Disentangling the Effects of Large Minimum Wage and VAT Changes on Prices: Evidence from Mexico

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Abstract

In January 2019, the minimum wage in the Mexican border with the United States increased by 100 percent. At the same time, the value-added tax (VAT) rate decreased by half. We propose an identification strategy that allows us to separate the effects of the minimum wage and the VAT on prices. We account for differential effects of the minimum wage on prices of goods with and without VAT. We find that the increase in the minimum wage is associated with economically and statistically significant increases in the prices of VAT goods, and with smaller, imprecisely estimated increases for Non-VAT goods, concentrated in food Non-VAT goods. The increments in prices due to the minimum wage were more than offset by decreases associated with the VAT, so in the absence of both policy changes, average prices would have been higher.

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1 Introduction

Large tax reductions and increases in the minimum wage have been gaining attention around the world as policies to increase the net incomes of lower-skilled workers. Such actions may have consequences on prices. Understanding them is essential to evaluate the effectiveness of higher minimum wages and tax reductions as instruments for supporting lower-income workers, because the changes in prices may lead to changes in inflation, effectively altering these policies' impact on workers' purchasing power.

We study the effects on prices of a sizable policy change in the value-added tax (VAT) and the minimum wage in Mexico. In January of 2019, the minimum wage increased in the Mexican border with the United States by a 100%. At the same time, the VAT rate was cut by half in that region, from 16% to 8%. In contrast, the minimum wage increased by 16.21% in the rest of the country, with no reduction in the VAT rate.

The Mexican context is interesting for two reasons. First, the changes are substantial compared to other policy changes analyzed in the minimum wage and VAT literature. The size of the changes helps to identify their effects as significant policy changes may require considerable price adjustments. In the U.S., the federal minimum wage has remained constant for ten years, and state-level adjustments in the minimum wage rarely double its amount so suddenly.[1] With regards to the VAT rate cut, the decrease in 8 percentage points in the northern border implied a reduction of 6.9% in the tax factor (1 + VAT rate), which is substantial compared to recent cuts in developed countries.[2] Second, the simultaneous implementation of both a minimum wage and a VAT policy change may unveil interactions of the policies on prices. A minimum wage increase and a VAT reduction may countervail each other, such that the net effect on prices may be small.

The simultaneous implementation of the minimum wage and VAT reforms poses an identification challenge. On the one hand, comparing the prices of goods subject to VAT ("VAT goods") between the northern border and the rest of the country would confound the effects of the minimum wage and the VAT rate changes. On the other hand, comparing the prices of goods that are not subject to VAT ("Non-VAT goods") across

[1] Recent increases in city-level minimum wages in the United States have tended to be large, but slower. For example, Seattle is on a path to increasing its minimum wage to $15 dollars for all workers in 2021, from an initial $9.47 dollars an hour, through gradual increases starting in 2014. Allegretto et al. (2018) shows a recent history of U.S. local minimum wages. Mexico had also been increasing its minimum wage recently, by 9.58% in 2017 and 10.39% in 2018.

[2] Benedek et al. (2015) calculate an average VAT reduction of 3.02% for 17 Eurozone countries from 1999 to 2013

areas would only be informative about the effects on Non-VAT goods. Ignoring the impact on VAT goods may be a glaring omission if the policies affect them differently.

Several economic reasons lead us to expect that this heterogeneity deserves attention. From the supply side, if labor informality and tax evasion rates are different between industries, we would expect heterogeneous effects of the minimum wage to be present, both between VAT and Non-VAT goods and among the goods in each category. We show that industries that produce VAT goods tend to have higher shares of formal labor, suggesting a larger mechanical effect of the minimum wage on their labor costs keeping employment constant. The impacts of the VAT rate reduction may also be different across goods, depending on the degree of market power that suppliers have. On the demand side, differential income effects from the minimum wage increase on the demand of each good, and substitution effects from the VAT rate reduction will lead to heterogeneous changes in prices across goods.

We, therefore, propose an empirical approach that, by accounting for potential differential effects of the minimum wage on VAT and Non-VAT goods, allows us to identify three effects separately. First, the effect of the minimum wage increase on the price of VAT goods. Second, the effect of the minimum wage increase on the price of Non-VAT goods, and third, the effect of the VAT rate reduction on the price of VAT goods. We identify each of these using different sources of variation within and across areas. We estimate all the effects using a regression framework that combines the different identification strategies for each effect. We implement our approach using microdata on the prices of more than a hundred thousand items listed in the national price index, and administrative data on the wages of the universe of private formal workers.

To estimate the effect of the minimum wage increase on VAT goods, we exploit variation in the incidence of the minimum wage across industries in the northern border. The differential incidence arises from variation in the percentage of workers affected by the minimum wage increase across industries. Affected workers are those whose wage in December of 2018 was below the new minimum wage that became effective in January 2019. The fraction of affected workers is also known as the "bite" of the minimum wage (Card, 1992; Stewart, 2002; Lemos, 2009; Cengiz et al., 2019). We compare the prices of VAT goods produced in industries with a large fraction of affected workers to the prices of VAT goods from industries with a smaller fraction affected. Since we restrict this comparison to VAT goods, it identifies the effects of the minimum wage.

Our identification assumption to estimate this effect is that, in the absence of a minimum wage change, the prices of VAT goods in the northern border with higher and lower fractions of affected workers would evolve in parallel over time. We provide evidence validating this assumption before 2019 by estimating panel event study specifications and showing the absence of pre-trends in the estimates in periods before the minimum wage changed. The price increase associated with the increased minimum wage we find is also present when we compare goods across industries within broader industry aggregates, alleviating concerns about differential price trends by industry. The minimum wage effect is also robust to possible confounding effects from the VAT decrease, such as a different pass-through of the VAT reduction for goods with a larger fraction of workers affected by the minimum wage increase, or for goods sold in formal and informal establishments.

To estimate the effect of the minimum wage increase on Non-VAT goods, we use the differential policy increase in the minimum wage in the northern border. We compare the prices of Non-VAT goods between the border and the rest of the northern region. Since Non-VAT goods are not directly affected by the VAT rate decrease, this comparison identifies the effect of the minimum wage in Non-VAT goods. The identification assumption is that in the absence of a minimum wage change, the prices of Non-VAT goods in the northern border would evolve in parallel to their counterparts in the rest of the northern region. We provide evidence of the absence of differential trends before the minimum wage change.

The third effect we calculate is on the prices of VAT goods because of the VAT rate reduction. We identify it by first comparing the prices of VAT goods in the northern border and the rest of the northern region, which yields the combined effect of the VAT and minimum wage changes on these prices. We then subtract the minimum wage effect on VAT goods prices to isolate the VAT effects. The strategy assumes that in the absence of policy changes, the prices of VAT goods would evolve in parallel in the northern border and the rest of the northern region.

We find economically and statistically significant effects of the policy changes on prices. For VAT goods, we find that doubling the minimum wage increased the price of an average VAT good in 2.4%. For Non-VAT goods, we estimate that the typical good saw a price increase of 0.2% because of the minimum wage change. The estimated effect is much lower than that on VAT goods, and it is imprecisely estimated. For the VAT rate decrease, we find that the VAT rate cut decreased the price of an average VAT good in 3.83%. The effects vary across industries. For VAT goods, we find that Non-food items seem to be more responsive to the minimum wage increase, and food items seem to respond more to the VAT rate decrease. Among Non-VAT goods, food items seem to increase more in response to the minimum wage change.

When we look at the overall combined effect of the policies, we find that the lower VAT rate counteracted most of the price increase caused by a higher minimum wage. We estimate that the increased minimum wage led to a 1.08 percentage point higher average annual inflation in the northern border during 2019. The reduced VAT lowered average annual inflation by 1.86 percentage points, counteracting the minimum-wage-driven price increase.

Our research contributes to the literature on the effects of the minimum wage and the VAT on prices. Many studies have found evidence of pass-through of higher minimum wages into prices in the U.S., with varying degrees of transmission (MacDonald and Aaronson, 2006; Aaronson et al., 2008; MaCurdy, 2015). Recently, Leung (2020) shows that grocery prices increase around 0.6% for a 10% increase in local minimum wages in the U.S. By analyzing supermarket scanner data in the U.S. and state-level increases in minimum wages between 2001 and 2012, Renkin et al. (2020) estimate that a 10% increase in the minimum wage raises grocery and drug prices by 0.36%. For developing countries, a survey by Lemos (2008) shows that for some developing countries, such as Brazil and Costa Rica, there are significant price effects of higher minimum wages. However, Lemos (2008) points out that the evidence is mixed, with other studies finding no impacts. More recently, Harasztosi and Lindner (2019) show a price increase of 10.8% for manufacturing firms in the medium term in response to a 96% higher minimum wage in Hungary. We contribute to this literature in four ways. First, we provide estimates of the effect of a large and sudden minimum wage increase in a middle-income country. Second, we elicit a strategy to disentangle the effects of the minimum wage in the presence of a simultaneous tax policy change. Third, we show that the impacts of the minimum wage vary across VAT and Non-VAT goods. Fourth, we demonstrate that the simultaneous effect of the tax reduction may mask the repercussions of the minimum wage on prices at the aggregate level.

On the VAT side, Batista P. and Mattos (2011) find an asymmetrical effect of VAT changes on food prices in Brazil, depending on the direction of the change. If the tax rate variation is positive, the authors find evidence of a full pass-through in 20% of the goods and tax over-shifting in 10% of them. On the contrary, when changes are negative, prices respond to a lesser extent than the VAT decrease in all cases. In contrast, Benedek et al. (2015) results suggest the absence of asymmetries between VAT cuts and VAT increases; however, they also find that, on average, changes in different categories of VAT rates did not have a full pass-through to consumer prices in 17 Eurozone countries. This result is in line with the one obtained by Kosonen (2015), who estimates an incomplete pass-through to hairdressers' prices when the VAT rate decreased in Finland. More recently, Benzarti and Carloni (2019) find that restaurant owners keep 55% of the VAT decrease, and the rest is shared among suppliers, employees, and consumers, being the latter group the one who benefits the least. We contribute by showing that VAT and Non-VAT goods react differently to the minimum wage, and posit an identification strategy that allows us to tease out the effects of each policy change. Our dynamic estimates show that the VAT rate reduction effect materializes quickly, occurring over the lapse of one month.

We also contribute to emerging literature about the price effects of the minimum wage and the VAT in the Mexican context. For the policy changes in Mexico studied in this paper, Campos-Vazquez and Esquivel (2020) estimate a combined effect on the consumer price index in the Mexican border of -1.8 percentage points (p.p), based on aggregate data. They conclude that this points towards a negligible effect of the minimum wage on prices, but do not provide separate estimates for the impact of each policy. By contrast, we find a positive effect of the minimum wage on prices that we can tease out by separating VAT and minimum wage effects and using price microdata. For a previous 2014 VAT rate reform, Mariscal and Werner (2018) estimate a 0.2 implicit elasticity of the prices of taxed goods to the VAT increase. Racimo (2018) estimates a 0.26 implicit elasticity for goods in formal establishments and a non-significant elasticity for goods in informal establishments. Our VAT elasticity estimates for the 2019 reform, during an economic slowdown, are higher than those in these previous studies for Mexico, which may point out to different effects of VAT rate reductions on prices at different positions in the economic cycle.

The rest of the paper proceeds as follows. Section 2 provides some context about the minimum wage and VAT reforms we study. Section 3 describes the data we use and provides some descriptive statistics. In section 4 we describe our estimation strategy. Section 5 shows our main results. We conclude in section 6.

2 The Minimum Wage and VAT Reforms of 2019 in the Northern Mexican Border

In January 2019, the minimum wage in Mexico increased differently across regions of the country. For municipalities of the northern border (ZLFN, for their name in Spanish, *Zona Libre de la Frontera Norte*), the minimum wage increased from 88.36 to 176.72 pesos per day.[3] On the rest of the country, it increased from 88.36 to 102.68 pesos per day.[4] At the same time, the federal government introduced a fiscal credit of 50% of the Value-Added Tax (VAT) in the ZLFN. It was applied to the 16% rate, decreasing it to 8%.[5,6]

Both the increase in the minimum wage and the VAT reduction were substantial in magnitude and constituted significant changes in absolute terms and relative to their variation in the last decade. Figure 1, panel (a), shows the evolution of the real minimum wage in the northern border and the rest of the northern region since 2010.[7] The minimum wage increase in the ZLFN stands out compared to recent history. Figure 1, panel (b), shows the evolution of the VAT rate for the ZLFN and the rest of the northern region since 2010. From 2010 to 2013, border cities used to have a lower VAT rate of 11% compared to 16% in the rest of the northern region. The rates were unified to 16% in 2014.

Figure 2 shows the evolution of average real wages for formal workers in the northern

[3] The northern border zone contains 43 municipalities. Appendix Table A.1 shows the entire list.

[4] In 2015, Conasami acknowledged that the wage-setting process for non-minimum wage workers used the minimum wage as a reference, which in turn could trigger inflationary pressures (Conasami (2015)). To break this informal bond, since 2017, Conasami has split minimum wage increases between a nominal adjustment in pesos and a percentage increase. The nominal increase aims to elevate the purchasing power of minimum wage workers. In 2019, the minimum wage increase in the ZLFN split into a nominal increase of 79.94 pesos, and a 5 percent increase. In the rest of the country, the increase split into a nominal adjustment of 9.43 pesos and a 5 percent increase (Conasami (2018)). Our reduced-form estimates capture the increases in prices that may come from increased labor costs for both minimum wage workers and workers earning higher wages. The effects we estimate may be smaller than the effects of minimum wage increases that do not have a distinction between nominal and percentage increases.

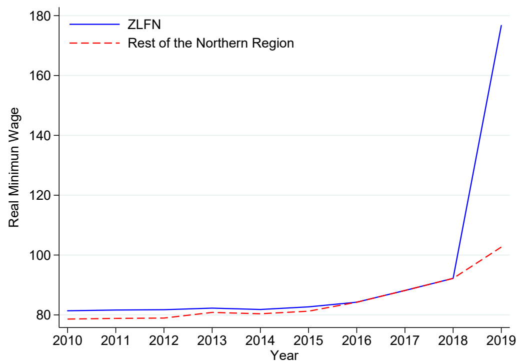
[5] To qualify for the VAT rate reduction, existing northern border firms had to apply by June 30th, 2019. New firms had to apply in the first two weeks of the month after they registered their firm for tax purposes. See Diario Oficial de la Federación (2018) for details.

[6] The fiscal stimulus package also included a reduced income tax for businesses in the northern border, through a tax credit for a third of the income tax. See Diario Oficial de la Federación (2018) for details. We focus on the effects of the minimum wage and VAT changes in this paper, but we discuss the implications of not modeling the income tax changes in section 4.

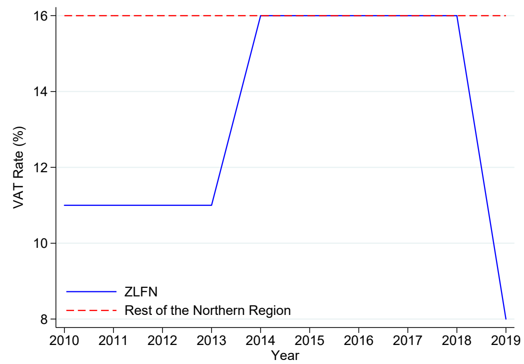
[7] The Northern Region includes the following states: Baja California, Coahuila, Chihuahua, Nuevo León, Sonora and Tamaulipas.

Figure 1: Evolution of the real minimum wage and of VAT rates

(a) Real daily minimum wage (January 2019 pesos)



(b) VAT rate



Source: Authors' calculations. Before 2012, Mexico used to have three different minimum wages that varied by municipality. These different minimum wages were unified to a single national minimum wage between 2012 and 2015. Because of this, real daily minimum wages on panel (a) from 2010 to 2015 are weighted averages of the minimum wages set by Conasami in the municipalities which comprise each region. The weights are the number of workers reported to IMSS in January of each year for each municipality. Minimum wages were deflated by the National Consumer Price Index computed by INEGI. VAT rates were obtained from Mariscal and Werner (2018) and Diario Oficial de la Federación (2018).

border and the rest of the northern region. The minimum wage appears to have had a positive effect on average wages in the border.[8]

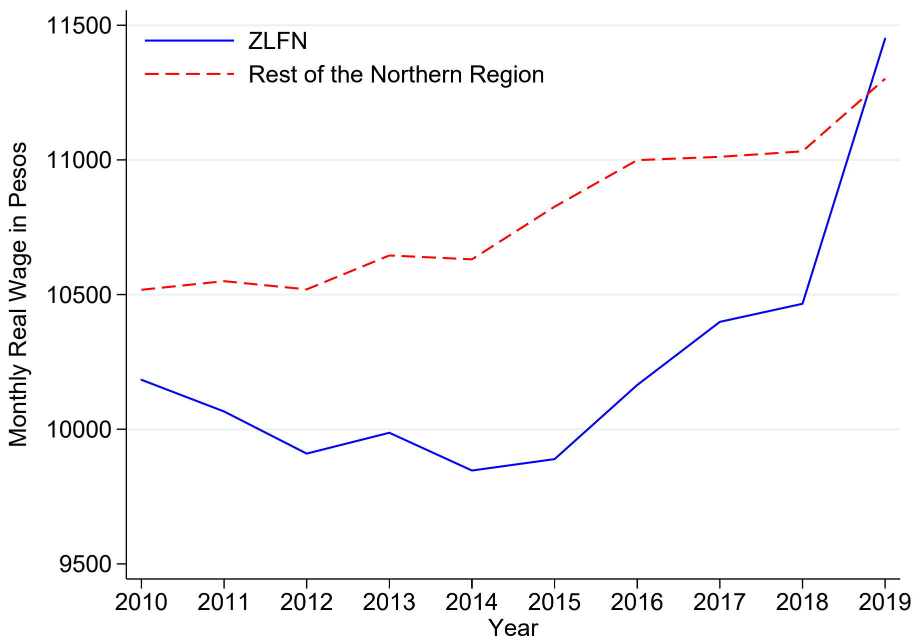
In summary, the minimum wage and VAT rate changes were substantial compared to recent history in Mexico and other countries. The minimum wage increase seems to have had an impact on average wages. We describe the data we will use to analyze the effects of these policies on prices in the next section.

3 Data

We use two sources of data on prices and labor market variables to estimate the effects of the minimum wage and VAT policy changes on prices. For price data, we use confidential product-level quotes used to build the National Consumer Price Index from the Mexican National Statistics Institute (*Instituto Nacional de Estadística y Geografía,*

[8] We do not estimate the impact of the minimum wage change on the wage distribution in this paper. Using differences-in-differences and synthetic control methodologies, Conasami (2019) estimates that average wages increased by 5 to 7% in the ZLFN as a result of the policy increase.

Figure 2: Evolution of average real wages in the formal sector. All formal workers.



Source: IMSS, authors' calculations. The average wage correspond to those reported to IMSS in January for each year. Real wages are presented at constant pesos of January 2019.

INEGI). For labor market data, we use a confidential administrative employer-employee dataset on formal workers in Mexico from the Mexican Social Security Institute (*Instituto Mexicano del Seguro Social, IMSS*).

Prices data. We use product-level microdata from the National Consumer Price Index dataset (INPC, from its acronym in Spanish) collected by INEGI. The INPC microdata contains semimonthly product-level prices for more than a hundred thousand goods and services at the national level. We refer to these products as "items". Several features uniquely define each item, including the city and commercial establishment where its price was collected, its detailed description, its weight (when applicable), and a key to follow its price evolution over time. It is also possible to identify if each product was on sale when the surveyor registered its price. The dataset also includes broader product categories of goods and services that are aggregates of items. We refer to these categories as "goods" from now on. A good may be a broad concept such as "soda", while an item may refer to "orange soda of brand X sold by store W in Mexico City".

Our sample covers price information from January 2017 to December 2019.[9] We focus our analysis on 14 cities in the northern region of the country where prices for the INPC are collected. Five of these cities are in the ZLFN.[10]

We keep 273 goods out of the 299 included in the current INPC basket (from the second half of July 2018). Surveyors do not collect prices directly from establishments for 26 goods in the database. We exclude these goods from our calculations.[11] Using the product descriptions, we manually classify every good (and item) in the INPC database to a particular 3-digit NAICS industry.

Labor market data. We use the social security records from the IMSS, a confidential monthly employer-employee administrative dataset of formal workers, most of them in the private sector.[12] It contains information on daily wages, industry, and work municipality of workers. We manually match the reported industries to a 3-digit NAICS classification. By doing this, we can merge the price data for the northern border to labor market data by industry.

For wages, we use the daily taxable income reported by the employer.[13] We exclude workers who do not have information regarding their wages.[14]

[9] When items are no longer available, similar items that may differ in some characteristics replace them. As a consequence, changes in price quotes in pesos may reflect those differences and not a price adjustment per se. We use indexes adjusted for product replacement instead of price quotes in pesos for each item to control for these changes.

[10] The ZLFN cities are Cd. Acuña, Coahuila; Cd. Juárez, Chihuahua.; Matamoros; Tamaulipas.; Mexicali, Baja California.; and Tijuana, Baja California. The other nine cities are Chihuahua, Chihuahua.; Esperanza, Sonora.; Hermosillo, Sonora.; Huatabampo, Sonora.; Jiménez, Chihuahua.; Monclova, Coahuila.; Monterrey, Nuevo León.; Saltillo, Coahuila.; and Torreón, Coahuila. We exclude Tampico, Tamaulipas., because, at the beginning of 2019, there was a fuel shortage in the city as a result of the federal government strategy to combat fuel theft. Besides the direct effect on fuel cost and availability, the prices of other items in this location might have also been affected.

[11] We exclude housing rents, house care and house upgrading, water, electricity, propane gas, natural gas, high octane gasoline, low octane gasoline, toll roads, parking, vehicle-related government fees, subway and rail transportation, urban bus transportation, bus transportation, taxi, computers, kindergarten tuition, elementary school tuition, high school tuition, university tuition, hotels, watches and jewelry, childcare, car insurance and fees for public sector documents. We drop these 26 goods because of two reasons. Some of them require special treatment in the process of collecting their prices or computing their index. Additionally, the government regulates the market of some goods, so their price dynamics reflect administrative decisions instead of market conditions.

[12] The dataset contains one observation per job. If a worker reports more than one employment with the same employer, we keep the job with the highest reported wage. If a worker records jobs with separate employers, we keep both of them for consistency with aggregate formal employment numbers from IMSS. Only 2.5% of workers reported having jobs with different employers in December 2018. Some formal workers in the public sector are not in the IMSS database, because a separate institution manages their social security.

[13] This includes some benefits such as paid vacations and year-end bonuses.

[14] These are workers who agree to have a reference salary in their contracts equal to the minimum

We focus on December 2018, the month before the implementation of the policies we analyze. During this month, the IMSS registered 19.9 million formal workers with wage data. Out of them, about 2 million worked in the ZLFN (10.3% of the total).

Descriptive Statistics. Table 1 shows some descriptive statistics about wages and workers for the industries associated with the goods in our estimation sample.[15] Workers in the ZLFN earn less, on average than workers in the rest of the Northern Region. By December 2018, around 26% of workers earned below the 2019 minimum wage in the ZLFN, where it increased by 100%. Only about 11% had wages below the minimum for the same year in the rest of the Northern Region, where the minimum wage only increased by 16%. Therefore, the 100% increase in the ZLFN affected a larger share of the workforce. In January of 2019, the average worker in the ZLFN earned about 11,325 pesos a month.

Table 1: Descriptive statistics for wages. Estimation sample.

	# of Workers (millions) Dec 2018	Below 2019 minimum Dec 2018	Industries	Average Real Monthly Wage(Jan 2019 pesos)		
				2017	2018	2019
ZLFN	1.5	26.4%	36	10,212	10,328	11,325
Rest of Northern Region	2.0	10.7%	36	11,154	11,157	11,462

Source: IMSS, authors' calculations. "Below 2019 minimum Dec 2018" is the percentage of workers who earned below 176.72 pesos a day in Dec 2018 in the ZLFN, and below 102.68 pesos in the Rest of the Northern Region.

4 Empirical Strategy

In this section, we describe an identification strategy to separate the effects on ZLFN prices of the minimum wage increase and the VAT decrease. We start by highlighting why the impact of the minimum wage on prices may vary between VAT and Non-VAT

wage in Mexico City, which does not reflect the value of the wages they earn. Monthly, they account for around 0.7% of total workers.

[15] We do not find substantial wage differences between this sample that excludes some industries and the full IMSS data. Table A.2 in the appendix shows statistics for the entire sample. The fraction of workers affected by the minimum wage increase is similar across samples, as well as the average wages in the ZLFN and the rest of the northern region.

goods. We then describe identification strategies to estimate three effects: The effect of the minimum wage increase on the price of VAT goods, the effect of the minimum wage increase on the price of Non-VAT goods, and the effect of the VAT reduction on the price of VAT goods. We outline a joint triple difference estimation strategy that recovers all the effects and formulate static and dynamic specifications.

Separating the effects of the minimum wage and VAT changes is challenging. Simple comparisons between prices in the ZLFN and the rest of the country would confound several relationships. Both a comparison of prices for all goods and a comparison of prices for VAT goods would mix the impacts of the minimum wage increase and the tax incentive. A comparison restricted to Non-VAT goods would only show how the change on minimum wage affects the prices of said goods but would not identify the effect of minimum wage increase for VAT goods. Ignoring VAT goods would be an omission because the impact of the minimum wage increase on prices may be different for goods with and without VAT. A joint estimation that ignores these differences would be biased. Understanding the distinct effects of VAT and the minimum wage is essential to comprehend how these policies redistribute real income.

There are several reasons why the impact of a higher minimum wage on prices could be different between VAT and Non-VAT goods. There may be different degrees of compliance with minimum wage regulation across industries, differences in labor costs structure and differences in labor market power.[16]

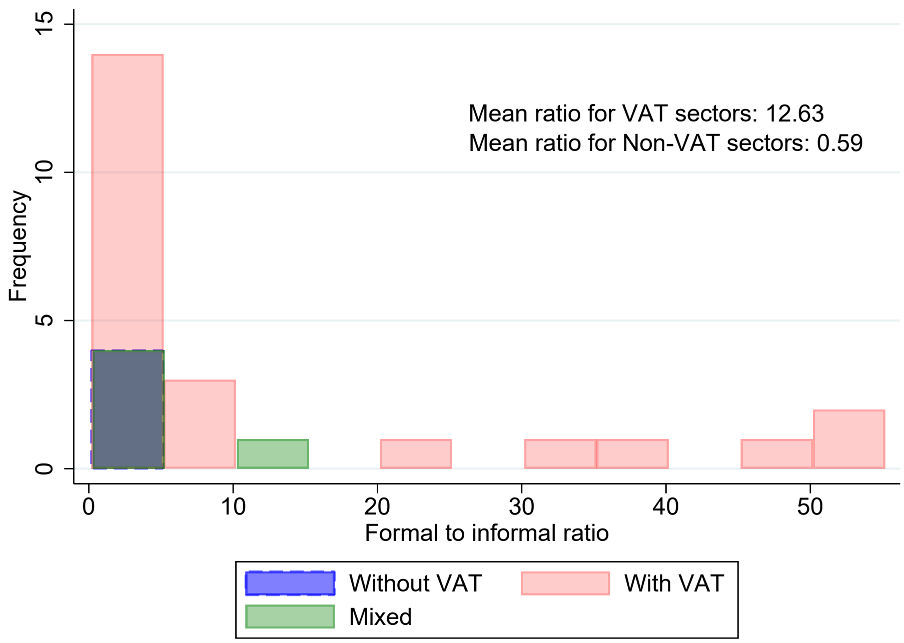
To provide evidence of different compliance with labor regulations, Figure 3 shows the distribution of the ratios of formal to informal labor at the national level, using information from Mexico's labor market survey (ENOE). Whereas the formal-to-informal labor ratio can be high in industries that produce VAT goods, in Non-VAT goods this ratio is small, and never exceeds five. Because of this difference in compliance with labor regulations, the prices of VAT goods may react more to the minimum wage change.

4.1 Effect of the Increase in the Minimum Wage on VAT Goods Prices

To estimate the effect of the increase to the minimum wage on the goods that are subject to VAT, we compare the prices of items across different sectors in the ZLFN. We identify the effect of the minimum wage by comparing sectors with varying fractions

[16] Azar et al. (2019) and Munguia Corella (2020) show that varying degrees of labor market power change the employment effects of minimum wages in the U.S.

Figure 3: National ratios of formal to informal workers by industry. 2018 Q4.



Source: ENOE, authors' calculations. Each observation is a 3-digit NAICS industry. The horizontal axis is the ratio of formal to informal workers in each industry. Colors correspond to whether the sector produces goods that are or are not subject to VAT.

of workers affected by the minimum wage increase (Card, 1992; Stewart, 2002; Lemos, 2009; Harasztosi and Lindner, 2019; Prez Pérez, 2020). We label this variable "fraction affected", although it is also known as the minimum wage "bite". We define each sector's fraction affected as the percentage of workers that in December 2018 were paid less than or equal to the minimum wage that took effect in January 2019. Under compliance with the minimum wage and keeping employment constant, these workers should have received a salary increase in response to the minimum wage increase, putting upward pressure on the firms' labor costs. Firms may transfer part of these net labor costs increases into prices.[17]

The "fraction affected" measure of minimum wage incidence has an advantage over

[17] Firms might incur extra labor costs from the increase in the minimum wage for several reasons. First, to comply with the minimum wage, they must increase the salaries of minimum wage workers. Second, they may face an incentive to increase some wages of minimum wage workers beyond the legal minimum wage increase to maintain worker hierarchy. Third, to maintain a wage hierarchy, firms could increase the salaries of higher-earning workers. All of these extra labor costs would tend to get bigger with a larger fraction affected, so the estimations presented on this paper take this effect into account in a reduced form fashion.

using the minimum wage level. It associates with the costs pressures that the employer would face in each production sector if employment remained constant. For example, in industries that already paid their workers more than 176.72 daily pesos, the fraction affected is zero. We would not expect to have "mechanical" increases on these sectors' payrolls from the minimum wage increase.

To calculate the fraction affected by good, we use the 3-digit NAICS industry that we manually assigned in the previous section. For each of these industries in the ZLFN, we calculate the percentage of workers in the IMSS dataset whose wage in December 2018 was lower than the minimum wage that took effect in January 2019 (176.72 pesos).

Figure 4 shows that there is substantial variation in the fraction of workers affected by the minimum wage increase across industries that produce VAT goods. It is high in sectors such as personal services, food services, and ground transportation. It is low for many manufacturing industries.

Figure 4: Fraction Affected by Industry, ZLFN. Industries for VAT goods in sample.

Source: IMSS, authors' calculations. Industries are from the 3-digit NAICS classification that were successfully matched to goods within the INPC. Fraction affected is the percentage of workers that on December 2018 were paid less than or equal to the minimum wage that took effect on January 2019.

We implement the comparison of prices for VAT goods with different fractions affected using a difference-in-differences specification:[18]

$$\log(Price)_{jt} = \alpha_0 + \alpha_t + \alpha_{g(j),c} + \theta_{FA}^{VAT} \times Post_t \times FA_{g(j)} + \alpha_1 Sale_{jt} + \varepsilon_{jt}. \quad (1)$$

Here, $\log(Price)_{jt}$ refers to the logarithm of the price of item j at time t. The coefficient α_0 is a constant term. The coefficients α_t and $\alpha_{g(j),c}$ are fixed effects for semimonthly time t and for good $g(j)$ of item j by city c. The fraction affected by the minimum wage increase in the industry that produces good $g(j)$ is $FA_{g(j)}$. The variable $Post_t$ takes the value of one on and after the first half of January 2019 and zero otherwise. The coefficient of interest, θ_{FA}^{VAT}, measures the percentage increase on the price of a good with VAT for each percentage point of fraction affected, relative to a scenario where the minimum wage would not have increased. The binary variable $Sale_{jt}$ indicates if the item is on sale at time t. The error term is ε_{jt}. We cluster standard errors by city and good using two-way clustering (Cameron et al., 2011). To obtain the average effect of the minimum wage increase on VAT goods, we multiply θ_{FA}^{VAT} by the average fraction affected across items $\overline{FA_{g(j)}}$: $\hat{\theta}_{MW}^{VAT} = \hat{\theta}_{FA}^{VAT} \times \overline{FA_{g(j)}}$.

The identification assumption is that the minimum wage effect in this panel event study design is that, in the absence of the minimum wage increase, the prices of VAT goods would have evolved similarly across industries with a different fraction affected. We test for the existence of pre-existing differences in the evolution of prices across sectors using a dynamic specification in section 4.4.

4.2 Effect of the Increase in the Minimum Wage on Non-VAT Goods Prices

To estimate the effect of the minimum wage on Non-VAT items, we compare their price evolution between the border municipalities and the rest of the northern region. Since Non-VAT goods were not affected by the VAT rate reduction, this comparison identifies the effect of the minimum wage on their prices. The identification rests on

[18] Several papers use this type of analysis to estimate the effects of the minimum wage on prices. In the case of Mexico, Solorzano and Dixon (2020) apply a difference in differences method to calculate the impact of the frequency of wage variations on the fraction of reset prices, using the minimum wage as an instrument. Leung (2020) uses a panel event study approach to estimate the effects of the minimum wage on prices in the U.S. Regarding the impact of VAT rate reductions on prices, Benzarti and Carloni (2019) and Kosonen (2015) also follow a natural experiment approach for France and Finland, respectively, in which they estimate the pass-through using difference-in-differences regressions.

an assumption of parallel trends in prices for Non-VAT goods across the ZLFN and the rest of the northern region in the absence of a minimum wage change. We choose this particular control region to address time-varying spatially correlated shocks that may affect this region differentially, thus invalidating the parallel trends assumption (Dube et al., 2010).

The difference-in-differences specification is:

$$\log(Price)_{cjt} = \beta_0 + \beta_t + \beta_{g(j),c} + \theta_{MW}^{NONVAT} \times Post_t \times ZLFN_c + \beta_1 Sale_{jt} + \epsilon_{cjt}. \quad (2)$$

As in equation (1), $\log(Price)_{jt}$ refers to the logarithm of the price of item j at time t. β_t and $\beta_{g(j),c}$ are fixed effects for semimonthly time t and for good $g(j)$ of item j by city c. The variable $Post_t$ takes the value of one on and after the first half of January 2019 and zero otherwise. The variable $ZLFN_c$ indicates that the city is in the northern border ZLFN region. The binary variable $Sale_{jt}$ indicates if the good or service is on sale at time t. The coefficient of interest θ_{MW}^{NONVAT} measures the effect of the minimum wage on the price of Non-VAT goods. We cluster standard errors by city and good using two-way clustering.

4.3 Effect of the VAT Rate Reduction on VAT Goods Prices

To estimate the effect of the VAT rate reduction, we first compare the price evolution of VAT items between the border municipalities and the rest of the northern region. This comparison yields the effect of both policies on the prices of VAT goods. We then adjust the estimate of the combined effect by the previously estimated impact of the minimum wage on VAT goods to isolate the effect of the VAT rate reduction. Identification relies on assuming that, in the absence of changes in the minimum wage and the VAT rate, the prices of VAT goods would evolve in parallel between the ZLFN and the rest of the northern region.

We first obtain the combined effect of both policies on VAT goods prices θ_{MW+VAT}^{VAT} from a difference-in-differences model:

$$\log(Price)_{jct} = \gamma_0 + \gamma_t + \gamma_{g(j),c} + \theta_{MW+VAT}^{VAT} \times Post_t \times ZLFN_c + \eta_{cjt}. \quad (3)$$

Where the variables are as in equations (1) and (2), and γ_t and $\gamma_{g(j),c}$ are fixed effects for semimonthly time t and for good $g(j)$ of item j by city c. We cluster standard errors by good and city. From this estimation, we can obtain the effect of the VAT rate reduction on the price of the VAT goods indirectly, using the estimates of equation (1):

$$\hat{\theta}^{VAT}_{VAT} = \hat{\theta}^{VAT}_{MW+VAT} - \hat{\theta}^{VAT}_{MW}.$$

4.4 Joint Estimation and Dynamic Specification

In practice, we estimate the three effects of the previous sections with a joint triple-difference estimation. This is convenient because it allows us to obtain joint standard errors for $\hat{\theta}^{VAT}_{MW}, \hat{\theta}^{NONVAT}_{MW}$ and $\hat{\theta}^{VAT}_{VAT}$. The specification is:

$$\begin{aligned}
\log(Price)_{jct} = \delta_0 &+ \theta^{VAT}_{FA} \times FA_{g(j)} \times VAT_j \times Post_t \times ZLFN_c \\
&+ \theta^{NONVAT}_{MW} \times Post_t \times ZLFN_c \times (1 - VAT_j) \\
&+ \theta^{VAT}_{VAT} Post_t \times ZLFN_c \times VAT_j + \delta_1 Sale_{jct} \\
&+ \delta_{c,g(j)} + \delta_{t,VAT_j} + \xi_{cjt}.
\end{aligned} \tag{4}$$

In this equation, the variable VAT_j takes the value of one if the good has VAT.. Just as in equation (1), $FA_{g(j)}$ is the fraction affected by the minimum wage increase, $Sale_{jct}$ takes the value of one if the good is on sale, and $Post_t$ equals one on and after the first half of January 2019, and zero before that. The triple difference specification includes three double interaction terms. First, an interaction of city and good indicators, $\delta_{c,g(j)}$. Second, an interaction of city and time indicators, which we restrict to vary only for the pre and post periods and between the ZLFN and the rest of the northern region. This is included as $Post_t \times ZLFN_c$. Third, an interaction of time and good effects, δ_{t,VAT_j}, which we restrict to vary only across VAT and Non-VAT goods to maintain consistency with equations (1) and (2). The error term is ξ_{jct}.

Dynamic specification The strategy we have outlined rests on several parallel trends assumptions. First, an equal evolution of the prices of VAT goods in the ZLFN across industries, in the absence of a minimum wage change. Then, parallel trends in the prices of Non-VAT goods across the ZLFN and the rest of the northern region absent the minimum wage change. Last, equal evolution of prices of VAT goods across the ZLFN and the rest of the northern region absent both policy changes. We provide evidence of parallel trends before the policy changes take place by using a panel event study (Borusyak and Jaravel, 2017; Freyaldenhoven et al., 2019). The dynamic specification is as follows:

$$\begin{aligned}
\log(Price)_{jct} &= \delta_0^D + \sum_k \theta_{FA,k}^{VAT} \times 1\,[t=k] \times FA_{g(j)} \times VAT_j \times ZLFN_c \\
&+ \sum_k \theta_{MW,k}^{NONVAT} \times 1\,[t=k] \times ZLFN_c \times (1 - VAT_j) \\
&+ \sum_k \theta_{VAT,k}^{VAT} \times \times 1\,[t=k] \times ZLFN_c \times VAT_j + \delta_1^D Sale_{jct} \\
&+ \delta_2^D Sale_{jct} \times VAt_j + \delta_3^D Sale_{jct} \times VAT_j \times ZLFN_c + \delta_{c,g(j)}^D + \delta_{t,VAT_j}^D + \xi_{cjt}^D. \qquad (5)
\end{aligned}$$

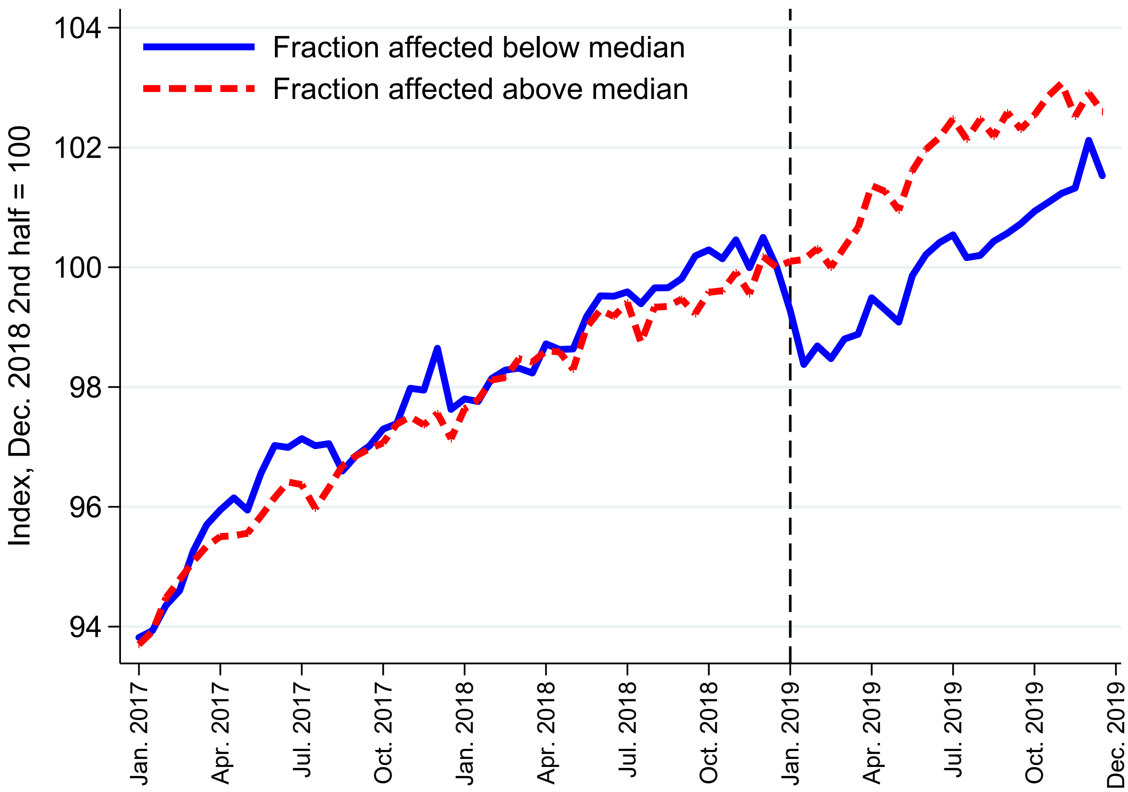
Here, $1\,[\ t=k]$ is a variable that equals one when $t=k$, and k varies semimonthly from Jan 2017 to Dec 2019. The superscript D differentiates the coefficients and the error term from their static counterparts. The coefficients $\theta_{FA,k}^{VAT}$, $\theta_{MW,k}^{NONVAT}$ and $\theta_{VAT,k}^{VAT}$ for $k<0$ measure lead effects to evaluate if there are parallel trends in the prices of items. Their counterparts for $k \geq 0$ measure lagged effects. We standardize $\theta_{FA,-1}^{VAT}$, $\theta_{MW,-1}^{NONVAT}$ and $\theta_{VAT,-1}^{VAT}$ to 0.

5 Results

We find an economically and statistically significant effect of the minimum wage increase in VAT goods in the ZLFN. The average VAT good in the ZLFN saw its price rise by about 2.46% because of the minimum wage change. Our estimate for the effect of the minimum wage increase on Non-VAT goods prices is smaller. Average Non-VAT prices in the ZLFN increased by about 0.2% due to the minimum wage increase, but this effect is imprecisely estimated. The VAT rate reduction brings about a decrease in the prices of VAT goods of 3.8% on average. We describe these results below.

Effect of the minimum wage on the price of VAT goods. We provide descriptive evidence of an increase in VAT goods prices associated with the minimum wage increase in Figure 5. We calculate the median across items of the fraction of affected workers by the minimum wage and separate the sample in two: fraction affected above and below the median. The median fraction affected across items is 19.06%. The prices of goods produced with a fraction affected above the median do not change their trajectory after January 2019, even though the VAT decreased. By contrast, the prices of goods produced with a fraction affected below the median show a substantial decrease at the beginning of 2019.

Figure 5: Price indexes for VAT goods in the northern border (ZLFN)



Source: Authors' calculations, Banco de Mexico, INEGI and IMSS. Each line is the simple average of price indexes across items that are subject to VAT. The average excludes the price indexes for energy, government services, housing and education. The median fraction of workers affected by the minimum wage increase across items was 19.06% in the 2nd half of December 2019. The solid line plots price indexes for items with fraction affected below the median. The dashed line plots price indexes for items with fraction affected above the median.

Table 2 shows the results of the separate and joint estimations of the minimum wage and VAT effects for all goods. Table 2, column (1), shows the effect of the minimum wage on the price of VAT goods, from estimation of equation (1). The coefficient $\hat{\theta}_{FA}^{VAT}$ measures the percentage increase on the price of a good with VAT for each percentage point of fraction affected, comparing to a scenario in which the minimum wage does not increase. The results show a positive and statistically significant impact of the minimum wage increase on prices. The coefficient implies that controlling by other factors, the prices of a good produced with a labor force in which half of the workers were affected by the minimum wage increase were 3.98% higher than the prices of goods produced without affected workers in the second half of December 2019. The average effect on prices is 2.46%. The implied elasticity of prices to the minimum wage is about 0.025, obtained by dividing the average effect by the percentage increase in the minimum wage (100%). Column (4) shows similar results using the joint estimation strategy.

Table 2: Estimates of the effect of the minimum wage and VAT policy changes on prices. Separate and joint estimates. All goods.

Coefficient	(1)	(2)	(3)	(4)
θ_{FA}^{VAT}	0.000801**			0.000800***
	(0.000195)			(0.000149)
θ_{MW}^{NONVAT}		0.00244		0.00244
		(0.00221)		(0.00309)
θ_{VAT+MW}^{VAT}			-0.0140***	
			(0.00388)	
θ_{VAT}^{VAT}				-0.0383***
				(0.00651)
N	246,410	632,042	695,504	1,327,546
R^2	0.215	0.415	0.210	0.367
# of industries	31	11	31	36
# of goods	146	121	146	267
# of items	4090	11,023	12,324	23,347
# of periods	72	72	72	72
Time fixed-effects	Yes	Yes	Yes	No
Time × VAT fixed-effects	No	No	No	Yes
City × good fixed-effects	Yes	Yes	Yes	Yes
Sale dummy	Yes	Yes	Yes	Yes
Mean fraction affected	30.74			30.74
Implied θ_{VAT}^{MW}	0.02462			0.02459
Implied θ_{VAT+MW}^{VAT}				-0.01371

Source: Author's calculations. Column numbers correspond the equation whose estimates are shown. "Mean fraction affected" is the average fraction of workers affected by the minimum wage increase across VAT items in the ZLFN in the second half of December 2019. "Implied θ_{MW}^{VAT}" is the product of θ_{FA}^{MW} and mean fraction affected, the average effect of the minimum wage on the price of VAT goods in the ZLFN. "Implied θ_{MW+VAT}^{VAT}" is the sum of "Implied θ_{VAT}^{MW}" and θ_{VAT}^{VAT} in column (4). Standard errors two-way clustered by good and industry in parentheses. *: p<0.1, **; p<0.05, ***: p<0.01.

Our estimate of the effect on goods prices is in line with the most recent evidence for the U.S. by Renkin et al. (2020). They find an elasticity of 0.02 of grocery prices to the minimum wage. They are smaller than previous U.S. estimates. Most of these older studies place this elasticity at around 0.04 Lemos (2008); MaCurdy (2015). Some studies find larger elasticities for restaurant prices MacDonald and Aaronson (2006); Aaronson et al. (2008).

In Table 3, we also restrict the joint estimation to categories of goods. We find positive effects of the minimum wage for VAT non-food items and services. Since these regressions are limiting the comparisons to items within the food, non-food and services categories, they provide evidence that the estimated effect is not driven by heterogeneous time trends across industries, at least at this coarse level. During 2019 Mexico experienced a growth deceleration, with firms in the non-food category experiencing a larger reduction in formal employment generation (Banxico, 2020). This heterogeneous growth across sectors could be a source of concern for our estimates since we use differences in prices across industries. It is encouraging that the effects we find are robust to comparing goods only within broad industry categories. We estimate a smaller, non-significant effect for food items. However, there are few goods nor industries in this category because most food items are not subject to VAT.[19]

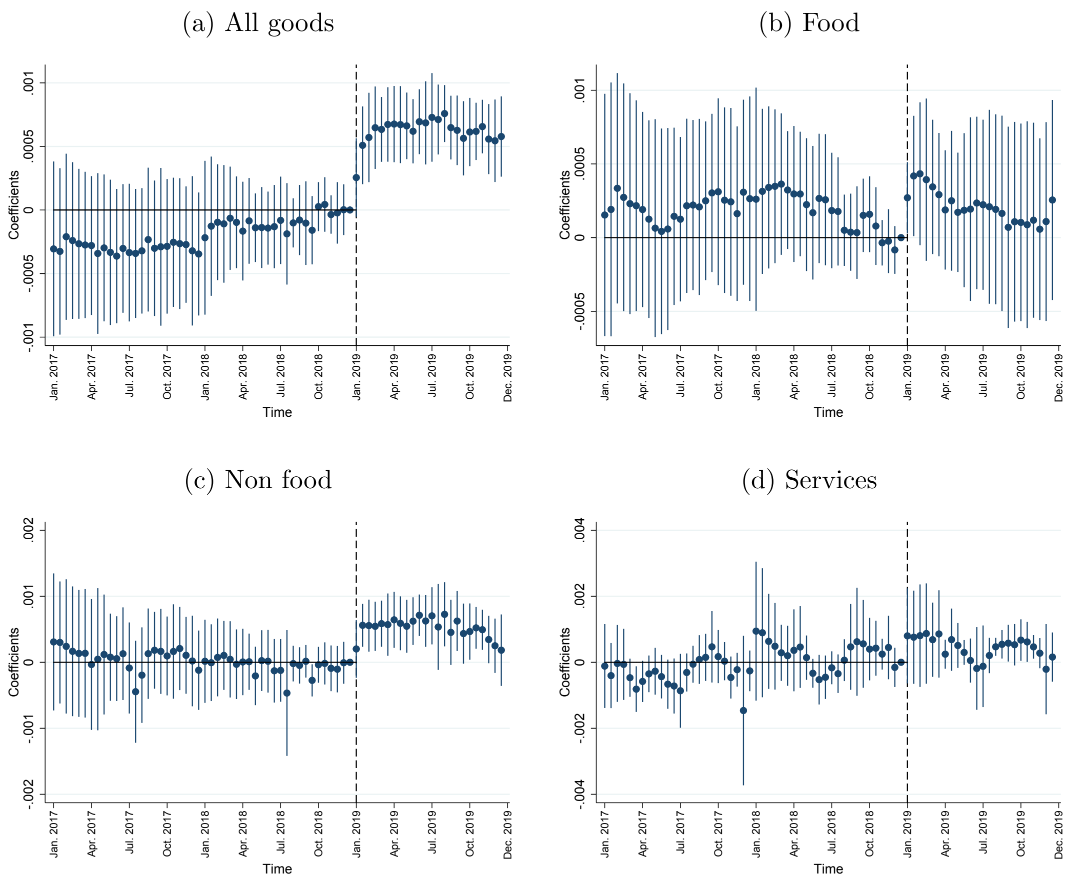
Figure 6 shows dynamic estimates from equation (5). Panel (a) shows the trajectory of the $\theta^{VAT}_{MW,k}$ coefficient. Before 2019, the difference in prices across goods with different fractions affected is not statistically significant. Although there may be some difference in prices during 2017, according to the point estimates, it disappears by 2018. Statistically significant differences become present by 2019. Initially, the difference in prices is small, but it grows over time and stabilizes around 0.0008 after March of 2019. The price differences persist until the end of 2019.

The evolution of the coefficients for other categories of goods shows some differences. Panel (b) shows the effects on food goods. Because of the small number of VAT food goods, these estimates are imprecise. Panel (c) shows estimates for non-food goods. In this case, the impact on prices is immediate, and not as persistent, since it decreases towards the end of the sample period. Panel (d) shows the effect on services, which is noisy, although the aggregate impact is significant. The uncertainty may be because there are only a few service industries in this regression.

Effect of the minimum wage on the price of Non-VAT goods. In Figure

[19] These are separate regressions. Each of them compares the goods with a larger fraction affected to a different control group. The range of fraction affected varies across good categories. So, the effect on all goods is not the average across the categories.

Figure 6: Dynamic estimates of the effect of the minimum wage on the price of VAT goods



Source: Author's calculations. The dots correspond to coefficient estimates $\theta^{VAT}_{MW,k}$ from equation (5). Vertical bars are confidence intervals at the 95% level. The vertical segmented line corresponds to Jan 2019, 1st half.

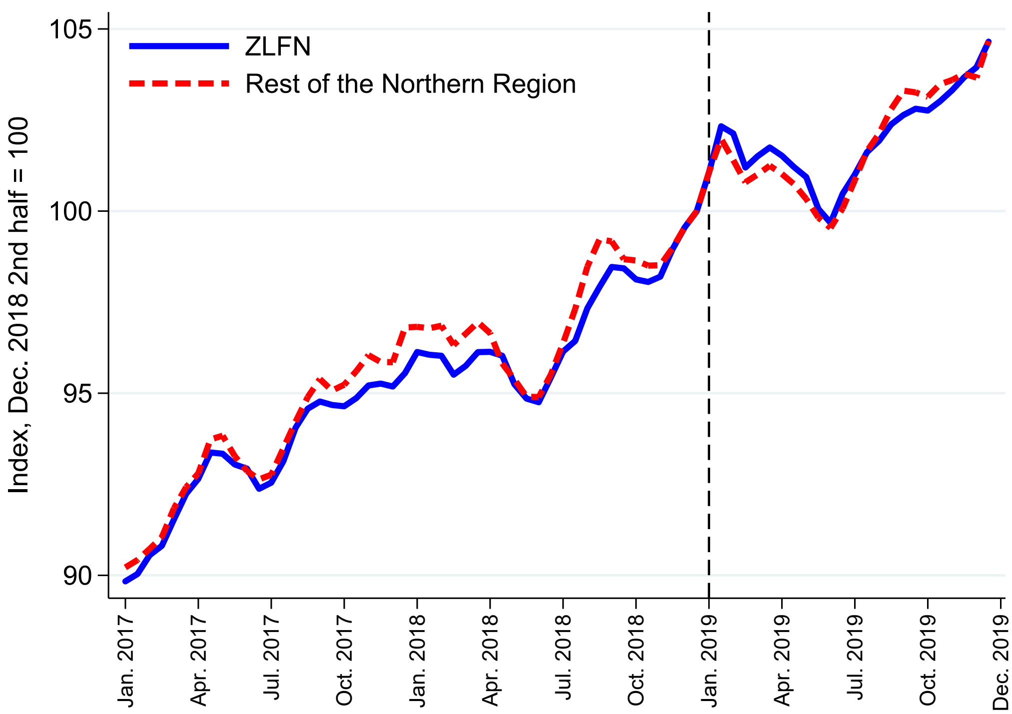
Table 3: Estimates of the effect of the minimum wage and VAT policy changes on prices. Joint estimates. All goods and categories of goods.

Coefficient	All goods	Food	Non-Food	Services
θ^{VAT}_{FA}	0.000800**	0.0000329	0.000512**	0.000435***
	(0.000149)	(0.000324)	(0.000190)	(0.000107)
θ^{NONVAT}_{MW}	0.00244	0.00620*	-0.00602	-0.00361
	(0.00309)	(0.00333)	(0.00875)	(0.00457)
θ^{VAT}_{VAT}	-0.0383***	-0.0207	-0.0325***	-0.00980
	(0.00651)	(0.0131)	(0.00586)	(0.0104)
N	1,327,546	304880	597710	158654
R^2	0.367	0.242	0.203	0.260
# of industries	36	4	19	15
# of goods	267	73	117	37
# of items	23,347	5670	10543	2735
# of periods	72	72	72	72
Time × VAT fixed-effects	Yes	Yes	Yes	Yes
City × good fixed-effects	Yes	Yes	Yes	Yes
Sale dummy	Yes	Yes	Yes	Yes
Mean fraction affected	30.74	34.11	25.24	52.12
Implied θ^{MW}_{VAT}	0.02459	0.00011	0.01292	0.02267
Implied θ^{VAT}_{VAT+MW}	-0.01371	-0.02059	-0.01958	0.01287
Implicit elasticity VAT to MW	0.02459	0.00011	0.01292	0.02267
Implicit elasticity Non-VAT to MW	0.0029	0.0074	-0.0071	-0.0043
Implicit elasticity VAT to VAT	0.478	0.258	0.406	0.1225

Author's calculations. Each column corresponds to a separate estimation of equation (4) with the goods belonging to each category. "Mean fraction affected" is the average fraction of workers affected by the minimum wage increase across VAT items in the ZLFN for this category in the second half of December 2019. "Implied θ^{VAT}_{MW}" is the product of θ^{MW}_{FA} and mean fraction affected, the average effect of the minimum wage on the price of VAT goods in the ZLFN. "Implied θ^{VAT}_{MW+VAT}" is the sum of "Implied θ^{MW}_{VAT}" and θ^{VAT}_{VAT}. "Implicit elasticity VAT to MW" is $100 \times \theta^{VAT}_{MW}$ over 100, the percentage increase in the minimum wage in the ZLFN. "Implicit elasticity Non-VAT to MW" is $100 \times \theta^{NONVAT}_{MW}$ over (100-16.21), the extra percentage increase in the minimum wage in the ZLFN compared to the rest of the northern region. "Implicit elasticity VAT to VAT" is $100 \times \theta^{VAT}_{VAT}$ over -8, the VAT rate reduction in the ZLFN. Standard errors two-way clustered by good and industry in parentheses. *: p<0.1, **; p<0.05, ***: p<0.01.

7, we show descriptive evidence of the impact of the minimum wage on Non-VAT goods. We compare the evolution of the prices of Non-VAT goods for the ZLFN and the rest of the northern region. The price indexes are similar between the ZLFN and the comparison region during 2017 and 2018. They are no longer as similar by 2019 when the price index for the ZLFN surpasses the index for the rest of the North. The differences dissipate by mid-2019, and they are not as stark as those seen for VAT goods with different fractions affected. These smaller differences suggest that the effect of the minimum wage increase on these goods was smaller.

Figure 7: Price indexes for Non-VAT goods in the northern border (ZLFN) and the rest of the northern region
Index, Dec. 2018 2nd half = 100



Source: Authors' calculations, Banco de Mexico, INEGI and IMSS. Each line is the simple average of price indexes across goods that are not subject to VAT. The average excludes the price indexes for energy, government services, housing and education.

Table 2 column (2) shows the results from separate estimation of equation (2), and column (4) shows the joint estimation. The estimate of θ_{MW}^{NONVAT} implies that Non-VAT goods prices in the ZLFN increased around 0.2% in comparison to the rest of the northern region. This effect is smaller than the effect on VAT goods, and it is not statistically significant. Table 3 shows the joint estimation across categories of goods. We find the price increases for Non-VAT goods come primarily from the food category, whose price had a statistically significant relative increase of about 0.6%. This effect is comparable to the effect of the minimum wage on Non-VAT goods. Even though food production is labor-intensive -such that we would expect a significant increase in production costs because of higher minimum wages- the production of Non-VAT food items involves more informal labor. This labor informality may explain why their prices may not be as affected by the minimum wage. The ratio of formal labor to informal labor for the food industry in figure 3 is 0.68, among the lowest across industries.

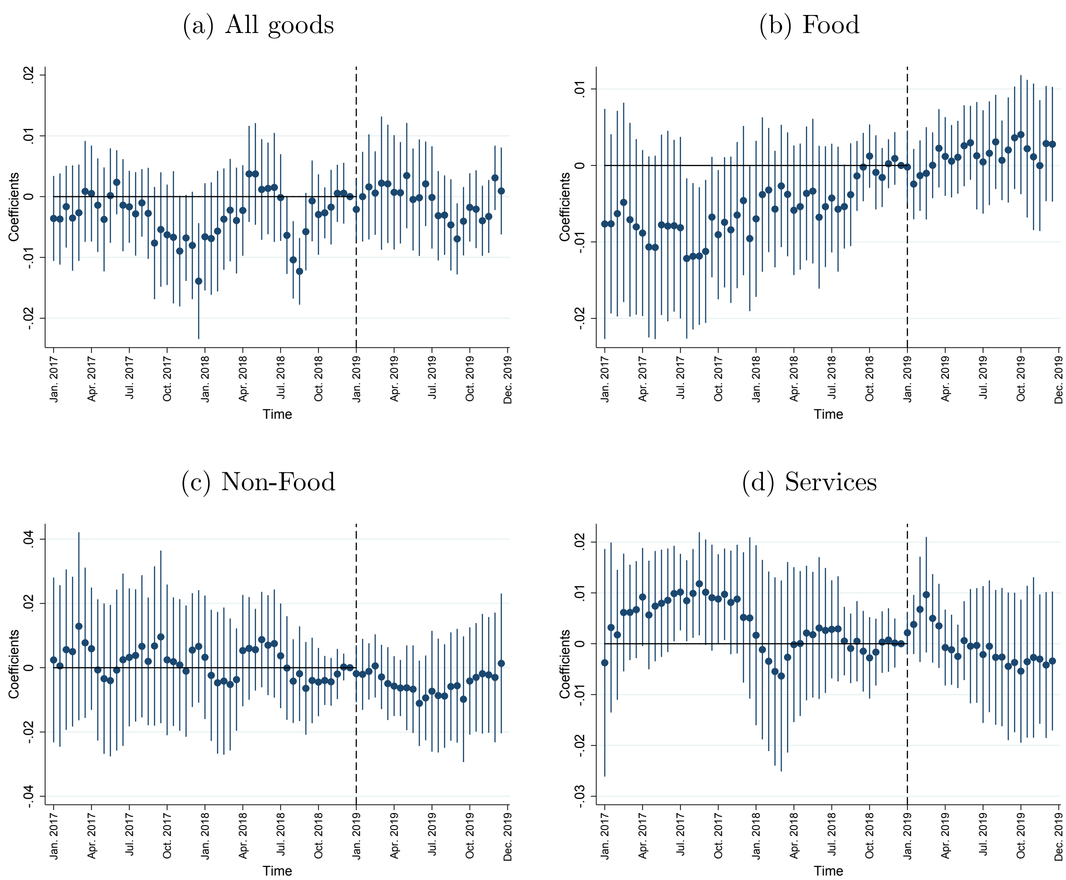
Figure 8 shows dynamic estimates of $\theta_{MW,k}^{VAT}$ from equation (5). Panel (a) shows the estimates for all goods. The estimates show a lot of volatility both before and after 2019. The coefficients become smaller around July of 2019, suggesting that any impact of the minimum wage increase on the price of these goods decayed in the second half of the year. Across groups, the food comparison in panel (b) shows some evidence of a trend before mid-2018, but no evidence in the second half of 2018.

Effect of the VAT rate reduction on the price of VAT goods. Figure 9 shows the price evolution for VAT goods in the ZLFN and the rest of the northern border. The figure shows a substantial decrease in the price of VAT goods, as documented by Campos-Vazquez and Esquivel (2020). Since these goods were affected by both the minimum wage and VAT policy changes, this graph only provides descriptive evidence of the combined effect of both policies. We also show the evolution of the prices of these goods separating by the fraction of workers affected by the minimum wage increase, as in figure 5. The prices of VAT goods with a fraction affected above the median show a substantially smaller drop.

The estimate for θ_{VAT}^{VAT} on table 3 shows that the reduction of VAT goods prices, adjusting for minimum wage effects, is estimated to be around 3.8%. The triple difference regression adjusts for minimum wage effects by subtracting the minimum wage effect estimated through θ_{FA}^{VAT}, from the combined effect of both policies.[20] For a VAT rate reduction of 8 p.p., the price reduction for VAT goods of 3.98% implies an elasticity of about 0.48. Mariscal and Werner (2018) estimate an average elasticity of 0.2 for the VAT reform in 2014 . Racimo (2018) estimates an elasticity of 0.26 for goods sold in formal establishments and a non-significant elasticity for goods in informal establishments. Our estimates are larger than the ones found in these previous studies. One

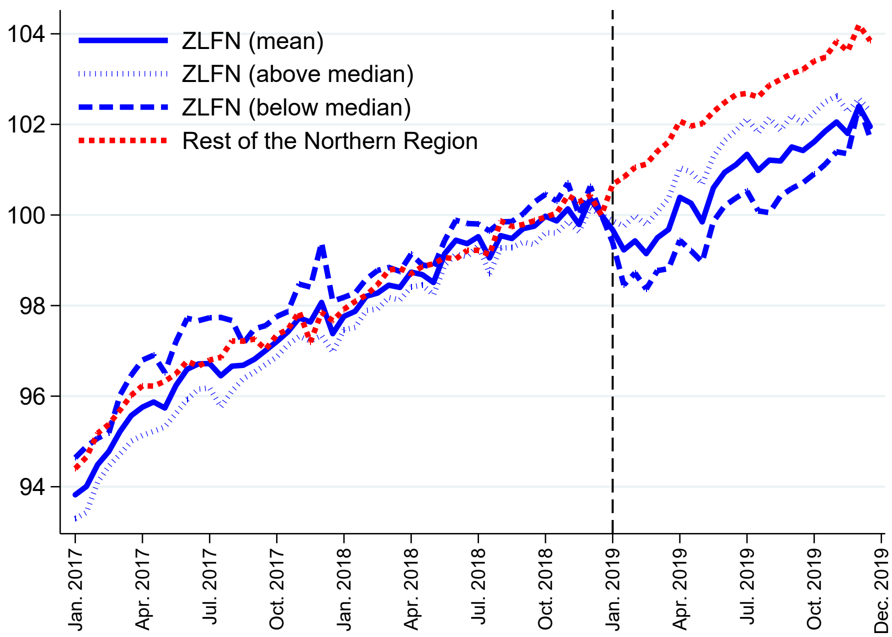
[20] The estimate for θ_{VAT}^{VAT} in the joint estimation is not exactly equal to subtracting the estimate of θ_{MW}^{VAT} of column (1) from the estimate of θ_{MW+VAT}^{VAT} from column (3), because the separate estimation of columns (1) allows for different time effects for VAT goods in the ZLFN. Still, the estimates are quite similar.

Figure 8: Dynamic estimates of the effect of the minimum wage on the price of Non-VAT goods



Source: Author's calculations. The dots correspond to coefficient estimates $\theta^{NONVAT}_{MW,k}$ from equation (5). Vertical bars are confidence intervals at the 95% level. The vertical dotted line corresponds to Jan 2019, 1st half.

Figure 9: Price indexes for VAT goods in the northern border (ZLFN) and rest of Northern Region
Index, Dec. 2018 2nd half = 100

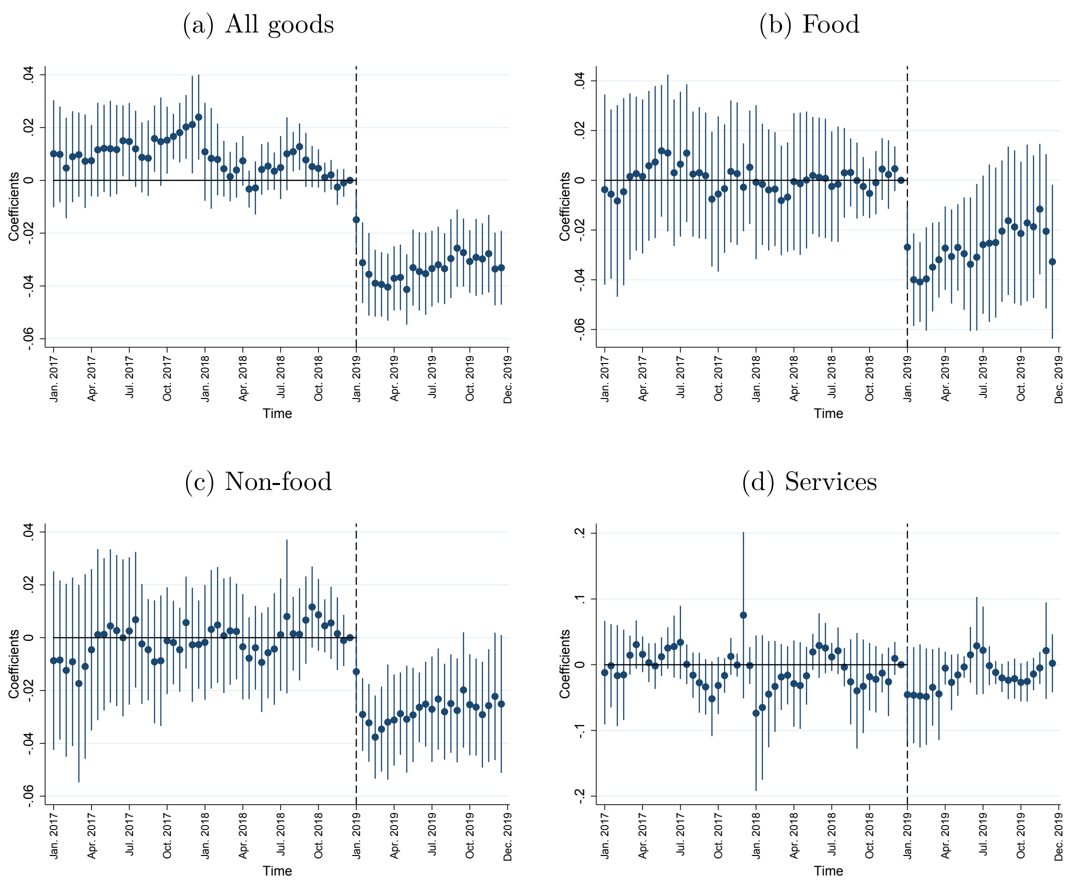


Source: INPC, IMSS, authors' calculations. Each line is the simple average of price indexes across VAT items. The vertical dotted line corresponds to Jan 2019, 1st half. The median fraction of workers affected by the minimum wage increase across items was 19.06% in the 2nd half of December, 2019. The solid line plots price indexes for all items. The thick dashed line plots price indexes for items with fraction affected below the median. The dotted line plots price indexes for items with fraction affected above the median. The thin dashed line plots price indexes for items in the rest of the northern region.

possible reason for this difference is a different position in the economic cycle since growth was slowing down during 2018 and 2019 in Mexico.

Figure 10 shows the dynamic estimates $\theta^{VAT}_{VAT,k}$ from equation (5). Although they are noisy before 2019, they are not systematically different from zero during 2018. After January 2019, the point estimates become negative. After the second half of 2019, the estimates become smaller in absolute value and hover around -3.5%. The patterns are similar across groups except for services in panel (d), which shows substantial noise. The VAT effect seems to appear quickly, which is consistent with previous evidence for Europe (Benedek et al., 2015) and Mexico (Mariscal and Werner, 2018).

Figure 10: Dynamic estimates of the effect of the VAT on the price of VAT goods



Source: Author's calculations. The dots correspond to coefficient estimates $\theta^{VAT}_{VAT,k}$ from equation (5). Vertical bars are confidence intervals at the 95% level. The vertical dotted line corresponds to Jan 2019, 1st half.

One drawback of these estimates is the lack of control for a simultaneous reduction of the income tax in the ZLFN. The minimum wage effect coming from the comparison of prices of Non-VAT goods between the border municipalities and the rest of the northern region would be biased toward zero if prices decreased in the border due to the income tax reduction. We, therefore, think that our estimates of the minimum wage effects on these prices of Non-VAT goods are conservative.

Robustness. We gauge the robustness of these results in several ways. First, we show that the results are robust to more flexible control variable specifications. Table A.3 shows results of estimating equation (4) under alternative specifications, using more flexible fixed effects and industry-specific trends. We obtain similar coefficients with specifications that include item fixed effects, as opposed to good fixed effects. We also include industry-specific linear trends to account for the possible differential growth of each industry over time. Our estimates for the effects of the minimum wage and the VAT changes on VAT goods are similar, albeit the point estimates are a bit smaller.

Second, we test two alternative explanations for the different evolution of prices for VAT goods with a higher fraction of workers affected by the minimum wage increase. The first possibility is that these goods are sold in informal establishments and are more prone to VAT evasion. If that were the case, their prices would not decrease in response to the VAT rate decrease, whereas the prices of goods with lower fractions affected and more VAT compliance would decrease. To examine this hypothesis, we use the information on the type of establishment that sells where each item in the INPC dataset, taking advantage of the detailed item information. We label establishments as formal or informal, using a classification proposed by Racimo (2018) and Bachas et al. (2020). We then calculate the share of informal establishments for each good and correlate it with fractions affected in Figure A.1 of the Appendix. We do find a significant correlation between the fraction affected and the share of informal establishments per sector. To account for a potentially different effect of the VAT on goods sold in formal and informal establishments, we re-estimate equation (1), allowing the time effects to interact with a formal establishment indicator. These estimates are in Table A.4 of the Appendix. We find similar results to those of table 2, which suggests that our minimum wage effects do not arise from heterogeneity in the VAT rate reduction response across formal and informal establishments.

Another alternative explanation for our results would be a heterogeneous pass-through of the VAT reduction to prices that happens to correlate with the fraction affected. Because the VAT and minimum wage policies intertwine in our setting, we can not separately identify heterogeneous VAT effects and minimum wage effects on prices.

If goods with a higher fraction of affected workers have smaller VAT pass-through, their prices may not fall as much because of the VAT reduction. The smaller decrease would bias our estimates of the effect of the minimum wage upwards. Nevertheless, we can rule out this bias using prior estimates of heterogeneous VAT pass-through. We obtain VAT pass-through estimates by good from Mariscal and Werner (2018). We then carry out two exercises. First, we correlate fraction affected to these estimates of VAT pass-through. Figure A.2 in the Appendix shows the relationship between these two variables: their correlation is not significant. Second, we conduct a placebo exercise where we impute 2019 prices for each VAT good according to their VAT pass-through from Mariscal and Werner (2018) and no effect of the minimum wage. We then re-estimate equation (1) on this imputed data. If the minimum wage effects we found were an artifact of heterogeneous VAT pass-through, and assuming that the VAT pass-through in 2019 was similar to these previous estimates, we would find a similar effect of fraction affected on prices in the imputed data. Appendix table A.5 shows that this turns out not to be the case. Our estimates using these imputed prices are small and not statistically significant.

Overall effect of the minimum wage and VAT policies on prices in the ZLFN. We use our estimates $\theta_{FA}^{\widehat{VAT}}$, $\theta_{MW}^{\widehat{NOVAT}}$ and $\theta_{VAT}^{\widehat{VAT}}$ to obtain the effect on overall inflation in the ZLFN. We compare to a counterfactual scenario where the minimum wage increase in the ZLFN would have been 5%, and where the VAT rate does not decrease. We use the estimates from equation (4) for convenience in calculating standard errors, but the estimates are only slightly smaller if we use the estimates of θ_{FA}^{VAT} from equation (1).

For the effect of the minimum wage on VAT goods prices, we use the following formula:

$$\begin{array}{l}\text{Effect of MW on VAT} \\ \text{goods average annual} \\ \text{inflation}\end{array} = \left[\hat{\theta}_{FA}^{VAT} \times 100 \times \sum_{i \in VAT} (FA_i \times \omega_i)\right] \times \frac{100-5}{100}. \qquad (6)$$

In this equation, $\hat{\theta}_{FA}^{VAT} \times 100 \times FA_i$ is the fitted value for good i from equation (5). We add these fitted values and weight them by the weight of each good in the ZLFN's price index, ω_i.[21] The resulting sum is the effect of a minimum wage increase of 100%. We re-scale it by $\frac{100-5}{100}$ to compare to our counterfactual where the minimum

[21] These weights are published by INEGI for each good and city according to the INPC basket.

wage increases by 5%.[22]

For the effect of the minimum wage on the inflation of Non-VAT goods we calculate:

$$\text{Effect of MW on Non-VAT goods average annual inflation} = \left[\hat{\theta}_{MW}^{NONVAT} \times 100 \times \sum_{i \in NONVAT} \omega_i\right] \times \frac{100-5}{100-16.21}. \quad (7)$$

The term in brackets is the effect of the minimum wage on the Non-VAT goods price index. Since this effect comes from a comparison of prices of the ZLFN and the rest of the northern region, where the minimum wage increased 16.21%, we divide by 100-16.21 to get the effect per p.p. of the minimum wage increase. We then multiply by 100-5 to obtain the impact of the 100% increase versus a 5% increase in the counterfactual.

For the effect of the VAT rate reduction on the inflation of VAT goods, we apply a similar formula:

$$\text{Effect of VAT on VAT goods average annual inflation} = \left[\hat{\theta}_{VAT}^{VAT} \times 100 \times \sum_{i \in VAT} \omega_i\right]. \quad (8)$$

To arrive at an overall effect on average annual inflation, we need additional assumptions on the effect on the prices of goods not included in our estimation. Out of these omitted goods, we make assumptions on the effects on three important groups of goods: housing, education, and gasoline. For housing and education, we assume they experience the same effects on prices as other Non-VAT goods and include them in the Non-VAT category. For gasoline, we assume a price drop equal to the VAT rate reduction, which fits what we see in the price data. Just in the first two weeks of January 2019, gas prices in the ZLFN dropped by 6.1%. The expected price drop from the VAT rate reduction from 16% to 8% would be (1.08/1.16) - 1 = - 6.9%.

The results of this exercise are in table 4. Overall, we estimate that both policies reduced the ZLFN's average annual inflation by 0.76 p.p through the end of 2019, relative to a scenario without a VAT rate reduction and a minimum wage increase of 5%. The minimum wage increase itself accounts for a difference in the ZLFN's average

[22] This re-scaling assumes that the effect of the minimum wage on the price of good i is linear on the fraction of affected workers FA_i. We think this is a reasonable assumption. Harasztosi and Lindner (2019) show that the impact of a minimum wage increase on prices in Hungary was linear on the fraction of workers affected at the firm level.

annual inflation of 1.01 p.p. relative to the counterfactual scenario if we only consider the impact on VAT goods. If we also consider the effect on Non-VAT goods, the minimum wage accounts for a 1.08 p.p difference relative to the counterfactual.

Table 4: Effect of the policy changes on inflation in the ZLFN

Effect	Incidence on ZLFN average annual inflation (p.p.)
Minimum Wage increase on VAT goods	1.01***
	(0.19)
Minimum wage increase on Non-VAT	0.07
	(0.08)
VAT rate reduction on VAT goods	-1.10***
	(0.19)
VAT rate reduction on gasoline	-0.73
Total Effect	-0.76***
	(0.13)

Source: Author's calculations. The numbers correspond to the contribution of each factor to the inflation of 2019 in percentage points. We make additional assumptions about the effect on prices of goods that are excluded from our estimation. We assume that the impact of the minimum wage increase on the prices of housing and education was the same as the average effect estimated for the other Non-VAT goods. We do not consider an impact of the minimum wage increase on prices that are regulated by the government. On the VAT side, we assume that gasoline prices drop in the same magnitude as the tax factor (-6.9%). For the prices of electricity, LPG and natural gas, toll roads, parking, computers, hotels, jewelry and watches, we assume the same average effect of the VAT rate reduction than the effect on the VAT goods that are included in the estimation. Standard errors calculated from equation (4) in parentheses. *: p<0.1, **: p<0.05, ***: p<0.01.

6 Concluding Remarks

We estimate the effect on prices of a substantial minimum wage increase and a VAT rate reduction, in the northern border between Mexico and the U.S. Our identification strategy separates the impacts of the two policy changes and accounts for heterogeneous consequences of the minimum wage increase on the prices of VAT and Non-VAT goods.

We find price increases for goods produced with a large share of minimum wage labor and price decreases for VAT goods. The elasticity of VAT goods prices to the minimum wage is around 0.025, while the elasticity of Non-VAT goods prices to the minimum wage is about 0.002. For the VAT rate reduction, the elasticity of prices is approximately 0.48. The total effect on prices in the border was a moderate reduction because the policies counteracted each other. We estimate that with a minimum wage increase in the ZLFN of only 5%, and with the VAT reduction, inflation in the ZLFN would have been 1.08 percentage points smaller.

Our estimates contribute to research on the effects of minimum wage and VAT changes on prices and highlight how these effects may vary across goods. The policy changes we study are significant, so our estimates may be informative for the design of policies that involve substantial changes in the minimum wage and the VAT rate. They also inform about the impacts of these policies in countries that implement them simultaneously.

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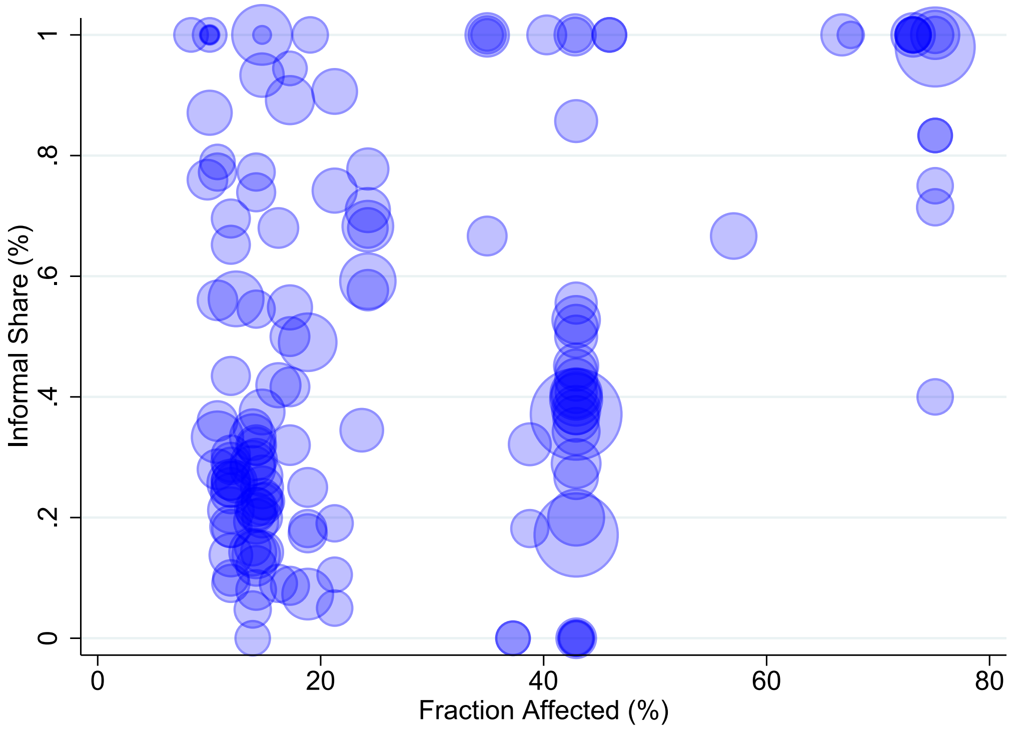
Appendix

A Additional Figures and Tables

Figure A.1: Fraction affected and share of specifics sold in informal establishments.



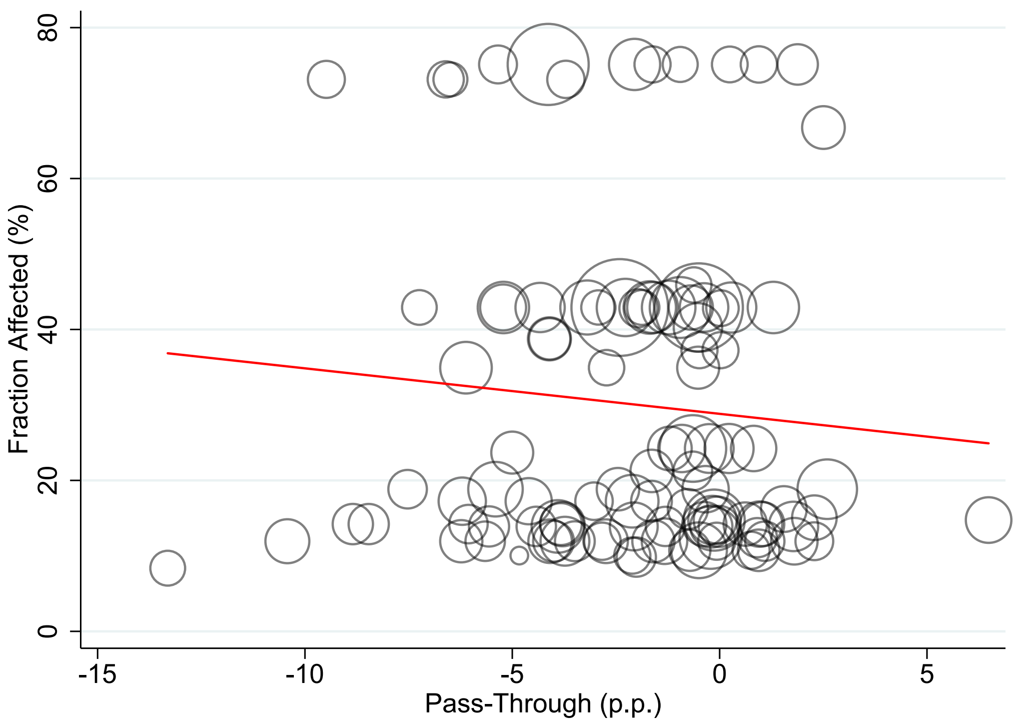
Source: IMSS, INPC, authors' calculations. The size of each bubble is the number of items in each sector. The share of items sold in informal establishments is calculated according to thew classification of Racimo (2018) and Bachas et al. (2020).

Table A.1: Municipalities in the Northern Border (ZLFN)

State	Municipality
Baja California Norte	Ensenada
	Playas de Rosarito
	Tijuana
	Tecate
	Mexicali
Sonora	San Luis Río Colorado
	Puerto Peñasco
	General Plutarco Elías Calles
	Caborca
	Altar
	Sáric
	Nogales
	Santa Cruz
	Cananea
	Naco
	Agua Prieta
Chihuahua	Janos
	Ascensión
	Juárez
	Praxedis G. Guerrero
	Guadalupe
	Coyame del Sotol
	Ojinaga
	Manuel Benavides
Coahuila	Ocampo
	Acuña
	Zaragoza
	Jiménez
	Piedras Negras
	Nava
	Guerrero
	Hidalgo
Nuevo León	Anáhuac
Tamaulipas	Nuevo Laredo
	Guerrero
	Mier
	Miguel Alemán
	Camargo
	Gustavo Díaz Ordaz
	Reynosa
	Río Bravo
	Valle Hermoso
	Matamoros

Source: Diario Oficial de la Federación (2018).

Figure A.2: VAT implicit elasticity estimated in Mariscal and Werner (2018) and fraction affected



Source: Mariscal and Werner (2018), IMSS, author's calculations. The size of each bubble corresponds to the number of goods in each sector. The line is a linear fit weighted by the number of goods.

Table A.2: Comparison of wage data: All industries vs. estimation sample excluding some industries

	# of Workers (millions) Dec 2018	Below 2019 minimum Dec 2018	Industries	Average Real Monthly Wage(Jan 2019 pesos) 2017	2018	2019
(a) IMSS Data						
ZLFN	2.1	28.3%	71	10,399	10,466	11,450
Rest of Northern Region	3.4	10.6%	71	11,011	11,032	11,302
(b) Estimation Sample						
ZLFN	1.5	26.4%	37	10,212	10,328	11,325
Rest of Northern Region	2.0	10.7%	37	11,154	11,157	11,462

Source: IMSS, authors' calculations. "Below 2019 minimum Dec 2018" is the percentage of workers who earned below 176.72 pesos a day in Dec 2018 in the ZLFN, and below 102.68 pesos in the Rest of the Northern Region.

Table A.3: Robustness

Coefficient	(1)	(2)	(3)
θ_{FA}^{VAT}	0.000800***	0.000749***	0.000530***
	(0.000149)	(0.000143)	(0.000105)
θ_{MW}^{NONVAT}	0.00244	0.00110	0.00119
	(0.00309)	(0.00255)	(0.00258)
θ_{VAT}^{VAT}	-0.0383***	-0.0368***	-0.0.302***
	(0.00651)	(0.00601)	(0.00527)
N	1,327,546	1,327,546	1,32,7546
R^2	0.367	0.607	0.609
# of sectors	36	36	36
# of goods	267	267	267
# of items	23,872	23,872	23,872
# of periods	72	72	72
Time X VAT fixed-effects	Yes	Yes	Yes
City X Good fixed-effects	Yes	No	No
City X Item fixed-effects	No	Yes	Yes
Industry Trend	No	No	Yes

Source: Author's calculations. Columns (1) to (3) are estimates of equation (4) with different specifications. Column (1) shows the baseline estimates. Column (2) adds item fixed-effects. Column (3) adds industry-specific linear time trends. Standard errors clustered by good and city in parentheses. *: p<0.1, **: p<0.05, ***: p<0.01.

Table A.4: Effect of the minimum wage on the price of VAT goods: Time effects vary by formal or informal establishments

Coefficient	All	Food	Non-food	Services
θ_{MW}^{VAT}	0.000649**	-0.000233	0.000489**	0.000350*
	(0.000144)	(0.000265)	(0.000120)	(0.000131)
N	246,410	20,594	182,218	43,598
R^2	0.127	0.209	0.119	0.156
# of sectors	31	3	18	13
# of goods	146	14	101	31
# of items	4,090	333	3,057	700
# of periods	72	72	72	72
good fixed-effects	Yes	Yes	Yes	Yes
Time fixed-effects by type of establishment	Yes	Yes	Yes	Yes

Source: Author's calculations. Coefficients correspond to estimates of equation (1) with time effects interacted with an indicator of whether the item is sold in a formal or informal establishment, using the classification from Racimo (2018) and Bachas et al. (2020). Standard errors clustered by good in parentheses. *: p<0.1, **: p<0.05, ***: p<0.01.

Table A.5: Regressions with counterfactual prices using VAT implicit elasticities from Mariscal and Werner (2018)

Coefficient	Original Price 2017-2019	Counterfactual Price 2017-2019	Original Price 2017-Jan 2019	Counterfactual Price 2017-Jan 2019
θ_{MW}^{VAT}	0.000762***	0.000366	0.000402**	0.00000564
	(0.000162)	(0.000303)	(0.000137)	(0.000205)
N	200,654	200,654	127,537	127,537
R^2	0.128	0.116	0.125	0.123
# of sectors	28	28	28	28
# of goods	110	110	110	110
# of items	3,179	3,179	3,179	3,179
# of periods	72	72	49	49
Time fixed-effects	Yes	Yes	Yes	Yes
good fixed-effects	Yes	Yes	Yes	Yes

Source: Author's calculations. "Original Price 2017-2019" shows estimates of equation (1) using the original data on a restricted sample of goods for which we could associate a VAT pass-through from Mariscal and Werner (2018). "Counterfactual Price 2017-2019" shows estimates using counterfactual prices, where the price of each good in 2019 is calculated from the VAT rate change and its elasticity to the VAT. "Original Price 2017-Jan 2019" and "Counterfactual Price 2017-Jan 2019" restrict the sample to end in Jan 2019, to avoid confounding heterogeneous VAT pass-through effects with dynamic minimum wage effects. Standard errors clustered by good in parentheses. *: p<0.1, **: p<0.05, ***: p<0.01.