The Minimum Wage in Formal and Informal Sectors: Evidence from an Inflation Shock

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This draft: Apr 15, 2019†

Abstract

I estimate the effect of the minimum wage on formal wages, informal wages, and employment. I exploit an unexpected increase in the real minimum wage during 1999 in Colombia. My analysis combines unconditional quantile regressions with a differences-in-differences design. I find evidence of wage responses for wages close to the minimum wage. The increases are present in both the informal and formal sectors, and are larger in the formal one. Wages around the minimum increase by around 3 percent in the formal sector for a 10 percentage points larger minimum wage incidence, and by around 1 percent in the informal sector. These increases are smaller than those implied by full compliance to minimum wage policy, but positive for some unaffected workers. This suggests employers partially comply with the minimum wage and use it as a reference. I find slight negative employment effects on the informal sector, but not on the formal sector. The effects in the informal sector are not driven by cross-sectoral effects. The

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†Declarations of interest: none. An earlier version of this paper, titled "Minimum Wages in Formal and Informal Sectors: Evidence from the Colombian Crisis" is part of my Ph.D. dissertation at Brown University. I thank Kenneth Chay, Darwin Cortés, Nathaniel Hilger and Juan Vargas for providing guidance and data for this project. I thank Andrea Garnero, Oskar Nordstrom-Skans, and three anonymous referees for Banco de México's working paper series for their discussion of the paper. This paper benefited from comments and suggestions from Jeffrey Clemens, Arindrajit Dube, Juan Gallego, Paula Herrera, David Jaume, Lawrence Katz, Melanie Khamis, Darío Maldonado, Blaise Melly, Sriniketh Nagavarapu, Carlos Sepúlveda, Matthew Turner, and seminar audiences at Banco de México, Brown University, LACEA and the World Bank. Diego Mayorga and Tatsiana Syman provided great research and editorial assistance. I acknowledge financial support from Fulbright-Colciencias. All remaining errors are my own.

results suggest the minimum wage has a direct impact on the informal labor market, although they may not apply to minimum wage changes in other countries or contexts, or to larger minimum wage increases.

Keywords Minimum wage, wage distribution, informal labor markets.

JEL Codes J31, J38, J46

1 Introduction

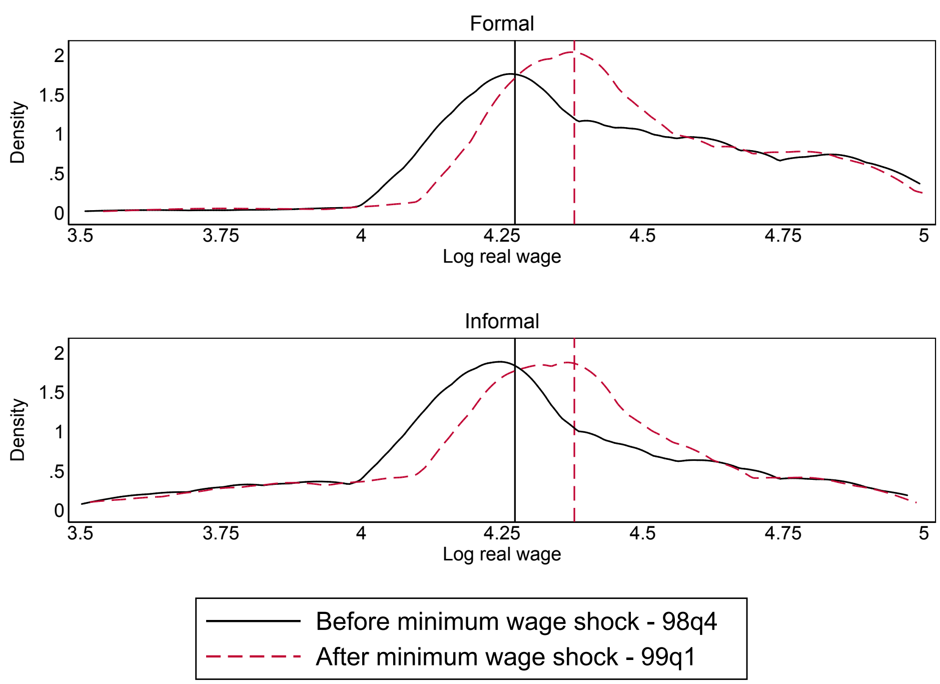
The minimum wage is a typical policy in developed and developing countries. It is a tool to prevent low skilled workers from earning below-subsistence wages. Most of the literature about the impact of the minimum wage focuses on the effects on a labor market with regulatory compliance. We know less about the effects of the minimum wage on informal labor markets. In them, labor regulations are unlikely to be binding and compliance is low.

A common finding in the labor literature for developing countries is the incidence of the minimum wage on informal labor markets (Maloney and Mendez, 2004; Gindling and Terrell, 2005; Lemos, 2009; Khamis, 2013). This literature shows that informal wage distributions peak at the minimum wage level. For formal markets in developing countries, the literature suggests the minimum wage affects the lower tail of the wage distribution (Bosch and Manacorda, 2010). There is less evidence about how the minimum wage impacts informal wages. It may have a direct impact on the informal market by influencing informal labor contracts. It may also have an indirect impact, through interactions with the formal sector.

In this paper, I estimate the effect of the minimum wage on the distribution of wages. I do this for formal and informal labor markets in Colombia. I define informal workers as those that do not have access to employee health insurance. I exploit an inflation forecast error in 1999, which produced a large unexpected real minimum wage increase. Colombian authorities increased the national minimum wage by 16 percent by the end of 1998. This minimum wage increase was equal to expected inflation in 1999. However, because of a crisis, actual inflation was below expected, and the real minimum wage had a steep increase.

Figure 1 shows the wage density for the formal and informal sectors before and after the minimum wage shock. Visual evidence suggests that both sectors react to the shock. The density shifts around the percentiles where the minimum wage binds. I estimate the effect of this unexpected shock on the marginal distributions of formal and informal wages. I also address direct and indirect effects on the informal sector. I do this in three steps. First, I measure the incidence of the minimum wage across different city-industry blocks in both sectors.

Figure 1: Density of Monthly Wages in the Formal and Informal Sectors.



Data are from the National Household Survey (ENH). Real wages for 1998, converted to US dollars using a 1 dollar = 2000 pesos exchange rate. Observations with log wages smaller than 3.5 or larger than 5.5 are excluded. Densities are estimated with a gaussian kernel and a bandwidth of 0.08. Vertical lines at the level of minimum wages in 1998q4 and 1999q1.

Second, I compare wage distributions between city-industry blocks with different incidence. To estimate the effect on these wage distributions, I use an unconditional quantile regression method (Firpo et al., 2009a), and exploit the minimum wage shock using a differences-in-differences design. Unconditional quantile regressions estimate the impact on the marginal distributions depicted in figure 1 directly, as opposed to estimating the effects on the conditional distribution of wages through conditional quantile regression, or on mean wages through linear regression.

A major challenge to identify the effects of the minimum wage in this context is the concurrence of the financial crisis and the minimum wage shock. Estimating the minimum wage effect by comparing city-industry blocks rests on a key identifying assumption: city-industry blocks with different minimum wage incidence should be differentially affected by the minimum wage shock, and not differentially affected by the crisis. Time-varying labor market differences between cities and industries may invalidate the design. I address this concern by controlling for city-specific trends and local labor demand shocks.

I measure the minimum wage incidence by the fraction of workers affected by the increase. I find that following the minimum wage change, higher incidence of the minimum wage implies larger wages. This occurs in both sectors around the percentiles where the minimum wage falls. The effects do not propagate to the rest of the distribution. For the formal sector, a 10 percentage points higher incidence implies 4 percent higher wages around the minimum wage. In the informal sector, wage responses are more limited and centered around the median. Wages are about 1.3 percent higher for a 10 percentage points larger incidence.

I compare these effects with a counterfactual scenario where all workers affected by the minimum wage received a wage increase. I find that the estimated effects are larger than the counterfactual for the lower tail of the distribution. They are smaller than the counterfactual around the minimum wage. This implies a partial response of formal wages to the increase, suggesting there is partial compliance with the minimum wage policy. This also suggests the minimum wage is used as a reference in wage-setting.

In the third part of the paper, I test for cross-sectoral effects from the formal to the informal sector. I do this by looking at the effect of the formal sector minimum wage incidence on informal wages. I find that the informal sector wage responses are not explained by cross-sectoral effects from the formal sector. High minimum wage incidence in the formal sector does not translate into informal wage responses. When I turn to employment effects, I find small and insignificant effects on the formal sector. However, I find some slight evidence of employment reductions in the informal sector. These results suggest informal employment is more flexible. This is consistent with theories of imperfect compliance with the minimum wage.

This paper contributes to the literature estimating the distributional effects of minimum wages. In the U.S., these studies have followed different approaches, like decompositions (DiNardo et al., 1996), quantile regressions (Lee, 1999; Autor et al., 2016), and panel data studies (Neumark et al., 2004). There are several theoretical explanations for effects on the entire wage distribution. Substitution from low skilled to high skilled labor could lead to wage gains for workers earning above the minimum. If the minimum wage is used as a reference value, then its increase can lead to a shift in the whole distribution.

There are also several papers estimating distributive minimum wage effects in developing countries. In Latin America, Bosch and Manacorda (2010) find reductions in inequality in Mexico attributed to minimum wage increases. Bouchot (2018) finds evidence of increases along the whole wage distribution in Mexico after a minimum wage increase. Gindling and Terrell (2005) argue the minimum wage reduced formal and informal wage differentials in Costa Rica, despite low enforcement. Gindling and Terrell (2007) find small negative employment effects in the Costa Rican formal sector, but not in the informal one. Lemos (2009) provides descriptive evidence of responses of wage distributions to the minimum wage in Brazil in both sectors. Khamis (2013) finds larger impacts of increases in the minimum wage in the informal sector when compared to the formal one in Brazil and Argentina. Moser and Engbom (2018) argue that higher minimum wages led to compression of the wage distribution in Brazil, according to both a wage ladder model and reduced-form estimates.

Unlike these U.S. and Latin American studies, this paper uses an unexpected shock in the real minimum wage as a source of identifying variation. I focus on the response in both sectors as well as the cross-sectoral effects across them. The fact that I do not find evidence of cross-sectoral effects is at odds with the theories of the interaction between sectors. In a competitive, segmented labor market model (Harris and Todaro, 1970), a rise in the minimum wage would raise covered sector wages above the competitive level for workers in the lower part of the covered sector wage distribution. Some of these workers would be dismissed, and would go to the uncovered sector at wages below the new minimum wage. The additional labor supply in the uncovered sector would decrease wages. However, I do not find evidence of wage decreases in the informal sector.

Effects in both sectors could also happen because of capital relocation into the informal sector. This would increase the marginal productivity of labor. The wage increase in the covered sector could also raise the demands for goods produced in the uncovered sector (Khamis, 2013). This is at odds with my findings since the formal sector minimum wage incidence does not seem to impact informal wages.

This paper also contributes to the literature about the effects of the minimum wage in Colombia. Maloney and Mendez (2004) argue the minimum wage is binding and induces spikes in the wage distribution. Using time series methods, they find that the minimum wage increases wages along the wage distribution. Unlike this paper, my results use cross-sectional variation in minimum wage incidence and a shock in its real value. I also analyze the effects on the unconditional distribution of wages (Aeberhardt et al., 2016; Lathapipat and Poggi, 2016; Bouchot, 2018).

Using dynamic panel data methods,Arango and Pachón (2007) find the minimum wage reduces formal sector family incomes in the first decile. They also find positive and significant effects for higher deciles, leading to an increase in inequality. They do not address the impact on the informal sector, nor do they examine wages. Arango and Flórez (2017) argue that the minimum wage increases informality in cities where it is high compared to the median. They do not carry out any distributional analysis.

Mondragón et al. (2010) use time and city variation in the median to minimum wage ratio to estimate its impact on the probability of being informal. They find that a 10 percent increase in the minimum wage raises the probability of being informal by 1 percent. This suggests the existence of cross-sectoral effects from the formal to the informal sector. My paper suggests that while the minimum wage affects the informal market, this impact is due to within-sector effects. I do not find increases in informal employment following the real minimum wage shock. However, I do not address the effect on the probability of transition between sectors.

The effects I find should be extrapolated with caution, due to the particularities of the institutional setting. One should not expect these effects to hold for other developing countries with high rates of informality, or to large real minimum wage increases that may not stem from inflation shocks.

The rest of the paper proceeds as follows. Section 2 provides some facts about the evolution of the minimum wage in Colombia and the inflation shock. In section 3 I discuss the empirical strategy. I describe the data and provide some facts about the size of the sectors and the incidence of the minimum wage in section 4. The main results and robustness checks are in section 5. Section 6 concludes.

2 The Minimum Wage in Colombia and the 1999 Shock

In this section, I provide key facts about minimum wage legislation in Colombia and explain the 1999 shock in the real minimum wage. I show that the 1999 financial crisis produced a steep, unexpected increase in the real minimum wage. I use this shock to estimate the effects of a higher minimum wage incidence on formal wages, informal wages, and unemployment.

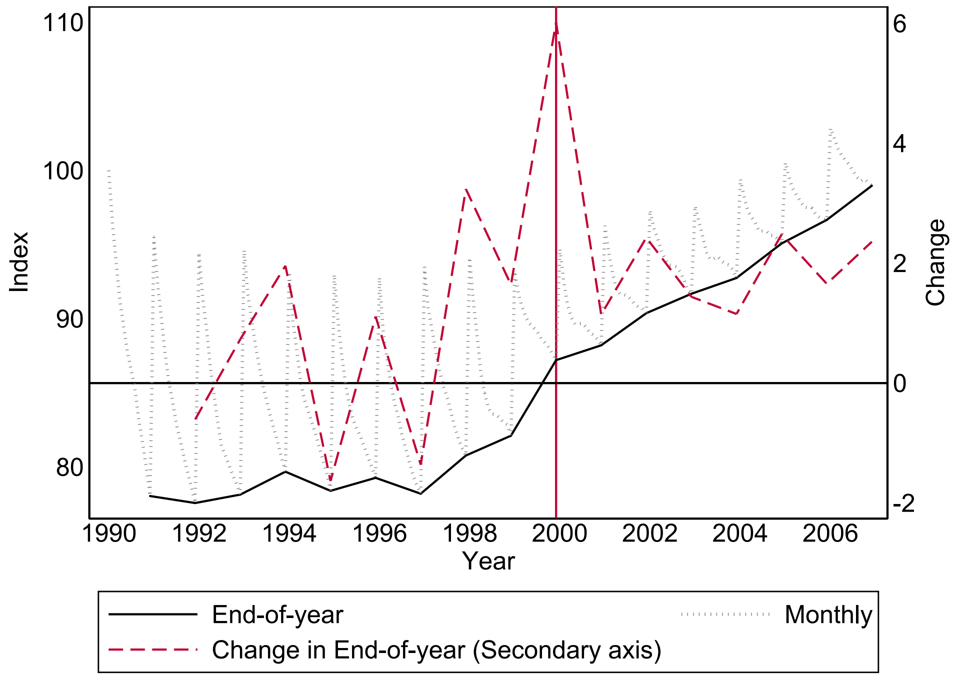
Arango et al. (2008b) summarize the evolution of the minimum wage in Colombia and the changes in minimum wage legislation. Current minimum wage regulation in Colombia is linked to living expenses and changes in labor productivity. In 1996, a commission to determine the minimum wage was established. It is formed by representatives of the government, firms, and unions. Every year, the commission negotiates a minimum wage increase for the following year. If the commission is unable to secure an agreement before December 15, the government decides the increase to the minimum wage before the end of the year.

Up to 1998, the government set the minimum wage according to several parameters: the inflation target for the following year, increases in labor productivity, GDP growth and the evolution of the consumer price index. From December 1999, the Constitutional Court also required the minimum wage's increase to not lie below the previous year's inflation. Because of this, the minimum wage has increased its real value since 2000. The minimum wage has historically been large in Colombia by Latin American standards. In 1998, the ratio of the minimum wage to the median wage was 0.68 (Maloney and Mendez, 2004).

Figure 2 shows the evolution of real minimum monthly wages since 1990. Over this period, the nominal minimum wage ranges from 88 current USD per month in 1990 to 123 USD per month at the end of 2012. The real value of the minimum wage jumps every January as the minimum wage is adjusted. Through the rest of the year, these real increases are dissipated by inflation. The end-of-year real value of the minimum wage remained stable until 1997 when it started increasing steadily. In 1999, the real minimum wage has a large increase.

The causes of the 1999 financial crisis in Colombia have been extensively studied (Parra and Salazar, 2000; Villar et al., 2005; Gómez-Gonzalez and Kiefer, 2009). Colombia experienced a credit boom in the 90's as a consequence of a financial liberalization. A significant expansion of the number of financial institutions and loans was accompanied by reductions in loan quality. Also, monetary policy contributed to increases in interest rates. By 1999 a large capital reversion and a decrease in the terms of trade occurred. Sudden increases in non-performing loans forced the government to intervene and liquidate many of the institutions. GDP decreased by about 4 percent in 1999, but the crisis subsided over the course of two years, and by 2001 it was back at its 1998 level. Unemployment spiked up during the crisis: in 19998q4 the unemployment rate for the 7 largest cities was 15.6%, and it increased to 18% by 1999q4, returning to pre-crisis levels in 2002.

Figure 2: Evolution of the Real Minimum Wage in Colombia. Index 1990=100.



Source: Colombia's Central Bank, Banco de la República. Author's calculations.

By the last quarter of 1998 inflation was expected to be 16 percent for the upcoming year, and the minimum wage was increased accordingly. However, inflation in 1999 turned out to be only 9.25 percent due to the financial crisis. The real minimum wage increased by 6.75 percent by the end of 1999. For the first quarter of 1999, inflation was about 5 percent, so the real minimum wage increased 11 percent between 1998q4 and 1999q1. This change was set by the government without agreement from the minimum wage commission.

Unlike the previous changes in 1997 and 1998, this change was due to a misalignment between the expected and actual inflation during 1999. Moreover, this change is different to posterior increases due to its unexpected nature. After 1999, the minimum wage increases continues to increase in real terms. These increases are expected, however, because of a 1999 court ruling that required minimum wage increases not to be below the inflation of the previous year, instead of fixing them according to expected inflation.[1]

Due to the unexpected and external nature of the financial crisis, this shock is ar-

[1] Corte Constitucional de Colombia (1999)

guably more exogenous than other minimum wage increases analyzed for developing countries (Lemos, 2009; Khamis, 2013). The change was nationwide, and the posterior inflation misalignment was unexpected, so the shock was unlikely to be driven by local labor market conditions. However, a major challenge to identification of the effects of the minimum wage shock is the concurrence of the minimum wage shock and the financial crisis. The crisis also caused changes in unemployment and in the wage distribution, and it is hard to isolate these effects form the effects of the minimum wage. In the next section, I describe a differences-in-differences strategy to estimate the minimum wage effects.

3 Empirical Strategy

In this section, I describe the empirical strategy used to estimate wage effects through the distribution of formal and informal wages and to estimate employment effects. To estimate the wage effects, I combine an unconditional quantile regression method and a differences-in-differences specification to estimate a quantile differences-in-differences model. I explain how this methodology relates to other estimation strategies of the distributional effects of the minimum wage. I show how I build measures of the minimum wage incidence around the 1999 real minimum wage shock. To estimate the employment effects, I use a standard differences-in-differences specification, which I describe at the end of the section.

3.1 Effects on the Wage Distribution

3.1.1 Unconditional Quantile Regressions

My objective is to estimate the effect of the change in the minimum wage on the unconditional wage distributions of figure 1. Assume that wages in either sector follow a structural model $W = h(X, \varepsilon)$, where X is a set of covariates which includes the minimum wage, ε is an unobservable term, and $h(.,.)$ is invertible in ε. I start from writing the marginal distribution of wages $F_W(w)$ in either sector as a function of the conditional distribution of wages $F_{W|X}$

and the joint distribution of covariates $F_X(x)$:

$$F_W(w) = \int F_{W|X}(w|X = x)dF_X(x). \tag{1}$$

Changes in the minimum wage alter the distribution of covariates to $G_X(x)$. Assuming the conditional distribution of wages $F_{W|X}$ remains constant, the counterfactual distribution of wages after a minimum wage change is:

$$G_W(w) = \int F_{W|X}(w|X = x)dG_X(x) \tag{2}$$

Counterfactual distribution methods (Mata and Machado, 2005; Chernozhukov et al., 2013) focus on estimating the conditional distribution $F_{W|X}$ to obtain $G_W(w)$. DiNardo et al. (1996), Lee (1999) and Autor et al. (2016) use this approach to estimate the effects of minimum wages on inequality in the United States. The key assumption behind these methods is the stability of the conditional distribution function $F_{W|X}$ when the distribution of covariates changes.[2]

Instead of estimating the entire counterfactual distribution, I follow Firpo et al. (2009a) and estimate the effect of a small change in the minimum wage on the distribution's quantiles. Let $Q_\tau(W) = Q_\tau(h(X, \varepsilon))$ denote the τ-th quantile of the distribution of wages $F_W(w)$, and $Q_\tau(W|X = x) = Q_\tau(h(X, \varepsilon)|X = x)$ be the conditional quantile given $X = x$. The conditional quantile effect (CQE) is the effect of an infinitesimal change on covariates on the conditional quantile:

$$CQE(\tau, x) \equiv \frac{\partial Q_\tau(h(X, \varepsilon)|X = x)}{\partial x}. \tag{3}$$

[2]This assumption may not hold in the presence of general equilibrium effects, where the structural model function h may change when covariates change. For example, it may not be valid to consider the effects of eliminating the minimum wage. It may also fail to hold in settings where there is selection in the unobservables ε, such that changing the covariates X would change the conditional distribution of unobservables ε. This could happen if there is self-selection based on unobservables. The quantile method described below only requires the conditional distribution $F_{W|X}$ to be stable for small changes of X. For details, see Fortin et al. (2011)

The key assumption to identify this effect is stability of the quantile function for small changes of X, which is linked to the stability of $F_{W|X}$. Conditional quantile effects can be estimated by standard quantile regression. These effects, however, would be uninformative about how changes in X impact the overall wage distributions of figure 1, instead of the conditional distributions. To calculate the impact on the overall distribution, the unconditional quantile effect (UQE) average these conditional quantile effects over the distribution of covariates, matching each conditional quantile to a quantile on the unconditional distribution. If q_τ is the τ-th quantile of the unconditional distribution of wages, the UQE is given by:

$$\begin{aligned} UQE(\tau) &\equiv E\left[\omega_\tau(X)\ CQE(s(X), X)\right] \\ \omega_\tau\left(x\right) &\equiv \frac{f_{W|X}\left(q_\tau|x\right)}{f_W\left(q_\tau\right)} \\ s\left(x\right) &\equiv \{s : Q_s\left(W|X=x\right) = q_t\}, \end{aligned} \tag{4}$$

where $f_{W|X}$ and f_W are the conditional and unconditional density functions of wages. For estimation purposes, Firpo et al. (2009a) show that the UQE can be rewritten as the average marginal effect from a binary response model on the probability of wages exceeding a particular conditional quantile value

$$UQE(\tau) = \frac{1}{f_W(q_\tau)} \int \frac{dPr\left(W > q_\tau|X=x\right)}{dx} dF_X(x), \tag{5}$$

To estimate this, the function $Pr\left[Y > q_\tau|X=x\right]$ can be estimated by linear regression. The coefficients on X in this regression are an estimate of $\frac{dPr(W>q_\tau|X=x)}{dX}$. They can then be rescaled by $\frac{1}{f_W(q_\tau)}$ and averaged over the distribution of X. Firpo et al. (2009a) show that this amounts to estimating a linear regression with the recentered influence function (RIF) as the dependent variable:

$$R\hat{I}F(W, \hat{q}_\tau) = \frac{1(W > \hat{q}_\tau)}{\hat{f}_W(q_\tau)} + \hat{q}_\tau - \frac{1-\tau}{\hat{f}_W(q_\tau)} \tag{6}$$

where $\hat{q}_\tau$ and $\hat{f}_W(q_\tau)$ are estimates of the quantile and the density at the quantile, respectively, and 1() is the indicator function.[3] [4]

In the following section, I explain how I combine this strategy with a differences-in-differences methodology to estimate the marginal effect of a minimum wage increase on these quantiles.

3.1.2 A Differences-in-Differences Strategy

Previous attempts to estimate quantile differences-in- differences models, starting from Meyer et al. (1995), assume a linear specification for the conditional quantile function $Q_\tau(h(X, \varepsilon))$ in equation (3). Other papers that estimate the effect of minimum wages on inequality, like Lee (1999), Bosch and Manacorda (2010) and Autor et al. (2016), also start from a linear model for conditional quantiles and assume they evolve in parallel across cities or industries. I depart from this assumption and assume a linear form of the function $E\left[Pr\left(Y > q_\tau | X = x\right)\right]$ in equation (5) directly. This allows me to estimate the UQE by linear regression and conduct inference using techniques available for OLS. OLS additionally provides the best linear approximation to this expectation function.[5]

To estimate the effect of the minimum wage, I compare wage distributions across city-industry blocks that have a different incidence of the minimum wage[6]. Let w_{icjt} be the wage

[3] I use traditional linear interpolation of closest ranks estimates for $\hat{q}_\tau$. For estimates of $\hat{f}_W(q_\tau)$, I estimate the density f_W non-parametrically with a gaussian kernel and a Silverman rule bandwidth. Then I plug in the estimates of $\hat{q}_\tau$ in the estimated density.

[4] Firpo et al. (2009a) note that because the density $\hat{f}_W(q_\tau)$ needs to be estimated non-parametrically, this estimator does not converge at the parametric rate. Therefore, a large number of observations is needed to estimate $\hat{f}_W(q_\tau)$. This may hold for quantiles around the minimum wage, but may not hold for the tails of the distribution. Additionally, there is some approximation error when assuming that the RIF is linear, which requires a large sample to be negligible. Details are in Firpo et al. (2009b).

[5] Firpo et al. (2009a) also use this assumption when comparing conditional and unconditional quantile effects in their empirical application, and find that this estimator performs well and provides estimates close to fully nonparametric estimates.

[6] The choice of city-industry level aggregation is consistent with search theories of labor demand. See, for example, Beaudry et al. (2018).

of individual i in city c and industry j at time t. My baseline specification is a differences-in-differences regression with the city-industry blocks as treatment units, and the incidence of the minimum wage as a continuous treatment regressor:

$$R\hat{I}F(w_{icjt}, \hat{q}_\tau) = \phi_{cj} + \phi_t + \theta MW_{cj}1(t > 1998q4) + \delta X_{cjt} + \varepsilon_{icjt} \tag{7}$$

In this regression, ϕ_{cj} is a city-industry effect and ϕ_t is a time effect, MW_{cj} is a measure of the minimum wage shock incidence, $1(t > 1998q4)$ is a dummy variable equal to 1 after the minimum wage shock, X_{cjt} are covariates and ε_{cjt} is an error term. Although the minimum wage incidence is measured MW_{cj} at the city-industry level, the RIF in equation (6) is calculated with reference to the unconditional wage density function. θ measures the effect of increasing the minimum wage incidence on this unconditional wage distribution.[7]

In absence of cross-sectional variation in the nominal minimum wage, I measure the minimum wage incidence using three different variables. The first variable is the "fraction affected" by the minimum wage increase, the proportion of workers earning between the old and the new real minimum wage. If this percentage is larger for a particular city-industry pair, this market should be more affected by the minimum wage increase. This variable has been used extensively in the minimum wage literature (Card, 1992; Stewart, 2002; Lemos, 2009; Khamis, 2013). I calculate this incidence for 1998q4, the quarter before the minimum wage changes.

$$\text{Fraction Affected}_{cj,98q4} = \frac{\#(mw_{98q4} < w_{icj,98q4} < mw_{99q1})}{N_{cj,98q4}} \tag{8}$$

I calculate this incidence for both formal and informal sectors. In figure 3 of section 4 I show that the minimum wage incidence varies widely across cities and industries. The second incidence variable is a "fraction at" measure, defined as:

[7]Since the RIF is measured for the unconditional distribution of wages, the full sample is used when estimating the density functions in (6), mitigating small-sample concerns that may arise because the treatment is calculated at the city-industry level.

$$\text{Fraction At}_{cj,98q4} \equiv \frac{\#(0.9 \times mw_{98q4} \leq w_{icj,98q4} \leq 1.1 \times mw_{99q1})}{N_{cj,98q4}} \tag{9}$$

This fraction counts the number of people who earn a wage within 10 percent of the minimum wage. The advantage of this measure, compared to "fraction affected" is that it may account for workers who are not classified as affected due to small measurement errors in wages. The weakness of this measure is that it involves a choice of the percent deviation from the minimum wage. Both fraction measures are calculated using real wages. This is in contrast with Lemos (2009), who calculates incidence measures based on nominal wages. The minimum wage shock I consider stems from both an expected increase in the nominal minimum wage as well as an unexpected increase in the real minimum wage. Because of this, I choose to use a real measure.

The third incidence measure is the minimum to median wage ratio at the city-industry level. This variable measures how large the minimum wage is compared to the wages in the market. While easier to interpret, this measure assumes that the minimum wage is more binding in low wage markets. This is not necessarily the case for low-wage informal markets where labor regulations may not apply at all.

I assume that the conditional probability of wages exceeding a given value can be approximated by a linear function. A second assumption, which is key for identification of the minimum wage effects, is that this conditional probability evolves in parallel across city-industry blocks.

Because the minimum wage shock occurs at the same time as the onset of the financial crisis, this is a strong assumption. There may be city-specific labor market shocks due to the crisis, that may affect only certain areas of the country. However, the crisis was affected by an external shock and a capital flow reversal. In other words, the crisis did not originate from adverse shocks within the country, which may have originated in particular cities or industries. However, the external shock may have affected cities or industries differentially. Some of the changes in the distribution may be due to this shock and not to the difference in minimum wage incidence. This would happen if the 1999 crisis caused different effects across industries.

While the unconditional probability of wages exceeding a value would certainly evolve differently across city-industries in presence of these crisis effects, the conditional probability may evolve in parallel. This would occur after controlling appropriately for the differential effects of the crisis across city-industry blocks. To address the existence of labor demand shocks that affect cities differently, I control for city-level employment and Bartik shocks as covariates X in equation (7). Bartik shocks are intended to capture labor demand shocks that are external to each city. To capture city-specific trends in the distributions, I allow for a linear city specific trend in some specifications. To address the differential impact of the crisis across industries, I also control for the national evolution of employment in each industry.

To conduct inference, I use the wild-bootstrap-t method of Cameron et al. (2008) and cluster by city, therefore allowing for correlation of the error terms in equations (7) across industries within each city. The bootstrap method is intended to reduce over rejection, which is frequent in differences-in-differences studies (Bertrand et al., 2004), and to address the limited number of clusters. I report parametric standard errors clustered by city, and p-values and confidence intervals obtained through the bootstrap procedure.[8]

3.2 Effects on Employment

I estimate effects on employment in both sectors using a differences-in-differences specification on data aggregated at the city-industry level. I estimate the analog of equation (7) for employment:

$$N_{cjt} = \phi_{cj} + \phi_t + \theta MW_{cj} 1(t > 1998q4) + \delta X_{cjt} + \varepsilon_{cjt} \tag{10}$$

[8] Note that since the p-values are obtained through the bootstrap, standard errors and p-values may point in different directions.

Here, N_{cjt} is employment at the city-industry level. As an alternative employment variable, I use hours worked during the last week at the individual level. As in the previous section, I also try different specifications to account for labor demand shocks and city trends.[9]

4 Data Sources and Descriptive Statistics

My data comes from Colombia's National Household Survey (ENH) for 1996q2 to 2000q2. The ENH was a quarterly cross-sectional survey used to calculate labor market indicators at the national and city levels. It is representative of the principal metropolitan areas of the country. The survey collects data on wages, employment, demographic and labor market variables. I restrict my sample to occupied workers in the government and private sector and exclude the self-employed. I only analyze data for the 7 metropolitan areas that are present in all quarters of the survey and that have a large sample size per city per quarter.[10] I classify formal and informal workers into 6 economic activities. [11] The sample has 149 city-industry blocks, followed for 17 quarters.

I classify workers who do not receive health insurance provided by their employer as informal. There are other measures of informality available, but all of them capture the same dynamics. The health measure is available for most of the sample, as opposed to other measures. Appendix A.2 and Mondragón et al. (2010) provide details about how this measure compares to the alternative ones.

Table 1 shows sample percentages by minimum wage incidence and formality. The informal sector is large: about 22 percent of workers in the pooled sample are informal according to my health insurance based measure. The minimum wage is binding in both sectors, with about 9 percent of workers earning around the minimum wage in either sector. While

[9] I do not control for city or industry level employment in these regressions since they are endogenous to the city-industry block employment rate.

[10] These cities are Barranquilla, Bogotá, Bucaramanga, Cali, Manizales, Medellín and Pasto.

[11] I use a 1-digit ISIC Rev. 2 classification. Although the survey has information at the 2 digit level, sample sizes within the 2 digit categories are small. From the 9 1-digit categories, I exclude Agriculture, Mining and Utilities due to small sample sizes. Overall these excluded industries comprise no more than 2 percent of the pooled sample.

most formal workers earn above the minimum wage, most informal workers earn below it. Nevertheless, more than 40 percent of informal workers earn above the minimum wage.

Table 1: Sample Percentages by Informality Relative to the Minimum Wage

Informality	**Relative to Minimum wage**			
	Below %	**At** %	**Above** %	**Total** %
Formal	18.0	9.2	72.7	100.0
Informal	47.9	9.3	42.9	100.0
Total	24.6	9.2	66.1	100.0
Sample size	36,116	15,746	87,126	138,988

Pooled data 1996q2-2000q2. All calculations based on real wages for 1998, converted to US dollars using a 1 dollar = 2000 pesos exchange rate. "At minimum wage" includes workers whose real wage is within 3 percentage points of the real minimum wage in their city.

In table 2, I describe the distribution of real wages across sectors. I calculate real wages using city-specific consumer price indices. The minimum wage is about 74.5 USD of 1998 throughout the sample. It falls at around the 25th percentile of the distribution of formal wages, and slightly above the median of the distribution of informal wages.

Table 2: Distribution of Real Wages, by Sample Characteristics. Dollars of 1998.

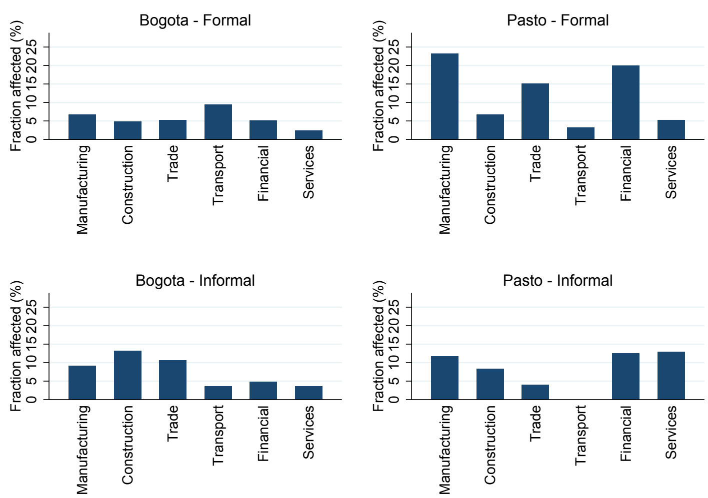
Informality	**Mean**	**P10**	**P25**	**P50**	**P75**	**P90**
Formal	185.0	68.2	76.5	114.6	197.6	362.3
Informal	99.9	39.7	63.5	73.1	97.5	153.7
Total	166.2	64.9	72.4	97.8	175.0	324.8
Sample size	138,988					

Pooled data 1996q2-2000q2. Columns show the mean and selected percentiles of the distribution of wages. All calculations based on real wages for 1998, converted to US dollars using a 1 dollar = 2000 pesos exchange rate.

In figure 3, I show there is substantial heterogeneity in the incidence of the minimum wage across locations and industries before the shock. In the formal sector, the fractions of workers affected by the minimum wage shock are larger in the smallest city in the sample.

The difference can be as large as 15 percentage points for some sectors. In the informal sector, the differences across cities are less evident. Manufacturing and construction are the sectors with the largest incidence across cities and sectors. There are minimum wage workers present in all industries, as opposed to the U.S., where they are predominantly in the restaurant industry (Dube et al., 2010).

Figure 3: Variation in Minimum Wage Incidence in 1998q4: Selected Cities.



Minimum wage incidence across city-industry blocks for the largest and smallest cities in the sample. Incidence is measured by "fraction affected", the fraction of workers between the old and new minimum wage, defined in equation (8).

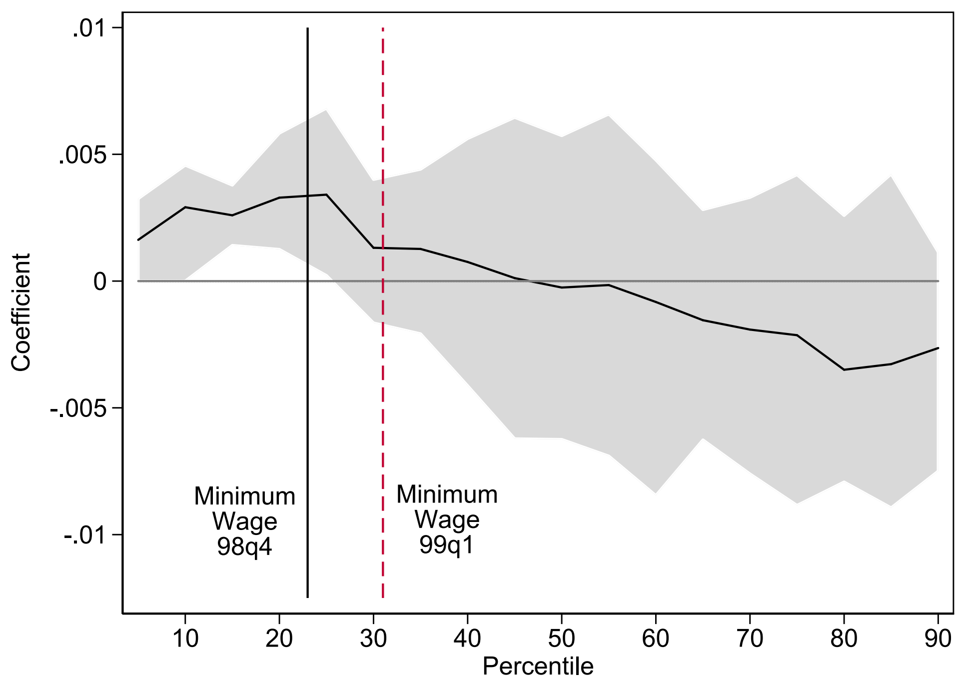
5 Results

5.1 Effects on Wages

5.1.1 Formal Sector

Figure 4 shows the estimated unconditional quantile effects for the formal wage distribution. I find evidence of increases in wages in the lower tail of the distribution, implying compression of the distribution. Effects are found up to the 30th percentile of the distribution, where the minimum wage binds. For higher percentiles, the effects are not significant. Since the minimum wage incidence measures are built by counting workers near the minimum wage, it is expected that the effects on higher percentiles of the wage distribution as less robust.

Figure 4: Effects of the Minimum Wage Increase on the Distribution of Formal Wages



Estimates of unconditional quantile effects for percentiles of the distribution of formal wages. Minimum wage incidence is measured by "fraction affected", the fraction of workers between the old and new minimum wage in each city-industry block. Controls include city-level employment and Bartik price shocks. Shaded areas are 95% confidence intervals obtained using a wild bootstrap-t procedure with 200 replications, clustered by city. Full estimation results for selected quantiles and alternate specifications are on table 3.

Table 3 shows these results for selected percentiles of the distribution. These are the increases in log wages at each percentile when incidence is 1 percentage point larger. The real minimum wage increased by 9.75 percent in the shock. Wages at the 5th percentile would have gone up by about 2 percent if incidence had been 10 percentage points higher. These effects grow larger up to the 25th percentile of the distribution, where wages would increase about 4 percent with a 10 percentage points higher incidence. The increase in incidence from the market with the least minimum wage incidence (social services in Bogotá) to the market with the most incidence (construction in Manizales) is of about 32 percentage points. My estimates imply that if all cities had this highest incidence, wages would grow around 12 percent for the quantiles close and below the minimum wage. It is encouraging that these effects are robust to controlling for trends and Bartik shocks, which address the heterogeneity of crisis-related shocks across city-industries.

To better assess the magnitude of these effects, I conduct two counterfactual exercises. Initially, I assume that after the minimum wage shock, all the affected workers between the old and the new minimum wage are paid the new minimum. I calculate the implied conditional quantile effect of equation (3) for each city and industry. Next, I obtain the implied unconditional quantile effect averaging over the distribution of workers across city-industry blocks using equation (4). I scale these effects by the incidence in each block to obtain an implied coefficient. The results are shown in figure 5.

The estimated effects are smaller than the implied effects from a mechanical increase in wages for those affected. The counterfactual effects are about twice as large. This suggests wages do not increase for all of the affected workers. However, in the lower tail of the distribution, the estimated effects are positive. In a framework where only affected workers earn the new minimum wage, these effects should be zero. Positive effects may be due to usage of the minimum wage as reference for wages below it. To see the degree of referencing for these below-minimum wages, I also calculate counterfactual effects if all workers below the minimum wage are brought to the new minimum. Although the estimated effects are positive for these percentiles, they are significantly smaller than the implied effect of increasing the wage to the minimum for workers whose wage is smaller.

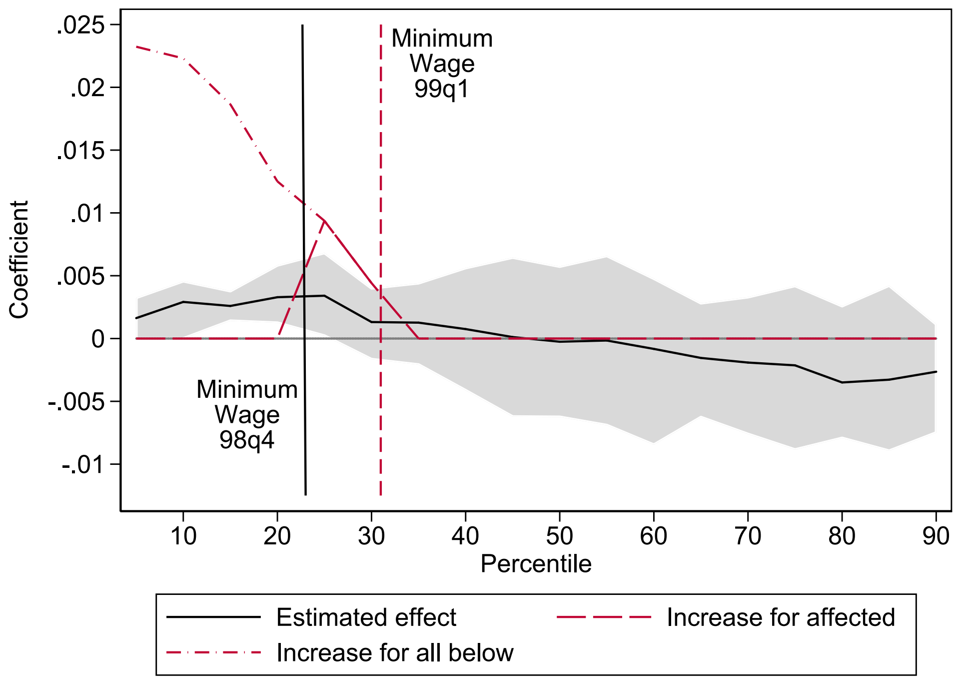
There are some caveats to these counterfactual exercises. First, the conditional quantile effects calculated neglect the effect of other covariates. Higher incidence cities may also be experiencing worse labor market conditions which allow smaller wage responses. If this were the case, merely comparing the estimates to the counterfactual coefficients underestimates the actual incidence of the minimum wage. Second, they assume the absence of an employ-

Table 3: Effect of the Minimum Wage Incidence on the Formal Wage Distribution. Selected Percentiles.

	(1)	(2)	(3)	(4)
p5	0.0016**	0.0018**	0.0003	0.0004
	(0.0007)	(0.0008)	(0.0007)	(0.0006)
	[0.050]	[0.050]	[0.776]	[0.408]
p10	0.0029**	0.0024*	0.0019**	0.0014
	(0.0006)	(0.0011)	(0.0003)	(0.0011)
	[0.010]	[0.075]	[0.030]	[0.229]
p15	0.0026***	0.0017*	0.0016*	0.0007
	(0.0005)	(0.0008)	(0.0007)	(0.0008)
	[0.000]	[0.080]	[0.055]	[0.438]
p20	0.0033**	0.0024**	0.0026	0.0016***
	(0.0009)	(0.0004)	(0.0013)	(0.0003)
	[0.015]	[0.015]	[0.109]	[0.000]
p25	0.0034**	0.0024**	0.0030	0.0019***
	(0.0012)	(0.0005)	(0.0016)	(0.0005)
	[0.030]	[0.030]	[0.184]	[0.000]
p30	0.0013	0.0004	0.0012	0.0004
	(0.0010)	(0.0006)	(0.0013)	(0.0007)
	[0.567]	[0.627]	[0.756]	[0.557]
p50	-0.0003	-0.0009	0.0005	0.0002
	(0.0023)	(0.0019)	(0.0022)	(0.0018)
	[0.841]	[0.677]	[0.910]	[0.905]
Observations	106468	106468	106468	106468
City x Industry FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Bartik Price Shocks	Yes	Yes	Yes	Yes
City Specific Trends		Yes		Yes
Industry Employment			Yes	Yes

Each row of the table corresponds to the estimates of unconditional quantile effects for a quantile of the distribution of formal wages. Minimum wage incidence is measured by "fraction affected", the fraction of workers between the old and new minimum wage in each city-industry block. Columns correspond to alternative specifications. Standard errors clustered by city in parentheses. P-values in brackets. P-values are obtained with a wild bootstrap-t procedure with 200 replications. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Figure 5: Comparison of Estimated Effects and Counterfactual Effects: Formal Sector



Comparison of unconditional quantile effects (UQE) for percentiles of the distribution of formal wages, with effects for counterfactual scenarios where wages are increased according to the minimum wage. "Estimated effect" corresponds to the UQE estimate of the effect of the minimum wage. "Increase for affected' shows implied UQEs in a scenario where for workers between the old and the new minimum wage, the wage is increased to the new minimum wage. "Increase for all below" shows implies UQEs in a scenario where all workers below the new minimum wage are brought up to the new minimum wage.

ment response. If, for example, all workers below the minimum wage were dismissed as a response to the shock, then the counterfactual estimates would be higher.

Table 3 shows estimates under alternative specifications that include city trends and industry employment. The effects are stable in the percentiles near the minimum wage and somewhat smaller in the lower tails for some specifications. I also estimate the effects using the two other measures of incidence: the fraction at the minimum wage and the minimum to median wage ratio. Figure B.1 in the appendix shows that the same pattern of effects emerges using different measures and different intervals around the minimum wage to measure "fraction at".

To check that my estimates are not simply capturing unobservables that vary with minimum wage incidence, I provide two pieces of evidence in the appendix. I reestimate the effects on the quarter previous to the minimum wage shock, from 1998q3 to 1998q4, using incidence for 1998q4 as the independent variable, and excluding all observations after 1998q4. Figure B.2 shows an absence of significant effects or patterns in the quantile effects.

I also illustrate the evolution of the formal density of wages across quarters in figure B.3 as a nonparametric way of seeing if the distribution changes from quarter to quarter. Changes only appear at the end of every year, where minimum wage shocks occur, and only around the percentiles where the minimum binds. These facts suggest the effects I estimated are not due to unobservable differences across city-industries or time trends in the distribution of formal wages.

Since there are also minimum wage changes at the end of 1996 and 1997, which seem to be reflected in changes in the distributions in figure B.3, I estimate the wage effects of these minimum wage increases. The results are shown in figure B.4. A comparison of these effects with the main estimated effects for 1999q1 is illustrative of the different effects of expected and unexpected minimum wage shocks. This is because the misalignment between expected and observed inflation in these years was smaller, as shown in figure 2, where the largest increase is in 1999q1. The estimated effects are noisier. For the increase in 1997, there are not statistically significant effects in either sector, although the formal sector coefficients are large. For the increase in 1998, there is some slight evidence of effects around the percentiles where the minimum wage binds, but these are much smaller than the effects in 1999.

Altogether, my results imply a positive and significant impact of the minimum wage shock on the distribution of formal wages, at quantiles below and around the minimum wage. A 10 percentage points higher minimum wage incidence across cities and industries would imply wage increases. These are of about 1.5 percent in the lower tail and of about 3 percent in the percentiles where the minimum wage binds. I turn to the effect on the distribution of informal wages in the following section.

5.1.2 Informal Sector

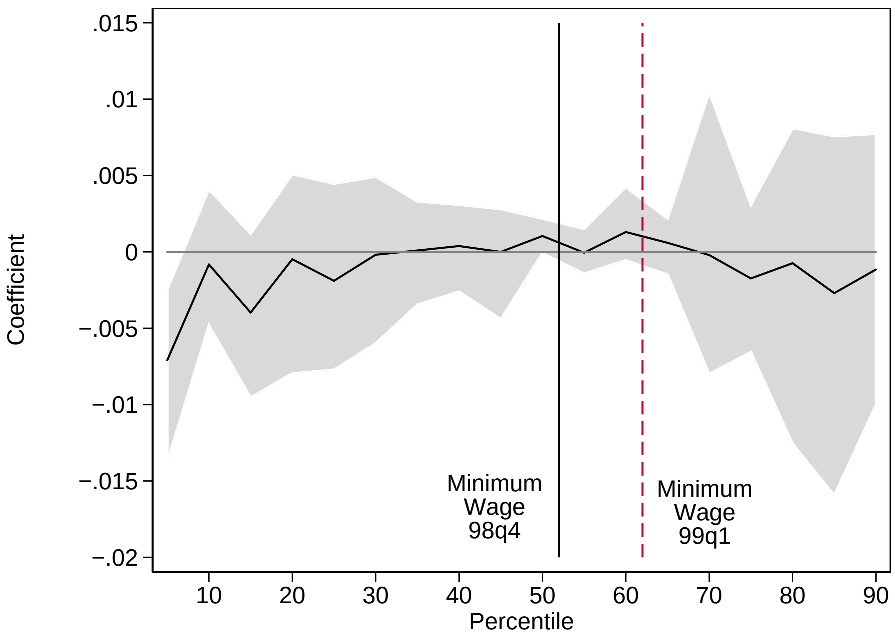
I follow the same strategy used in the previous section to estimate effects in the informal wage distribution. Figure 6 shows the estimated effects. Panel (a) shows the estimates using "fraction affected" as the incidence variable. The extent of the effects is limited compared to the effects in the formal sector. There is, however, some evidence of an increase in median wages. A 10 percentage points larger incidence of the minimum wage across cities and industries would imply 1 percent higher wages around the 60th percentile according to the last specification.

Panel (b) shows estimates with "fraction at". These are slightly larger and less noisy than those using "fraction affected", and appear from the 55th to the 70th percentile. Table 4 shows the full results for selected percentiles. In appendix figure B.5 I overlay the estimates with the three incidence measures. Estimates using the ratio of minimum to median yields negative, insignificant estimates, but also exhibits substantial bias at high percentiles, which may be due to measurement error (Chetverikov et al., 2006). Changing the interval around the minimum wage to measure "fraction at" changes the coefficients at low and high percentiles, but not for the percentiles around the minimum wage.

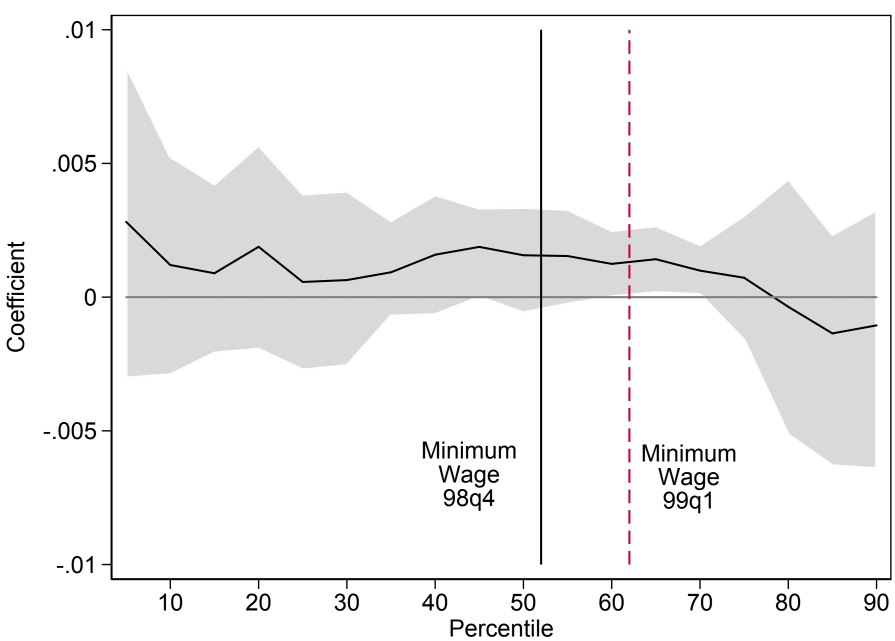
The estimates for the informal sector are statistically different from the formal sector

Figure 6: Effects of the Minimum Wage Increase on the Distribution of Informal Wages

(a) Fraction Affected



(b) Fraction At



Estimates of unconditional quantile effects for percentiles of the distribution of informal wages. In panel A, the minimum wage incidence is measured by "fraction affected", the fraction of workers between the old and new minimum wage in each city-industry block. In panel B, the minimum wage incidence is measured by "fraction at", the number of workers that earn between 0.9 and 1.1 times the new minimum wage in each city-industry block. Controls include city-level employment and Bartik price shocks. Shaded areas are 95% confidence intervals obtained using a wild bootstrap-t procedure with 200 replications, clustered by city. Full estimation results for selected quantiles and alternate specifications are on table 4 of the appendix.

Table 4: Effect of the Minimum Wage Incidence on the Informal Wage Distribution.

	(1)	(2)	(3)	(4)
p40	0.0016	0.0008*	0.0016	0.0008
	(0.0008)	(0.0005)	(0.0008)	(0.0005)
	[0.129]	[0.075]	[0.184]	[0.159]
p45	0.0019**	0.0010	0.0019**	0.0010
	(0.0006)	(0.0005)	(0.0006)	(0.0005)
	[0.020]	[0.129]	[0.020]	[0.134]
p50	0.0016	0.0007	0.0016	0.0006
	(0.0008)	(0.0005)	(0.0008)	(0.0005)
	[0.169]	[0.318]	[0.239]	[0.284]
p55	0.0015	0.0010	0.0015	0.0010
	(0.0007)	(0.0006)	(0.0007)	(0.0006)
	[0.139]	[0.124]	[0.149]	[0.104]
p60	0.0012*	0.0010**	0.0012*	0.0010*
	(0.0006)	(0.0005)	(0.0006)	(0.0005)
	[0.060]	[0.040]	[0.100]	[0.070]
p65	0.0014***	0.0011*	0.0014**	0.0011**
	(0.0004)	(0.0005)	(0.0004)	(0.0006)
	[0.000]	[0.075]	[0.020]	[0.040]
p70	0.0010**	0.0007	0.0010**	0.0007
	(0.0003)	(0.0004)	(0.0003)	(0.0004)
	[0.025]	[0.124]	[0.015]	[0.109]
Observations	32447	32447	32447	32447
City x Industry FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Bartik Price Shocks	Yes	Yes	Yes	Yes
City Specific Trends		Yes		Yes
Industry Employment			Yes	Yes

Each row of the table corresponds to the estimates of unconditional quantile effects for a quantile of the distribution of informal wages. Minimum wage incidence is measured by "fraction at", the number of workers that earn between 0.9 and 1.1 times the new minimum wage in each city-industry block. Columns correspond to alternative specifications. Standard errors clustered by city in parentheses. P-values in brackets. P-values are obtained with a wild bootstrap-t procedure with 200 replications. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

ones. In appendix table B.1 I show that the estimates are different for all percentiles, and for the percentiles where the minimum wage binds in the formal sector. Since the informal sector estimates are noisier, they are not different from the formal sector ones from percentiles 40 to 70.

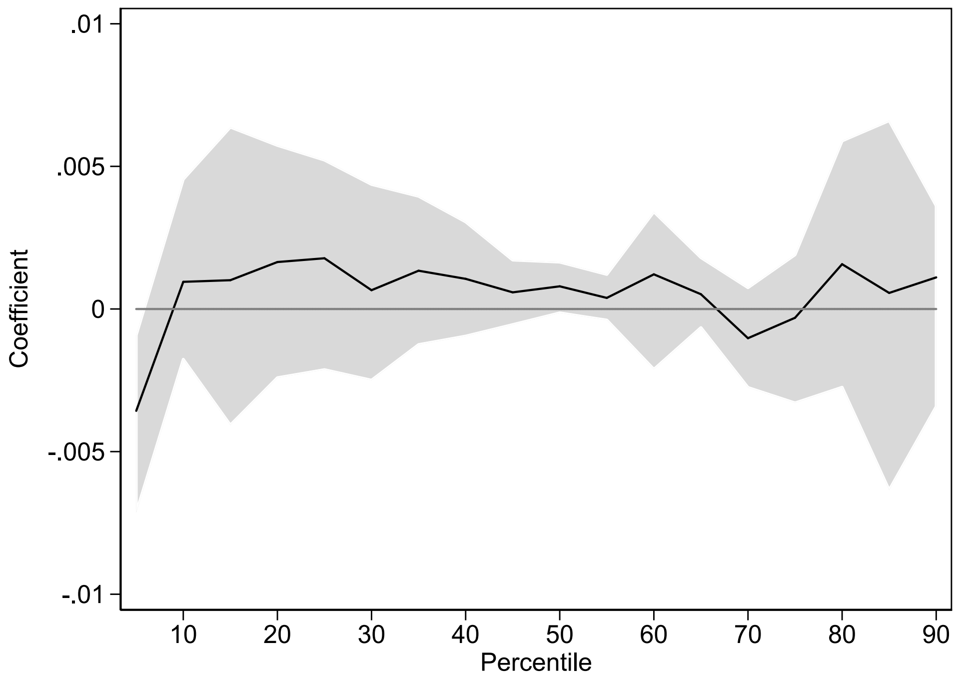
I reestimate the effects using "fraction at" (which yields the largest estimates) as the incidence measure, for 1998q3-1998q4, before the minimum wage change. These results are plotted in figure B.6 of the appendix. The estimates are very noisy, but, as with the formal sector, insignificant for percentiles around the minimum wage. It suggests that current estimates only capture the incidence of minimum wages. I do not find evidence of wage decreases in the informal sector, which would be suggested by a competitive model.

To summarize, I find that higher minimum wage incidence leads to wage increases in the informal sector around median wages, where the minimum wage binds. These effects are smaller and less robust than those for the formal sector. It is unclear if the effects we observe are due to feedback from the formal into the informal sector or if they are merely due to indexing in the informal sector. I evaluate the cross-sectoral effects hypothesis in the next section.

5.1.3 Effects Across Markets

One reason why we may observe wage increases in the informal sector in response to the minimum wage shock, in absence of compliance or indexing, is feedback from the formal sector. For example, if workers are dismissed from the formal sector in response to the shock and are employed in the informal sector paid at their marginal productivity, then we may observe increases in informal wages around the minimum wage. One advantage of the incidence measures is that they allow me to test this hypothesis. In figure 7, I report estimates of the effect of formal market incidence on the distribution of informal wages. I do not find any significant effects, implying the reaction of informal wages to the minimum wage occurs within the informal market. This test, however, assumes that cross-sectoral effects occur within each industry. As an alternative test, in Appendix figure B.7 I use the city-level minimum wage incidence (as opposed to the city-industry level incidence) in the formal sector as a regressor and also fail to find any impact in the informal sector.

Figure 7: Cross-sectoral Effects of Formal Minimum Wage Incidence on the Distribution of Informal Wages



Estimates of unconditional quantile effects for percentiles of the distribution of informal wages. Minimum wage incidence is measured by "fraction affected", the fraction of workers between the old and new minimum wage in the formal sector in each city-industry block. Controls include city-level employment and Bartik price shocks. Shaded areas are 95% confidence intervals obtained using a wild bootstrap-t procedure with 200 replications, clustered by city.

5.2 Effects on Employment

In this section, I report estimates of the effect of minimum wage incidence on employment for both sectors. I estimate the differences-in-differences models described in section 3.2 for several measures of employment.

Table 5 shows the estimates. For the formal sector, I do not find any significant effects on employment in each of the city-industry blocks, in either specification. This suggests that the wage increases shown in section 5.1.1 were unaccompanied by adjustments on the amount of labor used. While the 1999 crisis raised unemployment at the national level, my results suggest that in the formal sector, city-industries with a larger incidence of the minimum wage did not experience lower employment as a response to the shock. This is consistent with the recent literature on small employment effects of minimum wages (Belman and Wolfson, 2014). My results can exclusively address the short-term response to the minimum wage shock and are silent about long-term effects, or effects on employment growth.

Table 5: Effect of the Minimum Wage on Employment

	Formal			Informal		
Dep. var. (log)	(1)	(2)	(3)	(4)	(5)	(6)
Employment	-0.0035	-0.0023	0.0035	-0.0082*	-0.0053	-0.0033
	(0.0033)	(0.0040)	(0.0026)	(0.0042)	(0.0040)	(0.0032)
	[0.297]	[0.493]	[0.240]	[0.056]	[0.222]	[0.301]
Hours worked	0.0099	0.0189**	0.0013	-0.0002	0.0272**	0.0214
	(0.0086)	(0.0093)	(0.0098)	(0.0120)	(0.0128)	(0.0153)
	[0.325]	[0.030]	[0.876]	[0.942]	[0.020]	[0.297]
City - industry Cells	714	714	714	714	714	714
Observations	106468	106468	106468	32447	32447	32447
City x Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Bartik Price Shocks	Yes	Yes	Yes	Yes	Yes	Yes
City Specific Trends		Yes	Yes		Yes	Yes
Industry Trends			Yes			Yes

Each row of the table corresponds to the estimates of the coefficient on minimum wage incidence for a different employment variable. Minimum wage incidence is measured by "fraction affected", the fraction of workers between the old and new minimum wage in each city-industry block. Columns 1 to 3 correspond to formal employment. Columns 4 to 6 correspond to informal employment. Standard errors clustered by city in parentheses. P-values in brackets. P-values are obtained with a wild bootstrap-t procedure with 200 replications. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

For the informal sector, I find slight evidence of negative employment effects. I find a larger minimum wage incidence is associated with lower industry employment in the city-industry. From these estimates, a 10 percent higher incidence implies 0.5 to 1 percent lower employment in this city-industry block. The elasticity to incidence ranges from -0.05 to -0.1. These effects are of a similar magnitude to those found in other studies for developing countries. Using the "fraction at" measure, Lemos (2009) finds elasticities of employment to the minimum wage in the Brazilian informal ranging from -0.05 to 0.14, albeit not significant.

These results suggest there is some incidence of the minimum wage in the informal sector employment. Together with my results on wages, I argue that this effect is not explained by cross-sectoral effects from the formal sector. Instead, it could be explained by lower rigidities in the informal sector that make dismissing workers easier. This is consistent with Mondragón et al. (2010), who find that minimum wage increases are associated with transitions from high income to low income within the informal sector.

These findings are also consistent with models of imperfect compliance with the minimum wage (Basu et al., 2010; Soundararajan, 2014). In these models, there are employment losses due to minimum wage increases below a certain enforcement threshold, where the market is competitive, and limited employment losses above this threshold, where the model becomes an efficiency wage model. An alternative explanation would be the existence of monopsonies in the formal sector and their absence in the informal sector.

6 Concluding Remarks

In this paper, I have estimated the effect of an unexpected minimum wage shock on the informal and formal wage distributions in Colombia. By comparing markets with a high and a low incidence of the minimum wage, I find that only wages close to the minimum wage rise. The increase for a 10 percentage points higher incidence is about 4 percent in the formal sector, and 1.3 percent in the informal sector. I observe slight evidence of negative employment effects in the informal sector, that can not be explained by cross-sectoral effects from the formal sector.

My results concur with previous literature for developing countries. They are different from the previous findings about the effect of the minimum wage in Colombia. The difference in findings is in line with the emerging literature on the compelling research designs in minimum wage research (Allegretto et al., 2011, 2017). My design exploits cross-sectional variation as well as time variation and controls for time-varying heterogeneity, which makes my estimates more plausible.

The results suggest minimum wages affect the informal sector per se, and not through cross-sectoral effects from the formal sector, as the competitive model suggests. However, it may be difficult to extrapolate these results to the effects of minimum wages on the formal and informal sector in other developing countries. The results may not hold for larger minimum wage increases or for different contexts. Subsequent explorations may try examining the role of other explanations, like wage indexing, to explain the absence of cross-sectoral effects.

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Appendix

A Data

A.1 Data sources

The data on wages, demographic and labor market characteristics comes from Colombia's National Household Survey (ENH) for the years 1996-2000. The ENH was a quarterly rotating cross-sectional survey used to calculate labor market indicators at a National and City Level. It is representative of the main metropolitan areas in the country. From 2001, there was a change in the methodology of the survey and it was replaced by the Continuous Household Survey (ECH), with an extended sample and monthly data collection. As noted by Arango et al. (2008a), the methodological differences between surveys make time comparisons difficult, so I restrict my analysis to ENH data. I only analyze data for the 7 metropolitan areas that are present in all quarters of the survey and that have a large sample size per city per quarter: Barranquilla, Bogotá, Bucaramanga, Cali, Manizales, Medellín and Pasto. The survey collects labor market information on individuals, including occupation status, salaries and weekly hours of work, along with demographic and labor market characteristics.

The monthly minimum wage information comes from the Colombian Central Bank.[12] Employees who earn the minimum wage are also entitled to a transportation subsidy, which varies from around 8 to 10 percent of the monthly minimum wage. I obtained transportation subsidy information from the Colombian Institute of Tax Law. All minimum wage workers receive the transportation subsidy, although it is not considered part of the wage for social security purposes. All the minimum wage figures include this transportation subsidy as part of the minimum wage.

To obtain real wages, I use city-level consumer price indexes with 1998 as the base year from the Colombian National Department of Statistics (DANE).[13] This dataset includes

[12] http://www.banrep.gov.co/es/indice-salarios

[13] http://www.dane.gov.co/index.php/indices-de-precios-y-costos/indice-de-precios-al-consumidor-ipc

consumer price indices at the city-income group level. I use the city-level indices to separate the effects on the real wage distribution that may arise from differential inflation across different income groups.

A.2 Sample Selection and Classification of Workers as Formal or Informal

For the results on wages, I only consider occupied workers in the private and government sectors and exclude family-member non-remunerated workers, self-employed workers, and business owners. I also exclude domestic workers. A large share of these workers earns wages below the minimum wage, but their wages may be nevertheless indexed to it. I consider only workers who report wages for the last month, who are between 12 and 65 years of age, and who work between 30 and 50 hours a week. This is intended to mitigate the measurement error in hours, and to ensure that my results are comparable to those of Arango and Pachón (2007) to some degree. Following Solon et al. (2015), all my descriptive statistics use survey weights, but the main results of the paper instead use bootstrapping to account for the heteroscedasticity due to the survey design.

Formal workers are defined as workers who are covered by health insurance by their firm, as required by Colombian law. Specifically, in the time period I analyze, the law required the employer to enroll its permanent workers in health insurance, and share its costs with the employee. For transitory workers, a percentage of the worker's salary is intended to be used to pay for health insurance, and the employee has to provide proof of health insurance enrollment to the employer. For the second and fourth quarters of 1996, the survey did not ask specifically for health insurance coverage sponsored by the employer, but rather for general enrollment in health insurance. We use workers who reported to be covered by health insurance for those periods. For the rest of the sample, these variables are highly correlated. For 1996q3, only about 6 percent of workers in the estimation sample who were enrolled in health insurance did not have employer-provided health insurance, and these accounted for about 4.8 percent of total workers. If this percentage is similar for 1996q2 and 1996q4, then at most 4.8 percent of workers in the sample may be misclassified as formal in these quarters.

My choice of an informality measure is based on availability and performance. The health measure is available for all but two quarters of the sample, as mentioned above. Mondragón et al. (2010) show that this measure of informality and alternative measures, such as whether the employer contributes to the employee pension or whether the firm is large, mostly concur and exhibit the same dynamics. The firm size definition, as Mondragón et al. (2010) notes, is not related to labor market regulations. The pension-based definition is highly correlated with the health-based definition: according to Mondragón et al. (2010), each year only 1 percent of workers classified as informal under the health-based criterion would be labeled formal under the pension criterion. These alternative measures are not available for the entire sample I consider.

I classify formal and informal workers into economic activities using a 1-digit ISIC Rev. 2 classification. Although the survey has information at the 2 digit level, sample sizes within the 2 digit categories are small. From the 9 1-digit categories, I exclude Agriculture, Mining and Utilities due to small sample sizes. Overall these excluded industries comprise no more than 2 percent of the pooled sample.

A.3 Variable Construction

The nominal wage is self-reported by individuals. Although most wages are reported at the monthly level, some of them are reported at higher or lower frequencies: for those cases, I calculate monthly equivalents. I obtain real wages deflating this variable using city-level price indices, and I deflate the minimum wage using the countrywide consumer price index. I focus on log real monthly wages throughout all the analysis.

To account for local labor demand shocks, I use city-level Bartik shock variables, which are common in the local labor markets literature (Bartik, 1991). These are intended to capture local labor demand shocks unrelated to local labor supply. The Bartik price and Bartik quantity shocks are defined as

$$BP_{ct} \equiv \sum_{j=1}^{J} EmpShare_{cj,t-1} \times (Emp_{-c,j,t} - Emp_{-c,j,t-1}) \tag{A.1}$$

$$BQ_{ct} \equiv \sum_{j=1}^{J} EmpShare_{cj,t-1} \times (w_{-c,j,t} - w_{-c,j,t-1})$$

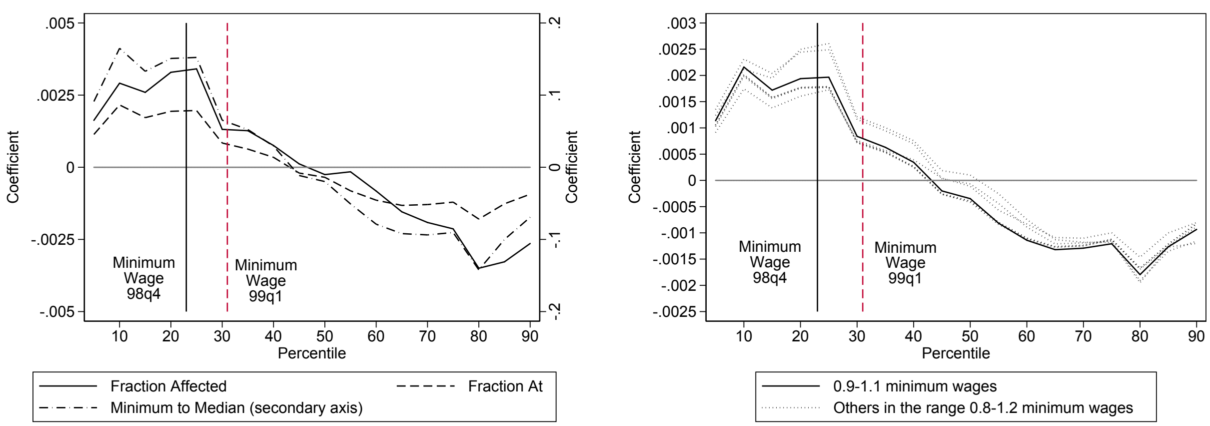
where $EmpShare_{cj,t-1}$ is the preexisting industry share, $Emp_{-c,j,t}$ is the average employment across cities in industry j excluding city c, and $w_{-c,j,t}$ is the average nominal wage across cities in industry j excluding city c.

B Additional Estimation Results

Figure B.1: Comparison of Estimated Effects on the Formal Wage Distribution. Different Measures of Minimum Wage Incidence.

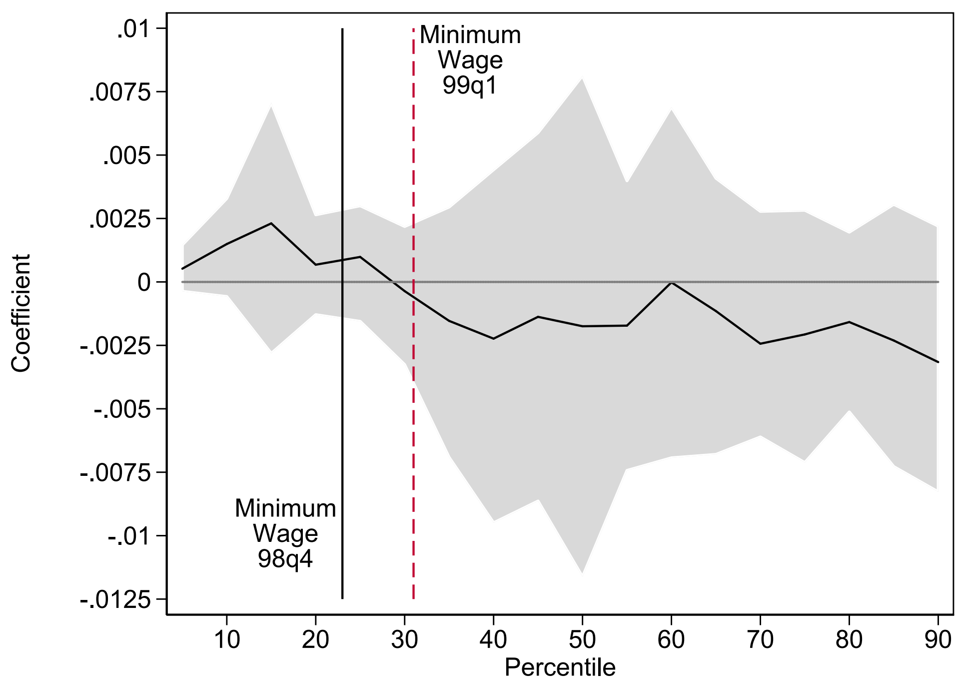
(a) Fraction affected, fraction at and minimum to median

(b) Fraction at for different percentages around minimum wage



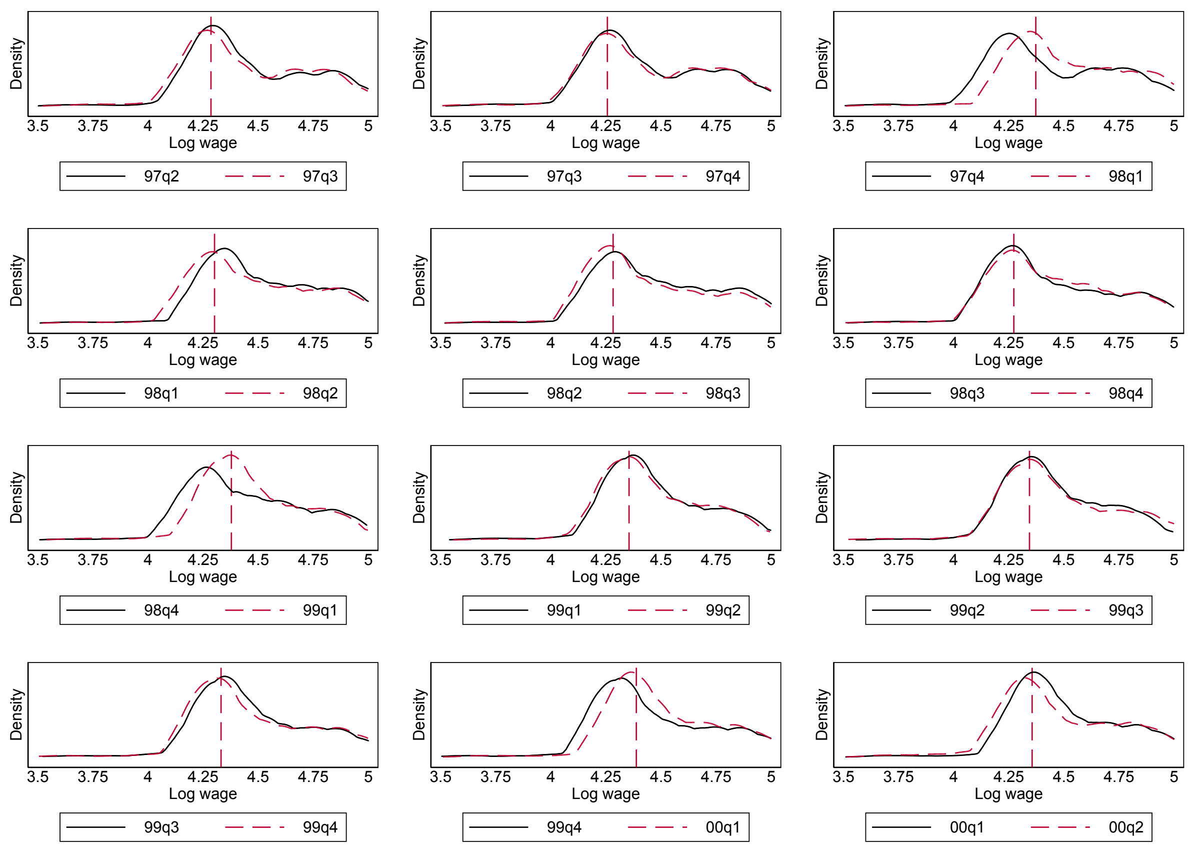
Comparison of unconditional quantile effects for percentiles of the distribution of formal wages, using different measures of minimum wage incidence. Panel (a) shows estimates using different minimum wage variables. "Fraction affected" counts the number of workers who are between the old and the new minimum wage in each city-industry block. "Fraction at" counts the number of workers that earn between 0.9 and 1.1 times the new minimum wage in each city-industry block. "Minimum to median" is the ratio of the new minimum wage to the old median wage in each city-industry block. Panel (b) uses "Fraction at" and changes the interval around the minimum wage, from 0.8-1.2 to 0.95-1.05, reducing the interval length by 0.5 each time.

Figure B.2: Placebo Check: Estimates of the Effect of Minimum Wage Incidence on Formal Wages previous to the Minimum Wage Shock, 1998q3-1998q4.



Estimates of unconditional quantile effects for percentiles of the distribution of formal wages before the minimum wage shock. Minimum wage incidence is measured by "fraction affected", Minimum wage incidence is measured by "fraction affected", the fraction of workers between the old and new minimum wage in each city-industry block. Controls include city-level employment and Bartik price shocks. Shaded areas are 95% confidence intervals obtained using a wild bootstrap-t procedure with 200 replications, clustered by city.

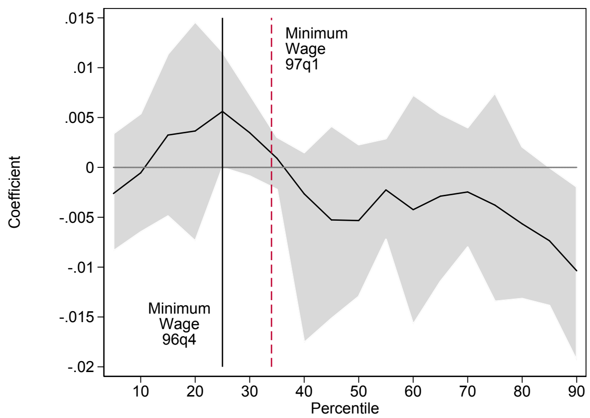
Figure B.3: Evolution of the Density of Formal Wages.



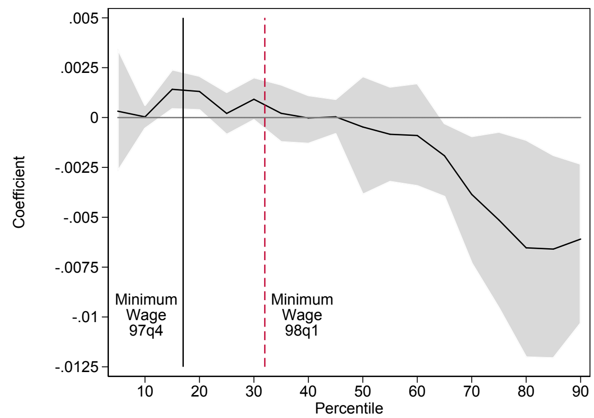
Comparison of densities for successive quarters. The density lines only separate in the first quarters of each year, where the minimum wage increases occur. Data are from the National Household Survey (ENH). Real wages for 1998, converted to US dollars using a 1 dollar = 2000 pesos exchange rate. Observations with log wages smaller than 3.5 or larger than 5.5 are excluded. Densities are estimated with a gaussian kernel and a bandwidth of 0.08. The vertical line is the level of real minimum wage for the latter quarter in each panel.

Figure B.4: Comparison of Estimated Effects after 1999q1 with Effects for Other Years

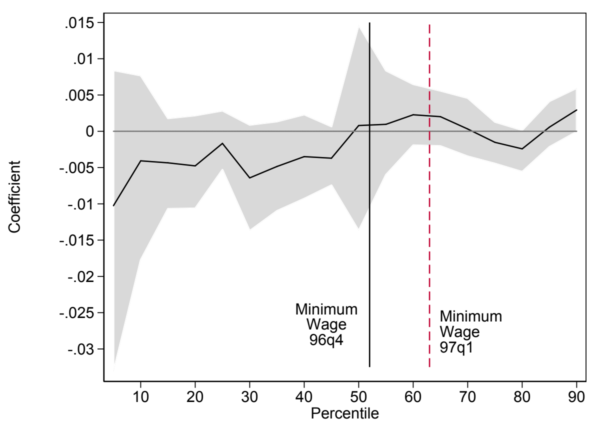
(a) Formal sector, 1996q2-1997q4, change in 1997q1



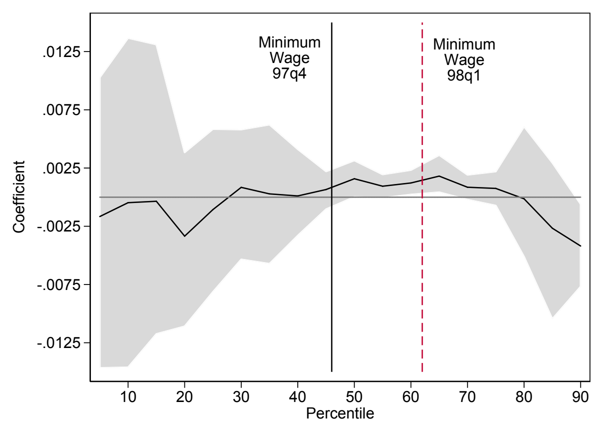
(b) Formal sector, 1996q2-1998q4, change in 1998q1



(c) Informal sector, 1996q2-1997q4, change in 1997q1



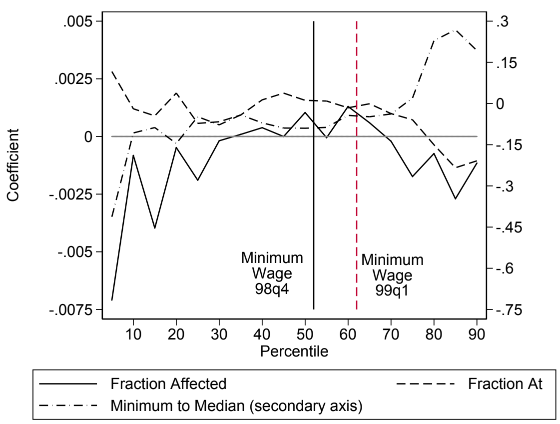
(d) Informal sector, 1996q2-1998q4, change in 1998q1



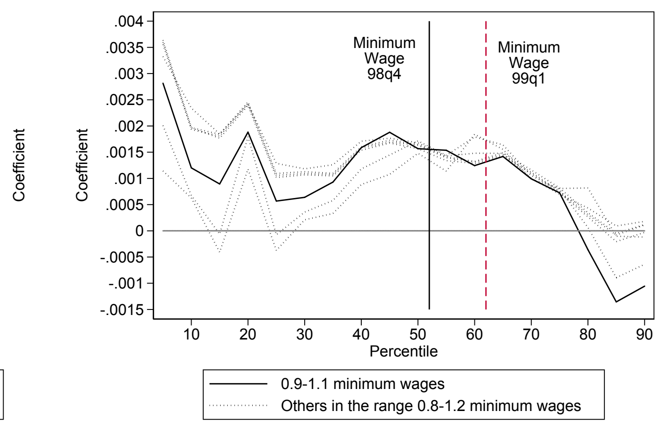
Unconditional quantile effects for percentiles of the distribution of formal and informal wages, for different dates. The minimum wage incidence is measured by "fraction affected", the number of workers between the old and new minimum wage. All regressions include controls for city-level employment and Bartik price shocks. Panels (a) and (c) show results for 1996q2-1997q4, using the change in the minimum wage in 1997q1. Panel (a) shows results for the formal sector, and panel (c) shows results for the informal sector. Panels (b) and (d) show results for 1996q2-1998q4, using the change in the minimum wage in 1998q1. Panel (b) shows results for the formal sector, and panel (d) shows results for the informal sector.

Figure B.5: Comparison of Estimated Effects on the Informal Wage Distribution. Different Measures of Minimum Wage Incidence.

(a) Fraction affected, fraction at and minimum to median

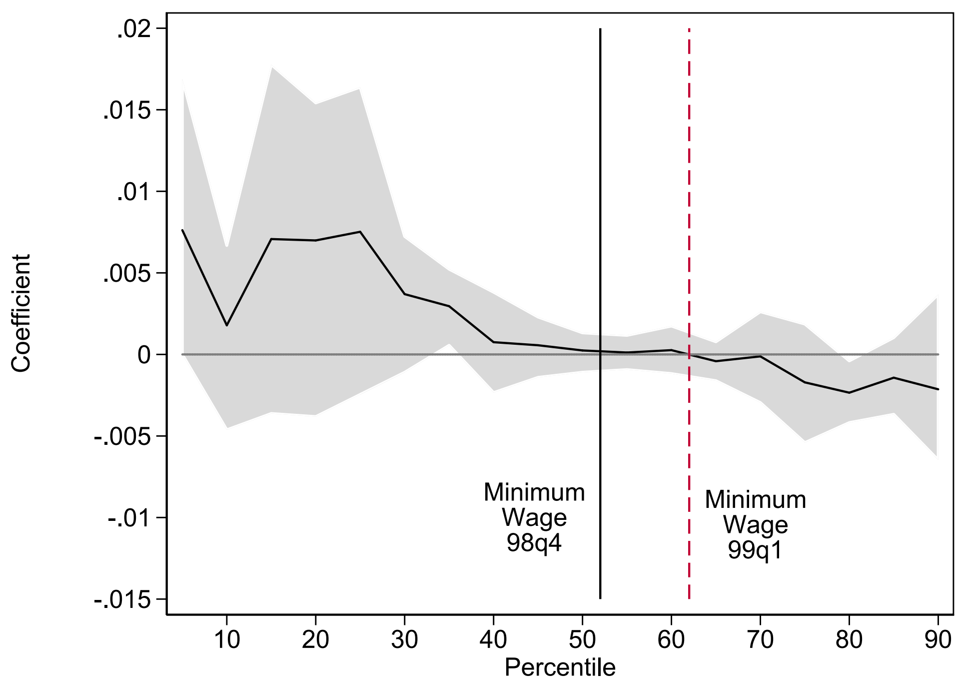


(b) Fraction at for different percentages around minimum wage



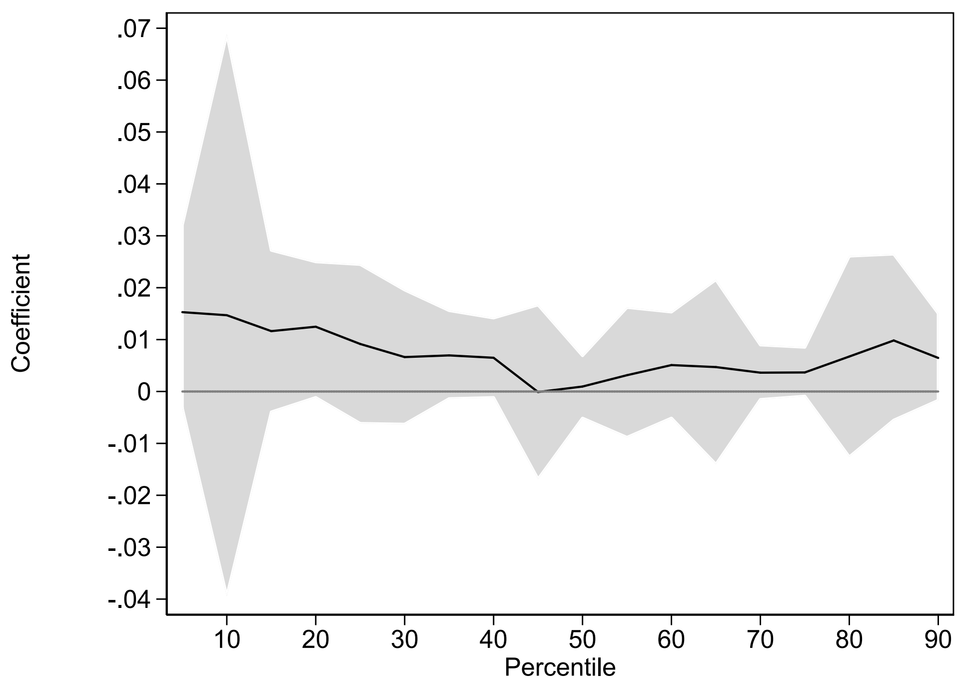
Comparison of unconditional quantile effects for percentiles of the distribution of formal wages, using different measures of minimum wage incidence. Panel (a) shows estimates using different minimum wage variables. "Fraction affected" counts the number of workers who are between the old and the new minimum wage in each city-industry block. "Fraction at" counts the number of workers that earn between 0.9 and 1.1 times the new minimum wage in each city-industry block. "Minimum to median" is the ratio of the new minimum wage to the old median wage in each city-industry block. Panel (b) uses "Fraction at" and changes the interval around the minimum wage, from 0.8-1.2 to 0.95-1.05, reducing the interval length by 0.5 each time.

Figure B.6: Placebo Check: Estimates of the Effect of the Minimum Wage Incidence on Informal Wages previous to the Minimum Wage Shock, 1998q3-1998q4.



Estimates of unconditional quantile effects for percentiles of the distribution of formal wages before the minimum wage shock. Minimum wage incidence is measured by "fraction at", the number of workers that earn between 0.9 and 1.1 times the new minimum wage in each city-industry block. Controls include city-level employment and Bartik price shocks. Shaded areas are 95% confidence intervals obtained using a wild bootstrap-t procedure with 200 replications, clustered by city.

Figure B.7: Cross-sectoral Effects of City Level Formal Minimum Wage Incidence on the Distribution of Informal Wages



Estimates of unconditional quantile effects for percentiles of the distribution of informal wages. Minimum wage incidence is measured by “fraction affected”, the fraction of workers between the old and new minimum wage in the formal sector in each city. Controls include city-level employment, city trends and Bartik price shocks. Shaded areas are 95% confidence intervals obtained using a wild bootstrap-t procedure with 200 replications, clustered by city.

Table B.1: Tests of differences between effects in the formal and informal sector

Fraction Affected	
Test	P-value
All Formal = All Informal	0.03
Formal p5-p25 = Informal p5-p25	0.00
Formal p40-p70 = Informal p40-p70	0.84
Formal p5-p25 = Informal p45-p65	0.00
Fraction At	
Test	P-value
All Formal = All Informal	0.00
Formal p5-p25 = Informal p5-p25	0.00
Formal p40-p70 = Informal p40-p70	0.08
Formal p5-p25 = Informal p45-p65	0.00

Each row of the table shows the results of a joint test of differences across estimates from the formal and informal sector. P-values are obtained from the results of a chi-squared test based on a joint coefficient bootstrap with 200 replications.