Do Institutions Remove Inflation's Grease? Evidence from Brazil's Indexed Minimum Wage*

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November 13, 2025

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Abstract

How do labor market institutions shape the propagation of inflation shocks? We address this question by studying Brazil's annually indexed minimum wage in a high-inflation context. Conventional wisdom suggests that inflation can "grease" labor market adjustments, but institutional wage-setting may alter this mechanism. Using administrative data, we show that indexation creates upward nominal wage rigidity: workers exposed to the policy experience fewer month-to-month wage increases before indexation events, and firms anticipate the policy by rigidifying wages of workers who will be newly bound. We evaluate the macroeconomic implications by introducing a cost-push shock to a New Keynesian model with heterogeneous labor and an indexed minimum wage. While staggered indexation amplifies the inflation as grease mechanism by introducing nominal rigidities, anticipation dampens it via intertemporal substitution. Overall, amplification matters more since cost-push shocks have a weaker effect compared to a setting where the minimum wage indexes every period. Our findings demonstrate that even in high-inflation environments, the institutional structure of wage-setting fundamentally shapes how shocks propagate through the economy.

*We are grateful to David Autor, Martin Beraja, Simon Jaeger, and Christian Wolf for their support and guidance at every stage of this project. We thank Constanza Abuin, Daron Acemoglu, Bautista Bassi, Pedro Martinez-Bruera, Tomas Caravello, Alberto Cavallo, Viola Corradini, Tishara Garg, Deivy Houeix, Martina Uccioli, Rafael Veiel, and Ivan Werning as well as participants of the MIT Labor and Macroeconomics lunches for their helpful comments and feedback.

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1 Introduction

Understanding the nature of nominal wage rigidity is a fundamental question in macroeconomics since it is one of the key mechanisms by which nominal shocks have real effects on output. For example, if nominal wages are rigid then an inflationary shock will lower the prevailing real wage and lead to an expansion of employment. This is popularly referred to as inflation "greasing the wheels" of the labor market (Tobin, 1972; Card and Hyslop, 1997), and is an argument often used in favor of targeting a positive inflation rate. However, to the extent that institutions determine nominal rigidities, and are themselves affected by inflation, they also play an important role in mediating the real effects of nominal shocks.

An important example of such an institution is the inflation-indexed minimum wage. This policy has become increasingly popular in recent years, with President Obama for example declaring in his 2013 State of the Union address that he would support indexing the federal minimum wage to inflation. To date, there are 19 states plus D.C. that have indexed their own minimum wage to inflation.[1] In theory, such a policy would remove inflation's grease altogether since it explicitly preserves the real minimum wage. However, in practice the indexation events do not take place in real-time with the inflation shocks, rather they do so on a pre-determined schedule. This creates stretches of time in between indexation events where nominal shocks may still have real effects.

In this paper, we study how Brazil's indexed minimum wage affects inflation's ability to grease the labor market. First, we find that minimum wage workers have more rigid earnings in between indexation events. Second, we show that firms set wages in a way that is consistent with them foreseeing the upcoming minimum wage increase. These empirical results imply that a nominal shock will additionally have distributional and anticipatory effects because of the policy. To understand how the policy affects the propagation of nominal shocks in equilibrium, we introduce a cost-push shock to a standard New Keynesian model augmented with heterogeneous labor types and a time-dependent, backward-looking, inflation-indexed minimum wage. First, we find that the timing of shocks matter. Compared to shocks that take place closer to the indexation event, those that happen further away have a stronger effect in the short run but a weaker one in the long run. Second, we show that the policy amplifies the inflation as grease mechanism by introducing nominal wage rigidities but dampens it via anticipation due to intertemporal substitution. Finally, we show that under this policy the shock has a smaller overall impact on inflation and output compared

[1] According to the Economic Policy Institute, these are Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Hawaii, Illinois, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, Nevada, New Jersey, New Mexico, New York, Ohio, Oregon, Rhode Island, South Dakota, Vermont, Virginia, Washington, Washington D.C., and West Virginia.

to a setting where the minimum wage indexes in every period.

Brazil between 2015-2016 is a unique opportunity to evaluate how an inflation indexed minimum wage interacts with the real effects of nominal shocks. The policy takes the form of a national minimum wage that indexes once a year in January. During this time period the country experienced one of the largest recessions in its history coupled with high inflation. Real gdp fell on average 3.4% each year, and inflation averaged 8.9% per annum. The "inflation as grease" mechanism is particularly useful in this setting since it allows real wages to adjust downwards in response to the negative real shock without nominal wage cuts. Moreover, the policy itself is very salient in Brazil since nearly 4% of all full time registered workers earn exactly the current minimum wage, while an additional 7% of them earn less than the following year's minimum wage.[2]

The empirical analysis focuses on the two indexation events in January of 2016 and January of 2017. For each result we first analyze the evidence in a non-parametric framework, and then in a regression framework. The analysis is based on monthly worker-level earnings observed in RAIS, an administrative employer-employee level dataset of all registered workers.

First, we find non-parametric evidence that workers bound by the minimum wage have more rigid earnings throughout the year than workers not bound by it. We measure upward nominal wage rigidity as the frequency of wage increases, which we proxy via sustained earnings increases. We find that between February and November it is 12% on average for minimum wage workers, and 19% on average for non-minimum wage workers. This means that non-minimum wage workers are much more likely to receive a wage increase throughout the year. However, this relationship flips in January when the minimum wage is indexed. 75% of minimum wage workers receive a wage increase compared to only 40% of non-minimum wage workers. The fraction of minimum wage workers who recieve an increase in January is not 100% because we classify workers in February so it is possible that they are above the threshold by the time the indexation event occurs.

Next, we find similar evidence on differential wage rigidity in a two-way fixed effects framework at the state-level. This strategy allows us to account for possible confounders such as a worker's relative position in the earnings distribution. Specifically, we measure variation in minimum wage bindingness at the state level using the Kaitz index. This index is defined as the distance between the current national minimum wage and the state-specific median. Then, we estimate how the frequency of wage increases varies at each earnings decile across states with different levels of minimum wage bindingness. On the one hand,

[2] An additional 60% of registered full time workers earn less than two multiples of the following year's minimum wage.

we find that workers at the second decile of earnings, who are more likely to be exposed to the policy, are 9 percentage points less likely to receive a wage increase between February and November in states where the minimum wage is one standard deviation more binding. On the other hand, they are 25 percentage points more likely to receive a wage increase in January. Higher earners, who are not exposed to the policy regardless of the state they live in, are a placebo test. As expected, their wage rigidity exhibits almost no difference across more versus less exposed states. As a robustness check, we also estimate a worker-level version of the same regression where we control for additional individual-level characterstics such as age, gender, education, region, and sector. We find similar results.

Second, we find non-parametric evidence that wage setting anticipates the minimum wage increase. Here we focus on "non-binding minimum wage" workers, which define as those who earn more than the current minimum wage but less than the upcoming minimum wage. They are special because their marginal product lies above the current minimum wage. Therefore, it cannot be the case that their wages are rigid because their competitive wage lies below the mandated nominal floor. Moreover, we would expect their wages to behave similarly to those of workers who earn more than the upcoming minimum wage. However, we find that non-binding minimum wage workers also experience more rigid wages throughout the year relative to workers unexposed to the increase. On average, only 14% of them experience a wage increase each month. Since the only thing that differentiates them from workers who are just above the upcoming minimum wage is the fact that they lie below it, this fact is consistent with firms anticipating the upcoming increase and adjusting their wage setting behavior accordingly. While we remain agnostic as to why these workers do not experience wage increases on par with unexposed workers, a possible explanation could be the "inflation as conflict" hypothesis. Guerreiro et al. (2024) find that workers must take costly actions to ensure that nominal wages keep up with inflation. This is consistent with the idea that minimum wage workers, who know that their wages will automatically catch up at the turn of the year, may be less willing to engage in these costly actions before then.

Next, we show that firms anticipate the upcoming minimum wage increase in an event study framework at the firm-level. This allows us to control for firm fixed-effects and other confounders such as a firm's region, industry, and its serial exposure to the minimum wage. We measure firm-level exposure to the minimum wage as the share of workers who earn less than the upcoming minimum wage, weighted by the distance between their earnings in the base year and the value of the minimum wage in the following year. We find that the average earnings of workers at less exposed firms *rise* relative to more exposed firms, *before* the policy comes into effect. This downward-sloping pre-trend indicates that firms anticipate the policy. Unfortunately, it also means that we cannot interpert the results causally. Additionally, we test an alternative explanation for this downward sloping trend in the coefficients, namely that a firm is responding to past exposure, not anticipating future exposure, and that these two exposures are correlated. However, we control for past exposure find no support for this hypothesis.

Motivated by these facts, we incorporate this type of minimum wage policy into a New Keynesian model with two types of labor to study how a nominal shock will propagate. The model assumptions are informed by our empirical findings: low skill labor is paid exactly the minimum wage which is rigid unless an indexation event occurs, and high skill labor is paid a completely flexible competitive wage. A representative household supplies both types of labor. The production side of the economy is composed of n competitive input firms, a continuum of monopolistically competitive intermediate firms, and a representative final good firm. The input firms hire high and low skill labor in different proportions, and sell their production at marginal cost to intermediate firms. Intermediate firms face nominal rigidities in price setting. This is the basis of an aggregate price Phillips curve to which the minimum wage is indexed. In the model, a period is defined at the quarterly level. The minimum wage updates once a year during the first quarter taking into account inflation over the previous four periods. This introduces a non-linearity in the model since the indexation rule is time-dependent.

In this setup, we study the impact of a cost-push shock. We focus on a cost-push shock to mimick the stagflationary environment in Brazil. In general, the variables respond as expected. Inflation rises, monetary policy reacts by setting a higher nominal interest rate, and output falls. However, as they return to steady state, their trajectory is interrupted by the first indexation event. With every new indexation event, inflation and the nominal interest rate spike upward while output spikes downwards, although by less than in response to the initial shock. The economy continues to cycle through this pattern following each subsequent minimum wage increase until the shock dissipates altogether and the nominal minimum wage stabilizes at a new higher level.

First, we find that the timing of the shock matters. Consistent with Olivei and Tenreyro (2007), shocks that occur further in advance of the indexation event have a stronger short-run effect since inflation has more time to accumulate. However, we also find they have the weakest effect in the long run. This is because inflation also has the most time to decline prior to the minimum wage increase which means that it will rise from a lower base.

Second, the shock also has important distributional effects. The real wages of low skill workers fall by less than those of high skill workers and their employment by more. However, they are driven by different factors. Since the nominal minimum wage is fixed, low skill real wages only adjust through inflation. In contrast, high skill nominal wages adjust freely and can respond to the decline in demand.

To disentangle the role of anticipation and nominal rigidities, we consider two extensions. First, we replace the cost-push shock to aggregate inflation with a cost-push news shock to the minimum wage. This allows us to isolate the role of anticipation. The shock raises the minimum wage which lowers output by raising marginal costs. We show that amplifies the decline in output via intertemporal substitution when workers and firms learn about the shock, and thus generates deflation. Even though firms begin setting higher prices due to precautionary pricing as the indexation event approaches, it is not enough make inflation positive. In comparison to the baseline scenario, the real wages of low skill workers rises before the indexation event, and their employment falls by even more. Thus, the anticipation generated by the policy removes inflation's grease.

In the second extension, we return to the original cost-push shock but change the policy so that the minimum wage adjusts in every period. Since there is no scope for anticipation, we can isolate the role of nominal rigidities by comparing these outcomes to the baseline. While the direction of the responses align with the baseline scenario, their magnitudes are different. Namely, the real wage of low skill workers falls by less and output falls by more. This dampening of the inflation as grease mechanism demonstrates that a staggered indexation regime amplifies it.

Overall we find that a staggered indexation regime acts against a cost-push shock by introducing nominal wage rigidities and ultimately delivers a weaker response of inflation and output via the inflation as grease mechanism. The timing matters, with shocks that take place further away from the indexation event having a stronger short-run effect but a weaker long-run effects. There are also important distributional effects, with minimum wage workers, who are subject to greater nominal rigidities, benefitting more.

Literature: This paper contributes to the literature on how labor market institutions interact with shocks to determine real outcomes (Blanchard and Wolfers, 2000). More specifically, it speaks to the literature on nominal wage rigidities and how they mediate nominal shocks, and to the literatures on indexation and the minimum wage.

The literature that directly measures nominal wage rigidities has mostly focused on developed economies. Some prominent examples include Le Bihan et al. (2012) who, using a large representative survey in France, find that the frequency of nominal wage adjustments is 38% at the quarterly frequency. Using the Survey of Income and Program Participation (SIPP), Barattieri et al. (2014) find a range between 21.1-26.6% for the probability that a US worker will experience a wage change in a given quarter. Finally, Sigurdsson and Sigurdardottir (2011) find that the frequency of monthly wage changes is 10.8% in Iceland. On average, these papers find that the monthly frequency of wage adjustment is approximately

10%. Our findings contribute to the literature on nominal wage rigidity by providing, to our knowledge, the first direct evidence of high-frequency micro-wage setting behavior in a large middle-income country. In our context, the average monthly frequency of adjustments is approximately 20% throughout the year, and much higher at the turn of the year.

There is also a rich literature studying the importance of labor market institutions for labor market outcomes. However, the idea that institutions interact with shocks in ways that matter for real outcomes was emphasized by Blanchard and Wolfers (2000). We contribute to this literature by

There is also a literature that studies the importance of nominal wage rigidities by evaluating the impact of monetary policy in differently rigid environments. Olivei and Tenreyro (2007) were the first to leverage variation in wage rigidity over time to make this point. They find that wage contracts in the US are more likely to adjust at the end of the fiscal year. Consistent with this fact, they find that monetary policy shocks have less impact on output when they take place right before this period of contract renewal and a larger one when they occur right after it. Similarly, Björklund et al. (2019) find that monetary policy shocks in Sweden have a 0.37 percentage point greater effect if they take place during periods where wage contracts are fixed relative to the average response. Minton and Wheaton (2022) leverage variation in wage rigidity across US states. They argue that states with a more binding minimum wage will have more rigid wages. Consistent with this, they find that employment responds more to monetary policy shocks in states with a relatively higher minimum wage. Finally, Faia and Pezone (2024) leverage variation in wage rigidity across firms in Germany. They find that firm's stock prices and employment respond more to monetary policy shocks in firms with more rigid wages as measured by their collective bargaining activity. Our paper relates most closely to Minton and Wheaton (2022) in that it leverages variation in wage rigidity arising from the minimum wage. However, we emphasize how the inflation-indexed minimum wage policy generates additional wage rigidity via an anticipation channel, and that its effects are stronger the greater is the inflationary shock. This indicates that the policy exposes low-skill workers by more to the very shock it was designed to protect them from.

Seminal papers on wage indexation include Gray (1976) and Fischer (1977). They argue that indexation protects workers from nominal shocks but exposes them to real ones since it mechanically preserves the real wage. However, as highlighted by Jadresic (1996), this conclusion depends on the specific indexation rule used. Recent theoretical work has focused on determining what are the optimal indexation rules. Carrillo et al. (2022) find that workers prefer to index to past inflation when real shocks dominate, but they prefer to index to trend inflation when nominal shocks dominate. Recent empirical work has focused on evaluating indexation schemes in practice. For example, Manacorda (2004) finds that the *Scala Mobile* indexation scheme in Italy had a significant impact on wage inequality. Bijnens et al. (2023) finds that a temporary suspension of wage indexation in Belgium had positive employment effects in 2015. Our paper contributes to this literature by emphasizing that indexation events generally occur sporadically, and not continuously. Therefore, it is important to study how wage setting and other outcomes evolve in between and vis a vis indexation events.

While economy-wide indexation is less prevalent than in the late 20th century, the policy survives in many places in the form of partial indexation schemes. Jaeger et al. (2024) highlight the importance of two wage setting institutions that often embed indexation policies. These are collective bargaining agreements and the minimum wage. Koester and Grapow (2021), who provide a recent survey of the prevalence of different wage indexation policies in the euro area, find that 18% of euro area private sector workers work in countries where the minimum wage is indexed to inflation. The partial nature of these schemes allow researchers to leverage differential exposure to it within the same economy to identify its effects (Tito, 2011). Our paper fits into this tradition, and brings in evidence from a middle-income country context. We highlight the distributional impact of such policies, both for the workers that are directly affected by them and for firms that are differentially exposed to them.

Finally, our paper also contributes to the literature on the minimum wage. The vast majority of it focuses on the effect of unexpected and large increases in the minimum wage (Dube and Lindner, 2024). This is largely because it is easier to identify causal effects in this context. However, there is a broad swath of both local and national governments, such as California, France, and Canada, that have adopted or are moving towards adopting some form of inflation-indexed minimum wage policy (Karlamangla, 2024; Campbell, 2024). Thus, it is important to study them, despite the identification challenges that arise from the foreseeable increases.

Outline: Our paper proceeds as follows. Section 2 provides background on the Brazilian minimum wage policy, describes the data, and presents descriptive evidence, including the non-parametric analysis. Section 3 analyzes how wage rigidity varies based on the bindingness of the minimum wage at the state- and worker-level in a two-way fixed effects framework. Section 4 presents the event studies that capture firm-level anticipation. Section 5 presents the model and discusses the implications of a backward-looking time-dependent inflation-indexed minimum wage for the propagation of inflationary shocks. Section 6 concludes.

2 Background, Data and Descriptive Evidence

2.1 The minimum wage in Brazil

Brazil has a long history of actively using minimum wage policy. There has been a nationwide minimum wage since 1984 which is closely watched because it also establishes the floor for pensions, welfare payments, and unemployment benefits. However, its use as an index for other contracts is forbidden.

There are two other main wage-setting institutions that we set aside primarily because the national minimum wage acts as a wage floor for both of them. These are (1) individual state's minimum wages, and (2) collective bargaining agreements. So far, five states set their own higher minimum wages[3]. However, their application is irregular both in terms of who it applies to, and when they are updated. Collective bargaining agreements are negotiated and therefore respond endogeneously to the specific conditions of the sector or firm to which they apply. In contrast, the national minimum wage is updated on a regular schedule and applies to all full time workers. It does not take any individual sector or firm's characteristics into account.

Prior to 2008, the minimum wage was determined via negotiations between trade union centrals and the central government. As part of his platform, President Lula proposed that minimum wages should automatically adjust every January based on a rule that accounted for inflation over the previous 12 months and GDP growth with a two-year lag. This rule was signed into law in 2011 and used until 2019. A notable exception occurred in 2017 and 2018 when the two-year lag of GDP growth was negative. In these cases, the law was interpreted to mean that the minimum wage would only ever *increase* (and never decrease) based on these two factors. After 2019, the new government reverted to updating the minimum wage exclusively based on inflation. However, they maintained the regularity of updating it every January.

Every year at the beginning of September, the Brazilian government publishes its own forecast of the following year's minimum wage as part of its annual budget law (Lei Orcamentaria Anual, or LOA). This is necessary since so many social programs and other government payouts are tied to the minimum wage. While the minimum wage increase is already predictable since it relies on a fixed and transparent formula, this is yet another instance where the public is made aware of the expected upcoming increase.

[3] These are Rio de Janeiro, Rio Grande do Sul, Paraná, Sao Paulo and Santa Catarina.

The analysis period: January 2015-January 2017

Our analysis focuses on the period between January 2015 and January 2017. It encompasses two minimum wage hikes which we examine separately. In January of 2016, the monthly minimum wage for full-time workers rose from 788R$ to 880R$, implying an 11.67% increase. This was the result of an 11.27% inflation rate in 2015, and a 0.5% real GDP growth rate in 2014. The forecast published in the annual budget law proposal of September 2015 was 865R$. In January of 2017 the minimum wage rose to 937R$, a 6.5% increase from the year prior. It reflected the 6.6% inflation rate in 2016 but, as explained above, it disregarded the -3.5% real GDP growth rate in 2015. The government's forecast published in September 2016 as part of the annual budget law proposal was 945R$.

2.2 Data on Earnings

We obtain labor market data from RAIS (*Relaçao Anual de Informacões Sociais*). This is an employer - employee matched annual mandatory survey for all registered firms in Brazil. We create three differente datasets. Section 3 uses a worker-level and a state-level dataset, while section 4 uses a firm-level dataset. In our sample we restrict to private sector workers with a standard 44 hour workweek aged 18 to 54, employed by firms with more than 5 workers. The final sample contains approximately 4 million workers per year, in roughly 300,000 firms, spread across 27 states.

In addition to a worker's characteristics such as age, gender, race and education, we observe their earnings in two ways. First, firms directly report a worker's annual average monthly earnings. For worker l in year t, we label this variable $\hat{y}_t^l$. Second, firms also report worker's monthly earnings in each month. For worker l in month m and year t we label this variable as y_{mt}^l. Firms are required to report how much they effectively pay each worker, including overtime but excluding the 13th salary.[4].

In our dataset, sometimes a worker's directly reported annual average monthly earnings $\hat{y}_t^l$ does not match the annual average predicted by averaging monthly earnings y_{mt}^l. This is likely due to measurement error in the monthly earnings, not in the directly reported annual average, since it is the latter that dictates eligibility for welfare benefits. See appendix A.1 for a fuller discussion. To address this issue, we restrict the sample to workers whose directly reported annual average monthly earnings are consistent with their monthly earnings.

Wage rigidity. In the analysis, we measure how wage rigidity varies with exposure to the minimum wage. This requires us to measure wage changes at the worker level. To proxy for

[4]The 13th salary is an annual bonus that is paid out in two parts. The first half must be paid before November, and the second half must be paid before December.

wage changes, we rely on sustained positive changes in earnings. This is a suitable proxy for two reasons. First, sustained earnings changes are less likely to reflect transitory changes in earnings due to factors such as changes in hours worked, or one-off bonus payments. Second, it is illegal for firms to unilaterally lower a worker's nominal wages.[5] We define a sustained earnings increase as a month-to-month increase in earnings that is at least maintained the following month regardless of whether a worker switches employers.

Summary Statistics. To get a better understanding of the characteristics of workers exposed and unexposed to the minimum wage, Table 1 describes workers along the wage distribution for the 2015-2016 sample.[6] We use their annual average monthly earnings in 2015 $\hat{y}_t^l$, to sort them. Each column corresponds to one of three groups: those earning less than the following year's minimum wage, those earning between the following minimum wage and less than two multiples of the following year's minimum wage, and those earning more than that.

Workers who earn less than the following year's minimum wage are surprisingly similar to those who earn up to two times the minimum wage. They are more likely to work in services, have a high school degree or less, and work in smaller establishments. In contrast, workers who earn more than two times the minimum wage are more likely to work in manufacturing, have a college degree, and work in larger establishments. Overall, as earnings increase the likelihood of living in the northeast decreases, and that of living in the southeast increases.

2.3 Non-parametric analysis

We start with a non-parametric analysis of wage-setting at the worker level. The objective is twofold. First, to establish that minimum wage workers have more rigid wages, and second, to show that firms anticipate the upcoming increase.

We measure wage-setting using the frequency of sustained earnings increases. It is defined as the share of workers who experience a sustained earnings increase in a given month. For example, if 20% of workers experience a sustained earnings increase each month, this implies that the average duration between sustained earnings increases is 5 months. A higher frequency of sustained earnings increases implies more flexible wages, while a lower frequency implies more rigid wages.

Figure 1 plots the frequency of sustained earnings increases for four types of workers at the monthly level. Each worker-type has varying degrees of exposure to the minimum wage. To capture possible anticipation, we focus on the period before each minimum wage increase.

[5]See Article 7, item VI of the 1988 constitution, and article 468 of the labor code (*Consolidação das Leis do Trabalho, CLT*).

[6]See appendix A.2 for the table corresponding to the 2016-2017 sample.

Table 1: Summary Statistics by Earnings Percentiles (2015)

	$\hat{y}_t < mw^{t+1}$	$mw^{t+1} < \hat{y}_t < 2 \cdot mw^{t+1}$	$2 \cdot mw^{t+1} < \hat{y}_t$
Observations	1000101	6288112	3068607
Female	0.45	0.40	0.23
Age	32.19	34.07	37.80
Education			
Less than High School	0.53	0.43	0.29
High School	0.45	0.52	0.45
More than High School	0.02	0.05	0.27
Establishment Size			
Small (<20)	0.19	0.22	0.16
Medium (20–250)	0.37	0.39	0.41
Large (>250)	0.44	0.39	0.44
Regions			
North	0.08	0.05	0.05
Northeast	0.37	0.16	0.10
Southeast	0.37	0.51	0.57
South	0.08	0.19	0.20
Centerwest	0.09	0.08	0.08
Sectors			
Agr. and Mining	0.17	0.08	0.05
Manuf. and Constr.	0.30	0.31	0.41
Services	0.53	0.60	0.52

Notes: This table presents summary statistics for workers in three groups defined by their average monthly earnings in 2015 relative to the upcoming minimum wage increase in January 2016. The first column includes workers who earn less than the 2016 minimum wage, the second column groups workers who earn more than that but less than two multiples of it, and the third column includes workers who earn more than two multiples of it.

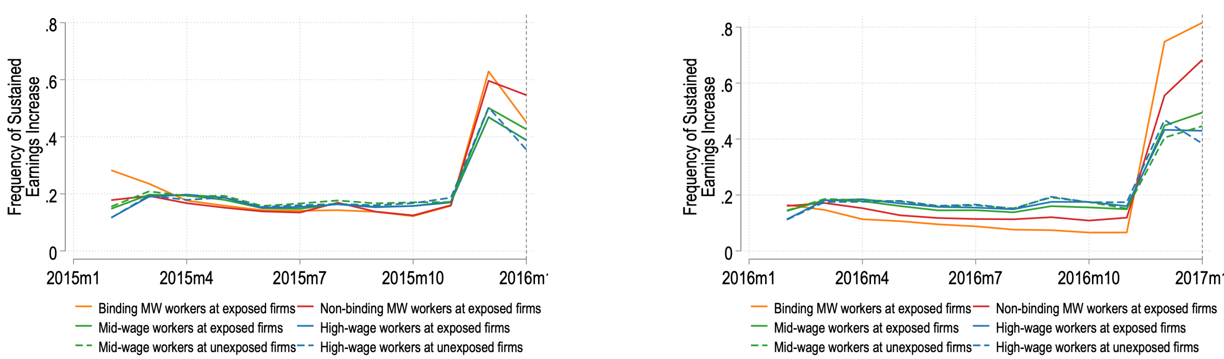
Panel 1a reports the results for 2015, while panel 1b reports the results for 2016.

Workers are classified into one of four types based on the first observation of their monthly nominal earnings. On the one hand, "Binding MW" and "Non-binding MW" workers are both exposed to the minimum wage increase in the sense that they earn less than the following year's minimum wage. The difference between them is that binding MW workers (orange line) earn exactly the current minimum wage while non-binding MW workers (red line) earn more than it.

"Mid-wage" and "High-wage" workers are both unexposed to the minimum wage increase in the sense that they earn more than the following year's minimum wage. Mid-wage workers (green lines) earn less than two multiples of next year's minimum wage while high-wage workers (blue lines) earn more than that. These unexposed worker types are additionally sorted into one of two firm types: exposed or unexposed. Exposed firms (solid lines) employ at least one exposed worker, while unexposed firms (dashed lines) employ none.

Figure 1: Non-parametric Evidence on Upward Nominal Wage Rigidity

(a) 2015-2016 (b) 2016-2017



Notes: This figure presents non-parametric evidence on the frequency of sustained earnings increases at the worker-level. The frequency of sustained earnings increases is defined as the share of workers with a month-to-month earnings increase that is at least maintained the following month. Workers are classified when they enter the sample. Binding MW workers are those that earn exactly the curent minimum wage. Non-binding MW workers are those that earn more than the current min wage but less than the following year's minimum wage. Mid-wage workers are those that earn more than the following year's minimum wage but less than two multiples of it. High-wage workers are those that earn more than two multiples of the following year's minimum wage.

Non-parametric evidence on differential wage rigidity:

The most important fact that emerges from Figure 1 is that exposed workers experience significantly more rigid wages throughout the year than unexposed workers. This is true in both sample periods. In general, binding MW and non-binding MW workers experience a frequency of sustained earnings increases of around 12-14% throughout most of the year, while mid-wage and high-wage workers experience a frequency of around 18-20%. This relationship flips at the turn of the year, when exposed workers are much more likely to experience a sustained earnings increase than unexposed workers.

To make progress on what may explain the correlation of minimum wage exposure and wage rigidity, we compare wage setting behavior across worker and firm types.

We find little evidence that it is the worker's level of earnings that drives the results. To check this, we compare the wage setting behavior of mid-wage relative to high-wage workers. While these two groups have significantly different earnings levels, they exhibit a strikingly similar frequency of earnings changes. This is especially meaningful given that these two types of workers are very different in terms of their characteristics, as reported in Table 1.

Finally, we find little support for the hypothesis that firm type drives the results. For this, we contrast similar workers in differently exposed firms. We find that mid-wage and high-wage workers at both exposed and unexposed firms have a similar earnings rigidity. This implies that other firm characteristics that may be correlated with firm-level minimum wage exposure, such as a firm's region or sector, do not drive the result. It further supports the hypothesis that worker-level exposure is the most important determinant of earnings rigidity.

Non-parametric evidence on anticipation:

The behavior of the non-binding MW workers suggests that firms anticipate the upcoming minimum wage increase. This group of workers is special because their competitive wage lies above the current minimum wage, so it cannot be that the rigidity of their earnings is explained by the policy's mechanical bindingness. Instead, what separates them from unexposed workers and ties them to binding MW workers, is the fact that they will be affected by the upcoming minimum wage increase. Thus, any similarities in their wage setting behavior can be attributed to this future exposure. Although we remain agnostic as to why exposure lends wage-setting power to firms, the empirical patterns are consistent with this being true. A possible explanation put forward by Guerreiro et al. (2024) suggests that workers must take costly actions to ensure that nominal wages keep up with inflation. Minimum wage workers, who know that their wages will catch up at the turn of the year, may be less willing to engage in these actions before then.

3 Wage Rigidity varies under the Minimum Wage

Exposure to the minimum wage may be correlated with wage setting practices for reasons other than the policy. To explore this possibility, we estimate a regression version of the non-parametric analysis to better address possible unobserved confounders. The biggest concern is that differential wage-setting across exposed and unexposed workers is due to a worker's relative position in the earnings distribution and not their exposure to the minimum wage. These two characteristics are correlated since it is low-wage workers that are exposed to the policy. The comparison of mid-wage and high-wage workers in the non-parametric analysis begins to address this concern by showing that the earnings rigidity of unexposed workers is similar at different points in the earnings distribution. However, it is not conclusive because there may be a non-linear relationship between a worker's position in the earnings distribution and how their wages are set.

To directly address this concern we rely on two empirical strategies. First, we directly compare wage-setting within the same earnings percentile across states where the minimum wage is more versus less binding. This allows us to isolate the effect of minimum wage bindingness from a worker's relative position in the earnings distribution. Throughout the year, we find that workers at the 2nd decile of earnings have a 9pp lower frequency of adjustment in areas with a one standard deviation more binding minimum wage. At the turn of the year, they have a 25pp higher frequency of adjustment in areas with a one standard deviation more binding minimum wage.

Second, we estimate a worker-level version of the same regression. This allows us to control for additional individual-level characterstics such as age, gender, education, region, and sector. We find similar results.

3.1 State-level Analysis

Econometric Framework

To correlate the minimum wage with the frequency of sustained earnings increases, we estimate a state-level two-way fixed effects model relying on state-level variation in minimum wage exposure. Since figure 1 shows that wage-setting behaves differently throughout the year versus at the turn of the year, we estimate the model separately for the period between February to November and the period from December to January. We pool the data prior to each minimum wage increase from the 2015-2016 and 2016-2017 event-windows. In the regression, the event-window is indexed by t. So, for example, January of 2016 belongs to the 2015-2016 event-window, while February of 2016 belongs to the 2016-2017 event-window.

We measure state-level minimum wage exposure using the Kaitz index (Lee, 1999; Autor et al., 2016). The Kaitz index in state s is defined as the difference between the log national minimum wage and the log state-median wage: $Kaitz_s = log(mw) - log(\hat{y}_s^{median})$. The measure captures how binding the minimum wage is in each state.

We specify the model as follows:

$$F_{smt}^d = \sum_{k=1}^{10} \beta^d(\mathbb{1}_{d=k} \times Kaitz_{st}) + \gamma_{sd} + \delta_{td} + \epsilon_{smtp}, \tag{1}$$

Where F_{smt}^d is the frequency of sustained earnings increases in state s at month m-event window t for earnings decile d. ρ_d are decile fixed effects. γ_{sd} are state-by-decile fixed effects and δ_{td} are event-window-by-decile specific time fixed effects. The sample includes all workers in firms with more than 5 employees. In each sample, workers are categorized into each earnings decile based on their first observed monthly earnings. Standard errors are clustered at the state level.

We control for unobserved state-level characteristics that are fixed over time with state-level-by-decile specific fixed effects. An important example is sectoral composition. If poorer states also have a greater share of their economic activity in a specific area, such as agriculture, then wage-setting practices specific to that economic activity will correlate with the minimum wage. However, since we do not expect aggregate sectoral composition to change significantly over the short two-year period under consideration, the fixed effects will account for this correlation.

The event-window-by-decile specific time fixed effects account for aggregate shocks that are common across states but may correlate with the bindingness of the minimum wage. Since the bindingness is constant within each event-window, only event-window specific time fixed effects are necessary. An important example of an aggregate shock this accounts for is the inflationary environment. Since inflation mechanically leads to a higher minimum wage, it is also associated with greater bindingness. The fixed effects account for any correlation between such aggregate shocks and wage setting practices.

Thus, this design allows us to compare workers in the same position of the earnings distribution in states where the minimum wage is more versus less binding. The coefficients of interest are the β^d coefficients which isolate the effect of minimum wage bindingness accounting for permanent differences across states within each event window and decile and across event windows within each state and decile. Higher earnings deciles are a natural placebo group for lower earnings deciles since the minimum wage is less likely to matter for them, regardless of the state-specific minimum wage bindingness.

Engbom and Moser (2022) also use an empirical strategy that relies on the Kaitz index in the context of Brazil. They study the correlation between the minimum wage and wage inequality. They do two things differently. First, they find that the minimum wage has positive and significant spillovers up to the 90th percentile of the earnings distribution. Thus, they argue that a Kaitz index built around the 90th percentile of earnings instead of the median is more appropriate. We conduct the analysis using this version of the Kaitz index and find similar results. Second, they include a quadratic term of the Kaitz index to capture non-linear effects of minimum wage bindingness. Our results are robust to this specification as well.

State-level Results on Differential Wage Rigidity

Figure 2 shows the results from estimating equation 1 for each time period. Panel 2a plots each β^d coefficient from pooling the months between February and November, while panel 2b reports the β^d coefficients from pooling together December and January. The standard deviation of the Kaitz index is 0.1. Thus, $\beta^d \times 0.1$ describes the percentage point change in the frequency of sustained earnings increases when the minimum wage bindingness increases by one standard deviation.

Panel 2a shows that workers at the bottom of the wage distribution have more rigid earnings in states where the minimum wage binds more. The negative and significant β^2 coefficient implies that a one standard deviation increase in the Kaitz index is associated with a 9 percentage point decrease in the frequency of sustained earnings increases for workers at the 2nd decile of the earnings distribution. This effect is economically significant. Given that the average frequency of sustained earnings increases for these workers is 12.6%, this implies a 71% decrease relative to the mean.

Panel 2b shows that this relationship flips at the turn of the year. Workers at the bottom of the earnings distribution have more flexible earnings in states where the minimum wage binds more. The positive and significant β^2 coefficient implies that a one standard deviation increase in the Kaitz index is associated with a 25 percentage point increase in the frequency of sustained earnings increases for workers at the 2nd earnings decile. Given that the average frequency of sustained earnings increases for these workers is 61.3%, this implies a 40% increase relative to the mean.

In both panels, the effect on deciles higher up in the distribution is not significantly different from zero. This is consistent with higher earnings deciles not being exposed to the minimum wage regardless of the state-level minimum wage bindingness.

Overall, both the direction and magnitude of the results for the lower earnings deciles and the higher earnings deciles are consistent with the non-parametric evidence presented in figure 1. They provide further evidence that nominal wage setting is more rigid for workers exposed to the minimum wage between February and November, but more flexible at the turn of the year.

3.2 Robustness: Worker-level Analysis

Econometric Framework

To further address concerns about unobserved confounders, we estimate a worker-level version of equation 1. This allows us to control for other worker-specific characteristics in addition to their earnings decile. We proceed by regressing a dummy variable indicating whether a worker l experiences a sustained earnings increase on the interaction of the Kaitz index with the worker's state-specific earnings decile.

$$D^F_{lsmt} = \sum_{k=1}^{10} \lambda^d \left(\mathbb{1}_{d=k} \times Kaitz_{st}\right) + \gamma_{sd} + \delta_{td} + X_l' + \epsilon_{lsmt}, \tag{2}$$

Where D^F_{lsmt} is a dummy variable that equals one if worker l in state s at month m event-window t experiences a sustained earnings increase. As before, ρ_d are earnings decile fixed effects, γ_{sd} are state-decile fixed effects and δ_{td} are event-window-decile specific time fixed effects. X_l' is a vector of worker-specific controls. This includes age, education, gender, sector, and region. The sample includes all workers in firms with more than 5 employees. Standard errors are clustered at the state level.

The coefficient of interest is λ^d. It describes how the likelihood of a sustained earnings increase differs for each earnings decile d in states where the minimum wage is more versus less binding.

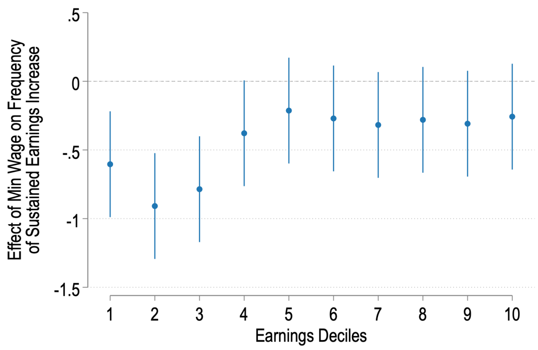
Worker-level Results on Differential Wage Rigidity

Figure 2c plots the λ^d coefficients from estimating equation 2 pooling together the months between February and November. The blue circles represent the coefficients from a baseline regression that includes controls for age, education, and gender. The orange triangles represent the coefficients from a regression that additionally includes sector and region fixed effects. The results are practically unchanged between the two specifications.

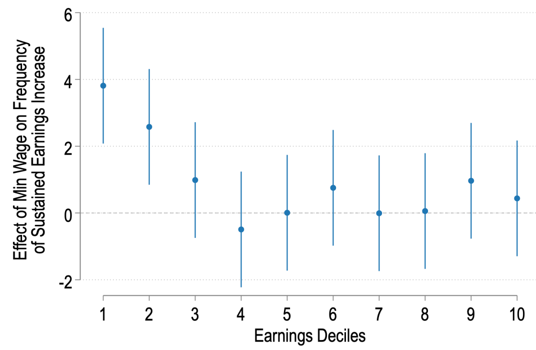
The results are consistent with the state-level analysis. Workers at the 2nd earnings decile in states where the minimum wage binds more are less likely to experience a sustained earnings increase relative to workers in the first earnings decile. The point estimates imply

Figure 2: State-level Regressions

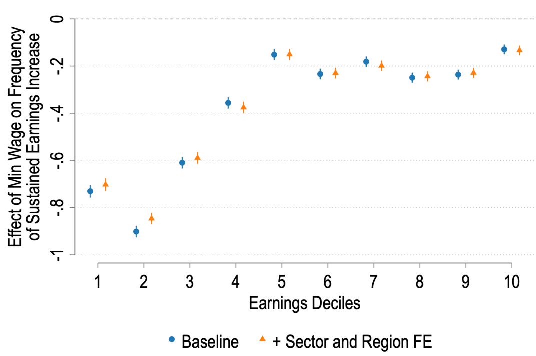
(a) State-level: February to November



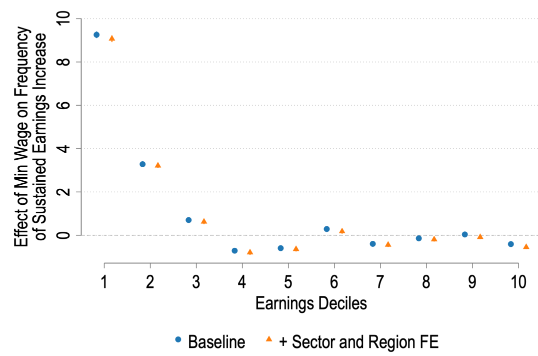
(b) State-level: December to January



(c) Worker-level: February to November



(d) Worker-level: December to January



Notes: Panels 2a and 2b figure plots the β^d coefficients from estimating equation 1 of the frequency of sustained earnings increases on the Kaitz index at each earnings decile, controlling for state-decile and time-decile fixed effects. The frequency of sustained earnings increases is defined as the share of workers with a month-to-month earnings increase that is at least maintained the following month. Standard errors clustered at the state level. Panels 2c and 2d plot the results from a single worker-level regression. The blue circles represent the λ^d coefficients described by equation 2. Specifically, the coefficients describe the change in the probability that a worker experiences a sustained earnings increase at each earnings decile as the state-level bindingness of the minimum wage increases. We control for worker characteristics such as age, education, gender and earnings deciles. The orange triangles represent the same λ^d coefficients from a regresssion that additionally controls for industry and region fixed effects.

that a 2nd earnings decile worker in a state where the minimum wage binds by 1 standard deviation more, is 9pp less likely (32pp more likely) to experience a sustained earnings increase throughout the year (at the turn of the year).

4 Firms Anticipate the Minimum Wage

Next, we build on the evidence presented in the non-parametric analysis showing that firm's anticipate the upcoming minimum wage. Specifically, we leverage an event study framework to evaluate how wage setting varies in firms that are more versus less exposed to the minimum wage increase, before and after it occurs. By focusing on the period before the indexation event, we can capture any anticipation. We find that the average earnings of workers at more exposed firms increase relative to those at less exposed firms before the minimum wage increase. In the results, this presents as a downward slope in the coefficients prior to the indexation event.

In this section, we start by constructing a firm-level measure of exposure to the minimum wage which we denote Z_f. Then, we describe the empirical specification we use to evaluate its impact during the two 24-month event windows spanning from January 2015 to December 2016 and January 2016 to December 2017. Finally, we discuss the results.

The Firm-level Exposure Measure

The exposure measure Z_f captures the predicted average earnings change at firm f due to the minimum wage increase. It is the analog to what Harasztosi and Lindner (2019) call the Wage Gap measure. If there is full compliance, no spillovers, and no disemployment effects, or if these exactly cancel each other out, it will exactly predict the actual change in a firm's average earnings in January.

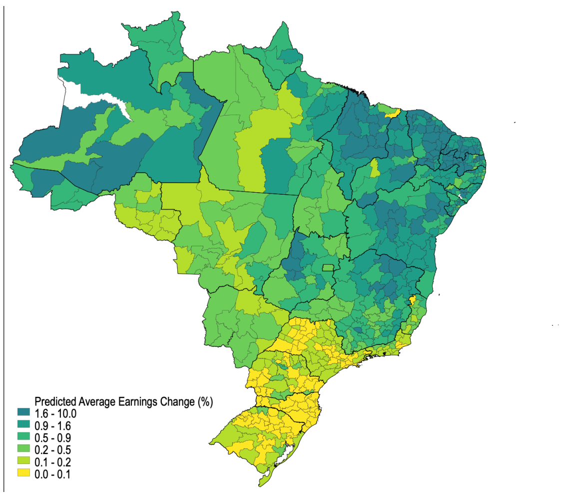
Equation 3 describes how Z_f is calculated. It takes the average of exposed and unexposed worker's expected earnings changes. Exposed workers are those whose annual average monthly earnings fall below the following year's new minimum wage. Since the minimum wage always updates in January, we use the calendar annual average in the previous year to avoid endogeneity concerns arising from earnings fluctuations in any specific month (especially December). The max operator takes on the value of zero for unexposed workers. Thus, the instrument incorporates information both on the extensive margin of exposure, how many workers at a firm are exposed, and the intensive margin, by how much.

$$Z_f = \frac{1}{N_f} \times \sum_{l \in N_f} \max\{(mw_{t+1} - \hat{y}^l_{ft}), 0\}, \tag{3}$$

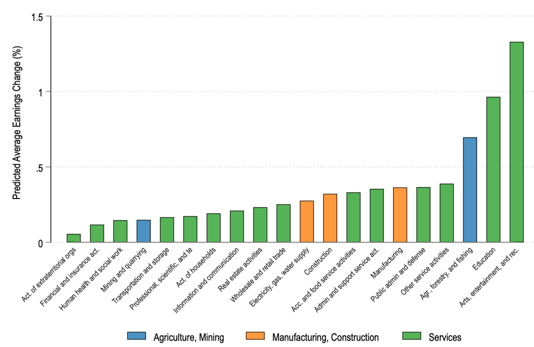
N_f is the total number of workers employed in firm f in December right before the minimum wage increase. mw_{t+1} is the new log minimum wage the following January. $\hat{y}^l_{ft}$ is the log directly reported annual average monthly earnings of worker l in firm f and year t who is employed in December.

We calculate Z_f separately for the two event windows. Both in the 2015-2016 and 2016-2017 samples, approximately 20% of firms have a positive value of treatment. For them, the average value of exposure is 1.6%.

Figure 3: Exposure to the minimum wage in Brazil



(a) Geographic variation



(b) Industry variation

Notes: The figures show the average variation in the exposure measure Z_f from 2015-2016 separately at the geographic and industrial levels. Panel 3a shows the average value of the treatment in each of the 558 microregions. Panel 3b shows the average value of the treatment across each of the 20 industries.

Figure 3 shows how the instrument varies across regions and industries. Panel 3a shows the average value of the instrument at the microregion level between 2015-2017. On average, the northeast region of the country is much more exposed (darker colors) than the southeast (lighter colors). This is consistent with the fact that the southeastern region is more economically developed.

Panel 3b shows the average value of treatment at the broad industry level between 2015-2017. On average, the service sector is very exposed to the minimum wage, especially in cases like the accommodation and food services industry, or the wholesale and retail trade industry. The agricultural sector is also relatively highly exposed. As might be expected, the least exposed industries are the financial and insurance activity industry, and the mining and quarrying sector.

Empirical Framework

A firm-level event-study model, described in equation 4, isolates how exposure correlates with the minimum wage over time in each 24-month event window. Since the minimum wage increase is predictable, we cannot interpret these coefficients causally. We interact the exposure measure Z_f with month-by-year-specific event time dummies $\mathbb{1}_{m=k}$, and include firm γ_f and month-by-year δ_m fixed effects separately. The period $m = 0$ corresponds to the month where the minimum wage increases. In the 2015-2016 sample this is January 2016, and in the 2016-2017 sample this is January 2017. In the baseline analysis, we normalize the $\beta_{m=0}^{Firm}$ coefficient to 0. Thus, the coefficients of interest β_m^{Firm} capture the change in outcome y_{fm} in more versus less exposed firms relative to their baseline difference in December of the pre-period.

$$y_{fm} = \sum_{\substack{k\neq -1 \\ k=-12}}^{k=11} \beta_m^{Firm}(\mathbb{1}_{m=k} \times Z_f) + \gamma_f + \delta_m + \varepsilon_{fm}, \tag{4}$$

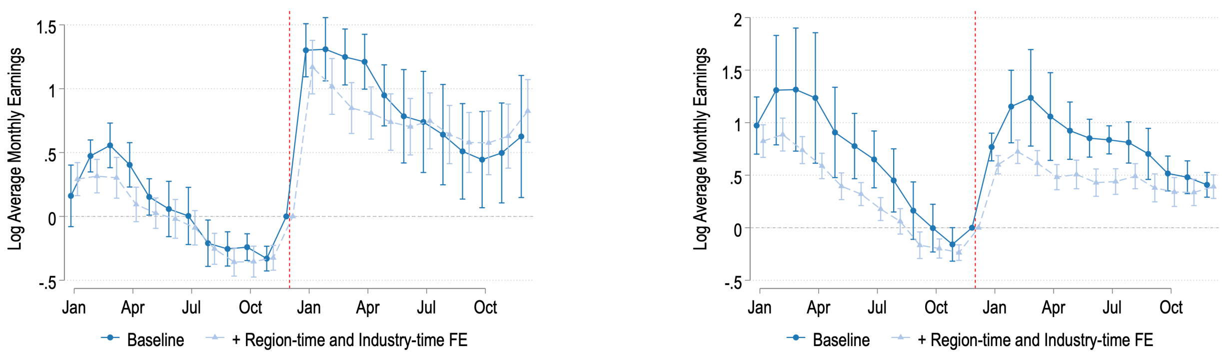
When the outcome is log average earnings, the benchmark value of the coefficient β_0^{Firm} is one. This happens when the exposure measure Z_f perfectly predicts the actual change in average earnings. It is also important to note that the nature of the instrument's construction normalizes the expected effect of the minimum wage. For example, whether the increase is large or small, whether a unit is very exposed or not, the baseline expected effect on log average earnings is one. In this sense, the coefficient is more comparable to an elasticity than to an absolute effect. While it can be informative of the underlying mechanisms, it may mask the actual impact of the minimum wage in reality. To obtain a sense of the actual impact, we must account for the underlying value of the instrument itself.

Firm-level Results on Anticipation

Figure 4 plots the β_m^{Firm} coefficients from estimating equation 4 using log average earnings as an outcome for each pair of years separately between 2015-2017. Panel 4a plots the results for 2015-2016 and Panel 4b plots the results for 2016-2017. The blue circles correspond to the baseline specification, while the light blue triangles correspond to the specification that additionally includes sector and region time-varying fixed effects. In the results presented here, we weight the regressions by the average number of workers in each firm.

Figure 4: Earnings at the Firm level

(a) 2015-2016 (b) 2016-2017



Notes: The figure plots the event study coefficients β_m^{Firm} from estimating equation 4 using firm-level average earnings as the outcome.In dark blue circles we report the coefficients from the baseline regression, and in light blue triangles we report the coefficients from the regression controlling for firm's region and sector. The regressions are weighted by each firm's average employment during the sample period.

The first takeaway is that in January log average earnings increase significantly in more exposed versus less exposed firms relative to their baseline difference in December prior. This suggests that our exposure measure captures some relevant aspect of how the minimum wage policy correlates with firm wage setting. This difference remains positive and significant throughout the year. Also, the patterns are quite similar across the two samples. This suggests that the effects are not coincidental, or explained by another concurrent event, but rather a feature of the minimum wage policy.

Second, prior to the indexation event the estimates are significant and they slope downward. This is consistent with anticipation effects. The trend implies that log average earnings at less exposed firms are increasing compared to exposed firms and relative to their difference in the base period. This is consistent with a story where unexposed workers are more likely to receive earnings increases throughout the year relative to exposed workers. To account for the possibility that specific regions and sectors correlate with minimum wage exposure and also have different wage setting behavior, we re-estimate the model including region-by-month-year and sector-by-month-year fixed effects. The results, represented by the light blue triangles, are very similar to the baseline. This suggests that other firm characteristics correlated with exposure do not drive our findings.

Robustness: Past exposure does not explain the downward trend.

An alternative explanation for the downward sloping trend in the coefficients is that firms exposed to the upcoming indexation event were also exposed to the previous one. In this world, the coefficients only reflect firm's reaction to past shocks. Stated differently, it could be the case that serial correlation in minimum wage exposure explains firm's wage setting behavior prior to the indexation event. To explore this, we estimate equation 4 but additionally control for the one, two and three year lag of the exposure measure by interacting it with month-year-specific event time dummies.

Panels 5a and 5c report the coefficients on the current value of the shock while controlling for its lags in teal triangles, they also report the baseline coefficients in dark blue circles for comparison. The results show that there is almost no difference between the two specifications. In both, the downward trend is present, and average log earnings respond strongly and positively to the indexation event.

Panels 5b and 5d report the coefficients on the lagged values of the shock from the same regressions reported in the other two panels. While lagged exposure has some predictive power, it is much smaller in magnitude than the current exposure variable, and doesn't do so in a consistent manner. These results support the view that the downward slope prior to the event is more likely due to anticipation than to serial corelation in exposure.

5 Model

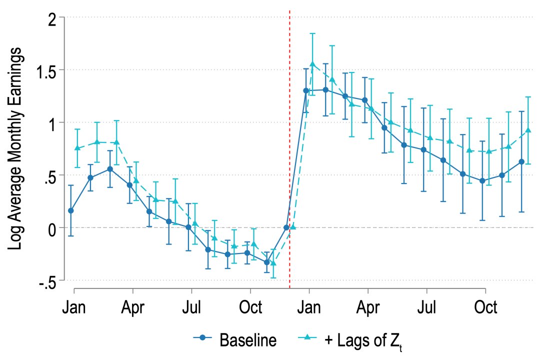
In this section, we present a minimum wage augmented New Keynesian model where the minimum wage is indexed to past inflation and updates once every four quarters. The model includes n input firms that combine high and low skill labor differently. Thus, these input firms are differently exposed to the minimum wage and will aid us in understanding the distributional impact of minimum wage hikes. We use the model to understand how such a minimum wage policy affects the propagation of an inflationary shock in the form of a cost-push shock on output and employment.

5.1 Model Setup

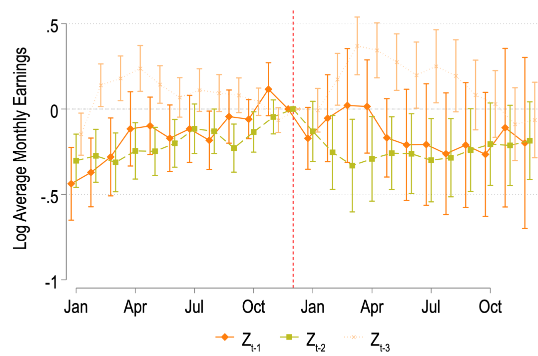
Formally, our economy is composed of n competitive input firms, a continuum of monopolistically competitive intermediate goods producers, a representative final good producer, and a representative household that provides both high and low skill labor. Input firms produce competitively using high and low skill workers and differ in their relative demand for each type of labor. The monopolistically competitive intermediate goods firms produce differen-

Figure 5: Serial correlation does not explain downward pre-trend

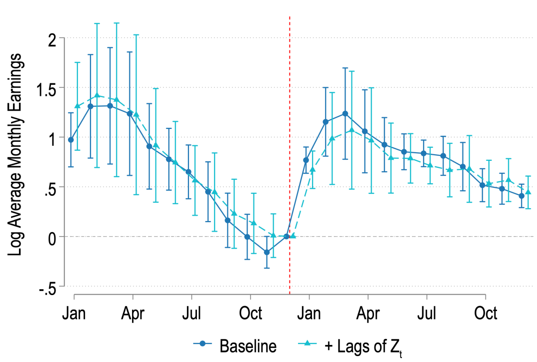
(a) 2015-2016: Effect of Exposure



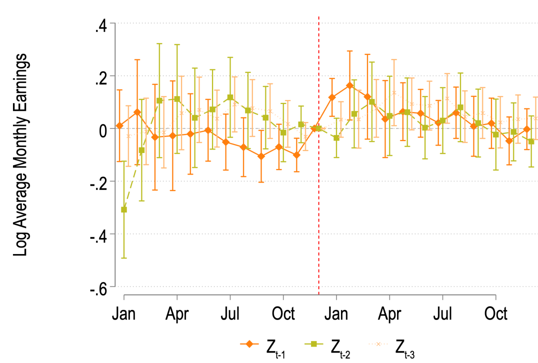
(b) 2015-2016: Effect of Lagged Exposure



(c) 2016-2017: Effect of Exposure



(d) 2016-2017: Effect of Lagged Exposure



Notes: The figure plots the coefficients from estimating equation 4 using log average monthly earnings as the outcome, and controlling for the 1-, 2-, and 3-year lag of treatment. Panels 5a and 5c report the event study coefficients β_m^{Firm} showing the effect of the treatment, while panels 5b and 5d report the effect of the lags themselves. The regressions are weighted by the average employment in each firm.

tiated output using the n inputs. Then, a competitive final good producer aggregates the intermediate goods. The household supplies its labor freely across sectors. Low skill labor is remunerated by the minimum wage, while high skill labor is compensated by a competitive wage rate.

Households and Wage Setting

A representative household derives utility from consumption, C_t, and disutility from labor. It supplies both high and low skill labor, denoted by H_t and L_t, freely across sectors. Their disutility of labor is given by ψ_H and ψ_L respectively. ν is the inverse Frisch elasticity. High skill labor is paid a competitive high-skill wage, denoted W_{Ht}, and low skill labor is paid the minimum wage, denoted W_{Lt}. Following Glover (2016), we incorporate the minimum wage by imposing an upper-bound constraint on low-skill labor. Additionally, households have access to a bond market. Households maximise:

$$\max_{C_t,H_t,L_t,B_{t+1}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \psi_H \frac{H_t^{1+\nu}}{1+\nu} - \psi_L \frac{L_t^{1+\nu}}{1+\nu} \right], \tag{5}$$

subject to:

$$P_t C_t + B_{t+1} = B_t R_{t-1} + W_{Ht} H_t + W_{Lt} L_t + \Gamma_t, \tag{6}$$

$$L_t \leq \bar{L}_t. \tag{7}$$

As in Glover (2016) and Schmitt-Grohé and Uribe (2016), the minimum wage constraint on low-skill labor is exogenous. This implies that low-skill labor is demand-determined. We define the stochastic discount factor as $Q_{t+k|t} = \beta(C_{t+k}/C_t)^{-\sigma}$. Optimization determines high skill labor supply and intertemporal substitution of consumption as follows

$$\frac{W_{Ht}}{P_t} = \psi_H H_t^{\nu} C_t^{\sigma}, \tag{8}$$

$$1 = R_t \mathbb{E}_t \left[Q_{t+1|t} \frac{P_t}{P_{t+1}} \right]. \tag{9}$$

Minimum Wage Policy

The minimum wage is indexed to past inflation and updates once every four quarters. The minimum wage rule is given by

$$W_{Lt} = \begin{cases} W_{L,t-1} + \pi_{t-1} + \pi_{t-2} + \pi_{t-3} + \pi_{t-4} & \text{if } t \text{ is the first quarter,} \\ W_{L,t-1} & \text{otherwise.} \end{cases} \tag{10}$$

Firms and Price Setting

Final good producer

A competitive final good firm aggregates intermediate goods $Y_t(j)$ using a CES aggregator. The profit maximisation problem is

$$\max_{Y_t(j)} P_t Y_t - \int_0^1 P_t(j) Y_t(j) dj \quad \text{s.t. } Y_t = \left(\int_0^1 Y_t(j)^{\frac{1}{\lambda^p}} dj \right)^{\lambda^p}, \tag{11}$$

Where P_t is the final good price index, $P_t(j)$ is the price of intermediate good j, and $\lambda^p > 1$ is the elasticity of substitution across intermediate goods. Profit maximisation yields the standard expression for demand of variety j in terms of overall demand for the final good, price of variety j, and the final good price.

$$Y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{\frac{\lambda^p}{1-\lambda^p}} Y_t. \tag{12}$$

Imposing zero profits, the final price index given by:

$$P_t = \left(\int_0^1 P_t(j)^{\frac{1}{1-\lambda^p}} dj \right)^{1-\lambda^p}. \tag{13}$$

Intermediate goods producers

A continuum of monopolistically competitive intermediate goods producers indexed by $j \in [0, 1]$ use inputs $\{X_{it}(j)\}_{i=1,\ldots,n}$ from each input firm to produce a differentiated good $Y_t(j)$ using a constant returns to scale technology. Their profit maximisation problem is given by

$$\max_{\{X_{it}(j)\}_{i=1,\ldots,n}} P_t(j) Y_t(j) - \sum_{i=1}^{n} P_{it} X_{it}(j) \quad \text{s.t. } Y_t(j) = \prod_{i=1}^{n} X_{it}(j)^{\lambda_i}, \tag{14}$$

Where the elasticity of substitution across inputs is given by λ_i such that $\sum_{i=1}^{n} \lambda_i = 1$. The cost of each input i, given by P_{it}, dictates its relative demand by each intermediate producer. It is given by

$$\frac{X_{i't}(j)}{X_{it}(j)} = \frac{P_{it}}{P_{i't}}. \tag{15}$$

Intermediate producer j's absolute demand for input i will depend on overall demand for variety j. The nominal marginal cost $MC^{(n)}$ faced by intermediate producer j will also be equal across intermediate producers and is given by

$$MC^n = \prod_{i=1}^{n} \lambda_i^{-\lambda_i} P_{it}^{\lambda_i}. \tag{16}$$

Price Setting

We assume that the intermediate goods producers are subject to a a Calvo-style friction and can only change their prices infrequently. Each period, a fraction $1 - \xi_p$ of firms can reset their price. Intermediate good producer j sets its price $P_t(j)$ to maximise profits as follows

$$\max_{P_t(j)^*} \sum_{k=0}^{\infty} \xi_p^k \mathbb{E}_t \left\{ Q_{t+k|t} \left(P_t(j)^* Y_{t+k|t}(j) - TC^n_{t+k|t}(Y_{t+k|t}(j)) \right) \right\}, \tag{17}$$

subject to

$$Y_{t+k|t}(j) = \left(\frac{P_t(j)^*}{P_{t+k}} \right)^{\frac{\lambda_p}{1-\lambda_p}} Y_{t+k} \qquad \forall k. \tag{18}$$

Where $Q_{t+k|t}$ is the stochastic discount factor for nominal payoffs. And $Y_{t+k|t}(j)$ denotes demand for output in period $t + k$ of firm j that last reset its price in period t. Note that, given our assumptions, all intermediate firms that re-optimize will set the same price.

Input goods producers

Each input firm, indexed by $i \in \{1, ..., n\}$, produces and input X_{it} competitively using a CES aggregate of high and low skill labor. They maximise profits subject to their production function:

$$\max_{L_{it},H_{it}} P_{it}X_{it} - W_{Lt}L_{it} - W_{Ht}H_{it} \quad \text{s.t. } X_{it} = \left[\alpha_i \theta L_{it}^{\frac{\eta-1}{\eta}} + (1-\alpha_i) H_{it}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \tag{19}$$

η is the elasticity of substitution between labor types, θ governs the efficiency of low skill workers relative to high skill workers and is always less than 1. α_i is the share of low skill workers (per efficiency units) used in production, it is input firm-specific.

The solution to the input firm problem gives demand for each type of labor H_{it} and L_{it} as a function of wages, and the quantity of input produced as follows

$$L_{it} = \left[\frac{(W_{Ht}\theta\alpha_i)^{\eta-1}}{(\theta\alpha_i)^\eta W_{Ht}^{\eta-1} + (1-\alpha_i)^\eta W_{Lt}^{\eta-1}}\right]^{\frac{\eta}{\eta-1}} X_{it}, \tag{20}$$

$$H_{it} = \left[\frac{((1-\alpha_i)W_{Lt})^{\eta-1}}{(\theta\alpha_i)^\eta W_{Ht}^{\eta-1} + (1-\alpha_i)^\eta W_{Lt}^{\eta-1}}\right]^{\frac{\eta}{\eta-1}} X_{it}. \tag{21}$$

Finally, this implies that marginal cost for input producers can be expressed as a function of wages as follows

$$MC_{it} = W_{Lt}W_{Ht}\left[(\theta\alpha_i)^\eta W_{Ht}^{\eta-1} + (1-\alpha_i)^\eta W_{Lt}^{\eta-1}\right]^{\frac{1}{1-\eta}}. \tag{22}$$

Since input producers are competitive, we have that $P_{it} = MC_{it}$.

Policy and Market Clearing

The central bank sets the nominal interest rate $\tilde{R}_t$ according to a standard Taylor rule:

$$\tilde{R}_t = \phi_\pi \hat{\pi}_t + \phi_y \hat{y}_t, \tag{23}$$

where ϕ_π and ϕ_y are the Taylor rule coefficients for inflation and output, respectively.

Market clearing gives us the final equilibrium conditions that must hold in the model. First, the final goods market clearing condition states that the supply of final good Y_t equals the demand from households C_t

$$Y_t = C_t. \tag{24}$$

Input market clearing requires that the supply of each input X_{it} equal total demand from all the intermediate goods producers.

$$X_{it} = \int_0^1 X_{it}(j)dj \qquad \forall i \in \{1, ..., n\}. \tag{25}$$

Finally, the labor market clears for each labor type. All the supply of high and low skill labor from households equals demand for each of the labor types from the inputs goods producers.

$$L_t = \sum_{i=1}^{n} L_{it}, \quad H_t = \sum_{i=1}^{n} H_{it}. \tag{26}$$

Equilibrium

An equilibrium is prices $\{P_t(j), MC_t^n, \{P_{it}\}_{i=1}^n, W_{Lt}, W_{Ht}, R_t\}$ and quantities $\{Y_t, C_t, Y_t(j),$ $\{X_{it}\}_{i=1}^n, \{X_{it}(j)\}_{i=1}^n, H_t, L_t, \{H_{it}\}_{i=1}^n, \{L_{it}\}_{i=1}^n, B_t\}$ such that, given the exogenous processes and government policy, all agents are optimizing and all markets clear.

5.2 Calibration

To solve the model, we set N=2 and log-linearize the equilibrium conditions around the steady-state. The full set of equations is presented in Appendix B. Special attention should be given to the minimum wage indexation rule which is described by the following law of motion:

$$w_t^{min} = \left(1 - \sum_{k=1}^{4} q_{kt} * a_k\right) * \left(w_{t-1}^{min} + \pi_{t-1} + \pi_{t-2} + \pi_{t-3} + \pi_{t-4}\right) \tag{27}$$

$$+ \left(\sum_{k=1}^{4} q_{kt} * a_k\right) * w_{t-1}^{min}, \tag{28}$$

where $(1-a_k)$ is the fraction of workers whose wage adjusts in each quarter k with $k = 1, ..., 4$, and q_{kt} are dummy variables that take on the value of one when period t is equal to quarter k. As in Olivei and Tenreyro (2007), this implies that wage setting is time-dependent. Therefore, the system is nonlinear and we use the nonlinear solution method of Fuhrer and Bleakley (1996) to solve the model.

Table 2 presents the calibration of the model. We set the minimum wage to update once a year in the first quarter. Accordingly $1 - a_k$, the probability that the minimum wage resets in quarter k, is equal to 1 if $k = 1$ and equal to 0 if $k \neq 1$. The parameter α_i governs the level of exposure of input firm i to the minimum wage. We set $\alpha_1 < \alpha_2$ such that input firm 1 is more high skill intensive relative to input firm 2. In the linearized conditions, α_i enters the parameter s_L^i which describes the share of firm-level output paid to low skill labor. We set $s_L^1 = 0.1$ and $s_L^2 = 0.9$.

The remaining parameters are standard in the New Keynesian literature. The discount factor β is equal to $1.04^{-\frac{1}{4}}$ which corresponds to an annualized real interest rate of 4%. The intertemporal elasticity of substitution σ is equal to 2, the inverse frisch elasticity ν is equal to 1, the price stickiness parameter ξ_p is equal to 0.35, and the taylor rule coefficients ϕ_π and ϕ_y are equal to 2 and 0.6 respectively.

Table 2: Model Calibration

Parameter	Description	Value	Source
β	Discount factor	0.99	Standard
σ	Intertemporal elasticity of substitution	2.0	Standard
ν	Inverse Frisch elasticity	1.0	Standard
ϕ_π	Taylor rule inflation coefficient	2.0	Standard
ϕ_y	Taylor rule output coefficient	0.6	Standard
ξ_p	Price stickiness parameter	0.35	Standard
λ	Elasticity of substitution across input goods	0.5	Standard
η	Elasticity of substitution between labor types	0.8	Standard
s_L^1	Low skill labor share in input firm 1	0.1	Assumed
s_L^2	Low skill labor share in input firm 2	0.9	Assumed
$1 - a_1$	Probability that minimum wage resets in quarter 1	1	Assumed
$1 - a_2, 1 - a_3, 1 - a_4$	Probability that minimum wage resets in quarter 2, 3, 4	0	Assumed

5.3 Propagation of a cost-push shock

To examine how an inflation-indexed minimum wage like the one in Brazil shapes the propagation of nominal shocks, we start with a baseline scenario where we introduce a cost-push shock and the minimum wage is indexed every four quarters to the accumulated inflation over the past year. Then we consider two extensions designed to highlight the mechanisms through which the policy interacts with the inflation as grease mechanism. In the first extension, we analyze the role of anticipation by introducing a cost-push *news* shock under the same annual indexation policy. We find it dampens the inflation as grease mechanism. In the second extension, we analyze the role of staggered indexation by analysing how a cost-push shock propagates when the minimum wage updates every period. We show that it reinforces the inflation as grease mechanism.

Propagation of cost-push shock with annual indexation

Figure 6 describes how each variable responds to four different 25 basis point aggregate cost-push shock in each of the first four quarters. In general, the variables respond as expected. Inflation, described in Panel 6a, rises. Monetary policy, described in Panel 6d, reacts by setting a higher nominal interest rate. This causes output, described in Panel 6c, to fall. Then, they return to steady state; inflation and the nominal interest rate fall while output rises. However, their trajectory is interrupted by the first indexation event. The nominal minimum wage, described in Panel 6b, evolves in a step function manner. It rises every first quarter taking into account inflation over the previous four periods, until it eventually stabilizes. With every new indexation event, inflation and the nominal interest rate spike upward while output spikes downwards, although by less than in response to the initial shock. The economy continues to cycle through this pattern following each subsequent minimum wage increase until the shock dissipates altogether.

In the short run, the effect of the shock is the largest when it takes place in the first quarter (blue line), right after the minimum wage has just been indexed. This is in line with the results in Olivei and Tenreyro (2007) who find that monetary policy shocks have the greatest impact when they take place right after the period of contract renewal. However, we find that in the long run this type of shock has the smallest effect. This can be explained by the interaction between each indexation event, its effect on inflation, and the role of nominal price rigidities. The first minimum wage increase is greatest in response to a first quarter shock because there is more time for inflation to accumulate before the indexation event takes place. However, it also has more time to decline which means that it will rise from a lower base. Thus, in the long run the peaks in inflation are lower and the minimum wage rises by less.

The shock also has important distributional effects. Panels 6e and 6f show that both low and high skill real wages fall, but for different reasons. Since low skill nominal wages are completely rigid, low skill real wages only fall because of the increase in inflation. On the other hand, high skill nominal wages which are completely flexible, are able to fall in response to the output decline. So, while employment falls for both groups due to the decline in aggregate demand, it does so more strongly for low skill workers as firms substitute towards the relatively cheaper high skill labor. See Appendix C for further details on the distributional effects.

Propagation of cost-push news shock with annual indexation

To isolate the effect of a rising minimum wage from the contemporaneous effect of the shock on inflation we introduce a cost-push *news* shock under the same policy. The results are described in Figure 7. As before, the shocks are introduced in each of the four quarters, but they only directly affect the minimum wage which updates in the first quarter of the following year. To isolate the effect even further, the minimum wage rule does not incorporate accumulated inflation. For this reason, as described in Panel 7b, the minimum wage increases by the same amount regardless of the quarter in which the shock is introduced. Thus, the behavior of the other variables before the minimum wage increase is a result of its anticipation.

First, output falls in anticipation of the minimum wage increase because of intertemporal substitution. The decline in aggregate demand lowers inflation as well. Monetary policy reacts by setting a lower interest rate, but not by enough to reverse the effects. After the initial decline, inflation begins to rise in anticipation of the minimum wage increase because of precautionary pricing. After the first minimum wage increase, the patterns are similar to those in the baseline scenario in response to a cost-push shock. This is because each increase in the nominal minimum wage introduces a marginal cost increase.

The distributional effects are also different to the baseline scenario and are indicative of anticipation working against the inflation as grease mechanism. In the short run, the low skill real wage rises due to the decline in inflation, while the high skill real wage still declines. This puts further downward pressure on output despite the decline in the nominal interest rate. Low skill employment falls by much more compared to the baseline scenario.

Propagation of cost-push shock with quarterly indexation

Finally, we compare how a cost-push shock propagates when the minimum wage updates every quarter. Figure 8 describes the impulse responses to four separate 25 basis point cost-push shock in each of the first four quarters. The direction of each variable is the same as in the baseline case. Inflation rises, monetary policy reacts by raising the nominal interest rate, and output falls. Both the low skill and the high skill real wage fall, although the low skill skill real wage does so by less.

However, there are two important differences to the baseline case. First, and as expected given the indexation rule, the propagation of the cost-push shock is identical regardless of the quarter in which the shock is introduced. Second, the overall incidence of inflation, and therefore of variation of all the variables, is higher. This is because in the baseline scenario, the rigidity of the nominal minimum wage in between indexation events allows the real low skill wage to fall by more. This boosts labor demand and by extension output - exactly highlighting the inflation as grease mechanism. Ultimately this force counteracts the output decline induced by the minimum wage increase.

Since the minimum wage updates every period, there is no role for anticipation.

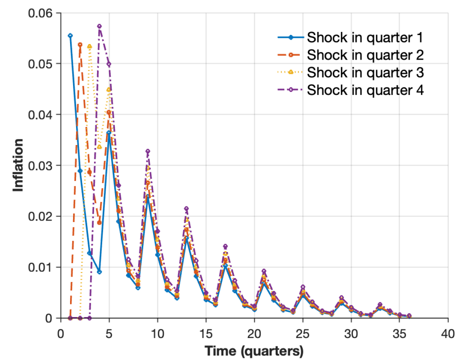
6 Conclusion

Overall, we have shown that an inflation indexed minimum wage interferes with how nominal shocks propagate. Using Brazil as a case study, we establish two empirical results. First, that the policy creates asymmetric upward nominal wage rigidity across exposed and unexposed workers. Second, that firms anticipate the minimum wage increase. Using a New Keynesian model augmented with two worker types and an inflation-indexed minimum wage, we show that anticipation can undo the effects of a nominal shock by lowering output through intertemporal substitution. Additionally, the shock now has distributional effects because of the policy's asymmetric effect on nominal wage rigidities, and it will have persistent effects because of the policy's backward-looking indexation.

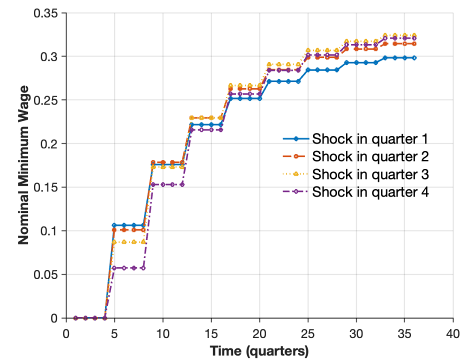
Our findings support the view that policymakers must account for how policies impact agent's expectations when designing them. In addition, we show how a policy designed to help low-wage workers can have unintended consequences through previously understudied channels, such as by inducing greater nominal wage rigidity. Ultimately, when evaluating how a nominal shock propagates, a deep understanding of the institutional context is key.

Figure 6: Impulse Response Functions to a Cost-Push Shock When Minimum Wage Updates Once Every Four Quarters

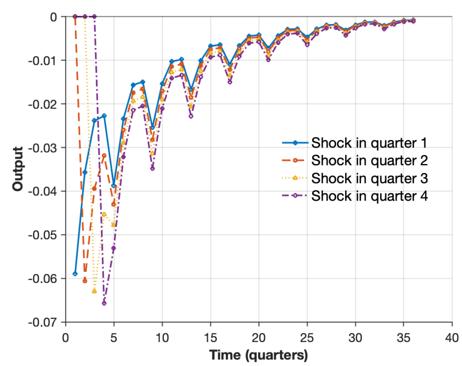
(a) Inflation



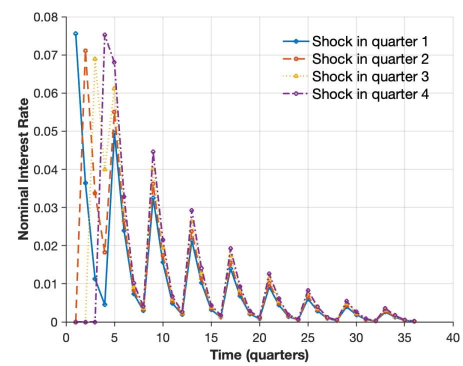
(b) Nominal Minimum Wage



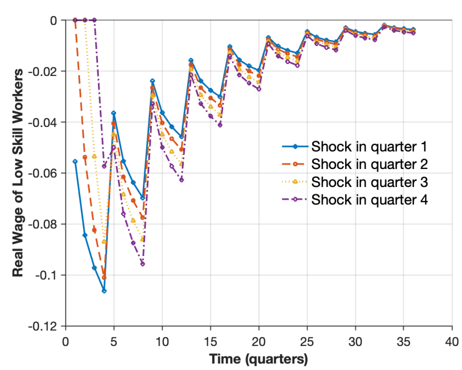
(c) Output



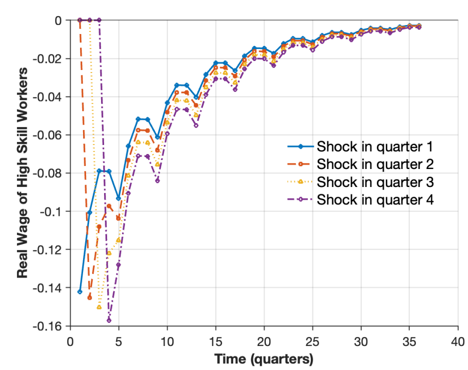
(d) Nominal Interest Rate



(e) Low Skill Real Wage



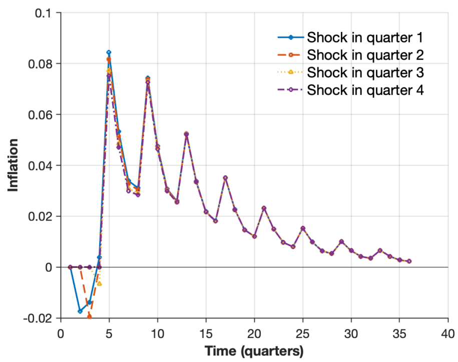
(f) High Skill Real Wage



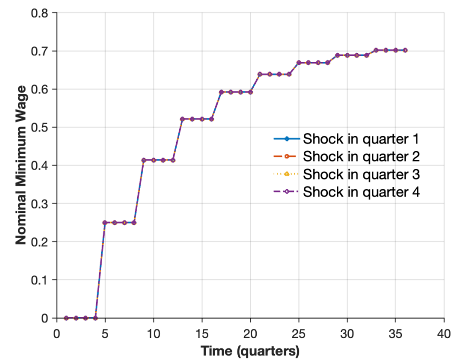
Notes: This figure plots the four impulse responses to a 25 basis point increase in aggregate inflation in the first, second, third and fourth quarters separately. We assume the shock occurs at the end of the quarter, when the other variables have already been determined.

Figure 7: Impulse Response Functions to a Cost-Push News Shock When Minimum Wage Updates Once Every Four Quarters

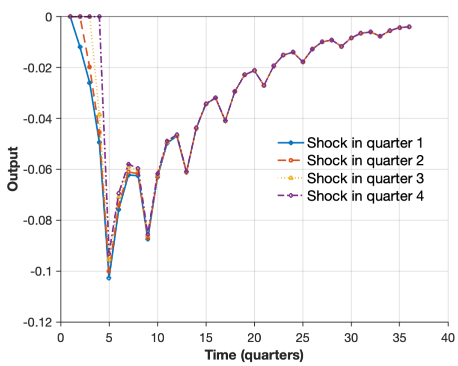
(a) Inflation



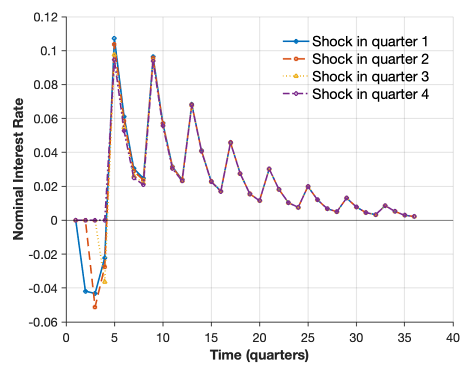
(b) Nominal Minimum Wage



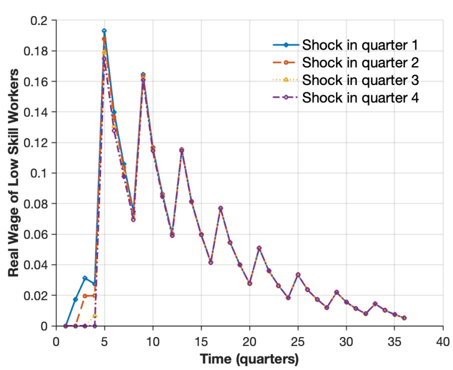
(c) Output



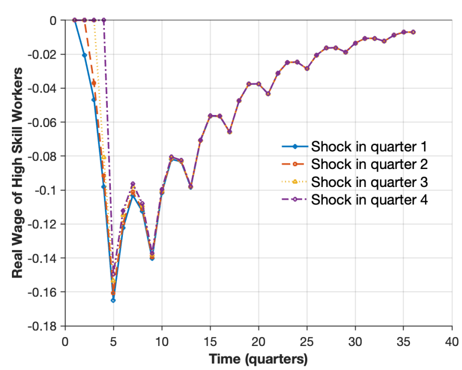
(d) Nominal Interest Rate



(e) Low Skill Real Wage



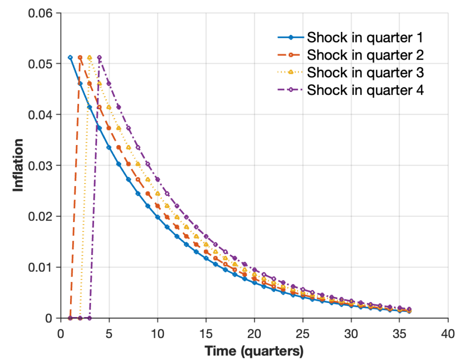
(f) High Skill Real Wage



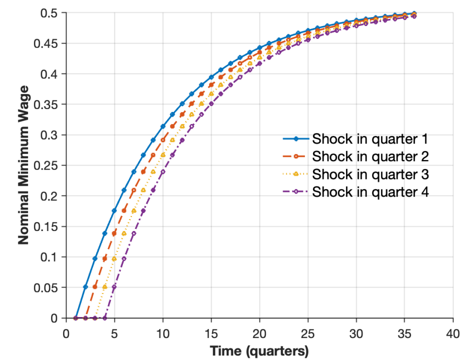
Notes: This figure plots the four impulse responses to a 25 basis point increase in aggregate inflation in the first, second, third and fourth quarters separately. We assume the shock occurs at the end of the quarter, when the other variables have already been determined.

Figure 8: Impulse Response Functions to a Cost-Push Shock When Minimum Wage Indexes Every Period

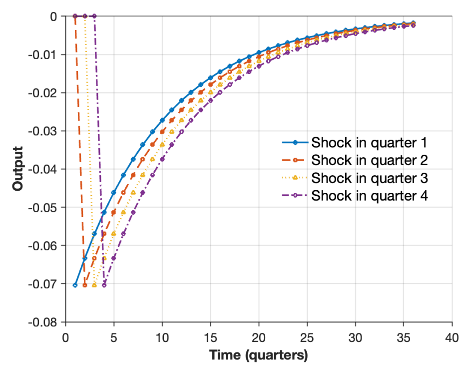
(a) Inflation



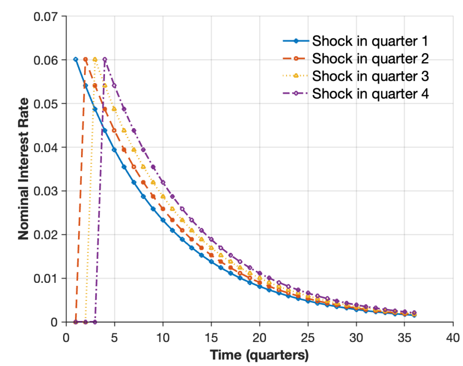
(b) Nominal Minimum Wage



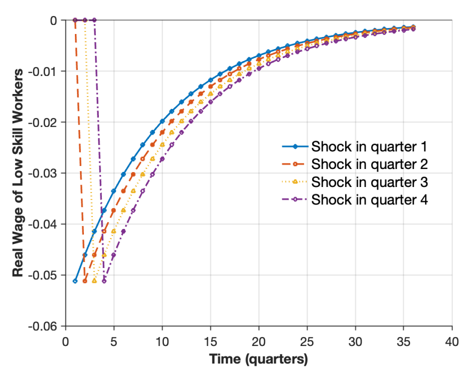
(c) Output



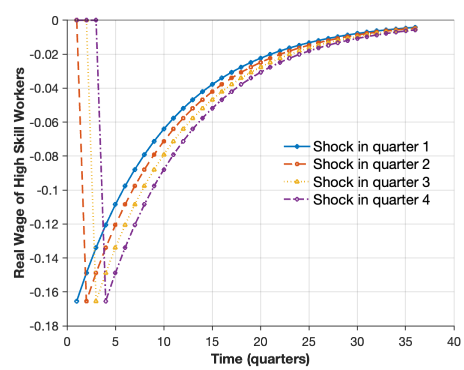
(d) Nominal Interest Rate



(e) Low Skill Real Wage



(f) High Skill Real Wage



Notes: This figure plots the four impulse responses to a 25 basis point increase in aggregate inflation in the first, second, third and fourth quarters separately. We assume the shock occurs at the end of the quarter, when the other variables have already been determined.

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List of Appendix Figures

A.1 Percent of verified earnings over time A1
A.2 Distribution of Measurement Error in Earnings (Identified Data) A2
A.3 Distribution of Measurement Error in Treatment (Identified Data) A2

A Appendix: Data

A.1 Measurement Error in Earnings and Treatment

There are two versions of RAIS. One of them is publicly available,[7] and the second is accessed through a data use agreement with the Ministry of Labour. The public version of RAIS tracks workers within a year, but not across them. For this reason, we call this the de-identified dataset and use it as a benchmark. In contrast, the private version identifies workers and firms with their national identification numbers. For firms, this number is known as the CNPJ, and for workers it is known as CEP. We refer to it as the identified dataset.

The key information in RAIS is a worker's earnings, which is recorded in two ways. First, firms report earnings for worker l in year t in each month m, y^l_{mt}. The survey required this information for the first time in 2015. From this, we can calculate the predicted annual average monthly earnings as $\hat{y}^{l,pred}_t = \frac{\sum_{m=1}^{m=12} y^l_{mt}}{12}$. Second, firms also directly report a worker's annual average monthly earnings $\hat{y}^l_t$. By common sense, the predicted average should coincide with the reported average: $\hat{y}^{l,pred}_t = \hat{y}^l_t$. We tag the workers for whom it does as having verified earnings.

Figure A.1: Percent of verified earnings over time

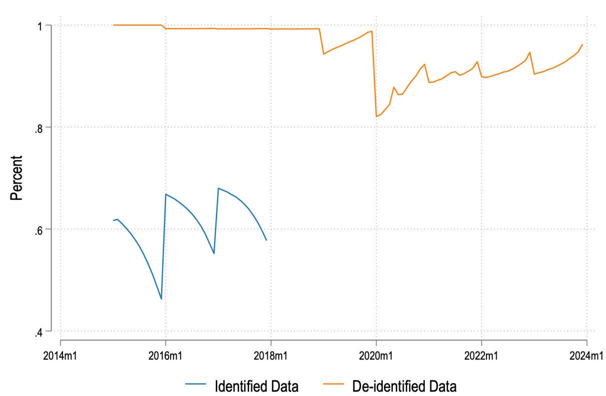
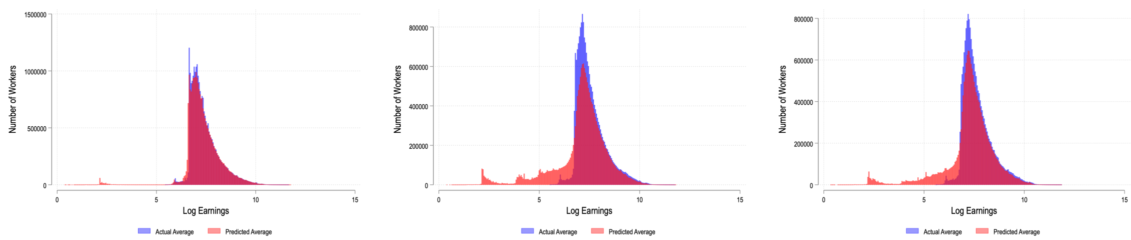


Figure A.1 reports, for each dataset, the percent of observations with verified earnings.

[7] We access the public version of RAIS through Base dos Dados, https://basedosdados.org/.

For the de-identified data (orange line), the percent of verified earnings is close to 100% up until the COVID pandemic in 2020. Then, it falls to roughly 80% and subsequently climbs back up to approximately 90%. The identified data suffers from measurement error in the earnings data to a much greater extent (blue line). There, the percent of verified earnings oscillates between 70% and 50%. Moreover, there is a striking seasonal pattern. The value jumps in January, and then falls steadily until December. Within a year, the percent of verified earnings can vary across months because of workers' entry into and exit out of the formal labor market.

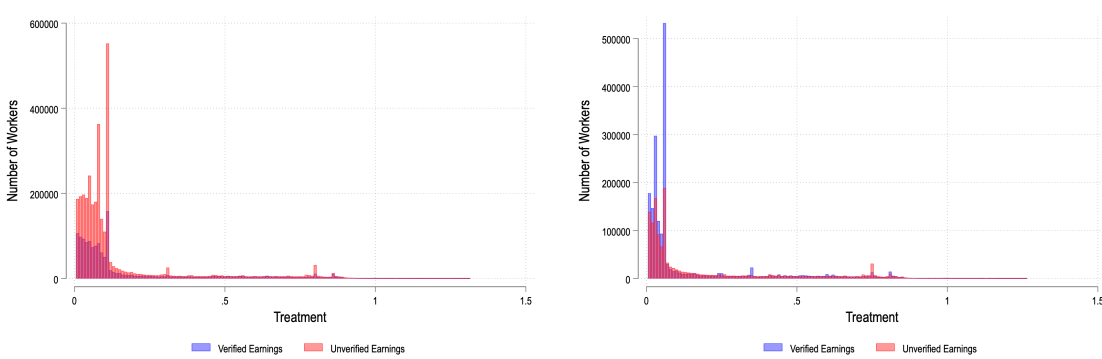
Figure A.2: Distribution of Measurement Error in Earnings (Identified Data)



(a) 2015 (b) 2016 (c) 2017

Given this evidence, figures A.2 and A.3 focus on the prevalence of measurement error in the identified data. Figure A.2 compares, for workers whose earnings are unverified, the distribution of their directly reported annual average monthly earnings $\hat{y}_t^l$ in blue, with the distribution of their predicted annual average monthly earnings $\hat{y}_t^{l,pred}$ in red. In all three years, the distribution of $\hat{y}_t^{l,pred}$ exhibits a long left tail. This reveals that when monthly earnings are mis-reported, they are consistently recorded to be "too low".

Figure A.3: Distribution of Measurement Error in Treatment (Identified Data)



(a) 2015 (b) 2016

Figure A.3 compares the distribution of treatment for workers with verified earnings in blue, with the distribution of treatment for workers with unverified earnings in red. Treatment is calculated as the predicted earnings increase due to the minimum wage: $ln(mw_{t+1}) - ln(\hat{y}_t^l)$. The figure restricts to workers whose treatment value is greater than zero. Although different in magnitude, the value of treatment across the two sets of workers is distributed similarly. This suggests that using the directly reported annual average monthly earnings $\hat{y}_t^l$ to calculate treatment ameliorates any concerns that it may be affected by measurement error in the earnings variable.

A.2 Summary Statistics by Earnings Percentiles

Table A.1 reports the summary statistics by earnings percentiles for the sample 2016-2017. It is similar to Table 1, which reports the same statistics for the year 2015.

B Appendix: Model with 2 Input Firms

The system of log-linearized equations is giving by:
<u>Household Block</u>

$$\text{Intertemporal Euler equation :} \qquad y_t = y_{t+1} - \frac{1}{\sigma}(r_t - \pi_{t+1})$$

$$\text{High-skill wage determination :} \qquad w_t^H = \nu h_t + \sigma y_t$$

Table A.1: Summary Statistics by Earnings Percentiles (2016)

	$\hat{y}_t < mw^{t+1}$	$mw^{t+1} < \hat{y}_t < 2 \cdot mw^{t+1}$	$2 \cdot mw^{t+1} < \hat{y}_t$
Observations	1035718	6928745	3252501
Female	0.42	0.40	0.24
Age	33.41	34.51	38.15
Education			
Less than High School	0.49	0.40	0.26
High School	0.47	0.53	0.45
More than High School	0.04	0.07	0.28
Establishment Size			
Small (<20)	0.26	0.26	0.18
Medium (20–250)	0.32	0.36	0.40
Large (>250)	0.42	0.38	0.42
Regions			
North	0.08	0.05	0.04
Northeast	0.41	0.18	0.10
Southeast	0.36	0.50	0.58
South	0.07	0.18	0.20
Centerwest	0.09	0.09	0.08
Sectors			
Agr. and Mining	0.22	0.09	0.06
Manuf. and Constr.	0.24	0.27	0.38
Services	0.53	0.63	0.55

Notes: This table presents summary statistics for workers in three groups defined by their average monthly earnings in 2016 relative to the upcoming minimum wage increase in January 2017. The first column includes workers who earn less than the 2017 minimum wage, the second column groups workers who earn more than that but less than two multiples of it, and the third column includes workers who earn more than two multiples of it.

Firm Block

$$\text{New Keynesian Phillips Curve}: \quad \pi_t = \frac{(1-\xi_p\beta)(1-\xi_p)}{\xi_p} mc_t + \beta\pi_{t+1} + \varepsilon_t^{\pi}$$

$$\text{Cost minimization condition}: \quad x_t^2 - x_t^1 = q_t^1 - q_t^2$$

$$\text{Final goods production function}: \quad y_t = \lambda x_t^1 + (1-\lambda)x_t^2$$

$$\text{Marginal cost of final goods producers}: \quad mc_t = \lambda q_t^1 + (1-\lambda)q_t^2$$

$$\text{Sector 1, low-skill labor demand}: \quad w_t^L = q_t^1 + \frac{1}{\eta}\left(x_t^1 - l_t^1\right)$$

$$\text{Sector 1, high-skill labor demand}: \quad w_t^H = q_t^1 + \frac{1}{\eta}\left(x_t^1 - h_t^1\right)$$

$$\text{Sector 2, low-skill labor demand}: \quad w_t^L = q_t^2 + \frac{1}{\eta}\left(x_t^2 - l_t^2\right)$$

$$\text{Sector 2, high-skill labor demand}: \quad w_t^H = q_t^2 + \frac{1}{\eta}\left(x_t^2 - h_t^2\right)$$

$$\text{Sector 1 - marginal cost}: \quad q_t^1 = s_{L,1}w_t^L + (1-s_{L,1})\, w_t^H$$

$$\text{Sector 2 - marginal cost}: \quad q_t^2 = s_{L,2}w_t^L + (1-s_{L,2})\, w_t^H$$

Market Clearing Conditions

$$\text{Goods market clearing condition}: \quad y_t = c_t$$

$$\text{High-skill labor market}: \quad h_t = H_1 h_{1,t} + H_2 h_{2,t}$$

Policy block and Definitions

$$\text{Monetary policy}: \quad r_t = \phi_\pi \pi_t + \phi_y y_t$$

$$\text{Inflation}: \quad \pi_t = p_t - p_{t-1}$$

$$\text{Low skill real wage}: \quad w_t^L = w_t^{min} - p_t$$

$$\text{Law of motion min wage}: \quad w_t^{min} = \left(1 - \sum_{k=1}^{4} q_{kt} * a_k\right) * \left(w_{t-1}^{min} + \pi_{t-1} + \pi_{t-2} + \pi_{t-3} + \pi_{t-4}\right) + \left(\sum_{k=1}^{4} q_{kt} * a_k\right) * w_{t-1}^{min}$$

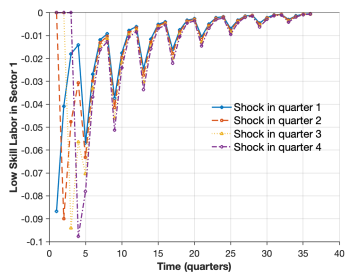
Note that the parameters s_L^1 and s_L^2 govern the share of low skill labor in each input firm. They represent the share of output of firm i that is attributable to low skill labor. They are given by:

$$s_L^i = \frac{(\theta\alpha_i)L_i^{\frac{\eta-1}{\eta}}}{(\theta\alpha_i)L_i^{\frac{\eta-1}{\eta}} + (1-\alpha_i)H_i^{\frac{\eta-1}{\eta}}} \tag{29}$$

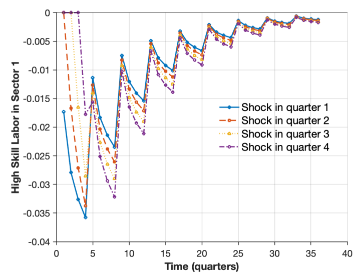
C Appendix: Additional IRFs

Figure C.4: Impulse Response Functions to a Cost-Push Shock When Minimum Wage Updates Every Four Quarters

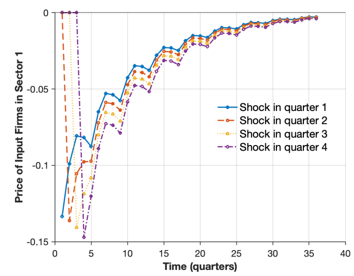
(a) Low Skill L in Sector 1



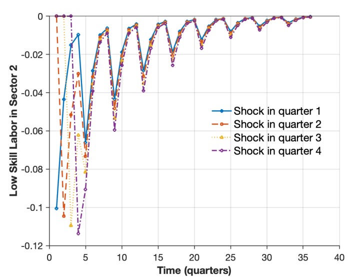
(b) High Skill L in Sector 1



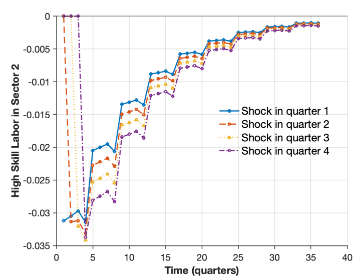
(c) Price of Sector 1



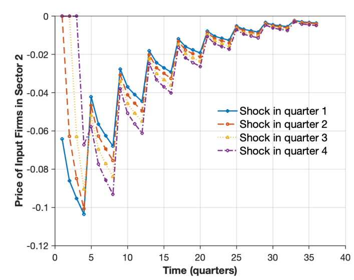
(d) Low Skill L in Sector 2



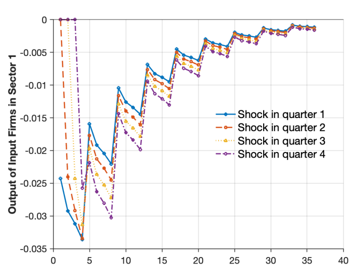
(e) High Skill L in Sector 2



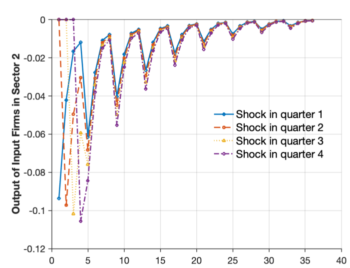
(f) Price of Sector 2



(g) Output of Sector 1



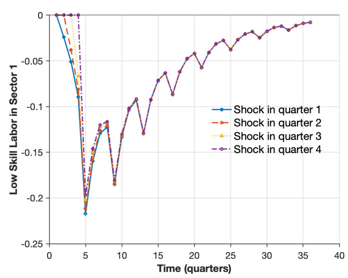
(h) Output of Sector 2



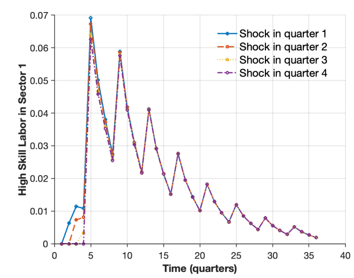
Notes: This figure plots the four impulse responses to a 25 basis point increase in aggregate inflation in the first, second, third and fourth quarters separately. We assume the shock occurs at the end of the quarter, when the other variables have already been determined. Input firm 1 is more high skill intensive while input firm 2 is more low skill intensive.

Figure C.5: Impulse Response Functions to a Cost-Push News Shock When Minimum Wage Updates Every Four Quarters

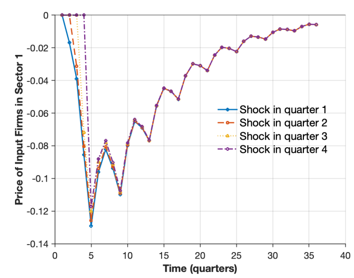
(a) Low Skill L in Sector 1



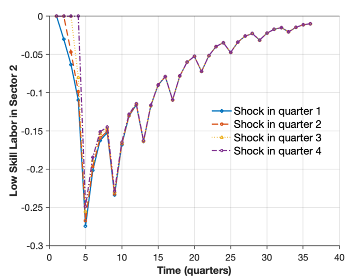
(b) High Skill L in Sector 1



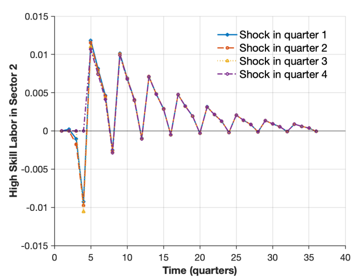
(c) Price of Sector 1



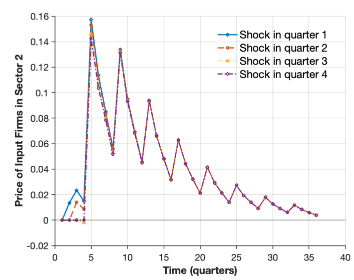
(d) Low Skill L in Sector 2



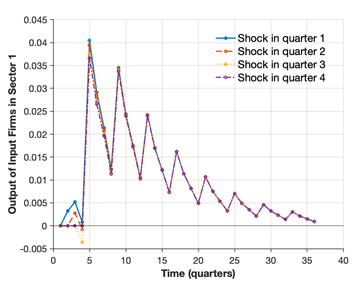
(e) High Skill L in Sector 2



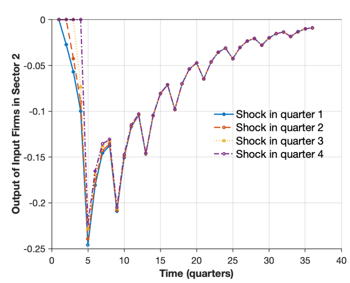
(f) Price of Sector 2



(g) Output of Sector 1



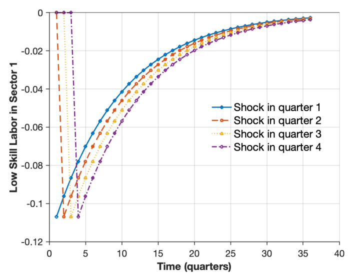
(h) Output of Sector 2



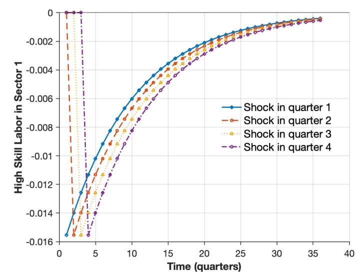
Notes: This figure plots the four impulse responses to a 25 basis point increase in aggregate inflation in the first, second, third and fourth quarters separately. We assume the shock occurs at the end of the quarter, when the other variables have already been determined. Input firm 1 is more high skill intensive while input firm 2 is more low skill intensive.

Figure C.6: Impulse Response Functions to a Cost-Push Shock When Minimum Wage Updates Every Quarter

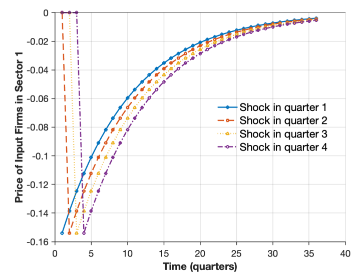
(a) Low Skill L in Sector 1



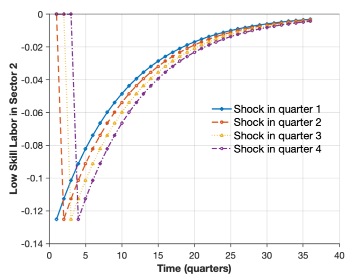
(b) High Skill L in Sector 1



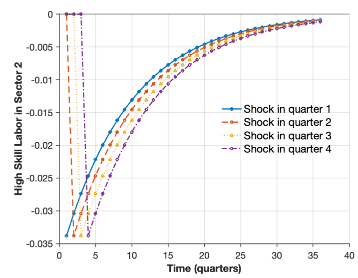
(c) Price of Sector 1



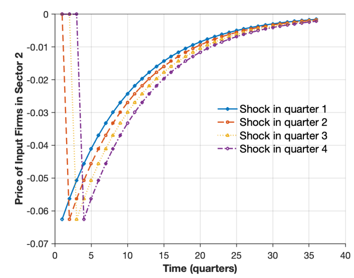
(d) Low Skill L in Sector 2



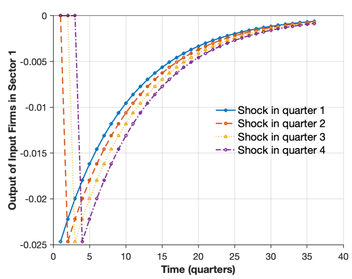
(e) High Skill L in Sector 2



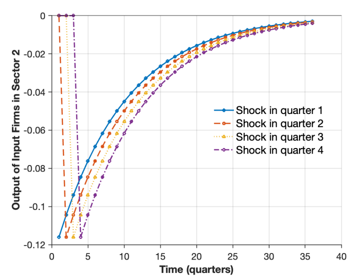
(f) Price of Sector 2



(g) Output of Sector 1



(h) Output of Sector 2



Notes: This figure plots the four impulse responses to a 25 basis point increase in aggregate inflation in the first, second, third and fourth quarters separately. We assume the shock occurs at the end of the quarter, when the other variables have already been determined. Input firm 1 is more high skill intensive while input firm 2 is more low skill intensive.