# Creative Destruction:
# Barriers to Urban Growth and the Great Boston Fire of 1872*

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## Abstract

Historical city growth, in the United States and worldwide, has required remarkable transformation of outdated durable buildings. Individual reconstruction decisions may be inefficient and restrict growth, however, due to externalities and transaction costs. This paper analyzes new plot-level data in the aftermath of the Great Boston Fire of 1872, estimating substantial economic gains from the created opportunity for widespread reconstruction. An important mechanism appears to be positive externalities from neighbors' reconstruction. Strikingly, impacts from this opportunity for widespread reconstruction were sufficiently large that increases in land values were comparable to the previous value of all buildings burned.

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The historical development of the United States has seen a remarkable transformation as modern metropolises have grown from small cities. Economic growth may strain the capacity of cities to evolve, however, restricting further growth. For example, when landowners' reconstruction choices do not internalize impacts on neighbors, private replacement of buildings diverges from the social optimum. While policy interventions in poor neighborhoods are widely studied and controversial (Jacobs, 1961; Wilson, 1966; Collins and Shester, 2013), even wealthy urban areas may not reach their economic potential in the presence of externalities. Indeed, in the aftermath of the Great Boston Fire of 1872, contemporaries speculated that this initially calamitous event would generate benefits through the opportunity for major reconstruction (Rosen, 1986), which suggests that substantial frictions in urban growth might be significantly eased through the opportunity for simultaneous large-scale reconstruction.[1]

This paper analyzes the Great Boston Fire of 1872, examining whether the Fire created real benefits and, if so, through what channels. This historical setting provides an opportunity to observe private landowners' responses to the opportunity for reconstruction during a period of urban growth, and avoids challenges of the modern period in which tighter land-use regulations and government reconstruction efforts often obscure market incentives. The government had little role in the reconstruction of 1873 Boston, prior to zoning regulations or stronger building codes in Boston (Rosen, 1986; Fischel, 2004).

We establish our null hypothesis based upon on a dynamic model of urban growth in which widespread urban destruction impacts land-use but generates no economic benefits. In this benchmark case, with no cross-plot externalities from reconstruction, the Fire might appear partly beneficial because destroyed buildings are replaced with new more valuable buildings, but the destruction generates no real economic benefits. In the presence of neighborhood externalities, however, reconstruction after the Fire does generate economic gains: the Fire temporarily improves the equilibrium outcome by forcing simultaneous widespread reconstruction, which temporarily mitigates the consequences of cross-plot externalities. This extended model provides a number of testable predictions that we take to the data: increases in land values in the burned area and nearby unburned areas; increases in building values in the burned area for even the most high-end buildings, and increases over time in nearby unburned areas; greater increases in building values following the Great Fire than following individual building fires; and no increase in land value following individual building fires.

The empirical analysis uses a new detailed plot-level dataset, covering all plots in the burned area and surrounding areas in 1867, 1872, 1873, 1882, and 1894. Our digitization

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[1] Throughout the paper we refer to economic inefficiency relative to the efficient economic outcome in the absence of transaction costs; that is, externalities create an "inefficiency" when transaction costs are prohibitive for external spillover effects to be internalized.

of city tax assessment records provides data on each plot's value of land, value of building, size, owner name, and occupant characteristics. Tax assessment data provide characteristics for all plots, though a potential concern is whether assessed values accurately reflect market conditions. We collected supplemental data from Boston's Registry of Deeds on plot sales, and show that assessed values align closely with the available sales data in the burned and unburned areas both before and after the Great Fire.

We begin by estimating impacts on plots in the burned area, relative to plots in the unburned area, and then allow the impacts to vary by distance to the burned area. The identification assumption, that areas would have changed similarly in the absence of the Fire, is more plausible over shorter periods of time and so we emphasize results in 1873 (and 1882) relative to 1894 (or later periods). While there are differences between the burned and unburned areas prior to the Fire, contributing to concerns that these areas might have otherwise changed differently over time, we present empirical specifications that control for differential levels and trends in pre-Fire plot-level characteristics. We mainly consider impacts of the Fire on average plot outcomes, supplementing these with quantile regressions to examine changes in the distribution of outcomes predicted by the model. Using data on individual building fires that occurred around this period, drawn from Boston fire department records, we also compare the impacts of individual building fires to the Great Fire.

The striking initial result is that land values increased substantially from 1872 to 1873 in the burned area, relative to the unburned area. These estimates imply economically substantial gains from the opportunity for widespread reconstruction, as individual landowners previously had the opportunity to replace their own building. Land values continued to be higher through 1882 and, consistent with the model, had reversed by 1894 although the identification assumption becomes more demanding in later periods. By focusing on plot-level data within Boston, we analyze the more short-run and medium-run dynamics and the mechanisms generating economic gains from reconstruction. Initial increases in land value reflect the creation of economic value, despite subsequent convergence through the gradual development of other neighborhoods.

Land values also increased immediately in nearby unburned areas, relative to further unburned areas. The nearest unburned areas received an increase in land value similar to the burned area, and the estimated impact declines until leveling at around 1400 feet (approximately 5-6 blocks or 25-35 buildings away). Given that buildings in the burned area had hundreds of other buildings within 1400 feet, it is unsurprising that transaction costs were prohibitive for landowners to internalize spillover impacts. Assuming no impact of the Fire beyond 1400 feet, the implied total impact on land values is comparable to the total value of buildings burned in the Fire. Any increase in land value is consistent with economic gains from the Fire, regardless of whether those gains exceed the direct losses from the Fire, but the value of burned buildings provides a natural benchmark for the economically substantial magnitude of the impacts. We cannot quantify all spillover effects at the city level, which might have positive and negative components, but increased land values imply at least large local gains from the opportunity for urban redevelopment. These relative effects of the Fire, and in particular the substantial cross-plot spillovers, continue to identify rigidities in urban growth. Given our estimation of spatial spillover effects, we also note that the statistical inference is robust to correcting for spatial correlation across plots.

Building values also increased substantially in the burned area, following reconstruction, and converged over time. These impacts were greatest at the lowest quantiles of building values, reflecting replacement of the worst building stock, but building values increased even at the highest quantiles. Seen through the lens of the model, these results suggest that even the most recently constructed (and, therefore, the highest value) buildings were replaced with substantially better buildings, consistent with neighborhood externalities. Likewise, in nearby unburned areas, estimated increases over time in building values are consistent with neighborhood spillover effects moving forward the time of optimal building replacement.

The great extent of the Fire appears central to its impacts, and perhaps the starkest indication of this phenomenon is seen in the comparison between the Great Fire's impacts and the impacts of individual building fires around this period. Building values increased following single building fires, but building values increased by more following the Great Fire. Further, while land values increased following the Great Fire, burned plots' land values were unchanged following an individual building fire. These estimates are again consistent with the Great Fire generating some multiplier effect, whether due to neighborhood externalities or some other mechanism.

The Fire might also generate economic gains through plot assembly, by discouraging hold-up and reducing transaction costs. We estimate only small immediate increases in plot size, however, and these increases are only robust when excluding declines in plot size from road widening. These changes accompanied a small decline in the number of unique landowners in the burned area, implying that large landowners did not buy up plots to coordinate reconstruction on a larger scale. Our interpretation is that the Fire did little to reduce transaction costs among landowners within a 1400 foot radius, either in coordinating land assembly or in coordinating building reconstruction, but instead the Fire temporarily reduced the negative consequences of uncoordinated reconstruction by forcing simultaneous widespread reconstruction.[2] The Appendix reviews these estimates, in addition to exploring

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[2] The continuation of transaction costs, even after the destruction of durable buildings, is consistent with substantial land rigidities in rural areas (Libecap and Lueck, 2011) and following other urban disasters

several additional mechanisms through which the Fire might generate economic gains.[3]

The Fire itself is not a policy proposal, but the Fire's impacts are indicative of underlying economic forces that restrict urban growth.[4] Our main interpretation, emphasizing neighborhood externalities, is consistent with research on neighborhood spillovers from urban revitalization (Rossi-Hansberg, Sarte and Owen, 2010), rent control (Autor, Palmer and Pathak, 2014), home foreclosures (Campbell, Giglio and Pathak, 2011; Mian, Sufi and Trebbi, 2014), and gentrification (Guerrieri, Hartley and Hurst, 2013). Policies might correct these externalities by encouraging large-scale coordinated redevelopment, removing regulatory impediments to redevelopment, subsidizing individual investments with positive spillovers, and/or taxing individual investments with negative spillovers. While various policies have been developed to address similar frictions, including eminent domain, building codes, and zoning regulations, these policies' application may be ineffective or counterproductive (Munch, 1976; Chen and Yeh, 2013; Turner, Haughwout and van der Klaauw, 2014). Widespread destruction in the modern era would not generate economic gains if these spillover effects have been internalized, through regulation or otherwise, but our purpose is to use the Fire to examine these underlying dynamics in urban growth rather than to estimate the general impact of destruction itself.

This historical episode highlights the challenges of maintaining economic growth with increasingly heterogeneous vintages of capital stock, to such a degree that the destruction of durable capital generated substantial economic gains. Positive externalities from capital replacement may be lower in other contexts, due to differences in the economic or policy environment, but these impacts will be salient in contexts with a return to coordinated investment. Our focus on a wealthy and growing urban area extends a literature that has focused largely on the economic impacts of large-scale urban renewal in poor or declining areas.[5] The historical transformation of American cities appears to have occurred despite

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(Ellickson, 2013).

[3] For example, the Fire may have caused changes in the composition of residential and commercial occupants, which generate spillover effects along with changes in building quality. Similarly, the Fire might provide an opportunity for industrial firms to change locations and improve the efficiency of their agglomeration, though we do not find systematic increases in industrial agglomeration. The Fire also created an opportunity to improve public infrastructure in the burned area, though there were only moderate changes in the road network and water pipes.

[4] Indeed, the implied magnitude of economic loss is larger because even widespread reconstruction after the Fire is not predicted to obtain first-best land-use in the presence of neighborhood externalities. The Fire did not decrease cross-building externalities or transaction costs, but temporarily lessened their economic consequences by spurring widespread reconstruction.

[5] In our context, it is the growth process itself, combined with the fixed costs of building replacement, that generates the inefficiencies that are partially alleviated by the opportunity for simultaneous reconstruction. In our model, areas with declining real estate demand would decline further after widespread destruction. Particular functional forms for neighborhood externalities could generate multiple equilibria, however, whereby widespread destruction could generate gains in both declining and growing areas.

the potential for substantially better economic outcomes, to the point that burning a large section of Boston generated substantial economic gains in the 19th century.

# I Historical Background

## I.A Great Fires in the United States

Urban fires were a more common occurrence in the 19th and early 20th century United States than in more recent periods. Dangerous heating and lighting methods led to frequent small fires amongst densely-located fire-prone buildings (Wermiel, 2000). Individual building fires exacted a substantial toll and, constrained only by primitive firefighting technologies, sometimes spread through central business districts completely destroying all buildings in a wide area.

Historians and contemporaries generally describe rapid recovery after major city fires, and even the potential for short-run losses to generate long-run gains (Rosen, 1986). Reconstruction was primarily managed by the private sector, though governments of burned cities considered improvements to public infrastructure. Political obstacles largely prevented the implementation of more ambitious proposals, however, as Rosen (1986) highlights following Great Fires in Boston, Chicago, and Baltimore. Following the San Francisco Fire (and Earthquake), estimates around the burned boundary find increases in residential density (Siodla, 2013) and firm relocation (Siodla, 2014).

## I.B The 1872 Great Fire of Boston

In November 1872, a small fire spread through a large section of Boston's business district, eventually destroying 776 buildings over 65 acres of the downtown Boston area (Figure 1).[6] Boston firefighters were unable to stop the fire before it spread, due partly to sickness amongst the fire department's horses that prevented the rapid deployment of equipment to the burning area (Fire Commission, 1873). The Fire burned for 22 hours, eventually stopping with the arrival of massive firefighting resources from surrounding areas. The Fire killed 20 people and caused approximately $75 million in damages, or 11% of the total assessed value of all Boston real estate and personal property (Frothingham, 1873).

In anticipation of the empirical analysis, a natural question concerns the endogeneity of which plots burned. The Fire began in the south-central part of the burned region and spread out and to the North, toward somewhat more valuable parts of the downtown area. Extensive investigations and hearings following the Fire provide no accounts of the fire department protecting areas differentially, which were all fairly high value at the time (Fire Commission, 1873; Fowler, 1873). Wide roads provided a natural barrier to the fire spreading, though the

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[6] Figure 1 also shows the location of individual land plots in our main sample, which we discuss below.

Fire sometimes crossed wide roads and sometimes ended within a block.[7] In practice, the empirical analysis will include controls for pre-Fire plot outcomes that allow for differential changes over subsequent periods.

In anticipation of the theoretical framework, we note that the Fire occurred following a period of growth in Boston real estate values (Appendix Figure 1). Boston real estate values declined in real terms later in the 1870's, during the national "Long Depression," but subsequently resumed their upward growth.[8]

The Fire prompted substantial inflows of private sector capital to fund reconstruction, given the strong demand for real estate investment in Boston. Boston capital markets were well-integrated at this time, both domestically and internationally, so we assume perfect capital markets in the model. Insurance payouts also partly funded reconstruction.[9] Insurance payouts should not impact optimal land-use in the presence of perfect capital markets, though we do explore in the empirical analysis whether landowners disproportionately exited the burned area.[10]

Individual landowners retained their land rights after the Fire, and reconstruction was largely managed privately. Although the weeks immediately after the Fire saw calls for government action to coordinate reconstruction, the ultimate role of the city government in post-fire reconstruction was limited. The city purchased some land to widen and extend downtown roads, though landowners' opposition stopped more-ambitious proposals to modify the road network. Similarly, calls for a strong building code were undermined, and the ultimate legislation was weak and substantially rescinded in 1873 (Rosen, 1986).

Newspapers and other contemporaries noted that buildings in the burned area were often better after reconstruction. On the one year anniversary of the Fire, the *Evening Transcript* concluded that the "improved aspect of the entire district shows that occurrences calamitous in their first effects sometimes result in important material good" (Rosen, 1986). Technological constraints precluded the reconstruction of taller buildings, and there had been no substantial recent changes in construction technologies, but buildings could be improved along more subtle dimensions (Rosen, 1986).[11]

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[7] We do not observe systematic differences in 1872 in land value and building value across the Fire boundary, using our data and restricting the sample to plots within 100 feet of the Fire boundary.

[8] We convert valuations to constant 1872 dollars using the David-Solar CPI (Lindert and Sutch, 2006).

[9] Insurance covered three-fourths of total fire damages, though many insurance companies were bankrupted by the Fire and payouts were roughly half of total damages (Fowler, 1873).

[10] In practice, some landowners may have been liquidity-constrained after the fire destroyed their property and the collateral needed to raise more capital. We would have been interested in testing this hypothesis more fully, though we have been unable to link particular plots to their insurance underwriter and the fraction paid out on the insurance policies.

[11] Qualitative accounts also include descriptions of the Fire encouraging the assembly of land into larger plots (Rosen, 1986).

Even substantial upgrading of buildings need not imply any economic gains from the Fire, however, and we formalize this intuition below in our benchmark model. We then present an extended model with neighborhood externalities, which highlights how the Fire might indeed result in important material good.

## II Dynamic Model of Urban Growth

### II.A Benchmark Model with Durable Buildings

Our benchmark model clarifies conditions under which the Fire may only *appear* to generate economic benefits. We consider the decisions of landowners choosing when to replace their building, but who experience no spillover impacts from nearby plots. This benchmark model formalizes our null hypothesis, in which the Fire does not generate any economic benefits. The benchmark model and the extended model yield dynamics similar to one-sided s-S models of price-setting and vintage capital replacement, and generate a number of testable predictions that we take to the data.

We assume that each landowner owns one plot, and that all landowners and plots are homogeneous. Landowners construct a sequence of durable buildings to maximize the net present value of rents from their plot, which are assumed to depend solely on the quality of their building ($q$) and the city's overall productivity ($\omega_t$). In each period, a building of physical quality $q$ generates rent of $r(q, \omega_t)$. In particular, we assume that the marginal return to building quality is increasing in city productivity: $\partial^2 r(q, \omega_t)/\partial q \partial \omega_t > 0$. We adopt a broad view of city productivity, which simply reflects aggregate market conditions that influence building rents.

We focus on the case in which city productivity is growing over time, which increases the return to building quality and encourages landowners to construct higher quality buildings. The predicted impacts of a Great Fire would differ in a city with declining productivity.[12]

For clarity, we assume that landowners may only completely replace their old building with a new building of quality $q'$ by paying a convex cost $c(q')$.[13] In particular, we assume that buildings cannot be renovated and that buildings do not depreciate. These two assumptions make the model's predictions more apparent, but do not qualitatively change the predictions.[14] As a matter of notation, we assume that building construction is instan-

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[12] Notably, the failure of declining cities to recover after disasters is not inconsistent with our predictions; indeed, we would predict that widespread destruction would hasten the decline of cities otherwise declining. Only in cities in which developers believe that returns to real estate investment will rise in the future would we predict that destruction generates increased building quality.

[13] The assumption of convex costs guarantees an interior solution.

[14] The model's qualitative predictions are robust to the introduction of building depreciation or partial renovation, as long as the cost of renovating to the optimal quality ultimately becomes greater than the costs of constructing a new building of the desired quality.

taneous.[15] We also assume there are no demolition costs.[16]

Building construction is a forward-looking dynamic optimization problem, in which each landowner considers the optimal time to replace a building. Landowners do not replace a building when it would generate higher static rents; rather, landowners solve for the optimal replacement policy incorporating the option value of retaining antiquated but still profitable buildings. This intuition is captured by the following Bellman equation, which reflects the landowner's value of owning a building of quality $q$ when the city has productivity $\omega_t$ (and includes the option to rebuild):

$$V(q,\omega) = \max \begin{cases} r(q,\omega) \ + \delta \mathbb{E}\left[V(q,\omega')\right] \\ r(q^*,\omega) + \delta \mathbb{E}\left[V(q^*,\omega')\right] - c(q^*) \end{cases}$$

where $q^*$ maximizes $r(q,\omega_t) + \delta \mathbb{E}\left[V(q,\omega')\right] - c(q)$. That is, $q^*$ represents the optimal quality building to construct if the landowner chooses to construct a new building. Buildings face a probability $d$ of experiencing an idiosyncratic fire that forces their owners to rebuild completely in the next period. Owners' expectations of future valuations are thus

$$\mathbb{E}\left[V(q,\omega')\right] = (1-d)\, V(q,\omega') + d \cdot V(0,\omega')$$

with $q = q^*$ if the building has been reconstructed that period.

The landowner faces a tradeoff between two choices: (1) receiving rent $r(q,\omega_t)$ and continuing with the old building of quality $q$; and (2) paying a lump sum cost $c(q^*)$ to construct a higher-quality building, receiving higher rents, and continuing with the new building of quality $q^*$. The random destruction of buildings, with some probability $d$, provides a mechanism to consider the impacts of an individual building fire. Notably, in this case of exogenous building destruction between periods, the landowner will choose to rebuild in the next period at quality $q^*$.

Landowners' optimal construction decisions involve periods of no activity and occasional quality upgrades, consistent with the equilibrium in one-sided s-S models. Given that city productivity is increasing, landowners over-build for contemporaneous conditions and then wait for city productivity to increase before replacing their then-obsolete building. To illustrate the equilibrium building growth paths, we assume $r(q,\omega)$ takes the Cobb-Douglas form $q^\alpha \omega^\beta$ $(\alpha \geq 0,\ \beta \geq 0,\ \alpha + \beta \leq 1)$, with $c(q) = cq^\gamma$ $(c > 0,\ \gamma > 1)$.[17] We generate a sample

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[15] Equivalently, foregone rents could be included in the cost of construction.

[16] Demolition costs could be included in the cost of construction, as a fixed cost component. Fire might reduce some portion of demolition costs, but these costs then become sunk and do not influence subsequent construction decisions or become capitalized into building value or land value.

[17] In our quantitative simulations we set $\delta = 0.9$, $\alpha = \beta = .5$, $\gamma = 2$, and $c = 5$. The probability of

of 3000 buildings and simulate the model until it reaches steady-state, i.e., until the growth rate of the distribution of buildings stabilizes.

Figure 2, Panel A, graphs the steady-state evolution of the building distribution. The thick central line shows the mean of log building quality, which grows at a constant rate in steady state driven by the constant growth in city productivity. There are discrete jumps, however, in the growth paths of individual buildings. Newly constructed buildings are the highest quality buildings for one period, before being surpassed by more-recently constructed buildings. The upper thin line denotes the maximum of log building quality in steady state, which reflects the optimal building to construct when constructing a new building in that period (whether by choice or because the building was exogenously destroyed).[18] Surviving buildings are endogenously replaced once city productivity increases sufficiently, and this minimum threshold in log building quality is represented by the lower thin line.

One example building growth path, shown as a dashed line in Panel A, reflects periods of endogenous reconstruction and exogenous destruction. In period 0, the building is exogenously destroyed and is reconstructed at a higher quality level. The building remains at this quality level as city productivity grows, until in period 42 the landowner finds it optimal to finally tear down the building and replace it with a substantially higher quality building. This building happens to be exogenously destroyed a few periods later, and is rebuilt to only slightly higher quality.

Figure 2, Panel B, graphs the steady-state evolution of the building distribution for a city that experiences a "Great Fire" in period 0 that destroys half of the buildings. Outcomes for the burned buildings are shown using dashed lines, and outcomes for the unburned buildings are shown using solid lines. The Fire induces all landowners in the burned area to reconstruct their building at the current optimal quality, which raises average building quality. Further, the Fire compresses the distribution of building qualities in the burned area around the maximum: burned buildings are rebuilt to the same quality as newly reconstructed buildings in unburned areas, such that there is no impact at the highest quantiles of the distribution of building values.[19] The Fire's impacts on building quality are greatest toward the bottom of the distribution, where the entire stock of older buildings is cleared out.

In this benchmark model, the Fire does not affect landowners in unburned areas. Over time, landowners in unburned areas choose to replace their buildings and landowners in the burned area delay further replacement, such that the distributions of building quality

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exogenous destruction ($d$) is set to 0.01, and the growth rate is set to 0.06.

[18] Note that the optimal new building is "over-built," as its quality is higher than the optimal quality if there were no expected future growth in city productivity.

[19] We assume the Fire does not directly raise construction costs temporarily, which might otherwise impact reconstructed building values or delay reconstruction.

converge. Notably, convergence is slower for the bottom of the distributions. As a result, the average quality of unburned buildings will surpass the average quality of rebuilt burned buildings for some periods and then oscillate until random building destruction induces long-run convergence.[20]

While the burned area might appear more-developed shortly after the Fire, there are no economic gains from the Fire in this benchmark model. All landowners could choose to replace their buildings in period 0 in the absence of the Fire, but the large majority of landowners instead prefer to postpone reconstruction. There would be economic gains from forcing individual landowners to reconstruct buildings if there were positive externalities from reconstruction, however, which we explore in the next section.

This benchmark model yields five main testable predictions. First, the Fire does not increase plot land values, which reflect the option value from each land plot, $V(0, \omega_t)$. Second, the Fire increases average building values in the burned area, following reconstruction, which then converge to average building values in unburned areas. Third, the Fire's impact on building values is decreasing in the quantile of building value, and is zero at the highest quantiles. Fourth, the Fire has the same impact on building values as individual building fires. Fifth, building values and land values are unaffected in unburned areas.

### II.B Extended Model with Neighborhood Externalities

We now extend the benchmark model, allowing for building rents to increase in the quality of nearby buildings. These spillover effects generate externalities, given assumptions that land ownership is fractured and transaction costs are prohibitive to coordinate construction decisions. In this extended model, the Fire generates economic gains that may partially or fully offset the direct losses from destruction.

Consider a modified building rent function of $r(q, Q, \omega_t)$, where $Q$ is a vector of nearby buildings' qualities with mean $\bar{Q}$. We assume that the number of surrounding buildings is sufficiently large that landowners take $Q$ as given, such that neighborhood spillovers represent a pure externality. In particular, higher building quality generates positive externalities, as building rents are increasing in the quality of nearby buildings $(\partial r(q, Q, w_t)/\partial \bar{Q} > 0)$. Further, the return to building quality is increasing in the quality of nearby buildings $(\partial^2 r(q, Q, w_t)/\partial q \partial \bar{Q} > 0)$.[21] We can adopt a broad view of "neighborhood quality," and the channels through which building rent is impacted by nearby plots. We have no strong prior

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[20] The model generates a sharp reversal, as landowners in the burned area choose to replace a large number of surviving buildings reconstructed after the Fire, though this dynamic would be smoother with some random shocks to the incentives for reconstruction.

[21] The first assumption causes widespread reconstruction to generate economic gains for landowners, whereas the second assumption generates a multiplier effect in which simultaneous reconstruction encourages even higher-quality reconstruction of burned buildings (and nearby unburned buildings).

regarding which buildings are sufficiently "nearby" to influence building rents, but make an assumption for the numerical simulation below and later estimate these spillover effects.

The landowner's value of owning a building of quality $q$ when the city has productivity $\omega_t$ is now given by:

$$V\left(q, Q, \omega_t\right) = max \begin{cases} r\left(q, Q, \omega_t\right) \;\; + \delta\mathbb{E}\left[V\left(q, Q', p'\right)\right] \\ r\left(q^*, Q, \omega_t\right) + \delta\mathbb{E}\left[V\left(q^*, Q', p'\right)\right] - c\left(q^*\right) \end{cases}$$

where $q^*$ maximizes $r\left(q, Q, \omega_t\right) + \delta\mathbb{E}\left[V\left(q, Q', p'\right)\right] - c\left(q\right)$ and the vector $Q$ reflects the building quality decisions of nearby landowners.

An individual building fire continues to have the same impacts as in the benchmark model. Following an individual building fire, with no change to the quality of nearby buildings, the burned building is reconstructed to quality $q^*$.[22]

The Great Fire, however, creates a positive multiplier effect because owners of burned properties take into consideration the simultaneous construction of many surrounding higher-quality buildings. This encourages even higher building qualities due to the assumption of complementarity, and higher overall rents due to the assumption of positive neighborhood spillovers. In nearby unburned areas, landowners benefit from higher building qualities in the burned area and some landowners choose to upgrade buildings earlier. Over time, landowners in further unburned areas also choose to reconstruct their buildings sooner and to a higher quality level due to increases in nearby buildings' quality. In this manner, the impacts of a Great Fire spread through the city.

Landowners' construction decisions are not efficient after the Fire, as the spillover effects are still not internalized by landowners, but the Fire temporarily reduces the inefficiency. Prior to the Fire, there is a disperse distribution of building qualities that includes some older, low-quality buildings. Since landowners consider the whole distribution of neighbors when reconstructing properties, new buildings are lower quality than if all other buildings were also replaced. The Fire transforms this sequential game into a simultaneous game, and in a growing city landowners construct buildings of yet higher quality.

We focus on a single equilibrium case, in which decreasing returns to quality cause the Fire's impacts to fade over time as city productivity increases and all buildings are replaced. Indeed, in some later periods, burned areas are relatively disadvantaged because of the large concentration of then-obsolete buildings constructed in the immediate aftermath of the Fire.

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[22] We assume that one building makes a trivial contribution to the overall vector of neighborhood buildings. In principle, the earlier-than-expected reconstruction of that one burned building has some small unexpected benefit to nearby landowners and encourages them to reconstruct their buildings sooner. This small increase in the expected future quality of neighboring buildings would encourage the burned building to be rebuilt to slightly higher quality.

By contrast, for other particular functional forms of neighborhood spillovers, the Fire could have persistent impacts due to multiple equilibria.

To illustrate the effects of the Fire, we extend the numerical simulation to include neighborhood spillover effects. We modify the rent function, dividing the productivity term into the effect of city-wide productivity ($\omega_t$) and the impact of neighborhood building quality ($Q$) : $r(q, Q, \omega) = q^{\alpha}(Q^{\eta}\omega^{1-\eta})^{\beta}$.[23] We assume that the average quality of neighboring buildings summarizes the spillover effects from neighbors: if building $i$ has $N$ neighbors, $Q_i = \left(\sum_{n=1}^{N} q_n\right)/N$. Otherwise, the simulation is the same as for the benchmark model. In the steady state, there is a constant rate of growth in neighborhood productivity ($Q^{\eta}\omega^{1-\eta}$).[24]

Figure 3, Panel A, shows the changes in building quality after a Great Fire for burned buildings whose "nearby" buildings all burn. Dashed lines show changes for the burned plots, and solid lines represent changes had there been no Fire. The presence of value spillovers creates a multiplier effect from simultaneous reconstruction that causes buildings' quality in the burned area to rise temporarily above that of the best buildings had there been no Fire. The Fire's impacts are again greatest toward the bottom of the distribution but, in contrast to the baseline model, continue to positively impact values at even the highest quantiles. Note that these effects would not apply to an individual building fire, where the milder predictions of the baseline model continue to hold. Over time, as in the benchmark model, building quality converges with oscillation to the same steady state had there been no Fire.

The Fire now affects landowners in unburned areas that are close enough to the Fire to experience changes in $Q$ due to post-Fire reconstruction. Figure 3, Panel B, shows the growth path for unburned areas for whom half of their "nearby" buildings burned, and the solid lines continue to represent changes had there been no Fire.[25] The Fire causes landowners in nearby unburned areas to upgrade their buildings sooner, due to reconstructed higher-quality buildings in the burned area.[26] These geographic spillover effects within the city complicate an analysis of the Fire's aggregate impacts, as even the comparison group is affected by the treatment, and we return to this issue in the empirical analysis.

Predicted impacts on land values are of particular interest. In the model, a natural

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[23] In our simulation, we set $\eta = 0.8$ (and continue to set $\alpha = \beta = 0.5$).

[24] One technical challenge concerns owners' beliefs about the transitional dynamics immediately after the Fire. For simplicity, we assume that owners expect productivity and neighboring building quality to grow at the same rate after the Fire as prior to the Fire. These beliefs are correct in the long-run, and the main numerical results are not sensitive to alternative beliefs during this period of transition. In particular, model predictions are qualitatively robust to the opposite, and overly pessimistic, assumption that neighboring building quality will cease to grow entirely after the Fire.

[25] In particular, we simulate a nearby unburned area in which plots receive 1/2 the $\bar{Q}$ spillovers of plots with all burned neighbors.

[26] In practice, if the Fire were to temporarily raise construction costs, then we might expect reconstruction of nearby unburned buildings to be delayed until after the burned area is reconstructed.

definition of land value is the option value from owning a plot with no building: $V(0, w_t)$.[27] There is no distribution of land values because plots are homogeneous, so we show changes in the value of land for each plot. Figure 4 shows the value of land in the benchmark model where the Fire has no impact on land value (lower black line). For the extended model with neighborhood spillovers, the upper red line shows increased land values in the burned area. The middle blue line shows smaller increases in land value for nearby unburned areas receiving spillovers from neighboring burned areas as described above.

The extended model with neighborhood externalities yields seven main testable predictions, of which five differ from predictions of the benchmark model. First, the Fire increases plot land values in the burned area and land values converge over time, perhaps even falling below land values in unburned areas. Second, the Fire increases land values in nearby unburned areas. Third, as in the benchmark model, the Fire increases average building values in the burned area, following reconstruction, which then converge to average building values in unburned areas. Fourth, the Fire's impact on building values is decreasing in the quantile of building value, as in the benchmark model, but there are temporary impacts at the highest quantiles. Fifth, the Fire increases building values in nearby unburned areas. Sixth, the Fire has a greater impact on building values than individual building fires. Seventh, as in the benchmark model, individual building fires have no impact on land values.

### II.C Additional Potential Mechanisms

There are several additional channels through which a Great Fire might impact urban growth. We discuss some of these channels below, and present some empirical analysis of these channels in the Appendix.

*Land Assembly and Ownership Concentration.* We have assumed that post-Fire redevelopment occurs within fixed land plots, though the Fire might have impacts through land assembly. Land assembly, or the combination of plots, allows the construction of larger buildings and might create more value per-unit of land when there are otherwise rigidities preventing land assembly (see, e.g., Brooks and Lutz, 2012).

There are two main reasons why the Fire might increase plot sizes in the burned area. First, the Fire might reduce transaction costs resulting from hold-up or other aspects of bargaining between plot buyers and sellers.[28] Second, local heterogeneity in building quality

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[27] Note that this value equals the value of owning a building of quality $\underline{q}$ that would be chosen for replacement (i.e., a "tear down" building): $V(0, w_t) = V(\underline{q}, w_t)$.

[28] The bargaining power of some landowners may decline after a fire: their outside option has worsened because they cannot live in the building or continue to operate a business without substantial reconstruction costs, and some may lack liquidity and become impatient (e.g., if they are less-wealthy or less-diversified). The Fire also reduces imperfect information about the value of burned plots, as there is no uncertainty regarding building value.

may discourage otherwise profitable plot consolidation even within a single owner's neighboring holdings.[29] By destroying all buildings in an area, the Fire coordinates the timing of new construction and lowers the cost of land assembly. The Fire might also concentrate land ownership, thereby improving the coordination of urban development.

*Business Agglomeration.* The Fire may also impact urban development by improving the efficiency of firms' location decisions. Whereas firms generally make sequential location decisions, the Fire may allow firms to move simultaneously into a more-productive spatial distribution. Firms have many reasons to locate near similar firms or firms producing inputs or complementary goods.[30] The size and location of industrial clusters may drift from the optimum over time, however, as the city develops and new technologies are introduced. The Fire might increase industrial agglomeration, or otherwise improve the efficiency of firm locations, by reducing moving costs and improving cross-firm coordination.

*Occupant Sorting.* Similarly, the Fire might impact residential or industrial sorting along with replacement of the building capital stock (see, e.g., Brueckner and Rosenthal, 2009). If occupant characteristics generate spillover effects, and occupants' location is fairly persistent, then these spillover effects could become capitalized into land values and influence land-use. In general, if occupant characteristics are correlated with building characteristics then we would consider building spillover effects to come from some potential combination of the two. Changes in occupant characteristics provide an additional mechanism through which building reconstruction generates spillover effects.

*Infrastructure Investment.* The Fire may create a unique opportunity for improvements in roads and other infrastructure. First, the absence of buildings lowers the costs of land acquisition and construction. Second, post-disaster solidarity may strengthen political will for public goods improvements.

## III Data Construction

### III.A Annual Tax Assessment Records

Historically, the City of Boston sent tax assessors to each building to collect information for annual real estate and personal property taxes. The Boston Archives contain these handwritten ledgers from 1822 to 1944, typed records until 1974, and then digitized data.

Tax assessors recorded information for each building unit, each commercial establishment, and each residential occupant. For each building unit, data include: street name and number, assessed value of the building, assessed value of the land, plot size, and name of

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[29] When reconstructing an older building, the nearby newer buildings may be prohibitively costly to tear down early to build one larger building.

[30] Optimal industry locations can reduce transportation costs, attract customers interested in cross-shopping, signal competitive prices, allow monitoring of competitors, or encourage learning.

the building owner. For each commercial occupant, data include: detailed industry, value of business capital, and proprietor name. For each residential occupant, data include the value of personal possessions and the name and occupation of all males aged 20 or older. We collected all of these variables, aside from commercial proprietors' names and residential occupants names and occupation.[31] We digitized data for 1867, 1872, 1873, 1882, and 1894, covering all plots in the area burned during the 1872 Fire (which occurred after that year's tax assessment) and all plots in surrounding downtown areas.[32]

### III.B Plot-Level City Maps

The assessment data contain addresses, but these addresses do not directly provide plots' geographical proximity to the Fire. We generated this measure by plotting each assessment entry on high resolution scans of the plot-level Sanborn and Bromely fire insurance maps of Boston in 1867, 1873, 1883, and 1895 (Sanborn Map Company, 1867-1895; G.W. Bromley and Co, 1883). These maps indicate the location of each building and its street address (Appendix Figure 2), and often indicate the plot's square footage and owner name, which were used in matching the assessed plots to their geographic location. We georeferenced these historical maps to a contemporary digital map of Boston, defining each map in geographic space. Figure 1 maps the location of digitized land plots in 1867, and we limit the sample to land plots in this same region in each subsequent year (Appendix Figure 3). There are 31,000 land plots in our main sample, pooling across all five years.[33]

The empirical analysis benefits in a number of ways from assigning the geographic location of each plot. First, we can calculate whether each plot is in the burned area and its distance from the burned area. Second, we can effectively analyze a panel dataset of fixed geographic locations despite potential changes over time in street addresses and plot boundaries. Third, we can match plots to their pre-Fire outcomes by city block or match plots to their nearest corresponding plot prior to the Fire, which allows the empirical specifications to control for differential changes associated with pre-Fire differences. Fourth, and similarly, we can

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[31] We collected commercial proprietors' industry, but did not collect residents' occupation because the land itself is used for housing and our analysis is focused on land-use. We also did not collect the names of commercial proprietors and residential occupants, as we would not be able to track individuals moving in/out of the neighborhoods analyzed and names are relatively costly to digitize.

[32] Through selective double-entry and back-checks, we have found initial entry and data cleaning to produce highly accurate data. Tax assessors totaled the numeric data at the bottom of each page (capital, possessions, land value, building value, plot size), which was used to validate the sum of entered data. The data include what are now the West End, North End, Financial District, Downtown Crossing, Leather District, Chinatown, and Fort Point. The data exclude more residential areas in what are now the South End, Back Bay, and Beacon Hill.

[33] We exclude wharfs, which are incompatible with the model in that the land area itself is endogenous. The estimated impacts on land and building value are similar, or somewhat higher, when including plots from wharfs.

calculate each plot's distance to the Old State House, as a proxy for the center of the central business district, and control for differential changes associated with this distance. Indeed, in principle, we could control for plots' distance to any other feature of downtown Boston that is not collinear with the burned area. Fifth, we can use plots' locations in adjusting for spatial correlation in the error term.

Once the debate over street widening had been resolved, the City of Boston produced a detailed map of the burned area that shows the plot-level outline of the fire and the area of land to be taken from all plots affected by road widening or the creation of Post Office Square (Appendix Figure 4). As with the fire insurance maps, we georeferenced images of this map to create a GIS polygon of the burned area and flagged all plots that lost area due to road widening.

### III.C Validity of Tax Assessment Records

A concern with tax assessment data is whether assessed values accurately reflect economic conditions. Assessors were instructed to assign market values to land and buildings, separately, and then also provide the total value. At that time, as in the modern period, properties were first assessed and then the tax rate was chosen to obtain the level of tax revenue targeted by the Boston City government (Fowler, 1873). Tax assessment ledger notes contain some references to disputed property valuations and sales valuations of that building or comparable units.

We collected supplemental data, from Boston's Registry of Deeds, to test the relationship between assessed values and the available data on property sales. We searched our assessment database for cases in which plots had changed owner names between 1867 and 1894, but retained the same street address and area in square feet. We then searched Boston's Registry of Deeds to confirm that a property sale had taken place, and obtained the sale price from the property's original deed of sale. This search yielded 72 preserved deeds for property sales outside the burned area and 16 property sales inside the burned area.

Appendix Figure 5 shows the relationship between properties' assessed value and sales value, along with the 45-degree line. Assessed values align closely with the available sales data in the burned and unburned areas, both before and after the Fire. Appendix Table 1 reports the average difference between assessed values and sales values, broken out by before and after the Fire in the burned and unburned areas. The estimated difference-in-difference estimate is small and statistically insignificant, although imprecisely estimated due to the small sample. Indeed, a main advantage of the tax assessment data is in providing valuations for all plots, both increasing power and avoiding selection bias in which plots are sold.

A remaining concern is whether assessed values and sales values are only aligned for properties that have been sold. The assessed values are from the period before the sales values, and so there is no mechanical effect whereby assessors would have used the sale of that particular plot in its assessment. Further, we can compare the assessed values of sold plots to the assessed values of other nearby plots to measure whether sold plots are systematically different. We do not observe a difference, on average, between the assessed land values of these sold plots and the assessed land values of unsold plots within the same city block and year.[34]

Another concern is whether assessors effectively provided separate valuations of land and buildings. The tax assessment ledgers contain some margin notes that indicate land assessments being calculated by multiplying plot size by an indicated value per-foot. Note, however, that the same per-foot valuation is not mechanically applied to all nearby plots (e.g., due to differences in street access and side of block). Assessors then appear to add an assessment of the building's value to obtain the recorded total value, and there exists much heterogeneity in the fraction of total value assigned to buildings.

There is generally no assessed land value premium for vacant plots, which suggests that tax assessors effectively separate plots' land value and building value.[35] Further, the empirical analysis will show impacts on land values in nearby unburned areas that are not vacant after the Great Fire. Assessors thus appear to effectively separate building value and land value, consistent with their instructions, margin notes, and the great variation in the fraction of total assessed value that is assigned to buildings.[36]

In our discussion of the empirical results, we will explore ways in which the results may or may not be consistent with potential biases from the use of tax assessment data.

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[34] In particular, we regress each plot's log assessed land value per square foot on a dummy variable for whether that plot was sold (i.e., included in our comparison of sold and assessed values) and block-by-year fixed effects. The estimated coefficient is -0.045 with a block-clustered standard error of 0.037. Perhaps not surprisingly, log building value per square foot is marginally higher for sold plots (coefficient of 0.131 with a block-clustered standard error of 0.072), since the sale of buildings might be associated with the upgrading of building structures or sold structures might otherwise be selected relative to nearby unsold structures. Land values provide the better test of comparability of assessment between sold and unsold plots, as land values are less likely to be associated directly with ownership changes.

[35] We do not estimate a substantial or statistically significant difference in the log value of land per square foot for vacant plots, compared to non-vacant plots within 100 feet.

[36] On average, building value makes up 37% of the combined value of buildings and land. In considering variation across plots in the fraction of total value assigned to buildings, the standard deviation across all plots and years is 19 percentage points. Conditional on block-by-year effects, which explain 49% of the variation in the fraction of total plot value assigned to the building, the standard deviation across plot residuals is 13 percentage points. Thus, even within a block and year, there remains substantial variation in the fraction of total assessed value that is assigned to a plot's building or land.

### III.D Individual Building Fires

We have also obtained a sample of individual building fires, drawing on archived records of the Boston Fire Department. These records contain the address of every fire to which the department responded, as well as the owner of the building and an estimate of damages. We digitized these records, from 1866 to 1891, and merged them to our georeferenced tax assessment data. Using tax assessment data, we can then estimate impacts of idiosyncratic building fires on building values and land values, and compare these estimates to the impacts of the Great Fire.

Our goal is to obtain a sample of idiosyncratic fires that completely destroyed the building, comparable to damage in the Great Fire. Fire Department records do not consistently note the level of destruction, however, so we focus on fires with building damages greater than \$5000 or those with less damage for which the record specifically mentions that the building was "totally destroyed." This procedure naturally skews our sample toward more-valuable buildings, but we use our tax assessment data to control for these buildings' characteristics prior to their idiosyncratic fire. We impose two further conditions to highlight the comparison between individual fires and the Great Fire. First, we exclude single building fires that occurred within the burned area after the Great Fire. Second, we exclude all fires that are noted as having been caused by arson or were suspected to be arson. Our remaining sample contains 109 major single building fires to compare with the Great Fire.

## IV Empirical Methodology

The main empirical analysis compares changes in the burned area to changes in unburned areas, and then separates the analysis by distance to the Fire boundary. Our data cover all land plots in the sample region in each sample year, but one technical issue is that there exists no direct link between every plot and its corresponding plot in other years. We circumvent this problem by estimating changes in fixed geographic areas, using information on the exact location of each plot.

Our initial empirical specification estimates differences between the burned area and the unburned area in each year, relative to differences between the burned area and the unburned area in 1872. We regress outcome $Y$ for plot $i$ in year $t$ on year fixed effects ($\alpha_t$), an indicator variable for whether the plot is within the burned area ($\mathbb{I}_i^{Fire}$), and interactions between the burned area indicator variable and indicators for each year (other than 1872):

$$\begin{aligned} (1) \qquad Y_{it} = \alpha_t \;&+\; \rho\mathbb{I}_i^{Fire} + \beta_{1867}\mathbb{I}_i^{Fire} \times \mathbb{I}_t^{1867} \\ &+\; \beta_{1873}\mathbb{I}_i^{Fire} \times \mathbb{I}_t^{1873} + \beta_{1882}\mathbb{I}_i^{Fire} \times \mathbb{I}_t^{1882} + \beta_{1894}\mathbb{I}_i^{Fire} \times \mathbb{I}_t^{1894} + \varepsilon_{it}. \end{aligned}$$

The estimated coefficient $\beta_{1873}$ reports the change from 1872 to 1873 in the burned area, relative to the change in unburned areas. The identification assumption is that plots in the burned area would have changed the same as plots in the unburned area, on average, in the absence of the Fire. This identification assumption is quantitatively more plausible over shorter periods of time, and becomes more demanding over long periods of time after the Fire. In practice, we relax the identification assumption by including additional controls that may be associated with differential changes, though estimates from later periods should still be interpreted with caution.

In our main specifications, we control for differential changes associated with plots' outcome prior to the Fire. While we cannot match each plot in later years to its own characteristics prior to the Fire, we can predict with great accuracy that plot's pre-Fire characteristics based on its precise geographic location. As a first approximation, we assign each plot the average pre-Fire values over all plots within its same fixed city block in 1867 and 1872. As a closer approximation, we assign each plot the characteristics of the nearest plot in 1867 and 1872. In practice, this "nearest neighbor" is very often that same plot in the earlier years.[37] We estimate a final specification including controls for both the nearest plot's value and the mean block value, as both may be independently predictive. That full empirical specification is similar to Equation 1, but includes interactions between year fixed effects and plot $i$'s predicted outcome from 1867 and 1872 based on its block average ($\bar{Y}^{block}_{i1867}$ and $\bar{Y}^{block}_{i1872}$) and based on its nearest neighbor ($\bar{Y}^{near}_{i1867}$ and $\bar{Y}^{near}_{i1872}$):[38]

$$\begin{aligned} (2) \qquad Y_{it} = \alpha_t \quad &+ \quad \eta_t \bar{Y}^{block}_{i1867} + \gamma_t \bar{Y}^{block}_{i1872} + \mu_t \bar{Y}^{near}_{i1867} + \kappa_t \bar{Y}^{near}_{i1872} \\ &+ \quad \beta_{1873} \mathbb{I}^{Fire}_i \times \mathbb{I}^{1873}_t + \beta_{1882} \mathbb{I}^{Fire}_i \times \mathbb{I}^{1882}_t + \beta_{1894} \mathbb{I}^{Fire}_i \times \mathbb{I}^{1894}_t + \varepsilon_{it}. \end{aligned}$$

The estimated coefficient $\beta_{1873}$ continues to report the relative change in the burned area from 1872 to 1873, but adjusting for the possibility that initially-different plots might have changed differently, over each time interval, even in the absence of the Fire. Our main specifications control for pre-Fire values of the outcome variable $Y$, which appears to summarize the relevant cross-sectional variation that predicts differential changes in that outcome variable. For example, later robustness checks show little additional predictive power from including additional year-interacted controls for distance to the Old State House, which land value data confirm is a marker of the historical center of the central business district.

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[37] For the few cases in which the closest plot has missing or zero values, such as if the building was under construction, we substitute data from the closest plot with non-zero values. In a few cases when the block-level building value average is zero (e.g., due to construction), we set the log value equal to zero and include an indicator variable for those plots.

[38] Note that the inclusion of nearest neighbor controls in 1867 and 1872 absorbs the "main effect" of the Fire ($\rho \mathbb{I}^{Fire}_i$) and the relative change from 1867 to 1872 ($\beta_{1867} \mathbb{I}^{Fire}_i \times \mathbb{I}^{1867}_t$).

For some specifications, we restrict the main sample of 31,000 plots to the 11,000 plots that are within 1000 feet of the burned area or were themselves burned. This focuses the empirical analysis on initially more-similar areas. There are important limitations in focusing on areas near the boundary of the burned area, however, as nearby unburned areas may be indirectly affected by the Fire. Indeed, the extended model predicts that nearby unburned areas would be affected by the Fire. These spillover effects would bias downward estimates of changes in the burned area from estimating the above specifications, and this bias is exacerbated by focusing on areas closer to the burned boundary.

Spillover effects from the burned area are of direct interest, and we also examine how proximity to the burned boundary impacts unburned areas. We begin with a nonparametric estimate of relative changes by distance to the burned boundary, and then parameterize this relationship. While we are unable to estimate aggregate city-wide impacts, given some potential impact on all plots, we can observe whether the spatial spillover effect appears to dissipate within some observed distance from the burned boundary.

Two additional empirical details are worth noting. First, the main regressions are weighted by plot size. Consider the case in which two smaller plots combine into one: the one plot continues to report land value for the same area covered by two plots previously, and weighting the analysis by plot size ensures this fixed geographic area is handled comparably over time.[39] Second, the standard errors are clustered by block to adjust for serial correlation and within-block spatial correlation. We also explore estimating Conley standard errors, which allow for more continuous spatial correlation within periods. We introduce additional empirical specifications and details as they are used.

## V Summary Statistics and Baseline Differences in the Burned Area

Table 1 reports summary statistics for plots' land value and building value prior to the Fire.[40] On average, in 1872, plots in the burned area were higher value (column 1) than in the unburned area (column 2). Column 3 reports this estimated difference, in logs, and indeed the overall cross-sectional differences in 1872 are substantial and statistically significant. Plot values had changed more similarly from 1867 to 1872, however, in the burned and unburned areas (column 4). Land value declined from 1867 to 1872, on average, for plots in the burned area relative to plots in the unburned area (at an annual rate of 3.2%).

The empirical methodology focuses on comparing changes after 1872 in the burned area, relative to changes in the unburned area. This research design avoids bias from fixed differ-

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[39] Otherwise, areas experiencing plot consolidation would mechanically receive less weight and there would be a shift in the composition of the area analyzed. In addition, weighting by plot size recovers the average effect per square foot, which is used in calculating the total impact in the burned area.

[40] Plot values per square foot are weighted by plot size to align exactly with the subsequent empirical analysis.

ences in the burned and unburned areas, though it is still a concern that initial cross-sectional differences might predict differential changes after 1872. For this reason, we focus on empirical specifications that control for differential changes associated with plots' pre-Fire outcome values in 1867 and 1872. Controlling for plot-level outcomes in both 1867 and 1872 adjusts for pre-Fire differences both in levels and in trends from 1867 to 1872. Below, we show that our main results are not sensitive to the inclusion of these controls, which implies there were not large differential changes across plots with different pre-Fire outcomes. We have greater confidence in the estimated changes over shorter periods of time, however, when these areas are less likely to have otherwise experienced substantial differential changes.

When restricting the sample to plots within 1000 feet of the Fire boundary, plot values in 1872 are more similar in the burned area (column 1) and restricted unburned area (column 5). Column 6 reports this estimated difference, in logs, and there is no longer a substantial or statistically significant difference in land value. The cross-sectional difference in building value is smaller, but remains statistically significant. Column 7 reports changes from 1867 to 1872 in the burned area, relative to the restricted unburned area, which are similar to the overall relative changes (column 4). We report some results based on this restricted comparison group, and continue to control for plots' pre-Fire characteristics in 1867 and 1872. We do not emphasize results from the restricted sample, however, as there would be accentuated bias from geographic spillover effects. Further, a focus on this restricted sample would obscure the geographic spillover effects that are of direct interest.

Table 1, Panel B, reports estimated baseline differences between the burned and unburned areas, controlling for plots' distance to the Old State House. The Old State House is a proxy for the center of the central business district and, while most of the sample region is the "central business district" from the perspective of the greater Boston metropolitan area, the Old State House is located at the peak of land values per square foot in the sample region (and three blocks from the burned area). A substantial portion of the cross-sectional difference between the burned and unburned areas is absorbed by controlling for plots' distance to the Old State House (column 3). We later explore the robustness of the empirical estimates to controlling for plots' distance to the Old State House, interacted with year, which serves as an additional check on whether burned and unburned areas might otherwise have changed differentially after the Fire.

## VI Results

### VI.A Impacts on Land Value

Table 2 reports estimated impacts on plot land values in the burned area, relative to plots in unburned areas. Column 1 reports estimates from our initial specification: land values relatively declined from 1867 to 1872 in the burned area (at an annual rate of 3.2%), increased sharply from 1872 to 1873 by 16% (or 14.9 log points), remained similar from 1873 to 1882, and by 1894 had declined below 1872 levels relative to the unburned area. Column 2 reports similar changes after the Fire, controlling for plots' average block land value prior to the Fire (in 1867 and 1872). Column 3 reports similar estimates controlling for pre-Fire values of the nearest plot, which mechanically absorbs all pre-Fire variation. Column 4 controls for pre-Fire values of the nearest plot and block averages. We prefer these controls to projecting the negative annual trend of 3.2% (in column 1), as asset values in principle should not exhibit large predictable changes.[41] From an *ex post* perspective, however, initial differences may predict differential changes and so we control for pre-Fire differences. Inclusion of these controls mechanically absorbs the pre-Fire trend, but estimated impacts after the Fire are strikingly robust to controlling for pre-Fire differences in 1867 and 1872.[42]

Estimated increases in land values from 1872 to 1873, of roughly 17%, capitalize substantial economic gains from the opportunity for widespread reconstruction. Increased land values are consistent with the extended model with neighborhood spillovers, rather than with the benchmark model in which land values are unchanged. Higher land values largely persist through 1882, suggesting that initial increases are not an artifact of tax assessment or over-exuberance in the immediate aftermath of the Fire. Land values declined relatively in the burned area by 1894, which may reflect predictions of the model as these areas face the replacement of an entire cohort of older buildings constructed just after the Fire. Estimates from later periods may be less reliable, however, as the burned and unburned areas might otherwise have experienced larger differential changes.

Estimated increases in land value are smaller when restricting the sample to plots within 1000 feet of the burned boundary (Table 2, columns 5 – 8), though this could be due to spillover effects on nearby unburned areas. Indeed, the extended model predicts the Fire will increase land values in nearby areas.

Figure 5 shows estimated changes in land value from 1872 to 1873, grouped by plots' distance to the burned boundary. The burned area is to the left of the dashed line, represented by negative distances, and the unburned area is to the right and grouped into bins of 100 feet. The estimated coefficients are relative to the omitted category of plots more than 2900 feet from the burned boundary, and the vertical lines represent 95% confidence intervals.[43]

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[41] Land values may exhibit some predictable changes along with predicted changes in location fundamentals, as in the extended model, but these changes are smoothed due to land values capitalizing the net present value of rents associated with any expected changes.

[42] We have also explored using kernel regressions to predict plot characteristics, as an intermediate case between block controls and neighbor controls, and the estimates are robust to that approach.

[43] For the interior of the burned region, plots more than 400 feet from the burned boundary are grouped.

The empirical specification controls for plots' pre-Fire outcomes, corresponding to the specification in column 4 of Table 2. Estimates from Table 2 are essentially the average difference between points to the left and the right of the dashed line, whereas Figure 5 provides much more empirical richness in the presentation of the results.

Land values increased in nearby unburned areas, and by a similar magnitude as the increase in land values throughout the burned area (Figure 5). Increases in land value become smaller as distance to the burned boundary increases, and appear to level off around 1500 feet. By contrast, Appendix Figure 6 (Panel A) shows that distance to the burned area was not associated with systematic changes in land value from 1867 to 1872. The relative decline in the burned area, corresponding to column 1 of Table 2, was driven by some interior burned areas having declining land values from 1867 to 1872.

Positive spillover effects generate two reasons why the Fire's total impact on land value would be understated by relative changes in the burned area (e.g., estimates from Table 2). First, the relative comparison understates the aggregate impact in burned areas because nearby unburned areas are also affected. Second, the impacts on nearby unburned areas should also be included in the aggregate impacts of the Fire. These problems could be overcome, however, if we assumed that further unburned areas are unaffected by the Fire. A within-city analysis is fundamentally limited in its ability to calculate city-wide impacts, but we can bound the Fire's impacts if spillovers are positive on net.

In principle, there could be negative spillover effects due to displacement of economic activity within Boston, which is not reflected in our model. For example, if the overall demand for some economic activity is fixed and increased activity is drawn into the burned area, then this comes at the expense of unburned areas. The downtown Boston economy was sufficiently integrated with the Greater Boston metropolitan economy, and even the world economy, that we suspect there is less scope for negative spillovers through displacement of economic activity from the unburned area to the burned area. Furthermore, the ultimate reversion of land valuations in the burned area suggests that any displacement was at best temporary. The potential for negative spillovers, however, is an important caveat to the estimated total impact.

We estimate the total impact on land value, subject to caveats, by parameterizing the spatial relationship seen in Figure 5. We begin by modeling the Fire's impact with a continuous linear function: constant within the burned area, decreasing linearly with distance outside the burned area, and then zero after some distance cutoff. The Appendix (Section A) discusses further details of the estimation, which uses non-linear least squares to jointly estimate the distance gradient and distance cutoff. This functional form visually matches the nonparametric results in Figure 5, and the Appendix explores the results' robustness to alternative functional forms.

These estimation results provide a predicted impact of the Fire on each plot's land value in 1873, which depends on its distance to the burned area. We then sum these impacts across all plots to obtain an estimated total impact on land value, and convert all dollar amounts to 1872 dollars using the David-Solar CPI (Lindert and Sutch, 2006).

Table 3, Panel A, reports these estimates based upon the estimated spillover cutoff of 1,394 feet from the burned area (column 1). The Fire is estimated to have increased land values by $5.5 million in the burned area (column 2), and by $9.7 million in the unburned area (column 3). The percent impact is greater in the burned area, but the level impact is greater in the unburned area because many more plots are affected. The estimated total impact is $15.2 million (column 4), or 1.17 times the 1872 value of buildings in the burned area (column 5). To give a sense of robustness, Panels B and C report estimated impacts when assuming the distance cutoff to be 1,149 feet or 1,639 feet (the 95% confidence interval for the estimated distance cutoff).[44]

The total impact on land values is comparable to the value of buildings burned, and may have been even greater.[45] This is not to imply that the Fire itself was value-enhancing, as the actual damages included lost property and goods and were estimated to be at least $75 million. The value of burned buildings provides a natural point of comparison, but the impact on land values does not need to exceed the value of buildings for there to be substantial economic inefficiencies from cross-plot externalities. Indeed, the null hypothesis from the benchmark model is that the Fire has no impact on land values.

In the immediate aftermath of the Fire, however, there may be something unusual about tax assessments or over-exuberance reflected in land values. Table 3, Panels D – F, presents analogous estimates of the total impact on land value in 1882. Estimates indicate that the Fire continues to exert a strong impact on land values. Appendix Figure 7 shows estimated changes in land value from 1872 to 1882 (Panel A) and from 1872 to 1894 (Panel B), grouped by plots' distance to the burned boundary. By 1882, land values remain higher in the burned area and have increased in nearby unburned areas relative to further unburned areas. Land values are lower in the burned region by 1894, though still higher in the nearby unburned area, which may reflect expectations that the burned area will become dragged down by a large cohort of increasingly obsolete buildings. The identification assumption becomes increasingly tenuous in later years, however, as plot values might have experienced more substantial differential changes in the absence of the Fire.

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[44] Note that the standard errors in Panel A, columns 2 to 5, do take into account the uncertainty in the estimated distance cutoff.

[45] We also suspect that assessed building values may overstate their "true economic value," as buildings are rarely assessed at close to zero value even when they are a "tear down" and due for replacement.

### VI.B Impacts on Building Value

Table 4 reports estimated impacts on building values in the burned area, relative to unburned areas, returning to the initial specifications that ignore spatial spillovers. Building values declined immediately due to destruction from the Fire, but building values became substantially higher by 1882.[46] The reconstruction of buildings to substantially higher values is consistent with the immediate increases in land value, such that anticipated economic gains appear to have materialized through the expected mechanism of upgraded building stocks. Building values had partially converged by 1894, consistent with the model, though the identification assumption is more demanding in later periods. The estimated changes in building value are more sensitive to the inclusion of pre-Fire controls, compared to the estimated changes in land value, but there are consistent indications of substantially higher building values by 1882 and partial convergence by 1894. The results are similar when restricting the sample to within 1000 feet of the burned area, though the magnitudes are smaller in a manner consistent with positive spillover effects on nearby areas.

Appendix Figure 8 shows estimated changes in building value, grouped by plots' distance to the burned boundary. From 1872 to 1873, building values declined in the burned area and were mostly unchanged in the unburned area (Panel A). Note that some buildings just inside the "burned area" appear not to have been completely burned, or may have been repaired or reconstructed quickly. The absence of immediate impacts on building values of nearby unburned plots, despite the immediate increase in assessed land values of nearby unburned plots, is consistent with tax assessors effectively separating land and building values. The destruction of building stocks might have temporarily raised building rents in unburned buildings, though reconstruction was rapid and temporary impacts on rents would have minimal impact on forward-looking building values.

By 1882, building values had increased substantially throughout the burned area (Appendix Figure 8, Panel B). Further, there appear to be some increases in the building value of nearby unburned plots, relative to unburned plots beyond 300 feet from the Fire boundary. By 1894, there appear to be larger impacts on building values of nearby unburned plots, which decline over a geographic distance of 1500 to 2000 feet (Panel C). For later periods, it is a stronger assumption that distance to the Fire boundary would not otherwise predict differential changes in building values, but there were not relative changes in these unburned areas' building value from 1867 to 1872 (Appendix Figure 6, Panel B). While reconstruction of burned buildings might have contributed to temporarily higher construction costs in Boston, delaying replacement of buildings elsewhere, reconstruction of the burned area

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[46] While vacant plots are excluded from analysis of the log value of buildings, many buildings were assessed in a partially-constructed state in the spring of 1873.

appears to have encouraged the subsequent upgrading of nearby buildings.

The increase in building values in the burned area is consistent with both the benchmark and extended models, but the apparent rise in building values in nearby unburned areas is indicative of the spillovers present in the extended model. The data suggest nearby landowners upgraded their buildings sooner to complement the increased quality of buildings in the burned area, and the distance of geographic spillovers appears to spread from 1882 to 1894 as further landowners react to upgrading in nearby unburned areas. By contrast, in the benchmark model, landowners in all unburned areas do not change their building construction decisions.

Impacts on the distribution of building values in the burned area may also be indicative of neighborhood spillover effects. While both the benchmark model and extended model predict increases in building quality, the extended model is associated with a multiplier effect that increases building quality at even the highest quantiles. We estimate quantile regressions that are analogous to the mean impacts reported in column 1 of Table 4.[47]

Appendix Figure 9, Panel A, shows estimated changes from 1872 to 1882, by quantile, for building values in the burned area. Building values increased significantly at even the highest quantiles, which is consistent with even the highest-quality buildings being replaced with buildings of substantially higher quality due to the Fire's multiplier effect generated by neighborhood spillovers.[48] The estimated impacts are only marginally significant across all higher quantiles, but would be more so when considering pooled estimates across higher portions of the distribution.[49] Building values increase much more at the lowest quantiles, which reflects the removal of less-valuable buildings and a compression in the bottom of the distribution. This latter result is consistent with both models, but illustrates a mechanism through which neighborhood quality increases. By contrast, there is a relatively consistent effect across quantiles of plot land value (Appendix Figure 10), indicating that higher land values are not driven by the removal of particular low-value areas (e.g., slums within the downtown area).

Appendix Figure 9, Panel B, shows that building values had converged by 1894 for all but the lowest quantiles. Both models predict that convergence would be slowest for the bottom

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[47] Estimates are similar from conditional quantile regressions, including controls for pre-Fire characteristics, but the interpretation of the conditional quantile results is less clear: the theory predicts that the worst buildings are upgraded the most, rather than the worst buildings conditional on their previous nearest neighbor value.

[48] By contrast, in the baseline model, the newest and highest quality buildings in the unburned area would be the same as the reconstructed buildings in the burned area (even in discrete time and with non-instantaneous construction).

[49] The quantile regressions are bootstrapped at the block level, such that the standard errors are adjusted for within-block correlation. Dashed lines report 95% confidence intervals.

of the distribution, and these estimates highlight that the moderate convergence reported in Table 4 is a combination of slow and fast convergence at different points in the distribution. There is even some indication of lower building quality in the burned area at higher quantiles. Thus, while average building values continue to remain higher in 1894 (Table 4), the decline seen in land values by 1894 may be more forward-looking about growth potential in future periods (Table 2). Over subsequent years, the burned area will possess an aging stock of buildings, built in the immediate aftermath of the Fire, that may reduce relative rents.

Negative medium-run impacts on land values and building values are predicted to be only temporary, however. As an epilogue to our results, the Appendix (Section B) reports estimated impacts on plots' combined value of land and buildings in 2012. We include these results with tremendous caveats given the scope for the burned and unburned area to have changed differentially and simply note that the burned area does not appear to have been negatively impacted in the very long-run.

### VI.C Robustness to Spatial Correlation, Weighting, and Distance Controls

One natural question concerns potential spatial correlation in plots' land value and building value, which might cause the empirical analysis to overstate the statistical precision of the estimates. Our main empirical specifications allow for spatial correlation within blocks, but we now consider allowing for spatial correlation across plots that declines linearly in geographic distance up to some distance cutoff (Conley, 1999). Appendix Table 2 presents the estimated impacts on land value and building value, along with standard errors that assume different distance cutoffs. The estimated coefficients correspond exactly to those in Table 2 and Table 4, and the estimated standard errors generally rise and then decline with further distance cutoffs. The statistical precision remains similar, however.

The main specifications are weighted by plot size, for reasons discussed above, but we also consider whether the estimates are sensitive to this specification choice. Appendix Table 3 reports similar estimated impacts of the Fire on land value and building value, with and without controls, as reported in Tables 2 and 4.

Controlling for differential changes associated with plots' distance to the Old State House, which proxies for distance to peak values at the center of the city, Appendix Table 4 reports similar estimated impacts of the Fire on land value and building value. Recall from Table 1 that distance to the Old State House had substantial predictive power in explaining cross-sectional differences between burned and unburned areas, and so these results are further indications that baseline cross-sectional differences are not strongly associated with differential changes over the sample period. Further, when estimating impacts on land value and building value by distance to the burned boundary, the estimated distance bin figures look indistinguishable when controlling for distance to the Old State House. While the results are more easily summarized in these tables, the distance bin figures are a better reflection of the empirical richness in the data and our preferred specifications.

### VI.D The Great Fire vs. Individual Building Fires

Comparing the impact of the Great Fire to the impact of individual building fires, we obtain a natural test of whether the Fire has impacts through widespread reconstruction. Both the benchmark model and extended model predict that individually-burned buildings will be replaced with higher quality buildings, but in the benchmark model this increase in quality is the same if a Great Fire destroys all buildings in an area. By contrast, the extended model predicts larger increases in building value due to the simultaneous reconstruction of neighboring buildings to higher quality.

We extend the previous estimating equation to include both the impact of the Great Fire and the impacts of individual building fires. For a direct comparison with the 1872 Great Fire's impacts in 1873, 1882, and 1894, we analyze the impacts of individual building fires after approximately 1 year, 10 years, and 22 years have passed since the individual building fire. To estimate individual fire effects after time interval $\tau$, we assign the indicator $\mathbb{I}_i^{IF}$ equal to 1 if the plot experienced an individual building fire and $\mathbb{I}_{it}^{\tau}$ equal to 1 for individual fire data approximately $\tau$ years prior to a round of digitized assessment data.[50] For plot $i$ in year $t$, the interaction of these two indicator variables defines whether that plot experienced an individual building fire $\tau$ years ago ($\mathbb{I}_i^{IF} \times \mathbb{I}_{it}^{\tau}$). The full estimating equation then becomes:

$$\begin{aligned}(3) \qquad Y_{it} = \alpha_t \; &+ \; \eta_t \bar{Y}_{i1867}^{block} + \eta_t \bar{Y}_{i1872}^{block} + \mu_t \bar{Y}_{i1867}^{near} + \mu_t \bar{Y}_{i1872}^{near} \\ &+ \; \beta_{1873} \mathbb{I}_i^{Fire} \times \mathbb{I}_t^{1873} + \beta_{1882} \mathbb{I}_i^{Fire} \times \mathbb{I}_t^{1882} + \beta_{1894} \mathbb{I}_i^{Fire} \times \mathbb{I}_t^{1894} \\ &+ \; \delta_1 \mathbb{I}_i^{IF} \times \mathbb{I}_t^{1} + \delta_{10} \mathbb{I}_i^{IF} \times \mathbb{I}_t^{10} + \delta_{22} \mathbb{I}_i^{IF} \times \mathbb{I}_t^{22} + \varepsilon_{it}.\end{aligned}$$

The estimated coefficient $\delta_1$ represents the 1-year impact from an individual building fire, and can be compared to the estimated impact of the Fire in 1873 ($\beta_{1873}$). Similarly, $\delta_{10}$ and $\delta_{22}$ can be compared to $\beta_{1882}$ and $\beta_{1894}$, respectively.

Table 5 reports estimated impacts of both the Great Fire and individual building fires.[51]

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[50] Since very few individual fires occurred exactly 1 year, 10 years, or 22 years prior to a round of digitized assessments, we consider individual fires that occurred within a 2-year window of this target. For example, we estimate 10-year effects on plots that experienced individual building fires between 1870 and 1874 (using 1882 tax assessment data) or between 1882 and 1886 (using 1894 tax assessment data). We then control for when the individual fire occurred in this 2-year window. The individual fire indicator $\mathbb{I}_{it}^{\tau} = 1$ if $\left|t - t_i^{IF} - \tau\right| < 2$. To control for when the fire occurred within this 2-year window, we interact $\mathbb{I}_i^{IF} \times \mathbb{I}_{it}^{\tau}$ with $t - t_i^{IF} - \tau$ and report the impact of $\mathbb{I}_i^{IF} \times \mathbb{I}_{it}^{\tau}$ when $t - t_i^{IF} = \tau$.

[51] We control for pre-Fire plot values in all specifications, as focusing on individual building fires with damages greater than \$5000 creates a mechanical association between individual fires and higher-value plots.

Building values are higher 10 years and 22 years after individual fires, but the increase in building values are smaller than increases in building value after the Great Fire (columns 1 and 2). These differences are mostly statistically significant, consistent with the extended model's prediction of a multiplier effect following the Great Fire.

We do not know the magnitude of selection bias associated with individual building fires, i.e., whether these buildings would have experienced differential changes in building values. We suspect that the bias is positive, however, as older buildings might be at greater risk of catching on fire and these older buildings may be due for upgrades. The analysis controls for buildings' characteristics in 1867 and 1872, however, which partly addresses these concerns.

There was no immediate increase in land value following individual building fires, in contrast to the immediate increase in land value following the Great Fire (Table 5, columns 3 and 4). One concern with the main analysis, discussed above, is that the Great Fire might cause a spurious increase in the assessment of land value. The absence of higher land values immediately following individual building fires further confirms that fires are not mechanically associated with increased assessment of land value.

Overall, the Great Fire's scale was fundamental to its impacts on land values and building values. We attribute much of this impact to spillover effects from the widespread reconstruction and upgrading of nearby plots. The Appendix (Section C) considers additional mechanisms through which the Fire may impact urban redevelopment, including particular channels through which displacement and resettlement might influence neighboring plots.

## VII Conclusion

Following the 1872 Great Fire of Boston, burned plots and nearby unburned plots experienced substantial increases in land value. Estimated total impacts on land value capitalize substantial economic gains: \$13 – \$22 million (in 1872 dollars). As a comparison, the 1872 value of buildings burned was \$13 million. In the burned area itself, increased land values were one-third the value of buildings burned, and so the total impact comes largely from spillover impacts to landowners in nearby areas. This comparison does not imply that the Fire itself was welfare-enhancing, however, as the Fire also destroyed non-building capital stocks, we do not quantify general equilibrium impacts at the city-level, and we do not consider welfare impacts on occupants themselves.

We largely attribute these increases in land value to positive externalities from the simultaneous reconstruction of many nearby buildings, drawing on predictions from a dynamic model of urban growth. Indeed, changes in building values, by distance to the Fire boundary and by quantile, are consistent with predicted impacts of neighborhood spillover effects on building reconstruction. By contrast, individual building fires had no impact on land value and consistently smaller impacts on building value. While our data provide various indications of cross-plot spillover effects, there is less evidence for substantial impacts through increased plot sizes, increased urban density, or increased industry agglomeration.

The Boston Fire provides a clear exogenous shock, and plot-level data provide a rich view of economic dynamics within the city. Our within-Boston empirical analysis is unable to quantify aggregate effects at the city level, though positive spillover impacts by distance to the Fire boundary appear to dissipate within the sample region. Furthermore, even if the direct Fire effects were largely due to displacement of economic activity, the presence of significant spillovers continues to support the fundamental mechanism of substantial cross-plot externalities. Relative increases in land value for nearby unburned plots imply at least large relative gains from widespread and simultaneous reconstruction at levels of building quality. Our research design is unable to provide credible long-run estimates, but the results are not inconsistent with other estimates of long-run convergence following widespread destruction.

Drawing on this historical context, in which there is limited regulation to obscure market incentives, there appears to be a fundamental and substantial inefficiency stemming from cross-plot externalities. Landowners might attempt to coordinate with their immediate neighbors, but transaction costs become prohibitive in coordinating with neighbors within further distances. The Fire did not reduce these transaction costs directly, but temporarily mitigated their economic importance by forcing widespread reconstruction. Land values converged over time, which is consistent with the model and could also reflect spurious differential changes, but the initial increases in land value still reflect the creation of substantial economic value through the temporary mitigation of inefficiencies from externalities. The spillover effect from landowners' reconstruction becomes reflected in neighbors' land value, but the spillover effect remains an externality because individual landowners do not internalize their impact on neighbors.

In the presence of cross-plot externalities, simultaneous reconstruction generated higher equilibrium values than the typical pattern of sequential construction decisions. Indeed, whenever there are returns to coordinated investment, we might expect simultaneous investment decisions to reach a better outcome. This phenomenon is not confined to underdeveloped contexts trapped in an inferior equilibrium, but is important in even wealthy and growing economies. A variety of mechanisms might encourage simultaneous investment, or induce investment decisions to internalize externalities, short of widespread destruction. Destruction from the Boston Fire provides a stark demonstration of this dynamic, however, to such a degree that increases in land value were comparable to the value of buildings burned.

## References

**Autor, David H., Christopher J. Palmer, and Parag A. Pathak.** 2014. “Housing Market Spillovers: Evidence from the End of Rent Control in Cambridge, Massachusetts.” *Journal of Political Economy*, 122(3): 661–717.

**Brooks, Leah, and Byron Lutz.** 2012. “From Today’s City to Tomorrow’s City: An Empirical Investigation of Urban Land Assembly.” *George Washington University.* Mimeo.

**Brueckner, Jan K., and Stuart S. Rosenthal.** 2009. “Gentrification and Neighborhood Housing Cycles: Will America’s Future Downtowns Be Rich?” *The Review of Economics and Statistics*, 91(4): 725–743.

**Campbell, John Y., Stefano Giglio, and Parag Pathak.** 2011. “Forced Sales and House Prices.” *American Economic Review*, 101(5): 2108–31.

**Chen, Daniel L., and Susan Yeh.** 2013. “The Impact of Government Power to Expropriate on Economic Growth and Inequality.” Mimeo.

**Collins, William J., and Katharine L. Shester.** 2013. “Slum Clearance and Urban Renewal in the United States.” *American Economic Journal: Applied Economics*, 5(1): 239–273.

**Conley, T.G.** 1999. “GMM Estimation with Cross Sectional Dependence.” *Journal of Econometrics*, 92(1): 1–45.

**Ellickson, Robert C.** 2013. “The Law and Economics of Street Layouts: How a Grid Pattern Benefits Downtown.” *Alabama Law Review*, 64(3): 463–510.

**Fire Commission.** 1873. *Report of the Commissioners Appointed to Investigate the Cause and Management of the Great Fire in Boston.* Rockwell & Churchill, City Printers.

**Fischel, William A.** 2004. “An Economic History of Zoning and a Cure for Its Exclusionary Effects.” *Urban Studies*, 41(2): 317–340.

**Fowler, William Worthington.** 1873. *Fighting Fire.* Dustin, Gilman and Co.

**Frothingham, Frank E.** 1873. *The Boston Fire.* Lee and Shepard, Publishers.

**Guerrieri, Veronica, Daniel Hartley, and Erik Hurst.** 2013. “Endogenous Gentrification and Housing Price Dynamics.” *Journal of Public Economics*, 100: 45–60.

**G.W. Bromley and Co.** 1883. *Atlases of the City of Boston.* Vol. 1.

**Jacobs, Jane.** 1961. *The Death and Life of Great American Cities.* Random House.

**Libecap, Gary D., and Dean Lueck.** 2011. “The Demarcation of Land and the Role of Coordinating Property Institutions.” *Journal of Political Economy*, 119(3): 426 – 467.

**Lindert, Peter H., and Richard Sutch.** 2006. “Consumer Price Indexes, for All Items: 1774-2003.” *Historical Statistics of the United States*, Table Cc1–2.

**Mian, Atif R., Amir Sufi, and Francesc Trebbi.** 2014. "Foreclosures, House Prices and the Real Economy." *University of Chicago Booth School of Business.* Working Paper.

**Munch, Patricia.** 1976. "An Economic Analysis of Eminent Domain." *Journal of Political Economy*, 84(3): 473–498.

**Ripley, Brian D.** 1977. "Modelling Spatial Patterns." *Journal of the Royal Statistical Society. Series B (Methodological)*, 172–212.

**Rosen, Christine.** 1986. *The Limits of Power: Great Fires and the Process of City Growth in America.* Cambridge University Press.

**Rossi-Hansberg, Esteban, Pierre-Daniel Sarte, and Raymond Owen.** 2010. "Housing Externalities." *Journal of Political Economy*, 118(3): 485–535.

**Sanborn Map Company.** 1867-1895. *Sanborn Map Company, Boston.*

**Siodla, James.** 2013. "Razing San Francisco: The 1906 disaster as a natural experiment in urban redevelopment." *Colby College.* Mimeo.

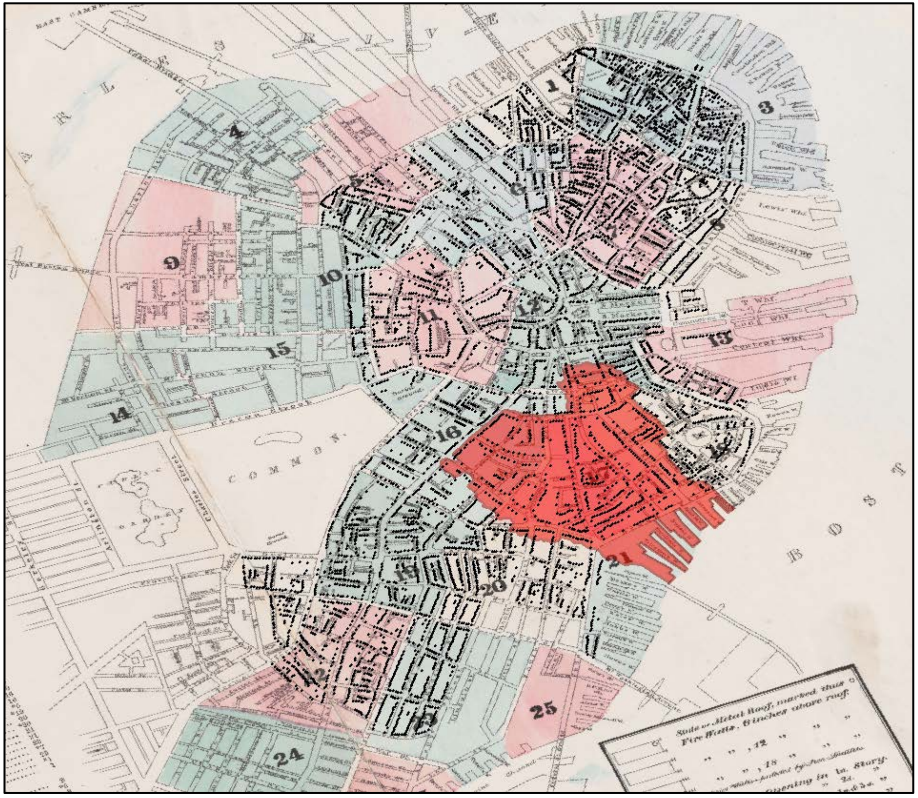
**Siodla, James.** 2014. "Making the Move: The Impact of the 1906 San Francisco Disaster on Firm Relocations." *Colby College.* Mimeo.

**Turner, Matthew A., Andrew Haughwout, and Wilbert van der Klaauw.** 2014. "Land Use Regulation and Welfare." *Econometrica*, 82(4): 1341–1403.

**Wermiel, Sara E.** 2000. *The Death and Life of Great American Cities.* Johns Hopkins Press.

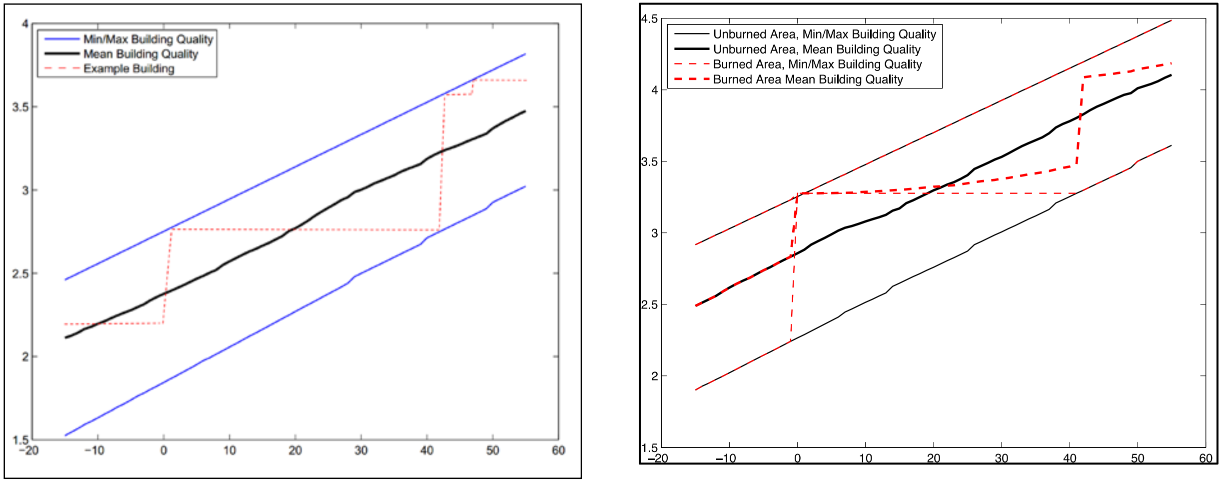
**Wilson, James Q.** 1966. *Urban Renewal: The Record and the Controversy.* MIT Press.

## Figure 1. Historical Downtown Boston, the Burned Area, and Sample Plot Locations



Notes: The shaded red area was burned during the 1872 Great Fire of Boston. Small black points denote each geo-located plot in our main sample for 1867, overlaid on downtown Boston in 1867 (Sanborn Map Company).

## Figure 2. Simulated Evolution of the Building Quality Distribution, Benchmark Model



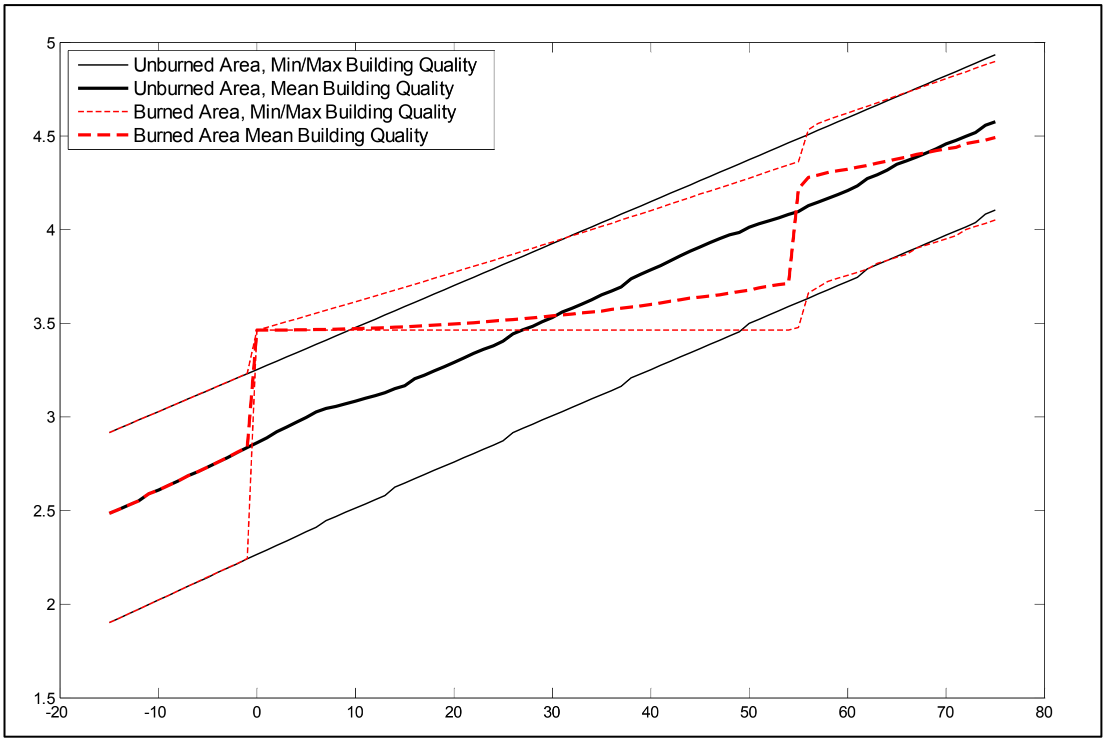
Panel A. Equilibrium Steady-State

Panel B. After a Great Fire in Period 0

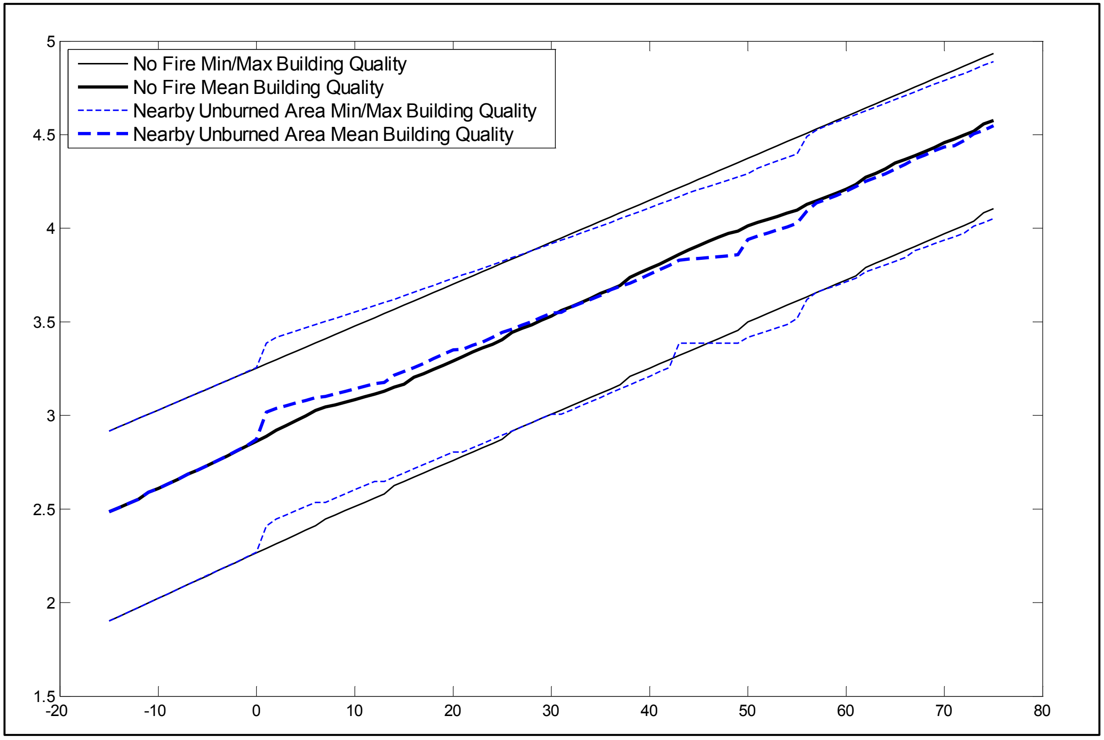
Notes: Panel A shows the simulated evolution of the steady-state in our benchmark model. The thick central line shows the mean of log building quality, and the upper/lower thin lines show the max/min of the building quality distribution. The thin dashed line shows the evolution of a particular example building. Panel B shows the simulated evolution of the steady-state in our benchmark model, following a Great Fire in period 0. The black lines represent the Unburned Area (same as in Panel A), and the red lines represent the Burned Area.

**Figure 3. Simulated Evolution of the Building Quality Distribution, Extended Model**

Panel A. Burned Area after a Great Fire in Period 0

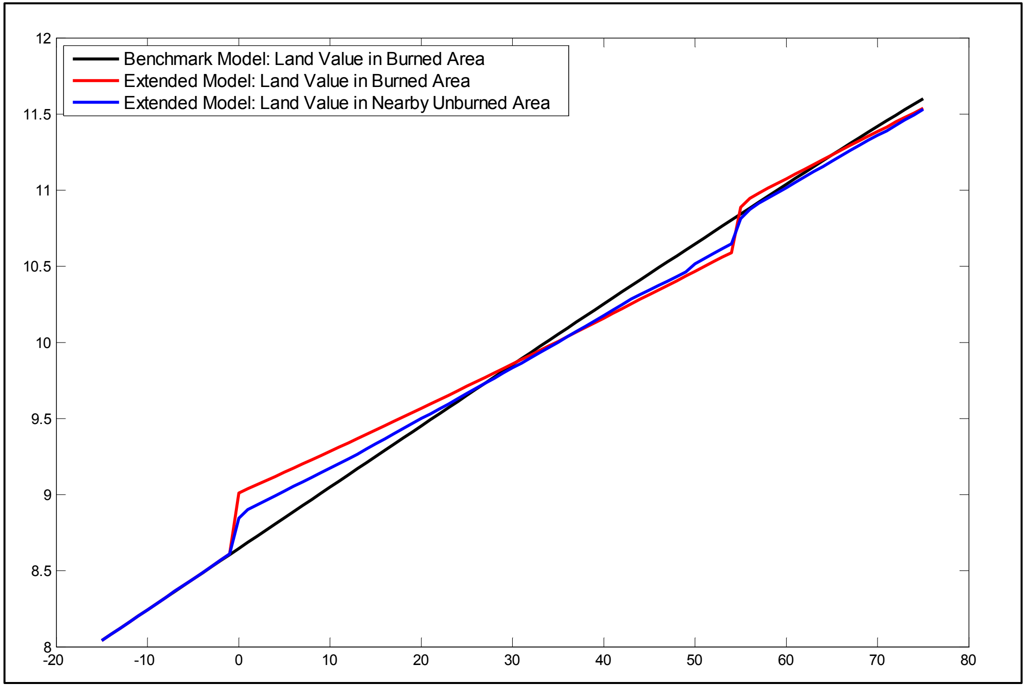


Panel B. Nearby Unburned Area after a Great Fire in Period 0



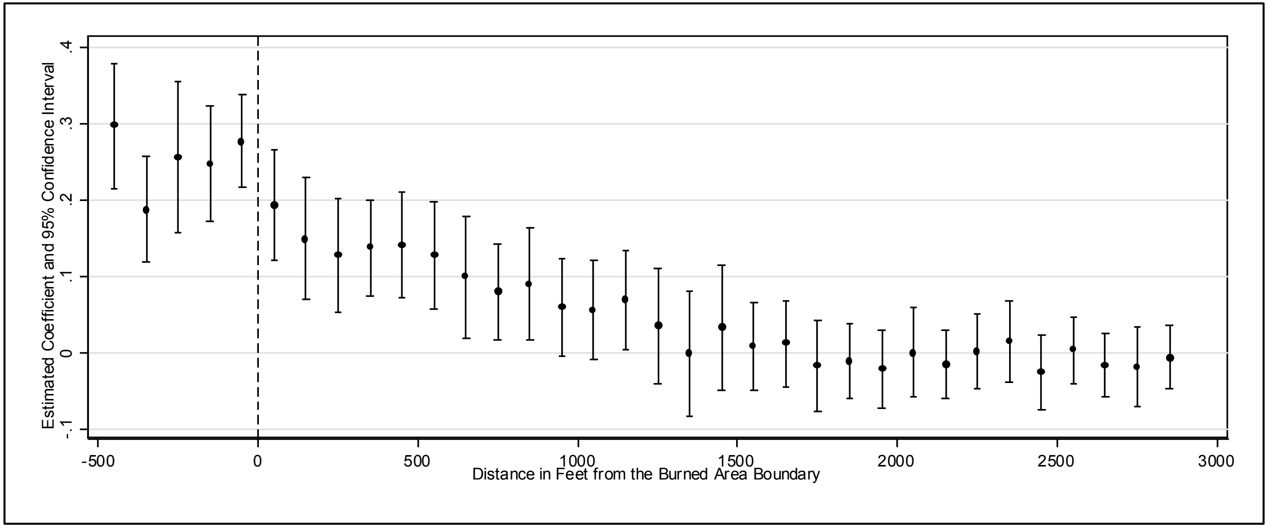
Notes: For our extended model with neighborhood externalities, Panel A shows the Burned Area following a Great Fire in period 0 (red lines) and the steady-state in the absence of a Fire (black lines). Panel B shows the steady-state in Nearby Unburned Areas (blue lines) and the steady-state in the absence of a Fire (black lines).

## Figure 4. Evolution of Land Value after Great Fire, Benchmark and Extended Model



Notes: Following a Great Fire in period 0, the upper red line shows the simulated evolution of land value in the Burned Area in our extended model with neighborhood externalities. The middle blue line shows the evolution of land value in a Nearby Unburned Area in our extended model. The lower black line shows the simulated evolution of land value in the Burned Area (or Unburned Area) in our benchmark model, which is the same as if there had been no Fire.

## Figure 5. Estimated Changes in Land Value from 1872 to 1873, by Distance to the Fire Boundary (in Feet)



Notes: For the indicated distance from the boundary of the burned area, each circle reports the estimated change in land value from 1872 to 1873 (and the vertical lines reflect 95% confidence intervals). The omitted category is plots more than 2900 feet from the burned area. Negative distances reflect areas within the burned area, and burned plots more than 400 feet from the Fire boundary are grouped together. The empirical specification includes controls for plots' predicted land value in 1867 and 1872 based on block average and nearest neighbor.

## Table 1. Plot Values in 1872, and Differences in the Burned Area

| | | | Differences in Logs: Burned vs. Unburned | | | Differences in Logs: Burned vs. Restricted Unburned | |
|---|---|---|---|---|---|---|---|
| | Burned Area | Unburned Area | Difference in 1872: (1) - (2) | Difference in Changes: 1867 to 1872 | Restricted Unburned Area | Difference in 1872: (1) - (5) | Difference in Changes: 1867 to 1872 |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Panel A. Summary Statistics | | | | | | | |
| Land Value | $13.95 | $8.44 | 0.774*** | -0.174*** | $14.69 | 0.087 | -0.165*** |
| per Square Foot | (6.77) | (8.83) | (0.084) | (0.041) | (11.32) | (0.093) | (0.045) |
| Building Value | $7.48 | $4.14 | 0.733*** | 0.182 | $5.94 | 0.246** | 0.136 |
| per Square Foot | (4.35) | (3.77) | (0.097) | (0.120) | (4.75) | (0.106) | (0.127) |
| Panel B. Controlling for Distance to Old State House | | | | | | | |
| Land Value | | | 0.409*** | -0.118*** | | 0.001 | -0.158*** |
| per Square Foot | | | (0.075) | (0.040) | | (0.072) | (0.043) |
| Building Value | | | 0.456*** | 0.192 | | 0.178* | 0.143 |
| per Square Foot | | | (0.093) | (0.125) | | (0.090) | (0.128) |
| Number of Plots | 580 | 6013 | | | 1837 | | |
| Total Plot Area | 1,724,877 | 10,642,991 | | | 3,753,481 | | |

Notes: For the indicated outcome variable, columns 1 and 2 report the average value across plots in the burned area and unburned area, respectively. Column 3 reports the estimated log difference in 1872 for plots in the burned area, relative to plots in the unburned area. Column 4 reports this estimated log difference in changes from 1867 to 1872, i.e., the difference in the burned area in 1872 (relative to the unburned area in 1872) relative to the difference in the burned area in 1867 (relative to the unburned area in 1867). Columns 5 to 7 correspond to columns 2 to 4, but for a restricted sample of plots within 1000 feet of the Fire boundary. Panel B reports estimated differences when controlling for plots' distance to the Old State House. All means and regressions are weighted by plot size. Robust standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

## Table 2. Estimated Impact on Land Values in Burned Area, Relative to 1872

| | Log Value of Land per Square Foot | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Full Sample | | | | Restricted Sample | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1867 x Burned | 0.174*** | 0.019 | - | - | 0.165*** | 0.016 | - | - |
| | (0.041) | (0.013) | ( ) | ( ) | (0.045) | (0.014) | ( ) | ( ) |
| 1872 x Burned | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) |
| 1873 x Burned | 0.149*** | 0.169*** | 0.168*** | 0.172*** | 0.125*** | 0.124*** | 0.131*** | 0.133*** |
| | (0.020) | (0.020) | (0.017) | (0.018) | (0.023) | (0.022) | (0.020) | (0.021) |
| 1882 x Burned | 0.157*** | 0.137*** | 0.139*** | 0.144*** | 0.059 | 0.073 | 0.052 | 0.083* |
| | (0.043) | (0.044) | (0.040) | (0.042) | (0.049) | (0.049) | (0.044) | (0.046) |
| 1894 x Burned | -0.102* | -0.147** | -0.172*** | -0.145** | -0.250*** | -0.196*** | -0.234*** | -0.188** |
| | (0.056) | (0.061) | (0.056) | (0.060) | (0.069) | (0.073) | (0.067) | (0.073) |
| Controls: | | | | | | | | |
| Year Fixed Effects | X | X | X | X | X | X | X | X |
| Year FE x Pre-Fire Block Average | | X | | X | | X | | X |
| Year FE x Pre-Fire Neighbor Value | | | X | X | | | X | X |
| R-squared | 0.153 | 0.797 | 0.934 | 0.938 | 0.116 | 0.689 | 0.885 | 0.888 |
| Number of Plots | 31302 | 31302 | 31302 | 31302 | 11367 | 11367 | 11367 | 11367 |

Notes: For all specifications, the outcome variable is the log value of land per square foot. From estimating equation 1 in the text, column 1 reports the estimated difference between plots in the burned area and plots in the unburned area in the indicated year, relative to the omitted year of 1872. From estimating equation 2 in the text, columns 2 to 4 include controls for plots' predicted characteristics prior to the Fire, based on their block and/or nearest neighbor (which is generally that same plot in the earlier year). Columns 5 to 8 correspond to columns 1 to 4, but for the restricted sample of plots within 1000 feet of the Fire boundary. The regressions are weighted by plot size. Robust standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

## Table 3. Estimated Total Impact of Fire on Land Values in 1873 and 1882

| | | Impact in $1000's of 1872 Dollars: | | | |
|---|---|---|---|---|---|
| | Distance Cutoff (1) | Burned Area (2) | Unburned Area (3) | Total Impact (4) | Ratio of (4) to Burned Building Value (5) |
| In 1873: | | | | | |
| Panel A. Estimated Cutoff | 1,394 | 5,545 | 9,666 | 15,211 | 1.18 |
| | (125) | (536) | (1,150) | (1,632) | (0.13) |
| Panel B. 1149 Foot Cutoff | 1,149 | 5,305 | 8,039 | 13,343 | 1.03 |
| | ( ) | (502) | (728) | (1,229) | (0.10) |
| Panel C. 1639 Foot Cutoff | 1,639 | 5,735 | 11,133 | 16,869 | 1.31 |
| | ( ) | (535) | (994) | (1,529) | (0.12) |
| In 1882: | | | | | |
| Panel D. Estimated Cutoff | 1,412 | 7,236 | 12,561 | 19,797 | 1.53 |
| | (189) | (1,313) | (2,562) | (3,781) | (0.29) |
| Panel E. 1040 Foot Cutoff | 1,040 | 6,749 | 9,408 | 16,157 | 1.25 |
| | ( ) | (1,287) | (1,714) | (3,001) | (0.23) |
| Panel F. 1784 Foot Cutoff | 1,784 | 7,376 | 14,894 | 22,270 | 1.73 |
| | ( ) | (1,328) | (2,572) | (3,899) | (0.30) |

Notes: Panels A to C consider the total effect on land value in 1873, adjusted to 1872 dollars using the David-Solar CPI (Lindert and Sutch 2006). We constrain the impact of the Fire to be constant within the Burned Area, declining linearly in the Unburned Area until some distance cutoff, and then zero after that distance cutoff (see Section A of the Appendix). Column 1, panel A, reports the estimated distance cutoff after which geographic spillover effects are zero. Column 1, panels B and C, report alternative assumed distance cutoffs. Column 2 reports the estimated total impact of the Fire on land value in the Burned Area, Column 3 reports the estimated total impact of the Fire on land value in the Unburned Area, and Column 3 reports the estimated total impact of the Fire in all areas. Column 5 reports the ratio of the estimates in Column 4 to the total 1872 value of buildings in the Burned Area. Panels D to E report analagous estimates, but for the impact on land value in 1882 (converted to 1872 dollars). Robust standard errors clustered by block are reported in parentheses.

## Table 4. Estimated Impact on Building Values in Burned Area, Relative to 1872

| | Log Value of Building per Square Foot | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Full Sample | | | | Restricted Sample | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1867 x Burned | -0.182 | -0.053 | - | - | -0.136 | -0.043 | - | - |
| | (0.120) | (0.052) | ( ) | ( ) | (0.127) | (0.059) | ( ) | ( ) |
| 1872 x Burned | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) |
| 1873 x Burned | -1.803*** | -1.881*** | -1.961*** | -2.016*** | -1.800*** | -1.890*** | -1.965*** | -2.011*** |
| | (0.161) | (0.160) | (0.167) | (0.168) | (0.161) | (0.160) | (0.167) | (0.171) |
| 1882 x Burned | 0.401*** | 0.478*** | 0.637*** | 0.511*** | 0.357*** | 0.402*** | 0.493*** | 0.441*** |
| | (0.067) | (0.069) | (0.056) | (0.055) | (0.070) | (0.066) | (0.050) | (0.049) |
| 1894 x Burned | 0.174** | 0.371*** | 0.546*** | 0.410*** | 0.090 | 0.203** | 0.274*** | 0.246*** |
| | (0.078) | (0.087) | (0.068) | (0.080) | (0.089) | (0.081) | (0.066) | (0.069) |
| Controls: | | | | | | | | |
| Year Fixed Effects | X | X | X | X | X | X | X | X |
| Year FE x Pre-Fire Block Average | | X | | X | | X | | X |
| Year FE x Pre-Fire Neighbor Value | | | X | X | | | X | X |
| R-squared | 0.108 | 0.474 | 0.775 | 0.788 | 0.163 | 0.467 | 0.735 | 0.743 |
| Number of Plots | 30198 | 30198 | 30198 | 30198 | 10595 | 10595 | 10595 | 10595 |

Notes: For all specifications, the outcome variable is the log value of building per square foot. From estimating equation 1 in the text, column 1 reports the estimated difference between plots in the burned area and plots in the unburned area in the indicated year, relative to the omitted year of 1872. From estimating equation 2 in the text, columns 2 to 4 include controls for plots' predicted characteristics prior to the Fire, based on their block and/or nearest neighbor (which is generally that same plot in the earlier year). Columns 5 to 8 correspond to columns 1 to 4, but for the restricted sample of plots within 1000 feet of the Fire boundary. The regressions are weighted by plot size. Robust standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

## Table 5. Estimated Impact of Fire: Great Fire vs. Individual Fires

| | Log Value of Building per Sqr. Ft. | | Log Value of Land per Sqr. Ft. | |
|---|---|---|---|---|
| | Full Sample (1) | Restricted Sample (2) | Full Sample (3) | Restricted Sample (4) |
| 1873 x Burned | -1.950*** | -1.944*** | 0.170*** | 0.129*** |
| | (0.173) | (0.178) | (0.018) | (0.022) |
| 1882 x Burned | 0.514*** | 0.445*** | 0.142*** | 0.080* |
| | (0.059) | (0.053) | (0.042) | (0.046) |
| 1894 x Burned | 0.413*** | 0.247*** | -0.156*** | -0.200*** |
| | (0.083) | (0.072) | (0.060) | (0.072) |
| ~1 Year After Individual Fire | -0.127 | -0.005 | -0.054 | -0.019 |
| | (0.131) | (0.028) | (0.062) | (0.042) |
| ~10 Years After Individual Fire | 0.346** | 0.128* | 0.084 | -0.008 |
| | (0.152) | (0.068) | (0.102) | (0.156) |
| ~22 Years After Individual Fire | 0.012 | -0.013 | -0.210 | -0.205 |
| | (0.085) | (0.083) | (0.269) | (0.298) |
| Test of Equality of Individual Fire and Great Fire Effects (p-value): | | | | |
| ~7 Month Interval | 0.000 | 0.000 | 0.001 | 0.002 |
| ~ 10 Year Interval | 0.299 | 0.000 | 0.606 | 0.600 |
| ~ 22 Year Interval | 0.000 | 0.003 | 0.848 | 0.988 |
| Controls: | | | | |
| Year Fixed Effects | X | X | X | X |
| Year FE x Pre-Fire Block Average | X | X | X | X |
| Year FE x Pre-Fire Neighbor Value | X | X | X | X |
| R-squared | 0.788 | 0.744 | 0.938 | 0.889 |
| Number of Plots | 30128 | 10525 | 31219 | 11284 |

Notes: The reported estimates are from equation 3 in the text, which jointly estimates the impact of the 1872 Great Fire and the impact of individual building fires. The first three rows report the estimated impacts of the 1872 Great Fire in 1873, 1882, and 1894 (corresponding to estimates in Table 2 and Table 4), and the second three rows report the impact of individual building fires after approximately 1 year, 10 years, and 22 years. Below, we report the statistical significance of the difference between the Great Fire impact and the corresponding individual fire impact. Columns 1 and 2 report impacts on building value, corresponding to columns 4 and 8 of Table 4. Columns 3 and 4 report impacts on land value, corresponding to columns 4 and 8 of Table 2. Note that this sample excludes plots in the 1872 Burned Area that also experienced individual building fires, as well as individual building fires that were suspected to be arson. Robust standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

## VIII Appendix

This Appendix has five sections. In the first section, we provide additional details on the estimation of the Fire's total impact on land value and alternative functional forms for parameterizing geographic spillover effects. In the second section, as a modern epilogue to the historical results in the paper, we present estimated impacts on the combined value of land and buildings in 2012. In the third section, we present empirical results on additional mechanisms through which the Fire might impact subsequent land-use, including: infrastructure investment, land assembly, ownership concentration, business agglomeration, and occupant sorting. The fourth section contains the Appendix Figures, and the fifth section contains the Appendix Tables.

### VIII.A Estimating the Total Impact of the Great Fire on Land Value

Our main specification is a piecewise linear function of the total impact of the Fire on plots' land value in the burned and unburned areas: constant within the burned area, decreasing linearly with plots' distance to the Fire boundary ($dist$),[52] and then zero after some distance cutoff ($c$):

$$V_{dist} = \beta_1 \max\left\{\frac{c - dist_{it}}{c}, 0\right\} \tag{4}$$

We then estimate Equation 2 in the main text, substituting this piecewise linear function for the indicator function denoting the burned area. Using non-linear least squares, we simultaneously estimate the fire effect $\beta_1$ and distance cutoff $c$ that best fits the data.

We then calculate the estimated effect of the Fire on each plot ($\hat{Y}_{it}$), based on the estimated impact in the burned area ($\hat{\beta}_1$) and the estimated cut-off point beyond which the Fire has no further effects ($\hat{c}$). Finally, for a given year, we calculate the fraction of each plot's land value that is due to the Fire and sum across all plots.

As robustness checks in the estimation of the spillover effects, we experimented with three alternative formulas for the spillover function:

1. A variant allowing the spillover to be non-linear:

$$V_{dist} = \beta_1 \max\left\{\left(\frac{c - dist_{it}}{c}\right)^{\gamma}, 0\right\}$$

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[52] This distance is zero for points within the burned area.

2. An asymptotic variant with no cut-off:

$$V_{dist} = \beta_1 \left( \frac{1}{1 + \beta_2 dist_{it}} \right)^{\gamma}$$

3. A fourth-degree polynomial with no cut-off:

$$V_{dist} = \sum_{n=1}^{4} \beta_n dist_{it}^n$$

Appendix Figure 11 shows the four estimated spillover functions, including the baseline piecewise linear model. All of the functions produce fairly similar estimates in approximating the nonparametric relationship apparent in Figure 5. The three non-linear specifications estimate the mean in the burned area to be slightly greater than the baseline model, a steeper decay in the spillover effect, and spillover effects continuing into plots further from the Fire. Divergent properties of polynomials are visible past 3000 feet, where the third function turns back upwards, as only 6.3% of the sample lies beyond 3000 feet from the burned area.

The first and second alternative models allow us to generate alternative estimates of the Fire's total impact, as they include an estimate of where spillover effects end. The first model estimates a total impact of \$16 million (with a standard error of \$3.8 million), which is only slightly larger than our baseline estimate. Estimates are less similar with the second alternative formula, as we must assume the Fire's spillover effects disappear only when distance goes to infinity, and the estimated impact is \$124 million. Identification of the second alternative model is tenuous, however, as the within-sample functional form is used to project impacts on distances far out of sample. Our baseline estimates are more conservative, assuming that the spillover effects go to zero at some cutoff within the sample region. Within the sample region, all four functional forms provide a broadly similar parameterization of the basic relationship seen in Figure 5.

### VIII.B Epilogue: Estimated Impacts in 2012

As an epilogue, we consider whether the burned area differs from unburned areas in the modern period. We use data on Boston property values from plot assessments in 2012, which are assessed at market value.[53] Separate valuations for land and buildings are unavailable for condominiums, which make up a substantial portion of the downtown Boston area, so we are limited to analyzing the total value of plots.

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[53] For details on assessment methodology, see: http://www.cityofboston.gov/assessing/assessedvalues.asp. We assigned plot locations by merging on plot ID to the Boston parcels map: http://boston.maps.arcgis.com.

Appendix Table 5 reports changes from 1872 to 2012 in the burned area, relative to changes in the unburned area. There is no statistically significant difference in the basic specification (column 1), but the burned area appears to become substantially more valuable conditional on controls for plots' pre-Fire characteristics (column 2). The influence of pre-Fire controls is somewhat surprising, as we expected plot characteristics in 1867 and 1872 to have little predictive power in 2012 data. The estimates are smaller, and statistically insignificant, when limiting the sample to areas within 1000 feet of the burned boundary. In principle, there may continue to be spillover effects on unburned areas, though a variety of confounding factors would be difficult to control for over such a long period of time. There is no indication that the burned area was disadvantaged over the long-run, though we suggest caution in interpreting these results as evidence of long-run gains. Given cross-sectional differences between the burned area and unburned areas, the identification assumption of parallel trends becomes increasingly tenuous over longer periods of time.

### VIII.C Additional Potential Mechanisms

*Infrastructure Investment.* Along with the opportunity for private landowners to reconstruct buildings, the Boston city government had an opportunity to improve public infrastructure in the burned area. Government plans were largely limited by resistance from landowners, but there were some moderate improvements to the road network.

Changes in the road network are certainly not exogenous, but we begin by considering whether plots on non-widened roads experienced increases in land value and building value. Appendix Table 6 reports these results, which show similar increases in land value and building value in these burned areas relative to unburned areas.

We have emphasized the gain to landowners from widespread reconstruction of neighboring buildings, but in principle these gains could be due to any new amenity in the burned area that also generates spillover effects. While we emphasize the amenity created by higher-quality nearby buildings, these impacts are difficult to distinguish formally from another amenity such as higher-quality roads, wider water mains, or new fire hydrants. The estimated changes in land value and building value are robust to controlling for year-interacted measures of plots' distance to the newly created Post Office Square, though some amenities could in principle be nearly collinear with the burned area. Whereas these changes in infrastructure are potentially long-lasting, however, we see convergence in land values and building values that appear more to reflect temporary upgrades to the building capital stock. Immediate increases in land value could reflect changes seen in the road network, though this is also somewhat inconsistent with landowners' coordinated resistance to changes in the road network despite compensation paid for lands used (Rosen, 1986). Given these considerations, and the limited effectiveness of changes in the road network in reducing traffic problems (Rosen, 1986), we do not expect this to be the primary source of the Fire's impacts.

*Land Assembly.* The Fire may also impact land values by lowering the cost of land assembly, i.e., combining land plots into larger units. There may be returns to scale in plot size, and yet various rigidities might prevent the assembly of plots into larger units that would increase the value of land per square foot (see, e.g., Brooks and Lutz, 2012).

Appendix Table 7 reports estimated impacts on log plot size in the burned area, relative to unburned areas, based on the same estimating equations as before. In the main sample (columns 1 and 2) and the restricted sample within 1000 feet (columns 3 and 4), there is little immediate change in average plot size from 1872 to 1873. There is some indication of higher plot sizes in later periods, following reconstruction, which is more consistent with the returns to land assembly increasing with neighborhood quality. If the immediate increase in land values were driven by declines in the cost of land assembly, then we should expect to see greater land assembly in 1873.

Some plots in the burned area were made smaller, however, due to road widening. Appendix Table 7, columns 5 to 8, report estimates that exclude plots of land in the burned area that were subject to road widening. Excluding those plots directly impacted by road widening, there are small increases in plot size from 1872 to 1873 and larger increases in later periods.[54]

Quantitatively, the observed increases in plot size would not explain the estimated increases in land value from 1872 to 1873. Focusing on the increase in plot sizes for areas without road widening, and assuming that the doubling of plot size provides a land premium of 13%,[55] a 10% increase in plot size would generate approximately a 1.3% increase in land value. In addition, this premium would be offset by areas losing plot size along with road widening. Further, the estimated land value premiums decline in later periods even as land assembly increases.

If we assume there are returns to land assembly, then it is interesting to consider the absence of substantial land assembly immediately after the Fire. The Fire provided an opportunity to assemble land without the need to coordinate on demolition of neighboring buildings, which suggests that rigidities in land assembly are more related to hold-up and transactions costs associated with the land itself. This interpretation is consistent with the

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[54] Quantile regressions indicate that these average impacts are driven by a decline in the number of small plots.

[55] Log land value per square foot is positively correlated with log plot size (coefficient of 0.119, standard error of 0.047), prior to the Fire and controlling for plots' distance from the Old State House as a proxy for distance from the central business district. We do not claim that this estimate reflects the causal impact of plot size on land value, but the assumed land value premium of 13% reflects this cross-sectional estimate.

importance of land market rigidities even in rural agricultural areas (Libecap and Lueck, 2011).

*Ownership Concentration.* The Fire might also lead to a concentration of land ownership in the burned area. Landowners might combine their own existing plots, buy-out neighbors to combine plots, or buy-out neighbors without combining plots to better coordinate redevelopment. Ownership might also concentrate in the burned area if some landowners were liquidity-constrained and induced to sell by the Fire.

Appendix Table 8 reports some basic statistics on the number of unique landowners in the burned area and unburned areas, over time.[56] There was a general decline in the number of unique owners over time, and a more rapid decline from 1872 to 1873 (columns 1-4). The magnitudes are fairly small, however, and 8 of the 19 owners that exited were a direct consequence of road changes eliminating their landholdings in the burned area. Further, we do not see evidence of some particular landowners greatly increasing their landholdings: only 2 landowners owned 3 more plots in the burned region in 1873 than in 1872, 10 landowners owned 2 more plots in 1873 than in 1872, and 85 landowners owned 1 more plot in 1873 than in 1872.

A similar exercise shows changes over time in the number of plots in the burned area and unburned areas (Appendix Table 8, columns 5-8). There were general declines in the number of plots over time, with a more rapid decline from 1872 to 1873. The magnitudes are also small, however, and 20 of the 61 plots eliminated were a direct consequence of road changes.

The Fire might have impacted landowners' incentives by concentrating landownership amongst a smaller group of wealthier landowners. We find little evidence for this mechanism, however. Dividing land holdings into the burned and unburned areas, we do not find differential changes in the concentration of landownership in the burned area (either in the log number of plots per owner or in the log land area per owner). In a related exercise, we do not find a systematic change in the total number of plots or total land holdings of individuals or trusts that owned land in the burned area after the Fire, which would reflect a change in the composition of landowners toward wealthier and potentially less credit constrained owners.

Overall, there were some small relative declines in the number of landowners. There is no indication, however, of small landowners in the burned area systematically selling off their properties. Landownership remained highly fractured, and there were few mechanisms for

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[56] Measuring the number of unique owners is challenging, due to multiple alternative spellings and ownership vehicles (trusts, associations, partnerships, etc.) under which a single individual might register land ownership. We have attempted to reconcile as many of these as possible through manual matching; nevertheless, ownership names remain noisy.

landowners to internalize their spillover effects on neighbors. Despite the Fire, we expect that reconstruction was still well below efficient levels of quality due to the inability to internalize spillover effects on nearby areas.

*Business Agglomeration.* The Fire may have allowed business owners to locate more efficiently, thereby increasing productivity in the burned area. We focus on whether industries took advantage of potential vacancies to agglomerate more closely, which is one of the more standard desirable features in firms' location decisions. We calculate a measure of spatial agglomeration (Ripley's $L$ function) for the 18 industries that had more than three establishments inside and outside the burned area in all sample years. We then consider how these industry-level statistics changed relatively in the burned area.

The $L$ function provides a normalized measure of the number of same-industry establishments within a radius $r$ of each establishment, relative to the number of establishments that would be expected under perfect spatial randomness (following Ripley, 1977). For industry $i$ with $N_{ib}$ establishments in an area $b$ with square footage $A_b$, let $\lambda_{ib}$ be the sample estimate of the density of establishments per square foot: $\lambda_{ib} = N_{ib}/A_b$. The value of $L_{ib}$ for radius $r$, is then given by:

$$L_{ib}(r) = \sqrt{\lambda_{ib}^{-1}\sum_{k=1}^{N_i}\sum_{j=1,j\neq k}^{N_{ib}} \mathbb{I}\left[d(k,j)<r\right]/\pi N_i} - r, \tag{5}$$

where $\mathbb{I}\left[d(k,j)<r\right]$ is an indicator function equal to one if firms $k$ and $j$ are within distance $r$ of each other. We calculate $L_{ib}(r)$ for three radius values (50, 100, 200) for 18 industries in 1867, 1872, 1882, and 1894.[57]

Values of $L_{ib} > 0$ are associated with greater agglomeration, whereas negative values signify a more uniform dispersion than would occur given a random distribution of points. A value of $L_{ib}$ equal to $-r$ is associated with complete dispersion (i.e, no establishments in industry $i$ have other establishments from industry $i$ with $r$ feet). A value of $L_{ib}$ equal to $\sqrt{A_b/\pi} - r$ is associated with complete agglomeration (i.e., all establishments in industry $i$ are within $r$ feet of each other).

To mitigate "edge effects," we do not consider firms within $r$ feet of the sample boundary in the outer summation, indexed by $k$, in equation 5. These firms near the boundary are included as potentially being part of clusters of firms near the non-boundary firms and are included in the $j$-indexed inner summation. Similarly, firms across the boundary of the burned area are counted as potentially being part of the cluster of firms on the other size of the boundary. Edges of the sample area that intersect with the ocean or the Boston Common

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[57] We exclude 1873 because many buildings were unoccupied then in the burned area.

(a large park) are not counted as boundaries since firms near these edges chose to locate in spots where the potential for agglomeration was naturally limited.

Appendix Table 9 presents these estimates of agglomeration, by industry, for the burned area and unburned areas.[58] Most industries display some clustering, but there is no systematic increase in industry agglomeration in the burned area, relative to the unburned area, from 1872 to 1882 (column 8) or from 1872 to 1894 (column 9). Industries appear to become somewhat less agglomerated over time in the burned area, especially the more common industries, though some industries become more agglomerated.

Appendix Table 10 reports estimated impacts on industry agglomeration in the burned area, relative to unburned areas. The estimating equations are analogous to before, but use the calculated $L_{ib}(r)$ values to characterize the degree of agglomeration in each industry and year, and weight each observation by the total number of sample establishments in its industry-year.[59] There is no indication of increased agglomeration in the burned area, and some indication of a decline in industrial agglomeration when controlling for industries' level of agglomeration in 1867 and 1872 (columns 2, 4, 6).

These results do not immediately support the hypothesis that changes in business location are driving the observed increases in land values, as much of the existing literature has argued that industry agglomeration is productivity enhancing. The literature has primarily examined the equilibrium relationship between clustering and productivity, however, rather than the transitional dynamics. It is possible that certain industries had become overly clustered prior to the Fire, and the increases in dispersion were associated with efficiency gains.

*Occupant Sorting.* The Fire may induce differential sorting of residents and commercial establishments, along with changes in building quality. For example, while industries did not become systematically more agglomerated in the burned area, there may have been displacement of particular industries that generate negative spillovers on neighbors. The spillover effects we estimate may work both through the direct effects of building quality as well as through the characteristics of the occupants of higher quality buildings.

We begin by considering the number of commercial and residential occupants, which we measure as the number of assessed occupants per 1000 square feet.[60] Appendix Table 11, columns 1 and 2, report increases in the number of commercial occupants following the initial decline in the immediate aftermath of the Fire. By contrast, columns 3 and 4 report declines in the number of residential occupants. Overall, there was a temporary decline in

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[58] For this Appendix Table, the distance radius is set to 100 feet.

[59] The results are robust to unweighted regressions.

[60] Tax assessment data report the number of commercial establishments and the number of male residents over 20 years of age.

the total number of occupants. These results suggest the fire caused a shift in neighborhood composition towards commercial uses, which may have been one channel through which positive spillovers operated.[61]

An analysis of occupants' capital value is greatly complicated by censoring, which is unfortunately inherent to the assessment of taxable property. Property was only taxed, and therefore assessed, for occupants whose income was greater than \$1000. We have an extreme censoring problem – even the median is censored – as many occupants had lower incomes and so their value of capital is unobserved. Appendix Table 11, columns 5 – 8, report estimated impacts on log capital per square foot when assigning a value of 500 to these missing values.[62] There is some indication of increased capital values of commercial establishments (column 6), but only after controlling for pre-Fire values and there is a differential trend in commercial capital value from 1867 to 1872. In contrast to the analysis of land value, there is no sense in which capital values in 1872 would already capitalize expected changes after 1872. There is also some indication of higher residential capital value after the Fire (column 7), but not after controlling for pre-Fire values. We estimate similar patterns for an outcome variable that is equal to one for all positive capital valuations and equal to zero for all censored capital valuations.

In the end, there may be changes in building occupancy and capital investment that are one channel through which building reconstruction generates economic gains and influences neighbors. The estimates are sensitive to the empirical specification, however. In addition, it is ultimately the replacement of buildings that drives changes in occupancy patterns (as in Brueckner and Rosenthal, 2009). Thus, our interpretation generally focuses on spillovers from higher quality buildings, with the understanding that these spillovers may operate in part through "higher quality" occupants.

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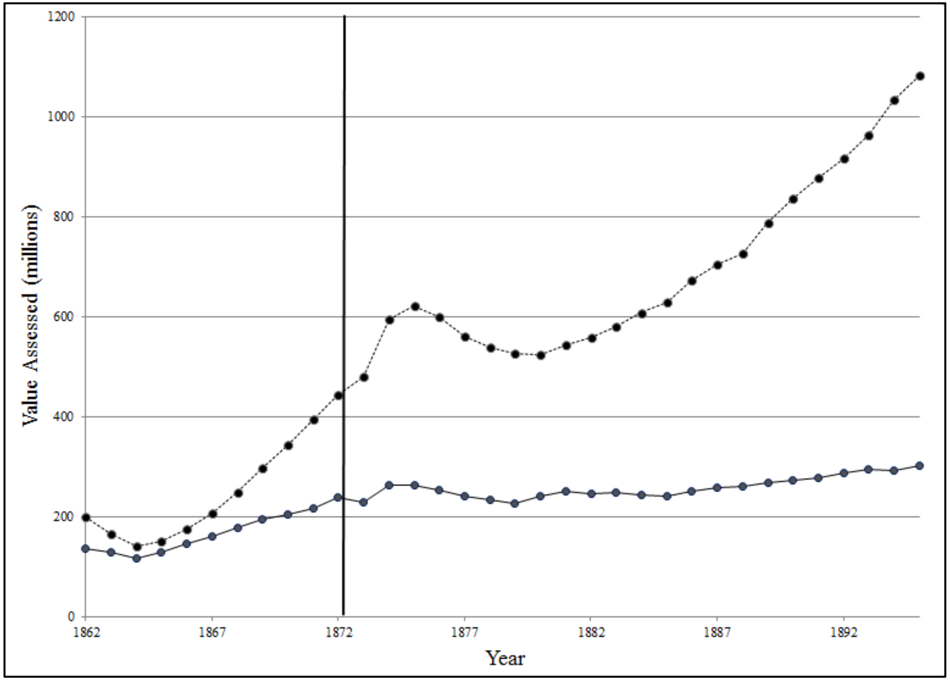
[61] These results should be interpreted with caution, however, as there was a pre-Fire trend towards lower residential density. In contrast to the analysis of land value, there is no sense in which 1872 residential density already capitalizes future changes in residential density.

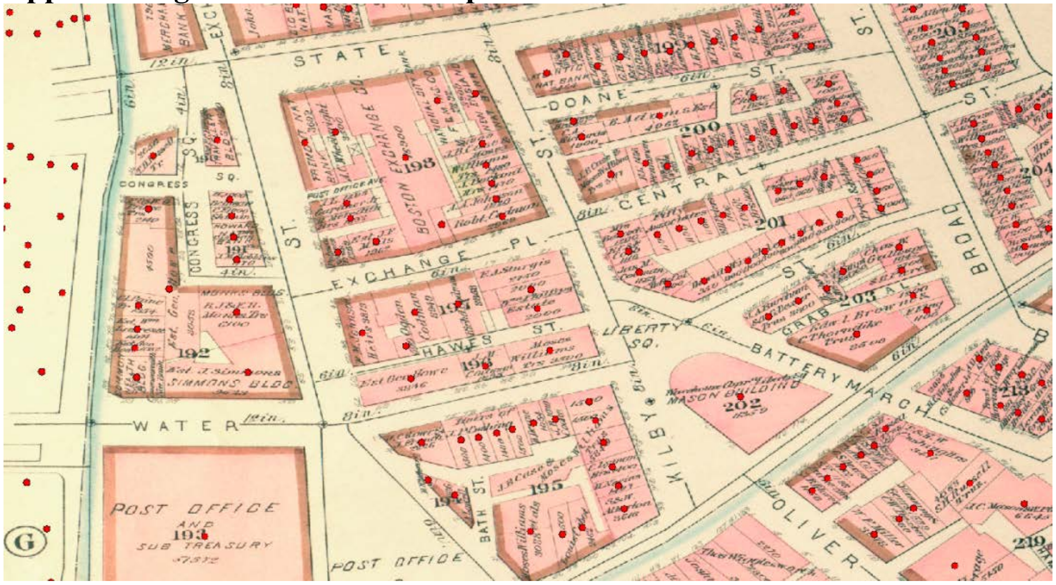
[62] Capital values of 500 are among the lower common values, and the estimates are similar when assigning values of 50 or 100 that are among the lowest values observed.

## Appendix Figure 1. Total Assessed Value of Boston Real Estate and Personal Property



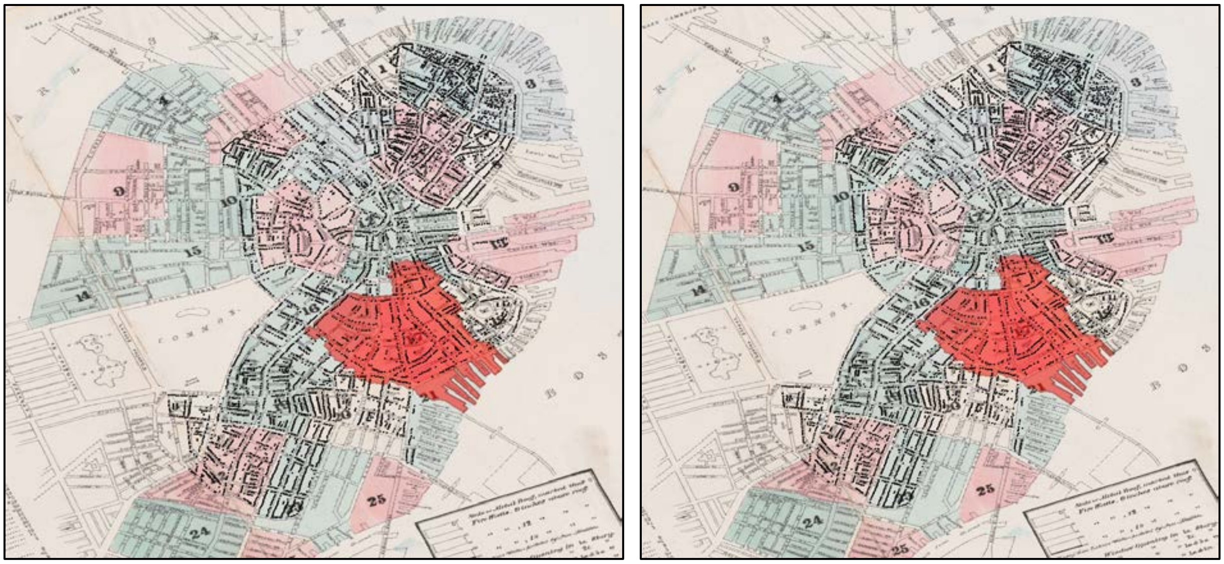
Notes: The upper line reflects the total assessed value of real estate, and the lower line reflects the total assessed value of property from the City of Boston's assessment record books (Boston Tax Records, 1822-1918. City of Boston, Boston Archives, available at the Office of City Clerk Archives and Records Management Division, 201 Rivermoor St., West Roxbury, MA 02132.). All values are converted to constant 1872 dollars using the David-Solar CPI (Lindert and Sutch 2006). The vertical line denotes the year of the Boston Fire.

## Appendix Figure 2. Plot-level Map with Detailed Information and Geo-Located Points



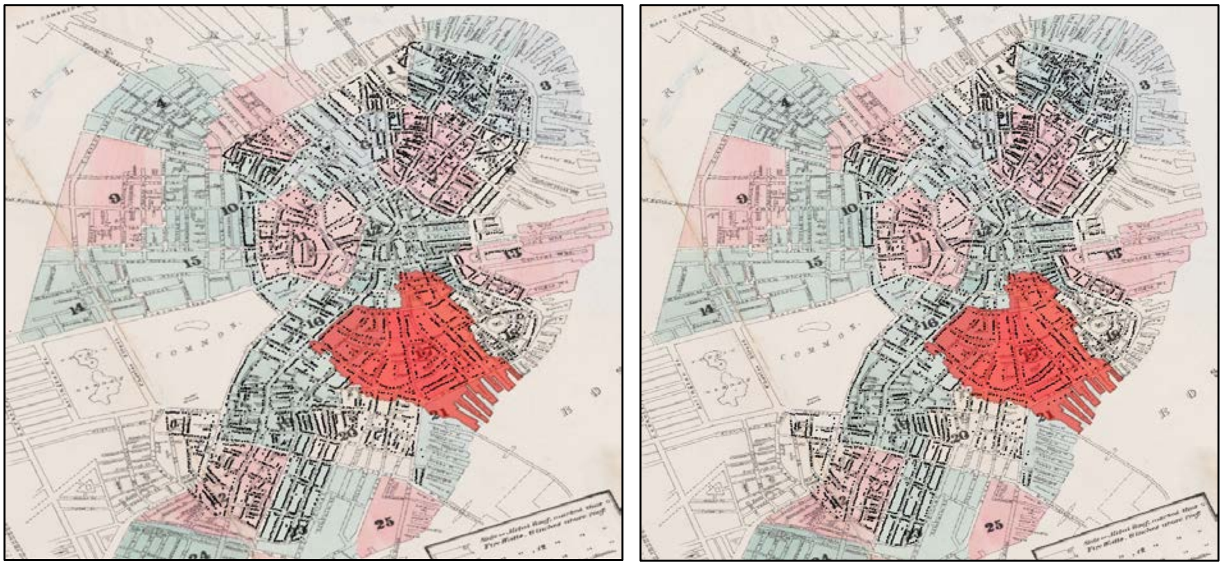
Notes: Detailed plot-level maps, such as the one above, are georeferenced to the Boston-wide map. These detailed maps often provide the plots' square footage and owner name. The overlaid red dots correspond to each plot and are assigned to particular tax assessment records.

**Appendix Figure 3. Sample Plot Locations in Each Subsequent Year**



Panel A. Plot Locations in 1872

Panel B. Plot Locations in 1873



Panel C. Plot Locations in 1882

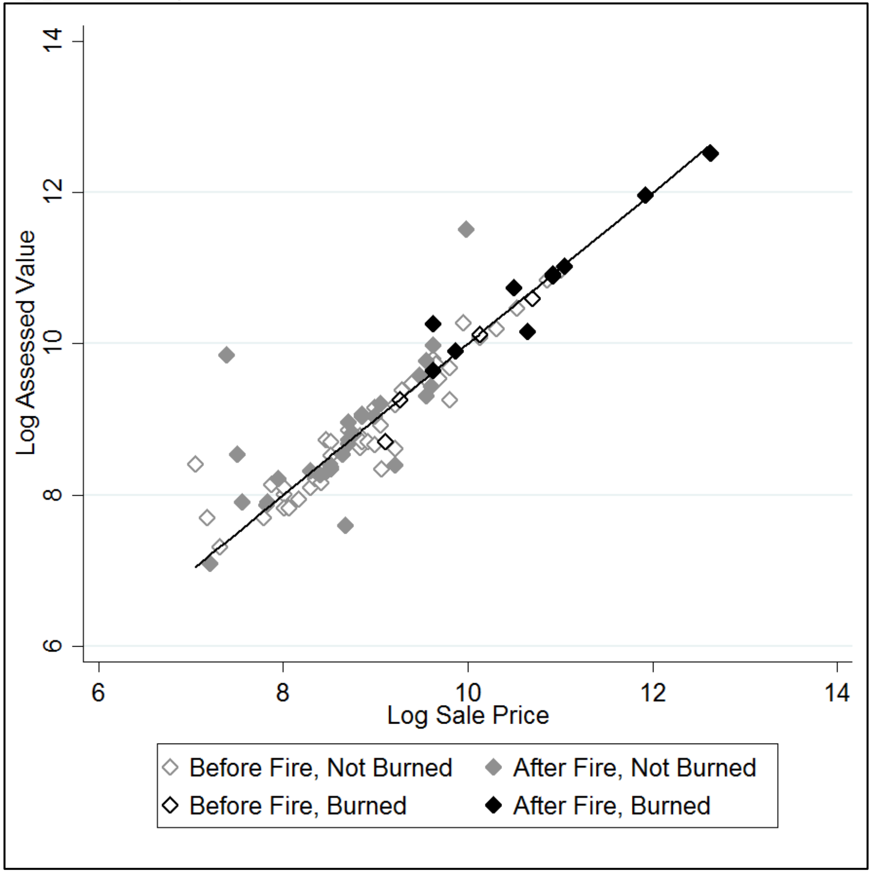
Panel D. Plot Locations in 1894

Notes: Each black point reflects one geo-located plot in our main sample for the indicated year. These points are overlaid on a map of Boston in 1867 and the area burned in 1872 (as in Figure 1).

## Appendix Figure 4. Post-Fire Changes in Boston Roads

Notes: Pink areas of the burned district were purchased by the City for road widening and Post Office Square.

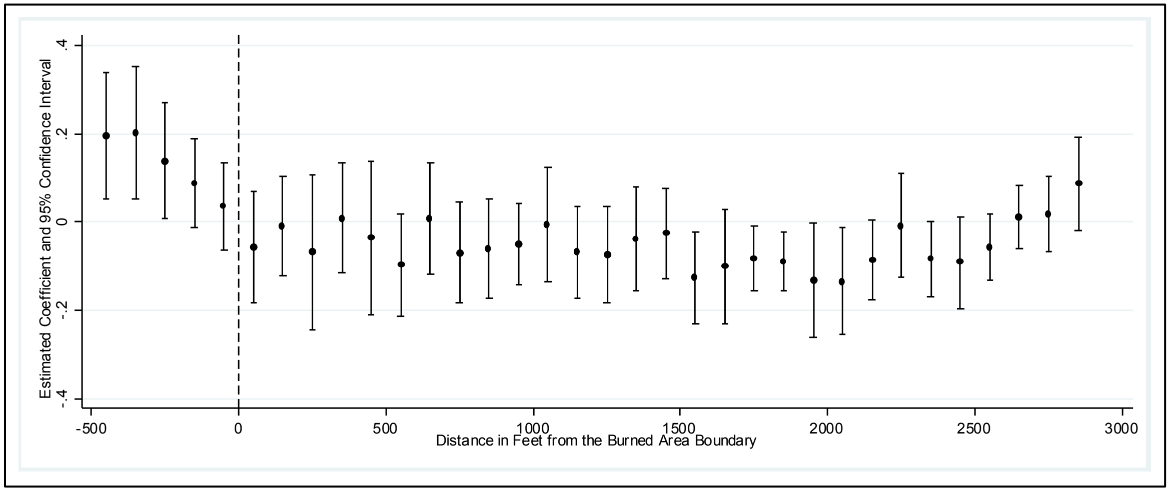
## Appendix Figure 5. Plot Assessed Value vs. Plot Sale Price



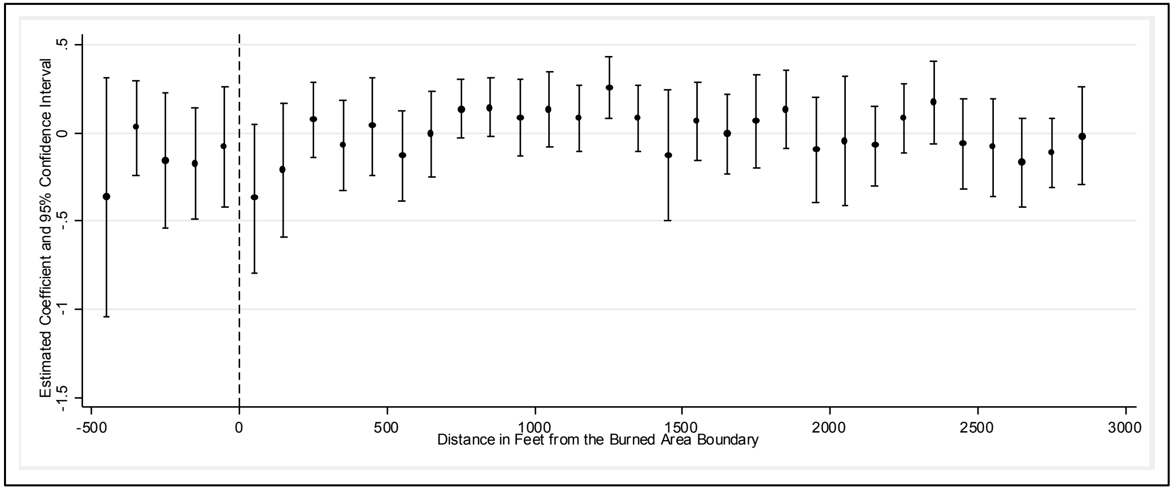
Notes: Log Assessed Value is plotted against Log Sale Price for a sample of 88 plots: 16 plots in the burned area (black) and 72 plots outside the burned area (gray). Plot observations are hollow diamond shapes when observed before the Boston Fire, and solid diamonds when observed after the Fire. Log Assessed Value is from the tax assessments, and Log Sale Price is from Boston's Registry of Deeds. Plots are shown against the 45-degree line.

## Appendix Figure 6. Estimated Differences in Values in 1867, Relative to 1872, by Distance to the Fire Boundary (in Feet)

Panel A. Estimated Differences in Land Value



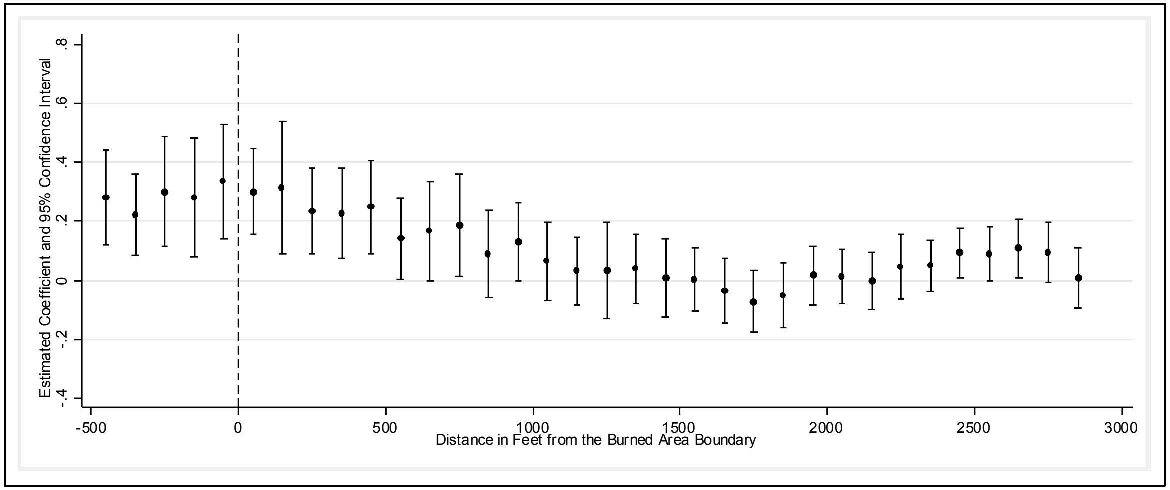
Panel B. Estimated Differences in Building Value



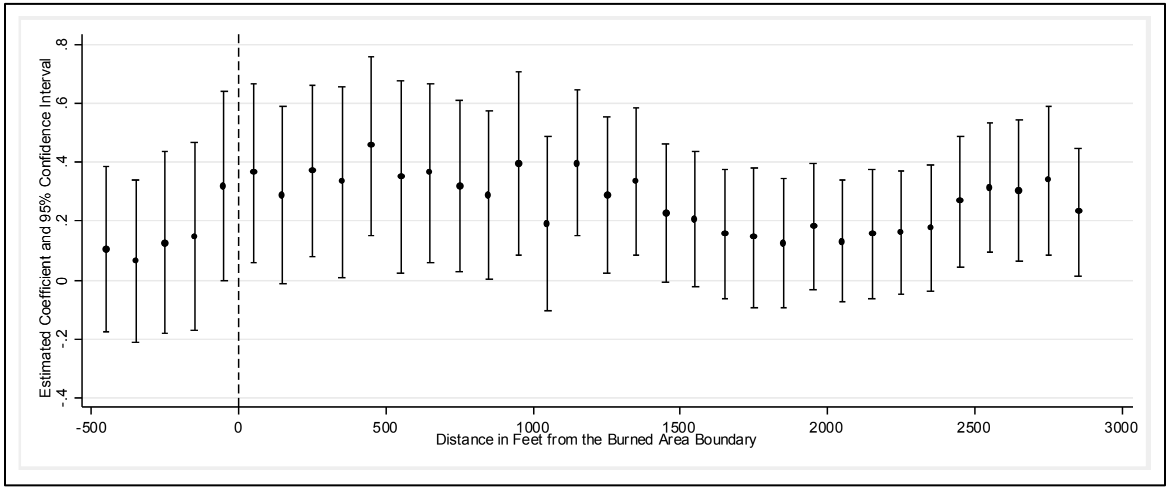
Notes: For the indicated distance from the boundary of the burned area, each circle reports the estimated impact on value in 1867 relative to 1872 (e.g., positive coefficients represent a decline from 1867 to 1872). Panel A presents estimates for the log value of land per square foot, and Panel B presents estimates for the log value of building per square foot. The specification does not include controls for plots' pre-Fire outcomes. The omitted category is plots more than 2900 feet from the burned area. Negative distances reflect areas within the burned area, and burned plots more than 400 feet from the Fire boundary are grouped together.

## Appendix Figure 7. Estimated Changes in Land Value by Distance to the Fire Boundary (in Feet)

Panel A. Estimated Impact in 1882, Relative to 1872



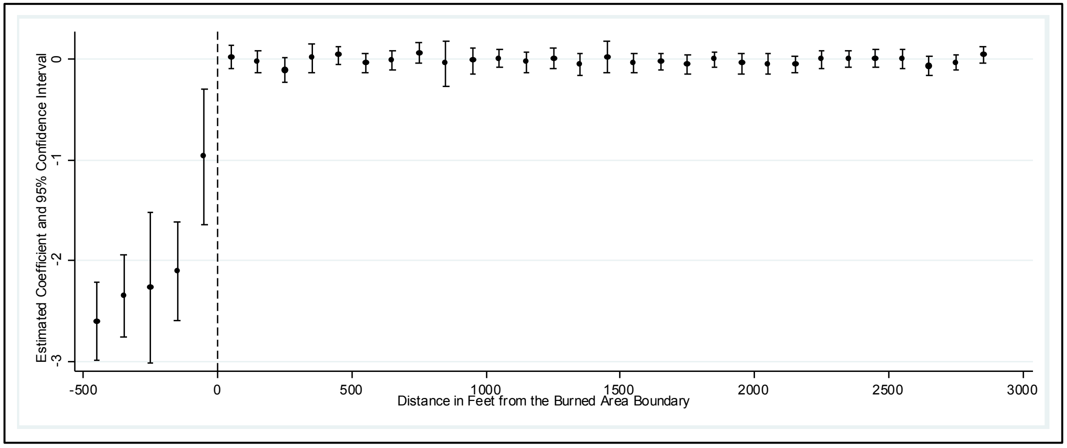
Panel B. Estimated Impact in 1894, Relative to 1872



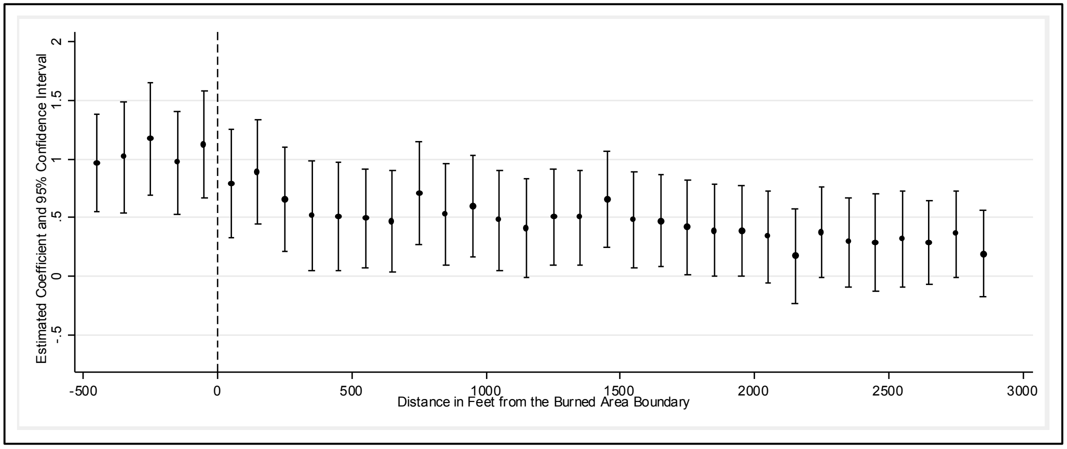
Notes: For the indicated distance from the boundary of the burned area, Panel A reports estimated changes from 1872 to 1882 and Panel B reports estimated changes from 1872 to 1894 (each circle reports the point estimate and the vertical lines reflect 95% confidence intervals). The omitted category is plots more than 2900 feet from the burned area. Negative distances reflect areas within the burned area, and burned plots more than 400 feet from the Fire boundary are grouped together. The empirical specification includes controls for plots' predicted land value in 1867 and 1872 based on block average and nearest neighbor.

## Appendix Figure 8. Estimated Impacts on Building Value, by Distance to the Fire Boundary (in Feet)

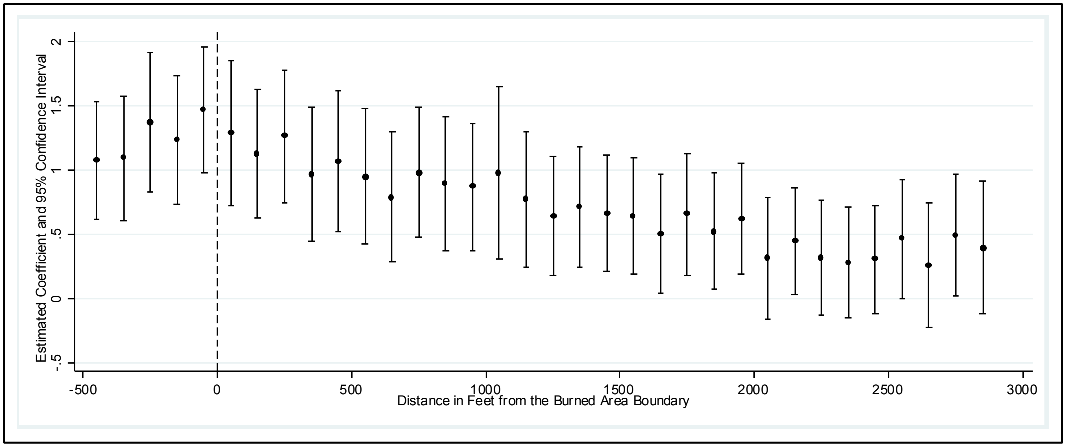
Panel A. Estimated Impacts in 1873



Panel B. Estimated Impacts in 1882



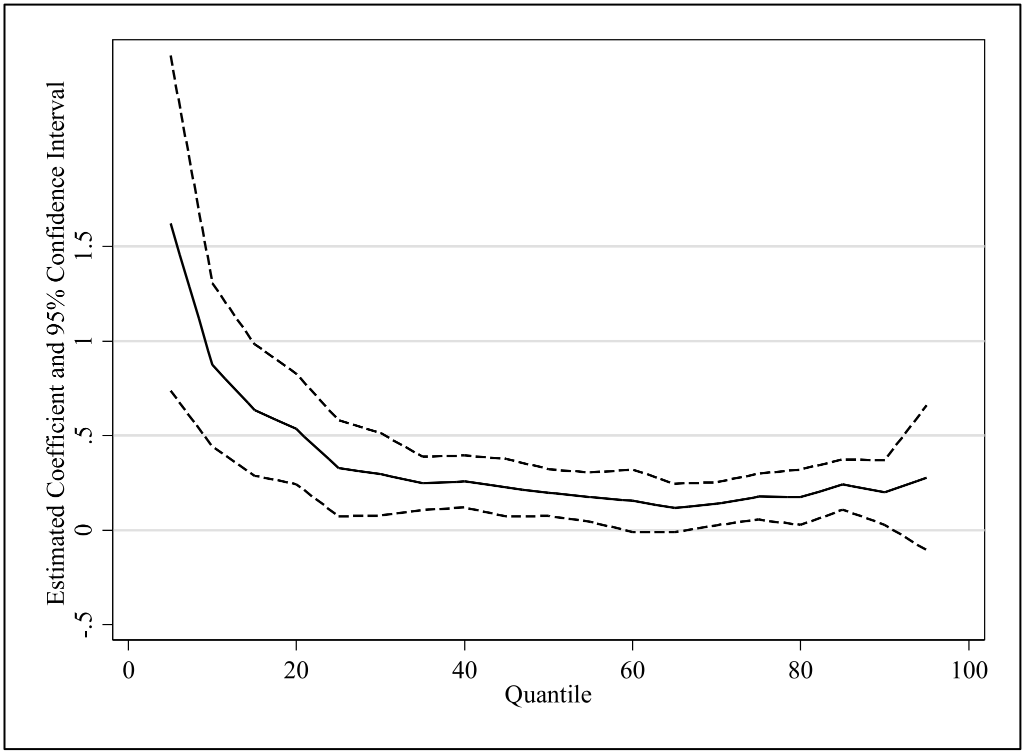
Panel C. Estimated Impacts in 1894



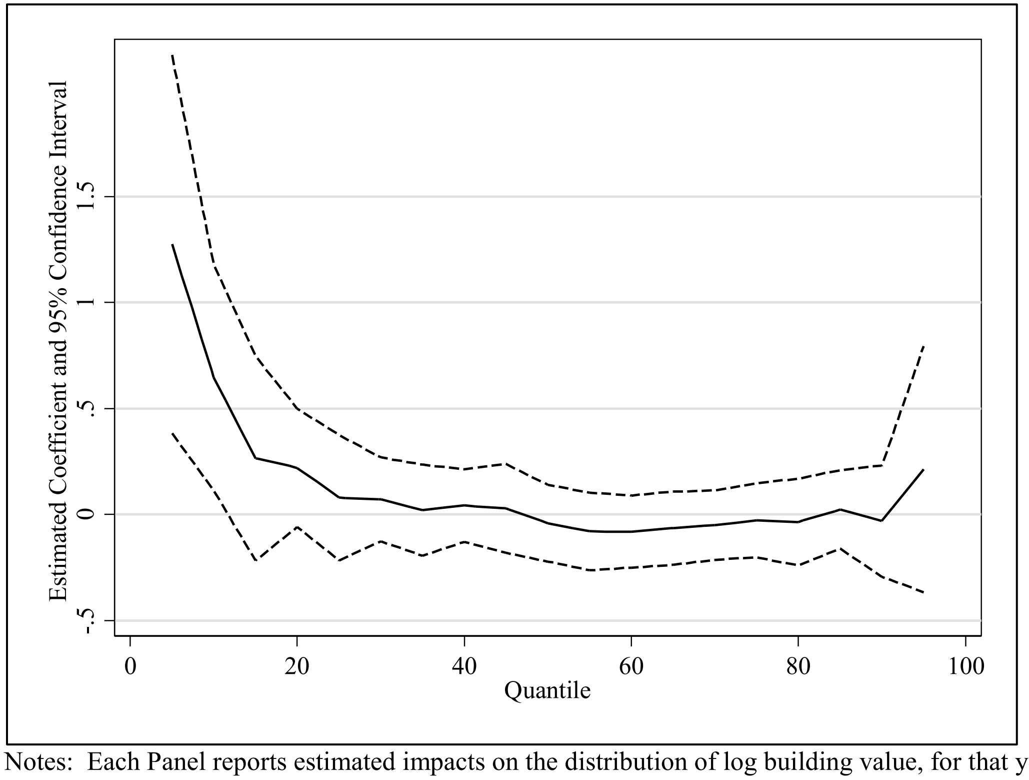
Notes: For the indicated distance from the boundary of the burned area, each circle reports the estimated change in building value from 1872 to the indicated year (by Panel). The vertical lines reflect 95% confidence intervals. The omitted category is plots more than 2900 feet from the burned area. Negative distances reflect areas within the burned area, and burned plots more than 400 feet from the Fire boundary are grouped together. The specifications include controls for plots' predicted building value in 1867 and 1872 based on block average and nearest neighbor.

**Appendix Figure 9. Estimated Impacts on Building Value in the Burned Area, by Quantile**

Panel A. Estimated Quantile Effects in 1882



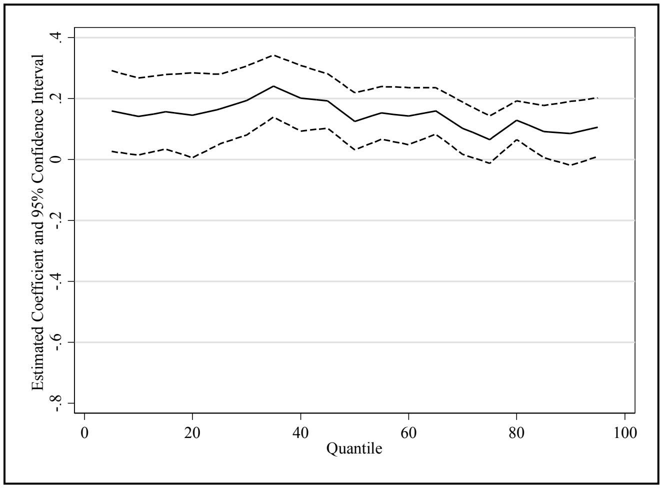
Panel B. Estimated Quantile Effects in 1894



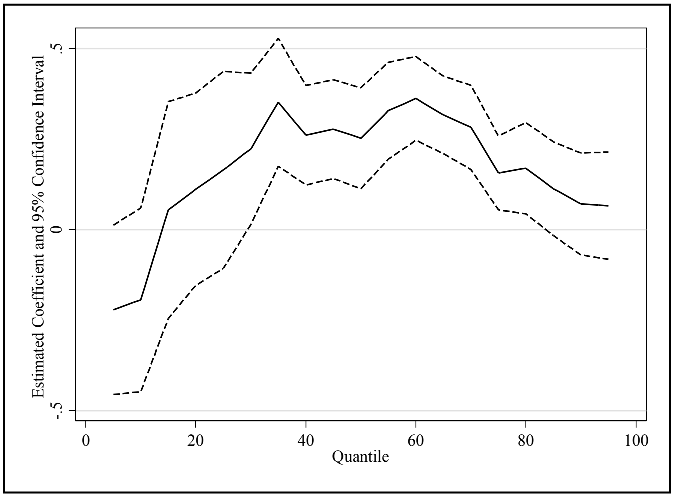
Notes: Each Panel reports estimated impacts on the distribution of log building value, for that year relative to 1872. Dashed lines report 95% confidence intervals, based on bootstrapped standard errors clustered by block.

## Appendix Figure 10. Estimated Impacts on Land Value in the Burned Area, by Quantile

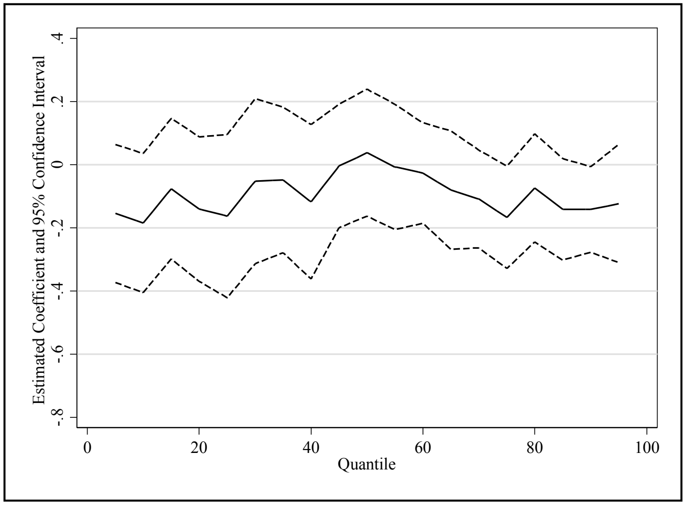
### Panel A. Estimated Quantile Effect in 1873



### Panel B. Estimated Quantile Effect in 1882

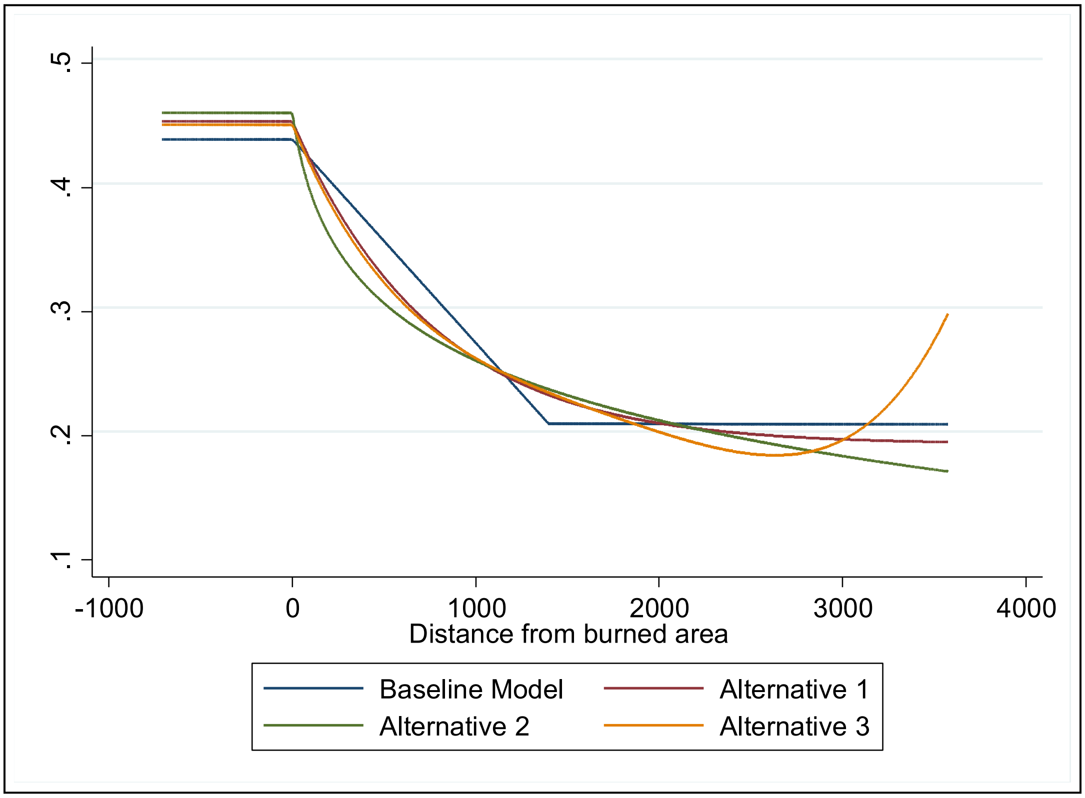


### Panel C. Estimated Quantile Effect in 1894



Notes: Each Panel reports estimated impacts on the distribution of log land value, for that year relative to 1872. Dashed lines report 95% confidence intervals, based on bootstrapped standard errors clustered by block.

## Appendix Figure 11. Functional Forms for Estimating Total Impact on Land Value



Notes: The baseline model shows the estimated functional form, based on equation 4 in the Appendix, which parameterizes the results shown in Figure 5. Alternative models 1 to 3 report alternative estimated functional forms, as described in Section A of the Appendix.

## Appendix Table 1. Average Log Sale Value Minus Log Assessed Value

| | After Fire: 1882 and 1894 (2) | Before Fire: 1867 and 1872 (1) | Difference: (2) - (1) (3) |
|---|---|---|---|
| Burned Area | -0.042 | 0.083 | -0.125 |
| | [0.297] | [0.162] | (0.119) |
| Unburned Area | -0.143 | 0.030 | -0.173 |
| | [0.631] | [0.312] | (0.124) |
| Difference | 0.102 | 0.054 | 0.048 |
| | (0.151) | (0.078) | (0.169) |

Notes: Based on data from Boston's Registry of Deeds, matched to our tax assessment database, cells report the average log difference in sale price and assessed value of plots (sale price - assessed value). Column 1 reports estimates from after the Fire (in 1882 and 1894), and Column 2 reports estimates from before the Fire (in 1867 and 1872). Row 1 reports estimates in the Burned Area, and Row 2 reports estimates in the Unburned Area. Standard deviations are reported in brackets. Row 3 reports the difference in the Burned Area, relative to the Unburned Area; and Column 3 reports the difference after the Fire, relative to before the Fire. Column 3, row 3, reports the difference-in-difference estimate. The sample includes 72 plots in the Unburned Area, and 16 plots in the Burned Area. Robust standard errors are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

## Appendix Table 2. Robustness to Conley Standard Errors at Varying Cutoffs

| | Log Value per Square Foot | | | |
|---|---|---|---|---|
| | Land Value | | Building Value | |
| | Full Sample (1) | Restricted Sample (2) | Full Sample (3) | Restricted Sample (4) |
| 1873 x Burned | 0.172 | 0.133 | -2.016 | -2.011 |
| Clustered by Block | (0.018) | (0.021) | (0.168) | (0.171) |
| 250 foot cutoff | (0.019) | (0.020) | (0.164) | (0.167) |
| 750 foot cutoff | (0.021) | (0.025) | (0.257) | (0.259) |
| 1,250 foot cutoff | (0.022) | (0.027) | (0.247) | (0.247) |
| 1,750 foot cutoff | (0.018) | (0.022) | (0.208) | (0.209) |
| | | | | |
| 1882 x Burned | 0.144 | 0.083 | 0.511 | 0.441 |
| Clustered by Block | (0.042) | (0.046) | (0.055) | (0.049) |
| 250 foot cutoff | (0.039) | (0.041) | (0.059) | (0.058) |
| 750 foot cutoff | (0.058) | (0.061) | (0.065) | (0.062) |
| 1,250 foot cutoff | (0.064) | (0.068) | (0.051) | (0.048) |
| 1,750 foot cutoff | (0.058) | (0.064) | (0.045) | (0.039) |
| | | | | |
| 1894 x Burned | -0.145 | -0.188 | 0.410 | 0.246 |
| Clustered by Block | (0.060) | (0.073) | (0.080) | (0.069) |
| 250 foot cutoff | (0.054) | (0.062) | (0.076) | (0.071) |
| 750 foot cutoff | (0.094) | (0.115) | (0.096) | (0.095) |
| 1,250 foot cutoff | (0.112) | (0.133) | (0.081) | (0.079) |
| 1,750 foot cutoff | (0.109) | (0.133) | (0.081) | (0.066) |
| | | | | |
| Controls: | | | | |
| Year Fixed Effects | X | X | X | X |
| Year FE x Pre-Fire Block Average | X | X | X | X |
| Year FE x Pre-Fire Neighbor Value | X | X | X | X |
| | | | | |
| R-squared | 0.987 | 0.991 | 0.902 | 0.934 |
| Number of Plots | 31302 | 11367 | 30198 | 10595 |

Notes: The reported coefficients correspond exactly to those reported in Table 2 and Table 4: column 1 corresponds to Table 2, column 4; column 2 corresponds to Table 2, column 8; column 3 corresponds to Table 4, column 4; and column 4 corresponds to Table 4, column 8. For each coefficient, alternative standard errors are reported based different assumed distance cutoffs in the estimation of Conley standard errors (Conley 1999): 250 feet, 750 feet, 1,250 feet, and 1,750 feet. As a basis of comparison, we also report our main standard errors that are clustered by block.

## Appendix Table 3. Robustness to Unweighted Specifications

| | Log Value per Square Foot | | | |
|---|---|---|---|---|
| | Land Value | | Building Value | |
| | Full Sample (1) | Restricted Sample (2) | Full Sample (3) | Restricted Sample (4) |
| 1873 x Burned | 0.192*** | 0.152*** | -1.693*** | -1.695*** |
| | (0.020) | (0.021) | (0.158) | (0.166) |
| 1882 x Burned | 0.147*** | 0.091* | 0.543*** | 0.494*** |
| | (0.048) | (0.052) | (0.058) | (0.051) |
| 1894 x Burned | -0.116* | -0.102 | 0.480*** | 0.377*** |
| | (0.064) | (0.074) | (0.064) | (0.060) |
| Controls: | | | | |
| Year Fixed Effects | X | X | X | X |
| Year FE x Pre-Fire Block Average | X | X | X | X |
| Year FE x Pre-Fire Neighbor Value | X | X | X | X |
| R-squared | 0.944 | 0.904 | 0.806 | 0.771 |
| Number of Plots | 31302 | 11367 | 30198 | 10595 |

Notes: The reported specifications correspond to those reported in Table 2 and Table 4, but not weighting the regressions by plot size. Robust standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

## Appendix Table 4. Robustness to Controlling for Distance to Old State House

| | Log Value per Square Foot | | | |
|---|---|---|---|---|
| | Land Value | | Building Value | |
| | Full Sample (1) | Restricted Sample (2) | Full Sample (3) | Restricted Sample (4) |
| 1873 x Burned | 0.174*** | 0.133*** | -2.014*** | -2.009*** |
| | (0.018) | (0.021) | (0.168) | (0.171) |
| 1882 x Burned | 0.142*** | 0.085* | 0.480*** | 0.445*** |
| | (0.041) | (0.043) | (0.051) | (0.045) |
| 1894 x Burned | -0.153*** | -0.178*** | 0.357*** | 0.245*** |
| | (0.058) | (0.065) | (0.072) | (0.066) |
| Controls: | | | | |
| Year Fixed Effects | X | X | X | X |
| Year FE x Pre-Fire Block Average | X | X | X | X |
| Year FE x Pre-Fire Neighbor Value | X | X | X | X |
| R-squared | 0.939 | 0.898 | 0.794 | 0.750 |
| Number of Plots | 31302 | 11367 | 30198 | 10595 |

Notes: The reported specifications correspond to those reported in Table 2 and Table 4, but include year-interacted controls for plots' distance to the Old State House (as a proxy for distance to the center of the central business district). Robust standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

## Appendix Table 5. Estimated Impact on Land and Building Value in 2012

| | Log Total Value per Square Foot | | | |
|---|---|---|---|---|
| | Full Sample | | Restricted Sample | |
| | (1) | (2) | (3) | (4) |
| 1867 x Burned | 0.081 | - | 0.069 | - |
| | (0.050) | ( ) | (0.054) | ( ) |
| 1872 x Burned | 0 | 0 | 0 | 0 |
| | ( ) | ( ) | ( ) | ( ) |
| 2012 x Burned | 0.123 | 0.569*** | 0.108 | 0.266 |
| | (0.217) | (0.207) | (0.233) | (0.209) |
| Controls: | | | | |
| Year Fixed Effects | X | X | X | X |
| Year FE x Pre-Fire Block Average | | X | | X |
| Year FE x Pre-Fire Neighbor Value | | X | | X |
| R-squared | 0.842 | 0.928 | 0.863 | 0.932 |
| Number of Plots | 15382 | 15382 | 5491 | 5491 |

Notes: For all specifications, the outcome variable is the log total value of land and buildings per square foot. From estimating equation 1 in the text, column 1 reports the estimated difference between plots in the burned area and plots in the unburned area in the indicated year, relative to the omitted year of 1872. From estimating equation 2 in the text, column 2 includes controls for plots' predicted characteristics prior to the Fire, based on their block and nearest neighbor. Columns 3 and 4 correspond to columns 1 and 2, but for the restricted sample of plots within 1000 feet of the Fire boundary. The regressions are weighted by plot size. Robust standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

## Appendix Table 6. Robustness to Excluding Plots With Road Widening

| | Log Value per Square Foot | | | |
|---|---|---|---|---|
| | Land Value | | Building Value | |
| | Full Sample (1) | Restricted Sample (2) | Full Sample (3) | Restricted Sample (4) |
| 1873 x Burned | 0.148*** | 0.108*** | -1.852*** | -1.841*** |
| | (0.019) | (0.023) | (0.202) | (0.211) |
| 1882 x Burned | 0.100** | 0.040 | 0.439*** | 0.374*** |
| | (0.046) | (0.048) | (0.051) | (0.047) |
| 1894 x Burned | -0.192*** | -0.239*** | 0.353*** | 0.178** |
| | (0.067) | (0.078) | (0.097) | (0.081) |
| Controls: | | | | |
| Year Fixed Effects | X | X | X | X |
| Year FE x Pre-Fire Block Average | X | X | X | X |
| Year FE x Pre-Fire Neighbor Value | X | X | X | X |
| R-squared | 0.937 | 0.890 | 0.784 | 0.739 |
| Number of Plots | 30289 | 10354 | 29320 | 9717 |

Notes: The reported specifications correspond to those reported in Table 2 and Table 4, but the sample excludes plots that lost land for road widening (Appendix Figure 4). Robust standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

## Appendix Table 7. Estimated Impact on Plot Sizes in Burned Area, Relative to 1872

| | Log Plot Size | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Plots Unaffected by Road Widening | | | |
| | All Plots | | Restricted Sample | | All Plots | | Restricted Sample | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1867 x Burned | -0.069 | - | -0.063 | - | -0.094 | - | -0.089 | - |
| | (0.043) | ( ) | (0.043) | ( ) | (0.064) | ( ) | (0.064) | ( ) |
| 1872 x Burned | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) |
| 1873 x Burned | 0.006 | -0.014 | -0.001 | -0.021 | 0.061*** | 0.050** | 0.055** | 0.040 |
| | (0.023) | (0.025) | (0.024) | (0.026) | (0.021) | (0.023) | (0.023) | (0.025) |
| 1882 x Burned | 0.090* | 0.067** | 0.094* | 0.057 | 0.156*** | 0.137*** | 0.160*** | 0.126*** |
| | (0.046) | (0.033) | (0.047) | (0.038) | (0.055) | (0.036) | (0.056) | (0.040) |
| 1894 x Burned | 0.088* | 0.029 | 0.023 | 0.011 | 0.165*** | 0.091** | 0.100 | 0.067 |
| | (0.051) | (0.036) | (0.057) | (0.041) | (0.061) | (0.044) | (0.066) | (0.045) |
| Controls: | | | | | | | | |
| Year Fixed Effects | X | X | X | X | X | X | X | X |
| Year FE x Pre-Fire Block Average | | X | | X | | X | | X |
| Year FE x Pre-Fire Neighbor Value | | X | | X | | X | | X |
| R-squared | 0.058 | 0.818 | 0.074 | 0.805 | 0.039 | 0.819 | 0.056 | 0.811 |
| Number of Plots | 31353 | 31353 | 11381 | 11381 | 30340 | 30340 | 10368 | 10368 |

Notes: For all specifications, the outcome variable is the log number of square feet per plot. From estimating equation 1 in the text, column 1 reports the estimated difference between plots in the burned area and plots in the unburned area in the indicated year, relative to the omitted year of 1872. From estimating equation 2 in the text, column 2 include controls for plots' predicted characteristics prior to the Fire, based on their block and nearest neighbor (which is generally that same plot in the earlier year). Columns 3 and 4 correspond to columns 1 and 2, but for the restricted sample of plots within 1000 feet of the Fire boundary. Columns 5 to 8 correspond to columns 1 to 4, but excluding plots that had land taken for the widening of roads (Appendix Figure 4). The regressions are unweighted. Robust standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

## Appendix Table 8. Number of Unique Owners and Number of Plots, by Burned and Unburned Areas

| | Number of Owners | | Annual Percent Change | | Number of Plots | | Annual Percent Change | |
|---|---|---|---|---|---|---|---|---|
| | Burned (1) | Unburned (2) | Burned (3) | Unburned (4) | Burned (5) | Unburned (6) | Burned (7) | Unburned (8) |
| Panel A. Full Sample | | | | | | | | |
| 1867 | 402 | 3,534 | | | 620 | 6,120 | | |
| 1872 | 367 | 3,390 | -1.74 | -0.81 | 580 | 6,013 | -1.29 | -0.35 |
| 1873 | 346 | 3,401 | -5.72 | 0.32 | 519 | 5,970 | -10.52 | -0.72 |
| 1882 | 322 | 3,287 | -0.77 | -0.37 | 486 | 5,504 | -0.71 | -0.87 |
| 1894 | 309 | 3,097 | -0.34 | -0.48 | 465 | 5,076 | -0.36 | -0.65 |
| 2012 | | | | | 112 | 1,964 | -0.64 | -0.52 |
| Panel B. Restricted Sample | | | | | | | | |
| 1867 | 402 | 1261 | | | 620 | 1911 | | |
| 1872 | 367 | 1160 | -1.74 | -1.60 | 580 | 1837 | -1.29 | -0.77 |
| 1873 | 346 | 1177 | -5.72 | 1.47 | 519 | 1808 | -10.52 | -1.58 |
| 1882 | 322 | 1108 | -0.77 | -0.65 | 486 | 1693 | -0.71 | -0.71 |
| 1894 | 309 | 971 | -0.34 | -1.03 | 465 | 1462 | -0.36 | -1.14 |
| 2012 | | | | | 112 | 439 | -0.64 | -0.59 |

Notes: Columns 1 and 2 report the number of unique owner names in the burned area and unburned area, respectively. Columns 3 and 4 report the annual percent change from the period before in the number of unique owners. Columns 5 and 6 report the number of individual land plots in the burned area and unburned area, and columns 7 and 8 report the annual percent change in this number from the period before. Note that 8 of the 19 owner decline between 1872 and 1873, and 20 of the 61 plots eliminated between 1872 and 1873, were a direct consequence of road changes (Appendix Figure 4).

## Appendix Table 9. Industry-by-Industry Changes in Agglomeration (Ripley's L Function, 100 foot radius)

| | | Clustering Index | | | | | | Difference-in-Difference | |
|---|---|---|---|---|---|---|---|---|---|
| | | Burned Area | | | Unburned Area | | | Burned vs. Unburned | |
| | Obs. | 1872 | 1882 | 1894 | 1872 | 1882 | 1894 | 1872 to 1882 | 1872 to 1894 |
| Industry | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Shoes | 297 | 215 | 143 | 189 | 229 | 555 | 376 | -398 | -173 |
| Leather | 159 | 171 | 178 | 185 | 222 | 1167 | 1100 | -937 | -864 |
| Clothes | 112 | 93 | 154 | 166 | 153 | 134 | 238 | 80 | -13 |
| Liquors | 110 | 224 | 287 | -100 | 199 | 202 | 185 | 60 | -310 |
| Dry Goods | 107 | 108 | 101 | -100 | 276 | 380 | 283 | -111 | -214 |
| Hats | 107 | 169 | 412 | 204 | 200 | 233 | 231 | 210 | 3 |
| Tailor | 88 | 311 | 457 | 142 | 211 | 350 | 295 | 7 | -254 |
| Machinery | 50 | 248 | 130 | 28 | 498 | 331 | 223 | 49 | 54 |
| Hardware | 48 | 62 | 118 | 221 | 422 | 276 | 254 | 203 | 327 |
| Jewelry | 48 | 571 | 648 | 703 | 373 | 553 | 638 | -103 | -133 |
| Printer | 48 | 78 | 99 | 105 | 283 | 197 | 221 | 107 | 89 |
| Fancy Goods | 46 | 140 | -100 | 318 | 161 | -100 | 414 | 21 | -75 |
| Teams | 45 | 26 | -11 | 24 | 210 | 329 | -100 | -156 | 308 |
| Kitchen Goods | 37 | 87 | 216 | -100 | 181 | 500 | 289 | -190 | -295 |
| Cigars | 35 | 318 | 318 | -100 | 98 | 235 | 188 | -137 | -509 |
| Paper | 34 | 145 | 169 | 111 | 351 | 115 | 219 | 260 | 98 |
| Clothing Accessories | 18 | 152 | 412 | 142 | 627 | 264 | 289 | 624 | 328 |
| Cotton | 13 | 165 | 71 | -100 | -100 | 659 | -100 | -853 | -265 |

Notes: For the 18 most common identifiable industries, column 1 reports the number of times that industry is observed in 1872. Columns 2 to 4 report agglomeration index values for that industry in the burned area in 1872, 1882, and 1890. Higher values correspond to greater agglomeration: these values are generated by Ripley's L function with a distance radius of 100 feet, and refer to Section C of the Appendix for details. Columns 5 to 7 report estimates for the unburned area in 1872, 1882, and 1894. Column 8 reports the change from 1872 to 1882 in the burned area, relative to the change in the unburned area; Column 9 reports the change from 1872 to 1894 in the burned area, relative to the change in the unburned area.

## Appendix Table 10. Estimated Impacts on Industrial Agglomeration, Relative to 1872

| | Ripley's L Function | | | | | |
|---|---|---|---|---|---|---|
| | Radius = 50 ft. | | Radius = 100 ft. | | Radius = 200 ft. | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| 1867 x Burned | -4.9 | - | -35.3 | - | -69.0 | - |
| | (65.7) | ( ) | (62.1) | ( ) | (87.0) | ( ) |
| 1872 x Burned | 0 | 0 | 0 | 0 | 0 | 0 |
| | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) |
| 1882 x Burned | -23.9 | -62.5 | -160.8 | -148.6* | -236.6 | -156.1* |
| | (69.4) | (38.3) | (115.3) | (82.1) | (177.8) | (87.4) |
| 1894 x Burned | -33.6 | -106.4*** | -161.5* | -187.5** | -209.6 | -194.2* |
| | (41.7) | (31.4) | (84.1) | (87.7) | (155.6) | (96.5) |
| Controls: | | | | | | |
| Year Fixed Effects | X | X | X | X | X | X |
| Year FE x Industry L Value in 1867 | | X | | X | | X |
| Year FE x Industry L Value in 1872 | | X | | X | | X |
| R-squared | 0.199 | 0.68 | 0.136 | 0.433 | 0.114 | 0.431 |
| Industry-by-Year Observations | 144 | 144 | 144 | 144 | 144 | 144 |

Notes: For these estimates, the unit of observation is an industry-year pair in the burned area or unburned area. For each industry-year, its level of agglomeration is calculated using Ripley's L Function for a distance radius of 50 feet for columns 1 and 2, 100 feet for columns 3 and 4 (as shown in Appendix Table 9), or 200 feet for columns 5 and 6. Refer to Section C of the Appendix for details on this formula. As in the main estimating equations, each column then reports differences in the burned area relative to the unburned area for the indicated year, relative to differences in 1872. Columns 2, 4, and 6 include controls for that industry's level of agglomeration in 1867 and 1872. Standard errors are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

## Appendix Table 11. Estimated Impacts on Occupant Density and Value of Capital, Relative to 1872

| | Number of Assessed Occupants per 1,000 Square Feet | | | | Log Value of Capital per Square Foot (Assigning 500 to Zero Values of Capital) | | | |
|---|---|---|---|---|---|---|---|---|
| | Commercial | | Residential | | Commercial | | Residential | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1867 x Burned | 0.146** | - | 0.362*** | - | -0.540** | - | -0.029 | - |
| | (0.067) | ( ) | (0.067) | ( ) | (0.227) | ( ) | (0.054) | ( ) |
| 1872 x Burned | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) |
| 1873 x Burned | -0.294*** | -0.368*** | -0.327*** | -0.202*** | -4.409*** | -3.917*** | -0.073 | -0.128** |
| | (0.043) | (0.052) | (0.064) | (0.069) | (0.232) | (0.243) | (0.051) | (0.061) |
| 1882 x Burned | 0.268*** | 0.251*** | -0.404*** | -0.328*** | -0.062 | 0.994*** | 0.258*** | 0.008 |
| | (0.066) | (0.075) | (0.072) | (0.088) | (0.212) | (0.191) | (0.078) | (0.105) |
| 1894 x Burned | 0.340*** | 0.289*** | -0.283*** | -0.158 | -0.347 | 0.872*** | 0.209** | -0.244** |
| | (0.066) | (0.077) | (0.080) | (0.097) | (0.226) | (0.217) | (0.090) | (0.121) |
| Controls: | | | | | | | | |
| Year Fixed Effects | X | X | X | X | X | X | X | X |
| Year FE x Pre-Fire Block Average | | X | | X | | X | | X |
| Year FE x Pre-Fire Neighbor Value | | X | | X | | X | | X |
| R-squared | 0.02 | 0.534 | 0.053 | 0.559 | 0.139 | 0.641 | 0.044 | 0.689 |
| Number of Plots | 31353 | 31353 | 31353 | 31353 | 31353 | 31353 | 31353 | 31353 |

Notes: In columns 1 to 4, the outcome variable is the number of assessed occupants per 1,000 square feet (commercial occupants for columns 1 and 2, and residential occupants for columns 3 and 4). In columns 5 to 8, the outcome variable is the log value of capital per square foot. The value of capital is censored for many observations, as discussed in the text, and we assign a capital value of 500 to all missing values (after summing across all occupants in that plot). For all observations, we then divide by the square footage and take logs.

The estimating equations are otherwise as before. From estimating equation 1 in the text, the odd columns report the estimated difference between plots in the burned area and plots in the unburned area in the indicated year, relative to the omitted year of 1872. From estimating equation 2 in the text, the even columns include controls for plots' predicted characteristics prior to the Fire, based on their block and nearest neighbor (which is generally that same plot in the earlier year). The regressions are weighted by plot size. Robust standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.