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MINIMUM WAGE, MINIMUM EFFORT: THE EFFECT OF THE MINIMUM WAGE POLICY ON LABOR PRODUCTIVITY IN THE ZONA LIBRE DE LA FRONTERA NORTE

TESINA

QUE PARA OBTENER EL TÍTULO DE

LICENCIADO EN ECONOMÍA

PRESENTA

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A mi familia, amigos, amigas, compañeros y compañeras, personas que me han enseñado que todo logro individual es un logro colectivo: a mi guía, apoyo, cariño y mi padre, Miguel; el apoyo y cariño invaluble de mi tío, Pepe; el cariño invaluable de Maxi, Abi y Mari, mis tías; al cariño, enseñanza e inspiración de mi hermana, Frani; a los recuerdos, cariños y enseñanzas de mis hermanos y primos, Oswaldo, Beto, Daniela, Belén, Isaac y Yaz; al amor, enseñanza, apoyo, luz y guía de Itzel; a la amistad sincera, compañía y cariño de mis amistades, Luis Ángel, Pavel, Mafer, Edu, Brian, Mariano y José Raúl. A la memoria de una mujer increíble que me dejó tanto y se fue tan pronto, mi madre, Lucila González Figueroa.

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Porque fueron, somos; porque somos, serán.

Abstract

This research investigates the impact of minimum wage increases on labor productivity within the Zona Libre de la Frontera Norte (ZLFN) in Mexico, utilizing a Differences-in-Differences design to exploit the exogenous variation introduced by the doubling of the minimum wage. The study focuses specifically on the manufacturing sector and finds that the wage increase resulted in a short-term boost in labor productivity, especially among blue-collar workers. The research examines various causal mechanisms, including potential organizational changes, shifts between the formal and informal sectors, and resource reallocation across economic sectors. The results show no evidence of organizational changes or efficiency wage effects. However, there was a slight reduction in the probability of informal work, indicating a possible transition of productive firms to the formal sector. This shift is likely attributable to tax reductions and fiscal incentives associated with the minimum wage increase, rather than the wage increase itself.

Contents

1. Introduction

Since the 1980s, labor rights have diminished in importance within public policy and economic regulation, driven by the belief that market forces alone would ensure widespread prosperity. Globally, free trade, deregulation, and the flexibilization of labor markets have come to dominate political economy. Latin America's history reflects a similar trend of deregulation, with Mexico being no exception. In fact, following the hyperinflation of the 1980s—when annual inflation reached 170%—a series of orthodox policies were implemented to control rising prices. One of the most significant measures was the freezing of the minimum wage, followed by the granting of autonomy to the central bank in 1994 (Navarrete, 1990).

As a consequence, the real minimum wage not only stagnated but also decreased slightly in 2008, recovering its previous level three years later. However, since 2016, the Mexican government has begun to increase the national minimum wage, and since 2018, it has doubled as part of the creation of the Zona Libre de la Frontera Norte. In addition to this policy, a reduction in Value Added Tax (VAT) and Income Tax (*Impuesto Sobre la Renta* in Spanish) was implemented.

Prior to the first increase, there was an extensive debate among Mexican economists. Some argued that raising the minimum wage would lead to higher inflation.[1] They claimed that the only way to increase wages was through growth in labor productivity, consistent with the mainstream theory of wages, where wages are a function of marginal productivity.

Nowadays, recent research and theory have challenged these ideas, thanks to the emergence of new approaches such as efficiency wage theory. In summary, this theory posits that labor productivity is a function of wages (Way, 2015). This research aligns with those investigations that adopt a non-mainstream approach to examining the effects of the minimum wage on macroeconomic variables.

The central question of this research is: Does the increase in the minimum wage in the Zona Libre de la Frontera Norte (ZLFN) positively affect labor productivity in the manufacturing

[1] For example, Agustín Carstens, who was the governor of the Mexican Central Bank at that time, argued that increasing the minimum wage would raise inflation. Carstens pide prudencia para aumentar el salario mínimo. (2017, November 10). *El Financiero*. https://www.eleconomista.com.mx/empresas/Carstens-pide-prudencia-para-aumentar-el-salario-minimo--20171110-0054.html

Figure 1.1: Labor Productivity Index and Real Minimum Wage.

Source: own creation with data from Instituto Nacional de Estadística y Geografía (INEGI) and Comisión Nacional de Salarios Mínimos (CONASAMI).

industry? The hypothesis to be tested is that doubling the minimum wage has had an impact on labor productivity in the manufacturing sector because the previously low wage levels did not provide sufficient motivation for workers to exert greater effort.

To address this question, I will begin in Section 2 by analyzing the literature on the effects of the minimum wage on employment levels and productivity. Secondly, I will describe in Section 3 the data used in this research. Next, I will present the methodology in Section 4, which includes a detailed explanation of the identification strategy and the Differences-in-Differences design, along with the assumptions necessary to support the findings. Additionally, this section will describe the methodology used to construct the Productivity Index based on the total number of workers.

Finally, Section 5 presents the results of the regressions used to identify the effects on productivity and the underlying causal mechanisms. Chapter 6 concludes.

2. Literature Review

The literature on the positive and direct relationship between wages and higher worker productivity indicators is not as extensive compared to other labor market topics, such as minimum wages and inflation. In fact, much of the empirical research on this subject has been produced recently and is limited to a few countries, such as the United States, China, and the United Kingdom. Although the findings are diverse—with some studies finding no significant effects—there is a notable lack of research in emerging markets like Mexico.

Overall, the literature suggests four primary mechanisms through which an increase in the minimum wage can enhance worker productivity: 1) efficiency wage theory, where the cost of losing a job increases, leading to greater worker effort; 2) organizational changes within firms, as companies strive to maintain profits in response to higher costs; 3) the reciprocity effect of wage increases;[2] and 4) a shift toward formality (i.e., movement to more productive firms). In the next subsection, a detailed description of each causal mechanism will be provided.

2.1. Efficiency wages mechanism

First of all, it is important to describe in detail what an efficiency wage is. As mentioned earlier, this concept refers to the idea that productivity is a function of wages. Specifically, the wage at which the increase in labor cost is offset by a corresponding increase in labor productivity is known as the efficiency wage. The classical reasoning behind this concept is that higher wages can improve workers' diets, leading to better performance. Other key effects include: 1) making it costly for workers to shirk their responsibilities, 2) reinforcing compliance and motivation in the workplace, 3) reducing turnover by making workers less likely to quit, and 4) attracting more qualified workers (Borjas, 2010).

Another explanation is provided by Fritoli et al. (2021), who emphasize the principal-agent problem and the asymmetry of information between them. This situation creates a need for the principal to motivate the agent due to differing interests. Consequently, paying a wage above the equilibrium level can motivate the worker when monitoring effort is costly for the principal.

[2] This could be more difficult to prove due to the limitations of available data. In general, this approach suggests that workers feel more satisfied with their jobs, see Charness (2004).

Coviello et al. (2022), using a border-discontinuity research design and data at the worker level from a US retailer, demonstrated that an increase in the minimum wage positively affects worker productivity. Utilizing the theoretical framework of the efficiency wage model proposed by Rebitzer & Taylor (1995), they explain the mechanism through which the minimum wage impacts worker productivity. They argue that low-type workers, who experience less monitoring, increase their effort in response to the higher cost of losing their jobs.

Using instrumental variables and data from more heterogeneous firms, Kong et al. (2020) analyze the relationship between workers' wages and firm innovation. They find a positive causal relationship between these variables and explain this through the concept of efficiency wages. According to their findings, higher wages enhance motivation, retention, and attraction of employees. Their study, based on data from Chinese firms, allows them to analyze the effect directly at the firm level.

Similarly, Kim & Jang (2018) find a positive effect of minimum wage policy on restaurant productivity during the first two years, based on data from restaurants in the United States from 1980 to 2014. They attribute this effect primarily to workers with the lowest wages. After these initial two years, the effect on productivity diminishes.

They explain that the primary mechanism is an increase in individual effort, which they attribute to motivation. This motivation can account for the temporary nature of the effect. Additionally, there appear to be limitations to increasing productivity solely through higher wages. The main limitation of this paper is that it uses data exclusively from the restaurant industry, though the authors describe a mechanism by which minimum wage affects productivity.

Finally, in 2020, Ku analyzed how the minimum wage increase in Florida in 2009 affected the effort of low-productivity workers and found no effect on high-productivity workers. He also notes that this effect may only apply within a certain range of minimum wages; in other words, at certain wage levels, this relationship disappears. Ku suggests that a possible explanation could be the presence of both physical and mental limitations that workers cannot overcome. To evaluate the effect of the minimum wage, he used high-frequency data on worker productivity in homogeneous tasks to make valid comparisons.

Regarding Latin America, Almeida & Raposo (2014) found evidence of a positive relationship between workers' effort and wage level in Brazil. Using a Switching Regression Model and employing the probability of working or not in a small-sized firm as an instrument for wages in the first stage, their study highlights this positive association.

In Mexico, Maloney & Ribeiro (1999) used instrumental variables (union workers' bargaining power) to investigate how unions affect employment and wage structures. Their findings suggest the presence of efficiency wages in the demand function for workers. In Colombia, Taborda & Guataquí (2003) provide evidence that firms paying wages above the industry aver-

age aim to increase the costs of job rotation, which may also indicate the existence of efficiency wages.

In conclusion, efficiency wage theory can explain increases in labor productivity, particularly when wage levels are relatively low and monitoring is minimal. Additionally, there is no consistent evidence of a long-term effect on productivity, nor is there evidence of substituting less productive workers for more productive ones. In this research, I will analyze the possible effects of increasing the costs of shirking using ENOE surveys.

As it is evident, identifying changes in motivation or effort as causal mechanisms for higher labor productivity presents some challenges. Additionally, the theory of efficiency wages assumes that increasing wages above the equilibrium level results in involuntary unemployment. The intuition behind this is that when wages are at equilibrium, a worker caught shirking will be fired but will quickly find another job at the same wage. However, raising wages above the equilibrium level leads to a lower demand for workers (Shapiro & Stiglitz, 1984).

In other words, unemployment becomes a penalty for shirking. Therefore, according to the efficiency wages theory, I should expect to find both an effect on productivity and an effect on unemployment. However, Alvarado-Pérez et al. (2023), Calderón et al. (2022), and Campos-Vázquez & Esquivel (2021) did not find any effect on employment levels across all sectors, which could undermine the efficiency wages mechanism. It is important to note, however, that their research did not focus on the manufacturing sector, where Fuentes et al. found a negative effect on employment. For this reason, this research will specifically analyze the impact on manufacturing employment to identify the presence of an efficiency wage mechanism.

2.2. Organizational change mechanism

The intuition behind this mechanism is as follows: an increase in the minimum wage leads to higher labor costs. Consequently, firms must either reduce costs by firing workers or adapt their organization to mitigate these costs. This prediction relies on the assumption of competitive markets, as firms cannot increase their prices arbitrarily. In this context: 1) if firms decide to fire workers, those who lose their jobs are likely to be less qualified; 2) firms may reduce other costs or their profits by reorganizing their internal structure;[3] or 3) firms might shift to informality (Del Carpio et al., 2017).[4]

This mechanism can be challenging to identify because it requires data that were previously unavailable, necessitating some assumptions. Nevertheless, some studies have identified an effect on productivity. For instance, using a Differences-in-Differences (DiD) design, Song *et*

[3] In the cited paper, point two is divided into two separate points, as reducing costs does not necessarily entail changes in the internal structure.

[4] This last point will be developed in detail as part of the third mechanism.

al. (2021) analyzed the impact of the minimum wage on costs, an EBITDA (earnings before interest, taxes, depreciation, and amortization) index, and total revenues of hotels in the United States.

Their research only found significant and negative effects on costs and EBITDA, concluding that there is no impact on labor costs, maintaining that there is no industry productivity response to the minimum wage increment. These findings suggest that hotels restructured their activities or costs to maintain revenues: in other words, hotels become more efficient. Nevertheless, they did not find any change on productivity, and their data is limited to hotels.

In a 2023 study, Haelbig et al. found that the increase in the minimum wage in Germany had a positive impact on productivity in the manufacturing sector, both in terms of labor productivity and total factor productivity. They observed that these gains were more significant in small firms. They explain that this increase in productivity was not due to a relocation of workers to more efficient companies, as previous studies had assumed. By using a decomposition method to analyze "within-component" variation, their study identifies changes in productivity, suggesting that workers with high abilities did not change jobs as a result of the wage increases. The data used in this study includes administrative information from a diverse range of firms, encompassing both manufacturing and service industries.

Similarly, Draca et al. (2011), studying the introduction of the National Minimum Wage policy in the United Kingdom using a DiD design, found no effect on employment levels or firm productivity in response to a minimum wage increase. These findings contrast with those of previously cited studies that have found positive effects from increasing the minimum wage. Draca et al. suggest that this discrepancy may be due to workers not altering their effort levels and firms simply adjusting their cost structures. Their research uses a database that includes heterogeneous firms, but it does not explicitly address the relationship between minimum wages and productivity. Nevertheless, it is valuable for contrasting the hypotheses in this analysis.

However, in analyzing the same minimum wage policy in the UK, Riley & Bondibene (2017) used firm-level data and concluded that the minimum wage policy had a positive effect on productivity, driven by an increase in total factor productivity resulting from organizational changes. In other words, they did not find evidence that firms substituted labor for capital or reduced total employment by dismissing less productive workers.

They explain that this is a response to the increase in labor costs induced by the minimum wage increase. In fact, firms are seeking hold utilities instead of loss competitiveness by increasing prices. Respect to previous research, they use a disaggregate database. Additionally, they show how minimum wages affects productivity through administrative changes.

Finally, with contrasting results on employment levels, Hau et al. (2020) found that the minimum wage increase in China had a positive effect on labor-to-capital substitution, reduced

the employment rate, and accelerated the growth of total factor productivity among private firms. These effects can be explained by the heterogeneity in firm management.

For their research, they used information from the Chinese Industry Database (CIED). Their results contrast with previous studies on the same topic, specifically showing labor-to-capital substitution, which other papers had not identified. Nevertheless, they highlight an important issue: the heterogeneity in firm management, which opens the door for future research into firms with more homogeneous management practices.

For the purpose of this research, the available data may not allow for the identification of internal structural changes. Nevertheless, by using data on expenditures related to human capital management, we can infer that firms likely strive to become more efficient to offset the higher labor costs.

2.3. Transitioning to formality

The last mechanism refers to fouth channel mentioned at the beginning of the section, which is related to firms moving into informality when labor costs increase. However, not only can firms move into informality, but workers can also transition to formality in order to obtain better wages. Some theories explain the differences between the formal and informal sectors from a productivity perspective, suggesting that these sectors represent dual markets, with the formal sector being more productive (Ulyssea, 2020). Therefore, changing employment sectors can result in changes in productivity.

Following this argument, the increase in labor costs will provide incentives for firms to transition to informality, which could lead to lower productivity or the firing of less productive workers who will seek informal jobs. On the other hand, higher wages in the formal sector can attract more productive workers to the formal sector. It is clear that these processes move in different directions and, therefore, their effects can offset each other.

In this context, a study conducted by Campos-Vázquez et al. (2017), using data from ENOE, found an effect on the probability of being in the formal sector. Specifically, they found that an increase in the minimum wage reduces the probability of being an informal worker by 14%. Although they did not analyze the effect on labor productivity, they did find effects on labor status. In contrast, Pérez-Pérez (2020) found in Colombia that a change in the real minimum wage leads to a slight reduction in employment in the informal sector and no effect on the formal sector. He suggests that this may indicate imperfect compliance with minimum wage policy, resulting in some workers being fired.

In Turkey, Bossavie et al. (2019) studied the effect of the minimum wage on firm destruction, employment, and formality. The results suggest that there is firm destruction, specifically among

small and less productive firms, and a loss of formal jobs due to this destruction. Additionally, there is no change in informal employment. While this research does not provide evidence of a change in productivity, it can be interpreted as an increase in productivity due to the reduction of less productive firms.

Later, using ZLFN exogenous variation, Campos-Vázquez et al. (2020) found that minimum wage policy does not have a significant effect on employment or formality. Again, in Mexico, it is unclear whether minimum wage affects employment levels, and there is insufficient research on firm destruction. The latter conclusion is outside the scope of this work. Nevertheless, I will analyze some variables related to changes in formality as a possible causal mechanism for changes in labor productivity.

For the present research, I will estimate regressions to attempt to replicate the findings of no effect on formal employment. If these findings can be reproduced here, it would indicate no evidence of a transition to a more productive sector. Additionally, I will study whether the number of firms registered in the IMMEX program (*Industria Manufacturera, Maquiladora y de Servicios de Exportación*) decreases in the ZLFN as a way to approximate the destruction of less productive firms.

2.4. Effects of doubling minimum wage in ZLFN

In addition to the previous literature related to minimum wages and productivity, a vast body of research has studied the diverse effects of doubling minimum wages in the ZLFN. For example, Alvarado-Pérez et al. (2023) investigated how this policy reduces the income gap between women and men. A DiD design was employed to identify these effects. Additionally, the study found no effect on employment, a higher probability of being in the formal sector, and higher wages. For the purposes of this research, this can indicate a reallocation of productive employees from the informal to the formal sector.

In the context of inflation effects, Calderón et al. (2022) analyzed the effects of doubling minimum wages and reducing VAT[5] on prices and other variables. They found a positive effect on prices, but this was offset by the reduction in VAT. Additionally, this study aligns with previous findings in that it did not find any change in employment. In contrast, Campos-Vázquez & Esquivel (2020), using a synthetic control method to identify whether minimum wage policy causes inflation, did not find any effect or found only a minimal effect on prices.

Additionally, Campos-Vázquez & Esquivel (2021), using a synthetic control approach, found no effect on employment but observed that doubling the minimum wage had an effect on income at the bottom of the distribution. This suggests that, for the purpose of this research, low-skill

[5] Value Added Tax.

workers were the main beneficiaries of the policy. This finding is consistente with a previous research for the period of 2012-2015 (Campos-Vázquez & Rodas, 2020).

Nevertheless, negative impacts have been found by Fuentes et al. (2020). Specifically, using data from the Mexican manufacturing sector and an input-output matrix, they estimated that doubling the minimum wage reduces gross production, employment, and added value due to the increase in labor costs. These findings challenge the results of this research, as the hypothesis of this work is that doubling the minimum wage actually increases productivity in the manufacturing sector. In general, these studies provide evidence of effects on income, specifically at the bottom of the distribution, and no effects on employment. This can be consistent with an efficiency wage approach for less productive workers.

In summary, the literature review has shown consistent evidence of how minimum wage policy can increase labor productivity, not just in a specific industry but also in the economy and through different mechanisms (worker level or firm level). Nevertheless, it is not clear which factors determine whether an effect exists or at which wage levels there is no effect. Additionally, there is relative consensus that minimum wage policy does not affect costs or unemployment at the firm level.

In most cases, the difference-in-differences design is a very useful tool to identify the causal relationship between productivity and minimum wage. This design is used because, in many cases, there are treated and control groups where the pre-treatment interest variable has the same trend over time (a convenient requirement that facilitates justifying a causal interpretation).

3. Data

For this study, the database of the IMMEX program was used to analyze the effect of the minimum wage policy on productivity. This database contains information only from firms registered in the program since July 2007.[6] Each firm applies to be part of this program, which offers tax incentives to promote the export of manufactured goods. This introduces a limitation to the external validity of the research.

The database contains monthly information on profits, costs, number of workers, worked hours, etc. Profits and costs can be disaggregated by concept. Additionally, the data is available at the municipality level but not at the firm level. Nevertheless, the number of firms for each municipality is available and is used as weights for estimation.

Despite a large number of municipalities being available, only 32 of them can be identified because they are presented in a disaggregated form. For this reason, the estimation uses only 20 municipalities in six states. The treated municipalities are: Ensenada, Mexicali, Tecate, Tijuana, Acuña, Juárez, Nogales, Matamoros, Nuevo Laredo, and Reynosa. The control group includes: Ramos Arizpe, Saltillo, Torreón, Chihuahua, Hermosillo, Apodaca, Guadalupe, Monterrey, San Nicolás de los Garza, Santa Catarina, and other municipalities (see Appendix A).

In addition, to study causal mechanisms, the ENOE (*Encuesta Nacional de Ocupación y Empleo*) was employed. Specifically, I focused on questions about 1) whether a worker is searching for another principal job,[7] 2) whether the worker has recently moved to the city,[8] 3) whether the main job is part of the formal sector, and 4) whether the job is in manufacturing. This survey has a quarterly frequency and is representative at the city level, which implies a limitation. Nevertheless, this database contains information at the household level.[9] Furthermore, to analyze structural changes within firms, we use the expenditure on management contracts reported in the IMEX database as a proxy.

In the next sections, I will first describe the method used to construct the labor productivity

[6] To estimate each regression, I use data from January 2013 to March 2020 to avoid the effects of lockdowns and to ensure synchronization of time series for both groups.

[7] The survey identifies if a worker is searching for an additional job or wants to change their main job.

[8] In this question, the household is asked whether they have recently moved to the current city, i.e., within the last quarter.

[9] To estimate regressions, as shown in the tables of causal mechanisms, 5 million observations were used, but the available treated cities are just four: Tijuana, Reynosa, Ciudad Juárez, and Mexicali.

index, using data from IMEX. After that, a set of regressions and their results will be presented. The main regression will have the labor productivity index (based on workers and based on worked hours) as the dependent variable. The remaining regressions will aim to identify causal mechanisms, using the following dependent variables: expenditure on planning (from IMEX), whether a worker is searching for another job (ENOE), workers in the formal sector (ENOE), and workers in the manufacturing sector (ENOE).

Table 3.1: ENOE variables description

Variables	Description	Values
CS_NR_MOT	Rationale for Transitioning to the city	**01 = Work**
		02 = Study
		03 = Marry
		04 = Divorce
		05 = Health
		06 = Family
		07 = Security
		08 = Birthplace
		09 = Omitted
		10 = Other
		99 = Unkown
BUSCAR5C	Seeking Alternative Employment	01 = Supplementary Employment
		02 = Employment Transition
		03 = Other
		04 = Not Seeking
		05 = Not Specified
TUE2	Type of employer	01 = Corporations
		02 = Firms with out societal status
		03 = Private
		04 = Public
		05 = Informal
		06 = Paid Housework
		07 = Self-consumption Agriculture
RAMA	Sector	06 = Agriculture
		01 = Construction
		02 = Manufacturing
		03 = Commerce
		04 = Services
		05 = Others
		06 = Not Specified

Source: own creation with data from INEGI.

4. Methodology

4.1. Empirical Strategy

As mentioned earlier, Mexico faced stagnation of the minimum wage as a result of a period of hyperinflation at the end of the 20th century. For example, in 1989, the average minimum wage was 8.3 pesos per day, and in 1994, it was 13.97 pesos per day. Although nominal adjustments occurred every year from 2000 to 2009, in real terms, the minimum wage decayed relatively slowly, starting at 75.60 pesos per day and finishing at 75.48 pesos per day over those years. Over 8 years (from 2010 to 2018), the real minimum wage increased on average from 75.98 pesos per day to 88.15 pesos per day (+12.17 pesos), representing a growth of 16%.[10]

In 2016, following the first attempt to raise the minimum wage, Mexican economists debated its impact. Opponents argue that increasing the minimum wage could lead to unemployment and higher inflation, as firms might cut well-paid jobs or raise prices to manage higher labor costs.[11] Conversely, proponents believe that raising the minimum wage is essential not just for reducing poverty and income inequality but also for boosting consumer spending and, in general, the national economy.[12]

Finally, in 2017, the real minimum wage increased from 81.04 pesos in 2016 to 84.47 pesos, representing a growth rate of 4% in just one year. By 2018, the minimum wage grew by 4 pesos (to 88.15 pesos), but the newly elected government under López Obrador announced a further increase of 14 pesos in nominal terms, which was 16% higher compared to the 2018 level. Additionally, he announced that increments would continue until the minimum wage doubles its current level. Currently, the minimum wage is approximately 374 pesos in the ZLFN and 249 pesos in the rest of the country, which represents double the level of 2019.

Furthermore, new minimum wage and tax policies were introduced:[13] Some municipalities in border states received a doubling of the minimum wage (from 102.68 to 176.2 pesos)

[10] CONASAMI, Evolución del Salario Mínimo Real

[11] In this position, a document published by Banxico, using a statistical approach, concludes an important effect on inflation, unemployment, productivity, etc. (Banco de México, 2016).

[12] There have been several statements in newspapers, forums, and opinion columns. Some economists argue in favor of increasing the minimum wage in various forums (Cámara de Diputados, 2016).

[13] Nevertheless, before 2010, there were already three minimum wage zones. From 2013 to 2015, the number of zones was reduced from three to two. Between 2016 and 2018, there was only one minimum wage zone.

and a reduction in VAT, while the rest of the country experienced only a single increase in the minimum wage and maintained the VAT rate. This created an exogenous variation among municipalities because the division between them was decided based not only on previous policy but also on political factors (Secretaría de Economía, 2020). This leads to addressing the issue of non-exogeneity in econometrics to accurately evaluate the real effect of a policy. In other words, we are dealing with a quasi-experiment, which will be explained in the next section.

4.2. Differences in Differences Design

In general, identifying a causal effect is likely the main complication in social sciences, and specifically in economic research. Theoretically, a causal effect is defined as the change in the outcome resulting from the treatment *ceteris paribus*, which can be perfectly identified if we have a perfect counterfactual—i.e., the scenario where the treatment occurs and the scenario where it does not. Nevertheless, it is not possible to recreate a scenario where the treatment does not occur on the same group, unit, or person. For this reason, constructing a credible counterfactual is fundamental for causal identification.

In fact, a counterfactual serves as the unit against which the outcomes of the treated unit are compared. Therefore, a counterfactual must be a comparable unit that does not receive the treatment. However, it is not as simple as selecting a group with similar observable characteristics, because differences between the treated and untreated groups could be due to unobservable characteristics. In other words, the treated unit might be self-selected based on factors such as their attitude toward participating in the experiment or their level of self-confidence in their performance. This is known as endogeneity, which limits the ability to identify causal effects because the treatment itself does not generate the changes in outcomes, but rather the attitude or self-confidence.

To address possible endogeneity —that is, when the relationship between independent and dependent variables is not causal it is essential to find an exogenous variation through an experiment where the treatment is assigned randomly.[14] This method can identify a causal relationship between the treatment and the variable of interest because the treatment is assigned exogenously, i.e, without relation with variables of the regression.

Nevertheless, RCTs are not common due to implementation challenges. These challenges have led to the development of alternative methods for identifying causal relationships, known as quasi-experiments. Quasi-experiments utilize uncontrolled variations in the variables of interest as sources of exogenous variation (natural experiments).[15] One such method is the Difference-

[14] The most common method is called Randomized Controlled Trials (RCTs), which involves determining control and treatment groups randomly.

[15] ”Natural” in this context does not refer to natural disasters or events but includes social events such as regulations,

in-Differences design, which can be employed in both quasi-experiments and natural experiments.

This method identifies causal effects by comparing the variable of interest between the group that receives the treatment and the group that does not. In contrast to other methods, DiD requires tracking the groups over time, which necessitates using panel data. The intuition behind the method is illustrated in Figure 4.1, which demonstrates that the level of each unit, in February, before treatment, is α and $\alpha - \gamma$, respectively.

After the treatment, in November, both groups are measured again. The observed level of labor supply is $\alpha - \lambda$ for the control group and $\alpha - \gamma + \delta$ for the treated group, where δ represents the treatment effect of the policy implemented to change labor supply. To establish this effect as causal, several important assumptions must be met. Before formally explaining these assumptions, I will describe the intuition behind them.

First of all, comparison between groups is fundamental, which implies that, in the absence of treatment, both groups exhibit similar behavior or labor supply. Formally, without treatment, the level observed for the treated group would be $\alpha - \gamma - \lambda$. In other words, the difference in levels should not be attributed to unobservable variables; rather, it is assumed to be random. This assumption is known as "parallel trends." In fact, this method uses the trend of the untreated group to estimate the counterfactual for the treated group, i.e., the scenario where the policy did not occur.

The second important assumption is known as treatment exclusivity, which intuitively means that, to identify the causal effect of a certain policy, only that policy should be in effect at the time. In a certain sense, this is similar to the concept of no omitted variables. Finally, another assumption requires that units did not anticipate the policy and, therefore, did not alter their behavior in order to receive the treatment. For example, if a social program is announced to be delivered to people living below $10 per day, a group living just above that threshold might reduce their income to qualify for the program.

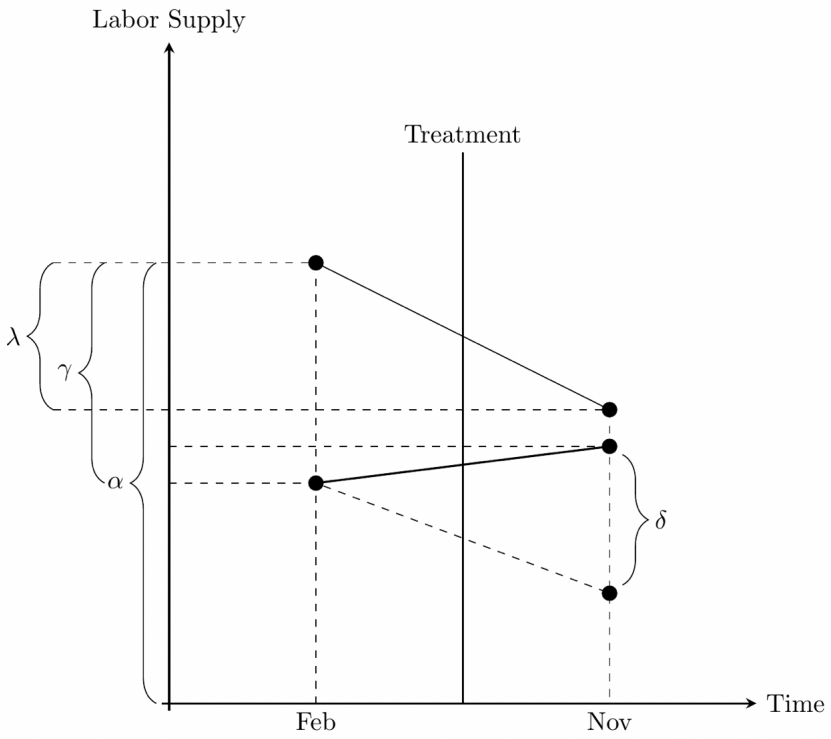
In summary, to apply this method and obtain an unbiased effect, the following assumptions must be met: (i) parallel trends, (ii) no anticipation, (iii) treatment exclusivity, and (iv) SUTVA (Stable Unit Treatment Value Assumption). These assumptions need to be satisfied in both natural experiments and randomized controlled trials.

Formally, suppose that $\overline{Y}_k^t$ is the variable of interest at time $t \in \{0, 1\}$, where 1 indicates after treatment and 0 indicates before treatment, and $k \in \{0, 1\}$, where 1 represents the treated group and 0 represents the untreated group. The effect (δ) can be computed non-parametrically as follows:[16]

political changes, and other similar occurrences.

[16] The following description is based on Scott Cunningham (2021), *The Mixtape*.

Figure 4.1: Graphic representation of DiD



Source: Scott Cunningham (2021). The Mixtape.

$$\delta = (\overline{Y}_1^1 - \overline{Y}_1^0) - (\overline{Y}_0^1 - \overline{Y}_0^0)$$

Moving to a parametric approach, the equation above can be rewritten using conditional means and switching equations, which use historical data to impute potential outcomes. For example, Y_1^1 refers to the potential outcome for the treated group after treatment, while *Post* and *Pre* both refer to the treatment status:

$$\delta = (E[Y_1^1|Post] - E[Y_1^0|Pre]) - (E[Y_0^0|Post] - E[Y_0^0|Pre])$$

By adding zero, $E[Y_1^0 \mid \textit{Post}] - E[Y_1^0 \mid \textit{Pre}]$, and rearranging the terms, the expression above leads to:

$$\delta = \underbrace{(E[Y_1^1|Post] - E[Y_1^0|Post])}_{\text{ATE}} + \underbrace{(E[Y_1^0|Post] - E[Y_1^0|Pre]) - (E[Y_0^0|Post] - E[Y_0^0|Pre])}_{\text{Parallel Trends = 0}} \tag{4.1}$$

The first term represents the Average Treatment Effect (ATE). This term is the difference between the scenario where the group received the treatment and the counterfactual scenario where they did not. The last term in this expression is not observable. The second term represents the formal expression of parallel trends. As mentioned earlier, this means that in the absence of treatment, both groups would follow the same trend, and the difference between outcomes before and after treatment would be the same in both groups. Formally:

$$E[Y_1^0|Post] - E[Y_1^0|Pre] = E[Y_0^0|Post] - E[Y_0^0|Pre]$$

This leads the expression equal zero, which implies that, when the parallel trends assumption holds, using pre-treatment outcomes is equivalent to using the unobservable counterfactual to estimate the causal effect.

Given these assumptions, it is possible to derive the following Difference-in-Differences (DiD) design in regression form:

$$y_{it} = \beta_0 + \beta_1 D_i + \beta_2 Post_t + \beta_3 D_i Post + \epsilon_{it} \tag{4.2}$$

where β_3 represents the Average Treatment Effect (ATE), i refers to the unit of observation, t indicates the time period, D_i is a dummy variable that equals 1 if the unit was treated and 0 otherwise, $Post$ equals 1 if the treatment has occurred and 0 otherwise, and the interaction between $Post$ and D_i equals 1 for every treated unit after the treatment. The term ϵ_{it} represents the stochastic error term.

For this particular case, y_{it} represents the productivity index, D_i is a dummy variable indicating 1 if the municipality is treated and 0 otherwise, and $Post_t$ equals 1 if the year is greater than or equal to January 2019 and 0 otherwise. Finally, ϵ_{it} represents the municipality-level errors in period t. This is equivalent to a fixed effects model at the municipality and time level. It can be written as follows:

$$y_{it} = \alpha_t + \alpha_i + \beta_2 D_{it} + \epsilon_{it} \tag{4.3}$$

where β_2 represents the Average Treatment Effect (ATE), and D_{it} equals 1 for post-treatment periods of treated units. To identify causal mechanisms, a similar equation was employed, with changes to the dependent variables or temporality when assessing the parallel trends assumption.

Using this methodology for the research, clustered errors are required to make valid inferences about the estimated effects because the error term ϵ_{it} is serially correlated within units, meaning that the current value of the outcome is correlated with its past values. For this research and the data employed, clustering could become an issue. As Abadie & Athey (2022) argue, a justification for clustered errors must be provided.

In this research, errors can be clustered at both the municipality level (29 municipalities) and the state level (32 states). Clustering errors at the municipality level appears to be reasonable. Nevertheless, the tables presented in the results section show clustered errors at both the municipality and state levels, in addition to robust standard errors.

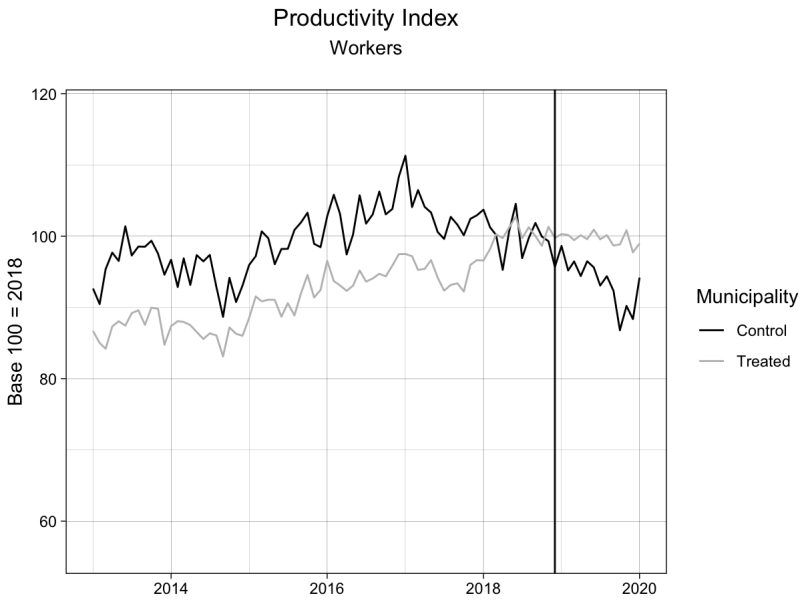
Figures 4.2 and 4.3 show that both groups of municipalities exhibited a similar trend in productivity from 2012 to the first quarter of 2020.[17] This similarity supports the use of a Difference-in-Differences design, exploiting exogenous variation in the dependent variables. However, it is important not only to present graphical evidence but also to provide statistical evidence of similar trends before the intervention, which will be demonstrated in the results section and detailed in the next section.

4.3. Productivity Index

The main challenge of this research is to construct a valid index to measure labor productivity using the available data. This section describes two methodologies employed by INEGI, which use total workers and total hours worked. Although INEGI provides a methodology to estimate labor productivity, this measurement is only available at the state level. To construct a similar index at the municipal level, data from the Economic Census, which are not yet available for the study years, is required.

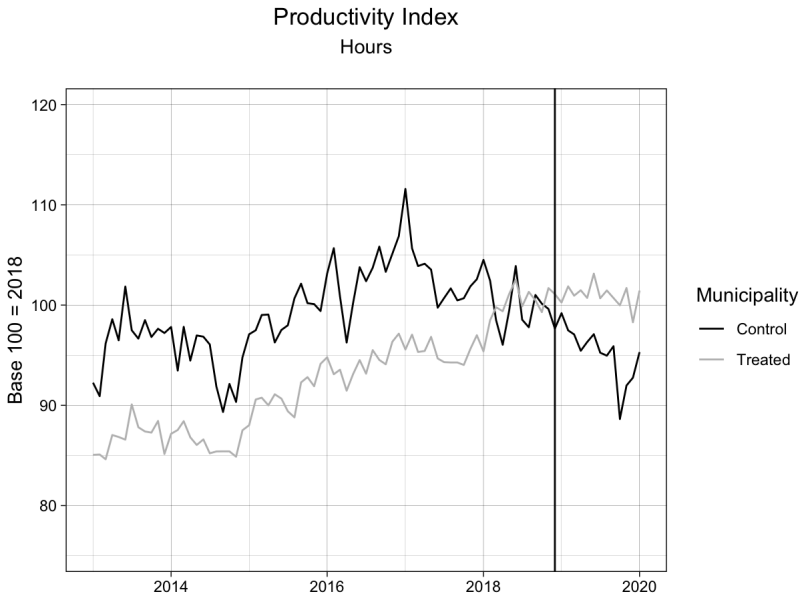
[17] Both time series were constructed as a weighted index based on the number of active firms at each time point. The plots illustrate this weighted and deseasonalized index.

Figure 4.2: Productivity Index of treated and non-treated municipalities



Source: own creation with data from INEGI. Vertical line is the begining of the minimum wage policy in January 2019.

Figure 4.3: Productivity Index of treated and non-treated municipalities



Source: own creation with data from INEGI. Vertical line is the begining of the minimum wage policy in January 2019.

The intuition behind this methodology is simple: consider a firm's total production, Y, which is produced by N workers. In other words, each worker produces exactly $y = Y/N$ units of product. If total production Y decreases while N remains constant, it indicates that each worker produces less, leading to a decline in labor productivity. Conversely, if Y increases while N remains constant, each worker produces more, thereby increasing productivity, i.e., y. Since we are dealing with a ratio, there are other combinations that also describe changes in productivity.

For this reason, the following method is proposed to estimate productivity in municipality m in month t, considering the number of workers, N, and profits, $Profits$, as the production Y of firms:[18]

$$ProductivityIndex_{mt} = \frac{ProfitsIndex_{mt2018}}{EmploymentIndex_{mt2018}} * 100 \tag{4.4}$$

Furthermore, the 2018 base Profits Index is constructed as follows for each municipality m:

$$ProfitsIndex_{mt2018} = \frac{BN_{mt} + FN_{mt} + BE_{mt} + FE_{mt} + OE_{mt} + ON_{mt}}{Profits_{m2018}} * 100 \tag{4.5}$$

and, $Profits_{m2018}$ are the mean of the sum described above along 2018 for each municipality:

$$Profits_{m2018} = BN_{m2018} + FN_{m2018} + BE_{m2018} + FE_{m2018} + OE_{m2018} + ON_{m2018}$$

where BN_{mt} represents the profits obtained from the sale of goods in the domestic market, BE_{mt} denotes the profits from the sale of goods in the foreign market, FN_{mt} refers to the profits received from the transformation of raw materials in the domestic market, FE_{mt} refers to the profits from the transformation of raw materials in the foreign market, and $OE_{mt} + ON_{mt}$ represents the profits received from various sources distinct from those previously mentioned, originating from both domestic and foreign markets.

In turn, the Employment Index was constructed by creating an index based on the average of the base year. Total employment was calculated as follows:

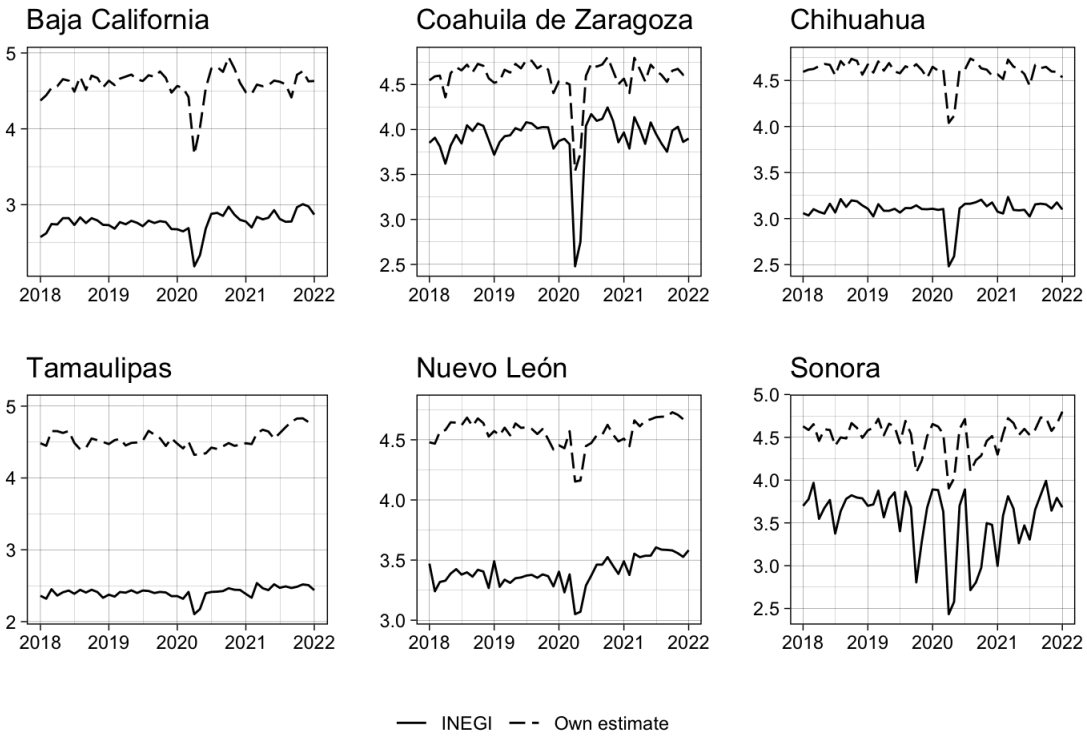
$$Employment_{mt} = O_{mt} + OE_{mt} + A_{mt} + AE_{mt} \tag{4.6}$$

and the Employment Index itself is constructed as follows:

$$EmploymentIndex_{mt2018} = \frac{Employment_{mt}}{O_{mt2018} + OE_{mt2018} + A_{mt2018} + AE_{mt2018}} \tag{4.7}$$

[18] To construct the Productivity Index based on hours worked, the same procedure is followed, but instead of using the total number of workers, an index of total hours worked is used.

Figure 4.4: Productivity Index of selected states



Source: own creation. Dashed line represents own estimation. Black line is Labor Productivity Index using INEGI methodology.

where O_{mt} refers to workers from the same firm and OE_{mt} refers to workers from a different firm (outsourcing). Meanwhile, A_{mt} denotes administrative employees from the same firm, and AE_{mt} denotes administrative employees from a different firm.

To assess the relevance of this index as a proxy for manufacturing industry productivity at the municipal level, we recreated the labor productivity variable at the state level using INEGI data based on the Survey of Manufacturing Industry. Using IMEX data, we then calculated the index at the state level with the method previously described, instead of at the municipal level.

Both indices—the one developed by INEGI and the one created here—exhibit very similar movements during the months for which data is available. Therefore, this method was used to construct a Manufacturing Industry Productivity Index for the municipalities of the ZLFN and the border municipalities that are not part of this program, as shown in Figure 4.4.

5. Results

5.1. Assumptions

5.1.1. Parallel Trends

A fundamental assumption in DiD analysis is the Parallel Trends assumption. However, there are alternative methods to address violations of this assumption, which will be discussed in Appendix B. One straightforward way to test this assumption is through an intuitive regression model. The intuition behind this model, similar to DiD for finding causal effects, is that if we restrict the data to the period before treatment, we should observe no difference in trends between the groups over time. In other words, $\alpha_3 = 0$. Additionally, this regression uses $Time$ as a continuous variable, taking values from 1 to t, rather than as a dummy variable.

$$log(y_{it}) = \alpha_0 + \alpha_1 Time + \alpha_2 Group + \alpha_3 Group * Time + u_{it} \tag{5.1}$$

The null hypothesis $\alpha_3 = 0$ is tested to provide evidence of parallel trends.[19] The results of Equation 5.1 are presented in Table 5.1. As with the other tables, clustered errors at the municipality level were utilized. Since we cannot reject the null hypothesis that $\alpha_3 = 0$, it is plausible to assume that parallel trends hold. For the index based on total hours worked, the Parallel Trends assumption holds, while for the index based on total workers, the assumption is statistically significant at the 90% level. In other words, at the 90% level, the trends of the two groups are parallel.

5.1.2. No-anticipation

This section will support the assumption of no anticipation effects. Using data from ENOE,[20] I examine whether there is a pattern of increased migration from control municipalities to treated municipalities. As shown in Figure 5.1, the estimated effects over time are inconclusive and do

[19] To run this regression, data from January 2013 to December 2018 is used because parallel trends must be established before the treatment period.

[20] The survey asks people who recently moved to the area about the reason for their move. A possible answer is that they are searching for a job.

Table 5.1: Parallel trends

	Dependent variable:	
	Log of Productivity Index	
	Total Workers	Worked Hours
	(1)	(2)
Treatment*Time	-0.003*	0.002
Cluster errors at municipality level	(0.002)	(0.002)
Cluster errors at State Level	(0.002)	(0.002)
Robust standar errors	(0.0008)	(0.0008)
Observations	841	841
R^2	0.446	0.443
Adjusted R^2	0.405	0.402
Residual Std. Error (df = 783)	0.129	0.128
Note:	*p<0.1; **p<0.05; ***p<0.01	

not support the assumption of no anticipation effects.[21]

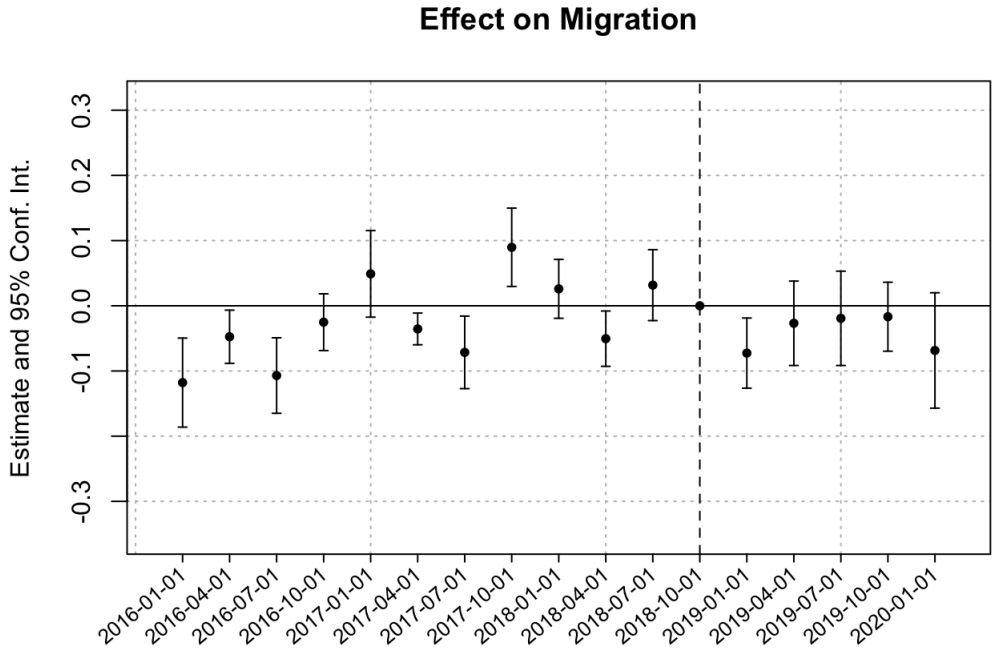
Nevertheless, there are negative effects even five years before the treatment. This suggests an unrealistic anticipation, given that the minimum wage increase was announced in December 2019. Although the effect is positive in 2017, overall, the effects are negative. In other words, being in the ZLFN generally reduces the probability of reporting a move due to job searching, except in 2017. A realistic conclusion is that no inferences can be made about migration between zones due to differences across time, both pre- and post-treatment. For this reason, Figure 4.2 might be sufficient to support the assumption of no anticipation effects.

5.1.3. Treatment exclusivity

This assumption is more difficult to uphold because, in the same year, a VAT reduction was implemented. The tax rate decreased from 16% to 8% in the treated municipalities. Calderón et al. (2022) proposed a method to separate these effects and determine whether the minimum wage had an impact on inflation. To summarize, they use instrumental variables to isolate both effects, specifically employing the proportion of workers earning at least one minimum wage as

[21] This plot was obtained by running a regression where the dependent variable is binary (0 or 1), and the regressors include a variable that takes the value of one if the city is part of the ZLFN and the date is equal to or later than 2019. Fixed effects at the city and date levels are also included.

Figure 5.1: Migration



the instrument.

For this research, the data is not yet available, making it impossible to isolate the policy effects. Following Alvarado-Pérez et al. (2023), I argue that the observed effect can be interpreted as an upper bound. This is because some studies have found that a reduction in the VAT rate affects firms' productivity by leading to a substitution of labor for capital (Yu & Qi, 2022).

5.1.4. SUTVA (Stable Unit Treatment Value Assumption)

This assumption requires that there are no spillover effects—in other words, that the outcomes of untreated units are not influenced by the outcomes of treated units. This assumption can be easily violated in cases where the treatment might be shared between control and treated units. For example, financial resources can be shared within a family, affecting the outcomes of all its members.

In this context, it is impossible to rule out the possibility that higher productivity in a ZLFN could positively influence the productivity of municipalities across the country or along the border. Bazzi et al. (2017) found spillover effects of increased productivity across firms. Therefore, it is possible to observe a bottom-up effect, where an increase in productivity in one area could translate into a general improvement in productivity across firms.

5.2. Treatment effects of Minimum Wage

Next, I present the results obtained from Equation 4.2. Overall, they indicate a positive effect on labor productivity, both in terms of hours worked and worker-based measures, specifically among blue-collar workers. In Appendix B, some robustness checks are provided, primarily consisting of placebos related to the timing of the treatment start. In summary, these checks did not show any effect before 2019.

5.2.1. Effect on Productivity Index

To mitigate the volatility of each time series, the data was aggregated into quarters, and logarithms were applied to reduce noise in profits. If necessary, the data was deflated and deseasonalized. When the minimum wage was doubled, the Productivity Index based on total workers was found to be 13.8% higher with 95% confidence, as shown in Table 5.2, while it was 13.7% higher using the Index based on worked hours, as shown in Table 5.3. Both effects are similar and statistically significant, indicating that productivity indeed increased.

Table 5.2: Results based on total workers

	Dependent variable:		
	Log of Productivity Index		
	Total Workers	Blue Collars	White Collars
	(1)	(2)	(3)
Doubling Minimum Wage	0.138**	0.137**	0.113
Cluster errors at Municipality Level	(0.061)	(0.058)	(0.092)
Cluster errors at State Level	(0.069)	(0.064)	(0.097)
Robust standar errors	(0.023)	(0.022)	(0.03)
Observations	841	841	841
R^2	0.446	0.443	0.443
Adjusted R^2	0.405	0.402	0.402
Residual Std. Error (df = 783)	0.129	0.128	0.128
Note:			*p<0.1; **p<0.05; ***p<0.01

As an approach to assessing heterogeneous effects, I constructed the same index using only

Table 5.3: Results based on worked hours

	Dependent variable:		
	Log of Productivity Index		
	Total Workers	Blue Collars	White Collars
	(1)	(2)	(3)
Doubling Minimum Wage	0.137**	0.138**	0.108
Cluster errors at Municipality Level	(0.059)	(0.057)	(0.083)
Cluster errors at State Level	(0.067)	(0.064)	(0.087)
Robust standar errors	(0.022)	(0.021)	(0.027)
Observations	841	841	841
R^2	0.446	0.443	0.443
Adjusted R^2	0.405	0.402	0.402
Residual Std. Error (df = 783)	0.129	0.128	0.128
Note:			*p<0.1; **p<0.05; ***p<0.01

Blue-Collar[22] and White-Collar workers.[23] However, it is not possible to differentiate profits between these groups of workers, which presents a limitation in accurately identifying the effect between different types of workers.

Focusing on Columns 2 and 3 of the tables mentioned above, the effect is significant only for Blue-Collar workers at different levels of clustered errors. This could be because Blue-Collar workers generally receive lower wages than White-Collar workers, and for those wage levels, there is a motivational effect, as suggested by Ku (2020).

Indeed, as depicted in Figure 5.2 of the Event Study, the effect on the Productivity Index based on total workers occurs in the same year as the policy implementation, specifically in the last quarter of 2019. In other words, after a period of one year, the effect diminishes. In the case of the Index based on worked hours, the story is repeated (see Figure 5.3).

[22] According to INEGI, this category includes workers who operate machinery to produce goods, perform auxiliary tasks, and also includes specialists, professionals, and delivery personnel.

[23] This category includes workers who perform office tasks, management, sales, accounting, executive duties, as well as planning, organization, and control within the firm.

Figure 5.2: Event Study of Effect on Productivity

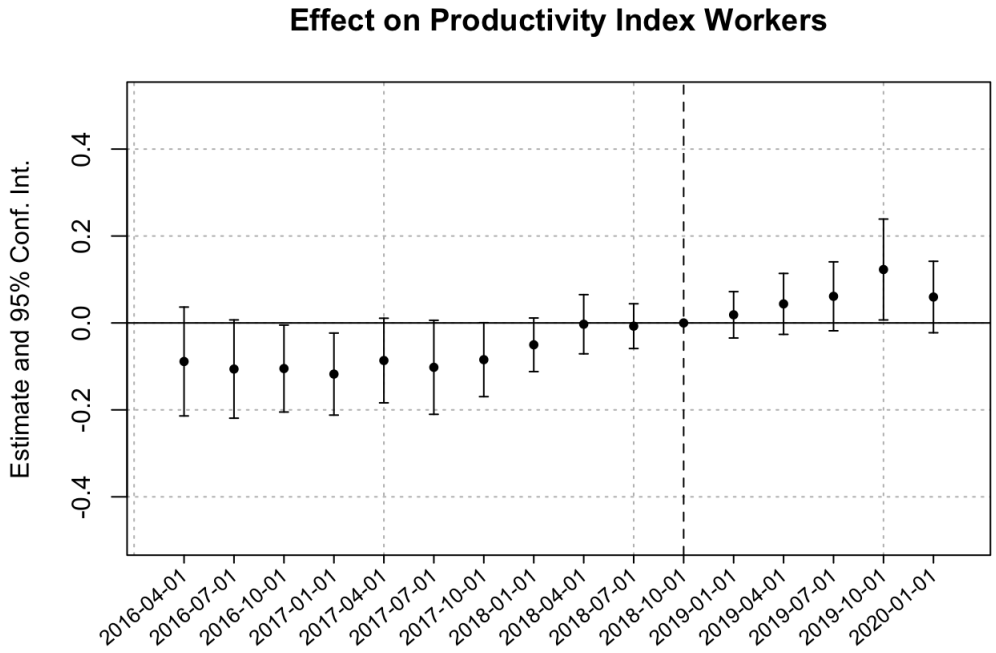
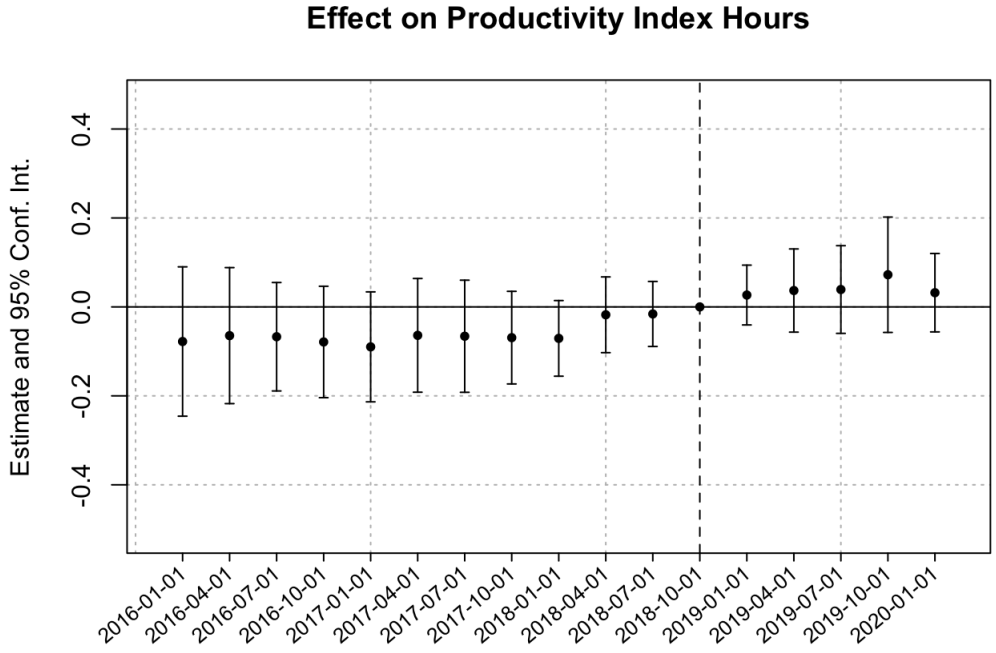


Figure 5.3: Event Study of Effect on Productivity based on Hours



5.3. Causal Mechanism

To comprehend which theory can elucidate the impact on productivity, it is imperative to consider different mechanisms. In this section, organizational changes will be analyzed. Due to the unavailability of data to directly discern motivation or effort, statistical inference is not feasible. However, the IMMEX database provides monthly data on firms' expenditure for workers who organize and lead human capital.

5.3.1. Effect on Expenditure on planning

Using a DiD design, Table 5.4 demonstrates that treated municipalities do not allocate more resources towards planning and organizational workers. Therefore, suggesting a shift in organizational structure within the firms is not plausible. Although the estimated effect is positive in treated municipalities, it is not statistically significant. Additionally, in an Event Study Plot, there is no effect in any period. This does not eliminate the possibility of organizational changes altogether, but with the available data, this analysis is not feasible.

Table 5.4: Mechanism: Expenditure on planning

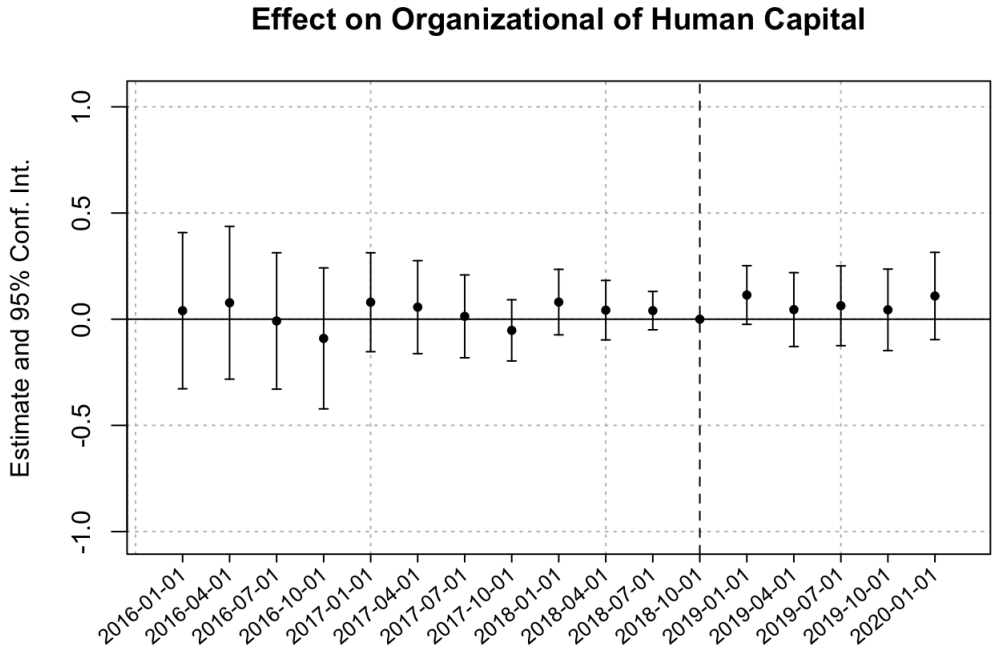
	Dependent variable:
	Log of Expenditure on planning
Double Minimum Wage	0.052
	(0.075)
Observations	841
R^2	0.019
Adjusted R^2	0.015
Residual Std. Error	0.898 (df = 837)
Note: Cluster Errors at Municiplaity Level	*p<0.1; **p<0.05; ***p<0.01

5.3.2. Effect on Searching another job

Another prediction of the theories presented above, specifically efficiency wage theory, is that the opportunity cost of losing a job increases (Coviello et al., 2022). There is no direct way to prove this hypothesis with the available data, as opportunity costs cannot be measured directly. Nevertheless, the ENOE provides useful information about workers' planning.

The intuition for validating whether there is an effect on opportunity cost, and thus evidence of efficiency wages, is as follows: the cost of losing a job is the wage earned in that job. When

Figure 5.4: Expenditure on planning



wages increase, the opportunity cost of losing the job also rises. If we assume that workers aim to maximize their utility or minimize their costs, a higher opportunity cost might lead them to either consume more leisure or seek a better-paying job. This is because the increased opportunity cost makes the current job less attractive compared to alternative options.

Table 5.5: Mechanism: Firms destruction

	Dependent variable:
	Number of firms
Double Minimum Wage	5.509**
	(2.169)
Observations	493
R^2	0.019
Adjusted R^2	0.011
Residual Std. Error	0.898 (df = 837)
Note: Cluster Errors at Municiplaity Level	*p<0.1; **p<0.05; ***p<0.01

In this context, whether a worker is seeking another job can be interpreted as a proxy for the

perceived opportunity cost, since a higher wage increases the cost of losing the job. Therefore, in treated cities, there will likely be fewer workers searching for another job compared to control cities. However, this is only a proxy, as it is not possible to directly measure the willingness to consume more leisure. Additionally, this approach suggests that both labor markets are not functioning efficiently, as there are individuals willing to seek better-paying jobs, consistent with the predictions of efficiency wage theory.

The results of this regression, presented in Table 5.6, suggest that the probability of searching for a job in treated municipalities is lower than in control municipalities. Nevertheless, this result is not statistically significant.

Table 5.6: Workers searching another job

	Dependent variable:
	Searching another job
ZLFN	-0.179
	(0.183)
Observations	2,788,734
Note: Cluster Errors at Household Level	*p<0.1; **p<0.05; ***p<0.01

5.3.3. Moving to Formality

In addition, another explanation for the main result is the movement of workers from the informal sector to the formal sector. This theory suggests that the formal sector is more productive than the informal sector. To evaluate this possibility, I present Table 5.7. The estimated effect is negative, meaning that being in the ZLFN reduces the probability of informal work. This may indicate a reallocation of productive resources from the informal to the formal sector. These findings are consistent with Alvarado-Pérez et al. (2023).

5.3.4. Effect on reallocation of productive workers

A complementary hypothesis for the reallocation of productive resources is that it occurs between economic sectors. It assumes that the manufacturing sector is more productive than others. For example, if the manufacturing industry is more productive than other sectors, workers from less productive sectors may move to manufacturing, which could increase their wages above those in less productive sectors, leading to higher overall productivity. A more accurate

Table 5.7: Workers in formal sector

	Dependent variable:
	Informal sector
ZLFN	-0.088^{***}
	(0.026)
Observations	2,788,734
Note: Cluster errors at household level	*p<0.1; **p<0.05; ***p<0.01

analysis would involve examining the productivity of each sector in the ZLFN, but this data is not yet available.

Table 5.8 shows that the estimated effect is positive. In other words, a reallocation of productive resources between sectors in the ZLFN is plausible based on the available data, but the magnitude of the effect should be interpreted with caution. Nevertheless, this result could indicate a significant change in the productive structure of the ZLFN, potentially influenced by additional policies related to tax reductions. A detailed analysis of the movement of firms will be developed in the next subsection.

Table 5.8: Workers in manufacturing sector

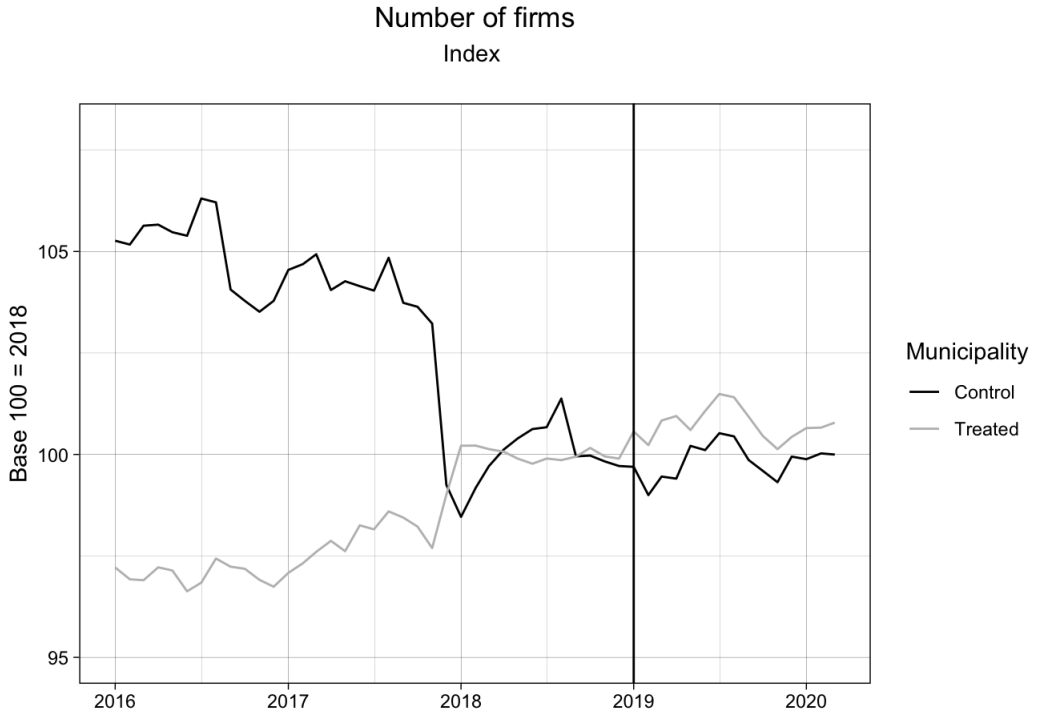
	Dependent variable:
	Manufacturing sector
ZLFN	0.276^{***}
	(0.039)
Observations	2,788,734
Note: Cluster errors at household level	*p<0.1; **p<0.05; ***p<0.01

5.3.5. Effect on Destruction of Firms

Now, I will analyze whether the effect on the number of firms can explain the significant increase in labor productivity. As mentioned earlier, an increase in labor costs can lead to the exit of less efficient firms, which in turn can boost the overall productivity of the sector.

In fact, the results of the regression show a positive effect: doubling the minimum wage makes it more attractive for firms to move to the frontier zone. Although this result might seem counterintuitive, it can be explained by the reduction in VAT and other potential policies

Figure 5.5: Number of firms Index



implemented alongside the minimum wage increase, such as reductions in income tax (ISR) or fiscal incentives. These measures may offset the increase in labor costs, making the move to the ZLFN more attractive. Firms with certain unobservable characteristics may be more inclined to relocate there.

Nevertheless, it is clear that this process appears to have occurred primarily in the last month of 2017, as shown in Figure 5.5. While explaining why this timing occurred is beyond the scope of this research, a potential line of investigation could be the uncertainty caused by the U.S. government under Donald Trump and his trade war against China during that period.

5.3.6. Effect on Unemployment

Finally, as described in the Literature Review section, efficiency wage theory suggests a reduction in employment levels. Although several studies on this policy did not find any effect on unemployment, these studies generally examined all industries. The only research focusing specifically on the manufacturing sector did find a reduction in employment within that sector.

In this research, although a negative effect was observed, it is not statistically significant at any level. For this regression, the unemployment rate was calculated for each city at each quarter of the year, rather than using a household representation of the data, as indicated in Table 5.9.

Figure 5.6: Event Study of Index of Number of Firms

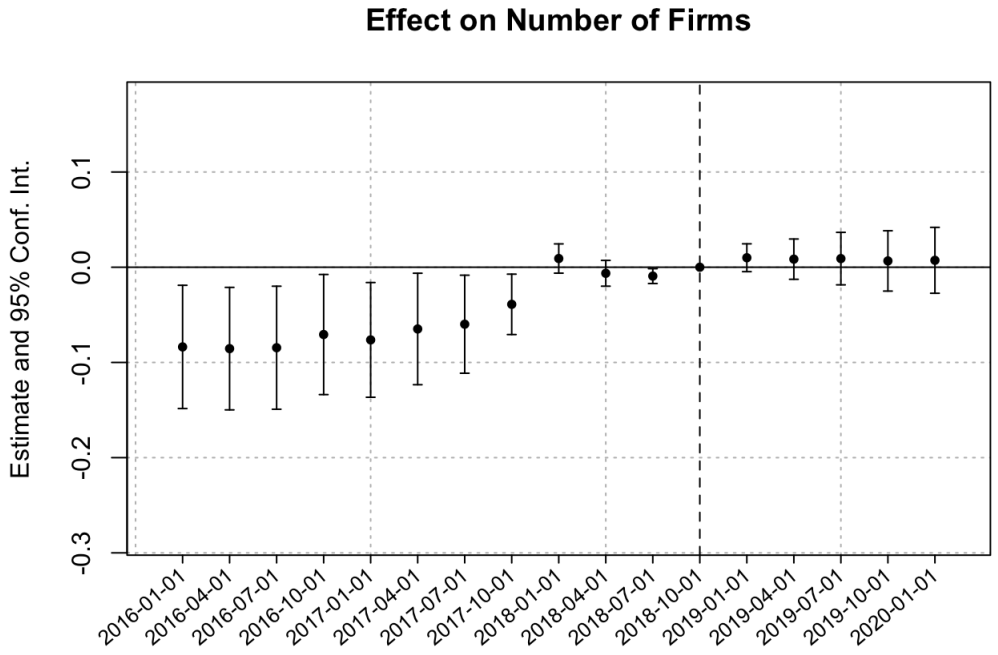


Table 5.9: Unemployment Rate

	Dependent variable:
	Unemployment Rate
ZLFN	−0.27
	(0.19)
Observations	146
Adjusted R2	0.789

Note: Cluster errors at city level *p<0.1; **p<0.05; ***p<0.01

6. Conclusion

This research has explored an alternative perspective on the relationship between minimum wages and productivity. Traditionally, mainstream economics, supported by various economists and institutions in Mexico, has argued that raising the minimum wage would not only fail to improve workers' real wages but would also lead to inflation and unemployment. However, a substantial body of literature with alternative economic approaches suggests that minimum wage policies may not only avoid negative effects on inflation and unemployment but could also enhance productivity levels, consistent with the efficiency wage theory and other theories which indicates effect on substitution of productive resources or transtioning to formality.

The findings of this research indicate that the increase in minimum wages in the ZLFN had a positive effect on labor productivity, but this effect was observed only in the short term and was specific to blue-collar workers rather than white-collar workers. This may be attributed to the lower wages of blue-collar workers, which could lead to a higher level of compliance with the minimum wage policy. This outcome aligns with the efficiency wage theory and existing literature, which suggests that minimum wage increases can positively impact productivity among lower-wage workers. However, this result is somewhat challenged by the lack of observed effect on unemployment, which complicates the direct application of the efficiency wage theory in this context.

For this reason, another possible explanation was considered: the increase in productivity could be a reciprocity effect of higher wages, where workers respond to increased wages with greater effort. Unfortunately, empirical evidence for this reciprocity effect is challenging to obtain without specific measures of effort at the employer level. Additionally, further analysis with more disaggregated data and additional information could potentially reveal effects related to the reallocation or substitution of productive resources across sectors.

In addition to the main results of this research, it is important to highlight that the possible causal mechanism of unproductive firm destruction could challenge the hypothesis of this work and the validity of its inferences. There is a clear change in the trend of the number of firms observed prior to the doubling of the minimum wage. It is also possible that the observed increase in productivity was influenced by reductions in income tax and VAT, which may have incentivized productive firms to relocate to the ZLFN. However, exploring these mechanisms

falls outside the scope of this research.

This result can be accompanied by two additional findings. First, consistent with previous research, a reduction in the probability of being part of the informal sector was observed. This suggests that productive firms may have moved to the ZLFN, increasing formal employment. Specifically, these firms are likely manufacturing firms, which could indicate that productive firms are relocating to the ZLFN and employing productive workers. Consequently, this shift may enhance the overall productivity of the sector in the ZLFN. This outcome appears to be a result of tax reductions rather than higher wages. In fact, Figures 4.1 and 4.2 show a reduction in the Productivity Index, indicating a reallocation of productive firms.

Finally, the evidence does not clearly indicate whether the observed increase in labor productivity was due to an efficiency wage mechanism or a motivation theory. Establishing a robust causal relationship between the minimum wage increase and productivity improvement remains uncertain. It is possible that the productivity increase could be attributed to a reallocation of productive firms moving to the ZLFN, which might have occurred before the minimum wage increase and fiscal incentives were implemented. Again, these hypotheses are beyond the scope of this research.

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A. Statistics of municipalities

Table A.1: General statistics in 2018. All firms of IMMEX database.

Statistic	Mean	St. Dev.	Min	Max
Firms	106.721	111.033	28	610
Blue Collars (BC)	39,114.190	51,119.060	3,453	230,788
White Collars (WC)	5,831.724	5,017.406	594	24,149
External BC	7,801.299	6,795.230	71	26,047
External WC	1,607.095	1,354.339	6	5,292
Wages BC	359,898.300	434,980.300	23,750	2,284,306
Wages WC	186,502.000	182,368.100	10,153	988,478
Worked hours BC	7,498.342	9,484.343	616	42,762
Worked hours WC	1,162.931	970.201	119	4,758
Worked hours external BC	1,538.721	1,342.420	15	5,716
Worked hours external WC	317.359	268.924	1	1,095
Worked days	2,496.603	2,512.307	576	14,627
Domestic income from sales	2,300,328.000	2,321,165.000	1,645	9,806,010
Domestic income from manufactur	36,016.750	54,973.160	0	240,946
Domestic income from manufactur	32,533.600	50,773.870	23	508,311
Foreign income from sales	3,409,316.000	4,209,717.000	22,782	18,530,756
Foreign income from manufactur	1,331,976.000	1,954,226.000	137	9,806,299
Foreign income from manufactur	6,055.885	12,618.920	0	91,325

Figure A.1: Productivity Index of municipalities (number of workers)

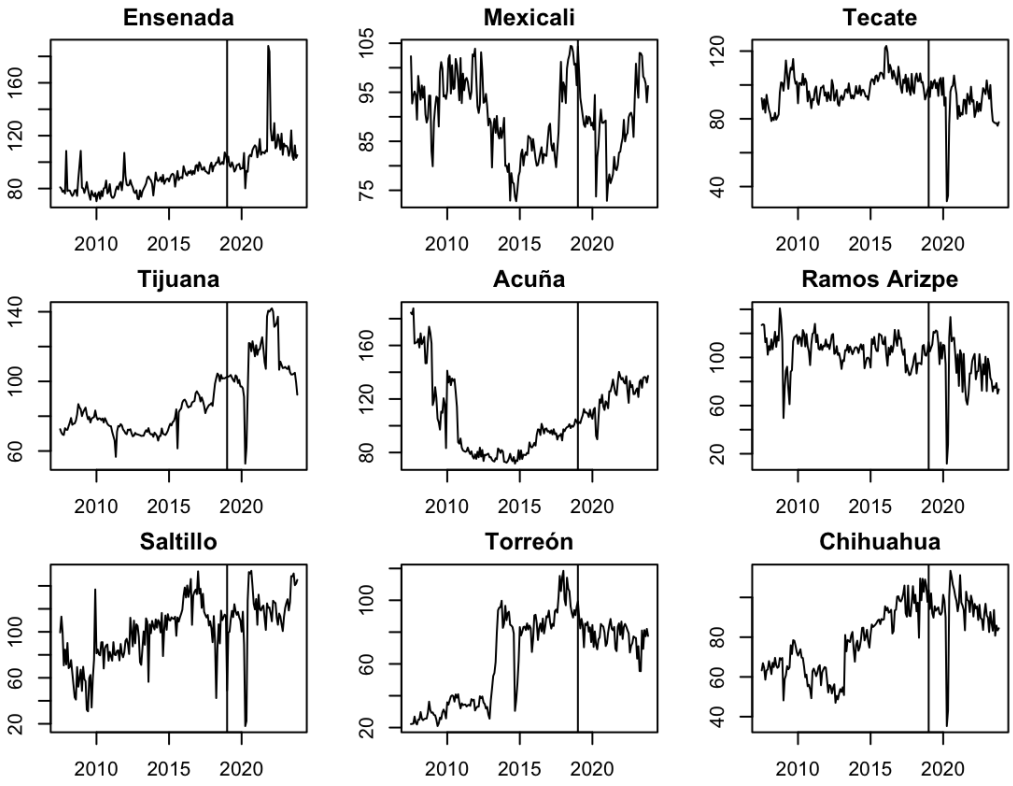


Figure A.2: Productivity Index of municipalities (number of workers)

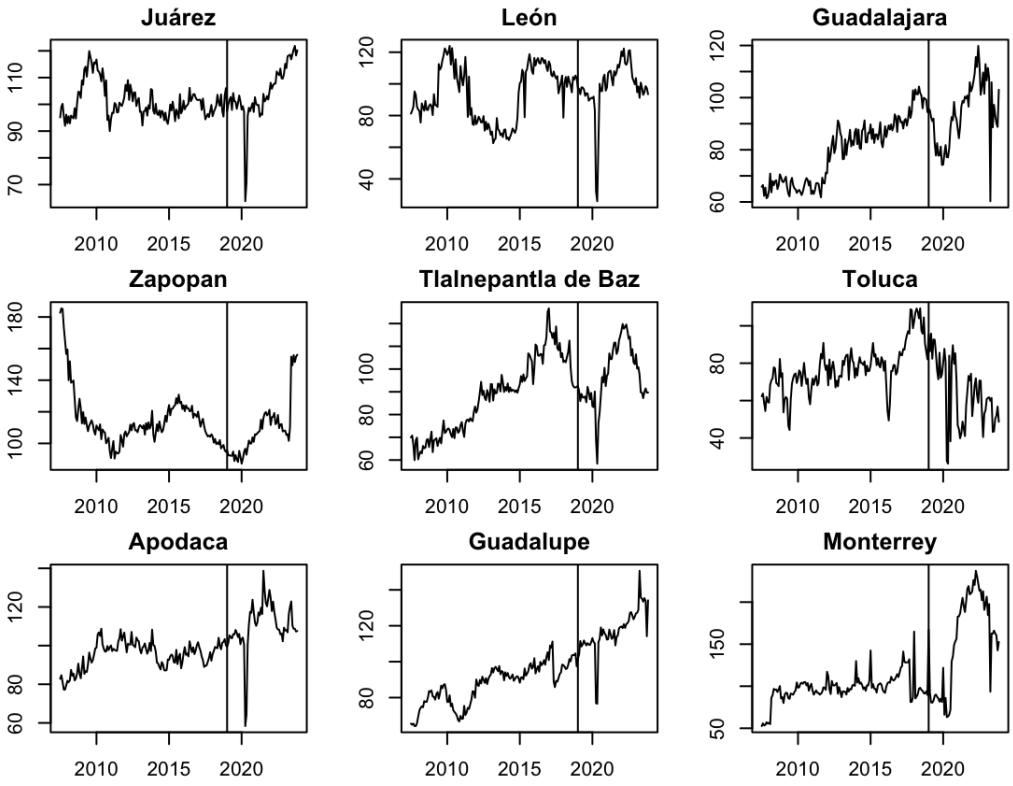


Figure A.3: Productivity Index of municipalities (number of workers)

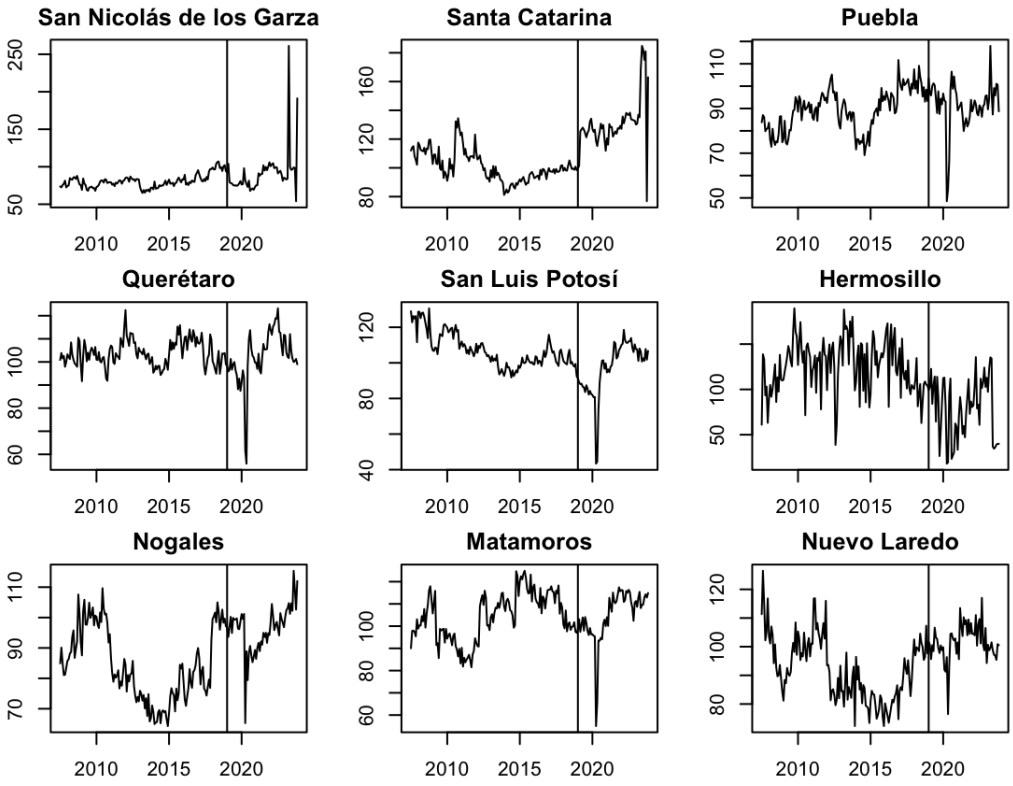


Figure A.4: Productivity Index of municipalities (number of workers)

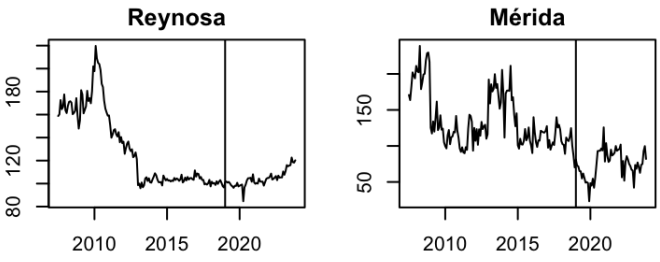


Figure A.5: Productivity Index of municipalities (number of hours)

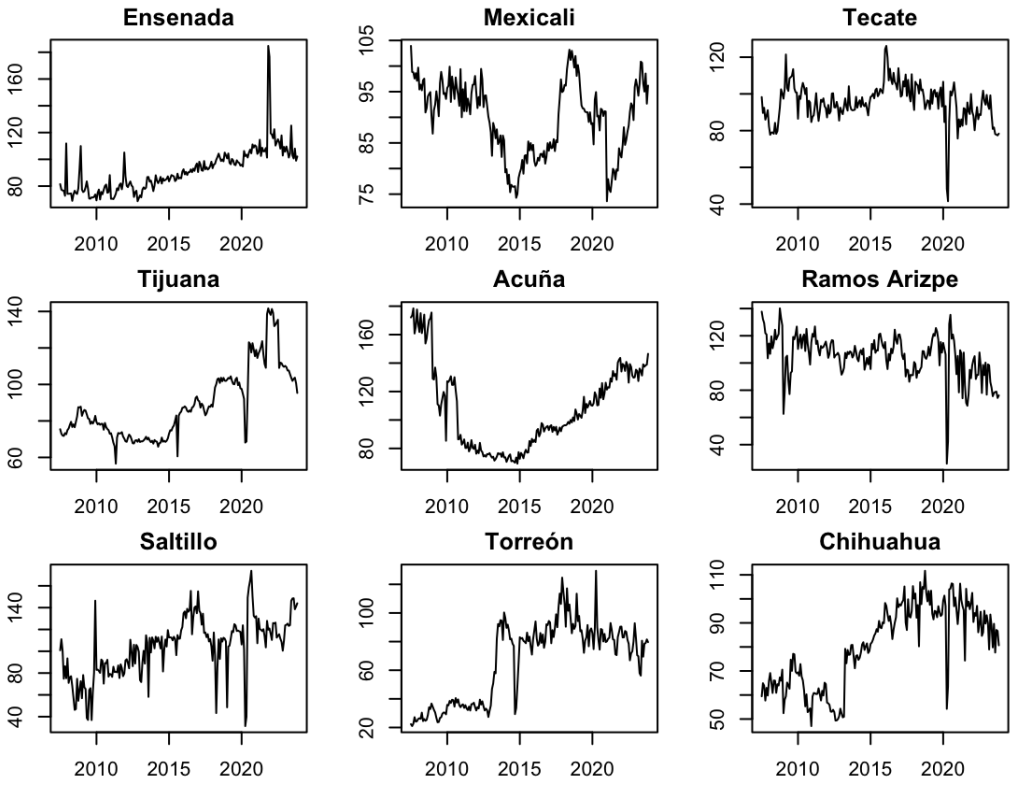


Figure A.6: Productivity Index of municipalities (number of hours)

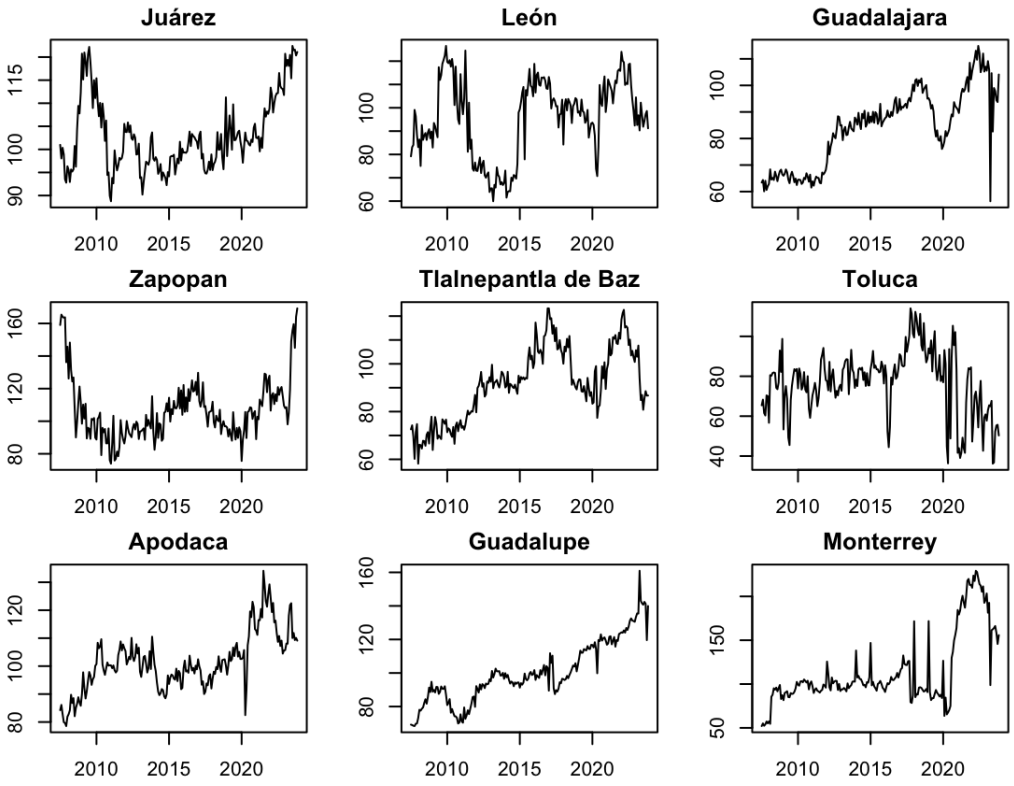


Figure A.7: Productivity Index of municipalities (number of hours)

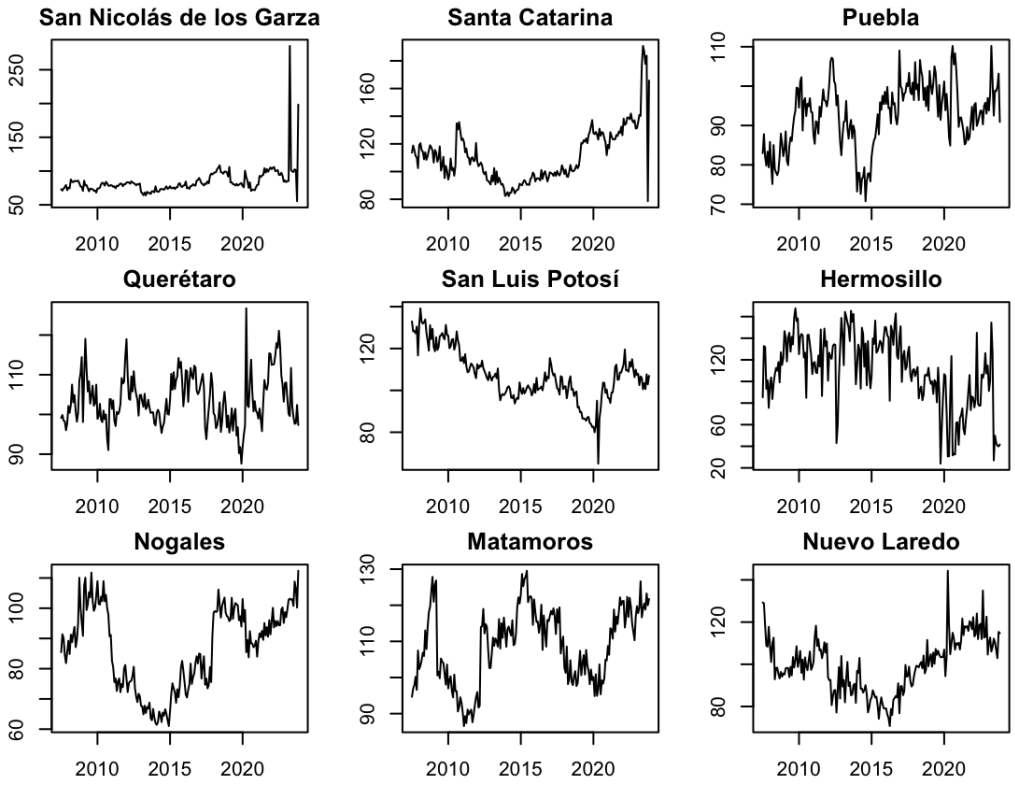
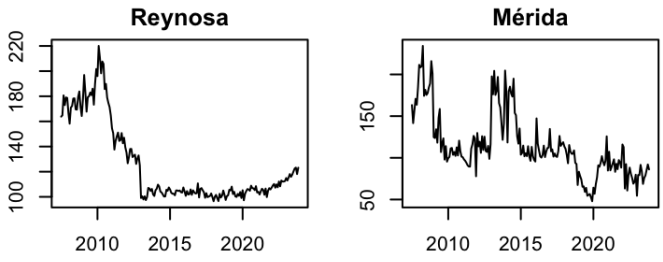


Figure A.8: Productivity Index of municipalities (number of hours)



B. Robustness check

In this section some typical standar test are presented. In Table B.1 a placebo test is presented using different dates.

Table B.1: Placebo test

	Dependent variable:		
	Log Index Productivity		
Quarter Placebo	2017/01	2018/01	2020/01
Doubling minimum wage	0.041	0.087	0.108
Cluster errors at municipality level	(0.056)	(0.062)	(0.068)
Cluster errors at state level	(0.058)	(0.067)	(0.081)
Observations	1,044	1,044	1,044
R^2	0.470	0.436	0.390
Adjusted R^2	0.436	0.395	0.350
Residual Std. Error (df = 783)	0.130	0.130	0.130

Note: To preserve observations a rolling window was applied to data.