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ABSTRACT

The boundary discontinuity method of causal inference may yield misleading results if a policy's impacts do not stop at the border of the implementing jurisdiction. We use geographically precise longitudinal employment data documenting worker job-to-job mobility to study policy spillovers in the context of three local minimum wage increases. Estimated spillover impacts on wages and hours are statistically significant, geographically diffuse, and sufficient to create concern regarding interpretation of results even using not-immediately-adjacent regions as controls. Spillover effects appear less concerning with smaller interventions or those or adopted in a smaller jurisdiction.

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1 Introduction

Policies adopted in one local jurisdiction may exert impacts beyond the borders of that jurisdiction. Such policy spillovers have important implications. Policy spillovers violate one condition underlying Tiebout's (1956) argument for the efficiency of local policy determination.[1] Second, and more relevant for this paper, the existence of policy spillovers will generate bias in estimates of policy effects when the researcher uses a "boundary discontinuity" method, which typically involves a difference-in-differences analysis whereby immediately adjacent jurisdictions are used as the "control" region.

This paper uses administrative employment records to study the extra-jurisdictional impacts of local minimum wage policies. We estimate the internal and external effects of minimum wage ordinances enacted in the Washington cities of Seattle, Tacoma, and SeaTac in 2014, 2016, and 2013, respectively. We use administrative unemployment insurance (UI) data, which contain quarterly earnings and hours worked for each UI-covered job.

Strategies for estimating spillover effects include examinations of direct impact of a policy intervention in one jurisdiction on those immediately adjacent, or estimating decay models that posit wider-ranging spillover effects. Such strategies embed assumptions regarding the nature of spillovers. We use detailed geographic data on the job-to-job moves of individual workers to identify a set of geographic locations where spillover effects might plausibly be found. Although this set is neither compact nor contiguous, evidence suggests minimum wage increases, particularly those large in magnitude implemented in large jurisdictions, raise wages and reduce hours worked therein. In the average Washington Census tract outside Seattle, that city's minimum wage increase is imputed to have wage effects half the magnitude of

[1] Tiebout's model assumes that "public services exhibit no external economics or diseconomies between communities" (p. 419). When this assumption fails, Tiebout notes that, "some form of integration may be indicated" (p. 423). That is, the existence of spillovers indicates that it may be more efficient to locate the policy at a higher level of jurisdictional aggregation (e.g., state or national level, rather than local level).

the own-jurisdiction effect, and hours impacts one-third the magnitude of the own-jurisdiction effect. Parametric decay models, as well as models grouping outlying jurisdictions by drive time to the implementing jurisdiction, yield similar conclusions. Significant spillover effects are seen up to a 40-minute drive from the Seattle city limits.

We find insubstantial spillover effects of the minimum wage laws in Tacoma and SeaTac. Tacoma's minimum wage increase was at most $0.50 above the state's minimum wage and did not require substantial adjustments for external businesses above their current wages offered, lessening external exposure. SeaTac, as a substantially smaller jurisdiction where the minimum wage only applies in certain sectors, exhibits less extensive cross border job-to-job flows.

Our results suggest three main conclusions. First, boundary discontinuity studies may be prone to understating the impacts of local policies. Second, spillovers do not necessarily decay neatly or lend themselves to quick methodological fixes. Three, spillovers are less prominent when the implementing jurisdiction is small or the policy intervention modest.

2 Conceptual Framework

Since the pioneering work by Holmes (1998) and Black (1999), the boundary discontinuity design, sometimes also called the spatial discontinuity design, has been widely applied in empirical research. In recent years, policy variation at the border has been used to study the effectiveness of enterprise zones (Neumark and Kolko, 2010), the impacts of unemployment benefits extensions (Lalive, 2008; Hagedorn, Manovskii and Mitman, 2015), minimum wage laws (Dube, Lester and Reich, 2010; Neumark, Salas and Wascher, 2014; Jha, Neumark and Rodriguez-Lopez, 2022), foreclosure laws (Pence, 2006; Mian, Sufi and Trebbi, 2015), local taxation (Duranton, Gobillon and Overman, 2011), and land use regulation (Turner, Haughwout and van der Klaauw, 2014).

Spatial and temporal variation in policy regimes provide a natural design in which regions that implement a policy are the treatment group, and regions that did not implement a policy in question make up the comparison group. Adjacent regions presumably share many underlying attributes, thus reducing concerns that unobserved differences confound estimates of policy impact. Put differently, the "parallel trends" assumption underlying quasi-experimental analysis is in many cases most plausible when comparing geographically proximate regions. Yet, the boundary discontinuity method may yield biased estimates if the adoption of a policy in one region affects outcomes in neighboring regions.

This spillover problem is particularly salient in the context of labor market and placed-based policies and has been well known in the literature (Heckman, Lalonde and Smith, 1999; Baum-Snow and Ferreira, 2015). A potential simple solution is to contrast the treatment area to the surrounding region excluding a buffer zone where there are concerns about possible spillover effects (e.g., Jardim et al., 2022). This approach can be questioned as it is not clear how large to make the excluded, buffer-zone area. In most applications there will be a tradeoff between finding a good counterfactual (suggesting less area to exclude) and finding an area without spillover effects (suggesting more area to exclude). Spillover effects might be expected in the case of local minimum wage laws given competition in the regional labor market for workers and the possibility of businesses to relocate. In neighboring regions, we might expect the higher minimum wage to prompt low-skill workers to shift their labor search to the treated municipality, thereby lowering labor supply in the adjacent areas, bidding up wages in these areas while lowering employment. Further, we might expect increased labor demand if firms relocate to the untreated region, which would bid up wages and increase hours worked in the surrounding region (Beaudry, Green and Sand, 2018).

If these spillover effects occur, then we should expect the border discontinuity method to lead to underestimates of the effect on wages in the treated region while having an ambiguous-signed bias on estimates of employment in the treated region. The bias imparted on employment elasticity estimates, i.e., the ratio of the effect on employment to the effect on wages, is of uncertain sign. The bias depends on the relative magnitude of the biases in wage and employment effects. Since employment elasticity is a key policy-relevant parameter, it is crucial to rule out the possibility of spillover effects or model them appropriately to obtain consistent estimates from boundary discontinuity methods.

Spillover effects can propagate through geographic space; effects on immediately adjacent regions can affect the next community over, and so on. It is not clear, *ex ante*, which areas should be considered safe from potential contamination, as the degree of labor market integration might vary from region to region and from one application to the other. However, note that in the labor market application, the supply channels are closely related to the ease of finding a job and commuting or relocating from one region to the other. Based on this observation, we will study three methods to model spillover effects, all yielding similar results. Our preferred measure creates an exposure index to the local policy change based on the direct measures of labor market integration, i.e., the probability that a worker currently employed in a particular Census tract in Washington will be employed in the treated region (e.g., Seattle) in the next six months. Our second and third methods rely on measuring integration via travel time distance to the treated district. We describe these methods in detail in section IV.

3 Policy Change

In 2014, Washington had the highest state minimum wage in the US at $9.32 per hour. The City of Seattle passed an ordinance in June of that year establishing a local minimum wage that would gradually increase to $15 per hour. The phase-in rate varies as a function of the number of employees the employer has worldwide and whether the employer pays toward medical benefits or the employees earned tips (see Table 1 for the full schedule). The first phase-in began in April of 2015 and raised the minimum wage for large employers by 16.2%, from $9.47 to $11. The second began in January of 2016 and raised the minimum wage to $13 for large employers, or by a further 18.2%. In this paper, we study the first two phase-ins, from the period between the second quarter of 2014 when the ordinance was passed, through the third quarter of 2016.

The Ordinance covers only work done within the Seattle City limits. Seattle, which is located within King County, has a dense population, a booming economy, and a labor market integrated with suburbs to the north, east, and south and across Puget Sound to the west.

Tacoma, Washington's third largest city, lies some 30 miles south of Seattle. Nestled between the two cities lies the incorporated city of SeaTac—a 10-square-mile community containing the Seattle-Tacoma International Airport. In 2013, SeaTac voters approved a ballot initiative raising the city's minimum wage to $15 per hour for transportation and hospitality workers, effective in 2014. In late 2015, Tacoma voters passed a ballot initiative gradually increasing their minimum wage to $12, with the first 9% increase effective in February of 2016. Following these local changes, Washington voters approved a ballot initiative increasing the state minimum wage to $13.50 by 2020, with the first step effective January 1, 2017. The details of these minimum wage schedules can be found in Table 1.

4 Data

We use quarterly administrative employment data from the Washington State Employment Security Department (ESD) from 2005 through the third quarter of 2016. These data include eleven quarters after the passage of SeaTac's minimum wage ordinance and six quarters after enforcement of Seattle's min-

Table 1: Schedule of Local Minimum Wage Ordinances in Seattle, SeaTac, and Tacoma

Start of Minimum Wage Period	Wash. State: All Employers	Seattle: >500 Empl., No Health Benefits	Seattle: >500 Empl., With Health Benefits	Seattle: ≤500 Empl., No Health Ben. or Tips	Seattle: ≤500 Empl., With Health Ben. or Tips	SeaTac: Transport. & Hospitality Employers	Tacoma: All Employers
1/1/2013	9.19	Col. (1)	Col. (1)	Col. (1)	Col. (1)	Col. (1)	Col. (1)
1/1/2014	9.32	Col. (1)	Col. (1)	Col. (1)	Col. (1)	15.00	Col. (1)
1/1/2015	9.47	Col. (1)	Col. (1)	Col. (1)	Col. (1)	15.24*	Col. (1)
4/1/2015	...	11.00	11.00	11.00	10.00	...	...
1/1/2016	9.47	13.00	12.50	12.00	10.50	15.24*	Col. (1)
2/1/2016	...	...	...	...	...	...	10.35
1/1/2017	11.00	15.00	13.50	13.00	11.00	15.34*	11.15
1/1/2018	11.50	15.45*	15.00	14.00	11.50	15.64*	12.00
1/1/2019	12.00	16.00*	16.00**	15.00	12.00	16.09*	12.35*
1/1/2020	13.50	16.39*	16.39*	15.75**	13.50	16.34*	Col. (1)
1/1/2021	13.69*	16.69*	16.69*	16.69**	15.00	16.57*	Col. (1)
1/1/2022	14.49*	17.27*	17.27*	17.27*	15.75**	17.54*	Col. (1)

Notes: After complete phase-in, minimum wage in all locations is adjusted for inflation annually. The right of the City of SeaTac to enforce the minimum wage ordinance at the Seattle-Tacoma International Airport was challenged in court. On December 27, 2013, King County Superior Court ruled that the Ordinance did not apply to the affected employees at the airport. However, on August 20, 2015, Washington State Supreme Court ruled that the minimum wage requirements and other employment standards could be enforced at the airport. Tacoma's minimum wage covers all employees who have worked at least 80 hours in a year within Tacoma city boundaries. "*" denote a change in the minimum wage resulting from indexing of the minimum wage by the consumer price index for urban wage earners and clerical workers, CPI-W. "**" reflect additional adjustments to equalize schedules. "Col. 1" denotes periods when there is no local minimum wage in force, and thus the state minimum wage from column (1) is the controlling local minimum wage. "…" denotes continuation of the same minimum wage as listed previously.

imum wage ordinance. These payroll records include all Washington workers covered by UI.

All US states collect quarterly payroll information from covered employers, but Washington is one of only four that also collect quarterly hours. The addition of hours data allow us to measure the average hourly wage paid to each job in each quarter, defined as total quarterly earnings divided by quarterly hours worked. These data give us the ability to identify jobs that are directly affected by an increase in the minimum wage and measure the magnitude of wage increase that would be required to bring the job into compliance with such an increase.

The ESD data identifies businesses as UI account holders. Business entities operating in more than one location can establish a separate account for each, or they can file all of their payroll information using one joint account that is marked as a multi-site firm. In the latter case, we are unable to distinguish the location of each of their employees. For this reason, we exclude multi-site single-account firms from the analysis. Owners of franchised businesses are treated as distinct entities by ESD (though not by Seattle's minimum wage ordinance). Single-location franchisees as well as multi-location franchisees with separate ESD accounts by location are included in our analysis.[2]

We geocode each business's latitude and longitude using mailing addresses and use these coordinates to precisely place each business into one of the 1,458 tracts in Washington. We then collapse employer-employee matched microdata to geographically aggregated panel data with tract and quarter as the unit of observation. We merge any tract with fewer than 70 low-wage jobs in any quarter with its largest neighbor, where "low-wage" is defined as less than $19 per hour.[3] To balance the dataset, we exclude tracts and tract clusters that have any quarter during which there are no low-wage jobs. The resulting dataset includes 1,174 tracts or tract clusters, 107 of which are in Seattle, 6 are in SeaTac, and 37 are in Tacoma.

[2]For a detailed discussion of the implications of multi-site firms and other employers not mapping to a physical location for the analysis of the impacts of the Seattle minimum wage, see our companion *AEJ:EP* paper, Jardim et al. (2022).

[3]We use the $19 threshold in Jardim et al. (2022) to allow for cascading effects of the minimum wage to workers currently earning above the new minimum wage. As we note there, any fixed threshold has the potential to miss cascading effects above that threshold. However, we present evidence that suggests that there are unlikely to be substantial cascading effects beyond the $19 threshold.

5 Methods

5.1 Base Model: Effect of the Policy Assuming No Spillover Effects

We model year-over-year growth in outcome Y (i.e., wages or hours worked by low-wage workers) in tract r in quarter t, ΔY_{rt}, as the sum of: (1) a treatment effect, β_q, which can vary across time; (2) an economic trend γ_{rt} that equals $\sum_{k=1}^{K} \lambda_{rk}\mu_{kt}$, where μ_{kt} is one of K unobserved factors, common across all regions in each year-quarter, and λ_{rk} is a tract-specific factor loading that is constant across time; and (3) ϵ_{rt}, an idiosyncratic shock occurring to tract r in period t. Our framework is similar to the conventional difference-in-differences specification, however differs by: (a) replacing region and quarter fixed effects with interactive fixed effects, relaxing the parallel trends assumption (Bai, 2009); and (b) allowing the treatment effect to vary across time.[4]

Let $q = 0$ denote the quarter during which SeaTac voters passed their local minimum wage initiative (i.e., 4th quarter of 2013) and $q = 1$ denote the first quarter of implementation of this policy (i.e., 1st quarter of 2014). Suppose tracts in SeaTac are uniformly affected by the city's minimum wage policy such that ΔY_{rt} increases by β_q during quarter $t = q$ after enforcement of the law. If there are no spillover effects of this policy, then ΔY_{rt} would be determined by the following data generating process, where T_{rt}^{SeaTac} is a treatment indicator that equals 1 if tract r is in SeaTac and quarter $t = q$:

$$\Delta Y_{rt} = \sum_{q=1}^{11} \beta_q T_{rt}^{SeaTac} + \sum_{k=1}^{K} \lambda_{rk}\mu_{kt} + \epsilon_{rt}. \tag{1}$$

[4] In Jardim et al. (2022), we estimate a similar model using both a levels specification (i.e., with the dependent variable as Y_{rt}) and a changes specification (i.e., with ΔY_{rt} as the dependent variable). We found no substantive difference in the conclusions between the levels and changes models.

Standard errors for $\hat{\beta}_q$ are obtained using the asymptotic distribution of the coefficients assuming that error terms ϵ_{rt} are independent.

We track outcomes in SeaTac for eleven quarters after implementation. For quarters 5-8, we calculate the cumulative effect of the minimum wage law as $\hat{\beta}_q^{Cum.} = (1 + \hat{\beta}_q)(1 + \hat{\beta}_{q-4}) - 1$, while for quarters 9-11, we calculate the cumulative effect as $\hat{\beta}_q^{Cum.} = (1+\hat{\beta}_q)(1+\hat{\beta}_{q-4})(1+\hat{\beta}_{q-8})-1$. Standard errors for the cumulative effects are computed using the delta method. Similar procedures are used for Seattle and Tacoma, but with later starting dates, 2015.2 ($q = 6$) and 2016.1 ($q = 9$), respectively.

5.2 Modeling Spillover Effects: Exposure Index Method

We propose an exposure index to the minimum wage laws which is exogenous and can be interpreted as the treatment intensity for each tract. We calculate two sets of indexes: an own-exposure index for tracts located in jurisdictions that increased their minimum wage, and an external-exposure index for tracts located elsewhere. The own-exposure index captures the increase in average wages we would expect if workers paid below the new minimum got a raise exactly up to that level while employment, hours, and wages of other workers remained exactly the same.[5] The external-exposure index is a function of the degree to which wages in a given tract fall below the new minimum in treated jurisdictions and the empirically observed pre-treatment probability of transitioning from that tract to the treated jurisdiction.

With regard to the Seattle minimum wage, we calculate the own-exposure index in quarter t for tract r located in Seattle as follows:

$$O_{rt}^{Seattle} = \left(\frac{\sum_i max(W_{ir,t-4}, MW_t^{Seattle}) H_{ir,t-4} L_{ir,t-4}}{\sum_i W_{ir,t-4} H_{ir,t-4} L_{ir,t-4}} - 1 \right) T_{rt}^{Seattle}, \quad (2)$$

[5]An "own exposure" index has been used in previous studies to determine employers' exposure to minimum wage hikes (Card and Krueger, 1994; Hirsch, Kaufman and Zelenska, 2015; Jardim and van Inwegen, 2019).

where i indexes jobs in region r in quarter $t-4$, W is the wage, H is the hours worked, $MW_t^{Seattle}$ is the minimum wage in Seattle in quarter t, and L is an indicator for this job paying less than \$19 per hour. Note that the own-exposure index captures the year-over-year percentage increase in aggregate earnings that would need to be paid to workers in "low-wage" jobs in region r and quarter t. We fix the distribution of hours worked in such jobs in this tract based on period $t-4$ to match the year-over-year outcomes of interest. O_{rt}^{Tacoma} is defined analogously to $O_{rt}^{Seattle}$. The own-exposure index for SeaTac is defined as follows, where C is an indicator denoting that the job is in an industry covered by the SeaTac ordinance:

$$O_{rt}^{SeaTac} = \left(\frac{\sum_i max(W_{ir,t-4}, MW_t^{SeaTac}) H_{ir,t-4} L_{ir,t-4} C_{ir,t-4}}{\sum_i W_{ir,t-4} H_{ir,t-4} L_{ir,t-4} C_{ir,t-4}} - 1 \right) T_{rt}^{SeaTac}, \tag{3}$$

To construct the index of external exposure to Seattle's minimum wage law for tracts outside of Seattle, we need to take into account both the level of wages paid in those tracts and the degree of the labor market integration with Seattle. We longitudinally track workers with low-wage jobs in region r in quarter t and who separate from their employer after quarter t. From this group, we compute the share that are employed in Seattle in either of the subsequent two quarters, $t+1$ and $t+2$. Denote this probability by $P_{rt}^{Seattle}$. We compute this measure for each of the pre-policy quarters between 2011.3 to 2013.2. Finally, we define $P_r^{Seattle}$ as the average of these measures, i.e., $P_r^{Seattle} = \frac{1}{8} \sum_{t=2011.3}^{2013.2} P_{rt}^{Seattle}$. We define P_r^{Tacoma} analogously. For P_r^{SeaTac}, the measure reflects the probability that a low-wage worker will be subsequently employed by a SeaTac firm in an industry that is covered by the SeaTac minimum wage.

Next, we define the external-exposure index of tract r to Seattle's minimum wage as follows:

$$E_{rt}^{Seattle} = P_r^{Seattle} \left(\frac{\sum_i max(W_{ir,t-4}, MW_t^{Seattle}) H_{ir,t-4} L_{ir,t-4}}{\sum_i W_{ir,t-4} H_{ir,t-4} L_{ir,t-4}} - 1 \right) N_{rt}^{Seattle}, \tag{4}$$

where $N_{rt}^{Seattle}$ is an indicator that tract r is not within Seattle and quarter $t = q$.

We calculate the exposure indexes to SeaTac's and Tacoma's minimum wages in a similar way, and create a composite external-exposure index by adding all three indexes, $E_{rt} = E_{rt}^{Seattle} + E_{rt}^{SeaTac} + E_{rt}^{Tacoma}$.

After calculating the exposure indexes, we estimate the following specification to capture the direct effects of the local minimum wages in the three treated regions ($\beta_q^{Seattle}$, β_q^{SeaTac}, and β_q^{Tacoma}) controlling for the indirect effect created by spillovers (γ_q):

$$\begin{aligned} \Delta Y_{rt} = \sum_{q=6}^{11} \beta_q^{Seattle} O_{rt}^{Seattle} + \sum_{q=1}^{11} \beta_q^{SeaTac} O_{rt}^{SeaTac} + \sum_{q=9}^{11} \beta_q^{Tacoma} O_{rt}^{Tacoma} \\ + \sum_{q=1}^{11} \gamma_q E_{rt} + \sum_{k=1}^{K} \lambda_{rk} \mu_{kt} + \epsilon_{rt}. \end{aligned} \tag{5}$$

Note the strategy in Equation (5) for identifying the external effects is that tracts with zero "exposure" are assumed to be unaffected, and therefore serve as the control group.

Relative not only to traditional boundary discontinuity methods but also to the parametric and semi-parametric distance-decay methods discussed below, this approach has several advantages. First, it allows us to estimate the effect of the minimum wage without making assumptions about the role of geographic proximity in propagating spillovers. In the traditional boundary-discontinuity methods researchers either assume that spillover effects are zero, or seek to exclude an area outside of the jurisdiction which implemented a policy to remove the contaminated areas (i.e., a buffer-zone approach), and thus have to make assumptions about how far the spillover propagates. Our method does not face this challenge because we are estimating the strength of the spillover effect based on the data. To be sure, a different sort of assumption underlies this model, namely that the minimum wage has no impact in regions with either zero affected workers or no observed labor market integration with a jurisdiction that changed policy.

Second, unlike the semi-parametric model discussed below, we need not assume there is an uncontaminated comparison group in the region. In fact, all regions in the area are considered treated. Third, this approach can accommodate multiple policy changes occurring at the same time, which often is a problem in practice. In our case, Seattle and Tacoma implemented minimum wage increases after SeaTac, and we can explicitly control for the magnitudes of these effects and ensure that our estimates of the effect in Seattle are not driven by these other policies. Finally, our estimation strategy allows us to recover both the effect on the jurisdiction that implemented the policy and the spillover effect.

These advantages do not come without costs. First, our estimation strategy hinges on the ability to accurately model exposure. While constructing the exposure index for the minimum wage is relatively straightforward, it can be unclear how to calculate such index in the case of other policies – or even in the 46 states that do not collect the information required to compute hourly wages. Second, though our method allows us to recover estimates of both the direct and spillover effects of the minimum wage, we face the reflection problem (Manski, 1993). In our case, SeaTac was the first city of implement the minimum wage increase in Washington. As a result, we may have difficulty separating the lagged effect of SeaTac's minimum wage on Seattle from Seattle's own minimum wage. We face a similar challenge with estimating the effect of the minimum age in Tacoma. In section V, we show that the external exposure of Seattle to SeaTac's and Tacoma's minimum wages were very low, so we believe the reflection problem to be a minimal consideration when estimating the effects of Seattle's minimum wage ordinance on tracts within Seattle.

5.3 Modeling Spillover Effects: Driving Time Methods

Our second and third methods, which we use to estimate the effects of Seattle's minimum wage policy, assume that spillover effects dissipate as a function of distance, measured as driving time to the treated jurisdiction. We use driving time owing to the peculiar topography of the Puget Sound region, in which two reasonably proximate areas might be separated by mile-high mountains or elongated bodies of water. Using the "Topologically Integrated Geographic Encoding and Referencing" data from the 2010 US Census to determine the population-weighted centroid of each tract, we calculate the time it takes to drive from the centroid of each tract to the closest main entrance to Seattle, which we hereafter call "distance". Most areas in the Puget Sound region are within 40-60 minute drive to Seattle, while the furthest areas of Washington are six hours away.

The second method assumes that the strength of the spillover effect dissipates at a constant rate with each additional minute of travel time. This assumption implies that the effect on tract r in quarter t, $\theta_r t$, can be expressed as follows:

$$\theta_r t = \beta_q \delta^{D_r}, \tag{6}$$

where D_r is the distance of tract r to Seattle, and the distance to Seattle is set to zero by definition for the tracts in Seattle. q is the number of periods after policy implementation.

In this specification, δ shows the strength of the spillover effect. If $\delta = 0$, there is no spillover effect of the local policy, and if $\delta = 1$ the policy has an equal effect on all surrounding areas that does not decay with distance. Intermediate values indicate a dissipating effect. $\hat{\beta}_q$ is the estimate of the effect in Seattle as the distance is set to zero for the tracts in Seattle. Therefore, we are able to describe all of the relevant policy effects based on the β_q and δ parameters. This specification allows the spillover effect to contaminate all potential control regions, and lets the data speak about the strength of this effect. This advantage comes at a cost of making a strong assumption about the parametric form of the spillover effect.

We estimate these effects using the following specification:

$$\Delta Y_{rt} = \sum_{q=6}^{11} \beta_q \delta^{D_r} T_{rt}^{Seattle} + \sum_{k=1}^{K} \lambda_{rk} \mu_{kt} + \epsilon_{rt}. \tag{7}$$

We implement the estimation via non-linear least squares with a factor-augmented error term, and obtain the standard errors through non-parametric bootstrap with 200 draws.

Our third method is a semi-parametric specification, similar to other studies interested in estimating spillover effects (Linden and Rockoff (2008); Campbell, Giglio and Pathak (2011); Anenberg and Kung (2014); Mian, Sufi and Trebbi (2015)). We combine tracts into twelve zones based on distance to Seattle, with Seattle's tracts constituting Zone 0. Zones 1-11 include, respectively, tracts that are <10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-90, 90-120, 120-180, 180-240, and >240 minutes' drive to Seattle.[6] We estimate the spillover effect using a flexible response function that allows the effects in Zone 0 though Zone 10 to be independent of one another and assumes that the effect in Zone 11 equals zero. It is necessary to anchor one zone's effect to zero to identify the other coefficients. We estimate the parameters of the following function, where T_{zt} is defined as an indicator variable that equals 1 if the job is located in Zone z and $t = q$:

$$\Delta Y_{rt} = \sum_{z=0}^{10} \sum_{q=6}^{11} \beta_{zq} T_{zt} + \sum_{k=1}^{K} \lambda_{rk} \mu_{kt} + \epsilon_{rt}. \tag{8}$$

[6]These zones, illustrated in online appendix Figure A1, form a rough bullseye around Seattle.

Since we normalize the treatment effect in Zone 11 to be zero in all periods, coefficients β_{zq} should be interpreted as the relative impact of Seattle's Minimum Wage Ordinance on outcomes in each zone compared to Zone 11.

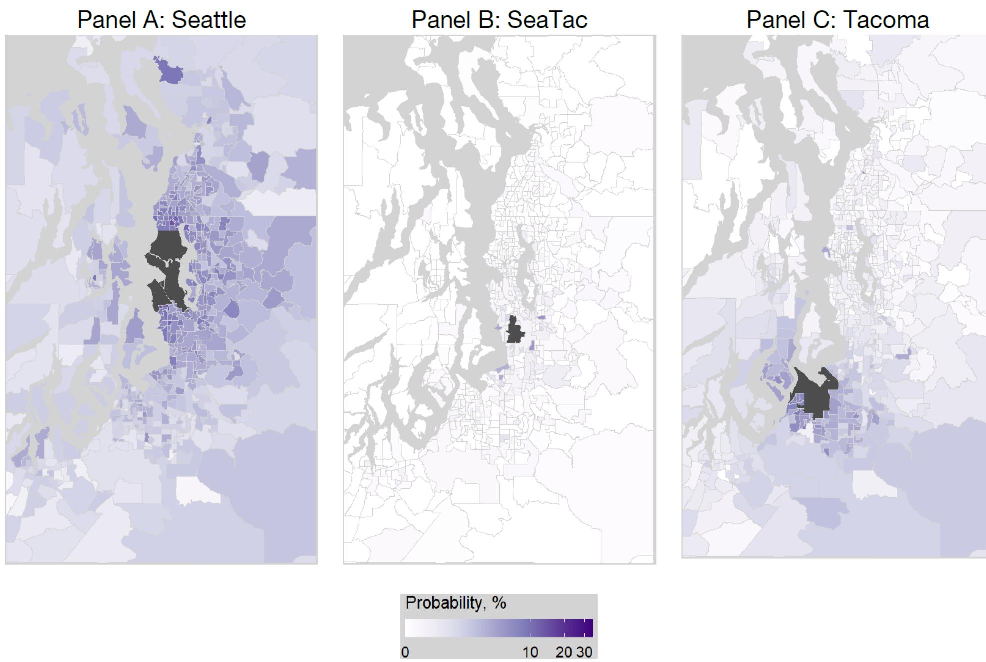
6 Results

Figure 1 plots the labor market integration measures, i.e., $P_r^{Seattle}$, P_r^{SeaTac}, and P_r^{Tacoma}. This heat map, by itself, does not prove that there are spillover effects, but suggests regions where we might expect them to occur. For a typical tract in the Puget Sound region, a worker is much more likely to transition to Seattle than SeaTac during the next two quarters given Seattle's much larger labor market. Consequently, changes in Seattle's minimum wage are likely to have more effect on bargaining in external regions than a change in SeaTac's. Tacoma's labor market integration is somewhere between Seattle and SeaTac's, with a substantial number of commuters coming from the south.

The patterns shown in Figure 1 do not fit a neat model of geometric or exponential decay. There are "hot spots" evident in many places. Tacoma is more integrated with tracts to its southside than its northside, likely due to competition for workers with the larger Seattle labor market to the north. Tacoma is also more competitive for worker flows from tracts to its northwest, given easier east-west commute over the Puget Sound via the Tacoma Narrows Bridge relative to more time-consuming cross-Sound ferry rides to Seattle. The heat map for SeaTac is much lighter, reflecting smaller size of the jurisdiction and the fact that we are measuring labor flows only into the covered industries.

Figure 2 illustrates the geographic and temporal differences in external exposure. The contrast between Panels A and B, which respectively show the external exposure to Seattle's initial $11 and subsequent $13 minimum wages, shows the importance of the magnitude of the minimum wage in generating

Figure 1: Low-Wage Labor Market Integration in the Puget Sound Region

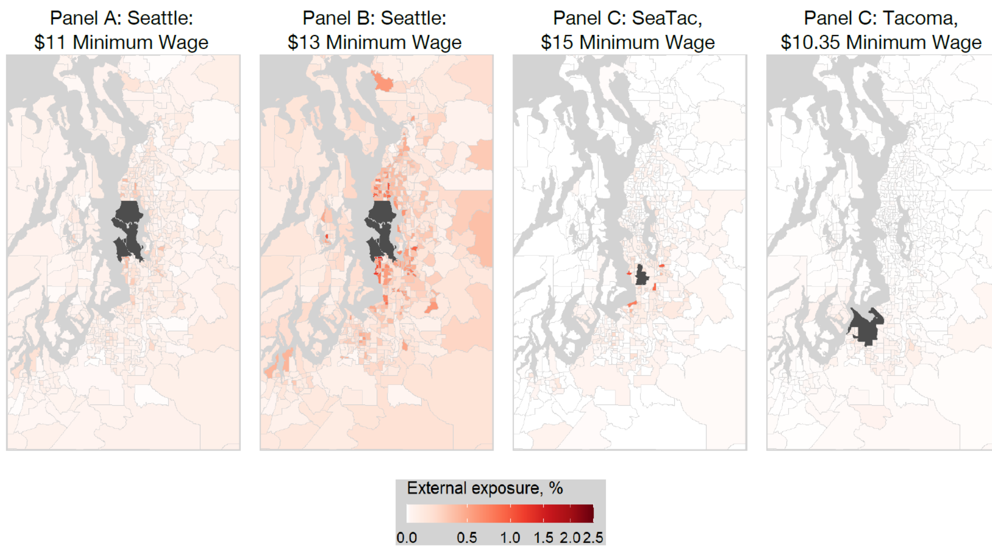


Notes: These figures show the probability that a worker earning less than $19 per hour in region r in quarter t will be employed in Seattle, SeaTac (in covered industries), or Tacoma, respectively, during the next two quarters (i.e., $t+1$ or $t+2$) conditional on separating from the worker's current employer in quarter t, based on observed behavior during 2011.3 to 2013.2. Black shading reflects the city boundaries of Seattle, SeaTac, and Tacoma, respectively.

greater external exposure. We find very modest external exposure to the SeaTac and Tacoma minimum wages, yet for different reasons. SeaTac had the highest minimum wage increase of the three cities, but the small amount of labor market integration with the rest of the state and the fact that the law only pertained to the transportation and hospitality industries limited the extent of external exposure. Tacoma has greater labor market integration than SeaTac, but its local minimum wage was only modestly above the state's minimum wage, thus not creating substantial competitive pressure to increase wages in surrounding tracts.[7]

[7]As shown in online appendix Table A1, employers in Seattle needed to raise the

Figure 2: External Exposure to the Seattle, SeaTac, and Tacoma Minimum Wage Laws



Notes: External exposure index is plotted for the first quarters during which the minimum wage increased in Seattle (i.e., 2015.2 and 2016.1) and Tacoma (2016.1) and was fully enforced in SeaTac (2015.3). Black shading reflects the city boundaries of Seattle, SeaTac, and Tacoma, respectively.

Table 2 shows the cumulative effects of Seattle's minimum wage law on the average tract in Seattle (i.e., $\hat{\beta}_q^{Seattle} O_{rt}^{Seattle}$) and the cumulative external effects of the three cities' laws on the average tract in the remainder of Washington (i.e., $\hat{\gamma}_q E_{rt}$).[8]

The first two columns of Table 2 show that Seattle's $13 minimum wage led to a 4-5% increase in wages paid to low-wage workers in Seattle, and low-

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aggregate wages paid to low-wage jobs by about 1% to comply with the minimum wage ordinance's first phase-in to $11, and about 4-5% to comply with the increase to $13. Covered employers in SeaTac faced a much larger exposure, needing to raise wages by more than 10% to comply with the $15 minimum wage. The Tacoma minimum wage, in contrast, produced a very small compliance cost, less than 1%. Further, this table reinforces Figure 2 in showing that nearly all of the external exposure was due to Seattle's minimum wage law.

[8]For the interested reader, online appendix Table A2 shows the full set of Equation (5) parameter estimates, i.e., $\hat{\beta}_q^{Seattle}$, $\hat{\beta}_q^{SeaTac}$, $\hat{\beta}_q^{Tacoma}$, and $\hat{\gamma}_q$.

Table 2: Internal Effects of Seattle's Minimum Wage on Low-Wage Jobs in Seattle and External Effects of the Minimum Wage Laws in Seattle, SeaTac, and Tacoma on Low-Wage Jobs Throughout Washington State

Quarter	Seattle Wages	Seattle Hours	WA State Wages	WA State Hours
2014.1	n.a.	n.a.	0.000	-0.001
			(0.000)	(0.001)
2014.2	n.a.	n.a.	0.000	-0.001
			(0.000)	(0.001)
2014.3	n.a.	n.a.	0.000	-0.001
			(0.000)	(0.001)
2014.4	n.a.	n.a.	0.000	0.000
			(.0000)	(0.001)
2015.1	n.a.	n.a.	0.001 ***	-0.001
			(0.000)	(0.001)
2015.2	0.009 ***	-0.004	0.003 ***	0.003
	(0.002)	(0.015)	(0.001)	(0.004)
2015.3	0.012 ***	-0.016	0.003 ***	0.000
	(0.002)	(0.015)	(0.000)	(0.004)
2015.4	0.011 ***	-0.028 **	0.005 ***	0.001
	(0.002)	(0.014)	(0.000)	(0.003)
2016.1	0.038 ***	-0.062 ***	0.010 ***	-0.010 **
	(0.004)	(0.016)	(0.001)	(0.005)
2016.2	0.043 ***	-0.093 ***	0.012 ***	-0.029 ***
	(0.003)	(0.022)	(0.001)	(0.006)
2016.3	0.045 ***	-0.060 ***	0.015 ***	-0.025 ***
	(0.003)	(0.022)	(0.001)	(0.006)

Notes: This table shows the cumulative effects estimated using the exposure method, Equation (5). ***, **, and * denote statistically significance using a two-tailed test with $p \leq 0.01$, 0.05, and 0.10. First five quarters for Seattle are "n.a." as these pre-date the implementation of Seattle's minimum wage. The Seattle results only capture effects of "own exposure" and do not include effects of exposure to SeaTac and Tacoma minimum wages.

ered their hours worked by 6-9%. These magnitudes are generally consistent with our prior paper, Jardim et al. (2022), and suggest an implied low-wage labor demand elasticity in the range of -1.3 to -2.2. The latter columns show that external exposure raised wages in the average Washington tract 1-2% during the first three quarters of 2016 during which Seattle's top minimum wage was $13, while decreasing hours worked 1-3%. These results imply a low-wage labor elasticity of -1.0 to -2.4. Notably, earlier quarters which had less external exposure show smaller increases in wages and statistically insignificant changes in hours worked.

Panels A and B of Figure 3 plot the coefficients and 90% confidence intervals for the estimated effects on wages and hours worked, respectively, using the driving time constant rate of decay and concentric circle methods for 2016.1, i.e., the first quarter during which Seattle's top minimum wage was $13.[9] The estimates are noisy for wages, but suggest positive spillover effects that dissipate with distance. We find strong evidence for spillover effects on hours worked and the estimated effects are statistically significant out to 40 minutes driving time to Seattle.[10]

The major implication of these findings of significant and substantial spillover effects is that the boundary discontinuity method applied to study Seattle would yield biased results attenuating both the effects on wages and hours worked. If we were to divide the downwardly biased hours effect by the downwardly biased wage effect to get an elasticity, the ensuing bias would depend on the relative magnitude of the biases for hours and wages.

[9] A similar pattern of results are seen for other quarters. The graphical results for all quarters are shown in online appendix Figures A2 and A3 and corresponding numerical estimates are contained in online appendix Tables A3 and A4.

[10] As shown in online appendix Table A2, the estimated decay coefficient, $\delta = 0.960$, is significantly greater than 0, and since it is close to 1, it suggests the spillover effect on hours worked dissipates slowly with a half-life of nearly 17 driving minutes.

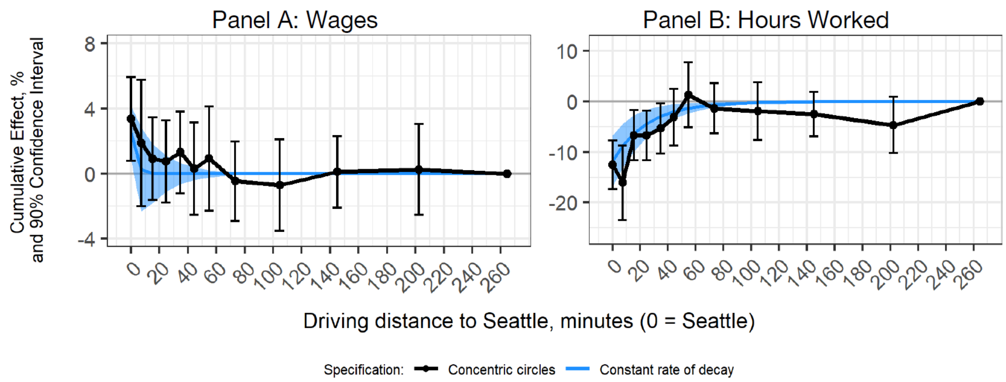

Figure 3: Effect of Seattle's Minimum Wage Law on Wages and Hours Worked in Jobs Paying <$19 Within Seattle and Surrounding Areas During 2016.1, Estimated Using Driving Time Methods

7 Conclusion

Boundary discontinuity methods that compare outcomes in a "treated" region to those in adjacent, local regions may yield biased estimates for policies that have spillover effects. If these spillover effects are of the same sign as the effects in the implementing jurisdiction, then boundary discontinuity methods will yield understated estimates of actual policy effects. This bias gets more complicated when one is looking at the ratio of two policy effects (e.g., in estimating minimum wage elasticities).

One simple method to account for this contamination is to exclude data from the area where contamination is believed to exist. This "buffer-zone" or "donut-hole" approach, while appealing, has the limitation that it is not clear, in most contexts, how large to make the buffer zone, and throwing out information from the buffer zone might exclude data from areas that have the strongest claim for parallel trends in the absence of the policy. In theory, models that directly estimate the spillover offer possible improvements in methodology and can eliminate the bias. The challenge, as described above, is identifying a "correct" model of spillovers.

We illustrate three methods for modeling spillover effects to evaluate the impacts of local minimum wage ordinances three Washington cities, Seattle, Tacoma, and SeaTac. Our preferred method models the spillover effect by computing the exposure of other communities to these cities' minimum wage ordinances as a function of labor market integration between a given Census tract and these cities. This method places structure on the geographical relationships, which is desirable, but requires information that might not be available in all contexts. Our second and third methods use driving time distance to the Seattle city limit. The second method estimates a parametric model based an assumed constant decay of the spillover effect. The third takes a semi-parametric approach based on estimating effects on concentric rings around the city assuming no spillover effect on the furthest ring. These two distance-based methods can be used in many contexts with readily available data. We find that these methods yield a similar pattern of spillover effects as the first method, but are noisier, likely due to their unrealistic assumption that labor-market integration is a monotonic function of driving time to the boundary.

Finally, note that the minimum wage ordinances in SeaTac and Tacoma contributed little to the estimated spillover effects. SeaTac's minimum wage was a large immediate increase above the state's minimum wage but only applied to the transportation and hospitality industries. Further, SeaTac is a relatively small employer in the Puget Sound region, dwarfed by the larger labor markets to the north (Seattle) and south (Tacoma). Consequently, this ordinance may have not yielded a substantial plausible threat of exit for low-skill workers in surrounding communities and thus yielded a small spillover effect. Tacoma is a larger employer of low-skill labor and more integrated with the region to its south and northwest. Yet, the minimum wage in Tacoma was only set slightly above the state's minimum wage. The external pressure on wages caused by Seattle's minimum wage ordinance was much greater than that caused by the ordinances in SeaTac and Tacoma. These results suggest that spillover effects are less likely to be a concern with smaller interventions in big jurisdictions or bigger interventions in small jurisdictions.

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A Online Appendix

A.1 Methods Notes

- SeaTac's minimum wage law's covered hospitality employers are restricted to those who operate "within the City any Hotel that has one hundred (100) or more guest rooms and thirty (30) or more workers or who operates any institutional foodservice or retail operation employing ten (10) or more nonmanagerial, nonsupervisory employees" and covered transportation employers are restricted to those who employ twenty-five or more nonmanagerial, nonsupervisory employees (City of SeaTac, Undated a). There are a number of other restrictions included in the law. Since our administrative data do not contain information that would allow us to perfectly identify whether an employer meets the coverage definitions, we are defining "covered employers" more broadly as inclusive of any employer with a NAICS (North American Industrial Classification System) code matching the list supplied by the City, found in (City of SeaTac, Undated b).

- The SeaTac minimum wage ordinance was scheduled to go into effect on January 1^{st}, 2014. However, a few days before its implementation date, the law lost a court challenge, stopping the new minimum wage from applying to transportation and hospitality workers employed at the airport (about two-thirds of the SeaTac workforce) while allowing it to hold for SeaTac's hospitality and transportation workers outside the airport. The case was appealed and the state Supreme Court upheld the law. Thus, SeaTac's minimum wage went up to $15 for covered airport hospitality and transportation employers on August 20, 2015. We treat the third quarter of 2015 as treated for these transportation and hospitality workers employed at the airport.

- Note that employers in the Seattle-Tacoma International Airport face external exposure to the SeaTac minimum wage increase in the non-airport portions of SeaTac prior to the resolution of the court decision. Thus, with regard to the computation of E_{rt}^{SeaTac}, for 2014 and the first two quarters of 2015, P_r^{SeaTac} is defined as the probability of moving employment to a hospitality or transportation employer located in SeaTac, but outside the airport. Beginning in the third quarter of 2015, P_r^{SeaTac} is defined as the probability of moving employment to a hospitality or transportation employer located anywhere in SeaTac, including the airport. Likewise, the N_{rt}^{SeaTac} indicator variable is defined as 1 if $t = q$ and either (a) the employer's tract r is outside SeaTac or (b) the employer is located within the the airport. Thereafter, N_{rt}^{SeaTac} is set to zero for employers within the airport.

- Seattle has four different minimum wage schedules depending on the company's number of employees worldwide and whether employees receive benefits and/or tips. However, in our data we do not observe whether workers get fringe benefits, and similarly we have no way of calculating the number of worldwide employees. As a result, we cannot observe which schedule applies to each job, and we assign all workers to the highest minimum wage in each period, i.e., \$11 or \$13 per hour.

- Seattle has six main road entrances, I-5 express and highway 522 from the North, the 520 bridge and I-90 express from the East, I-5 express and highway 509 from the South, and two ferry docks (accessible from Bremerton, Bainbridge Island, Southworth, and Vashon Island) from the West. We use the Google Maps Application Programming Interface to determine the time it would take to drive a car from the centroid of each tract to each entrance to Seattle, such that you would arrive at the Seattle entrance at 9:00AM on Tuesday, March 7^{th}, 2017, and choose the minimum time. For Census tracts that were merged together, we take time to be the average of the times for all merged tracts, weighted by least number of low-wage jobs.

- To select the optimal number of factors, K, for inclusion in Equations (5), (7), and (8), we evaluate K being in the range of 1 to 20 and we select the model with the optimal number of factors using the criterion in Bai and Ng (2002). These models are estimated using the program developed by Gobillon and Magnac (2016).

A.2 Supplemental Figure and Tables

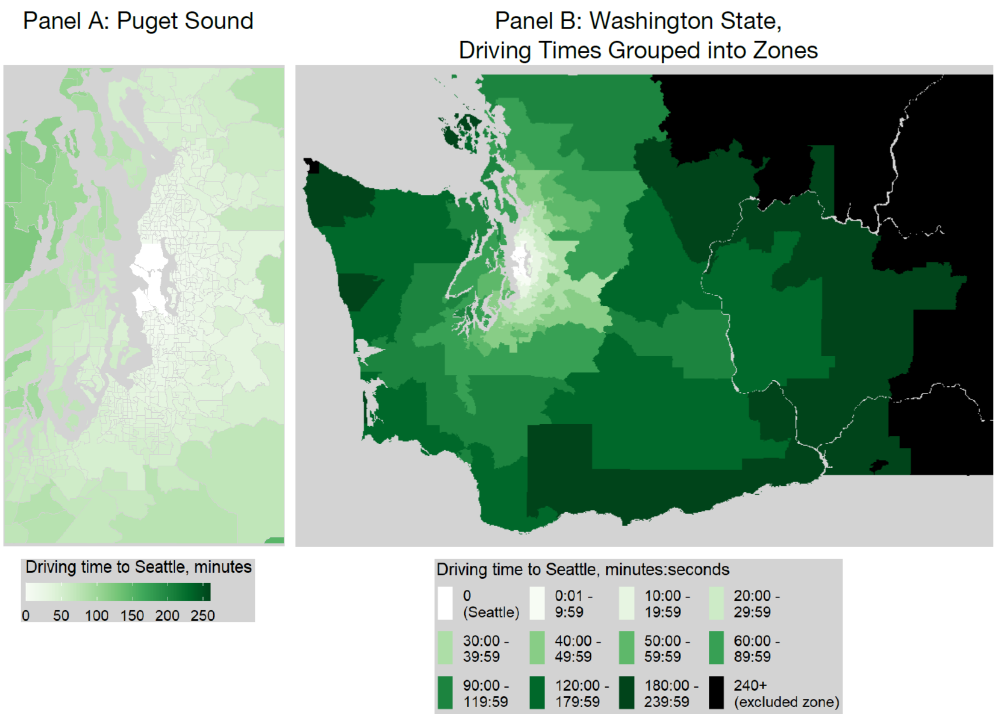

Figure A1: Driving Time to Seattle

Table A1: Extent of Exposure to Own Minimum Wage Law and External Exposure to Other Areas' Local Minimum Wage Laws

Quarter	$O_{rt}^{Seattle}$	O_{rt}^{SeaTac}	O_{rt}^{Tacoma}	$E_{rt}^{Seattle}$	E_{rt}^{SeaTac}	E_{rt}^{Tacoma}	E_{rt}
2014.1		10.52			0.01		0.01
2014.2		10.21			0.01		0.01
2014.3		11.72			0.01		0.01
2014.4		10.14			0.01		0.01
2015.1		8.92			0.01		0.01
2015.2	1.33	8.98		0.05	0.01		0.06
2015.3	1.29	10.92		0.05	0.02		0.06
2015.4	0.94	9.52		0.04	0.02		0.05
2016.1	4.80	8.49	0.61	0.16	0.02	0.00	0.18
2016.2	4.20	9.64	0.76	0.17	0.02	0.01	0.19
2016.3	3.76	8.95	0.73	0.16	0.01	0.00	0.18

Notes: "Own Exposure" is the percentage change in aggregate wages paid to workers in low-wage jobs (i.e., those earning less than $19 per hour) that is necessary to raise wages from their level in quarter $t-4$ to the level required by the top minimum wage in the treated city in quarter t. Own Exposure for SeaTac is computed only for firms that are covered by SeaTac's minimum wage. "External Exposure" is the percentage change in aggregate wages paid to low-wage workers within the tract necessary to raise wages from their level in quarter $t-4$ to the level required by the top minimum wage in the treated city in quarter t multiplied by the probability that the worker will relocate employment from this tract to the treated city during the next two quarters conditional on separating from the worker's current employer. These measures are computed assuming no change to hours worked and number of jobs. The first three columns show the average Own Exposure across tracts located in Seattle, SeaTac, and Tacoma, respectively, while the latter four columns show the average External Exposure for tracts located in Washington outside these three cities.

Table A2: Effects of Exposure to Own Minimum Wage Law and External Exposure to Minimum Wages on Year-Over-Year Growth of Wages and Hours Worked in Jobs Paying less than $19 Per Hour

	Wage Regression				Hours Worked Regression			
Quarter	$O_{rt}^{Seattle}$	O_{rt}^{SeaTac}	O_{rt}^{Tacoma}	E_{rt}	$O_{rt}^{Seattle}$	O_{rt}^{SeaTac}	O_{rt}^{Tacoma}	E_{rt}
2014.1		0.132 *		1.915		-0.110		-7.713
		(0.072)		(1.595)		(0.552)		(12.928)
2014.2		0.115		3.667		-0.051		-13.558
		(0.105)		(2.242)		(0.562)		(13.779)
2014.3		0.088		3.186		-0.563		-9.389
		(0.130)		(2.654)		(0.522)		(14.217)
2014.4		0.168		4.638		-0.417		0.958
		(0.168)		(3.037)		(0.584)		(15.555)
2015.1		0.239		8.153 ***		-0.186		-6.179
		(0.173)		(2.076)		(0.678)		(14.242)
2015.2	0.698 ***	0.066		5.035 ***	-0.305	-0.248		6.810
	(0.117)	(0.139)		(0.841)	(1.139)	(0.684)		(7.160)
2015.3	0.910 ***	0.286 ***		4.906 ***	-1.238	-0.143		0.650
	(0.138)	(0.096)		(0.625)	(1.129)	(0.533)		(5.278)
2015.4	1.131 ***	0.348 ***		8.413 ***	-2.935 **	0.125		1.256
	(0.226)	(0.109)		(0.778)	(1.490)	(0.605)		(5.763)
2016.1	0.785 ***	0.166	-0.394	4.903 ***	-1.294 ***	-0.255	3.438	-4.979 *
	(0.085)	(0.153)	(0.638)	(0.576)	(0.329)	(0.661)	(3.948)	(2.579)
2016.2	0.805 ***	0.452 **	-0.231	4.933 ***	-2.121 ***	1.406 **	-5.419 *	-16.979 ***
	(0.124)	(0.177)	(0.672)	(0.738)	(0.377)	(0.603)	(3.154)	(2.582)
2016.3	0.871 ***	0.331	-1.003	6.266 ***	-1.207 ***	0.607	-4.879	-13.750 ***
	(0.151)	(0.216)	(0.788)	(0.906)	(0.419)	(0.668)	(3.221)	(2.850)

Notes: 50,482 tract-quarter observations are included in each regression. R^2 equals 0.826 (0.261) and K=15 (1) for the wage (hours worked) regression. ***, **, and * denote statistically significance using a two-tailed test with $p \leq 0.01$, 0.05, and 0.10, respectively.

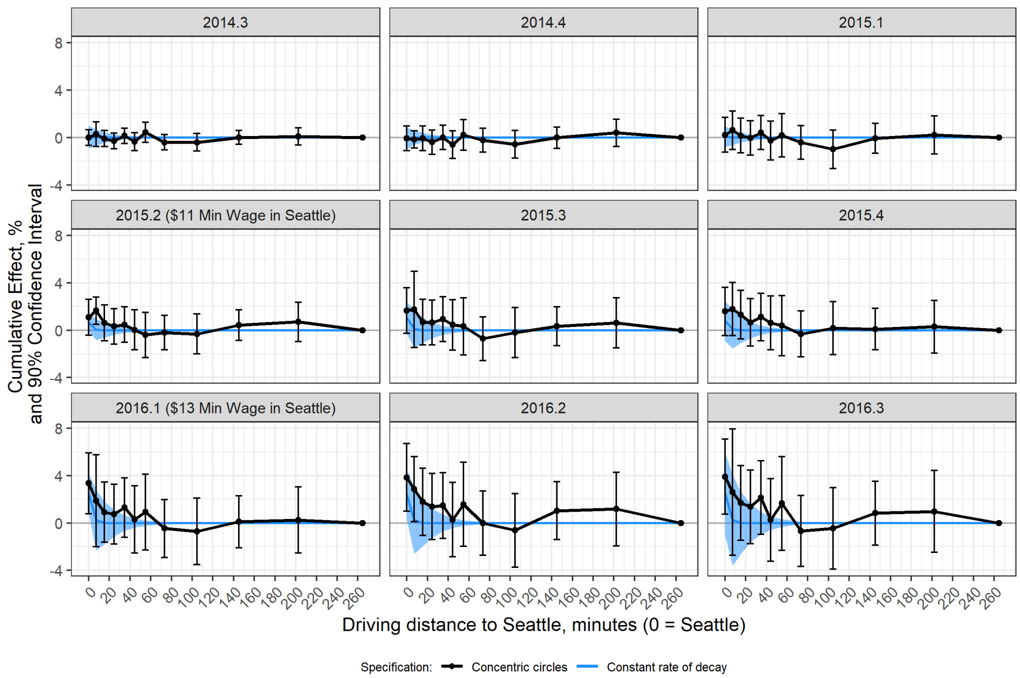

Figure A2: Cumulative Effects on Wages in Jobs Paying < $19 Per Hour, Estimated Using Driving Time Methods

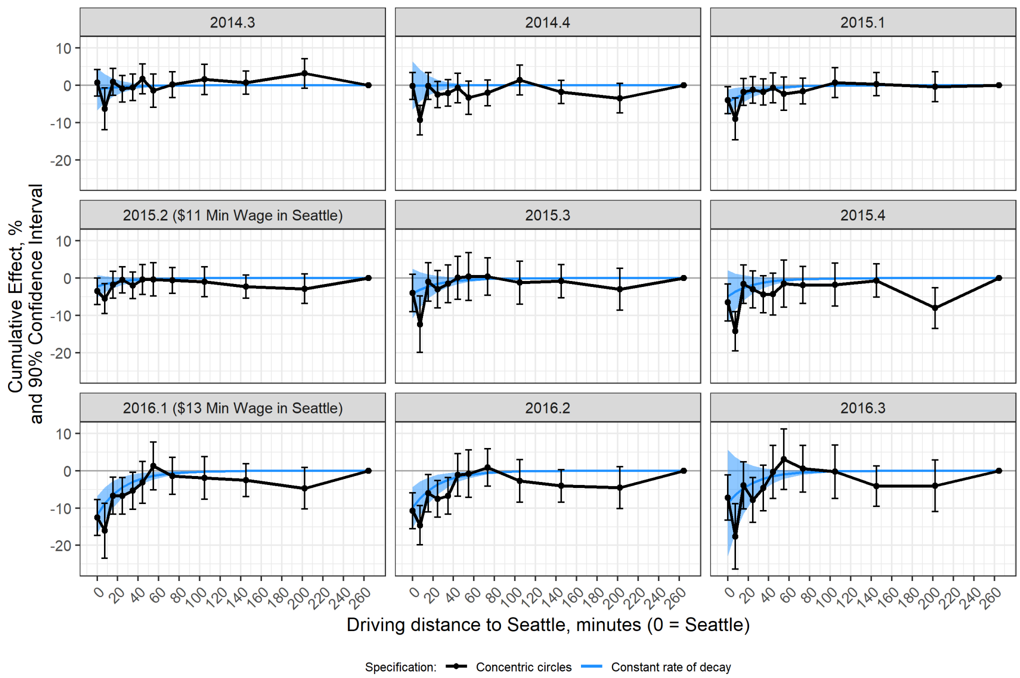

Figure A3: Cumulative Effects on Hours Worked in Jobs Paying < $19 Per Hour, Estimated Using Driving Time Methods

Table A3: Cumulative Effects on Wages in Jobs Paying less than \$19/hour Found Using Driving Distance Methods

	Equation (7)		Equation (8), β_{zq} for zones defined by driving minutes to Seattle:										
Quarter	β_q	δ	0	>0-10	>10-20	20-30	30-40	40-50	50-60	60-90	90-120	120-180	180-240
2014.3	0.001		0.000	0.003	-0.001	-0.003	0.001	-0.004	0.004	-0.004	-0.004	0.000	0.001
	(0.002)		(0.004)	(0.006)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)	(0.005)	(0.003)	(0.004)
2014.4	0.000		-0.001	-0.002	-0.001	-0.004	0.000	-0.006	0.002	-0.002	-0.006	0.000	0.004
	(0.003)		(0.006)	(0.004)	(0.006)	(0.006)	(0.006)	(0.007)	(0.008)	(0.006)	(0.007)	(0.005)	(0.007)
2015.1	0.001		0.002	0.006	0.002	0.000	0.004	-0.003	0.002	-0.004	-0.010	-0.001	0.002
	(0.002)		(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.010)	(0.011)	(0.009)	(0.010)	(0.008)	(0.010)
2015.2	0.007 ***		0.011	0.017 **	0.006	0.003	0.005	0.000	-0.004	-0.002	-0.003	0.004	0.007
	(0.002)		(0.009)	(0.007)	(0.009)	(0.009)	(0.009)	(0.010)	(0.012)	(0.009)	(0.010)	(0.008)	(0.010)
2015.3	0.011 ***		0.017	0.018	0.007	0.007	0.009	0.005	0.003	-0.007	-0.002	0.003	0.006
	(0.003)		(0.012)	(0.020)	(0.012)	(0.012)	(0.012)	(0.013)	(0.015)	(0.011)	(0.013)	(0.010)	(0.013)
2015.4	0.008 **		0.016	0.018	0.013	0.007	0.011	0.006	0.004	-0.003	0.002	0.001	0.003
	(0.003)		(0.012)	(0.014)	(0.012)	(0.012)	(0.012)	(0.014)	(0.015)	(0.012)	(0.014)	(0.011)	(0.014)
2016.1	0.025 ***		0.034 **	0.019	0.009	0.007	0.013	0.003	0.009	-0.005	-0.007	0.001	0.002
	(0.003)		(0.016)	(0.024)	(0.016)	(0.015)	(0.015)	(0.017)	(0.019)	(0.015)	(0.017)	(0.013)	(0.017)
2016.2	0.024 ***		0.038 **	0.029 *	0.018	0.014	0.015	0.003	0.016	0.000	-0.006	0.010	0.012
	(0.005)		(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.019)	(0.022)	(0.016)	(0.019)	(0.015)	(0.019)
2016.3	0.025 ***		0.039 **	0.026	0.017	0.014	0.021	0.003	0.017	-0.007	-0.005	0.008	0.010
	(0.008)		(0.019)	(0.032)	(0.019)	(0.019)	(0.019)	(0.021)	(0.024)	(0.018)	(0.021)	(0.016)	(0.021)
		0.726 ***											
		(0.013)											

Notes: 50,482 tract-quarter observations are included in each regression. R^2 equals 0.825 (0.826) and K=15 (15) for the Equation 7 (Equation 8) regression. ***, **, and * denote statistically significance using a two-tailed test with $p \leq 0.01$, 0.05, and 0.10, respectively.

Table A4: Cumulative Effects on Hours Worked in Jobs Paying less than \$19/hour Found Using Driving Distance Methods

	Equation (7)		Equation (8), β_{zq} for zones defined by driving minutes to Seattle:										
Quarter	β_q	δ	0	>0-10	>10-20	20-30	30-40	40-50	50-60	60-90	90-120	120-180	180-240
2014.3	-0.011		0.007	-0.063 *	0.009	-0.009	-0.006	0.017	-0.014	0.002	0.016	0.007	0.032
	(0.026)		(0.022)	(0.034)	(0.022)	(0.021)	(0.022)	(0.024)	(0.027)	(0.021)	(0.024)	(0.019)	(0.024)
2014.4	-0.001		-0.002	-0.093 ***	-0.002	-0.025	-0.020	-0.007	-0.033	-0.020	0.014	-0.018	-0.035
	(0.029)		(0.022)	(0.024)	(0.022)	(0.021)	(0.022)	(0.024)	(0.027)	(0.021)	(0.024)	(0.019)	(0.024)
2015.1	-0.045 ***		-0.040 *	-0.090 ***	-0.018	-0.012	-0.018	-0.007	-0.022	-0.016	0.007	0.003	-0.004
	(0.013)		(0.022)	(0.034)	(0.022)	(0.021)	(0.022)	(0.024)	(0.027)	(0.021)	(0.024)	(0.019)	(0.024)
2015.2	-0.022		-0.035	-0.055 **	-0.018	-0.005	-0.020	-0.004	-0.004	-0.006	-0.010	-0.023	-0.029
	(0.014)		(0.022)	(0.024)	(0.022)	(0.021)	(0.022)	(0.024)	(0.027)	(0.021)	(0.024)	(0.019)	(0.024)
2015.3	-0.041		-0.040	-0.124 ***	-0.010	-0.030	-0.015	0.001	0.004	0.004	-0.012	-0.008	-0.030
	(0.027)		(0.031)	(0.046)	(0.031)	(0.03)	(0.031)	(0.035)	(0.039)	(0.031)	(0.035)	(0.027)	(0.034)
2015.4	-0.049		-0.065 **	-0.143 ***	-0.016	-0.030	-0.044	-0.043	-0.015	-0.019	-0.018	-0.007	-0.080 **
	(0.032)		(0.030)	(0.032)	(0.031)	(0.030)	(0.030)	(0.034)	(0.039)	(0.030)	(0.035)	(0.027)	(0.033)
2016.1	-0.117 ***		-0.126 ***	-0.161 ***	-0.067 **	-0.067 **	-0.054 *	-0.031	0.013	-0.014	-0.019	-0.025	-0.047
	(0.017)		(0.029)	(0.045)	(0.030)	(0.030)	(0.030)	(0.034)	(0.039)	(0.030)	(0.035)	(0.027)	(0.034)
2016.2	-0.098 ***		-0.107 ***	-0.146 ***	-0.061 **	-0.075 **	-0.067 **	-0.011	-0.008	0.009	-0.027	-0.041	-0.045
	(0.018)		(0.030)	(0.032)	(0.031)	(0.030)	(0.030)	(0.035)	(0.039)	(0.031)	(0.035)	(0.027)	(0.034)
2016.3	-0.086		-0.072 *	-0.176 ***	-0.039	-0.078 **	-0.046	-0.003	0.031	0.006	-0.003	-0.041	-0.040
	(0.054)		(0.037)	(0.054)	(0.038)	(0.036)	(0.037)	(0.043)	(0.049)	(0.038)	(0.044)	(0.033)	(0.042)
		0.960 ***											
		(0.171)											

Notes: 50,482 tract-quarter observations are included in each regression. R^2 equals 0.260 (0.261) and K=1 (1) for the Equation 7 (Equation 8) regression. ***, **, and * denote statistically significance using a two-tailed test with $p \leq 0.01$, 0.05, and 0.10, respectively.