp$  is similar to equation (2), but with the PPP-converted import variable in levels at the time of the survey, and with food expenditures taken in 1989 (at the beginning of the sample). In the baseline specification, the  $Indiv$  variable is a dummy for

women who have completed secondary or tertiary education (‘high education’) or an indicator for women currently unemployed (i.e., the individual-level counterparts of the shares included in the state-level regressions (1)), and  $H$  contains individual-level controls.<sup>37</sup> We absorb ‘level’ effects of time-varying state covariates by including state-year fixed effects  $\gamma_{s,t}$ . Table A5 in the Appendix reports the main estimates.

Exposure to U.S. foods magnifies the existing schooling gradient (of about 4%-points) in obesity risk. The interaction effect associated with the high education indicator is negative and significant (column (1)). To better gauge the importance of this interaction effect consider Figure 9 where we plot the difference in the probability of being obese between women with low and high education against normalised state-level food imports from the U.S.. The results imply that a highly educated woman is 5%-points less likely to be obese than a low educated one if they both live in a state with average exposure to U.S. foods – echoing the stacked first-difference model where obesity correlates negatively with the share of ‘high education’ women (recall Table A4). If exposure to U.S. foods becomes one standard deviation (0.5) higher, the gap grows by a further percentage point and almost doubles if the *USimp* variable reaches its maximum at 2.9.

Interacting the *USimp* variable with the unemployment indicator in column (2) does not deliver any significant effects, with employed and unemployed women in our sample showing similar obesity risks (consistent with the insignificant coefficient on the unemployment share in the state-level regression). In column (3), we control for different socio-economic interactions, including between U.S. foods and household income as proxied by indicators for women living in the central part (from 20th to 80th percentile) and top 20% of the wealth index distribution. While middle-income women face the highest risk of being obese, this gradient does not change with exposure to U.S. foods. The interaction with the unemployment dummy is now negative, but the average difference in obesity risk across employment status is still insignificant. Moreover, controlling for these socio-economic variables does not alter the education-import interaction.

The empirical patterns point to a significant (but moderately sized) interaction between exposure to U.S. foods and education in predicting the risk of being obese. The results are consistent with the well-documented link between education and health.<sup>38</sup> The educational gradient may magnify in food environments where individuals are faced with more unhealthy

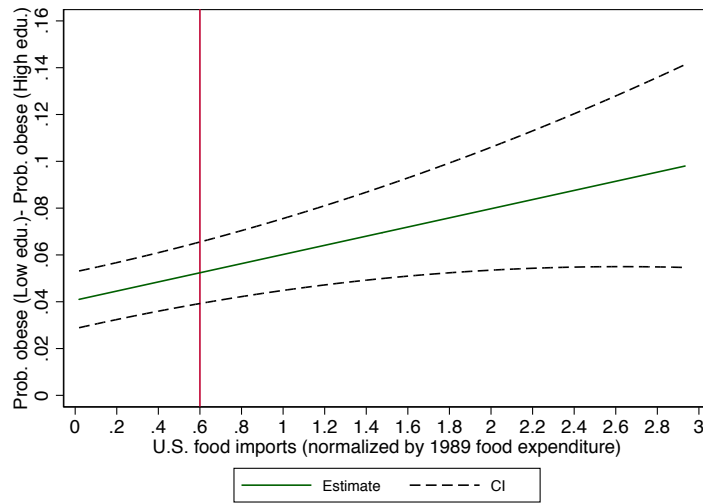
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<sup>37</sup>These are individual and household characteristics such as age, being the household head, speaking indigenous languages, having chronic diseases and wealth from the health surveys (see section 3).

<sup>38</sup>Theoretically, educated individuals may obtain a larger marginal return from any investment in health capital (“productive efficiency” (Grossman, 1972)) and may be more efficient at selecting inputs into health investment (“allocative efficiency” (Rosenzweig and Schultz, 1983)).

food choices (Allcott et al., 2019). We find some corresponding, suggestive evidence in columns (4) and (5) of Table A5 where we split the food imports from the U.S. according to the USDA classification (unreported patterns are confirmed with the ‘vegs. vs. no-vegs’ classification). Exposure to unhealthy U.S. foods exacerbates the education gradient in obesity, while the obesity gap between high and low educated women does not vary significantly with more exposure to healthy U.S. foods. In our setting, highly educated women in Mexico may be in a better position to assess the nutritional content of or to avoid some unhealthy imported foods.

Figure 9: Obesity inequality between education groups and food imports from the U.S.



Note: The vertical line indicates the sample average of the *USimp* variable. Estimates from column (1) of Table A5 are used to generate the graph.

## 5 Potential mechanisms

The empirical findings point to a sizeable and robust effect of food imports from the U.S. on obesity prevalence – an effect that is mainly driven by imports of unhealthy foods. In this sub-section, we explore potential mechanisms that might explain this impact.

Greater penetration of food imports can affect nutrition and body weight by altering domestic food markets. This channel can be rationalized in a standard obesity model following Philipson and Posner (2003) (see also Lakdawalla et al. (2005) and Lakdawalla and Philipson (2009)): Assume the utility of an individual  $U(f, c, w)$  relates positively to food consumption  $f$  and non-food or other consumption  $c$ ; and non-linearly to body weight  $w$ . An individual’s utility increases (decreases) in body weight when weight is below (above) a weight target  $w_o$ . In other words, if  $w > w_o$  the individual would want to diet, and gain weight otherwise. Weight in turn depends positively on food consumption  $w(f)$

(with  $w' > 0$ ), where for simplicity we maintain physical activity at a constant level. When  $U(f, c, w)$  displays separability in its arguments and is maximised with respect to the budget constraint  $I = c + Pf$ , then weight  $w$  (through  $f$ ) is decreasing in the price of food  $P$  and increasing in income  $I$  (see Philipson and Posner (2003)). This theoretical framework motivates us to examine if changes in relative food prices and income can explain the effect of food imports on body weight.<sup>39</sup> Extensions of this simple framework introducing taste (or habit) formation (e.g., in Atkin (2013); and Dragone and Ziebarth (2017)) beg the additional question of whether prolonged exposure to imported foods can have reinforcing effects on food consumption and hence body weight.

#### (a) Price mechanism

Greater openness to imports may lower relative prices of imported and import-competing goods through several channels (see Goldberg and Pavcnik (2016) for a detailed discussion). In our setting, American food exporters become more competitive through lower export prices and greater market access (e.g., due to the NAFTA-induced reduction in trade barriers). Both lead to an expansion in the U.S. export supply and a lower domestic price of imported U.S. foods.<sup>40</sup> Holding constant the price of local foods, the overall consumer price of a food product (including both local and foreign varieties) decreases with the price of imports, although the strength of this relationship depends on the market structure and demand conditions (e.g., on the substitutability between foreign and domestic varieties).

Greater import penetration in food markets might further reduce consumer prices by exerting competitive pressure on local food producers. This pro-competitive effect emerges in models with imperfect competition and variable markups as domestic firms lower markups and prices in order to accommodate a downward shift in the residual demand curve and greater price elasticity of demand (Krugman, 1979; Edmond et al., 2015). These mechanisms clearly suggest a negative relationship between U.S. export supply of foods to Mexico and Mexican consumer food prices, which could in turn explain the reduced-form effect of exposure to U.S. foods on obesity prevalence.<sup>41</sup>

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<sup>39</sup>Increasing income and falling food prices will only initially lead to weight gains and not-monotonically so due to the ideal weight  $w_o$  (see Philipson and Posner (2003) for details). We focus on the linear and initial relationships as what is perceived as “ideal” weight may change over time (Strulik, 2014), thus making tests for non-monotonicity problematic.

<sup>40</sup>Under the small country assumption, the export price ( $p_g^*$ ) and trade costs ( $t_g$ ) pin down the consumer price of a given food product  $g$ . With perfect competition or monopolistic competition and CES demand, changes in the domestic price of imported goods are proportional to changes in the export price or in multiplicative (iceberg or ad-valorem) trade costs ( $\ln p_g = \ln p_g^* + \ln t_g$ ).

<sup>41</sup>Trade liberalisation can reduce the price of domestically produced foods by providing domestic firms with

We test if Mexican consumer food prices decrease with U.S. food exports both at the national and sub-national level using the CPI microdata made available by [Gagnon \(2009\)](#) (for details see section 3). We compute the annual price for each food product that could be matched with the ENIGH (and trade) classification as the average of the (log) monthly price quotes – a monthly quote is identified by a store, city, and food product. These national prices are regressed on (logs of) annual U.S. food exports to other countries than Mexico – our instrument for product-specific U.S. food supply –, controlling for product and year fixed effects, from 1995 to 2010 (the period when the CPI data are available). The negative and significant elasticity in column (1) of Table 7 supports the prediction of a price-reducing effect of exposure to greater U.S. export supply of foods. Since food prices went up during this period along with prices of other goods<sup>42</sup>, the estimates suggest that the rise in food prices was dampened by U.S. food export supply.

In columns (2) to (4) of Table 7 we verify the robustness of these results to the inclusion of other trade variables that might affect relative food prices. Standard comparative advantage arguments would predict that the relative (*producer*) price of exported foods from Mexico should increase as producers gain market access to the U.S. and other countries. To isolate exogenous (in this case, demand-side) determinants of Mexican food exports, we use total food imports by the U.S. (a major destination of Mexican food exports) from all origins except Mexico. As shown in column (2), the elasticity of Mexican food prices with respect to this instrument for Mexican export opportunities is negative, close to zero and imprecisely estimated. While not conclusive, this piece of evidence indicates that exposure to exports markets did not have significant effects on food consumption (and hence body weight) through local food prices. Importantly, the negative elasticity with respect to U.S. food exports remains unchanged (see column (3)). Further controlling for Mexican food imports from other countries (ROW) in column (4) alters only marginally the elasticity of interest.

Greater exposure to U.S. food supply should affect Mexican food prices through higher food imports from the U.S.. We investigate this casual chain from U.S. food exports to consumer food prices more closely by estimating IV models. U.S. food exports to other countries serve as an instrument for the value of Mexican food imports from the U.S., while food imports by the U.S. from other countries than Mexico is the instrument for Mexican

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access to a greater variety of (cheap) intermediate inputs (see [Amiti and Konings \(2007\)](#) and [Goldberg et al. \(2010\)](#) for evidence from Indonesia and India across all manufacturing industries). This channel is however likely to be weak in our setting where most of the food products considered are for final consumption.

<sup>42</sup> Following the Mexican peso crisis at the end of 1994, inflation skyrocketed to 40% during 1995 and much of 1996 ([Gagnon, 2009](#)). Prices increased steadily thereafter, although at a lower pace. The official CPI for foods, beverages and tobacco products in 2010 was about three times its value in 1996 – a similar increase is observed for the overall CPI (data from the [INEGI website](#)).

food exports to the U.S. The results, reported in columns (5) to (7) of Table 7, confirm the price-reducing effect of greater exposure to U.S. foods. Food products become relatively less expensive to Mexican consumers as penetration of U.S. foods increases – a result of the expanding U.S. food export supply.

The magnitudes implied by the elasticities of consumer food prices with respect to shocks in U.S. food exports are in line with the findings of the literature on the price effects of import liberalisation. As reported at the bottom of Table 7, the average increases in U.S. food exports to other countries (in columns (1),(3) and (4)) and to Mexico (in columns (5) to (7)) observed between 1995 and 2010 mandate 3 to 12 percent reductions (depending on the specification used) in the consumer prices of foods in our sample, which were on average 120 percent higher in 2010 than in 1995 (overall inflation was even higher during the same period – see footnote no.42). Incidentally, these magnitudes are in the ballpark of the 10 percent decline in domestic prices due to import tariff liberalisation in India found by [Topalova \(2010\)](#); and [De Loecker et al. \(2016\)](#). The attenuated price response that we find is consistent with different theoretical mechanisms ([Goldberg and Pavcnik, 2016](#)), and can be related to our empirical setting. Unlike the aforementioned papers exploiting direct changes in trade costs, we identify an indirect effect of an export supply shock that should be matched by a drop in the domestic price of imported foods and in turn transmit to overall consumer prices. Persistence in food consumption habits as in the model of [Atkin \(2013\)](#) can further diminish price responses to trade liberalisation, if Mexican consumers hold tastes for local food varieties that were available before U.S. ones. In spite of these limitations, findings corroborate a price channel behind the impact of exposure to U.S. foods on obesity.<sup>43</sup>

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<sup>43</sup>The dependent variable of the price regressions, computed from the CPI microdata as average across price quotes, should encompass the price effect of new and disappearing food varieties as quotes are added and dropped from the dataset. Importantly though, the CPI microdata do not allow us to distinguish domestic from imported varieties, nor to follow price quotes after 2002 (see section 3). Furthermore, lack of data on expenditures at the variety (i.e., price quote) level prevents us from computing exact price indices that formally incorporate the influence of changes at the extensive margin (e.g., as in [Feenstra \(1994\)](#); and [Broda and Weinstein \(2006\)](#)).



Table 7: Food prices and U.S. food exports to Mexico

|  | (1)                    | (2)                  | (3)                    | (4)                    | (5)                   | (6)                  | (7)                   |
|--|------------------------|----------------------|------------------------|------------------------|-----------------------|----------------------|-----------------------|
|  | Reduced form OLS       |                      |                        |                        | IV                    |                      |                       |
| Ln(U.S. food exports to ROW)                         | -0.0437***<br>(0.0157) |                      | -0.0429***<br>(0.0152) | -0.0452***<br>(0.0153) |                       |                      |                       |
| Ln(U.S. food imports from ROW)                       |                        | -0.00903<br>(0.0187) | -0.00482<br>(0.0188)   | 0.00427<br>(0.0175)    |                       |                      |                       |
| Ln(food imports from U.S.)                           |                        |                      |                        |                        | -0.0634**<br>(0.0308) | -0.0732*<br>(0.0438) | -0.0824*<br>(0.0443)  |
| Ln(Mex. exports to U.S.)                             |                        |                      |                        |                        |                       | -0.0152<br>(0.0551)  | -0.0359<br>(0.0584)   |
| Ln(food imports from ROW)                            |                        |                      |                        | -0.00485<br>(0.00388)  |                       |                      | -0.00284<br>(0.00580) |
| <i>First-stage results – food imports from U.S.:</i> |                        |                      |                        |                        |                       |                      |                       |
| Ln(U.S. food exports to ROW)                         |                        |                      |                        |                        | 0.688***<br>(0.236)   | 0.657***<br>(0.216)  | 0.661***<br>(0.214)   |
| Ln(U.S. food imports from ROW)                       |                        |                      |                        |                        |                       | 0.188<br>(0.133)     | 0.206<br>(0.155)      |
| F-stat excluded instr.                               |                        |                      |                        |                        | 8.48                  | 4.63                 | 4.78                  |
| <i>Percent impact of 2010 - 1995 ave. change in:</i> |                        |                      |                        |                        |                       |                      |                       |
| Ln(U.S. food exports to ROW)                         | -3.40***<br>(1.220)    |                      | -3.35***<br>(1.182)    | -3.28***<br>(1.109)    |                       |                      |                       |
| Ln(food imports from U.S.)                           |                        |                      |                        |                        | -10.76**<br>(5.226)   | -10.73*<br>(6.415)   | -11.91*<br>(6.400)    |
| Obs  | 1,848                  | 1,896                | 1,848                  | 1,738                  | 1,840                 | 1,756                | 1,661                 |
| R <sup>2</sup>                                       | 0.977                  | 0.977                | 0.977                  | 0.976                  | 0.974                 | 0.973                | 0.969                 |

Note: The dependent variable is the annual average of price quotes (in logs) by food product. All regressions include product and year fixed effects. The product expenditure share in 1995 is used as weight. First-stage results are estimates on the excluded instruments only. Robust standard errors clustered at the product level are in parentheses. Significant at: \*10%, \*\*5%, \*\*\*1% level.

Similar patterns emerge when we exploit variation within Mexico. For each state and year, we take the expenditure-weighted average of food prices across products (where product-level prices equal in turn the mean of logged price quotes), holding the expenditure weights fixed at their values in 1995. This annual food price index for each state is regressed on U.S. food exports and other trade variables, allocated across states and normalized by total state's food expenditure using expenditure values in 1995 (see equation 2). The state-year panel specification further controls for state and year fixed effects, so as to identify the price effect of exposure to U.S. foods from variations within states over time and across food products. The estimates, reported in Table A6 in the Appendix, show a negative effect of penetration of food imports from the U.S. on state-level food prices – both in reduced form and IV –, which is unaltered by controlling for exposure to foreign demand for Mexican foods and other state-level covariates (food imports from ROW, GDP per capita, FDI over GDP, and migrants).<sup>44</sup> The price-reducing effect is robust to the addition of non-food prices

<sup>44</sup>We take log of GDP per capita, and the inverse hyperbolic sine transformation of FDI over GDP and returning migrants over state's population in the presence of zero observations (4 for the FDI variable, and

in columns (3) and (6), also computed from the CPI microdata made available by [Gagnon \(2009\)](#).<sup>45</sup> While this control variable might be endogenous to food prices, the stability of the coefficient on the U.S. food variable suggests that greater trade penetration makes foods *relatively* cheaper locally. To be clear, food became cheaper relative to non-food, as the latter were not significantly impacted by U.S. food supply.<sup>46</sup>

By exploiting within-state variation over time, the annual panel regressions follow the same type of variation that we use in the obesity regressions. In Table A7, we closely mirror the obesity specification in equation (1) by estimating the price effects of exposure to U.S. foods in 2006 - 1999 changes across Mexican states – this is the only period where there is overlap between the 1995-2010 price data from [Gagnon \(2009\)](#) and the obesity data in 1988, 1999, 2006 and 2012. Price changes by product and state are aggregated at the state level using state-specific expenditure weights at the beginning of the period (in 1999).<sup>47</sup> In spite of the limited sample size, we find a consistently negative impact of changes in U.S. food exports to other countries on changes in food prices between 1999 and 2006.<sup>48</sup> The addition of the same control variables used in the baseline obesity specification (lagged obesity trend, lagged food expenditure share, and changes in unemployment and high-educated shares of adult women in the health surveys) does not alter the price-reducing effect of U.S. foods (see column (3)). Again, these patterns support a price mechanism underlying the pro-obesity effect of U.S. foods, also relative to non-food prices.<sup>49</sup>

The average impact of U.S. food penetration on Mexican consumer prices can mask important variation across food products that are more or less ‘obesity-prone’. The simple obesity model described above could be extended to allow for foods with different characteristics that are related to their ‘healthiness’ (borrowing from [MacInnis and Rausser \(2005\)](#) and their model with ‘unprocessed’ and ‘processed’ foods): unhealthy foods are more intensive in calories than healthy ones and thus more obesity prone as captured in the properties of the body weight production function:  $w(f^h, f^{unh})$ ; with  $\frac{\partial w(.)}{\partial f^{unh}} > \frac{\partial w(.)}{\partial f^h}$  – where

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6 for the migrant one).

<sup>45</sup>These are aggregated at the state level using expenditure weights in 1995. Twenty percent of the non-food price quotes is dropped following [Gagnon \(2009\)](#)’s guidelines (e.g., product categories mixing products and service provision, quotes referring to small stores or city-wide price indexes). The same criteria led to a mere loss of 3% in the food sample – mainly because of changing weighting units of tortilla and bread between 1995 and 2002 (see also section 3).

<sup>46</sup>There is an insignificant effect of U.S. food supply on the price of non-food products as dependent variable in the same state-level specifications of Table A6 – results available upon request.

<sup>47</sup>As pointed out in section 3, the micro price quotes changed in 2003. The averaged product-level prices in 2006 and 1999 might thus represent different sets of product varieties.

<sup>48</sup>IV estimates are imprecise because of a weak first-stage in the 2006-1999 difference.

<sup>49</sup>As in the annual panel regressions, we find no significant impact of U.S. food supply on non-food price changes over the 2006-1999 period (results available upon request).

$f^{unh}$  and  $f^h$  identify consumption of unhealthy and healthy foods, respectively. When prices of unhealthy relative to healthy foods decline, relative unhealthy consumption goes up and body weight increases – for any given level of total food consumption. Empirically, the identification of effects on the relative price of unhealthy foods hinges upon our rather coarse classifications of foods into healthy and unhealthy aggregates.

At the national level, we estimate reduced-form and IV price regressions (akin to Table 7) on separate samples of healthy and unhealthy food products defined according to the USDA classification and our more conservative ‘vegs+’ grouping. Results from both splits reported in Table 8 deliver plausible findings: the price-reducing effect of greater exposure to U.S. foods is concentrated in the unhealthy sample. In the healthy foods sample, the effect is insignificant and the first-stage linking U.S. food exports to ROW and Mexican imports from the U.S. is weak. These patterns accord well with trends in Figures 3 and 4 showing how U.S. food exports to Mexico became increasingly specialised in unhealthy foods – the supply shock that we are identifying is thus concentrated in these. They also match up with the findings from the obesity regressions in Table 2 suggesting that the pro-obesity effect of total food imports from the U.S. is largely due to the increase in unhealthy imports.<sup>50</sup>

To investigate more directly the relative unhealthy price mechanism, we estimate the effects of the U.S. food variable separately on the prices of unhealthy and healthy foods at the state level, using the same empirical specification as in Table A6. The results, reported in Table A8, show that exposure to (total) U.S. food supply has a robust price-reducing effect on unhealthy foods within states. The effect on the local price of healthy foods is also negative, but less precisely estimated and somewhat smaller than the one on unhealthy foods. In estimates available upon request, we find similar patterns (greater penetration of U.S. foods reducing especially the price of unhealthy foods) in regressions on 2006 - 1999 changes.

These findings suggests that rising exposure to U.S. foods lowered – at least qualitatively – the price of unhealthy foods. The lack of stronger and more precise evidence on relative prices might be the consequence of substitutability between healthy and unhealthy foods – the price-reducing effect of greater supply of (mainly) unhealthy foods may lead to lower demand, and hence price, of healthy foods. At the same time, these patterns concord well with the obesity regressions in that both USDA food groups correlate positively with obesity. However, the (standardized) effect associated with imports of unhealthy foods is larger (see

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<sup>50</sup>The comparability with the obesity results is further enhanced by estimates of state-year panel regressions where the price and trade variables are computed separately for healthy and unhealthy foods. Again, the negative effect of exposure to U.S. food supply on consumer prices is robust only with unhealthy foods (results available upon request).

Table 2, column (3)).

Table 8: Food prices and U.S. food exports to Mexico – unhealthy vs. healthy products

|  | (1)                    | (2)                   | (3)                    | (4)                  | (5)                    | (6)                  | (7)                  | (8)                 |
|--|------------------------|-----------------------|------------------------|----------------------|------------------------|----------------------|----------------------|---------------------|
|  | Unhealthy foods        |                       |                        |                      | Healthy foods          |                      |                      |                     |
|  | USDA                   |                       | Vegs+                  |                      | USDA                   |                      | Vegs+                |                     |
| Ln(U.S. food exports to ROW)                         | -0.0497***<br>(0.0130) |                       | -0.0564***<br>(0.0150) |                      | -0.00810<br>(0.0704)   |                      | 0.1000<br>(0.0750)   |                     |
| Ln(U.S. food imports from ROW)                       | -0.00920<br>(0.0227)   |                       | 0.00224<br>(0.0223)    |                      | 0.0188<br>(0.0484)     |                      | -0.0208<br>(0.0398)  |                     |
| Ln(food imports from U.S.)                           |                        | -0.0860*<br>(0.0441)  |                        | -0.127<br>(0.0794)   |                        | -0.0604<br>(0.167)   |                      | 0.581<br>(0.893)    |
| Ln(Mex. exports to U.S.)                             |                        | -0.0558<br>(0.108)    |                        | -0.121<br>(0.140)    |                        | -0.0266<br>(0.116)   |                      | 0.0417<br>(0.156)   |
| Ln(food imports from ROW)                            | -0.00919*<br>(0.00509) | -0.00898<br>(0.00756) | -0.00782<br>(0.00487)  | -0.0102<br>(0.00900) | -0.000760<br>(0.00819) | 0.00386<br>(0.00716) | 0.00240<br>(0.00612) | -0.0159<br>(0.0385) |
| <i>First-stage results – food imports from U.S.:</i> |                        |                       |                        |                      |                        |                      |                      |                     |
| Ln(U.S. food exports to ROW)                         |                        | 0.648***<br>(0.242)   |                        | 0.669***<br>(0.229)  |                        | 0.556***<br>(0.157)  |                      | 0.233<br>(0.152)    |
| Ln(U.S. food imports from ROW)                       |                        | 0.319<br>(0.215)      |                        | 0.297<br>(0.192)     |                        | -0.151<br>(0.142)    |                      | -0.023<br>(0.102)   |
| F-stat excluded instr.                               |                        | 4.29                  |                        | 4.74                 |                        | 6.85                 |                      | 1.18                |
| Obs  | 983                    | 934                   | 1,128                  | 1,065                | 755                    | 727                  | 610                  | 596                 |
| R <sup>2</sup>                                       | 0.981                  | 0.789                 | 0.978                  | 0.608                | 0.959                  | 0.774                | 0.967                | 0.222               |

Note: The dependent variable is the annual average of price quotes (in logs), by food product. Odd-numbered columns report reduced-form OLS results, even-numbered columns report IV results. See text for descriptions of the unhealthy vs. healthy classifications. All regressions include product and year fixed effects. The product expenditure share in 1995 is used as weight. First-stage results are estimates on the excluded instruments only. Robust standard errors clustered at the product level are in parentheses. Significant at: \*10%, \*\*5%, \*\*\*1% level.

#### (b) Income effects

Trade liberalisation can affect food consumption and obesity prevalence through changes in individuals' income. As shown above, body weight is expected to increase with income (as long as  $w < w_o$ ). In our obesity regressions, the relationship between obesity and income per capita is however insignificant (see Table 1), and controlling for this variable does not affect the pro-obesity effect of exposure to U.S. foods. More generally, our focus on food imports and our empirical strategy geared towards a nutrition channel (i.e., through the use of expenditure shares to capture exposure) make it unlikely that income changes can explain the obesity effects that we find.

The empirical literature on local income effects of increased import competition and export opportunities relies on exposure through industry of employment (see Topalova (2010); McCaig (2011); Kis-Katos and Sparrow (2015); McCaig and Pavcnik (2018) for evidence from developing countries). Our empirical strategy leverages differences in exposure through initial expenditure to imports across more than 150 food and beverages products.

The significance of employment variations at such level of detail remains unclear.<sup>51</sup> When we do control for labour market characteristics of our sample of adult women in our regressions (see Table A4), the positive and significant effect of food imports from the U.S. on obesity rates is unaltered. Furthermore, results from the price regressions do not show significant effects of exposure to food export markets, although the negative effects on the consumer prices of import competing foods could lead to lower labour earnings for workers employed in the production of those foods.<sup>52</sup> These different pieces of evidence tentatively show that income changes do not affect or relate to our main finding. A different empirical setup (e.g., leveraging exposure through local employment) from the one used in this paper might be better suited to identify the income effects of trade shocks.

### (c) Changes in tastes and U.S. foods

A final mechanism that we explore is related to changing tastes following increased exposure to U.S. foods. In the theoretical model proposed by [Atkin \(2013\)](#) explaining nutrition patterns across India, individuals form habits in consumption and buy more of a food product if its past prices were low (relative to other foods). Such a model can also rationalise an expansion in food consumption (leading to higher body weight) if U.S. foods complement pre-existing food preferences by Mexican consumers. Therefore, our empirical strategy that allocates changes in food imports according to expenditure shares at the start of the period is consistent with a reinforcing relationship between penetration of U.S. foods and habits in food consumption.<sup>53</sup>

Since we find that higher U.S. food exports are significantly correlated with lower consumer prices, we would expect that, under habit formation, Mexican households devote larger shares of expenditure to foods that were relatively cheaper in the past because of exposure to U.S. supply. To shed light on this mechanism, we adapt the empirical approach of [Atkin \(2013\)](#). In a first stage, we regress household food expenditure shares by nine food aggregates on total real food expenditure, household-level controls, and state-year

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<sup>51</sup>Industry employment by Mexican state could be computed using data the Economic Censuses (see [Chiquiar et al. \(2017\)](#) for an application), where the NAICS industry classification is used.

<sup>52</sup>Greater import competition in the food sector can proxy for penetration of foreign retailers, as it could be the case of Walmart in Mexico (see subsection 4.2). [Atkin et al. \(2018\)](#) however find little evidence for a significant effect of retail FDI on local income or employment in Mexico, and our results show that controlling for the local presence of Walmart stores had no important impact of the relationship between obesity and exposure to food imports from the U.S..

<sup>53</sup>Notably, the utility function discussed above could for instance feature past exposure to foods  $F$ , allowing for their interactions with current consumption  $f$  through a non-zero cross partial  $U_{F,f}$  (for such a model of food consumption and weight gains see [Dragone and Ziebarth \(2017\)](#)).

fixed effects. The estimated state-year fixed effects from the first step varying across food aggregates are then regressed on exposure to U.S. food exports to the ROW (our instrument), controlling for current own and cross-product price effects, as well as state-product and state-year fixed effects.<sup>54</sup>

Table A9 summarizes the results (the notes at the bottom of the table provide more details on the estimation). We first include our contemporaneous trade variable by itself (column (1)), which correlates positively with expenditure shares by product aggregate. As one would expect and in line with the aforementioned price mechanism, this correlation vanishes once we control for prices (column 2). In columns (3),(5) and (7), we include lags of the trade variable without controlling for prices. The average effect across lags is positive and significant (as reported in a separate row below the individual point estimates), suggesting that past exposure to U.S. foods leads to persistence in food consumption. Given the arbitrary choice of the number of lags, we also report a Bayesian Information Criterion (BIC), which indicates that the model without lags or the one with just one lag is preferred to including several lags.<sup>55</sup> However, once we control for current prices (see columns (4), (6) and (8)), the average effect on the lags becomes negative. In sum, we find some evidence of a persistent effect of exposure to U.S. food supply on budget shares, which is however driven by current prices, in turn leaving little room for the identification of a taste mechanism. One important caveat to notice is that changes in tastes are likely slow moving and we are restricted to a relatively short period of analysis (1995 - 2010).

## 6 Concluding remarks

A handful but growing set of studies has documented the adverse effects of trade liberalisation on health through income and labour market channels (Colantone et al., 2019; Adda and Fawaz, 2017; Pierce and Schott, 2018; Hummels et al., 2016; Lang et al., 2019; McManus and Schaur, 2016).

We contribute to this literature by providing novel evidence on the effects of trade in foods on obesity. Our results advance the idea that the U.S. has exported some of its obesity

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<sup>54</sup>See equation n. 5 of Atkin (2013) for a similar specification. The household budget regression is motivated by a linear approximation of the Almost Ideal Demand System (AIDS) (Deaton and Muellbauer, 1980), under the assumption of weak separability between food expenditure ( $f$ ) and expenditure on other goods ( $c$ ) – justifying the use of real food expenditure instead of total real expenditure. Unlike in Atkin (2013), our price data can be matched with the expenditure data only at the state level – i.e., the same spatial level of our trade variables. For this reason, we include the price variables only in the second step of our estimation, where household-level characteristics are netted out from the state-level budget shares.

<sup>55</sup>We stop at three lags as in any case the BIC increases as we add more lags.

epidemic to Mexico. Our causal estimates suggest that plausibly exogenous variation in U.S. food exports to Mexico explains up to twenty percent of the total rise in obesity prevalence among Mexican women observed between 1988 and 2012. This effect amounts to around two million additional obese women over the period. The magnitudes are comparable to the obesity effects found in other studies examining the role of changes in the food environment in different contexts ([Courtemanche and Carden, 2011](#)). U.S. exports of unhealthy foods are driving the pro-obesity impact of exposure to U.S. foods, thus corroborating a nutritional channel. We also find evidence for a price-reducing effect of exposure to U.S. food supply, which might rationalize the findings on obesity.

In combining health, expenditure, and trade data over a long period of time, our empirical analysis faces some limitations – future work might address some of these. First, the results stem from a relatively small number of observations (32 states observed over four periods). The large variations in obesity and food imports observed over the period and across states, and the robustness of our findings to a host of checks (e.g., lead tests, dropping single states, and alternative outcome variables) alleviate this concern to some extent. Second, we find no evidence for an income mechanism, in part as our empirical strategy is geared towards identifying a consumption channel. Finally, the relatively short period under consideration might not allow us to pinpoint the effect of prolonged exposure to U.S. foods on tastes, which might take decades to manifest itself.

With these caveats in mind, the baseline findings still imply a significant and sizeable contribution of U.S. food exports to the ongoing nutrition transition and associated spread of the obesity epidemic in Mexico. Like other emerging economies, the country would have attained high levels of obesity prevalence even without increasing exposure to American (unhealthy) foods. Our empirical analysis – which controls for trends in obesity prevalence across Mexican states – shows that the rising penetration of U.S. food exports has moved Mexican consumers on a steeper obesity trajectory.

Our paper supports the idea that health concerns should matter for the determination of trade policies, especially when it comes to unhealthy food products. Our paper is consistent with anecdotal evidence of a positive link between trade and investment liberalisation and the observed rise in obesity in Mexico ([Jacobs and Richtel, 2017](#)). As the UN Special Rapporteur on the Right to Food stated in 2012, the widespread belief is that at least part of the obesity emergency could have been avoided if “the health concerns linked to shifting diets had been integrated into the design of the country’s trade policies” ([Guardian, 2015](#)).

That said, future work should investigate further the health consequences of trade liberalisation in the food sector. There are possible negative health externalities associated



with trade integration, especially when trading partners have a comparative advantage in unhealthy foods. Yet, it remains unclear how these health externalities measure up to the much heralded consumers' welfare gains from trade due to access to new and less expensive varieties.

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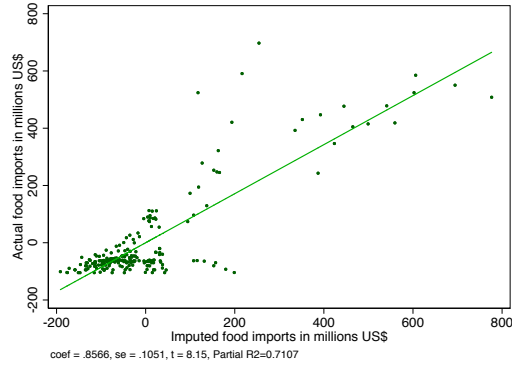


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# Appendix

Figure A1: Relationship between actual and imputed food imports between 2006 and 2012

Panel (a): Controlling for year fixed effects



Panel (b): Controlling for state and year fixed effects

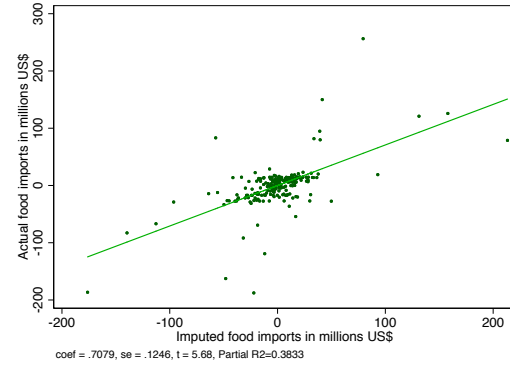


Figure A2: Changes in normalized imputed food imports from the U.S. ( $\Delta U S_{imp}$ ) between 1988 and 2012

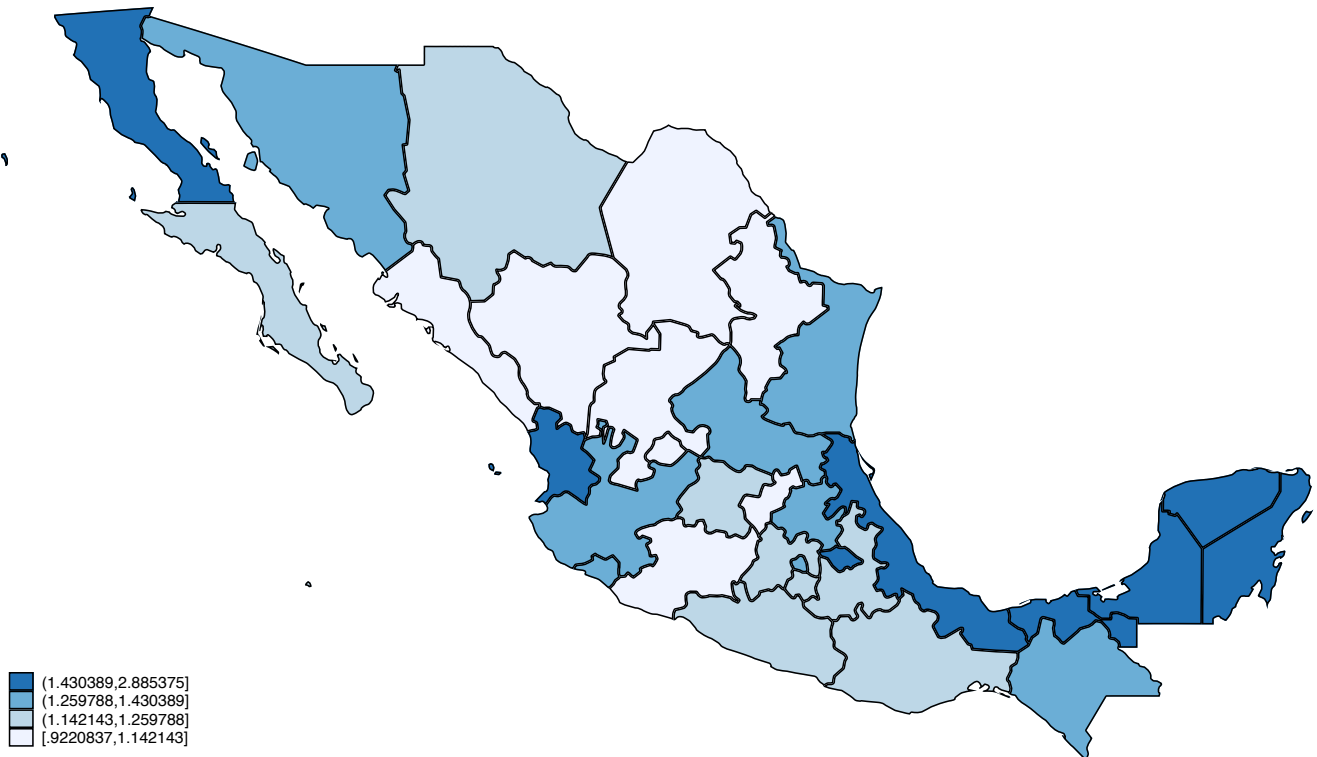
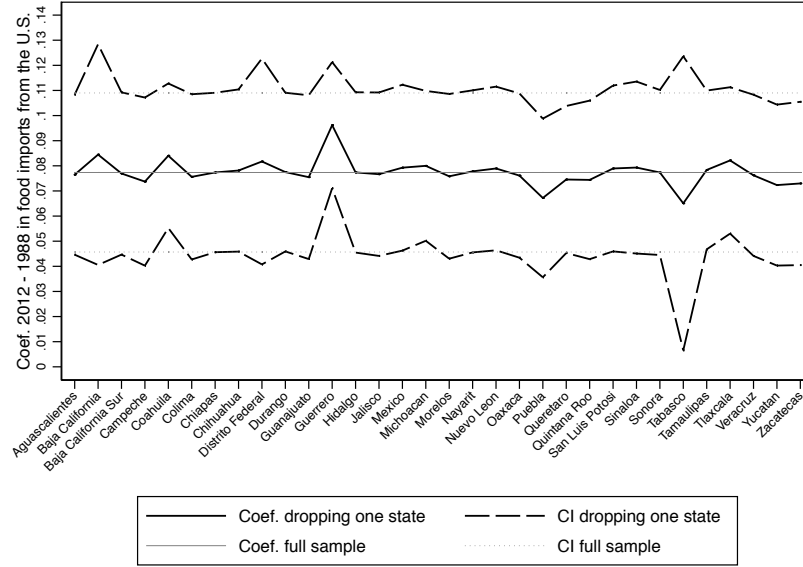
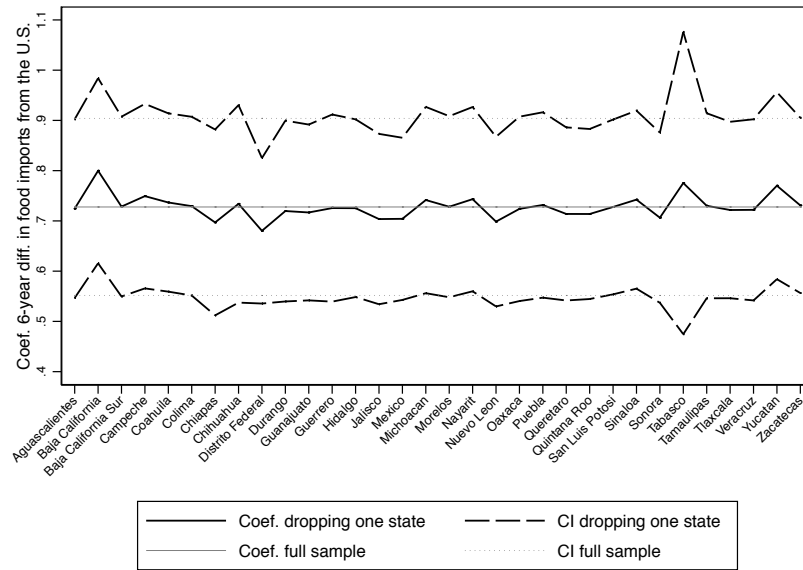


Figure A3: Obesity prevalence and food imports from the U.S. – Excluding one state at a time

Panel (a): Long-difference (2012 - 1988)



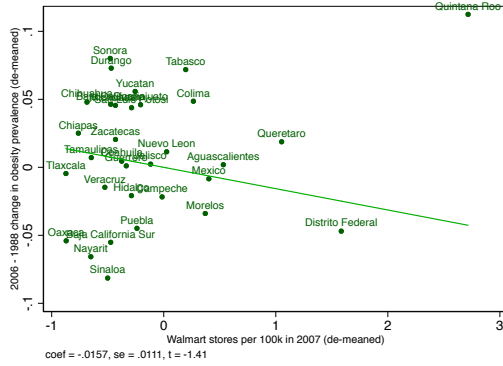
Panel (b): Stacked first-difference



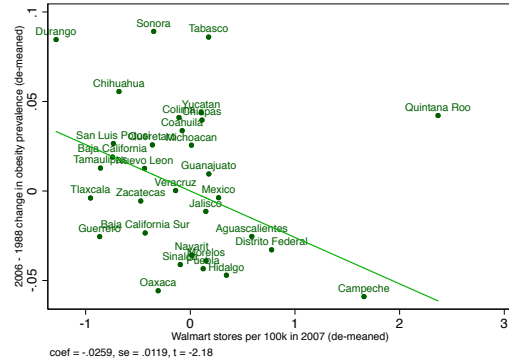
Note: Panel (a) use the OLS specification in Table 1, column (1), Panel (d.i). Panel (b) uses the OLS specification in Table 1, column (4), Panel (d.ii).

Figure A4: Obesity prevalence, Walmart, food imports from the U.S.

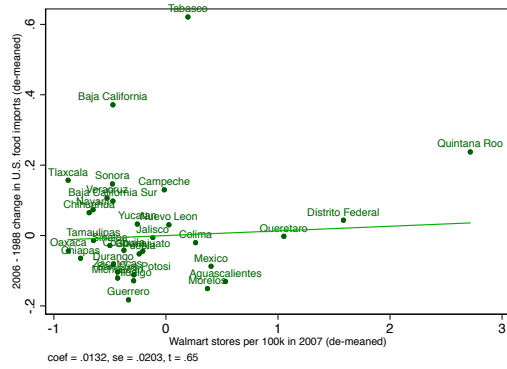
Panel (a): Obesity and Walmart, unconditional



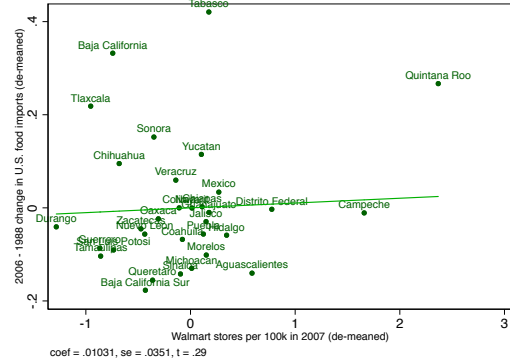
Panel (b): Obesity and Walmart, with covariates



Panel (c): U.S. foods imports and Walmart, unconditional



Panel (d): U.S. foods imports and Walmart, with covariates



Note: Variables on the vertical and horizontal axis are 'partialled out' of the constant term, controls and lagged obesity (in Panels (b) and (d)). The state share of national female population between 18 and 59 years of age in 1990 is used as weight.

Table A1: List of Food and Beverages products

| Product                                      | QFAHPD category | Healthy (USDA) | Healthy (Vegs+) |
|--|-----------------|----------------|-----------------|
| Apple  | 1               | 1              | 1               |
| Avocado                                      | 1               | 1              | 1               |
| Grape  | 1               | 1              | 1               |
| Guava  | 1               | 1              | 1               |
| Lemon  | 1               | 1              | 1               |
| Mannece apple                                | 1               | 1              | 1               |
| Mango  | 1               | 1              | 1               |
| Melon  | 1               | 1              | 1               |
| Orange                                       | 1               | 1              | 1               |
| Other citrus fruits: lime, grapefruit        | 1               | 1              | 1               |
| Other: soursop, fig, coconut, tamarind       | 1               | 1              | 1               |
| Papaya                                       | 1               | 1              | 1               |
| Peach and apricot                            | 1               | 1              | 1               |
| Pear   | 1               | 1              | 1               |
| Pineapple                                    | 1               | 1              | 1               |
| Strawberry                                   | 1               | 1              | 1               |
| Tabasco banana                               | 1               | 1              | 1               |
| Watermelon                                   | 1               | 1              | 1               |
| Boxed juices                                 | 3               | 1              | 0               |
| Cabbage                                      | 4               | 1              | 1               |
| Coriander                                    | 4               | 1              | 1               |
| Courgette                                    | 4               | 1              | 1               |
| Cucumber                                     | 4               | 1              | 1               |
| Epazote, celery, papalo                      | 4               | 1              | 1               |
| Lettuce                                      | 4               | 1              | 1               |
| Mixed bagged vegetables                      | 4               | 1              | 1               |
| Parsley                                      | 4               | 1              | 1               |
| Spinach, algae                               | 4               | 1              | 1               |
| Carrot                                       | 6               | 1              | 1               |
| Corn   | 8               | 1              | 0               |
| Other bananas: plantain etc.                 | 8               | 1              | 1               |
| Other: yam, sweet potato, beetroot           | 8               | 1              | 1               |
| Pea  | 8               | 1              | 1               |
| Potato                                       | 8               | 1              | 0               |
| Sweetcorn                                    | 8               | 1              | 1               |
| Nixtamal (boiled maize/corn) and others      | 9               | 1              | 0               |
| Nopales                                      | 10              | 1              | 1               |
| Serrano pepper and jalapeno                  | 10              | 1              | 1               |
| Dried and powdered chillis                   | 11              | 1              | 1               |
| Green tomato                                 | 12              | 1              | 1               |
| Pepper                                       | 12              | 1              | 1               |
| Red tomato                                   | 12              | 1              | 1               |
| Bean   | 14              | 1              | 1               |
| Chayote                                      | 14              | 1              | 1               |
| Chickpea                                     | 14              | 1              | 1               |
| Garlic                                       | 14              | 1              | 1               |
| Green bean                                   | 14              | 1              | 1               |
| Onion  | 14              | 1              | 1               |
| Other: artichoke, radishes                   | 14              | 1              | 1               |
| Other: lentil, broad bean                    | 14              | 1              | 1               |
| Bean (tinned or boxed)                       | 15              | 1              | 1               |
| Corn dough                                   | 16              | 1              | 0               |
| Corn tortilla                                | 16              | 1              | 0               |
| Grains of rice                               | 16              | 1              | 0               |
| Oats   | 16              | 1              | 0               |
| Other cereals: barley, rye                   | 16              | 1              | 0               |
| Wheat tortilla                               | 16              | 1              | 0               |
| Corn flour                                   | 17              | 1              | 0               |
| Other: yoghurt, sour cream                   | 17              | 0              | 0               |
| Other rice products: flour, toasted          | 19              | 0              | 0               |
| Other wheat products: flakes, prepared flour | 19              | 0              | 0               |
| Pasta for soup                               | 19              | 0              | 0               |
| Sliced bread                                 | 19              | 0              | 0               |
| White bread                                  | 19              | 0              | 0               |
| Wheat flour (refined and wholemeal)          | 20              | 0              | 0               |
| Evaporated milk                              | 22              | 1              | 0               |
| Formula milk                                 | 22              | 1              | 0               |
| Fresh cheese                                 | 23              | 1              | 0               |
| Manchego                                     | 23              | 0              | 0               |
| Condensed milk                               | 25              | 0              | 0               |
| Other milk: goat, donkey                     | 25              | 0              | 0               |
| Pasteurised milk                             | 25              | 0              | 0               |
| Powdered milk (whole or skimmed)             | 25              | 0              | 0               |
| Butter                                       | 26              | 0              | 0               |
| Chihuahua cheese                             | 26              | 0              | 0               |
| Mature cheese                                | 26              | 0              | 0               |
| Oaxaca                                       | 26              | 0              | 0               |

Continued in next column

Table A1: List of Food and Beverages products (*continued*)

| Product                                       | QFAHPD category | Healthy (USDA) | Healthy (Vegs+) |
|---|-----------------|----------------|-----------------|
| Other: Chilled, Gruyere, Parmesan             | 26              | 0              | 0               |
| Cream   | 27              | 0              | 0               |
| Goat  | 28              | 1              | 0               |
| Mutton and lamb                               | 28              | 1              | 0               |
| Beef: chop and rib                            | 29              | 0              | 0               |
| Beef: fillet                                  | 29              | 0              | 0               |
| Beef: round (piece or ground)                 | 29              | 0              | 0               |
| Beef: special cuts: t-bone, roast             | 29              | 0              | 0               |
| Beef: steak and breaded                       | 29              | 0              | 0               |
| Beef: stew/stock with bone                    | 29              | 0              | 0               |
| Lard  | 29              | 0              | 0               |
| Other beef: offal (liver), tongue, head, foot | 29              | 0              | 0               |
| Other pork: insides (liver, kidney)           | 29              | 0              | 0               |
| Other: rabbit, iguana, venison                | 29              | 0              | 0               |
| Pork: chop and rib                            | 29              | 0              | 0               |
| Pork: fillet and leg                          | 29              | 0              | 0               |
| Pork: mince, steak, piece                     | 29              | 0              | 0               |
| Sausage                                       | 29              | 0              | 0               |
| Bacon   | 30              | 0              | 0               |
| Chillied or smoked meats                      | 30              | 0              | 0               |
| Chorizo and longaniza                         | 30              | 0              | 0               |
| Dried beef, cured meat, machaca               | 30              | 0              | 0               |
| Ham   | 30              | 0              | 0               |
| Other: chicken pie, salami, mortadella        | 30              | 0              | 0               |
| Other birds: turkey, duck, pigeon             | 31              | 1              | 0               |
| Roast chicken                                 | 31              | 1              | 1               |
| Whole hen or in pieces                        | 31              | 1              | 1               |
| Chicken in pieces                             | 32              | 1              | 1               |
| Chicken insides: heart, liver                 | 32              | 1              | 1               |
| Other: oyster, octopus, abalone               | 33              | 1              | 1               |
| Sardines                                      | 33              | 1              | 1               |
| Dried: cod, prawn, charal                     | 34              | 1              | 1               |
| Tuna  | 34              | 1              | 1               |
| Jam, jelly, peanut butter                     | 36              | 1              | 1               |
| Hen egg                                       | 37              | 1              | 1               |
| Other: olive oil                              | 38              | 1              | 1               |
| Vegetable oil                                 | 38              | 1              | 1               |
| Vinegar                                       | 38              | 1              | 1               |
| Margarine                                     | 39              | 0              | 0               |
| Mole  | 39              | 0              | 0               |
| Other condiments: dressings                   | 39              | 0              | 0               |
| Vegetable fat                                 | 39              | 0              | 0               |
| Compote or conserve                           | 40              | 0              | 0               |
| Honey   | 40              | 0              | 0               |
| Other: corn syrup, powdered brown sugar       | 40              | 0              | 0               |
| White or brown sugar                          | 40              | 0              | 0               |
| Mineral water (flavoured or unflavoured)      | 41              | 0              | 0               |
| Soft drinks (sparkling or still)              | 41              | 0              | 0               |
| Aguardiente, mescal, sotol                    | 42              | 0              | 0               |
| Beer  | 42              | 0              | 0               |
| Brandy  | 42              | 0              | 0               |
| Other: cider, eggnog, sherry, vodka           | 42              | 0              | 0               |
| Pulque  | 42              | 0              | 0               |
| Ron   | 42              | 0              | 0               |
| Tequila                                       | 42              | 0              | 0               |
| Wine  | 42              | 0              | 0               |
| Purified water                                | 43              | 1              | 0               |
| Ice creams and ices                           | 44              | 0              | 0               |
| Jellies, flans and puddings                   | 45              | 0              | 0               |
| Toffee and caramel                            | 45              | 0              | 0               |
| Powdered chocolate or chocolate bar           | 46              | 0              | 0               |
| Sweet biscuits                                | 46              | 0              | 0               |
| Sweets and lollipops                          | 46              | 0              | 0               |
| Savoury biscuits                              | 47              | 0              | 0               |
| Sweet bread                                   | 47              | 0              | 0               |
| Other: soup, salad, pizza, pie                | 48              | 0              | 0               |
| Instant coffee                                | 49              | 0              | 0               |
| Instant tea                                   | 49              | 0              | 0               |
| Mayonnaise                                    | 49              | 0              | 0               |
| Mustard                                       | 49              | 0              | 0               |
| Other: soup and tinned vegetables, olives     | 49              | 0              | 0               |
| Spicy sauces                                  | 49              | 0              | 0               |
| Chicken and tomato stock                      | 51              | 0              | 0               |
| Barbecued pork and pork rind                  | 52              | 0              | 0               |
| Barbeque                                      | 52              | 0              | 0               |

Note: See [Volpe et al. \(2013\)](#), Table 1 for a list of the QFAHPD categories. The USDA healthy categorization is read from column (3) of their Table. The “Healthy (vegs+)” classification classifies all vegetables, fruits, fish and poultry products as healthy.

Table A2: Values of  $\Delta\text{USimp}$ 

| State               | 1999 - 1988 | 2006 - 1999 | 2012 - 2006 | 2012 - 1988 |
|---------------------|-------------|-------------|-------------|-------------|
| Aguascalientes      | 0.10        | 0.04        | 0.06        | 0.94        |
| Baja California     | 0.20        | 0.08        | 0.07        | 2.00        |
| Baja California Sur | 0.16        | 0.04        | 0.04        | 1.18        |
| Campeche            | 0.14        | 0.11        | 0.08        | 1.70        |
| Chiapas             | 0.12        | 0.07        | 0.05        | 1.29        |
| Chihuahua           | 0.14        | 0.09        | 0.05        | 1.15        |
| Coahuila            | 0.13        | 0.07        | 0.06        | 1.12        |
| Colima              | 0.12        | 0.06        | 0.04        | 1.26        |
| Distrito Federal    | 0.13        | 0.05        | 0.07        | 1.33        |
| Durango             | 0.11        | 0.06        | 0.05        | 0.92        |
| Guanajuato          | 0.12        | 0.04        | 0.05        | 1.26        |
| Guerrero            | 0.09        | 0.07        | 0.05        | 1.14        |
| Hidalgo             | 0.11        | 0.04        | 0.07        | 1.33        |
| Jalisco             | 0.12        | 0.05        | 0.06        | 1.37        |
| Mexico              | 0.11        | 0.05        | 0.07        | 1.17        |
| Michoacan           | 0.10        | 0.04        | 0.05        | 1.10        |
| Morelos             | 0.10        | 0.05        | 0.07        | 1.15        |
| Nayarit             | 0.14        | 0.06        | 0.11        | 1.50        |
| Nuevo Leon          | 0.15        | 0.05        | 0.08        | 1.12        |
| Oaxaca              | 0.12        | 0.06        | 0.08        | 1.18        |
| Puebla              | 0.12        | 0.05        | 0.05        | 1.17        |
| Queretaro           | 0.14        | 0.04        | 0.04        | 1.12        |
| Quintana Roo        | 0.15        | 0.06        | 0.06        | 1.57        |
| San Luis Potosi     | 0.12        | 0.04        | 0.05        | 1.34        |
| Sinaloa             | 0.12        | 0.05        | 0.05        | 1.13        |
| Sonora              | 0.16        | 0.07        | 0.06        | 1.41        |
| Tabasco             | 0.24        | 0.11        | 0.15        | 2.89        |
| Tamaulipas          | 0.13        | 0.04        | 0.05        | 1.31        |
| Tlaxcala            | 0.15        | 0.04        | 0.05        | 1.87        |
| Veracruz            | 0.15        | 0.04        | 0.06        | 1.74        |
| Yucatan             | 0.10        | 0.10        | 0.08        | 1.45        |
| Zacatecas           | 0.11        | 0.04        | 0.05        | 1.14        |

Table A3: Summary statistics for state-level variables

|   | (1)                           | (2)       | (3)   | (4)   | (5)                 | (6)       | (7)   | (8)   |
|---|-------------------------------|-----------|-------|-------|---------------------|-----------|-------|-------|
|   | Long difference (2012 - 1988) |           |       |       | Stacked first-diff. |           |       |       |
|   | Mean                          | Std. Dev. | Min   | Max   | Mean                | Std. Dev. | Min   | Max   |
| $\Delta$ Obesity                        | 0.26                          | 0.03      | 0.19  | 0.37  | 0.06                | 0.04      | -0.06 | 0.19  |
| $\Delta$ Overw.                         | 0.38                          | 0.06      | 0.28  | 0.53  | 0.08                | 0.07      | -0.11 | 0.25  |
| $\Delta$ BMI                            | 4.67                          | 0.58      | 3.63  | 5.94  | 1.04                | 0.71      | -0.90 | 2.86  |
| $\Delta$ USimp                          | 1.32                          | 0.30      | 0.92  | 2.89  | 0.08                | 0.04      | 0.04  | 0.24  |
| $\Delta$ USimp unh. (USDA)              | 0.86                          | 0.17      | 0.62  | 1.41  | 0.05                | 0.03      | 0.02  | 0.15  |
| $\Delta$ USimp h. (USDA)                | 0.46                          | 0.24      | 0.18  | 1.88  | 0.03                | 0.02      | 0.01  | 0.13  |
| $\Delta$ USimp unh. (Vegs+)             | 1.00                          | 0.29      | 0.72  | 2.48  | 0.06                | 0.03      | 0.03  | 0.19  |
| $\Delta$ USimp h. (Vegs+)               | 0.33                          | 0.08      | 0.15  | 0.41  | 0.02                | 0.01      | 0.00  | 0.05  |
| $\Delta$ U.S. food exports              | 7.08                          | 1.25      | 4.84  | 11.80 | 0.48                | 0.33      | 0.04  | 1.59  |
| $\Delta$ Obesity <sub><i>t-1</i></sub>  | 0.10                          | 0.03      | 0.04  | 0.23  | 0.08                | 0.03      | -0.01 | 0.23  |
| $\Delta$ Overw <sub><i>t-1</i></sub>    | 0.35                          | 0.07      | 0.20  | 0.53  | 0.19                | 0.13      | -0.07 | 0.53  |
| $\Delta$ BMI <sub><i>t-1</i></sub>      | 23.94                         | 0.79      | 22.34 | 26.21 | 8.92                | 10.69     | -0.35 | 26.21 |
| Food expen. share <sub><i>t-1</i></sub> | 0.22                          | 0.05      | 0.13  | 0.34  | 0.18                | 0.05      | 0.10  | 0.34  |
| $\Delta$ ROWimp                         | 0.45                          | 0.09      | 0.23  | 0.60  | 0.03                | 0.02      | 0.01  | 0.08  |
| $\Delta$ Ln(GDP per cap.)               | 3.35                          | 0.21      | 3.02  | 4.35  | 1.12                | 0.81      | 0.13  | 2.46  |
| $\Delta$ Ln(FDI/GDP)                    | 1.48                          | 1.96      | -3.20 | 5.95  | 0.49                | 1.26      | -4.21 | 6.16  |
| $\Delta$ Ln(Migrant/Pop)                | 0.72                          | 0.79      | -1.81 | 2.75  | 0.24                | 1.17      | -2.68 | 3.25  |
| $\Delta$ High educ. share               | 0.27                          | 0.06      | 0.14  | 0.49  | 0.09                | 0.06      | -0.09 | 0.32  |
| $\Delta$ Unemp. share                   | -0.16                         | 0.04      | -0.35 | -0.03 | -0.05               | 0.10      | -0.31 | 0.20  |
| $\Delta$ Malls share food expen         | 0.03                          | 0.10      | -0.12 | 0.42  | 0.01                | 0.06      | -0.21 | 0.22  |
| $\Delta$ Restaurant share food expen.   | 0.09                          | 0.05      | -0.09 | 0.23  | 0.03                | 0.08      | -0.21 | 0.16  |
| Walmart stores per 100k persons (2007)  | 1.14                          | 0.74      | 0.26  | 3.85  |                     |           |       |       |

Note: Long-difference statistics are based on 32 observations. Stacked first-difference statistics are based on 96 observations.  $\Delta$  Obesity<sub>*t-1*</sub>,  $\Delta$  Overw<sub>*t-1*</sub> and  $\Delta$  BMI<sub>*t-1*</sub> equal their respective values in 1988 for the long-difference statistics. The state share of national female population between 18 and 59 years of age in 1990 is used as weight.

Table A4: Obesity prevalence and food imports from the U.S. – Control variables

|  | (1)                     | (2)                    | (3)                     | (4)                     | (5)                     | (6)                     | (7)                     | (8)                    | (9)                     |
|--|-------------------------|------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|------------------------|-------------------------|
|  |                         | OLS                    |                         |                         | IV                      |                         |                         | IV residuals           |                         |
| Panel (a): <b>Long difference</b> (2012 - 1988)                                    |                         |                        |                         |                         |                         |                         |                         |                        |                         |
| $\Delta$ Food imports from U.S.  | 0.0529***<br>(0.0140)   | 0.0761***<br>(0.0199)  | 0.0774***<br>(0.0188)   | 0.0455***<br>(0.0170)   | 0.0756***<br>(0.0229)   | 0.0787***<br>(0.0208)   | 0.0533***<br>(0.0167)   | 0.0666***<br>(0.0211)  | 0.0708***<br>(0.0211)   |
| $\Delta$ Ln(Migrant/Pop)   | -0.00892**<br>(0.00419) | -0.00473<br>(0.00602)  | -0.00499<br>(0.00599)   | -0.00844**<br>(0.00393) | -0.00475<br>(0.00508)   | -0.00494<br>(0.00494)   | -0.00895**<br>(0.00413) | -0.00515<br>(0.00502)  | -0.00528<br>(0.00489)   |
| $\Delta$ High educ. share  | -0.0299<br>(0.0687)     | 0.00550<br>(0.108)     | 0.0147<br>(0.103)       | -0.0253<br>(0.0676)     | 0.00529<br>(0.0910)     | 0.0153<br>(0.0850)      | -0.0302<br>(0.0632)     | 0.00204<br>(0.0930)    | 0.0121<br>(0.0879)      |
| Food expenditure share <sub>t-1</sub>  |                         | -0.000944<br>(0.105)   | -0.0693<br>(0.186)      |                         | -0.00118<br>(0.0895)    | -0.0691<br>(0.154)      |                         | -0.00485<br>(0.0917)   | -0.0702<br>(0.157)      |
| $\Delta$ Ln(GDP per cap.)  |                         | -0.000661<br>(0.0312)  | 0.0126<br>(0.0405)      |                         | -0.000332<br>(0.0269)   | 0.0119<br>(0.0349)      |                         | 0.00481<br>(0.0267)    | 0.0160<br>(0.0326)      |
| $\Delta$ Ln(FDI/GDP)   |                         | -0.00264<br>(0.00336)  | -0.00313<br>(0.00383)   |                         | -0.00263<br>(0.00281)   | -0.00318<br>(0.00310)   |                         | -0.00234<br>(0.00291)  | -0.00292<br>(0.00333)   |
| $\Delta$ Unemp. share  |                         | 0.138<br>(0.169)       | 0.137<br>(0.154)        |                         | 0.138<br>(0.142)        | 0.137<br>(0.128)        |                         | 0.131<br>(0.138)       | 0.132<br>(0.125)        |
| $\Delta$ Food imports from ROW   |                         | -0.143*<br>(0.0707)    | -0.154**<br>(0.0709)    |                         | -0.142**<br>(0.0680)    | -0.157**<br>(0.0639)    |                         | -0.125**<br>(0.0625)   | -0.142**<br>(0.0663)    |
| Obesity <sub>t-1</sub>   |                         |                        | -0.157<br>(0.283)       |                         |                         | -0.158<br>(0.233)       |                         |                        | -0.154<br>(0.237)       |
| Obs  | 32                      | 32                     | 32                      | 32                      | 32                      | 32                      | 32                      | 32                     | 32                      |
| R <sup>2</sup>   | 0.273                   | 0.386                  | 0.402                   | 0.268                   | 0.386                   | 0.402                   | 0.273                   | 0.382                  | 0.400                   |
| Panel (b): <b>Stacked first difference</b> (2012 - 2006, 2006 - 1999, 1999 - 1988) |                         |                        |                         |                         |                         |                         |                         |                        |                         |
| $\Delta$ Food imports from U.S.  | 0.530***<br>(0.122)     | 0.608***<br>(0.119)    | 0.728***<br>(0.105)     | 0.348**<br>(0.173)      | 0.556***<br>(0.131)     | 0.735***<br>(0.120)     | 0.418**<br>(0.180)      | 0.478***<br>(0.165)    | 0.556***<br>(0.137)     |
| $\Delta$ Ln(Migrant/Pop)   | -0.0125**<br>(0.00534)  | -0.0130**<br>(0.00511) | -0.0133***<br>(0.00443) | -0.0118**<br>(0.00519)  | -0.0128***<br>(0.00474) | -0.0133***<br>(0.00403) | -0.0121**<br>(0.00544)  | -0.0126**<br>(0.00513) | -0.0127***<br>(0.00447) |
| $\Delta$ High educ. share  | -0.245***<br>(0.0371)   | -0.239***<br>(0.0372)  | -0.213***<br>(0.0375)   | -0.242***<br>(0.0375)   | -0.239***<br>(0.0346)   | -0.213***<br>(0.0346)   | -0.243***<br>(0.0366)   | -0.239***<br>(0.0351)  | -0.214***<br>(0.0353)   |
| Food expenditure share <sub>t-1</sub>  |                         | 0.182***<br>(0.0515)   | 0.120**<br>(0.0504)     |                         | 0.176***<br>(0.0474)    | 0.121***<br>(0.0460)    |                         | 0.168***<br>(0.0485)   | 0.106**<br>(0.0470)     |
| $\Delta$ Ln(GDP per cap.)  |                         | -0.000748<br>(0.00978) | 0.00829<br>(0.0145)     |                         | -0.000416<br>(0.00926)  | 0.00826<br>(0.0133)     |                         | 7.93e-05<br>(0.0100)   | 0.00879<br>(0.0138)     |
| $\Delta$ Ln(FDI/GDP)   |                         | -0.00225<br>(0.00332)  | -0.000854<br>(0.00296)  |                         | -0.00219<br>(0.00310)   | -0.000858<br>(0.00272)  |                         | -0.00211<br>(0.00316)  | -0.000771<br>(0.00285)  |
| $\Delta$ Unemp. share  |                         | -0.0214<br>(0.0479)    | -0.0507<br>(0.0438)     |                         | -0.0227<br>(0.0447)     | -0.0506<br>(0.0396)     |                         | -0.0245<br>(0.0453)    | -0.0529<br>(0.0427)     |
| $\Delta$ Food imports from ROW   |                         | -0.472<br>(0.305)      | -0.650***<br>(0.235)    |                         | -0.457<br>(0.285)       | -0.653***<br>(0.230)    |                         | -0.434<br>(0.296)      | -0.591**<br>(0.234)     |
| $\Delta$ Obesity <sub>t-1</sub>  |                         |                        | -0.380***<br>(0.0754)   |                         |                         | -0.381***<br>(0.0722)   |                         |                        | -0.357***<br>(0.0776)   |
| Obs  | 96                      | 96                     | 96                      | 96                      | 96                      | 96                      | 96                      | 96                     | 96                      |
| R <sup>2</sup>   | 0.613                   | 0.645                  | 0.714                   | 0.606                   | 0.644                   | 0.714                   | 0.610                   | 0.641                  | 0.708                   |

Note: All regressions include a constant term. Regressions in Panel (b) include year dummies (for 2006 and 2012) and a dummy for states with imputed obesity prevalence in 1999 (for 1999 - 1988, and 2012 - 2006). The state share of national female population between 18 and 59 years of age in 1990 is used as weight. Robust standard errors clustered at the state level are in parentheses. Significant at: \*10%, \*\*5%, \*\*\*1% level.



Table A5: Food imports from the U.S. and health disparities

|                                 | (1)                     | (2)                     | (3)                     | (4)                     | (5)                     |
|---------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| U.S. food var.:                 |                         | Total                   |                         | Unh.                    | H.                      |
| U.S. foods $\times$ High educ.  | -0.0195**<br>(0.00722)  |                         | -0.0199***<br>(0.00684) | -0.0350***<br>(0.0102)  | -0.0328<br>(0.0198)     |
| High educ.                      | -0.0407***<br>(0.00628) | -0.0501***<br>(0.00639) | -0.0406***<br>(0.00655) | -0.0392***<br>(0.00638) | -0.0446***<br>(0.00699) |
| U.S. foods $\times$ Unemp.      |                         | -0.00855<br>(0.00654)   | -0.0130**<br>(0.00612)  | -0.0165<br>(0.0101)     | -0.0357***<br>(0.0127)  |
| Unemp.                          | 0.00257<br>(0.00515)    | 0.00657<br>(0.00616)    | 0.00916<br>(0.00639)    | 0.00816<br>(0.00640)    | 0.00861<br>(0.00605)    |
| U.S. foods $\times$ Middle inc. |                         |                         | 0.00254<br>(0.00924)    | 0.00176<br>(0.0151)     | 0.00961<br>(0.0223)     |
| U.S. foods $\times$ High inc.   |                         |                         | -0.0141<br>(0.0123)     | -0.0280<br>(0.0201)     | -0.0121<br>(0.0255)     |
| Middle inc.                     | 0.0547***<br>(0.00793)  | 0.0543***<br>(0.00805)  | 0.0535***<br>(0.00841)  | 0.0543***<br>(0.00859)  | 0.0528***<br>(0.00830)  |
| High inc.                       | 0.0165<br>(0.0155)      | 0.0171<br>(0.0160)      | 0.0229<br>(0.0156)      | 0.0250<br>(0.0157)      | 0.0184<br>(0.0156)      |
| Obs                             | 56,713                  | 56,713                  | 56,713                  | 56,713                  | 56,713                  |
| R <sup>2</sup>                  | 0.111                   | 0.111                   | 0.111                   | 0.111                   | 0.111                   |

Note: All regressions include state-year fixed effects and the following individual level covariates: age and age squared; an indicator for women who speak indigenous languages; a dummy for chronic diseases, and one for being the household head. The variable “U.S. foods” equals total *USimp* in “Tot.” columns and its unhealthy and healthy parts in the “Unh.” and “H.” columns, respectively. The state share of national female population between 18 and 59 years of age in 1990 is used as weight. Standard errors clustered at the state level are in parentheses. Significant at: \*10%, \*\*5%, \*\*\*1% level.

Table A6: State food prices and exposure to U.S. foods

|  | (1)                    | (2)                    | (3)                    | (4)                   | (5)                  | (6)                  |
|--|------------------------|------------------------|------------------------|-----------------------|----------------------|----------------------|
|  | Reduced form OLS       |                        |                        | IV                    |                      |                      |
| U.S. food exports to ROW                             | -0.0423***<br>(0.0129) | -0.0452***<br>(0.0126) | -0.0435***<br>(0.0125) |                       |                      |                      |
| U.S. food imports from ROW                           |                        | 0.0179<br>(0.0209)     | 0.0172<br>(0.0217)     |                       |                      |                      |
| Food imports from U.S.                               |                        |                        |                        | -0.285***<br>(0.0895) | -0.329***<br>(0.116) | -0.314***<br>(0.113) |
| Mex. exports to U.S.                                 |                        |                        |                        |                       | 0.0517<br>(0.0743)   | 0.0495<br>(0.0772)   |
| <i>First-stage results – food imports from U.S.:</i> |                        |                        |                        |                       |                      |                      |
| U.S. food exports to ROW                             |                        |                        |                        | 0.148***<br>(0.0155)  | 0.131***<br>(0.0196) | 0.131***<br>(0.0194) |
| U.S. food imports from ROW                           |                        |                        |                        |                       | -0.0118<br>(0.0212)  | -0.0117<br>(0.0210)  |
| F-stat excluded instr.                               |                        |                        |                        | 91.69                 | 23.40                | 23.53                |
| Controls   | N                      | Y                      | Y                      | N                     | Y                    | Y                    |
| Non-food prices                                      | N                      | N                      | Y                      | N                     | N                    | Y                    |
| Obs  | 512                    | 512                    | 512                    | 512                   | 512                  | 512                  |
| R <sup>2</sup>                                       | 0.991                  | 0.991                  | 0.991                  | 0.990                 | 0.990                | 0.991                |

Note: The dependent variable is the expenditure-weighted average of price across food products (with weights fixed at their values in 1995) for each state and year. All regressions include state and year fixed effects. First-stage results report estimates associated with the excluded instruments only. Robust standard errors clustered at the state level are in parentheses. Significant at: \*10%, \*\*5%, \*\*\*1% level.

Table A7: State food prices and exposure to U.S. foods – 2006 - 1999 changes

|                                     | (1)               | (2)                | (3)                | (4)                 |
|-------------------------------------|-------------------|--------------------|--------------------|---------------------|
| $\Delta$ U.S. food exports to ROW   | -0.290<br>(0.171) | -0.288*<br>(0.153) | -0.286*<br>(0.151) | -0.308*<br>(0.162)  |
| $\Delta$ U.S. food imports from ROW |                   | -0.0966<br>(0.115) | -0.105<br>(0.111)  | -0.0947<br>(0.0859) |
| Controls                            | N                 | Y                  | Y                  | Y                   |
| Controls obesity reg.               | N                 | N                  | Y                  | Y                   |
| Non-food prices                     | N                 | N                  | N                  | Y                   |
| Obs                                 | 32                | 32                 | 32                 | 32                  |
| R <sup>2</sup>                      | 0.103             | 0.307              | 0.523              | 0.636               |

Note: Reduced form OLS estimates. The dependent variable is the 2006 - 1999 difference in state-level food prices, weighted by state-specific food expenditure shares in 1999. Robust standard errors clustered at the state level are in parentheses. Significant at: \*10%, \*\*5%, \*\*\*1% level.

Table A8: State-level prices of healthy and unhealthy foods and exposure to U.S. foods

|                            | (1)                    | (2)                 | (3)                    | (4)                  | (5)                 | (6)                  | (7)                  | (8)                |
|----------------------------|------------------------|---------------------|------------------------|----------------------|---------------------|----------------------|----------------------|--------------------|
|                            | Unhealthy              |                     |                        |                      | Healthy             |                      |                      |                    |
|                            | USDA                   |                     | Vegs+                  |                      | USDA                |                      | Vegs+                |                    |
|                            | OLS                    | IV                  | OLS                    | IV                   | OLS                 | IV                   | OLS                  | IV                 |
| U.S. food exports to ROW   | -0.0487***<br>(0.0131) |                     | -0.0461***<br>(0.0142) |                      | -0.0305<br>(0.0214) |                      | -0.0433*<br>(0.0253) |                    |
| U.S. food imports from ROW | 0.0350<br>(0.0272)     |                     | 0.0169<br>(0.0323)     |                      | 0.00105<br>(0.0230) |                      | 0.0243<br>(0.0174)   |                    |
| Food imports from U.S.     |                        | -0.331**<br>(0.141) |                        | -0.334***<br>(0.120) |                     | -0.235<br>(0.156)    |                      | -0.303<br>(0.212)  |
| Mex. exports to U.S.       |                        | 0.113<br>(0.101)    |                        | 0.0475<br>(0.114)    |                     | -0.00617<br>(0.0826) |                      | 0.0756<br>(0.0656) |
| Obs                        | 512                    | 512                 | 512                    | 512                  | 512                 | 512                  | 512                  | 512                |
| R <sup>2</sup>             | 0.990                  | 0.989               | 0.988                  | 0.988                | 0.985               | 0.985                | 0.985                | 0.984              |

Note: The dependent variable is the expenditure-weighted average of price across healthy or unhealthy food products (with weights fixed at their values in 1995) for each state and year. All regressions include state and year fixed effects, and the same controls as in Table A6, plus the non-food price index. Robust standard errors clustered at the state level are in parentheses. Significant at: \*10%, \*\*5%, \*\*\*1% level.

Table A9: Contemporary tastes and past U.S. food exports

|   | (1)                  | (2)                | (3)                  | (4)                  | (5)                  | (6)                   | (7)                   | (8)                   |
|---|----------------------|--------------------|----------------------|----------------------|----------------------|-----------------------|-----------------------|-----------------------|
| U.S. food exports to ROW <sub>t</sub>   | 0.135***<br>(0.0452) | 0.0106<br>(0.0392) | 0.0174<br>(0.0529)   | 0.114*<br>(0.0661)   | 0.0179<br>(0.0579)   | 0.0831<br>(0.0658)    | 0.0497<br>(0.0558)    | 0.128*<br>(0.0700)    |
| U.S. food exports to ROW <sub>t-1</sub> |                      |                    | 0.157***<br>(0.0590) | -0.136**<br>(0.0574) | 0.0229<br>(0.0655)   | -0.219***<br>(0.0788) | 0.0127<br>(0.0708)    | -0.231***<br>(0.0865) |
| U.S. food exports to ROW <sub>t-2</sub> |                      |                    |                      |                      | 0.224***<br>(0.0570) | 0.197***<br>(0.0556)  | 0.415***<br>(0.0757)  | 0.481***<br>(0.0804)  |
| U.S. food exports to ROW <sub>t-3</sub> |                      |                    |                      |                      |                      |                       | -0.281***<br>(0.0657) | -0.418***<br>(0.0795) |
| Avg. effect of lags                     |                      |                    | 0.157***<br>(0.0590) | -0.136**<br>(0.0574) | 0.123***<br>(0.0386) | -0.0110<br>(0.0343)   | 0.0486**<br>(0.0228)  | -0.0559**<br>(0.0265) |
| Price controls                          | N                    | Y                  | N                    | Y                    | N                    | Y                     | N                     | Y                     |
| BIC                                     | -11279               | -12190             | -11278               | -12189               | -10056               | -11044                | -10062                | -11079                |
| Obs                                     | 2,592                | 2,592              | 2,592                | 2,592                | 2,304                | 2,304                 | 2,304                 | 2,304                 |
| R <sup>2</sup>                          | 0.513                | 0.707              | 0.514                | 0.708                | 0.532                | 0.744                 | 0.534                 | 0.749                 |

Note: The dependent variable is estimated as state-year fixed effects from regressions of households' expenditure shares by food aggregate on real food expenditure and other household characteristics. Years of the expenditure survey are 1996, 1998, 2000, 2002, 2004, 2005, 2006, 2008, and 2010. We use nine food aggregates (obtained by aggregating the QFAHPD categories – see Table A1): fruits; vegetables; grains; dairy products; meats; oils and fats; sugary products; drinks; prepared foods and others. Household controls used in the first step of the empirical strategy include: age (and its square term), sex, occupation, education and sector of employment of the household head, household size (and its square term) and composition. “U.S. food exports to ROW” is exposure to U.S. food exports by food aggregate computed as the average  $\frac{E_{g,s,1994}}{E_{g,1994}} \ln(X_{g,t}^{US})$  across food product  $g$  within the same aggregate –  $X_{g,t}$  is the PPP-adjusted value of U.S. food exports to ROW. The set of “price controls” equals the state expenditure-weighted (with 1994 weights) average price of each food aggregate interacted with dummies for all the food aggregates (thus allowing for cross-aggregate price effects). All regressions include food-state and state-year fixed effects. Standard errors clustered at the food-state level are in parentheses. Significant at: \*10%, \*\*5%, \*\*\*1% level.