Making the Move: The Impact of the 1906 San Francisco Disaster on Firm Relocations

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Abstract

This paper studies the impact of the 1906 San Francisco earthquake and fire on firm relocations and the spatial distribution of industries in the city. The disaster disrupted normal business activity through the destruction of over 28,000 buildings on more than 500 city blocks. Using data gathered from historical city business directories, this study estimates the impact of a large-scale disaster on firm relocations. Evidence reveals that burned-out firms were more likely to move to different city blocks after 1906 relative to firms on unburned blocks, so that the fire significantly increased the likelihood of relocating by at least 30 percentage points. Additionally, the average post-disaster move was nearly one-half mile in length. The study also provides an overview of industry localization before and after the disaster, revealing a large impact of the disaster. These outcomes imply that fixed investments, which represent commitments to current locations, discourage firm relocations.

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1 Introduction

The location patterns of firms have been the subject of much research and attention among urban economists and economic geographers. Studies often focus on the productivity benefits of industry clusters and the economic reasons behind observed location patterns. The impact of a large-scale disaster on such patterns, however, has been much less studied. The goal of this paper is to understand this phenomenon in the context of the 1906 San Francisco earthquake and fire, which destroyed more than 28,000 buildings on over 500 city blocks, thereby disrupting normal business activity. Did the disaster encourage firms to relocate in its wake, thereby impacting their spatial distribution within San Francisco? In answering this question, this paper seeks to understand the role of fixed investments in restraining firm relocations, which the fire eliminated for thousands of firms.

As Head and Mayer (2004) describe, there is a need to understand the relationship between large urban shocks and firm location patterns. Studies estimating the impact of such shocks have thus far focused on the implications for urban systems. Using the Allied bombings of Japanese cities during World War II as a shock to city size, Davis and Weinstein (2002) find that large shocks have little long-run impact on the population density of urban areas or the spatial organization of particular regions. In their paper on the bombing of German cities during the war, Brakman et al. (2004) test the hypothesis that such destruction had a large effect on city growth in subsequent years, finding evidence that large shocks have a significant, although temporary, effect on subsequent city population growth. These studies are primarily concerned with inter-city phenomena, showing that cities are able to recover and return to normal growth patterns fairly quickly following large disruptions.

As with previous studies, this paper exploits an exogenous shock in order to study a particular aspect of urban development or redevelopment. Koster et al. (2012) use a World War II bombing boundary to estimate the costs of regulation in the housing sector. Rosen

(1986) provides qualitative evidence of a large impact of the major fires that occurred in Chicago, Boston, and Baltimore around the turn of the twentieth century. For the few industries she studies, she finds a seemingly large impact of the Chicago and Boston fires on business location patterns, with relatively little impact in the Baltimore case.[1] Her study, however, does not quantify industry localization, nor does it determine if burned-out firms were relatively more likely to move than unburned businesses after the disasters. A study by Fales and Moses (1972) exploits the Chicago fire as a mechanism providing a clean slate upon which to rebuild and observes the post-disaster outcome in the city's industrial spatial distribution. However, the study provides no comparison to the pre-fire city. In a related study, Siodla (2013) finds a 40 percent relative increase in residential density upon reconstruction in San Francisco, suggesting that durable capital is an important barrier to redevelopment, a barrier that was swept away by the fire.

Using the case of San Francisco's disaster in 1906 as a natural-experiment setting, this paper compares pre- and post-disaster firm locations across well-defined treatment and control groups. Employing a border-discontinuity approach, the fire's boundary serves as the differential point of treatment, with firms located on either burned (treated) or unburned blocks at the time of the disaster. Using historical city directories to determine firm locations over time, this paper's main contribution is an estimate of the likelihood of firm relocations upon reconstruction from the San Francisco disaster, which provides insight into the role of fixed investments in restraining firm relocations. Evidence presented in the paper shows that burned-out firms, which became relatively freer to move after the disaster, were more likely to relocate relative to unburned firms and moved an average of nearly one-half mile away from their pre-disaster locations. The implication of this result is that firms are restrained from moving due to the costs associated with relocating and their fixed commitments to

[1] The Baltimore fire was smaller and less destructive than the Chicago and Boston fires, and certainly less so than the conflagration in San Francisco.

current locations (i.e., buildings and physical capital). In addition, the paper provides an overview of the impact of the shock on industry localization within the city.

San Francisco lost thousands of buildings through a disastrous occurrence, and the bigger the impact on firm relocations, the more influence fixed investments are seen to exert in determining long-run firm location outcomes. Studies have shown that city locations (Bleakley and Lin (2012)) and urban density (Brooks and Lutz (2013)) can persist for long periods of time, even well after the determinants of original outcomes are gone. Ultimately, since cities are concentrations of durable capital and are thus not malleable, a large shock is likely to have a profound impact on many urban outcomes, including firm location patterns. The goal of this paper is to determine whether firms are restrained from relocating under normal circumstances by estimating the likelihood of relocation when fixed investments are destroyed.

2 Historical Background

At the time of the disaster in 1906, San Francisco was experiencing the type of growth witnessed in many cities during this time of heavy U.S. industrialization. With over 340,000 people in 1900, the city's population grew over 20 percent between 1900 and 1910 (Issel and Cherny (1986, p. 24, Table 1)). The city's manufacturing sector was also experiencing growth leading into the time of the disaster, with 1,748 establishments in 1899 and 2,251 in 1904 (Douty (1977, p. 366, Table 29). Over this time period, there were also large increases in the number of wage earners employed in the manufacturing sector, as well as increases in total wages, capital, and output. While the disaster temporarily impacted these numbers for the worse, they were all higher than their 1904 levels in 1914 with the exception of the number of wage earners, which declined by nearly a fifth over this time period.

Although the fire was preceded by an earthquake, the bulk of the damage was caused by the fire. In total, 28,188 buildings were consumed across 2,831 acres of land. Figure 1 shows the coverage of the fire, which is represented by the darkest area on the map. The buildings in unburned areas suffered from the earthquake, but were much less compromised relative to those which burned. It is estimated that the fire's destruction represents at least 80 percent of the total damage inflicted by the disaster.[2]

Reconstruction was fairly rapid, one indicator of which is the number of building permits issued in each year following the fire itself. Data gathered from municipal reports show that city-wide building permit issuance returned to pre-disaster levels by 1914 (Siodla (2013)). Building over this time period largely occurred within a free market for land. Even a far-reaching plan developed just prior to the disaster to reorganize the city's layout was ignored upon reconstruction, suggesting that private interests were largely left to rebuild the city. Although attempts were made to implement new building codes, most aspects of the new codes were ignored in the rush to rebuild, including height limitations and requirements for fire-resistant walls (Fradkin (2005)). The most significant changes in this realm were a moderate expansion of the city's fire limits (where buildings were required to be largely non-combustible), a new fireproof roof area, and the legal permissibility of concrete in buildings (Tobriner (2006)).

Another important regulation to consider is zoning. San Francisco passed its first zoning ordinance in 1921, but no official regulatory body was charged with overseeing it until 1928. As Weiss (1988) notes, zoning played a relatively minor role in San Francisco until after the Great Depression. Overall, aside from changes to the fire limits and the new fireproof roof area, the regulatory environment was largely unchanged after the disaster and should not have an impact on the results of the study.

[2]Tobriner (2006) believes this figure is understated, estimating that the fire accounts for 95 percent of total property damage.

3 Related Literature and Theory

Firms make location and relocation decisions based on a number of factors. Foundational studies on intra-city business location patterns include Alao (1974) and Moomaw (1980). These papers are primarily concerned with initial firm location decisions in a city, and not the decision to relocate. A study which develops a theory of industrial firm relocation in the face of moving costs is that of Cooke (1983). In his empirical analysis, he finds three primary determinants of firm relocations: changes in demand, initial plant size, and changes in transport costs. Changes in demand and transport costs are likely to occur over time, and thus dynamic firms must adjust accordingly. Initial plant size acts as a fixed investment, so that larger plants are relatively more anchored to initial locations and thus less likely to relocate. Due to fixed capital investments, a firm's choice of a particular location has an impact on future location and relocation decisions, and thus past commitments partly determine future decisions. Hence, it also necessary to understand historical location decisions in order to gauge current firm behavior (Stahl (1987)).

Closely related to firm location and relocation decisions is the concept of agglomeration economies in production. Mills and Hamilton (1994, p. 118) describe agglomeration economies as weakening with distance to the CBD, thus encouraging firms to locate near the center of the city. In a paper about the decentralization of economic activity in twentieth century urban areas, Moses and Williamson (1967) focus on the importance of nineteenth century transport costs in determining the propensity of firms to locate near one another. The authors provide evidence that the high costs of moving goods relative to moving people help explain business clustering in old cities. Ellison and Glaeser (1997) develop an index for analyzing recent U.S. industrial data at a regional level. They find strong indications of localization among all industries, with several displaying particularly strong tendencies to agglomerate. They also find evidence that these extreme cases are likely due to natural advantages, although they assert that there is much concentration left to explain.

Although much research has been conducted on the drivers and nature of firm location outcomes, there is little research on the role of relocation costs and fixed investments in impeding the process of firm relocation. Consider the following simple model in which firms decide to move based on profits earned in a new location, profits earned in the current location, and the annualized costs associated with relocating. Let π denote firm profits, so that π_{current} represents profits in the current location and π_{new} represents the new location's profits. The costs of relocating include moving costs (M), construction costs for a new building (C), and the transaction costs (T) associated with finding and securing property for a new location. Given these considerations, firms decide to relocate when

$$\pi_{\text{new}} - r(M + C + T) > \pi_{\text{current}}, \tag{1}$$

where r is an interest rate faced by firms. Thus, relocation occurs when π_{new} less annualized relocation costs exceeds π_{current}.

Notice in (1) that when relocation costs are substantial, firms will be less likely to relocate. In such a setting, π_{new} would need to be high, or π_{current} low, to warrant such a decision. While construction costs are most important, only those firms constructing their own buildings would incur such costs. Moving costs may be substantial if firms have heavy machinery and other fixed investments to move. Transaction costs are a factor whenever a firm is looking to relocate. For instance, firms must first determine a new location, and then engage in the real estate market to purchase a new property or agree on rental terms with a landlord. The land at a new location may also be utilized in some other way (i.e., residential), which introduces transaction costs in reorganizing its use. None of these relocation costs are incurred when firms remain in their current location. Thus, fixed investments in buildings and physical capital represent a commitment to a location where firms earn π_{current}.

Some of these frictions were greatly reduced when thousands of buildings were destroyed by fire in San Francisco in 1906. For all firms in the city, the fire reduced T in the razed area by clearing the land. For many burned-out firms, the fire may have reduced M through the destruction of physical capital, thus making moving costs less salient. For those constructing their own buildings, C enters into the relocation decision, although this cost is incurred regardless of the circumstances. Thus, most importantly for the relocation decision as it applies to burned-out firms, the disaster eliminated fixed investments, making π_{current} equal to zero. The result was an opportunity to potentially earn higher profits by relocating.

4 Data

4.1 Data Construction

The primary data sources for this study are the San Francisco city directories published by Crocker-Langley. Figure 2 shows a sample page from the 1915 directory. Each of these volumes contains a classified business directory which categorizes firms by trade (e.g., bakeries, cigar manufacturers, printers, etc.) and provides street addresses for each. These addresses are then linked to city blocks, which represent the spatial unit of analysis in the study.[3] Additionally, firms are matched by name across years. The result is a longitudinal dataset of firms and their locations in 1900, 1905 and 1915.[4] Relocations are then determined across 1900 and 1905, and 1905 and 1915. For the purpose of the paper, a relocation is defined as a move to a different city block, whether it is a move to a neighboring block or a more distant block.

The data include both firms and sole proprietorships for over 100 business classifications chosen to reflect a variety of retail, wholesale, service, and manufacturing establishments.

[3] Throughout the paper, firm locations are at the city block level.

[4] Most firms were unmatched. This outcome can arise for many reasons, including births or deaths, and even the slightest of name changes across years.

Business classification dummies are constructed in order to control for industry-specific effects. These classifications sometimes vary over time, with firms not always listed in every relevant category every year. Sole proprietorships are identified as those listings showing names of individuals rather than firm names. Each city directory also has a street address index that is used in conjunction with the Sanborn maps to develop the block-matching algorithm.[5]

Other important facets of the study include the determination of the blocks that were razed in the disaster and the spatial area of focus. Figure 1 shows the map used to determine which blocks were burned and which were left unscathed. The darker portion of the map refers to the city blocks that burned in 1906. The majority of firms were located near the core of the city, which was mostly burned by the fire. Thus, this study will focus on firms located in the primary areas of the city, such as Downtown, Western Addition, South of Market, and Mission District. The relatively few firms in the residential Richmond, Sunset, and Outer Mission districts are coded according to their general neighborhood location rather than a specific city block. These areas are depicted in Figure 3. Treatment and control groups are assigned according to the treatment status of the block on which each firm was located at the time of the disaster. Those firms located on burned blocks comprise the treatment group, while firms located in the unburned area are in the control group.

The paper will focus on two different samples, one of which is a cross section and the other a balanced panel. The cross section uses information from the 1905 and 1915 periods, where firm relocation is determined across these years. The panel is constructed using data from all three periods where relocations (or non-relocations) are determined across 1900 and 1905, and across 1905 and 1915. In order to control for the relocation behavior of firms prior to the disaster, this panel dataset is balanced so that only firms appearing in all three

[5]This paper uses the block numbering system of the Sanborn maps, which primarily relied on the tax assessor's system of block identification.

periods are included. The estimation results are similar across these two samples.

4.2 Data Summary

Table 1 provides a data summary for both the cross-section and panel samples. In the cross section, 68 percent of firms relocated after the disaster. Of the firms located on burned blocks just prior to the disaster, 70 percent had relocated by 1915, whereas only 46 percent of firms in unburned areas moved after the disaster. There is a greater proportion of sole proprietors in the unburned area, while a greater proportion of burned-out firms exists in the 1900 data. These differences highlight the need to control for variations in these outcomes across observations.

For the panel sample, summary statistics are given for relocations by 1905 and 1915 by burned block in the previous period. The table reveals that while a similar proportion of firms had relocated by 1905 across groups (approximately 30 percent), a significantly greater proportion of burned-out firms had relocated by 1915 (70 percent versus 43 percent). There is also a difference in the proportion of sole proprietorships across burned and unburned areas. In both samples, a greater proportion of burned-out firms relocated after the disaster relative to unburned firms. The next section presents estimation results of the treatment effect while controlling for other potential sources of variation.

5 Estimation Methods and Results

5.1 Identification Strategy

This section provides estimates of the impact of the shock on the probability that a firm moved to a different block after the disaster. If post-disaster opportunities to relocate were exploited, then firms located on burned blocks would have been more likely to move after the disaster relative to firms located on unburned blocks. To estimate the impact of the fire on relocations, this study will utilize both cross-section and panel techniques.

The identification strategy relies on the sharp delineation between city blocks consumed by fire and those left unburned. The boundary of the fire represents the point at which otherwise similar city blocks were differentially treated by the disaster. Thus, a border-discontinuity approach is employed to identify the disaster's impact on firm relocations.

As described in Section 4.1, the dataset contains observations for the years 1900, 1905, and 1915. Since this paper studies firm relocation, it is necessary to use two years of data to determine relocations, so that two periods of data can be used at most. The cross section contains locations for firms with a pre-disaster observation in 1905 and a post-disaster observation in 1915, thus comprising moves (or non-moves) over the period 1905 to 1915. Additionally, the paper incorporates estimations using a panel dataset which includes firms also observed in 1900, thus comprising both pre- and post-disaster periods. The panel estimations are undertaken primarily to control for individual heterogeneity and to determine if a treatment effect is absent prior to the disaster, which is important for robust identification of the treatment effect.

The focus of the paper is on the role of relocation costs and fixed investments in restraining firm relocations. If such factors are indeed important determinants of whether firms relocate, then burned-out firms should have been relatively more likely to do so after the fire when these barriers were greatly reduced. The following sections present results of estimating the disaster's impact on this likelihood.

5.2 Econometric Models of Firm Relocation

5.2.1 Cross Section

Although Section 4.2 shows preliminary evidence of a treatment effect on the likelihood of relocating, it is important to control for other potential sources of variation. Consider the following econometric model of firm relocation where a business i relocated if it changed city blocks between one period and the next. Let y_i be an indicator of relocation so that

$$y_i = \begin{cases} 1 & \text{if the firm relocated,} \\ 0 & \text{if the firm did not relocate.} \end{cases} \tag{2}$$

Thus, y_i equals one if a firm moved between 1905 and 1915 and zero if not. With relocations defined, the primary effect of interest is the impact of being on a burned block just prior to the disaster. Thus, the following model is estimated:

$$\Pr[y_i = 1 | B_i, X_i] = F(\delta B_i + X_i' \beta), \tag{3}$$

where B_i equals one if the business was located on a burned block in 1905, X_i contains controls such as industry (i.e., business classification) dummies, an indicator for sole proprietorship, and a proxy indicator for older firms, and F is a cumulative distribution function. Maximum likelihood estimates are presented for the logit model and OLS estimates for the linear probability model (LPM). The coefficient of interest is δ, which captures the impact of the disaster on a firm's probability of relocating to a different city block.

Table 2 presents regression results for the model given by (3). In the simple specification with no controls, firms located on a burned block in 1905 were more likely to move to a different block after the disaster. Adding a control for sole proprietorship and an interaction term for a burned-out sole proprietorship strengthens the burned coefficient slightly, with it remaining significant at the 1% level. Although the coefficient on burned-out sole proprietorship is negative and significant at the 1% level, the net effect for these businesses is close to zero. Column 3 adds an indicator for whether the firm also exists in the 1900 cross section, the inclusion of which controls for potential variation in firm characteristics such as firm age.[6] Column 4 adds industry dummies, which wipes out the treatment effect for burned-out sole proprietorships and strengthens the overall treatment coefficient, which is still significant at the 1% level. A firm's presence in the 1900 data has mo effect on relocating after the disaster. The computed marginal effects for columns 3 and 4 are 0.327 and 0.349, revealing that being located on a burned block in 1905 increased the relative likelihood of a post-disaster relocation by roughly 33 percentage points.

Notice in column 4 that 40 observations are dropped when including industry dummies. This outcome is due to the perfect prediction problem inherent in the maximum likelihood estimation of discrete choice models.[7] Thus, column 5 shows estimates of an LPM, which does not suffer from this shortcoming. The LPM estimates reveal results similar to those obtained in the logit case. Specifically, a pre-disaster location in the burned area increases the probability of relocating by about 36 percentage points. Aside from restoring the excluded observations, the cross-section LPM estimation also provides a benchmark with which to compare the panel estimates, which are shown next for the random-effects LPM.

5.2.2 Panel

In addition to the cross-section estimates, it is informative to estimate a model using a balanced panel dataset in which firms are observed in 1900, 1905, and 1915. This exercise provides insight into the relocation behavior of firms prior to the disaster. For the panel

[6]Firms established after 1900 would not exist in the 1900 data and might exhibit different location behavior after the disaster.

[7]Maximum likelihood estimation of the model with industry dummies results in perfect prediction of relocation, thus not allowing for parameter estimation unless such observations are dropped. This outcome is likely the case due to the relatively large number of industries considered and the fairly limited sample size.

setting, let y_{it} be an indicator of relocation for firm i in time t so that

$$y_{it} = \begin{cases} 1 & \text{if the firm relocated between } t-1 \text{ and } t, \\ 0 & \text{if the firm did not relocate between } t-1 \text{ and } t. \end{cases} \tag{4}$$

Thus, y_{it} equals one if a firm moved between 1900 and 1905 or 1905 and 1915, and zero if not. In this panel setting, consider the following individual-effects model, which is estimated over $t = 1905$ and $t = 1915$:

$$\Pr[y_{it} = 1 | B_{it-1}, X_{it}, S_i, d_t, \theta_i, \alpha] = \alpha + \lambda d_t + (B_{it-1} \times d_t)'\delta_t + X'_{it}\beta + \rho S_i + \theta_i + \varepsilon_{it}, \tag{5}$$

where B_{it-1} equals one if the business was located on a burned block in $t-1$, X_{it} contains time-varying controls, S_i is an indicator for sole proprietorship, d_t is a year indicator, θ_i is an individual effect, and ε_{it} is an error term. The primary parameter of interest is δ_t, which represents the effect in the current period of being located on a burned block in the previous period. It is expected that being located in the burned area has no effect on relocations prior to the disaster, so that $\delta_{1905} = 0$. A treatment effect is expected after the disaster, so that $\delta_{1915} > 0$. By estimating these effects in a panel setting, it is possible to determine if a treatment effect is absent leading up to the disaster for firms that were present over the entire period, which provides further evidence that the fire was indeed the primary determinant of post-disaster relocations, as implied in the cross-section estimates.

Results are not given for the panel logit model due to the complicated nature of estimating binary outcome models using panel data.[8] Thus, estimates are instead presented for the random-effects LPM, estimated by GLS. A test of the difference between the random-effects and fixed-effects models reveals that random-effects estimation is consistent and favored

[8] Such estimation is complicated by the individual effects, or θ_i in this case, which introduce an incidental parameters problem in maximum likelihood estimation.

over fixed-effects estimation due to its efficiency.[9] Thus, a random-effects model is estimated rather than a fixed-effects model. Also, since the causation is clear in this natural-experiment setting, so that θ_i is likely uncorrelated with treatment status and other regressors, random-effects estimation is appropriate.

Table 3 presents the results for estimating the model using the balanced panel dataset. The random-effects estimates are shown in columns 1 through 3. Column 1 presents the base specification with a time dummy and treatment indicators. As expected, there is no treatment effect of the fire in 1905 and a positive effect, significant at the 1% level, in 1915. As column 2 shows, these results remain, and the 1915 effect is stronger, when including controls for sole proprietorship and relevant interaction terms. The results in column 3 are little changed when adding industry dummies which, as described previously, exhibit some variation across time. In this full specification, the treatment effect in 1915 is slightly smaller in magnitude than the cross-section LPM result, but still significant at the 1% level. Specifically, the likelihood of relocating is 30 percentage points higher for firms that were located on a burned block just prior to the disaster.

Overall, the cross-section and panel estimation results provide evidence that burned-out firms were more likely to move after the disaster relative to unburned establishments. Additionally, firms located on burned blocks in 1900 were not more likely to relocate by 1905, thus providing further evidence of the fire's impact. Since the fire eliminated buildings and physical capital, these outcomes imply that fixed investments discourage firm relocations.

[9] The associated p-value from a Hausman test of the fully specified (with only time-varying regressors) fixed-effects model versus the random-effects model is roughly 0.98, thereby suggesting no systematic difference between the two models. Thus, the null hypothesis that random-effects estimation is consistent and efficient cannot be rejected.

5.3 Spatial Aspects of Firm Relocation

The previous section provides evidence that the fire caused many firms to relocate to different city blocks upon reconstruction. Given this greater propensity to move, what were some of the spatial aspects of these moves? For instance, what was the average distance moved, and did firms tend to move closer to, or farther away from, the primary central landmarks of the city? To help answer these questions, Table 4 provides summary statistics describing various spatial aspects of firm relocations.

As the table shows, burned-out firms moved an average distance of nearly one-half mile from their pre-disaster locations. Depending on the location in the city, a half-mile could be a move in length of anywhere from three to eight blocks. The largest move was nearly three miles in length. On average, firms moved only slightly closer to city hall, yet nearly one-tenth mile farther from downtown. Relocations farther from downtown suggest either an expanding CBD or decentralization of economic activity. Also, as the evidence from the table suggests, 53 percent of firms moved closer to city hall and roughly 54 percent moved farther from downtown. Together, these statistics suggest that relocations following the disaster were spatially significant.

5.4 Industry Localization

The purpose of this section is to provide an overview of the localization patterns of industries before and after the disaster. As the previous section showed, firms located on burned blocks prior to the disaster were more likely to move after the disaster relative to those on unburned blocks. Given this evidence, it is expected that the fire would also have an impact on the localization of firms at the industry level.

The analysis relies on a measure proposed by Mori et al. (2005), denoted as D in the tables. The index, described in the appendix, requires a count of firms for each industry in each spatial unit, which in this case is a city block. It relates the degree of localization found among particular industries across blocks to a reference distribution that assumes complete spatial dispersion of firms. In this study, the reference distribution is assumed to be uniform across city blocks. Each industry has an index value with a unique minimum value of zero and where a larger value indicates a greater level of firm localization relative to the reference distribution. Comparisons across industries and time can then be made to provide insight into the industry-specific and dynamic effects of the disaster.

To provide a summary of the industries most impacted by the fire, Tables 5 and 6 show results for the industries that changed most over this period. A total of 82 industries is represented in the analysis. Table 5 shows the ten industries that became the most localized after the disaster, while Table 6 shows the ten industries that experienced the most dispersion during this period. For each industry, the tables report index values for 1905, 1915, and the change in localization experienced between 1905 and 1915. A broad selection of manufacturing, retail/wholesale, and service-oriented establishments became more localized after the disaster, while industries that experienced the most dispersion were largely in the manufacturing sector.

Figure 4 shows the changes in localization for all industries in the study between 1900 and 1905 (y axis) relative to their levels in 1900 (x axis). There are very small changes in localization over this time period as most industries are clustered around the zero-change line. Figure 5 shows the changes for the period 1905 to 1915, and in contrast to Figure 4, reveals larger changes in localization among many industries. There are fewer observations near the zero-change line, thereby suggesting that the disaster had an impact on industry clustering.

Tables 7 and 8 provide a summary of changes in localization across three industry sectors: manufacturing, retail/wholesale, and services. Table 7 shows the percentage of firms across sectors which became more or less localized over the two time periods. Between 1900 and

1905, 31 industries became more localized and 51 industries became less localized. This trend reverses between 1905 and 1915, a period in which 51 industries became more localized and 31 industries became less localized. Thus, industries became more localized overall in the 1905-1915 period relative to the 1900-1905 period. At the sector level, the largest proportional post-disaster changes in localization occurred within the retail/wholesale sector.

Table 8 shows the percentage of firms by sector which became more or less localized over the two time periods. Most of the industries are in the manufacturing sector, followed by services, and retail/wholesale industries. The retail/wholesale industries experienced the greatest changes in localization across the two time periods, becoming relatively more localized than the other sectors.

The changes described above suggest that the disaster not only fostered such changes, but also had a mostly localizing effect on firm location patterns. This outcome may be due to the costs associated with locating nearer to similar firms under normal conditions, when the mix of land use is difficult to change. Many barriers must be overcome when relocating a firm, especially to well-developed areas. In thriving cities where relatively little land is vacant near desirable areas, it is costly to relocate to these built-up areas. The evidence presented in this section, which shows more dispersion happening prior to the disaster and more localization afterward, supports this view. The fire razed buildings and physical capital, thereby providing firms with the opportunity to relocate and thus achieve new outcomes in localization at the industry level.

6 Conclusion

There are many studies focusing on the nature of firm location patterns in urban areas. However, little is known empirically about the role of fixed investments, which represent commitments to current locations, in discouraging relocations. Likewise, little is known about the impact of large shocks on firm location patterns. This paper aims to fill this gap by estimating the impact of the 1906 San Francisco disaster on the propensity of firms to relocate to different areas of the city upon reconstruction, as well as how it impacted the spatial distribution of firms and industries across city blocks.

Evidence suggests that being located on a burned block just prior to the disaster significantly increased the probability of moving to a different block afterward, with the average post-disaster move being about one-half mile in distance. The disaster also had an impact on the spatial distribution of firms in San Francisco. Most industries experienced a localizing effect from the fire while fewer became more dispersed, which was a complete reversal of the trend leading up to the disaster. These results imply that fixed investments in buildings and physical capital restrain relocations and localization under normal circumstances.

Appendix

This appendix describes the localization index used in this study. The index, developed in Mori et al. (2005), is a divergence statistic that is independent of sample size. Following the authors, for each industry ι, the theoretical index value D is given as

$$D(p_\iota \mid p_0) = \sum_{i=1}^{B} p_{\iota i} \ln\left(\frac{p_{\iota i}}{p_{0i}}\right), \tag{6}$$

where industries $\{\iota\}$ are located on B city blocks. The probability of a randomly sampled industry-firm being located on block i is given by $p_{\iota i}$ and the reference distribution, p_{0i}, is the probability that a randomly sampled industry-firm is located on block i under spatial dispersion. In this study, the reference distribution is a uniform distribution. Since $p_{\iota i}$ is not directly observable, a sample estimate is given as $\hat{p}_{\iota i} = \frac{N_{\iota i}}{\sum_{j=1}^{B} N_{\iota j}}$, where industry ι has $N_{\iota i}$ firms on block i. This yields the following statistic:

$$D(\hat{p}_\iota \mid p_0) = \sum_{i=1}^{B} \hat{p}_{\iota i} \ln\left(\frac{\hat{p}_{\iota i}}{p_{0i}}\right) \approx D(p_\iota \mid p_0). \tag{7}$$

Thus, greater relative localization of firms (so that $\hat{p}_{\iota i}$ is high relative to p_{0i}) implies larger values of D.

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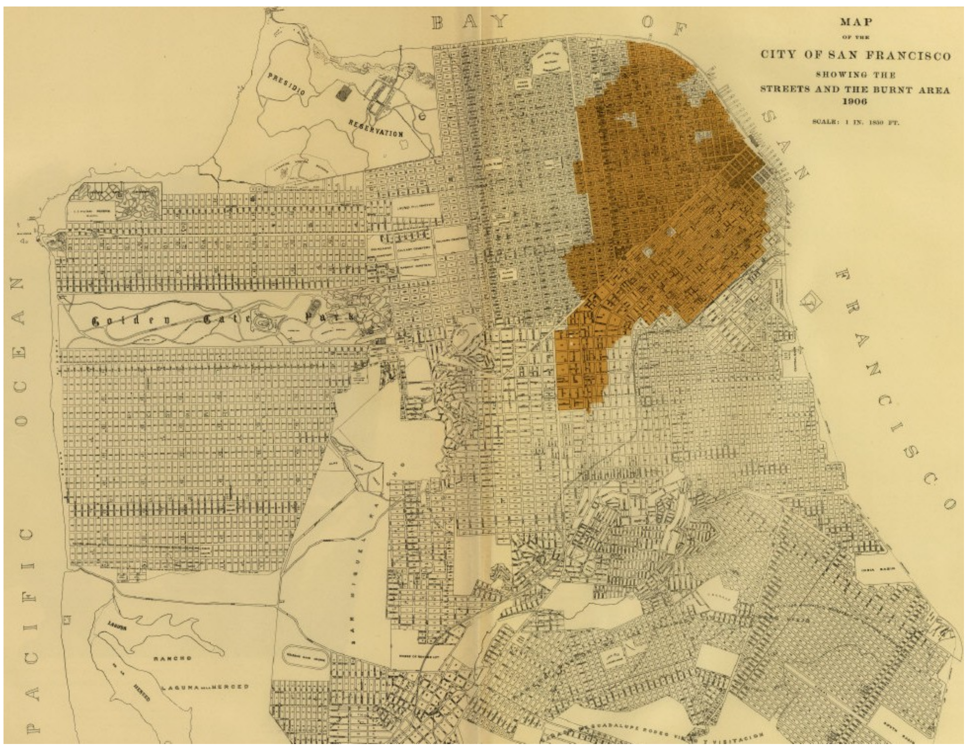
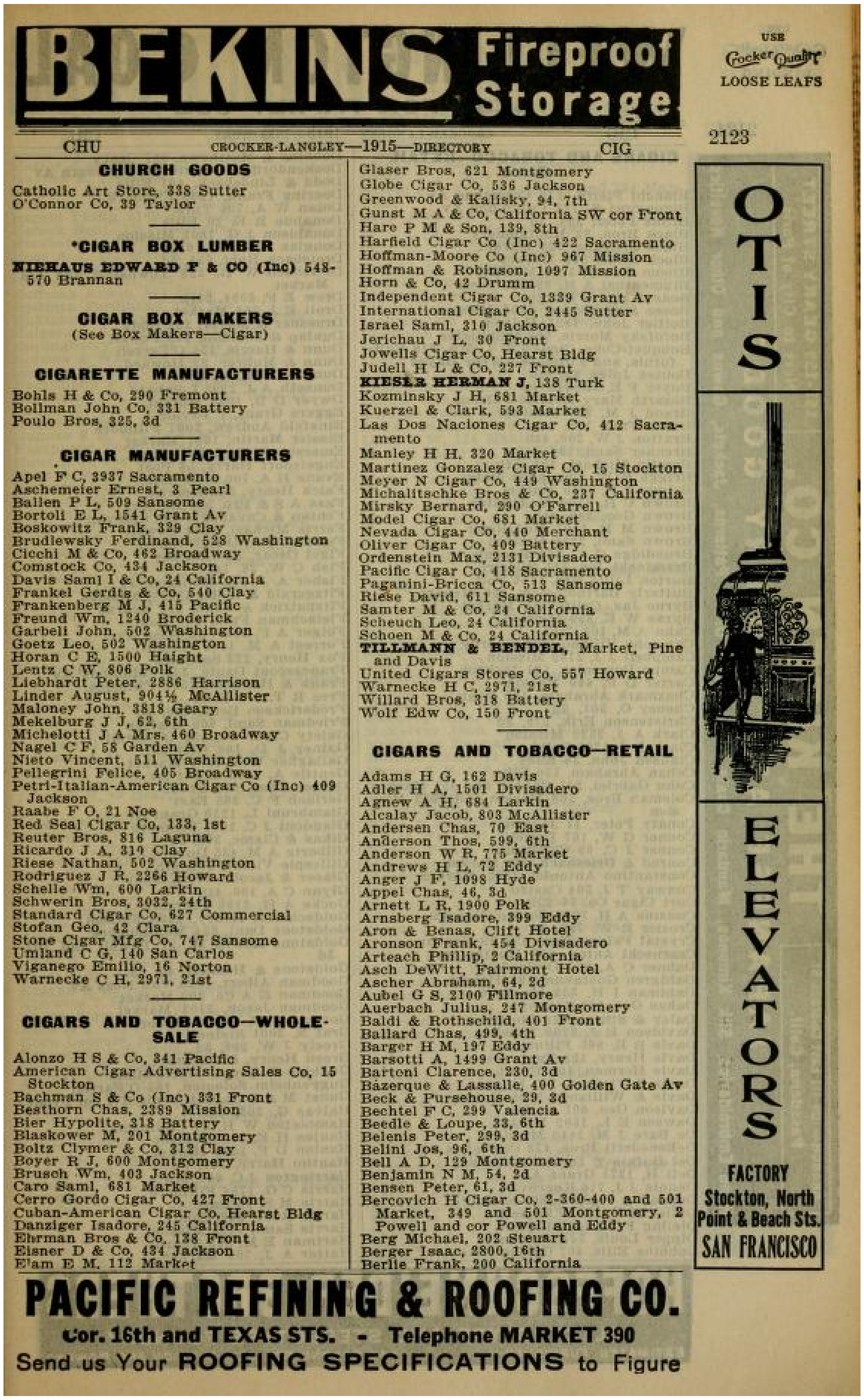


Figure 1: Fire coverage from the 1906 San Francisco disaster as depicted by SEIC (1908)
Source: David Rumsey Historical Map Collection (www.davidrumsey.com).



BEKINS Fireproof Storage

USE Crocker Quality LOOSE LEAFS

CHU CROCKER-LANGLEY—1915—DIRECTORY CIG 2123

CHURCH GOODS

Catholic Art Store, 338 Sutter
O'Connor Co, 39 Taylor

***CIGAR BOX LUMBER**

NIEHAUS EDWARD F & CO (Inc) 548-570 Brannan

CIGAR BOX MAKERS
(See Box Makers—Cigar)

CIGARETTE MANUFACTURERS

Bohls H & Co, 290 Fremont
Bollman John Co, 331 Battery
Poulo Bros, 325, 3d

CIGAR MANUFACTURERS

Apel F C, 3937 Sacramento
Aschemeier Ernest, 3 Pearl
Ballen P L, 509 Sansome
Bortoli E L, 1541 Grant Av
Boskowitz Frank, 329 Clay
Brudlewsky Ferdinand, 528 Washington
Cicchi M & Co, 462 Broadway
Comstock Co, 434 Jackson
Davis Saml I & Co, 24 California
Frankel Gerdts & Co, 540 Clay
Frankenberg M J, 415 Pacific
Freund Wm, 1240 Broderick
Garbeli John, 502 Washington
Goetz Leo, 502 Washington
Horan C E, 1500 Haight
Lentz C W, 806 Polk
Liebhardt Peter, 2886 Harrison
Linder August, 904½ McAllister
Maloney John, 3818 Geary
Mekelburg J J, 62, 6th
Michelotti J A Mrs, 460 Broadway
Nagel C F, 58 Garden Av
Nieto Vincent, 511 Washington
Pellegrini Felice, 405 Broadway
Petri-Italian-American Cigar Co (Inc) 409 Jackson
Raabe F O, 21 Noe
Red Seal Cigar Co, 133, 1st
Reuter Bros, 816 Laguna
Ricardo J A, 310 Clay
Riese Nathan, 502 Washington
Rodriguez J R, 2266 Howard
Schelle Wm, 600 Larkin
Schwerin Bros, 3032, 24th
Standard Cigar Co, 627 Commercial
Stofan Geo, 42 Clara
Stone Cigar Mfg Co, 747 Sansome
Umland C G, 140 San Carlos
Viganego Emilio, 16 Norton
Warnecke C H, 2971, 21st

CIGARS AND TOBACCO—WHOLESALE

Alonzo H S & Co, 341 Pacific
American Cigar Advertising Sales Co, 15 Stockton
Bachman S & Co (Inc) 331 Front
Besthorn Chas, 2389 Mission
Bier Hypolite, 318 Battery
Blaskower M, 201 Montgomery
Boltz Clymer & Co, 312 Clay
Boyer R J, 600 Montgomery
Brusch Wm, 403 Jackson
Caro Saml, 681 Market
Cerro Gordo Cigar Co, 427 Front
Cuban-American Cigar Co, Hearst Bldg
Danziger Isadore, 245 California
Ehrman Bros & Co, 138 Front
Eisner D & Co, 434 Jackson
Elam E M, 112 Market
Glaser Bros, 621 Montgomery
Globe Cigar Co, 536 Jackson
Greenwood & Kalisky, 94, 7th
Gunst M A & Co, California SW cor Front
Hare P M & Son, 139, 8th
Harfield Cigar Co (Inc) 422 Sacramento
Hoffman-Moore Co (Inc) 967 Mission
Hoffman & Robinson, 1097 Mission
Horn & Co, 42 Drumm
Independent Cigar Co, 1339 Grant Av
International Cigar Co, 2445 Sutter
Israel Saml, 310 Jackson
Jerichau J L, 30 Front
Jowells Cigar Co, Hearst Bldg
Judell H L & Co, 227 Front
KIESLER HERMAN J, 138 Turk
Kozminsky J H, 681 Market
Kuerzel & Clark, 593 Market
Las Dos Naciones Cigar Co, 412 Sacramento
Manley H H, 320 Market
Martinez Gonzalez Cigar Co, 15 Stockton
Meyer N Cigar Co, 449 Washington
Michalitschke Bros & Co, 237 California
Mirsky Bernard, 290 O'Farrell
Model Cigar Co, 681 Market
Nevada Cigar Co, 440 Merchant
Oliver Cigar Co, 409 Battery
Ordenstein Max, 2131 Divisadero
Pacific Cigar Co, 418 Sacramento
Paganini-Bricca Co, 513 Sansome
Riese David, 611 Sansome
Samter M & Co, 24 California
Scheuch Leo, 24 California
Schoen M & Co, 24 California
TILLMANN & BENDEL, Market, Pine and Davis
United Cigars Stores Co, 557 Howard
Warnecke H C, 2971, 21st
Willard Bros, 318 Battery
Wolf Edw Co, 150 Front

CIGARS AND TOBACCO—RETAIL

Adams H G, 162 Davis
Adler H A, 1501 Divisadero
Agnew A H, 684 Larkin
Alcalay Jacob, 803 McAllister
Andersen Chas, 70 East
Anderson Thos, 599, 6th
Anderson W R, 775 Market
Andrews H L, 72 Eddy
Anger J F, 1098 Hyde
Appel Chas, 46, 3d
Arnett L R, 1900 Polk
Arnsberg Isadore, 399 Eddy
Aron & Benas, Clift Hotel
Aronson Frank, 454 Divisadero
Arteach Phillip, 2 California
Asch DeWitt, Fairmont Hotel
Ascher Abraham, 64, 2d
Aubel G S, 2100 Fillmore
Auerbach Julius, 247 Montgomery
Baldi & Rothschild, 401 Front
Ballard Chas, 499, 4th
Barger H M, 197 Eddy
Barsotti A, 1499 Grant Av
Bartoni Clarence, 230, 3d
Bàzerque & Lassalle, 400 Golden Gate Av
Beck & Pursehouse, 29, 3d
Bechtel F C, 299 Valencia
Beedle & Loupe, 33, 6th
Belenis Peter, 299, 3d
Belini Jos, 96, 6th
Bell A D, 129 Montgomery
Benjamin N M, 54, 2d
Bensen Peter, 61, 3d
Bercovich H Cigar Co, 2-360-400 and 501 Market, 349 and 501 Montgomery, 2 Powell and cor Powell and Eddy
Berg Michael, 202 Steuart
Berger Isaac, 2800, 16th
Berlie Frank, 200 California

OTIS ELEVATORS
FACTORY Stockton, North Point & Beach Sts. SAN FRANCISCO

PACIFIC REFINING & ROOFING CO.
Cor. 16th and TEXAS STS. - Telephone MARKET 390
Send us Your ROOFING SPECIFICATIONS to Figure

Figure 2: Sample page from the 1915 business directory
Source: Internet Archive (www.archive.org).

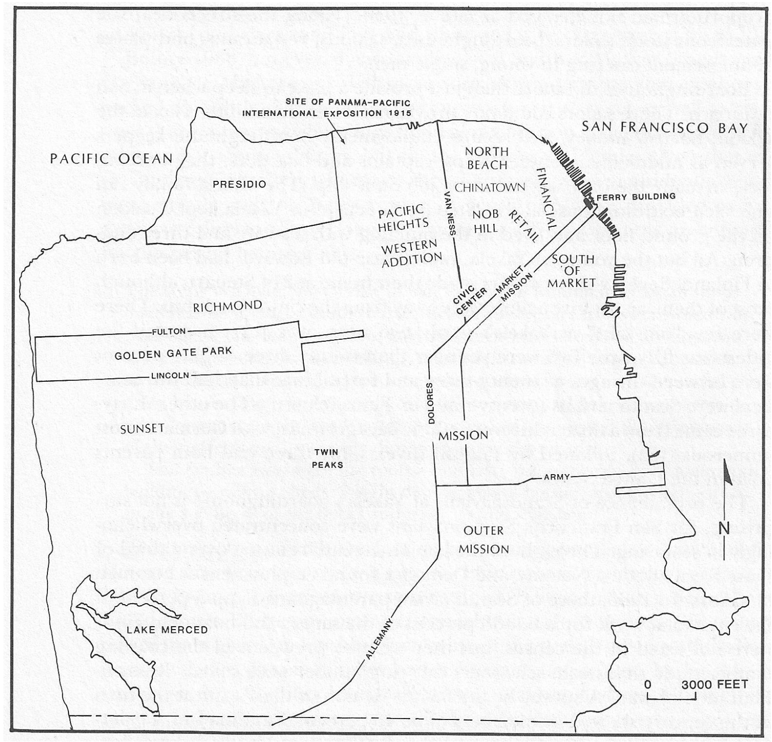


Figure 3: Primary neighborhoods
Source: Issel and Cherny (1986).

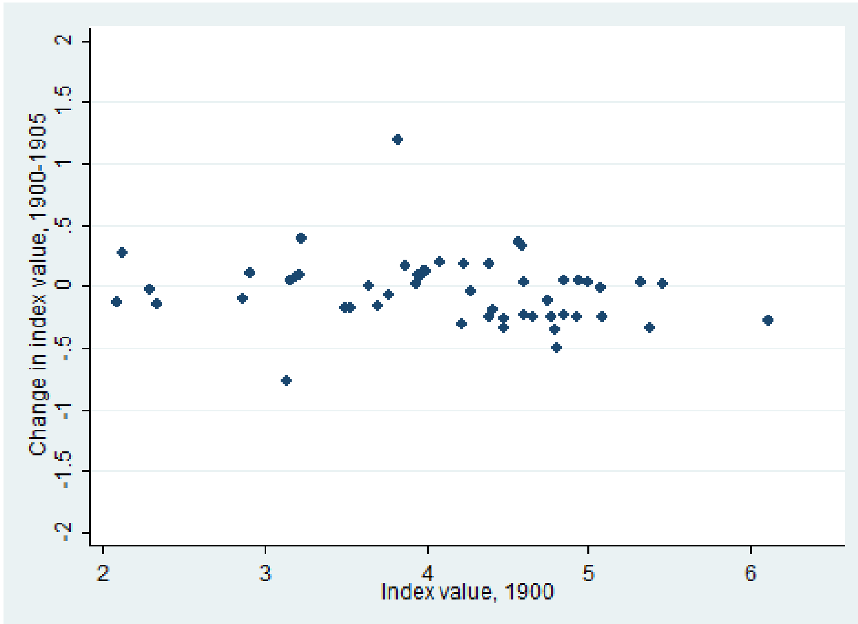


Figure 4: Change in industry localization between 1900 and 1905
Source: see text.

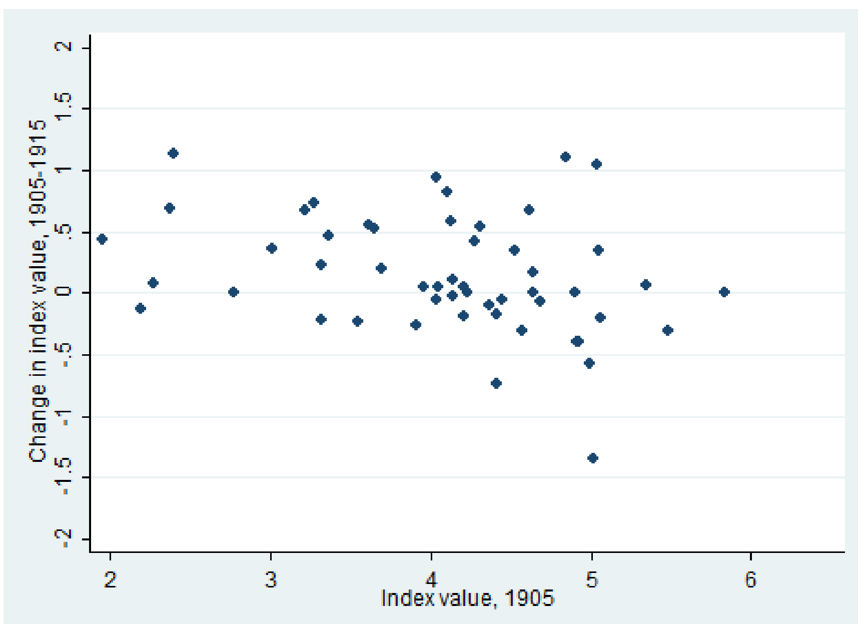


Figure 5: Change in industry localization between 1905 and 1915
Source: see text.

Table 1: Summary statistics

	Total		Burned$_{t-1}$		Unburned$_{t-1}$	
	Mean	SD	Mean	SD	Mean	SD
Cross section:						
Relocated by 1915	.678	.468	.698	.459	.456	.503
Sole proprietorship	.255	.436	.241	.428	.404	.495
Exists in 1900 data	.553	.498	.559	.497	.491	.504
Panel:						
Relocated by 1905	.308	.462	.305	.463	.333	.480
Relocated by 1915	.677	.468	.697	.460	.429	.504
Sole proprietorship	.198	.399	.194	.396	.250	.441

Notes: Values represent the proportion of businesses having the given characteristic.

Table 2: Cross-section estimation results

	Dep. variable: relocated between 1905 and 1915				
	(1)	(2)	(3)	(4)	(5)
	Logit	Logit	Logit	Logit	LPM
Burned block 1905	1.014***	1.508***	1.507***	2.143***	0.364***
	(0.280)	(0.363)	(0.364)	(0.507)	(0.094)
Sole proprietorship		0.149	0.085	-0.470	-0.056
		(0.542)	(0.545)	(0.671)	(0.142)
Burned 1905 × sole		-1.674***	-1.643***	-0.068	-0.007
		(0.577)	(0.579)	(0.727)	(0.146)
Exists in 1900 data			-0.208	-0.251	-0.030
			(0.176)	(0.244)	(0.032)
Industry dummies	No	No	No	Yes	Yes
Observations	683	683	683	643	683
Pseudo R^2	0.015	0.086	0.088	0.330	0.376

Notes: Robust standard errors are given in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels.

Table 3: Panel estimation results

	Dep. variable: relocated		
	(1)	(2)	(3)
Burned block 1900 × 1905	-0.029	-0.023	-0.037
	(0.094)	(0.107)	(0.109)
Burned block 1905 × 1915	0.271***	0.326***	0.299***
	(0.097)	(0.106)	(0.109)
Sole proprietorship		0.025	-0.060
		(0.166)	(0.175)
Burned 1900 × 1905 × sole		-0.012	0.134
		(0.180)	(0.193)
Burned 1905 × 1915 × sole		-0.271	-0.122
		(0.176)	(0.185)
Industry dummies	No	No	Yes
Observations ($n \times t$)	756	756	756
R^2	0.270	0.290	0.312

Notes: Individual cluster-robust standard errors are given in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels.

Table 4: Spatial aspects of burned-out firm relocations

Outcome	Mean	Std. Dev.	Minimum	Maximum
Average distance moved	0.450	0.533	0.056	2.979
Δ distance to city hall	-0.012	0.316	-1.014	1.377
Δ distance to downtown	0.097	0.388	-0.691	2.006
% closer to city hall	.531	.500	-	-
% closer to downtown	.462	.499	-	-

Notes: All distances are given in miles. Δ refers to the change between 1905 and 1915. The sample consists of 431 burned-out firms that relocated after 1906.

Table 5: Industry localization index values, $\Delta D > 0^*$

Industry	1905	1915	ΔD
Varieties	2.392	3.528	1.136
Paper products	3.586	4.715	1.129
Provisions - wholesale	4.842	5.940	1.098
Metal importers	4.850	5.940	1.090
Carpenters and builders	2.454	3.450	0.995
Tobacco - leaf	5.073	6.023	0.951
Junk dealers	4.040	4.975	0.935
Cigar manufacturers	3.355	4.229	0.874
Oil products	4.850	5.717	0.867
Watchmakers and jewelers	3.047	3.894	0.846

$^*\Delta D$ refers to the change in the index value between 1905 and 1915.
Source: see text.

Table 6: Industry localization index values, $\Delta D < 0^*$

Industry	1905	1915	ΔD
Chemicals	5.232	4.301	-0.931
Iron foundries	4.209	3.637	-0.572
Wire	5.680	5.139	-0.541
Printers' supplies	5.780	5.255	-0.524
Cabinet makers	4.511	3.998	-0.513
Engineers' and machinists' supplies	5.304	4.900	-0.404
Furniture - wholesale and manufacturers	4.930	4.527	-0.402
Boilers and boiler makers	4.914	4.517	-0.397
Insurance companies	4.992	4.629	-0.362
Oil dealers	4.466	4.123	-0.343

$^*\Delta D$ refers to the change in the index value between 1905 and 1915.
Source: see text.

Table 7: Localization summary

	1900-1905	1905-1915
More localized	31	51
% manufacturing	45.2	41.2
% retail/wholesale	22.6	29.4
% services	32.3	29.4
Less localized	51	31
% manufacturing	43.1	48.4
% retail/wholesale	27.5	19.4
% services	29.4	32.3
Observations	82	82

Source: see text.

Table 8: Localization summary by sector

	1900-1905	1905-1915
Manufacturing	36	36
% more localized	38.9	58.3
% less localized	61.1	41.7
Retail/wholesale	21	21
% more localized	33.3	71.4
% less localized	66.7	28.6
Services	25	25
% more localized	40.0	60.0
% less localized	60.0	40.0
Observations	82	82

Source: see text.