Banco de México

Working Papers

N° 2022-13

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

Mariana Calderón Cerbón
Banco de México

Josué Fernando Cortés Espada
Banco de México

Jorge Pérez Pérez
Banco de México

Alejandrina Salcedo
Banco de México

November 2022

La serie de Documentos de Investigación del Banco de México divulga resultados preliminares de trabajos de investigación económica realizados en el Banco de México con la finalidad de propiciar el intercambio y debate de ideas. El contenido de los Documentos de Investigación, así como las conclusiones que de ellos se derivan, son responsabilidad exclusiva de los autores y no reflejan necesariamente las del Banco de México.

The Working Papers series of Banco de México disseminates preliminary results of economic research conducted at Banco de México in order to promote the exchange and debate of ideas. The views and conclusions presented in the Working Papers are exclusively the responsibility of the authors and do not necessarily reflect those of Banco de México.

Documento de Investigación
2022-13

Working Paper
2022-13

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

Mariana Calderón Cerbón†
Banco de México

Josué Fernando Cortés Espada‡
Banco de México

Jorge Pérez Pérez§
Banco de México

Alejandrina Salcedo**
Banco de México

Abstract: In January 2019, the authorities increased the minimum wage and decreased the value-added tax (VAT) in an effort to boost activity on the northern Mexican border. In this paper we estimate the effects of both policies on prices. We find that the upward pressures on prices due to the minimum wage hike were more than offset by the downward pressures associated with the VAT. In the absence of the VAT reduction policy, average prices in the northern Mexican border would have been higher. We estimate that the effects of the minimum wage on prices tended to be smaller for goods or services produced with a larger share of informal labor.

Keywords: Minimum wage, Value-Added Tax, Prices
JEL Classification: J38, J46, H20

Resumen: En enero de 2019, las autoridades incrementaron el salario mínimo y redujeron la tasa del impuesto al valor agregado (IVA) en la frontera norte de México con el objetivo de estimular la actividad económica. En este documento se estiman los efectos en los precios al consumidor de cada una de las políticas. Se encuentra que las presiones al alza sobre los precios atribuibles al aumento del salario mínimo fueron más que contrarrestadas por las presiones a la baja asociadas a la reducción del IVA. En ausencia de la política de reducción al IVA, los precios promedio en la frontera norte habrían sido más altos. Se estima que los efectos del salario mínimo sobre los precios tendieron a ser menores para aquellos bienes o servicios producidos con una mayor proporción de trabajo informal.

Palabras Clave: Salario Mínimo, IVA, Precios

*We thank Diego Mayorga, Stefano Molina, Karla Neri, Michelle Avataneo, Sheila Cadet and Eduardo Torres for data and research assistance. We also thank the editor and referees, Raymundo Campos-Vazquez, Daniel Chiquiar, Gerardo Esquivel, Leon Fernandez, Nicolas Gavoille, David Jaume, Julio Leal, Carolina Rodriguez Zamora, Tatsiana Syman, and participants at multiple conferences for feedback. The data was accessed through the EconLab at Banco de Mexico. The EconLab collected and processed the data as part of its effort to promote evidence-based research and foster ties between the research staff of Banco de Mexico and the academic community. Please send inquiries about the terms for data access to: econlab@banxico.org.mx.

† Dirección General de Investigación Económica. Email: mcalderon@banxico.org.mx.

‡ Dirección General de Investigación Económica. Email: jfcortes@banxico.org.mx.

§ Dirección General de Investigación Económica. Email: jorgepp@banxico.org.mx.

** Dirección General de Investigación Económica. Email: asalcedo@banxico.org.mx.

1 Introduction

In January 2019, the Mexican authorities increased the minimum wage at the country's northern border by 100% and decreased the value-added tax (VAT) rate from 16% to 8%. The policy combination aimed at boosting investment at the border while reducing incentives to migrate to the US (Diario Oficial de la Federación, 2018; Conasami, 2018). In the rest of the country, the minimum wage was raised by 16.21%, and there was no change in the VAT rate. We study the effects of such sizable policy changes on prices at the northern border, as understanding the price impact is essential to evaluate the effects on workers' purchasing power (ILO, 2016).

The Mexican context is relevant, first, because the changes are substantial compared to other policy shifts analyzed in the minimum wage and VAT literature. Their magnitude helps identify their effects, as they may induce considerable price adjustments.[1,2] Second, it is also relevant because of the simultaneous implementation of both policies. Their effect on prices may be countervailing, reducing the risk of a price increase that the minimum wage hike could bring about. More generally, these policies can impact employment, earnings, and living standards and may reinforce or counteract each other.

The combination of a higher minimum wage and a lower VAT tax rate may be specific to the Mexican context. However, it is not uncommon for governments to implement policy combinations when trying to achieve particular goals. Therefore, it is usually a challenge for policy evaluation to rigorously identify the specific effects of each policy on the economy and the behavior of economic agents. We are able to disentangle the effects of the two simultaneously implemented policies by exploiting a combination of industrial and geographical differences that translate into exogenous variation in the incidence of each reform.

Our identification strategy can be summarized as follows. First, to estimate the effect of the minimum wage increase on goods subject to VAT, we exploit the variation in the incidence of the minimum wage across industries on the northern border. Second, we identify the effect of the minimum wage increase on Non-VAT goods using the differential increases in the minimum wage along the country's Northern Region (northern border vs. rest of the Northern

[1] In the US, the federal minimum wage has remained constant for ten years, and state-level adjustments in the minimum wage are seldom as large as the sudden doubling of the minimum wage we see in Mexico. Recent increases in city-level minimum wages in the US have tended to be large but slower. For example, Seattle raised 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 US local minimum wages. Mexico recently increased its minimum wage by 9.58% in 2017 and by 10.39% in 2018.

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

Region). Third, to estimate the effect of the VAT rate reduction, we first compare the prices of VAT goods between the northern border and the rest of the Northern Region (which yields a combined effect of VAT and minimum wage changes). Then, we subtract the estimated effect of the minimum wage on VAT goods.

We find that the lower VAT rate counteracted the price increase caused by a higher minimum wage. We estimate that the minimum wage led to a 1.2% increase in the Mexican northern border's consumer price index. In contrast, the VAT rate reduction resulted in a 2.57% decrease, for an overall combined effect of a 1.37% price reduction. The increase in the minimum wage by itself would have, on the net, increased the purchasing power of low-wage workers at the expense of reducing real wages for high-wage and informal workers. However, the VAT rate decrease implied that the overall policy's effect was an increase in the purchasing power of all workers.

The degree of informal labor in the production of different goods seems to be playing a role in the impact of the minimum wage on prices. In particular, the effect on Non-VAT goods, produced with a higher share of informal labor, is small and imprecisely estimated. At the same time, it is economically and statistically significant for VAT goods, which tend to have a lower degree of informality. Moreover, among VAT goods, those with lower levels of labor informality show a higher pass-through. Our analysis suggests that it is essential to consider this heterogeneity while evaluating the effects of the minimum wage on prices in countries where labor informality is a critical element in the labor market's structure.

Many studies have found evidence of the pass-through of higher minimum wages onto prices in the US, with varying degrees of transmission (MacDonald and Aaronson, 2006; Aaronson et al., 2008; MaCurdy, 2015; Renkin et al., 2020; Leung, 2021). For developing countries, a survey by Lemos (2008) suggests that the evidence is mixed, although more recent studies find significant positive impacts.[3] We contribute to the literature by providing estimates of the effect of a large and sudden minimum wage increase in a middle-income country. We also suggest that it is relevant to look at informal labor shares in the production of goods to understand the magnitude of the pass-through. The context also allows us to show how the effects can be counteracted by simultaneously implemented policies, like the VAT rate decrease in this case. Separating the effects is relevant for proper identification and because of the policy implications. In this regard, Campos-Vazquez and Esquivel (2020) ana-

[3]Leung (2021) shows that grocery prices go up around 0.6% for a 10% increase in local minimum wages in the US. Renkin et al. (2020) estimate that a 10% increment in the minimum wage raises grocery and drug prices by 0.36% in the US. 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.

lyze the same episode as the one analyzed in this paper but do not provide separate estimates for the impact of each policy.

On the VAT side, several papers estimate different pass-through rates of VAT changes onto prices, and some of them document important asymmetries in the effects of VAT rate increases and reductions (Politi and Mattos, 2011; Benedek et al., 2015; Kosonen, 2015).[4] Our estimates for Mexico show a partial pass-through of the VAT reduction onto prices that materializes quickly, occurring over the lapse of one month. For the Mexican context, Aportela and Werner (2002) and Mariscal and Werner (2018) study the effect of a VAT rate increase in 1995 and 2014. Our VAT elasticity estimates for the 2019 reform are higher than those found in the referred studies. Also, for Mexico, Racimo (2018) looks at elasticities to the VAT rate separating goods that are sold in formal and informal establishments, finding that they are not statistically significant in the latter case.

The rest of the paper proceeds as follows. Section 2 gives 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 outline our estimation strategy. Section 5 shows our main results. We conclude in section 6.

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

In January 2019, the minimum wage increase was differentiated across the Mexican regions. The differential increase ocurred alongside the creation of a new zone with different minimum wage and tax policies, dubbed the free northern border zone. (ZLFN, for its acronym in Spanish, *Zona Libre de la Frontera Norte*). At the same time, the federal government introduced a fiscal credit of 50% of the Value-Added Tax (VAT) in the ZLFN. It applied to the 16% rate, decreasing it to 8%.[5,6] Some of the objectives of this policy combination

[4]Politi and Mattos (2011) find an asymmetrical effect of VAT changes on food prices in Brazil, depending on the direction of the change. Benedek et al. (2015) find a partial pass-through and no asymmetries for VAT changes in 17 Eurozone countries. Kosonen (2015) finds an incomplete pass-through to hairdressers' prices when the VAT rate decreased in Finland. Benzarti and Carloni (2019) and Benzarti et al. (2020) also find a partial pass-through and increases in firms' profits from VAT decreases.

[5]To qualify for the VAT rate reduction, existing northern border firms had to apply in the first month of 2019. This deadline was later extended to June 30, 2019. New firms had to apply in the first two weeks of the month after they registered their firm for tax purposes. There are not any additional restrictions on opening firms in the ZLFN. See Diario Oficial de la Federación (2018), for details.

[6]The fiscal stimulus package also included a reduced income tax for businesses on the northern border through a tax credit for a third of the income tax. See Diario Oficial de la Federación (2018), for details. We

were to boost investment and employment creation in the ZLFN, to support the recovery of the purchasing power of low-income workers, and to reduce the incentives to migrate across the border to the US (Diario Oficial de la Federación, 2018; Conasami, 2018).[7] Inside the Zone, the minimum wage increased from 88.36 to 176.72 pesos per day.[8] In the rest of the country, it increased from 88.36 to 102.68 pesos per day. The minimum wage increases were announced as a countrywide 5% increase, plus a nominal 79.94 pesos increase in the ZLFN or a nominal 9.43 pesos increase in the rest of the country.[9]

The increase in the minimum wage and the VAT reduction were substantial 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.[10] 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. The minimum wage and VAT rate changes were substantial compared to the recent record in Mexico and other countries.

The evolution of average real wages for formal workers in the northern border and the rest of the Northern Region is shown in Appendix Figure A.1. The minimum wage appears to have had a positive effect on average wages at the border. We examine these effects further in section 5.

---

focus on the effects of the minimum wage and VAT changes in this paper. However, we discuss the implications of not modeling the income tax changes in section 4.

[7]There is limited evidence that the simultaneous implementation of both policies was aimed at reducing the negative impacts of the minimum wage hikes on firms. Diario Oficial de la Federación (2018), however, suggests that the resources from lower VAT rates could be channeled towards higher wages.

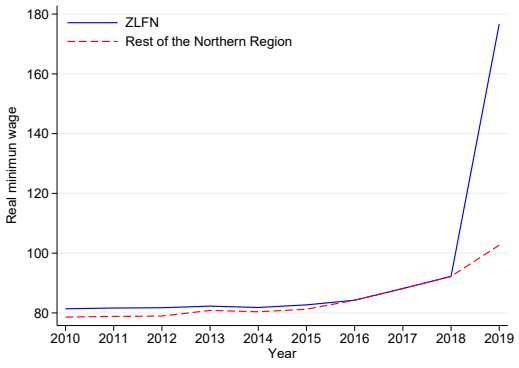
[8]The ZLFN contains 43 municipalities. Appendix Table A.1 shows the entire list.

[9]In 2015, the National Minimum Wage Commission, 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). Since 2017, Conasami has split minimum wage increases between a nominal adjustment in pesos and a percentage increase to break the informal bond between the minimum wage and other wages. The nominal increase aims to elevate the minimum wage workers' purchasing power without contaminating wage revisions along the rest of the wage distribution. Our reduced-form estimates capture the increases in prices resulting from increased labor costs for both minimum wage workers and workers earning higher wages. The effects we estimate may be smaller than the impact of minimum wage increases that do not distinguish between nominal and percentage increases because of possible reduced spillover effects on the rest of the distribution.

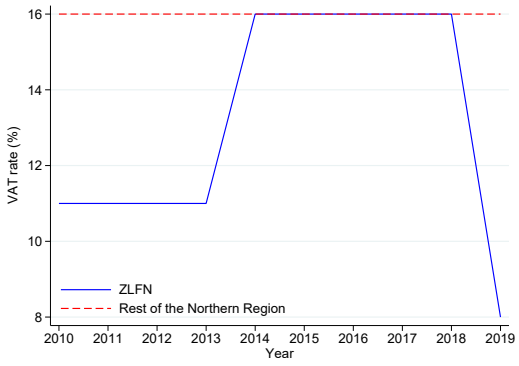
[10]The Northern Region includes the following states: Baja California, Coahuila, Chihuahua, Nuevo León, Sonora, and Tamaulipas.

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

(a) Real daily minimum wage
(Pesos of January 2019)



(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 registered in 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).

3 Data

We use two data sources 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, 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*). Our sample spans from January 2017 to December 2019.

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, 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. Additionally, the dataset includes broader product categories of goods and services that are aggregates of items. We refer to these categories as "goods" from now on, although each category may include goods and services. A "good" represents 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.[11] 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.[12] The data is limited in that it only covers cities. Therefore, we can only compare prices among cities, and not necessarily across spatially-adjacent areas, as it is usual in papers that use minimum-wage variation across ad-

[11] When items are no longer available, similar items that may differ in some characteristics replace them. Consequently, changes in price quotes in pesos may reflect those differences rather than 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. This adjustment follows the official computation of the consumer price index.

[12] The ZLFN cities are Cd. Acuña, Coahuila; Cd. Juárez, Chihuahua.; Matamoros; Tamaulipas.; Mexicali, Baja California.; and Tijuana, Baja California. The other nine cities are in the rest of the Northern Region: 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 due to the federal government's strategy to combat fuel theft. Besides the direct effect on fuel cost and availability, prices of other items in this location might have also been affected. Some of the price quotes for Huatabampo, a city outside the ZLFN, come from municipalities inside the ZLFN but in Huatabampo's metropolitan area. The results are unchanged if we exclude these price quotes from the estimation.

ministrative borders (Dube et al., 2010; Leung, 2021).

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.[13] Using product descriptions, we manually match every good (and item) in the INPC database against a particular 3-digit NAICS industry to be able to link prices to the labor market data that we describe below.

Labor market data. We use the social security records from IMSS, a confidential monthly employer-employee administrative dataset of formal workers, most of them in the private sector.[14] It contains information on daily wages, industry, and the municipality where workers work. We manually match the reported industries to a 3-digit NAICS classification. Doing this allows to merge the price data for the northern border with labor market data by industry.

For wages, we use the daily taxable income reported by the employer.[15] We exclude workers who do not have information regarding their wages.[16] Unfortunately, the dataset does not include information on hours worked a day or days worked a month, so we cannot see other firm responses to minimum wage adjustments such as employment adjustments along the intensive margin (Doppelt, 2017; Clemens, 2021).

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

Descriptive statistics. In Appendix Table A.2 we show some descriptive statistics about wages and workers for the industries associated with the goods in our estimation sample after merging prices and labor market data. In our estimation sample, workers in the ZLFN earn

[13]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 for two reasons. Some of them require special treatment to collect their prices or compute their index. Additionally, the government regulates the market of some goods, so their price dynamics reflect administrative decisions rather than market conditions.

[14]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 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.

[15]This includes certain benefits, such as paid vacations and year-end bonuses.

[16]These are workers who agree to have a reference salary in their contracts equal to the minimum wage in Mexico City, which does not reflect the value of the wages they earn. On a monthly basis, they account for around 0.7% of total workers.

less, on average, than workers in the rest of the Northern Region. By December 2018, the earnings of around 27% of workers were below the 2019 minimum wage in the ZLFN, where the minimum wage 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.[17]

4 Empirical Strategy

This section describes an identification strategy to separate the effects of the minimum wage increase and the VAT decrease on ZLFN prices. We highlight that because different productive sectors have different degrees of labor informality, the minimum wage hike's impact on prices may vary between VAT and Non-VAT goods. Our strategies hinge on using two sources of variation: the differential change in the minimum wage and the VAT rate across areas and the different incidence of the minimum wage increase across sectors. We 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.

There are several reasons why the impact of a higher minimum wage on prices could vary across different types of goods. An essential reason behind heterogeneous effects in the Mexican context is the different degrees of compliance with minimum wage regulation across industries. We argue that this difference is likely to result in different effects of the minimum wage hike on the prices of VAT and Non-VAT goods, even though there is no underlying reason why VAT-exempt status per se should affect the price elasticity to the minimum wage.[18]

Table 1 shows the distribution of the ratios of formal to informal labor at the national level for industries in the estimation sample, separating them into those that do and do not produce

[17] Our estimation sample does not include many industries from the labor market dataset because the goods associated with these industries are not in the consumer price index. We do not find substantial wage differences between this sample –which excludes some industries– and the full IMSS data. Table A.2, panel (b) 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.

[18] Besides labor informality, there are additional reasons why the effects of a minimum wage may differ across goods, such as differences in labor cost structure and labor market power. Abramovsky et al. (2015) document differences in price and income elasticities for VAT and Non-VAT goods in Mexico. 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 US.

VAT goods. We obtain information on formal and informal worker numbers by industry using Mexico's labor market survey (ENOE). On average, there are 12 formal workers for each informal worker in industries that produce VAT goods; in Non-VAT goods-producing industries –where food and health industries concentrate– there are two informal workers per one formal worker. Because of this difference in labor informality, the prices of VAT goods may have a stronger reaction to the minimum wage change.

It is challenging to separate the effects of the minimum wage and VAT changes. Simple comparisons between prices in the ZLFN and the rest of the country would confound several relationships. Comparing prices for all goods or 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 in the minimum wage affects the prices of said goods but would fail to identify the effect of the minimum wage increase on 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, as mentioned. A joint estimation that ignores these differences would be biased. Understanding the distinct effects of VAT and the minimum wage is essential to comprehending how these policies redistribute real income.

Table 1: Ratios of formal to informal workers by industry. 2018 Q4.

VAT	# of industries	Mean	Percentile 25	Median	Percentile 75
Yes	24	12.11	0.74	2.08	15.38
No	5	0.48	0.16	0.18	0.22
Mixed	6	2.75	0.27	1.31	2.60

Source: ENOE, authors' calculations. Each observation is a 3-digit NAICS industry. We exclude industry 339, Miscellaneous Manufacturing, because ENOE does not have data of workers in this industry.

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

To estimate the effect of the increase in the minimum wage on the goods subject to VAT, we compare the prices of items across different sectors in the ZLFN. We identify the effect of the minimum wage adjustments by comparing sectors with varying fractions of workers affected by the minimum wage increase (Card, 1992; Stewart, 2002; Lemos, 2009; Harasztosi and Lindner, 2019; Cengiz et al., 2019; Pérez 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. In compliance with the minimum wage and keeping employment constant, these workers should have received a salary increase consequent on the minimum wage increase, thus putting upward pressure on the firms' labor costs. Firms may transfer part of these net labor costs increases onto prices.[19]

The fraction affected measure of minimum wage incidence has an advantage over the minimum wage level. It is associated with the cost pressures that the employer would face in each production sector if employment remained constant. For example, the fraction affected is zero in industries that already paid their workers more than 176.72 daily pesos. We would not expect to have "mechanical" increases on these sectors' payrolls following the minimum wage increase.

We use the 3-digit NAICS industry that we manually assigned in the previous section to calculate the fraction affected by good. 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 2 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.

We implement the comparison of prices for VAT goods with different fractions affected using a difference-in-differences specification:[20]

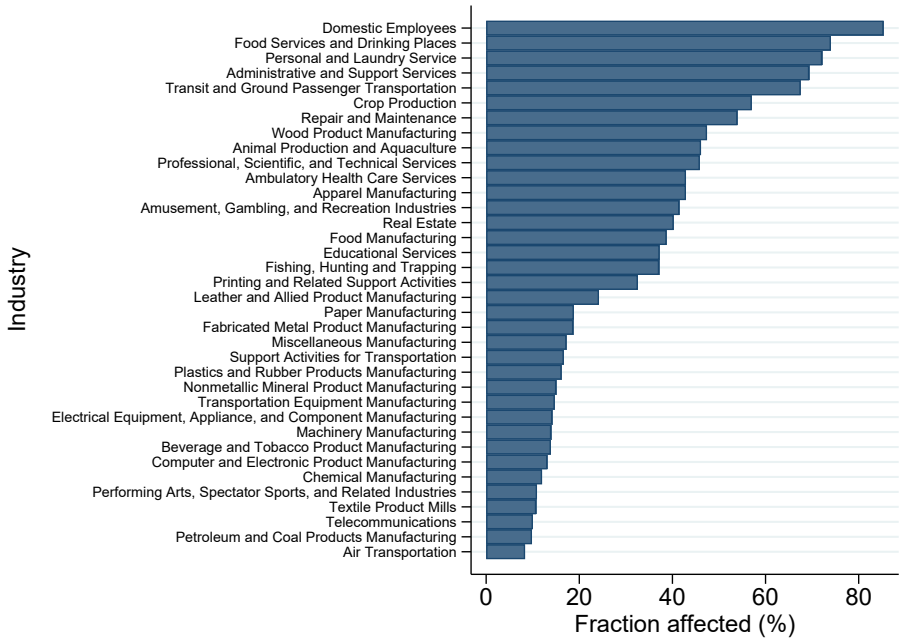
$$Y_{jct} = \alpha_0 + \alpha_1 Post_t \times FA_{g(j)} + \alpha_2 Sale_{jct} + \alpha_{g(j),c} + \alpha_t + \varepsilon_{jct}. \quad (1)$$

Here, Y_{jct} refers to the logarithm of the price of an item –indexed by its description j and its city c– at time t. The coefficient α_0 is a constant term. The variable $Post_t$ takes the

[19]Firms might incur extra labor costs derived 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, and they may face further wage increase requests from their workers. Third, to maintain a wage hierarchy, firms could raise the salaries of higher-earning workers. Fourth, there may be pressures to increase wages if other firms in the industry are increasing wages (Derenoncourt et al., 2021). These extra labor costs would tend to get bigger with a larger fraction affected, so the estimations presented in this paper take this effect into account in a reduced-form fashion.

[20]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 (2021) uses a panel event study approach to estimate the effects of the minimum wage on prices in the US. For 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.

Figure 2: 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 in December 2018 were paid less than or equal to the minimum wage that took effect on January 2019.

value of one in and after the first half of January 2019 and zero, otherwise. The fraction affected by the minimum wage increase in the industry that produces good g is FA_g. The coefficient of interest, α_1, measures the percentage increase in the price of an item with VAT for each percentage point of the fraction affected, relative to a scenario where the minimum wage would not have increased. The binary variable $Sale_{jct}$ indicates if the item is on sale at time t. The coefficients α_t and $\alpha_{g(j),c}$ are fixed effects for semimonthly time t and for good g by city.[21] The error term is ε_{jct}. 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 items, we multiply α_1 by the average fraction affected across items.

The identification assumption in this design is that, in the absence of the minimum wage increase, 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.[22]

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 in the border cities that have price data against cities with such data in 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 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 from the rest of the country, thus invalidating the parallel trends assumption (Dube et al., 2010).

The difference-in-differences specification is:

[21] Recall that a good g is a broader category than an item j, c. In our main specification here, the fixed effects vary by good, but we show that our estimates are robust to item fixed effects in section 5.

[22] A natural question to ask would be why we do not implement this strategy for Non-VAT goods: we could estimate the effect of the minimum wage by comparing across sectors with different fractions affected. A quick look at the evolution of the prices of Non-VAT goods shows that the prices of low-fraction-affected Non-VAT goods would not be a good counterfactual for the prices of Non-VAT goods with high fraction affected. Figure A.2 in the Appendix shows that the prices of Non-VAT goods with a fraction affected above the median are very volatile and do not track the prices of other Non-VAT goods. Prices of food goods are the main drivers of volatility in this average. For the sake of completeness, we show estimates of the effect of fraction affected for Non-VAT goods in Appendix Table A.3, both for the effect of the minimum wage increase in the ZLFN and the rest of the country. These estimates are noisy and not statistically significant.

$$Y_{jct} = \beta_0 + \beta_1 Post_t \times ZLFN_c + \beta_2 Sale_{jt} + \beta_{g(j),c} + \beta_t + \varepsilon_{jct}. \quad (2)$$

Here 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 $ZLFN_c$ indicates that the city is in the ZLFN region. The coefficient of interest β_1 measures the effect of the minimum wage on the price of Non-VAT items. The error term is ε_{jct}.

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 in the border cities against the cities in the rest of the Northern Region. This comparison yields the effect of both policies on the prices of VAT goods. We then adjust the combined effect estimate 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 both in the ZLFN and the rest of the Northern Region.

We first obtain the combined effect of both policies on VAT goods' prices γ_1 from a difference-in-differences model:

$$Y_{jct} = \gamma_0 + \gamma_1 Post_t \times ZLFN_c + \gamma_{g(j),c} + \gamma_t + \eta_{jct}. \quad (3)$$

Here, 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,c. 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) and the average fraction affected across items, $\overline{FA}$:

$$\text{Effect of the VAT on VAT goods} = \gamma_1 - \alpha_1 \overline{FA}.$$

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 α_1, β_1 and γ_1. The specification is:

$$
\begin{aligned}
Y_{jct} =& \delta_0 + \alpha_1 FA_{g(j)} \times VAT_j \times Post_t \times ZLFN_c + \beta_1 Post_t \times ZLFN_c \times (1 - VAT_j) \\
&+ \delta_1 Post_t \times ZLFN_c \times VAT_j + \delta_2 Sale_{jct} + \delta_3 Sale_{jct} \times VAT_j \\
&+ \delta_4 Sale_{jct} \times ZLFN_c + \delta_5 Sale_{jct} \times VAT_j \times ZLFN_c + \delta_{c,g(j)} + \delta_{t,VAT_j} \\
&+ \xi_{jct}. \qquad (4)
\end{aligned}
$$

In this equation, the variable VAT_j takes the value of one if the item has VAT. 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 interaction is included as $Post_t \times ZLFN_c$ and varies by VAT and Non-VAT goods. 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 in the absence of the minimum wage change. Last, equal evolution of prices of VAT goods across the ZLFN and the rest of the Northern Region in the absence of either policy change. We provide evidence of parallel trends before the policy changes take place by using a panel event study (Borusyak et al., 2022; Freyaldenhoven et al., 2021). The dynamic specification is as follows:

$$
\begin{aligned}
Y_{jct} =& \delta_0^D + \delta_{c,g(j)}^D + \delta_{t,VAT_j}^D + \sum_k \alpha_{1,k}^D 1\left[t = k\right] \times FA_{g(j)} \times VAT_j \times ZLFN_c \\
&+ \sum_k \beta_{1,k}^D 1\left[t = k\right] \times ZLFN_c \times (1 - VAT_j) + \sum_k \delta 1, k^D 1\left[t = k\right] \times ZLFN_c \times VAT_j \\
&+ \delta_2^D Sale_{jct} + \delta_3^D Sale_{jct} \times VAT_j + \delta_4^D Sale_{jct} \times ZLFN_c \\
&+ \delta_5^D Sale_{jct} \times VAT_j \times ZLFN_c + \xi_{cjt}^D. \qquad (5)
\end{aligned}
$$

Here, $1\left[\, t = k\right]$ is a variable that equals one when $t = k$, and k varies on a semimonthly basis from January 2017 to December 2019. The superscript D differentiates the coefficients and the error term from their static counterparts. The coefficients $\alpha_{1,k}^D$, $\beta_{1,k}^D$ and $\delta_{1,k}^D$ 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 $\alpha^D_{1,-1}$, $\beta^D_{1,-1}$ and $\delta^D_{1,-1}$ to 0.

Recent literature has highlighted that two-way fixed effects estimates such as the ones we obtain from equations 4 and 5 may not recover treatment effects of interest in the presence of treatment effect heterogeneity by cohort or by units (de Chaisemartin and D'Haultfœuille, 2020; Goodman-Bacon, 2021). We note that we are not in a staggered adoption setting because the policies affect all items at once, so cohort heterogeneity should not be a concern. To address heterogeneity in effects across goods, we report estimates by good categories.

5 Results

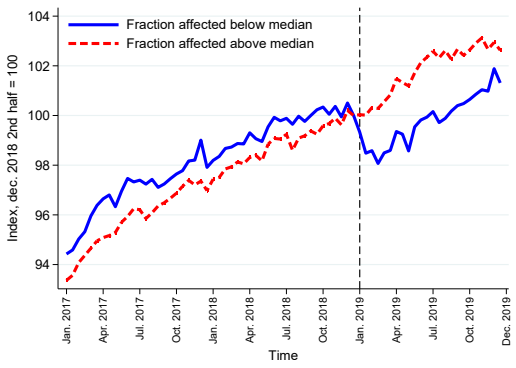
We find an economically and statistically significant effect of the minimum wage increase in VAT goods in the ZLFN. The average VAT item in the ZLFN saw its price rise by about 2.56% because of the minimum wage change. Our estimate for the effect of the minimum wage increase on Non-VAT goods prices is smaller than the estimate for VAT goods. Average Non-VAT item prices in the ZLFN increased by about 0.2% due to the minimum wage increase, but this effect is imprecisely estimated. As mentioned, the different effects of the minimum wage across VAT and Non-VAT goods seem to be due to the differences in labor informality that we showed in Table 1. We do not consider them as being due to the VAT status per se. The VAT rate reduction brings about a decrease in the prices of VAT items of 3.91%, on average. We describe these results below.

Effect of the minimum wage on VAT goods' prices. We provide descriptive evidence that an increase in VAT goods prices is associated with the minimum wage increase in Figure 3 panel (a). We calculate the median across items of the fraction of affected workers by the minimum wage and separate the sample into two: fraction affected above and below the median. The median fraction affected across items is 18.84%. 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.

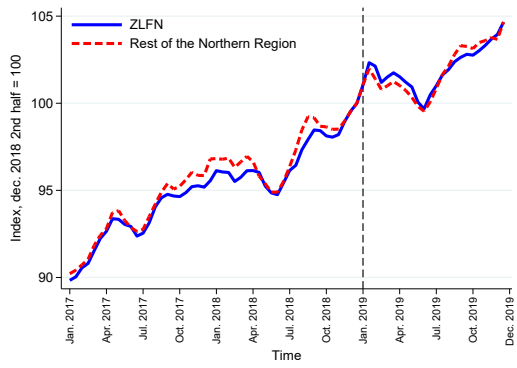
Table 2 shows the results of separate and joint estimations of the minimum wage and VAT effects for all goods. Table 2, column (1) displays the effect of the minimum wage on the price of VAT goods, from estimation of equation (1). The coefficient α_1 measures the percentage increase in the price of an item for a good with VAT for each percentage point of fraction affected, compared to a scenario where the minimum wage does not increase. The results

Figure 3: Price indexes for goods in the northern border (ZLFN) and in the rest of the Northern Region

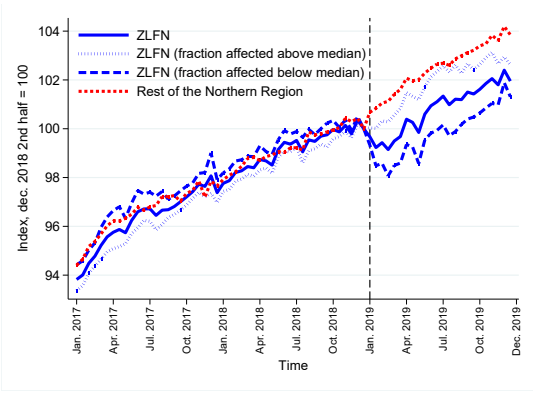
(a) VAT goods, ZLFN



(b) Non-VAT goods, ZLFN and rest of Northern Region



(c) VAT goods, ZLFN and rest of Northern Region



Source: Authors' calculations, Banco de México, INEGI and IMSS. Panel (a) shows average prices for VAT goods in the ZLFN, separating them according to fraction affected. Each line is the simple average of price indexes (Dec. 2018 2nd half = 100) across items in goods that are subject to VAT. The averages exclude the price indexes for energy, government services, housing rents and education. The median fraction of workers affected by the minimum wage increase across items was 18.84% in the 2nd half of December 2019.Panel (b) shows average prices for Non-VAT goods in the ZLFN and the rest of the Northern Region. Each line is the simple average of price indexes (Dec. 2018 2nd half = 100) across items for Non-VAT goods. Panel (c) shows the simple average of price indexes (Dec. 2018 2nd half = 100) across VAT items. The vertical dotted line corresponds to Jan 2019, 1st half. The solid line plots price indexes for all VAT goods in the ZLFN. 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.

show a positive and statistically significant impact of the minimum wage increase on prices. The coefficient implies that the price of a good produced with 50% minimum-wage-affected workers was 4.2% higher than the price of a good produced without affected workers, after controlling for other factors. The average effect on prices is 2.56%. The implied elasticity of prices to the minimum wage is about 0.0256, 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.

Our estimate of the effect on prices is smaller than previous US 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). Our current estimate is in line with the most recent evidence for the US by Renkin et al. (2020), who find an elasticity of 0.03 of grocery prices to the minimum wage.

There are two reasons why our elasticity estimates may be lower than the previous estimates for the US. The first one is potential misreporting in the IMSS wages. Kumler et al. (2020) document that "take-home" wages measured by Mexico's household surveys can be larger than wages reported in IMSS data, especially for wages below three minimum wages. They argue that this problem is not crucial for large firms and has diminished over time as accurate wage reporting has become more critical for calculating pension benefits. Nevertheless, wage misreporting may imply that some workers are registered as minimum-wage earners when they earn higher wages. Misreporting may lead to overestimating the fraction affected and underestimating the elasticity of prices to the fraction affected and to the minimum wage increase. The second reason may be that the minimum wage increase we analyze was announced as split into a percentage increase and a nominal increase, limiting the spillover effects of minimum wages to other wages and, thereby, limiting increases in labor costs.

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 limit the comparisons to items within food, non-food, and services categories, they prove 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 showing a more considerable reduction in formal employment generation (Banxico, 2020). This heterogeneous growth across sectors could be a 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 within broad industry categories. We estimate a smaller, non-significant effect for the food items in our estimation sample. However, there

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)
Fraction affected on VAT goods (α_1)	0.000841*** (0.000155)			0.000841*** (0.000143)
Minimum wage on Non-VAT goods (β_1)		0.00244 (0.00221)		0.00244 (0.00288)
Joint effect on VAT goods (γ_1)			-0.0136*** (0.00399)	
VAT on VAT goods (δ_1)				-0.0391*** (0.00642)
N	254,880	632,042	718,198	1,350,240
R^2	0.213	0.415	0.207	0.365
# of industries	31	11	31	36
# of goods	152	121	152	273
# of items	4,243	11,023	12,759	23,782
# of periods	72	72	72	72
Time fixed-effects	Yes	Yes	Yes	No
Time $\times$ VAT fixed-effects	No	No	No	Yes
City $\times$ good fixed-effects	Yes	Yes	Yes	Yes
Sale dummies and interactions	Yes	Yes	Yes	Yes
Mean fraction affected	30.53			30.53
Implied MW effect on VAT goods	0.02568			0.02568
Implied joint effect on VAT goods				-0.01342

Source: Authors' calculations. Column numbers correspond to 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 MW effect on VAT goods" is the average effect of the minimum wage on the price of VAT goods in the ZLFN. This is the product of $\hat{\alpha}_1$ times 100 times the mean fraction affected, divided the percentage increase in the minimum wage (100%). "Implied joint effect on VAT goods" is the sum of "Implied MW effect on VAT goods" and $\hat{\delta}_1$ in column (4). Standard errors two-way clustered by city and good in parentheses. *: p<0.1, **; p<0.05, ***: p<0.01.

are few goods used for estimation in this category because most food items are not subject to VAT.[23]

Figure 4 shows dynamic estimates from equation (5). Panel (a) shows the trajectory of the $\alpha^D_{1,k}$ coefficient, the effect of fraction affected on the price of VAT goods. Before 2019, the difference in prices across goods with different fractions affected was not statistically significant. Although there may have been be some difference in prices during 2017, according to the point estimates, it disappeared by 2018. Statistically significant differences emerge by 2019. Initially, the price difference is small, but it grows over time and stabilizes at around 0.0008 after March 2019. The price differences persist until the end of 2019.

The evolution of coefficients for other categories of goods exhibits some differences. Panel (b) shows the effects on food items. These estimates are imprecise because of the small number of VAT food goods. Panel (c) shows estimates for non-food items. 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 due to the few service industries in this regression.

We have argued that the higher share of formal labor in VAT goods implies a higher effect of the minimum wage relative to Non-VAT goods. Moreover, we find that within VAT goods, the effect is larger for those with low informality (relative to those exhibiting higher informality). We show this by interacting the variables that measure the effects of the minimum wage with another that indicates whether the sector has an informality rate above the median across sectors in equation 4.[24] These results appear in Appendix Table A.4.

We also look at whether the effects of the minimum wage increase are different for sectors that have a larger exposure to international trade. We would expect that it is harder for firms to translate cost increases into prices in sectors with larger trade exposure. We make our minimum wage and VAT incidence variables interact with indicators for high exposure to imports or a high share of exports in revenue.[25] We find that in VAT sectors with lower import exposure, the effect of the minimum wage increase is higher, and the effect of the VAT reduction is smaller. This differential effect suggests that firms were able to pass through a

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

[24]We do not find heterogeneity in the effect on Non-VAT goods, but this heterogeneity is hard to measure because there are only a few sectors with low informality among Non-VAT sectors.

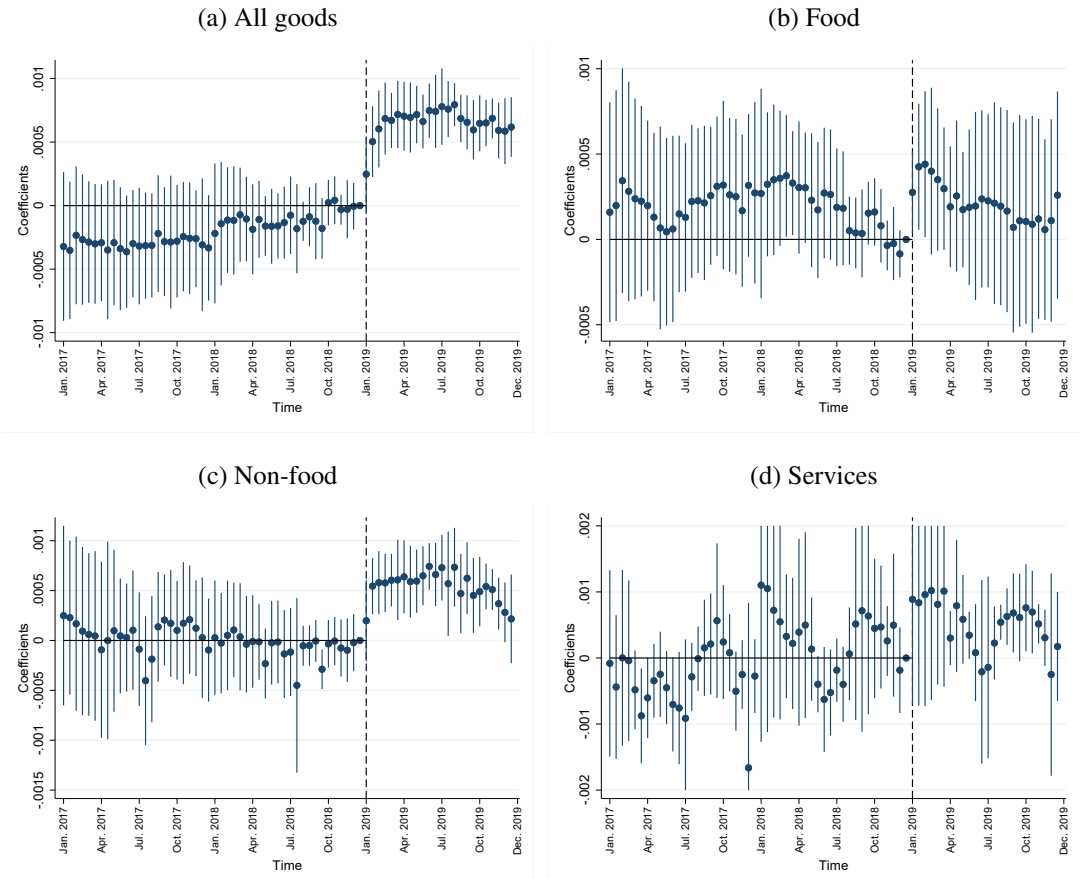
[25]We measure export intensity as the percentage of exports over total demand from INEGI's National Account Systems information. We measure import intensity as the percentage of imports over national demand from INEGI's Annual Survey of the Manufacturing Industry data.

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
Fraction affected on VAT goods (α_1)	0.000841*** (0.000143)	0.0000311 (0.000329)	0.000547*** (0.000175)	0.000483*** (0.000131)
Minimum wage on Non-VAT goods (β_1)	0.00244 (0.00288)	0.00620* (0.00333)	-0.00602 (0.00876)	-0.00361 (0.00473)
VAT on VAT goods (δ_1)	-0.0391*** (0.00642)	-0.0206 (0.0132)	-0.0325*** (0.00604)	-0.0130 (0.0113)
N	1,350,240	304,880	620,404	158,654
R^2	0.365	0.242	0.200	0.260
# of industries	36	4	19	15
# of goods	273	73	123	37
# of items	23,782	5,670	10,978	2,735
# of periods	72	72	72	72
Time × VAT fixed-effects	Yes	Yes	Yes	Yes
City × good fixed-effects	Yes	Yes	Yes	Yes
Sale dummies and interactions	Yes	Yes	Yes	Yes
Mean fraction affected	30.53	33.78	24.91	53.59
Implied MW effect on VAT goods	0.02568	0.00105	0.01363	0.02588
Implied joint effect on VAT goods	-0.01342	-0.01955	-0.01887	0.01288
Implicit elasticity VAT to MW	0.02568	0.00105	0.01363	0.02588
Implicit elasticity Non-VAT to MW	0.0029	0.0074	-0.0072	-0.0043
Implicit elasticity VAT to VAT	0.4888	0.2575	0.40625	0.16250

Source: Authors' 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 MW effect on VAT goods" is the product of $\hat{\alpha}_1$ and mean fraction affected, the average effect of the minimum wage on the price of VAT goods in the ZLFN. "Implied joint effect on VAT" is the sum of "Implied MW effect on VAT goods" and $\hat{\delta}_1$. "Implicit elasticity VAT to MW" is $100\times$ $\hat{\alpha}_1$ over 100, the percentage increase in the minimum wage in the ZLFN. "Implicit elasticity Non-VAT to MW" is $100\times$ $\hat{\beta}_1$ 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 $100 \times \hat{\delta}_1$ over -8, the VAT rate reduction in the ZLFN. Standard errors two-way clustered by city and good in parentheses. *: p<0.1, **; p<0.05, ***: p<0.01.

Figure 4: Dynamic estimates of the effect of the minimum wage on the price of VAT goods



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

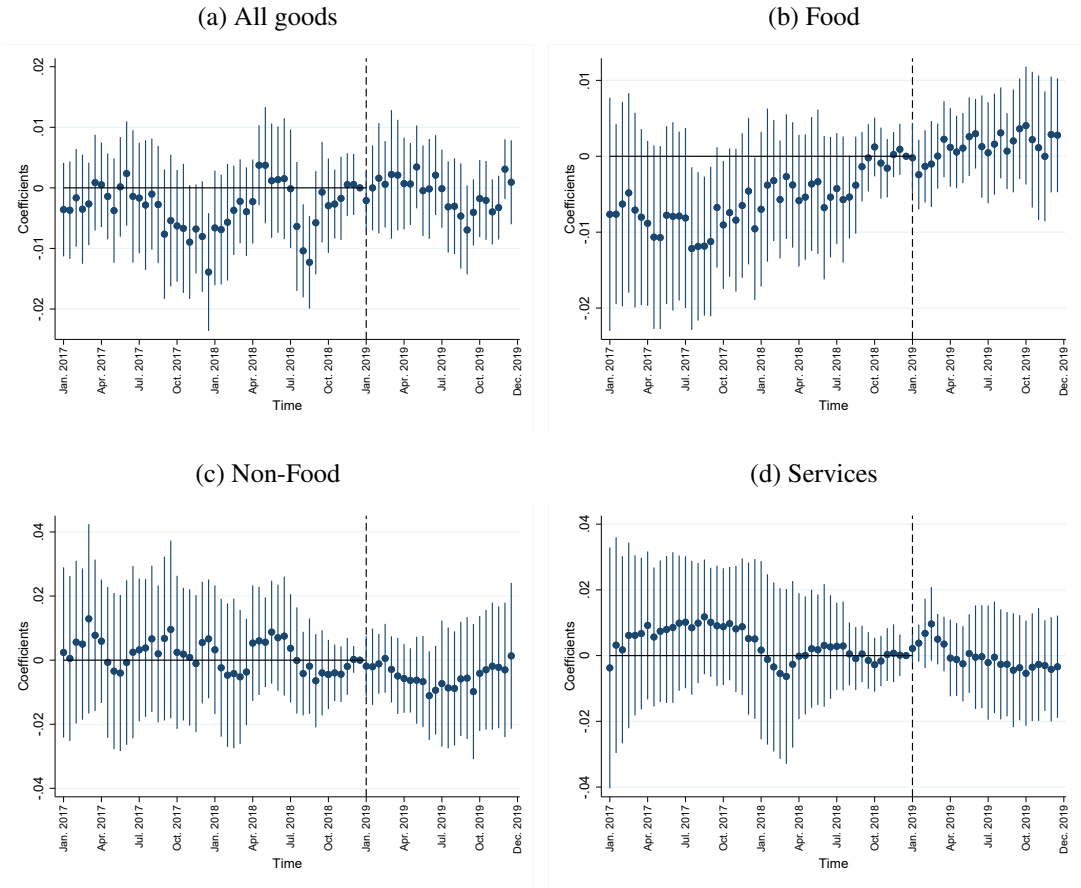
larger share of the increase in labor costs to consumers in these sectors. They also did not pass through as much of the VAT reduction. Similarly, we find a larger price reduction due to the VAT decrease in high-export sectors but not a lower effect of the minimum wage. Full results are in Appendix Table A.5.

Effect of the minimum wage on Non-VAT goods' prices. In Figure 3 panel (b), we show the descriptive evidence of the impact of the minimum wage on Non-VAT goods. We compare the evolution of prices of Non-VAT goods in 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 that 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 more minor differences already suggest that the effect of the minimum wage increase on these goods was smaller than the effect on VAT goods.

Again, Table 2 column (2) shows the results from the separate estimation of equation (2), and column (4) shows the joint estimation. The estimate of β_1 implies that average Non-VAT item prices in the ZLFN increased by around 0.2% compared to the rest of the Northern Region. This effect is smaller than the effect on VAT items, and it is not statistically significant. Table 3 shows the joint estimation across categories of goods. We find that the price increases for items from Non-VAT goods come primarily from the food category, whose item prices had a statistically significant relative increase of about 0.6%. Many factors may account for this response. We expect non-VAT food goods to have large income elasticities and low price elasticities in Mexico, as documented by Abramovsky et al. (2015). These would imply demand increases in response to increased wages. However, a smaller labor cost pass-through from labor informality may explain the price response. 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 than the production of other goods, as shown in Table 1. This smaller effect on Non-VAT goods supports our hypothesis that a higher labor informality limits the increase in labor costs and, therefore, the price response.

Figure 5 shows dynamic estimates of $\beta^D_{1,k}$ from equation (5). Panel (a) shows the estimates for all goods. The estimates display much volatility both before and after 2019. The coefficients become smaller around July 2019, suggesting that any impact of the minimum wage increase on the price of these items 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 thereof in the second half of 2018.

Figure 5: Dynamic estimates of the effect of the minimum wage on the price of Non-VAT goods



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

Effect of the VAT rate reduction on VAT goods' prices. There was a substantial decrease in the price of VAT goods in the ZLFN in 2019, as documented by Campos-Vazquez and Esquivel (2020). In Figure 3, panel (c), we show the price evolution for VAT goods in the ZLFN and the rest of the northern border. 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, separated by the fraction of workers affected by the minimum wage increase. The prices of VAT goods with a fraction affected above the median show a substantially smaller drop.

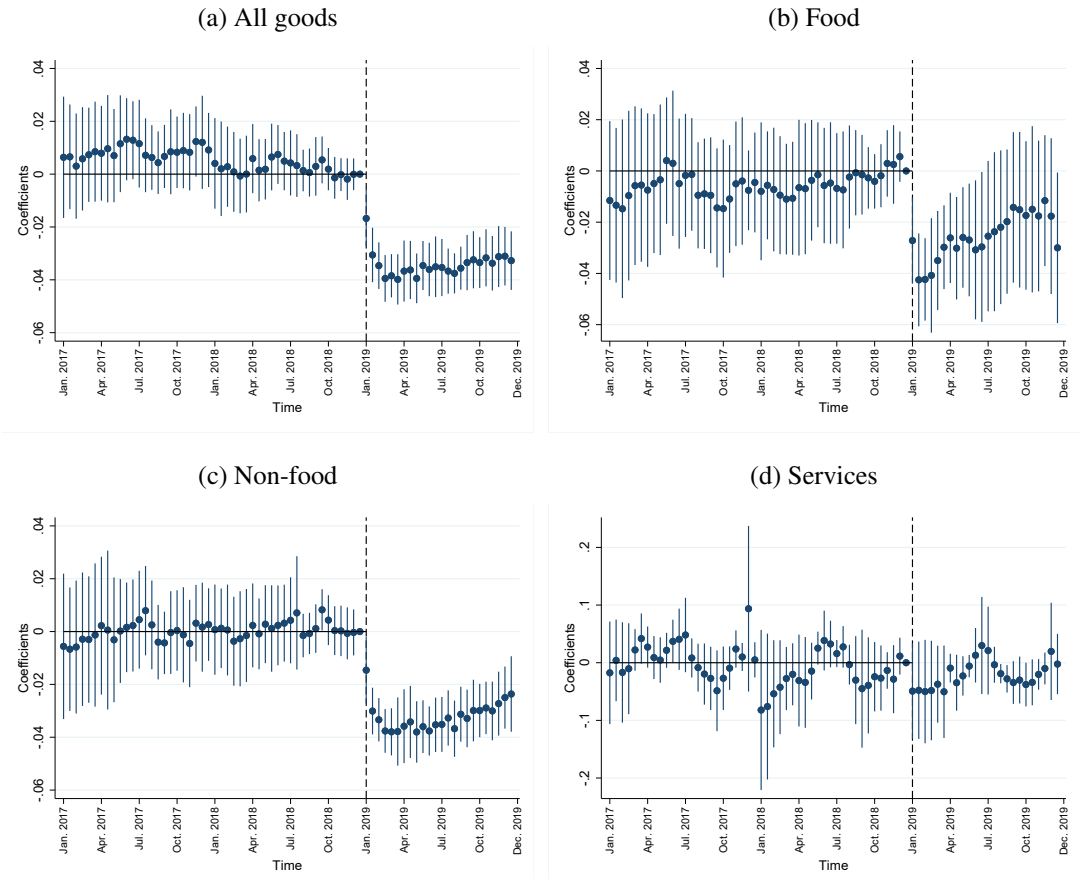
The estimate for δ_1 in Table 3 shows that the reduction of average prices for items in VAT goods, adjusting for minimum wage effects, is estimated to be around 3.91%. The triple difference regression adjusts for minimum wage effects by subtracting the minimum wage effect estimated through α_1 from the combined effect of both policies.[26] For a VAT rate reduction of 8 p.p., the price reduction for items in VAT goods of 3.91% implies an elasticity of about 0.49. Mariscal and Werner (2018) estimate an average elasticity of 0.2 to 0.4 for the VAT increase in 1995 and of 0.14 to 1.19 for the 2014 reform. 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 possible reason for the divergent estimates is a difference in the baskets of goods considered.

Figure 6 shows the dynamic estimates of $\delta^D_{1,k}$ from equation (5). Although they were noisy before 2019, they were 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 the previous evidence for Europe (Benedek et al., 2015) and Mexico (Mariscal and Werner, 2018).

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 comparing prices of Non-VAT goods between the border cities and the cities in the rest of the Northern Region would be biased toward zero if prices decreased on 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

[26]The estimate for δ_1 in the joint estimation is not exactly equal to subtracting the estimate of "Implied MW effect on VAT goods" of column (1) from the combined effect estimate from column (3). The discrepancy occurs 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 6: Dynamic estimates of the effect of the VAT on the price of VAT goods



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

goods are conservative.

Wage effects. The minimum wage increase may raise labor costs for both VAT and Non-VAT producing industries, therefore pushing prices upwards. Its impact, however, is mediated by whether firms make adjustments by reducing formal employment. The VAT decrease may further affect wages through increased product demand, translating into higher labor demand.

To estimate the effect of the policies on wages, we first calculate average wages at the sector-municipality-time level from the IMSS dataset. We restrict our estimation to wages in the formal sector. We then estimate analogs of equations (4) and (5) with indicators by sector instead of by good and by municipality belonging to the ZLFN instead of by city. This estimation yields the effects of the VAT and the minimum wage changes on wages in VAT and Non-VAT goods-producing sectors.

Wage estimates point to a statistically significant effect on wages in VAT and Non-VAT producing sectors. The minimum wage hike's implicit effect on an average VAT-producing sector is a 10.50% increase in wages. Under our specification, this effect is heterogeneous across sectors depending on the fraction affected. The effect on overall wages for VAT sectors is 7.90%, once we calculate the effect for each sector using its fraction affected and then average the effect across sectors weighting by employment in December 2018. In the non-VAT producing sector, the wages increase by 4.72%. The estimate of the increase in VAT-producing-sector wages due to the VAT rate decrease is small and not significant. Averaging these estimates for VAT and Non-VAT sectors (weighting again by employment), the overall effect on wages is 7.74%. The "mechanical" effect on average wages that would come merely from increasing the wage of affected workers to the new minimum wage is 3.6%. Our estimate is larger suggesting that there were wage increases beyond this mechanical effect, or changes in the composition of the formally employed labor force via employment effects.[27] The full results are in Appendix Table A.6, column (1). The dynamic estimates of these wage effects follow the pattern of the static estimates, with the wage effects of the minimum wage increase materializing almost immediately. The effects of the VAT on wages are noisy. Full results are in Appendix Figure A.3.

[27] 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 changes. Campos-Vazquez et al. (2020) estimate the increase in labor income to be around 9%. Campos-Vazquez and Esquivel (2021) estimate that wage increases were largest for those earning below the new minimum wage, who received an increase of about 37% in their wages. The wage estimates are smaller than the 18.40% reported by Leung (2021) for poor counties. One possible explanation may be that such a large increase prevented firms from raising the wage of workers who earn above the minimum wage because of budget constraints. On the other hand, we are considering most industries in the economy, whereas Leung (2021) focuses on the retail sector, where the minimum wage tends to be more binding and thus may have larger spillover effects.

We have argued that higher price effects on VAT goods may be due to a higher increase in labor costs in sectors with low labor informality. To show additional evidence supporting this, we use our wage estimates to obtain effects on average wages by sector, assuming no effects on informal sector wages. We then correlate these effects with the informality rate in each sector. The wage effects are higher in the sectors characterized by lower informality rates, and they are higher in the VAT sectors. Part of this effect is mechanical, coming from the higher informality rate in Non-VAT sectors. We also calculate the percentage increase in labor costs in each sector, assuming no increase in informal wages, by multiplying the wage effect in the formal sector by the share of labor costs in this sector from formal employment. Labor costs increase more in low-informality sectors. The full results are in Appendix Figure A.4.

Our wage estimates also allow us to calculate the implied effect on prices derived from the minimum wage hike coming only from the labor costs increase. Following Leung (2021) and Campos-Vazquez and Esquivel (2020), we estimate a pass-through elasticity to consumer prices by multiplying the implicit elasticity of wages to the minimum wage by the labor cost share. The measures of the labor share available to us are imperfect but vary between 12% and 29%. With these measures, the pass-through elasticity ranges from 0.0118 to 0.0285, implying that the 100% minimum wage increase could have raised prices between 1.18% and 2.85%. Our estimate for the effect of the minimum wage increase on prices for the average VAT sector (2.56%) is in the upper half of this range, while our estimate for Non-VAT goods is much smaller.[28]

Employment effects. Our estimation of employment effects is analogous to that for wages. The dependent variable is now formal employment aggregated by sector, municipality and time. Our employment effects are non-significant throughout these static estimates, in line with recent evidence by Conasami (2019) and Campos-Vazquez et al. (2020). Dynamic estimates of the effects on employment are mostly non-significant. We see a statistically significant negative employment effect in the short run on VAT goods sectors due to the minimum wage increase. The effect is at most -5.5% for the 100% minimum wage increase,

[28] A labor cost measure consistent with our labor market data, which only covers the formal sector, would ideally reflect the proportion of total payroll over total production costs of firms that hire formal labor. However, there is no data available in this regard, so we use two related measures of the labor costs share. Data from the input-out matrix yields a labor cost share estimate of 29%. This measure is consistent with the National Accounts System and reflects the country's economic activity in both formal and informal sectors. Using the Economic Censuses, the labor cost share is 12% as computed by Campos-Vazquez and Esquivel (2020). The Economic Censuses collect information from formal and informal establishments nationwide, but they do not consider the economic activity of anything produced outside an establishment. Therefore, we expect that they will partially cover informal labor costs.

translating into a -0.055 negative employment elasticity. The full results are in Appendix Table A.6 and Figure A.3.[29]

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.7 shows the 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 rather than 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 smaller than those in the main specification.

Second, we test two alternative explanations for the absence of a decrease in the prices of VAT goods with a high fraction affected. The first possibility is that these high-fraction-affected goods are sold in informal establishments and are more prone to VAT evasion. If that were the case, even without a minimum wage increase, the prices of high-fraction-affected goods would not decrease in response to the VAT rate decline, whereas the prices of goods with lower fraction affected and more VAT compliance would. To examine this hypothesis, we resort to the detailed information on the point of sale of each item in the INPC dataset. We label each item's point of sale as either formal or informal, using a classification proposed by Racimo (2018) and Bachas et al. (2020).[30] We then calculate the share of items sold in informal points of sale for each good and correlate this share with fractions affected in Figure A.5 of the Appendix. We 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 rate reduction on goods sold in formal and informal establishments, we re-estimate equation (1) allowing the time effects to interact with a formal point of sale indicator. These estimates are in Table A.8 of the Appendix. We find similar results to those presented in Table 2, which suggests that our minimum wage effects do not arise from heterogeneity in the response to the VAT rate reduction across formal and informal points of sale.

Another alternative explanation for our results would be a heterogeneous pass-through

[29]Campos-Vazquez et al. (2020) obtain imprecise estimates of the effects of the policy combination on employment. Conasami (2019) does not find employment effects from the policy combination. Banxico (2019) finds evidence of negative employment effects of the minimum wage increase in the short run, with an elasticity of -0.02 by April 2019. The income tax reduction may be playing a role by reducing negative small employment effects.

[30]Racimo (2018) and Bachas et al. (2020) classify points of sale in the INPC data as either formal or informal. Formal points of sale are department stores, supermarkets, price clubs, convenience shops affiliated to a chain, and health centers. Informal points of sale comprise informal stores, public markets. convenience shops that do not belong to a chain, and specialized stores not classified as formal.

of the VAT reduction to prices that correlates with the fraction affected. Because the VAT and minimum wage policies intertwine in our setting, we cannot separately identify heterogeneous VAT effects and minimum wage effects on prices. If goods with a higher fraction of affected workers have a smaller VAT pass-through, their prices may not fall as much because of the VAT reduction. A smaller decrease would bias our estimates of the effect of the minimum wage to the upside. Nevertheless, we can try to rule out this bias using prior estimates of the 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 the fraction affected to these estimates of VAT pass-through. Figure A.6 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 impute the prices for January 2019 by simply adding the VAT effect as implied for these external VAT pass-through estimates to the December 2018 prices. For the rest of 2019, we carry forward the January 2019 imputed prices with the observed growth in prices. 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. This turns out not to be the case (Appendix Table A.9), either using the imputed data for the entirety of 2019 or using only prices until January 2019 to avoid imputations using observed 2019 price data. Our estimates using these imputed prices are small and not statistically significant.

Third, we consider more local control groups in our comparison of the ZLFN with other cities. We compare the cities in the ZLFN with nine cities in the rest of the Northern Region in our baseline estimates. However, these may not be an adequate control group if they differ from the ZLFN cities in time-varying unobservables. A common approach in the minimum wage literature is to use places that are as geographically close as possible to the places where the minimum wage changed, arguing that these places are likely to be more similar to the affected places (Dube et al., 2010). Although we cannot use the municipalities contiguous to the ZLFN because we do not have prices data for every municipality, we can restrict our control group to cities closer to the ZLFN at the expense of a smaller sample size. Table A.10 in the Appendix shows that the results remain virtually unchanged when we consider only cities close to the ZLFN as a control.

Overall effect of the minimum wage and VAT policies on prices in the ZLFN. We use our estimates $\hat{\alpha}_1$, $\hat{\beta}_1$, and $\hat{\delta}_1$ to obtain the effect on the overall price level in the ZLFN,

measured with the ZLFN's consumer price index. We use the estimates from equation (4) for convenience in calculating standard errors. However, the estimates are only slightly smaller if we use the estimates of α_1 from equation (1).

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

$$\text{Effect of MW on VAT goods prices} = \left[\hat{\alpha}_1 \times 100 \times \sum_{i \in VAT} (FA_i \times \omega_i)\right]. \tag{6}$$

In this equation, $\hat{\alpha}_1 \times 100 \times FA_i$ 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.

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

$$\text{Effect of MW on Non-VAT goods prices} = \left[\hat{\beta}_1 \times 100 \times \sum_{i \in NONVAT} \omega_i\right] \times \frac{100}{100 - 16.21}. \tag{7}$$

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

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

$$\text{Effect of VAT on VAT goods prices} = \left[\hat{\delta}_1 \times 100 \times \sum_{i \in VAT} \omega_i\right]. \tag{8}$$

To arrive at an overall effect on the ZLFN's price index, 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 about the effects on three important groups of goods: housing rents, education, and gasoline. For education, we assume they experience the same effects on prices as other Non-VAT goods and include them in the Non-VAT category. We assume a zero effect on housing rents. We also assume a price drop equal to the VAT rate reduction for gasoline, which fits what we see in the price data. 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%.

Overall, we estimate that both policies reduced the ZLFN's average price level by 1.37%

in 2019. The 95% confidence interval around this estimate is [-1.68,-1.05]. The minimum wage increase accounts for an increase of 1.13% [0.77, 1.49] if we only consider the impact on VAT goods. After adding the effect on Non-VAT goods, the minimum wage increase accounts for a 1.2% [0.66, 1.75] difference. The VAT reduction counteracts these price increases associated with the minimum wage change. The VAT rate reduction effect on the prices of goods in our estimation sample accounts for an overall price index reduction of 1.84% [-2.41, -1.27], and the effect on the price of gasoline explains a further 0.73% decrease, for an overall effect of -2.57% [-3.14, -2.00].

Overall effects on real wages. Quantifying who gains and loses from the policy combination requires acknowledging that the policies have different effects on different individuals. Low-wage formal workers benefit the most from the minimum wage increase, as they accrue the largest wage gains. On the other hand, the unemployed and possibly informal workers do not perceive wage increases but are affected by higher prices due to the minimum wage hikes. Estimating the welfare effects of these policies would require a complete model of the policies' labor and product market effects and even possibly public spending redistribution, which is beyond our scope here. We can, however, use the results of our estimates to give a sense of the impact of the policies on individuals' purchasing power of individuals by looking at real wages, considering that we find no effects on employment beyond the initial months.

Because we estimate that the policy combination raised average wages in the ZLFN and reduced the average price level, it must have increased average real wages in the ZLFN. We quantify this effect on real wages by combining our wage effects and price effect estimates. We weight the wage effects of the minimum wage increase in VAT and Non-VAT sectors by the employment share of each sector in the ZLFN in December 2018. We then subtract the effect on prices from both policies to arrive at an effect on real wages. We assume that the effect of the VAT reform on wages is zero from our estimates in Appendix Table A.6.

In columns 1 to 4 of Table 4, we calculate the effect on real wages for different groups of individuals: low-wage, high-wage, informal workers, and unemployed and inactive individuals.[31] We then estimate wage regressions such as those in equation (4) for low-wage and high-wage workers and assume that wage effects are null for informal workers and un-

[31]We classify a worker as low-wage if they earned below 176.72 pesos in 2017-2018 or 230 pesos in 2019. We derive this upper limit by following workers affected by the minimum wage increase from December 2018 to January 2019 and looking at their wages after the minimum wage hike. 95% of affected workers earned below 230 pesos in January 2019, ensuring that we are primarily looking at affected workers in this low-wage group. Nevertheless, there may be workers in this group who earned above 176.72 pesos in 2018 and below 230 pesos in 2019 and may have perceived spillover effects on their wages. As a reminder, the after-policy minimum wage in the ZLFN in January 2019 was 176.72

employed/inactive individuals.[32] For the effects on prices, we consider different consumption baskets for different groups. Consumption baskets of low-wage workers may vary from those of high-wage workers: for example, they may allocate a higher share of their income to food. We would therefore expect the impact on prices to affect each group's purchasing power differently. We calculate consumption baskets based on 2018 Income and Expenditure Household Survey (ENIGH) for each group.[33]

Column 1 shows that the real wages of low-wage workers increase the most due to the policy combination. On average, the real wage of a low-wage worker in the ZLFN increased by 25.89% due to the policy combination, whereby 24.93 p.p. of this increase is due to the wage increase, and the rest is due to the prices decrease.

Column 2 shows the effect on high-wage workers. We estimate a noisy and statistically insignificant effect on their nominal wages. We, therefore, assume that the effect on their wages is zero. Despite the positive price effects from the minimum wage increase, their real wages increase by 1.20 p.p. thanks to the VAT decrease. Since they consume a larger share of their budget in gasoline, the gasoline price reduction from the VAT decrease has a larger impact on their purchasing power.

The picture is more straightforward for informal workers and unemployed or inactive individuals in columns 3 and 4. They do not receive wage increases from the policies, but they do perceive the price effects. We estimate their real wages increased by 0.99% and 1.07%, respectively, because of slight differences in their consumption basket. We note that they only gain purchasing power thanks to the policy combination. If a VAT rate reduction had not accompanied the minimum wage hike, their real wages would have decreased by 1.32 and 1.25%, respectively.

[32]The estimate for the effects on wages of informal workers is a lower bound. There is some evidence of the impacts of minimum wages on wages in the informal sector in developing countries (Khamis, 2013; Pérez Pérez, 2020). The estimate for inactive and unemployed workers may be an upper bound because they may experience a negative effect on their earnings in the presence of adverse employment effects.

[33]We consider an individual as employed if they report having at least one job, and consider them low-wage if they earned below the 2019 minimum wage in 2018. We consider workers as informal if their employer does not contribute to social security. Their consumption basket corresponds to that of their household.

Table 4: Effect on real wages

Effect	Low-wage (1)	High-wage (2)	Informal (3)	Inactive (4)
Prices	-0.96***	-1.20***	-0.99***	-1.07***
(Contribution to overall change, p.p.)	(0.16)	(0.17)	(0.16)	(0.15)
Minimum Wage on VAT goods	1.24***	1.40***	1.24***	1.17***
	(0.20)	(0.23)	(0.20)	(0.19)
Minimum Wage on Non-VAT goods	0.07	0.06	0.08	0.08
	(0.08)	(0.07)	(0.09)	(0.09)
VAT on VAT goods (excluding gasoline)	-1.75***	-1.85***	-1.74***	-1.70***
	(0.28)	(0.29)	(0.28)	(0.27)
VAT on gasoline	-0.53	-0.81	-0.57	-0.63
Wages	24.93***	0	-	-
(Percentage change)	(2.89)	-	-	-
Minimum Wage on VAT Sectors	24.96***	0.71	-	-
	(3.01)	(1.45)	-	-
VAT Sectors Employment Share	0.96	0.95	-	-
Minimum Wage on Non-VAT Sectors	24.21***	-0.69	-	-
	(0.50)	(1.23)	-	-
Non-VAT Sectors Employment Share	0.04	0.05	-	-
Real Wages	25.89***	1.20***	0.99***	1.07***
(Percentage change)	(2.90)	(0.17)	(0.16)	(0.15)

Source: Authors' calculations. Column (1) shows the effects on real wages for low-wage workers, earning below 176.72 pesos in 2017-2018 and below 230 pesos in 2019. Column (2) shows the effects for high-wage workers, the rest of the workers. Column (3) shows the effect for informal workers, defined as those who do not contribute to social security. Column (4) shows the effects for inactive and unemployed workers. The consumption baskets for each group are different. We obtain them from ENIGH 2018 data. To obtain the overall effect on wages, we multiply the employment share of VAT or Non-VAT sectors with the respective estimated effect on their average wages. For the high-wage sub-sample, we impose an effect equal to zero for wages since the estimates indicate a noisy null effect. Standard errors clustered by sector/good and by city/municipality in parentheses. The regressions for prices and wages were stacked to obtain joint standard errors: the degrees of freedom and cluster small sample corrections for the standard errors are those of the stacked regression. *: $p<0.1$, **: $p<0.05$, ***: $p<0.01$.

6 Concluding Remarks

We estimate the effect on prices of a substantial minimum wage increase and a VAT rate reduction on the northern border between Mexico and the US. The context is relevant for the literature that studies these policies precisely because of the sizable change and because of their interaction. Our estimation separates the impacts of the two policies. We find price increases for goods produced with a large share of minimum wage labor and price decreases for VAT goods. Overall, the decrease associated with the VAT rate reduction counteracted the effect of the minimum wage on prices. We estimate that real wages increased for all workers.

Our estimates show that the effects of minimum wage changes on prices may vary depending on labor informality. Because of this, we separately estimated the effect of a higher minimum wage on goods that have to pay VAT –whose production involves a higher share of formal labor –, and on goods that do not pay VAT, produced with a lower share of formal labor. This heterogeneity is essential to evaluate the effects of minimum wages on prices in other countries where labor informality may play a role.

References

Aaronson, Daniel; French, Eric and MacDonald, James (2008). "The Minimum Wage, Restaurant Prices, and Labor Market Structure". *Journal of Human Resources*, **43(3)**, pp. 688–720.

Abramovsky, Laura; Attanasio, Orazio and Phillips, David (2015). "Value Added Tax policy and the Case for Uniformity: Empirical Evidence from Mexico". *Working Paper 15/08*, Institute for Fiscal Studies.

Allegretto, Sylvia; Godøy, Anna; Nadler, Carl Marc and Reich, Michael R. (2018). "The New Wave of Local Minimum Wage Policies: Evidence From Six Cities". *Policy report*, CWED.

Aportela, Fernando and Werner, Alejandro (2002). "La Reforma al Impuesto al Valor Agregado de 1995: Efecto Inflacionario, Incidencia y Elasticidades Relativas". *Working paper 2002-01*, Banco de México.

Azar, José; Huet-Vaughn, Emiliano; Marinescu, Ioana Elena; Taska, Bledi and Von Wachter, Till (2019). "Minimum Wage Employment Effects and Labor Market Concentration". *SSRN Scholarly Paper ID 3416016*.

Bachas, Pierre; Gadenne, Luciene; Jensen, Anders and Racimo, Mariana (2020). "Tax Incidence in the Presence of an Informal Sector: Evidence from the VAT in Mexico". *Working paper*.

Banxico (2019). "Informe Trimestral". *Banco de México*, **Abril-Junio 2019**, pp. 28–32.

Banxico (2020). "Reporte sobre las Economías Regionales". *Banco de México*, **Octubre-Diciembre 2019**, pp. 31–33.

Benedek, Dora; De Mooij, Ruud A and Wingender, Mr Philippe (2015). *Estimating VAT Pass Through*. International Monetary Fund.

Benzarti, Youssef and Carloni, Dorian (2019). "Who Really Benefits from Consumption Tax Cuts? Evidence from a Large VAT Reform in France". *American Economic Journal: Economic Policy*, **11(1)**, pp. 38–63.

Benzarti, Youssef; Carloni, Dorian; Harju, Jarkko and Kosonen, Tuomas (2020). "What Goes Up May Not Come Down: Asymmetric Incidence of Value-Added Taxes". *Journal of Political Economy*, **128(12)**, pp. 4438–4474.

Borusyak, Kirill; Jaravel, Xavier and Spiess, Jann (2022). "Revisiting Event Study Designs: Robust and Efficient Estimation". *Technical Report CWP11/22*, The Institute for Fiscal Studies.

Cameron, A. Colin; Gelbach, Jonah B. and Miller, Douglas L. (2011). "Robust Inference With Multiway Clustering". *Journal of Business & Economic Statistics*, **29(2)**, pp. 238–249.

Campos-Vazquez, Raymundo M.; Delgado, Victor and Rodas, Alexis (2020). "The Effects of a Place-based Tax Cut and Minimum Wage Increase on Labor Market Outcomes". *IZA Journal of Labor Policy*, **10(1)**.

Campos-Vazquez, Raymundo M. and Esquivel, Gerardo (2020). "The Effect of Doubling the Minimum Wage and Decreasing Taxes on Inflation in Mexico". *Economics Letters*, **189**, p. 109051.

Campos-Vazquez, Raymundo M. and Esquivel, Gerardo (2021). "The Effect of Doubling the Minimum Wage on Employment and Earnings in Mexico". *Economics Letters*, **209**, p. 110124.

Card, David (1992). "Using Regional Variation in Wages to Measure the Effects of the Federal Minimum Wage". *ILR Review*, **46(1)**, pp. 22–37.

Cengiz, Doruk; Dube, Arindrajit; Lindner, Attila and Zipperer, Ben (2019). "The Effect of Minimum Wages on Low-wage Jobs". *The Quarterly Journal of Economics*, **134(3)**, pp. 1405–1454.

Clemens, Jeffrey (2021). "How Do Firms Respond to Minimum Wage Increases? Understanding the Relevance of Non-employment Margins". *Journal of Economic Perspectives*, **35(1)**, pp. 51–72.

Conasami (2015). "Boletín de Prensa, Diciembre 11 de 2015".

Conasami (2018). "Boletín de Prensa. Diciembre 20 de 2018".

Conasami (2019). "Evaluación de Impacto. Efectos del Aumento del Salario Mínimo en la Zona Libre de la Frontera Norte (ZLFN)". *Technical Report*.

de Chaisemartin, Clément and D'Haultfœuille, Xavier (2020). "Two-Way Fixed Effects Estimators with Heterogeneous Treatment Effects". *American Economic Review*, **110(9)**, pp. 2964–96.

Derenoncourt, Ellora; Noelke, Clemens and Weil, David (2021). "Spillover Effects from Voluntary Employer Minimum Wages". *Working paper*.

Diario Oficial de la Federación (2018). "Decreto de Estímulos Fiscales Región Fronteriza Norte".

Doppelt, Ross (2017). "Minimum Wages and Hours of Work". *Technical Report 2017 Meeting Papers 1578*, Society for Economic Dynamics.

Dube, Arindrajit; Lester, T William and Reich, Michael (2010). "Minimum Wage Effects across State Borders: Estimates Using Contiguous Counties". *The Review of Economics and Statistics*, **92(4)**, pp. 945–964.

Freyaldenhoven, Simon; Hansen, Christian; Pérez Pérez, Jorge and Shapiro, Jesse M (2021). "Visualization, Identification, and Estimation in the Linear Panel Event-Study Design". *Working Paper 29170*, National Bureau of Economic Research.

Goodman-Bacon, Andrew (2021). "Difference-in-differences with Variation in Treatment Timing". *Journal of Econometrics*, **225(2)**, pp. 254–277.

Harasztosi, Péter and Lindner, Attila (2019). "Who Pays For The Minimum Wage?" *American Economic Review*, **109(8)**, pp. 2693–2727.

ILO (2016). *Minimum Wage Policy Guide*.

Khamis, Melanie (2013). "Does the Minimum Wage Have a Higher Impact on the Informal than on the Formal Labour Market? Evidence from Quasi-experiments". *Applied Economics*, **45(4)**, pp. 477–495.

Kosonen, Tuomas (2015). "More and Cheaper Haircuts After VAT Cut? On the Efficiency and Incidence of Service Sector Consumption Taxes". *Journal of Public Economics*, **131**, pp. 87–100.

Kumler, Todd; Verhoogen, Eric and Frías, Judith (2020). "Enlisting Employees in Improving Payroll Tax Compliance: Evidence from Mexico". *The Review of Economics and Statistics*, **102(5)**, pp. 881–896.

Lemos, Sara (2008). "A Survey of the Effects of the Minimum Wage on Prices". *Journal of Economic Surveys*, **22(1)**, pp. 187–212.

Lemos, Sara (2009). "Minimum Wage Effects in a Developing Country". *Labour Economics*, **16(2)**, pp. 224–237.

Leung, Justin H (2021). "Minimum Wage and Real Wage inequality: Evidence from Pass-Through to Retail Prices". *Review of Economics and Statistics*, **103(4)**, pp. 754–769.

MacDonald, James M and Aaronson, Daniel (2006). "How Firms Construct Price Changes: Evidence from Restaurant Responses to Increased Minimum Wages". *American Journal of Agricultural Economics*, **88(2)**, pp. 292–307.

MaCurdy, Thomas (2015). "How Effective Is the Minimum Wage at Supporting the Poor?" *Journal of Political Economy*, **123(2)**, pp. 497 – 545.

Mariscal, Rodrigo and Werner, Alejandro M (2018). *The Price and Welfare Effects of The Value-Added Tax: Evidence from Mexico*. International Monetary Fund.

Munguia Corella, Luis Felipe (2020). "Minimum Wages in Monopsonistic Labor Markets". *SocArXiv abpj9*, Center for Open Science.

Pérez Pérez, Jorge (2020). "The Minimum Wage in Formal and Informal Sectors: Evidence from an Inflation Shock". *World Development*, **133**, p. 104999.

Politi, Ricardo Batista and Mattos, Enlinson (2011). "Ad-Valorem Tax Incidence and After-Tax Price Adjustments: Evidence from Brazilian Basic Basket Food". *The Canadian Journal of Economics*, **44(4)**, pp. 1438–1470.

Racimo, Mariana (2018). "VAT Incidence on Mexican Prices". *Working paper, Banco de Mexico Ph.D. Summer Internship Program*.

Renkin, Tobias; Montialoux, Claire and Siegenthaler, Michael (2020). "The Pass-Through of Minimum Wages into US Retail Prices: Evidence from Supermarket Scanner Data". *The Review of Economics and Statistics*, pp. 1–99.

Solorzano, J. D. and Dixon, H. (2020). "Relationship Between Nominal Wage and Price Flexibility: New Evidence". *Working paper 2020-20*, Banco de México.

Stewart, Mark B (2002). "Estimating the Impact of the Minimum Wage using Geographical Wage Variation". *Oxford Bulletin of Economics and Statistics*, **64**, pp. 583–605.

Online Appendix - Not for Publication

A Additional Figures and Tables

Table A.1: Municipalities in the northern border (ZLFN)

State	Municipality
Baja California	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).

Table A.2: Descriptive statistics for wages. Estimation sample and entire dataset.

	# of Workers (millions) Dec 2018	Below 2019 minimum Dec 2018	Industries	Average Real Monthly Wage(Jan 2019 pesos) 2017	2018	2019
(a) Estimation Sample						
ZLFN	1.5	26.4%	36	10,193	10,310	11,309
Rest of Northern Region	2.0	10.7%	36	11,156	11,160	11,466
(b) IMSS Data						
ZLFN	2.1	28.3%	73	10,399	10,466	11,450
Rest of Northern Region	3.4	10.6%	73	11,011	11,032	11,302

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: Effects of fraction affected on Non-VAT goods prices

Coefficient	Entire country (1)	Outside ZLFN (2)	ZLFN (3)
Fraction affected on Non VAT goods (α_1)	0.00024 (0.000306)	0.000424 (0.000577)	0.000486 (0.000500)
N	1,844,446	1,619,506	224,940
R^2	0.376	0.368	0.426
# of industries	11	11	11
# of goods	121	121	121
# of items	34,703	30,993	3,710
# of periods	72	72	72
Time fixed-effects	Yes	Yes	Yes
City $\times$ good fixed-effects	Yes	Yes	Yes
Sale dummies and interactions	Yes	Yes	Yes
Mean fraction affected	19.25	16.13	41.61
Implied MW effect on Non-VAT goods	0.0046	0.0068	0.0202

Source: Authors' calculations. Columns (1) to (3) are estimates of equation (1) for Non-VAT goods, using different regions. Column (1) shows estimates for the entire country. Columns (2) and (3) show estimates outside and inside the ZLFN. Standard errors clustered by good and city in parentheses. *: p<0.1, **: p<0.05, ***: p<0.01.

Table A.4: Heterogeneity of the minimum wage effect on VAT goods by sector informality

Coefficient	All	Low informality	High informality
	(1)	(2)	(3)
Fraction affected on	0.000841***	0.00161***	0.000997***
VAT goods (α_1)	(0.000143)	(0.000405)	(0.00015)
Minimum wage on	0.00244	-0.00556	0.00370
Non-VAT goods (β_1)	(0.00288)	(0.0092)	(0.00375)
VAT on VAT goods (δ_1)	-0.0391***	-0.0483***	-0.0483***
	(0.00642)	(0.00867)	(0.00867)
N	1,350,240	1,350,240	1,350,240
R^2	0.365	0.365	0.365
# of sectors	36	18	18
# of sectors on VAT & Non-VAT	6	2	4
# of VAT sectors	25	15	10
# of Non-VAT sectors	5	1	4
# of goods	273	273	273
# of items	23,782	23,782	23,782
# of periods	72	72	72
Time X VAT fixed-effects	Yes	Yes	Yes
City X Good fixed-effects	Yes	Yes	Yes
Sales dummies and interactions	Yes	Yes	Yes

Source: Authors' calculations. Columns (1) to (3) are estimates of equation (4) with different specifications. Column (1) shows the baseline from Table 2, column (4). Columns (2) and (3) show the effects on low-informality and high-informality sectors from a regression that interacts the minimum wage terms with a dummy variable for sectors with above-median and below-median labor informality rates. We use the average informality rate of the municipalities in the ZLFN in 2018, obtained from the National Occupation and Employment Survey (ENOE). Strictly speaking, the survey is not representative at this level, but the results are similar if we use the informality rates for Tijuana or for the State of Baja California, which are included in the ZLFN and for which the survey is representative. The coefficients on Fraction affected on VAT goods on columns (2) and (3) are statistically different at the 10% level. Standard errors clustered by good and city in parentheses. *: p<0.1, **; p<0.05, ***: p<0.01.

Table A.5: Heterogenous effects by import and export intensity

			Import intensity		Export intensity	
Effect	All	Manufactures	Low	High	Low	High
Fraction affected on VAT goods (α_1)	0.000841***	0.000460**	0.000673*	0.000502**	0.000319	0.000784***
	(0.000143)	(0.000166)	(0.000368)	(0.000212)	(0.000248)	(0.000203)
Minimum wage on Non-VAT goods (β_1)	0.00244	0.000664	0.0044	-0.00167	0.000664	0
	(0.00288)	(0.00202)	(0.00396)	(0.00704)	(0.00219)	(0)
VAT on VAT goods (δ_1)	-0.0391***	-0.0307***	-0.0250**	-0.0369***	-0.0149	-0.0470***
	(0.00642)	(0.00625)	(0.00924)	(0.0085)	(0.00882)	(0.00653)
N	1,350,240	982,682	816,724	816,724	982,682	982,682
R-sq	0.365	0.203	0.212	0.212	0.203	0.203
# of sectors	36	20	8	18	10	10
# of sectors on VAT & Non-VAT	6	3	3	3	3	0
# of VAT sectors	25	16	5	14	6	10
# of Non-VAT sectors	5	1	0	1	1	0
# of goods	273	198	170	170	198	198
# of items	23,782	17,508	14,566	14,566	17,508	17,508
# of periods	72	72	72	72	72	72

Source: Authors' calculations. Each column corresponds to a separate estimation of equation (4) with the goods belonging to each category. Export intensity is measured as the percentage of exports over total demand with INEGI's National Account Systems information. Import intensity is measured as the percentage of imports over national demand with INEGI's Annual Survey of the Manufacturing Industry (EAIM) data. Standard errors clustered by good in parentheses. *: p<0.1, **: p<0.05, ***: p<0.01.

Table A.6: Effects on wages and employment

Coefficient	Log wages (1)	Log employment (2)
Fraction affected on VAT sectors (α_1)	0.00325***	-0.000960
	(0.000295)	(0.000772)
Minimum wage on Non-VAT sectors (β_1)	0.0472**	-0.0113
	(0.0230)	(0.0708)
VAT on VAT sectors (δ_1)	0.00867	0.00803
	(0.0140)	(0.0326)
N	110,146,184	100,067
R^2	0.985	0.986
# of sectors	31	31
# of periods	36	36
Time X VAT fixed-effects	Yes	Yes
Municipality X sector fixed-effects	Yes	Yes
Mean fraction affected	32.30	32.33
Implied MW effect on VAT sectors	0.1050	-0.0310
Implied joint effect on VAT sectors	0.1136	-0.0230

Source: Authors' calculations. Columns (1) to (2) are estimates of an analog of equation (4) with log wages and log employment as dependent variables, respectively. Wage regressions are weighted by employment in Dec 2018. "Mean fraction affected" is the average fraction of workers affected by the minimum wage increase across VAT sectors in the ZLFN in the second half of December 2019. "Implied MW effect on VAT sectors" is the average effect of the minimum wage on the wage/employment of VAT sectors in the ZLFN. This is the product of $\hat{\alpha}_1$ times 100 times the mean fraction affected, divided the percentage increase in the minimum wage (100%). "Implied joint effect on VAT sectors" is the sum of "Implied MW effect on VAT sectors" and $\hat{\delta}_1$. Standard errors clustered by sector and municipality in parentheses. *: p<0.1, **: p<0.05, ***: p<0.01.

Table A.7: Alternative specifications

Coefficient	(1)	(2)	(3)
Fraction affected on VAT goods (α_1)	0.000841***	0.000790***	0.000538***
	(0.000143)	(0.000133)	(0.000089)
Minimum wage on Non-VAT goods (β_1)	0.00244	0.00110	0.00119
	(0.00288)	(0.00246)	(0.00257)
VAT on VAT goods (δ_1)	-0.0391***	-0.0377***	-0.0301***
	(0.00642)	(0.00590)	(0.00526)
N	1,350,240	1,350,240	1,350,240
R^2	0.365	0.606	0.608
# of sectors	36	36	36
# of goods	273	273	273
# of items	23,782	23,782	23,782
# 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: Authors' 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.8: 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
Fraction affected on VAT goods (α_1)	0.000652** (0.000142)	-0.000233 (0.000265)	0.000489** (0.000107)	0.000394** (0.000117)
N	243,870	20,594	180,358	42,918
R^2	0.127	0.209	0.120	0.153
# of sectors	29	3	17	12
# of goods	144	14	100	30
# of items	4,041	333	3,028	680
# 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: Authors' 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.9: 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
Fraction affected on VAT goods (α_1)	0.000762*** (0.000161)	0.000359 (0.000295)	0.000404** (0.000131)	0.00000022 (0.000200)
N	198,794	198,794	126,344	126,344
R^2	0.129	0.117	0.127	0.125
# of sectors	27	27	27	27
# of goods	109	109	109	109
# of items	3,150	3,150	3,150	3,150
# of periods	72	72	49	49
Time fixed-effects	Yes	Yes	Yes	Yes
Good fixed-effects	Yes	Yes	Yes	Yes

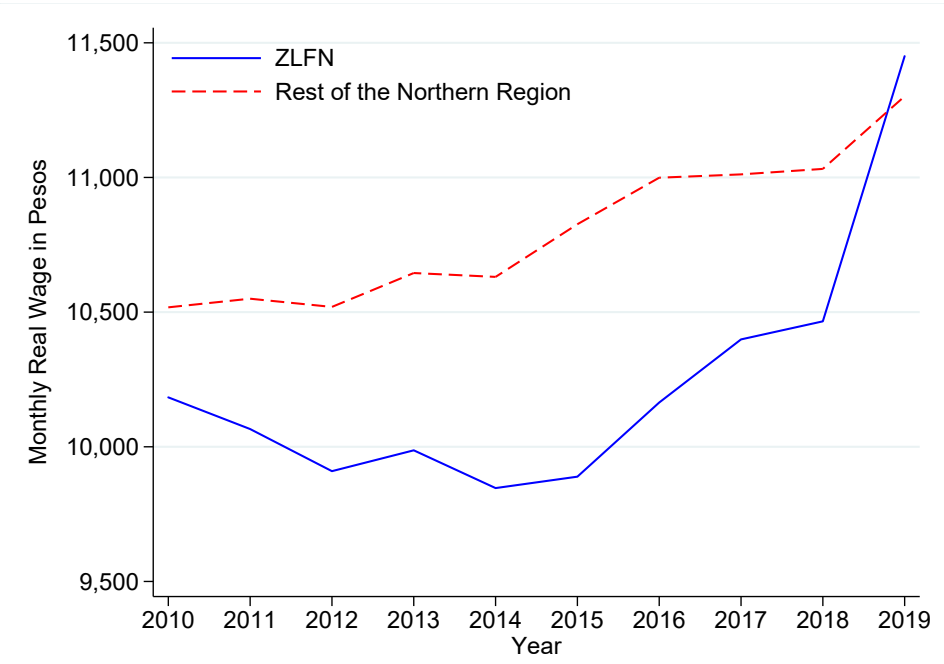
Source: Authors' calculations. "Original price 2017-2019" shows estimates of equation (1) using the original data on a restricted sample of goods for which we could associate a VAT pass-through from Mariscal and Werner (2018). "Counterfactual price 2017-2019" shows estimates using counterfactual prices, where the price of each item 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.

Table A.10: "Border design" control groups

Coefficient	(1)	(2)	(3)
Fraction affected on VAT goods (α_1)	0.000841***	0.000844***	0.000844***
	(0.000143)	(0.000144)	(0.000145)
Minimum wage on Non-VAT goods (β_1)	0.00244	0.00132	0.00197
	(0.00288)	(0.00292)	(0.00274)
VAT on VAT goods (δ_1)	-0.0391***	-0.0367***	-0.0379***
	(0.00642)	(0.00600)	(0.00595)
N	1,350,240	1,115,998	1,043,878
R^2	0.365	0.376	0.377
# of cities in control group	9	6	5
Maximum distance of control cities to US-Mexico border		400 km	300 km
# of sectors	36	36	36
# of goods	273	273	273
# of items	17,732	18,968	17,732
# of periods	72	72	72
Time X VAT fixed-effects	Yes	Yes	Yes
City X Good fixed-effects	Yes	Yes	Yes
Sale dummies and interactions	Yes	Yes	Yes
Mean fraction affected	30.53	23.55	24.19

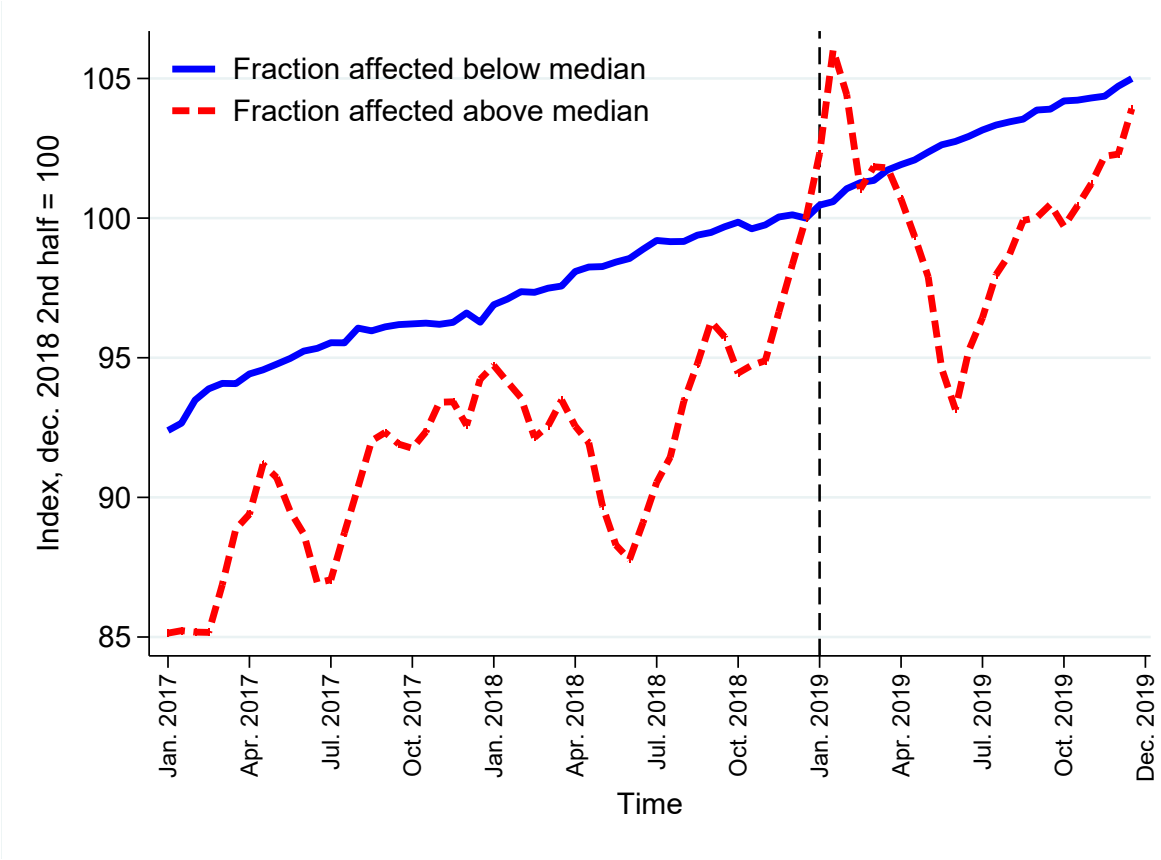
Source: Authors' calculations. Columns (1) to (3) are estimates of equation (4) with different control groups. Column (1) shows the baseline estimates, including nine cities: Chihuahua, Chihuahua.; Esperanza, Sonora.; Hermosillo, Sonora.; Huatabampo, Sonora.; Jiménez, Chihuahua.; Monclova, Coahuila.; Monterrey, Nuevo León.; Saltillo, Coahuila.; and Torreón, Coahuila. Column (2) restricts the control group to those cities in the rest of the Northern Region which are at most 400 km away by road from the closest city in the ZLFN. It excludes Esperanza, Sonora.; Huatabampo, Sonora.; and Torreón, Coahuila. Column (3) further restricts the control group to those cities located at most 300 km away by road, additionally excluding Jiménez, Chihuahua. We calculate the road distances with Google Maps. Standard errors clustered by good and city in parentheses. *: p<0.1, **: p<0.05, ***: p<0.01.

Figure A.1: Evolution of average real wages in the formal sector.



Source: IMSS, authors' calculations. Average wages of formal workers reported to IMSS by their employers in January of each year. Real wages in pesos of January 2019.

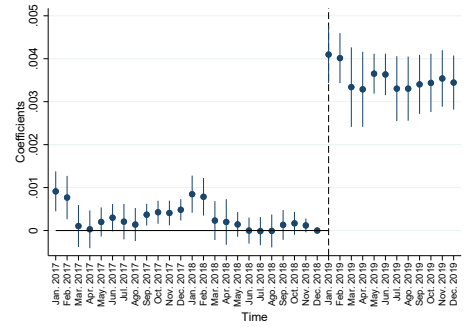
Figure A.2: Price indexes for Non-VAT goods in the northern border (ZLFN)



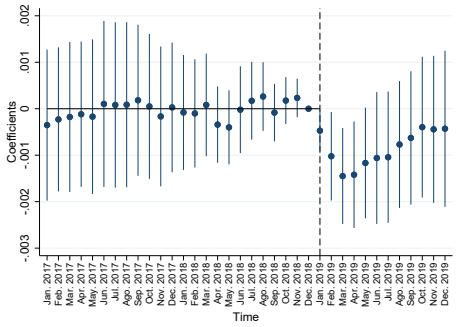
Source: Authors' calculations, Banco de México, INEGI and IMSS. Each line is the simple average of price indexes across items that are not subject to VAT. The average excludes the price indexes for energy, government services, housing rents and education. The median fraction of workers affected by the minimum wage increase across items was 38.76% 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.

Figure A.3: Event-study estimates for wages and employment

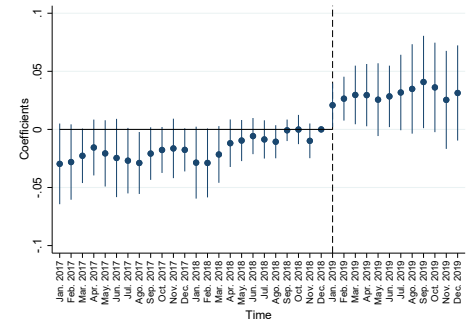
(a) Log wages, fraction affected on VAT sectors



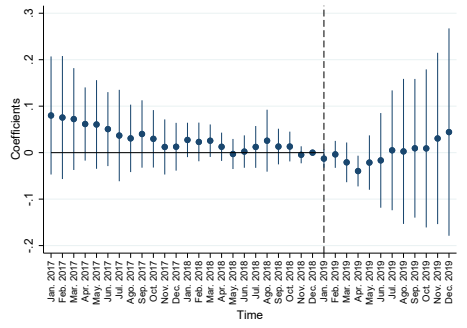
(b) Log employment, fraction affected on VAT sectors



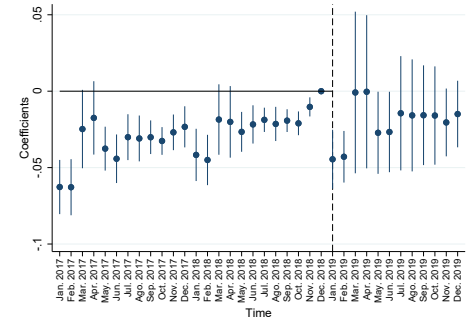
(c) Log wages, fraction affected on Non-VAT sectors



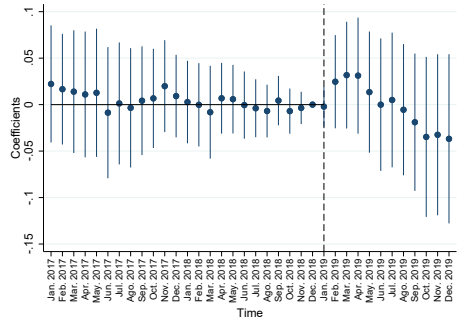
(d) Log Employment, Fraction Affected on Non-VAT sectors



(e) Log wages, VAT effects on VAT sectors



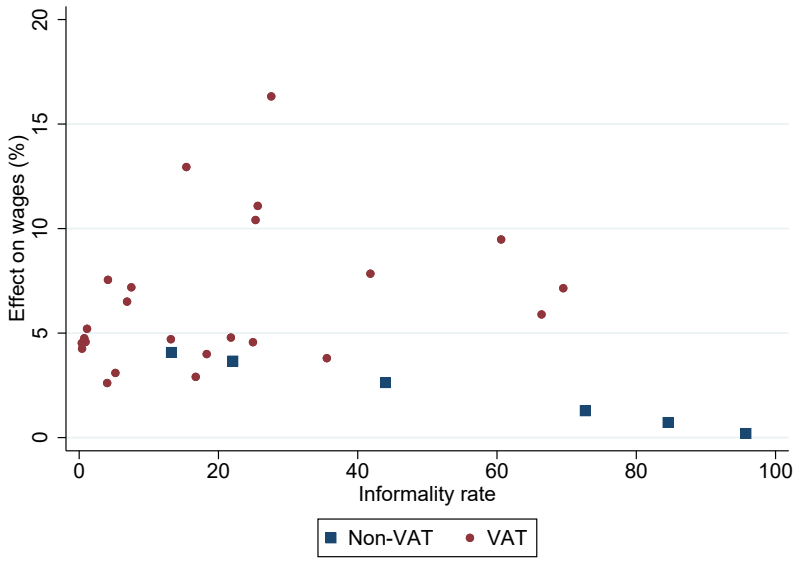
(f) Log employment, VAT effects on VAT sectors



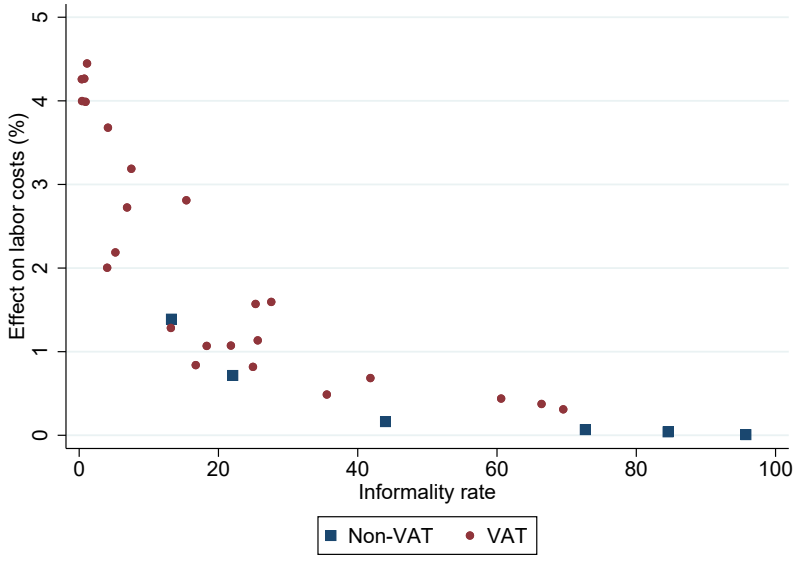
Source: Authors' calculations. The dots correspond to coefficient estimates $\alpha^D_{1,k}$, $\beta^D_{1,k}$, and $\delta^D_{1,k}$ from an analog of equation (5) using log wages and log employment by sector as dependent variables. Wage regressions are weighted by employment in Dec 2018. Vertical bars are confidence intervals at the 95% level. The vertical dotted line corresponds to Jan 2019, 1st half.

Figure A.4: Effect of the minimum wage increase on wages and labor costs by sector

(a) Effect on wages

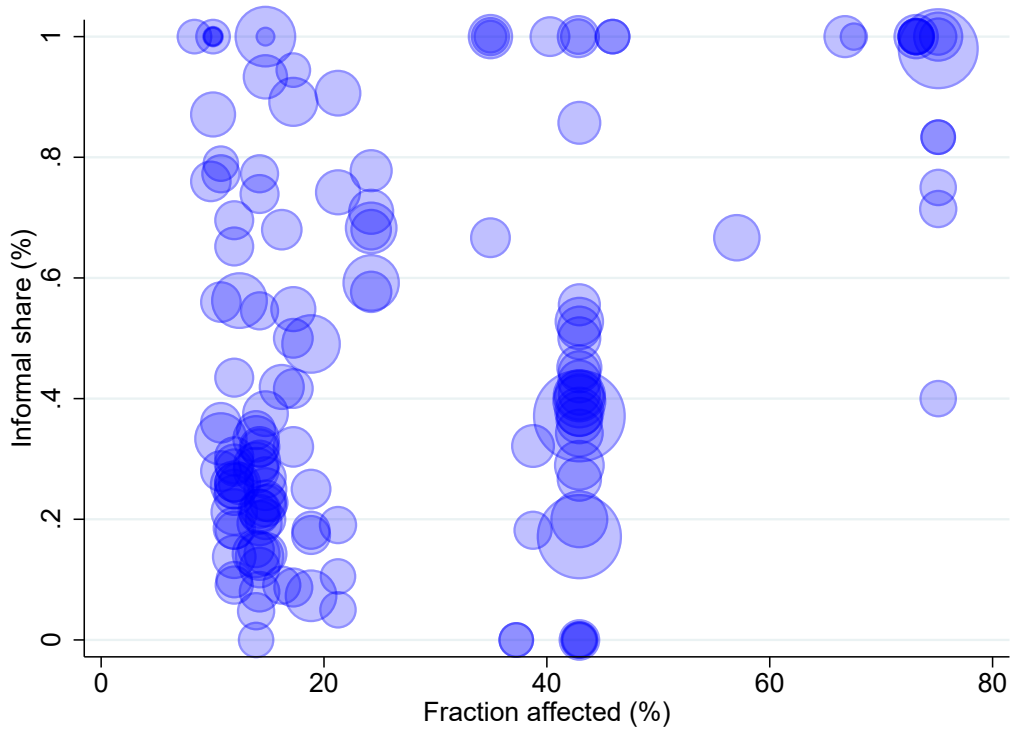


(b) Effect on labor costs



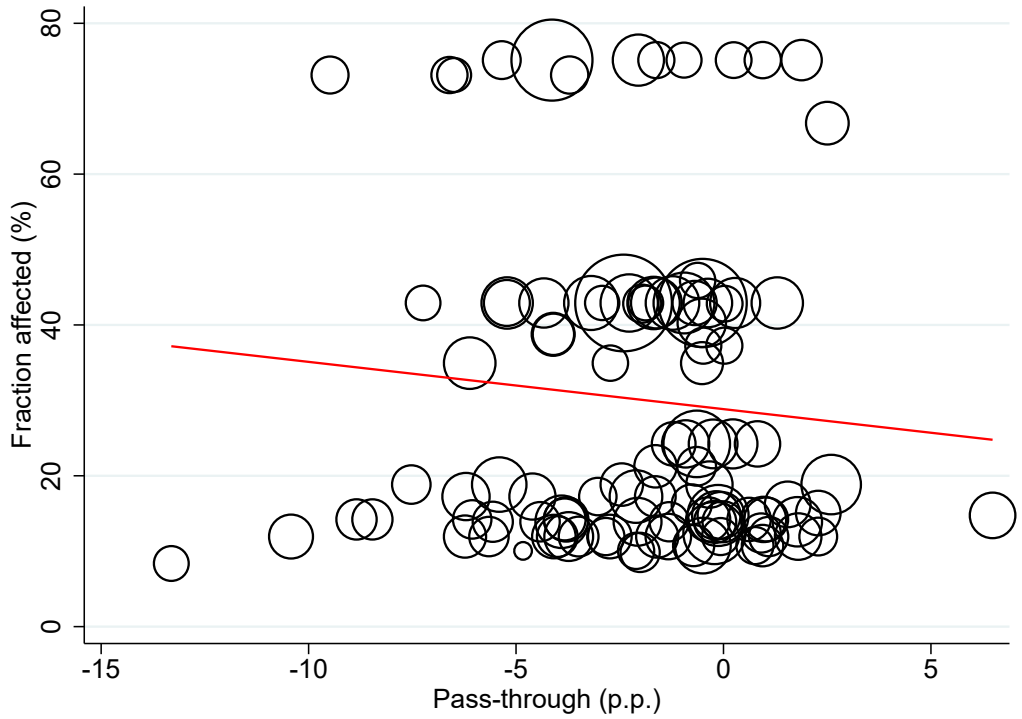
Source: Authors' calculations. Each dot corresponds to the effect on wages (panel a) and labor costs (panel b) of the minimum wage increase implied by the estimates of equation 4 for formal wages, assuming that informal wages do not react and that employment effects are zero. Informality rates are from ENOE 2018.

Figure A.5: Fraction affected and share of items 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 the classification of Racimo (2018) and Bachas et al. (2020).

Figure A.6: VAT implicit elasticity estimated in Mariscal and Werner (2018) and fraction affected



Source: Mariscal and Werner (2018), IMSS, Authors' 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.