American Economic Journal: Economic Policy 2016, 8(3): 69–105
http://dx.doi.org/10.1257/pol.20130399

From Today's City to Tomorrow's City: An Empirical Investigation of Urban Land Assembly†

By Leah Brooks and Byron Lutz*

Because cities are constrained by the boundaries of land ownership, fundamental urban modifications require land delineation changes. We evaluate whether there is enough land assembly—the joining together of two or more parcels of land—to put land to its highest value use. We hypothesize that in the absence of market frictions such as holdouts, the price of land sold for assembly should not exceed the price of land sold for other uses. Empirically, we find that to-be-assembled land in Los Angeles trades at a 15 to 40 percent premium and conclude that significant frictions prevent assembly. (*JEL* K11, P14, Q21, R14, R30, R52, R58)

Cities are composed of individual pieces of land called parcels. Just as atoms dictate the properties of matter, parcels dictate the size, shape, and placement of the built infrastructure of which cities are composed. Changes in technology and economic conditions cannot induce fundamental changes to this built infrastructure without changes to parcel boundaries. Thus, the long-run evolution of cities—and the economic growth and innovation they generate—depends upon the ease of modifying parcel boundaries.

* Brooks: Trachtenberg School of Public Policy and Public Administration, George Washington University, 805 21st Street NW, Washington, DC 20006 (e-mail: lfbrooks@gwu.edu); Lutz: Research Division, Board of Governors of the Federal Reserve System, MS 83, Washington, DC 20551 (e-mail: Byron.F.Lutz@frb.gov). The analysis and conclusions set forth are those of the authors and do not indicate concurrence by the Board of Governors of the Federal Reserve. We are extremely grateful to staffers Bulmaro Borrero, Rex Hartline, and Alan Santos at the Los Angeles County Assessor's office for providing data and guidance while we endlessly assembled the dataset for this paper. We are also appreciative to the Lincoln Institute for Land Policy, McGill University, and the John Randolph Haynes and Dora Haynes Foundation, all of which contributed funds towards the construction of the dataset. We thank Gustavo Bobonis, Edward Coulson, Richard England, Lynn Fisher, Edward Glaeser, Robert Inman, Jeffrey Lin, Dan McMillen, Raven Molloy, Kathy O'Regan, Vasia Panousi, Jaren Pope, Hui Shan, William Strange, David Wildasin, and participants at the 2010 and 2011 International American Real Estate and Urban Economics Association conferences, 2010 Federal Reserve System Regional Analysis conference, 2010 Lincoln Institute conference (October), 2010 National Tax Association Annual Conference, 2011 ASSA meetings, 2011 Lincoln Institute Urban Economics and Public Finance Conference (May), 2011 NBER Summer Institute (Law and Economics and Economics of Real Estate and Local Public Finance), 2011 Planning Law and Property Rights (Alberta), the Philadelphia Federal Reserve, the Federal Trade Commission, the Urban Institute, the University of Michigan Economics Department, the University of Toronto Economics Department, and the Federal Reserve Board of Governors. We are very grateful to the planners and developers that shared insights with us and greatly improved the paper; they are listed in the bibliography. Two anonymous referees enhanced the paper with many helpful suggestions, and we are appreciative. Finally, this paper would not exist but for the superior research assistance of Brian McGuire.

† Go to http://dx.doi.org/10.1257/pol.20130399 to visit the article page for additional materials and author disclosure statement(s) or to comment in the online discussion forum.

Changes to parcel boundaries within a city usually involve the assembly of multiple individually-owned parcels into one larger, singly-owned parcel—a process called land assembly. Because land assembly requires geographic contiguity, an individual parcel owner has a form of monopoly power when his neighbor wishes to assemble land (Merrill 1986). Does this monopoly power create economically meaningful frictions? In this paper we address this question by testing whether the market produces enough assemblies to put land to its highest value use. In doing so, we estimate what is, to the best of our knowledge, the first overall premium to land assembly.

Theorists, economic historians, and practitioners all argue that market imperfections yield "too little" land assembly—and that this failure can hinder economic growth. Whether due to inefficiencies from asymmetric information (Strange 1995), or positive externalities arising from assembly (Grossman and Hart 1980; O'Flaherty 1994), theorists argue that holdout behavior is likely to prevent profitable assemblies.[1] Economic historians contend that the ability to assemble ownership interests is often a crucial prerequisite for economic growth, citing examples as diverse as how fragmented powers of eminent domain in pre-Revolutionary France inhibited profitable irrigation projects (Rosenthal 1990), and how the land subdivision boom of the 1920s caused subsequent problems of land assembly and stagnation in the 1930s (Field 1992).[2] Practitioners, such as urban planners, concur with this dour assessment and call land assembly the "single biggest obstacle to central city redevelopment" (Nelson and Lang 2007).

If land cannot be assembled in sufficient quantity, cities will fail to adjust to new economic realities. Most significantly, land assembly allows cities to become denser. Market frictions that inhibit assembly therefore cause land to be misallocated to suboptimally dense uses.[3] Moreover, cities exist largely due to agglomerative externalities, which increase with density (Duraton and Puga 2004; Rosenthal and Strange 2004). Insufficient land assembly, by restraining density, reduces the magnitude of agglomerative effects. Similarly, it may lower economic growth by forcing some workers to reside in less productive cities (Hsieh and Moretti 2015). Cities that fail to redevelop at the center due to problems with land assembly may instead expand at the edge, yielding congestion and attendant environmental ills (Miceli and Sirmans 2007). Moreover, problems of land assembly may cause cities

[1] Other theoretical work on land assembly includes Asami (1988); Eckart (1985); Grossman, Pincus, and Shapiro (2010); and Menezes and Pitchford (2004). Cadigan et al. (2011) conduct experimental research on the potential private market inefficiencies in land assembly. Kominers and Weyl (2010), Plassman and Tideman (2008), and Tanaka (2007) suggest mechanisms for solving the holdout problem.

[2] Bogart and Richardson (2009) contend that the British Parliament's willingness to "assemble" ownership interests in land following the Glorious Revolution of 1688 yielded dividends in economic growth. Rosen suggests that problems of land assembly inhibited redevelopment even after very large shocks, such as the Great Chicago Fire of 1871 (Rosen 1986). Hornbeck and Keniston (2014)'s empirical work on Boston's 1872 Great Fire confirms this view. Relatedly, differences in systems of land demarcation across the US states (Libecap and Lueck 2011) and across former British colonies (Libecap, Lueck, and O'Grady 2010) yield divergent economic outcomes. Finally, legal scholars such as Heller (1998) argue that problems of land assembly helped to inhibit redevelopment in Eastern Europe.

[3] For instance, as cities grow in population, more capital intensive use of the land is optimal (Henderson 1977). The inability to assemble land impedes this population driven evolution toward a denser city.

to turn to eminent domain: nearly 70 percent of legally contested eminent domain cases involve land which has been seized for use in a land assembly (Merrill 1986).[4]

"Too little" land assembly also has important consequences for how economists think about cities. The canonical model of urban redevelopment posits that land is redeveloped when the present value of the capital situated on it is exceeded by the present value of redevelopment.[5] If land assembly is required for capital adjustment, but assembly is blocked by market frictions, capital decay alone is insufficient to generate redevelopment.

Finally, understanding if and why the market fails to produce land assembly also helps us to understand how the more general problem of fragmented ownership—the "tragedy of the anticommons"—may impede efficient outcomes (Heller 1998; Fennell 2004). Other problems of fragmented ownership include the resolution of sovereign debt consolidations (Pitchford and Wright 2008), and the efficient use of multiple related patented discoveries (Heller and Eisenberg 1998).

We begin with a simple theoretical framework that considers an area where the parcel boundaries, set at the time of initial development, are no longer optimal. Specifically, we assume that the per square foot price of a large parcel has come to exceed the price of a small parcel (motivated by the greater range of uses available for larger parcels). As a result, there is an economic incentive to assemble land. We also assume free entry into the market for assembly and that, correspondingly, developers earn zero profits and all surplus from assembly goes to the landowners who sell into an assembly. This framework yields the following testable assertion: in a market free of frictions, the price of land sold for assembly should not differ from the price of land sold for other purposes. In a competitive market, any differences in the land price per square foot should be arbitraged away. This test is similar in spirit to Glaeser, Gyourko, and Saks (2005).

To evaluate this contention, we require a method to value land in isolation from any capital which may be situated on it. We rely on the technique pioneered by Rosenthal and Helsley (1994) and refined by Dye and McMillen (2007) that identifies the price of land from parcels sold shortly before the structure is subsequently torn down. Because the structure is worthless to the new owner, the sale value represents only the land value. Similarly, the value of properties sold just before assembly should recover the price of land for assembly properties.

To further address the endogenous selection of land into assembly, we compare sales just before teardown to sales just before assembly, conditional on small neighborhood (tract or block group) fixed effects that net out the main component of land value: location. We also perform falsification tests to assess whether land very near teardown properties is priced differently than land near assembly properties; we find no such evidence.

For our empirical work, we construct what is, to the best of our knowledge, the most appropriate existing dataset for this question. We have assembled a panel

[4] The recent *Kelo v. City of New London* case (545 US 469 (2005)), in which the city of New London used its power of eminent domain to assemble land that it then provided to a private developer, brought these issues into focus.

[5] See Brueckner (1980b), Brueckner (1980a), Wheaton (1982), and Wheaton (1983); see also Rosenthal (2008) for empirical work.

dataset that traces each of the 2.3 million parcels in Los Angeles County over a 13-year period from 1999 to 2011. The dataset is based on annual cross sections containing all parcels in the county and a database, provided by the county assessor, which identifies all instances of changes to parcel boundaries and links each parcel that ceases to exist with its descendant. Our dataset allows us to follow each individual piece of land in the county over this entire period.[6]

We find that assembly land sells at a 15 to 40 percent premium relative to non-assembly land. We show that this premium is not likely driven by the endogenous location of assembly by using a repeat sales specification in addition to the falsification check. We argue that our results are not driven by owners' subjective valuations of their properties (i.e., high reservation prices), by considering the premium by property use and by owner occupancy. Taken together, we interpret our results as evidence that the market for land assembly is subject to substantial frictions.

The frictions we document could result from imperfections in both the public and private spheres. Public frictions arise from the regulation of land by local governments, including zoning restrictions, development fees, and building codes (Glaeser, Gyourko, and Saks 2005). Private market failures stem from bargaining problems between the developer of the assembled land and the land sellers, causing problems such as holdouts. To establish whether private market frictions are an important part of the problem, we perform two additional tests motivated by theoretical conjectures about the relationship between parcel size and both assembly probability and the sales price of assembled parcels. We find suggestive evidence that private market imperfections are substantial.

I. Theoretical Framework

A. *Surplus to Assembly*

We begin our analysis with a simple theoretical framework that generates testable predictions about land assembly. Assume that at the time of initial development, time $t - j$, $j > 0$, land is developed into parcels of size a and $2a$. The relative quantities of the different sized parcels are chosen optimally given market conditions at time $t - j$ such that the per square foot price of parcels size a and size $2a$ is equal. As time passes, those initial parcel definitions may become suboptimal. In this vein, we assume that by time t, market conditions have evolved such that larger parcels size $2a$ command a premium relative to smaller parcels sized a. In other words, the relationship between land value and parcel size has become convex, such that $V(2a) > 2V(a)$, where $V(x)$ is the market price of a parcel of size x. Consistent with our empirical approach, which focuses on the value of land and not capital, we assume that any capital placed on the land at time $t - j$ has depreciated to zero by time t. Figure 1, panel A, graphically presents the convexity of the land price

[6]Relative to the country as a whole, land in Los Angeles is expensive and highly regulated. In this vein, our results should be interpreted as being most applicable to large coastal metropolitan areas, which tend to be expensive and highly regulated. See a full comparison in Section VA.

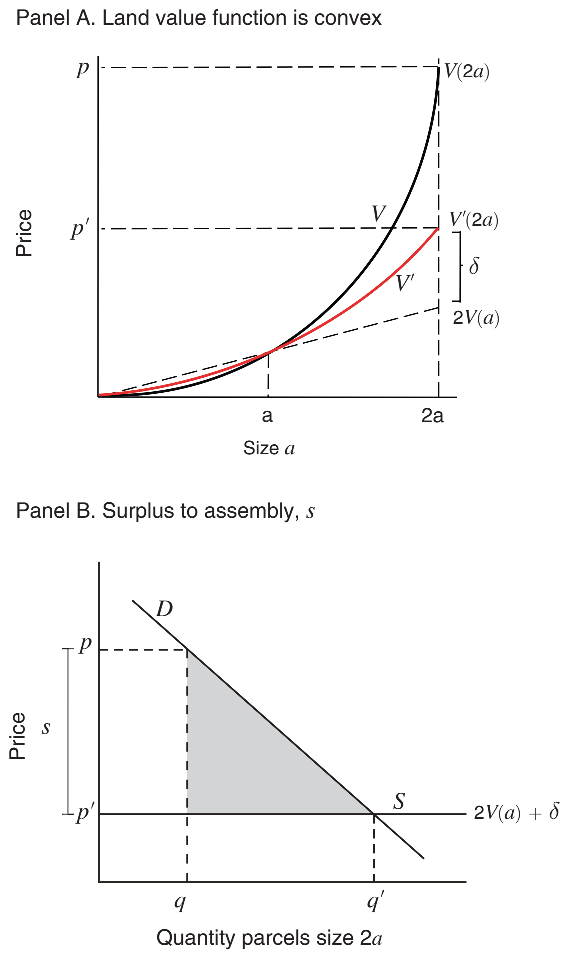

Figure 1. Theoretical Framework

Notes: Figure 1, panel A, illustrates convexity in land prices. Were land prices to increase linearly, they would follow the dashed line ending at $2V(a)$. When prices are convex, as shown with the thick curve, $V(2a) > 2V(a)$. The thin curve shows how the convex curve flattens out as developers complete assemblies and the market moves toward equilibrium. In equilibrium, we expect the price of assembled and unassembled parcels to differ only by the "good institution" cost of assembly, δ.

function, V. The price per unit a of land increases with the size of the parcel. In contrast, the thin dashed line, ending at $2V(a)$, illustrates a linear land value function where the price per unit a of land is constant.

Land values tend to become convex when the optimal capital to land ratio increases. Convexity arises because the density implied by high capital to land ratios requires large lots. For example, taller buildings typically require larger footprints. Similarly, builders may require large lots in order for buildings to be of sufficient size to absorb fixed costs such as elevators.

The optimal capital to land ratio in a metropolitan area may increase for any number of reasons. Population growth tends to increase the optimal capital to land ratio

(Henderson 1977). Similarly, increased commute times in an urban area may push the optimal ratio up in the urban core. The optimal ratio may also rise when land use shifts geographically over time. For instance, land initially developed into small single family lots may eventually become more valuable for commercial purposes. Commercial uses typically imply a higher capital to land ratio, and thus larger lot sizes. Finally, technological shocks may also change this ratio. For example, Willis (1995) describes how the invention of fluorescent lighting changed the shape of office buildings and thus increased the optimal lot size for such buildings.

The convexity in the land value function implies that assembly generates a surplus relative to maintaining existing parcel boundaries. We define surplus value, s, as

$$s = V(2a) - \delta - 2V(a), \tag{1}$$

where δ is the cost of assembly and captures factors such as conversion costs (e.g., demolition, grading to-be assembled parcels with different slopes, etc.) and "good-institution" transactions costs. Crucially, δ only includes costs which would reasonably arise in a well-functioning land market free of frictions. We use the term "good-institution" to sharply distinguish transactions costs consistent with a well-functioning land market from "bad-institution" transactions costs better viewed as frictions. "Bad-institution" transactions costs might include holdouts. For example, δ includes the cost of changing title to a property, but not delays to change in title caused by protesting neighbors.

Convexity in the land price function is a necessary condition for land assembly to occur (Shoup 2008). The cost of assembly, δ, can only be covered when the value of the assembled parcel, $V(2a)$, exceeds the value of the unassembled parcels, $2V(a)$. The value of the unassembled parcels, $2V(a)$, is the opportunity cost of assembly; it represents the economic returns to the unassembled land foregone in exchange for realizing the higher return to the assembled land.

In a frictionless world, arbitrage ensures that all surplus is realized and that assemblies continue until the market price of land has adjusted such that any surplus is eliminated. Specifically, as assemblies occur, the supply of lots sized $2a$ expands and the price of these lots falls. Assembly ceases when the return to assembled and unassembled lots has equalized: $V(2a) - \delta = 2V(a)$ and $s = 0$.[7] Figure 1, panel B—a supply and demand graph for parcels sized $2a$—displays this process. For simplicity, we assume that the quantity of parcels sized a is arbitrarily large relative to the demand for parcels sized $2a$. As a result, $V(a)$ is fixed and the supply curve for parcels sized $2a$ is horizontal at the marginal cost of producing such parcels: $2V(a) + \delta$. In the absence of frictions, the market will assemble land until there are q' parcels sized $2a$. When the market reaches equilibrium following the period of assembly activity, the land value function has flattened out from V to V' in Figure 1, panel A, and the price difference between parcels sized a and $2a$ is the cost of assembly, δ.

[7] It is also possible that the market reaches a corner solution such that all parcels have been assembled. As this is not relevant empirically, we do not further consider this case.

If frictions are present, the surplus available from assembly may not be arbitraged away. For instance, holdouts may ask excessive prices for their parcels and thereby make projects infeasible for the developer (Eckart 1985; Strange 1995).[8] Similarly, individual landowners may attempt to increase their share of the surplus by being the final sale into an assembly. Such strategic delay may cause assemblies to fail (Menezes and Pitchford 2004; Miceli and Segerson 2007; Miceli and Sirmans 2007). The public goods aspect of land assembly—the fact that assembly may increase the value of neighboring parcels not participating in the assembly—may also block arbitrage opportunities (Grossman and Hart 1980; O'Flaherty 1994). Finally, land use regulations may systematically block arbitrage opportunities. For example, regulation may bar a large building that would optimally occupy an assembled site. Returning to Figure 1, panel B, if frictions block all assemblies, there will only be q parcels of size $2a$ (the initial endowment), and the surplus to assembly, s, will persist. In the absence of spillovers, the shaded region is the deadweight loss associated with the frictions.[9]

B. *Testing for Frictions*

We now lay out a strategy to assess whether or not land assembly is inhibited by frictions.[10] Our test estimates the magnitude of the surplus s accruing to successful assemblies in order to obtain a rough sense of the magnitude of the assembly market frictions. A large estimate of s is consistent with substantial frictions in the market for assembly. This approach is similar in spirit to the work of Glaeser, Gyourko, and Saks (2005) and Glaeser and Gyourko (2002) on the regulatory tax. These articles reason that in the absence of regulation the extensive value of land—the per unit value of land with a house on it—will equal the intensive value of land—the value of a marginal increase in the area of a lot. If the extensive value exceeds the intensive value, landowners should optimally choose to subdivide their land and sell a portion of it. Our approach applies what is, in essence, the reverse of this logic: in the absence of market imperfections, if land is worth more combined than divided, owners will choose to combine it.

Inferring the existence of frictions from the presence of surplus requires two assumptions. The first assumption is free entry into the market for development (or assembly). Developers earn zero profits; therefore the owners of the initial parcels

[8] In Eckart (1985) and Strange (1995), holdouts arise primarily due to two factors. First, land owners may have imperfect information on the value of the completed assembly and may therefore demand prices in excess of the value of the completed project. Second, assembly is characterized by indivisibility. A developer must assemble contiguous parcels and therefore cannot simply purchase an alternative parcel if he encounters a holdout.

[9] We only consider the effect of frictions on the quantity of assembled parcels. Frictions may also cause the final land area assembled to be smaller than it would otherwise be. Munch (1976) and McDonald (2007) model this possibility.

[10] The extremely limited empirical evidence on land assembly does not directly address the central question of how successfully the land market produces assemblies. Cunningham (2013) and Fu, McMillen, and Somerville (2002) document that the final seller in a land assembly receives a premium. Harding, Rosenthal, and Sirmans (2003) provide evidence of more general deviations from the competitive equilibrium in the market for housing. A distinct literature explores whether the price per square foot of land increases in the size of the plot and is indirectly related to assembly (Coulson 1989; Colwell and Munneke 1999, 1997; Colwell and Sirmans 1993; Brownstone and DeVany 1991).

size a capture any surplus s available from assembly. The value of an assembled parcel is $V(2a) + K$, where K is the amount of capital placed on the newly assembled parcel. If the developer earns zero profits, this post-assembly value must equal his costs. The developer's costs are capital, K, assembly costs, δ, and the purchase price of the unassembled land, p_u. Thus, $V(2a) + K = K + \delta + p_u$, which yields $p_u = V(2a) - \delta$. We can therefore estimate surplus as the difference between the sales price of to-be-assembled parcels, $V(2a) - \delta$, and the sales price of not assembled parcels, $2V(a)$: $V(2a) - \delta - 2V(a)$.[11]

The second assumption required to infer the existence of frictions from the presence of surplus is that the frictions in the urban land market operate purely as a supply constraint on assembly. This occurs if regulation prohibits assembly or if landowners cause assemblies to fail by asking prices that drive developer profits below zero. These supply restraints prevent arbitrage from entirely eliminating the surplus to assembly.

If the free entry and supply constraint assumptions fail to hold, we will likely understate frictions in the market for assembly for at least two reasons. First, if there are barriers to entering the market for development, developers may capture a portion of the assembly surplus. The portion of the surplus accruing to the developer is reflected in the post-assembly sales price of the newly assembled parcel, not in the pre-assembly price we use to infer surplus. As a result, our estimate of surplus would be biased downward. Second, although the frictions described above almost certainly act as supply constraints on assembly, other types of frictions may exist as well. For instance, frictions such as regulatory costs (e.g., the time spent getting approval for a project) and strategic delay may increase the developer's costs. Such an increase will reduce our measured value of surplus by depressing the amount a developer is willing to pay for assembled land. A given assembly may have no measurable surplus under our methodology, but large surplus in the absence of the friction-induced increase in developer costs. Thus, even a finding of no price premium for to-be-assembled parcels does not rule out the possibility that frictions influence the market for assembly.

We now discuss four potential conceptual objections to our test. (We leave the important issue of empirical bias arising from positive selection into assembly and other endogeneity concerns to Section II.) First, a strict claim of inefficiency requires that surplus exceeds zero for the marginal assembly, while our empirical procedure recovers the average surplus to assembly. In our simple framework, this is not a concern because there is no heterogeneity and the average and marginal surplus equate. In reality, though, there may be heterogeneity in the costs of assembly (keeping in mind that "good-institution" transactions costs are not driven by market frictions). With heterogeneous assembly costs, average surplus can exceed zero even if the surplus to the marginal parcel is zero.[12]

[11] We deliberately remain agnostic on how sellers of input parcels split the surplus from assembly.

[12] Assume that there are contiguous pairs of parcels with unique assembly costs, δ_i, that there are no frictions in the land market, and that the market is in equilibrium (and hence no assembly takes place because all positive surplus assemblies have already occurred). Then a shock increases $V(2a)$. Order the surplus of each pair, $s_i = V(2a) - \delta_i - 2V(a)$, so that $s_1 > s_2 > s_3 \ldots$ unless all parcels assemble, there must be an s_{i^*} such that $s_{i^*-1} > s_{i^*} = 0 > s_{i^*+1}$. The index i^* implicitly defines the number of assemblies produced by the shock. The marginal parcel i^* earns zero surplus, and all inframarginal parcels earn a surplus. We thank Robert Helsley for helpful discussion on this point.

This type of heterogeneity in assembly costs, however, is unlikely to explain our findings for two reasons. First, we find that average surplus equals 15 to 40 percent of the market value of a parcel in its unassembled state. Assembly costs—demolition, land grading, "good-institution" transaction costs, etc.—are negligible relative to the value of some of the most expensive urban real estate in the United States.[13] For heterogeneous assembly costs to explain our estimates, such assembly costs would have to be extremely large relative to the value of the land in its unassembled state. Second, the distribution of assembly costs would have to be extremely disperse to generate an average surplus of 40 percent and a marginal surplus of zero.

Similarly, there may be variation across locations in the difference between the value of a parcel in its assembled state, $V(2a)$, and its unassembled state, $V(a)$, and hence in the surplus to assembly. However, in the absence of frictions, arbitrage should drive the assembly surplus to zero in all locations regardless of the initial surplus available. Were the outputs of assembly projects unique local properties, this might not be the case: imagine a developer who assembles land to build a supermarket in an area that can support only one such store. However, our data show that over three-quarters of land assembled and developed is used for residential purposes. Such residential development is not the unique output that might give rise to this concern.

The second potential objection to our test is that it may take time for the market to complete enough assemblies to drive surplus to zero. During such a transition, surplus would be positive, even in the absence of frictions. However, the market for construction is quite deep in Los Angeles County. Many developers participate and even large construction projects can typically be completed quickly. The Census Bureau reports that a small multifamily building worth less than \$3 million is completed in less than a year on average. Even very large buildings valued over \$10 million with over 100 units usually take less than 2 years to complete (US Census Bureau 2015). Thus, any transition period should be relatively short and is unlikely to explain a 15 to 40 percent surplus to assembly. While assemblies often take a significant amount of time to complete, the delay is typically caused by the very frictions, such as holdouts, whose impact we are attempting to quantify, not by the normal adjustment process of a well functioning land market.

The third possible objection to our surplus test is that many plots are constrained from assembly. For instance, physical barriers such as steep slopes may prevent assembly. Public capital, such as roads, may separate parcels and prevent assembly. A parcel ready for redevelopment may be next to a parcel with new or valuable capital, making redevelopment as part of an assembly economically infeasible. These factors are reasonably viewed as materially different from factors such as zoning and holdouts which may also prevent assembly. It would be unreasonable to label the failure to assemble two parcels separated by a road a market "friction." However, arbitrage opportunities should cause the price of assembled and

[13] Rosenthal and Helsley (1994) document that demolition costs are only around 1.5 percent of the value of the underlying land for single family homes in Vancouver (which, like Los Angeles, has relatively expensive land). Similarly, Dye and McMillen (2007) document that demolition costs are low enough in metro Chicago that they can effectively be ignored for purposes of using teardowns to establish the value of land (see p. 48).

unassembled teardown parcels to converge—and surplus to go to zero—unless there is a corner solution where no feasible assemblies exist. At least in Los Angeles, it seems clear that ample assembly opportunities remain and that a corner solution has not been reached (Landis and Hood 2005).

The fourth potential objection to our test is that potential sellers into an assembly may have reservation prices higher than the market price for idiosyncratic reasons. For example, retirees may prefer to remain in their long-term place of residence or parents may wish that their children continue to attend a particular school. The need to buy contiguous parcels may force a developer to transact with such owners. (In contrast, in most market settings a buyer would choose to transact with a seller whose reservation price is less than or equal to the market price.) Thus, high reservation prices may cause properties selling into an assembly to transact at above market prices even in the absence of market frictions (Miceli, Sergerson, and Sirmans 2008).[14]

We believe that reservation prices are unlikely to explain our surplus estimates for two reasons. First, while individuals with elevated reservation prices undoubtedly exist, the surplus to assembly should be arbitraged away as long as there are some potential assemblies where the owners have reservation prices equal to market prices (that is, as long as there are enough such potential assemblies that surplus is driven to zero before developers must begin transacting with high reservation price sellers). Second, our empirical work devotes considerable effort to determining the extent to which our surplus estimates reflect high reservation prices. We use a number of different approaches, all of which suggest our surplus estimates primarily reflect market frictions, not high reservation prices. Most notably, although owners of commercial property are likely less prone to having idiosyncratically high reservation prices (Ellickson 1973), these properties display the same surplus to assembly as do residential properties.

C. *Sources of Land Assembly Frictions*

In the presence of nonzero surplus, we propose two tests to examine the source of frictions in the market for land assembly. For the first of these tests, assume that at time t parcels of size $\frac{a}{2}$ and a exist. Assembly technology allows for generating parcels of size $2a$ through any combination of parcels yielding an area of $2a$. The convexity of the land value function suggests that $V(a) > 2V\left(\frac{a}{2}\right)$. The assembly surplus is therefore higher for assemblies involving only parcels of size $\frac{a}{2}$ because these smaller parcels have a lower opportunity cost than the larger parcels. As a result, in a market free of frictions, small parcels should be more likely to be assembled than larger parcels.[15]

[14] To illustrate, assume that the developer can always buy the first parcel of an assembly at market price and that the reservation price of the owner of the second parcel, $R(a)$, exceeds the market price: $R(a) > V(a)$. The true surplus from assembly becomes $s = V(2a) - \delta - 2V(a) - (R(a) - V(a))$. Reservation prices are unobservable and the measured surplus remains $s = V(2a) - \delta - 2V(a)$. The surplus estimate is therefore biased *upward* by the amount by which the reservation price exceeds the market price: $R(a) - V(a)$.

[15] Assembly costs, δ, may be a function of the number of parcels included in an assembly (e.g., real estate transaction fees would be expected to be a function of the number of parcels). In such a case, we implicitly assume that as the number of input parcels increases, holding the size of the end assembly fixed, the opportunity cost of

However, theorists argue that small parcels may increase the likelihood of private market frictions. Owners of small parcels may be more likely to ask excessive prices because, as a lower share of the ultimate assembly, their asking price is less likely to scuttle the project (Eckart 1985; Strange 1995). Similarly, the greater number of parcel owners involved in an assembly, the greater the odds of strategic delay (Miceli and Sirmans 2007). Both these factors may cause assemblies with positive surplus to fail.

Given this, our first test for the sources of surplus examines the influence that parcel size has on the probability of assembly. A finding that larger parcels are more likely to be assembled suggests that private market frictions inhibit assembly.

Our second test for the sources of surplus examines the relative sales prices of to-be-assembled parcels by size. Evidence that small parcels command a significant per square foot price premium over large ones, despite a lower opportunity cost of selling into assembly, would support the theoretical predictions that small parcels owners are unusually likely to ask excessive prices and engage in strategic delay. These two additional tests shed light on the source of the frictions, as both focus on frictions likely caused by private market failures.

II. Empirical Approach: Establishing the Existence of Surplus

In this section, we outline how we take the surplus test to the data. In the results section, we discuss robustness checks, including repeat sales methods, a falsification check, and a consideration of the role of reservation prices.

To estimate surplus, s, we must recover the land value of both assembled and unassembled parcels. We recover the land value of an unassembled parcel using the technique pioneered by Rosenthal and Helsley (1994) and refined by Dye and McMillen (2007). This technique recovers the value of land using sales of properties where the structure is torn down shortly after sale. The value of such a teardown sale reflects only the value of the underlying land, since the capital is discarded and demolition costs are generally very small relative to land values (see footnote 13 for information on costs).

We apply a similar logic to value the land used in assemblies. Most assemblies discard the existing capital and place new capital on the assembled site to take advantage of the larger building area. Intuitively, if the capital on the initial parcels were retained, there would be no gain from assembly. As a result, we assume that to-be-assembled parcels are teardowns and also use their sales price as a measure of the value of the land. We then estimate surplus as the difference between the value of assembly sales and the value of teardown sales.

---

the input parcels falls more than the increase in assembly costs $\left(\text{roughly } \frac{\partial \delta(n)}{\partial n} < -\frac{\partial V(n)}{\partial n}\right)$. This is a reasonable assumption given that assembly costs are small relative to the value of land.

We estimate this difference with the following specification

$$(2)\quad \log\left(\frac{\textit{real sale price}}{\textit{lot square footage}}\right)_{i,g,t} = \alpha_0 + \alpha_1 \textit{assembly}_i + \sum_{t=1}^{T} \textit{year-quarter}_t + \sum_{g=1}^{G} \textit{neighborhood}_g + \alpha_2 \mathbf{X}_{i,t} + \alpha_3 \mathbf{amenities}_i + \varepsilon_{i,g,t},$$

where $\frac{\textit{real sale price}}{\textit{lot square footage}}_{i,g,t}$ is the per square foot price of land for parcel i in neighborhood g at time t and $\textit{assembly}_i$ equals one for an assembly and zero for a teardown.

The estimation sample includes only teardown and assembly sales. Specifically, we select the sales sample in the following way. Each assembly has a start and end year (which may be the same, but frequently are not). We identify all parcels which are "input" parcels to assembly. We then identify the sales of these parcels that are no more than four years before the beginning of the assembly, no more than three years after the beginning of the assembly, and before the end of the assembly. Of these, we keep only the final sale. We use this window to keep only sales "close" to the time of assembly, which should be sales that reflect the value of land. For teardown sales, we keep only sales that are four or fewer years before the structure is torn down.[16]

With this sample, α_1 captures the surplus to assembly relative to redevelopment within the existing parcel boundaries measured by teardowns. If $\alpha_1 = 0$, there is no surplus to assembly, consistent with an absence of market frictions.

Interpreting α_1 as the surplus to assembly requires that assemblies and teardowns are comparable in the unobserved determinants of price, $\varepsilon_{i,g,t}$. However, there are reasons to suspect that assembly may be correlated with unobservable determinants of price. Most significantly, developers choose parcels of land for assembly and may prefer relatively more valuable land. For instance, rising land values often dictate increasing the capital-to-land ratio and may therefore motivate assembly. For our estimation, we are concerned with whether positive selection into assembly exceeds positive selection into teardown.

To illustrate the bias from potential positive selection into assembly a bit more formally, consider neighborhoods H and L which are initially identical and have linear land price functions such that there is no land assembly: $V^H(2a) = 2V^H(a) = 2V^L(a) = V^L(2a)$. Then a positive demand shock hits area H, producing two changes. First, parcels of a given size in H are now more valuable than identically sized parcels in area L. Second, the increased demand in H creates the need for larger lot sizes and, hence, the land value function becomes convex and there is excess return to land assembly: $V^H(2a) > 2V^H(a) > 2V^L(a) = V^L(2a)$. The true economic surplus to assembly is $s = V^H(2a) - \delta - 2^H V(a)$. In the context of our empirical approach, it is possible that we observe teardowns in area L, and assemblies in area H.

[16] Our results are robust to the use of alternative pre-assembly and pre-teardown windows.

If so, the empirical estimate of surplus, $\hat{s}$, is biased: $\hat{s} = V^H(2a) - \delta - 2^L V(a)$. The magnitude of the bias is $\hat{s} - s = 2(V^H(a) - V^L(a))$. We view this positive selection into assembly relative to teardown as likely the most important potential source of correlation between assembly and $\varepsilon_{i,g,t}$.

A parcel's preexisting zoning is one specific example of a basis for selection into assembly. For instance, assembly may be more likely on permissively zoned parcels of land because such zoning permits the type of large, dense projects that make assembly valuable. If more lenient zoning boosts the value of both assembled and unassembled parcels, and assemblies are more likely than teardowns to occur in leniently zoned areas, then our estimates could be biased upward by positive selection into assembly.[17] On the other hand, zoning may make high value land less likely to assemble. If high value land tends to be more stringently zoned, assembly may be more likely than on less stringently zoned low value land. High land value may be high value for reasons having nothing to do with the likelihood of assembly, and this could introduce downward bias. Thus, zoning may introduce positive or negative bias.

We tackle these endogeneity concerns by observing that the value of land, virtually by definition, is a function of location. We therefore include a very fine set of geographic fixed effects, either census tract indicators or census block group indicators, $\sum_{g=1}^{G} neighborhood_g$.[18] The comparison of land price between assemblies and teardowns therefore comes only within very small areas. There are 2,054 census tracts and 6,346 block groups in Los Angeles County. The median tract contains 985 parcels, and the median block group 290.[19]

Of course, some elements of location vary even within small geographic areas. For instance, access to a highway may differ within a neighborhood. We therefore control for distance to the nearest major highway, nearest major road, and the shortest distance to urban and commuter rail with the $\mathbf{amenities}_i$ vector. To control for the market-wide evolution in price over time, we include a full set of indicators for each quarter in our sample, $\sum_{t=1}^{T} year\text{-}quarter_t$ (i.e., indicators for 1999:I, 1999:II, etc., are included), and we allow the coefficients on these indicators to vary by the

[17] Positive selection bias from lenient zoning will only occur if two conditions hold. First, lenient zoning must be present on assembled sites but not teardown sites. Second, lenient zoning must increase the value of both assembled and unassembled parcels. This need not be the case. For instance, lenient zoning may increase the value of a large assembled parcel because it allows for building a more dense, more valuable building, but not increase the value of a small parcel because you cannot build a large condo building on a row house lot even if it is zoned for it. In this case, the teardown control group provides an appropriate value for an assembled parcel in its counterfactual, unobservable unassembled state.

[18] If this strategy is valid, the average variation in land price should decline as we consider smaller geographies. Using our teardown sample to isolate the value of land, we find that the standard deviation of log sales price is 28 percent of the mean at the county level. In contrast, when we take the mean and standard deviation of log price by tract and then average across all tracts, we find that the tract standard deviation is 18 of the mean. At the block group level, this figure falls to 16.

[19] Our test relies on the coexistence, in geographically comparable areas, of both teardown and assembly parcels. Appendix Figure A1 shows census tracts in Los Angeles County, and marks areas that ever (1999 to 2010) have both at least one assembly and one teardown; areas that ever have only teardowns; areas that have only assemblies; and areas that have neither. Roughly three-quarters of all tracts have an assembly over the period of study; this figure is 80 percent for tracts with teardowns. Roughly 65 percent of all tracts have at least one assembly and at least one teardown over the period of study. The map shows that these redeveloped areas are located widely across the county.

residential or nonresidential status of the input parcel.[20] To control for parcel attributes, we include a vector of parcel characteristics, $\mathbf{X}_{i,t}$, which includes a cubic in lot size and indicators for the pre-assembly or pre-teardown use of the parcel (e.g., single family). "Use" is the current use of the parcel, and may in practice be distinct from the parcel's zoned use.[21] Finally, we report standard errors clustered at the city level; Los Angeles County has 88 cities.[22]

III. Land Assembly Definition and Institutions

This section presents our empirical definition of land assembly and discusses the institutions for assembly in Los Angeles County.

To define land assembly, we first define a "parcel change group." A parcel is part of a parcel change group if it or its ancestor or descendant parcel(s) ever changes. However, parcels combine and disaggregate in a number of different ways, so membership in a parcel group does not alone indicate assembly. The list below presents three examples of possible parcel changes:

(A) $3 \rightarrow 1 \rightarrow 7$

(B) $1 \rightarrow 5$

(C) $8 \rightarrow 1 \rightarrow 2$

We define a change group to have land assembly if any part of the parcel change group goes from $n > 1$ properties to one. In the example above, this includes cases A and C, but excludes case B. Case A is an instance of net disassembly (three parcels into seven parcels), though it contains assembly as an intermediate step (three parcels into one parcel). We define case A as a land assembly because in most such instances redevelopment cannot occur without the assembly step. For instance, a developer may wish to convert multiple detached single family home parcels into denser townhouse style homes. The lots first need to be combined before they can be properly subdivided into the smaller townhouse lots.[23]

When is the type of land assembly we have defined required? Regulations for land assembly are the province of cities, or the county for unincorporated areas. In general, cities do not require developers to assemble parcels, even when a new structure spans more than one parcel. Importantly, legal assembly has no implications for zoning. The prior zoning on the land as previously delimited continues to apply.

[20] Pooling different property types together in equation (2) is appropriate because we are valuing land, not structures. Furthermore, it is quite common for the input parcel use to differ from the assembled parcel use (e.g., commercial properties are assembled and a condo building placed on the new parcel).

[21] The use classifications we use are single family, non-condo multifamily, condo, vacant, and other. Parcels can have a use classification which differs from their zone code. For instance, a commercially zoned property is almost always allowed to host a residential dwelling. Such a property will have use and zoning codes which differ. Unfortunately, we do not have reliable data on zoning for our entire sample.

[22] See online Appendix "Teardown Selection Issues" for an important deviation from the teardown method.

[23] Though this definition of land assembly could include parcels assembled via eminent domain, our empirical analysis of prices uses only arm's length sales. Furthermore, the municipal officials with whom we spoke suggested that eminent domain is used very sparingly.

Legal assembly is the jurisdiction of the county; zoning regulations are the province of individual municipalities.

There are two circumstances under which formal assembly is required.[24] The first is when the new land use will be condominiums. Each unit in a condominium must have a separate parcel, as each unit may have a unique legal owner. Therefore, any land combined for condos must be assembled. The second exception from the laissez-faire policy is a function of the use of the property. Suppose that a city's zoning requires two parking spaces for each multifamily unit, and that the developer has purchased two parcels upon which to build a new multifamily development. If the developer builds the parking on one parcel and the structure on the other, he is required to legally assemble the parcels. Cities make such a requirement to ensure that all future sales keep parcels in compliance with zoning regulations.

Outside of these two exceptions, a developer may purchase adjoining land with the intent of building new structures but not go through the formal process of legal assembly.[25] It is the legal assembly which we observe in the data. For the purposes of our estimation, this type of underreporting likely biases our estimates of the prevalence of frictions downward, by misclassifying some assembled parcels—the treated group—as teardown parcels, which are the control group.[26]

While there are substantial benefits to legal assembly, the costs in terms of administrative burden and fees are extremely low. Once an owner acquires adjacent parcels, if he wishes to legally combine them, he need only fill out a form from the county assessor's office. There is no charge. Importantly, the legal land assembly process does not trigger a reassessment under California's Proposition 13. Proposition 13 limits the increase in a property's assessed value to 2 percent per year, with the assessed value resetting to the market value at sale. A developer may face an increased assessment due to property purchase, but not due to the legal act of assembly (Special Investigations Section, Los Angeles County Assessor 2013). Thus, legal assembly is virtually costless. Turning to the benefits of assembly, interviews with practitioners suggest that legal assembly is very likely for projects[27] requiring financing, since assembly lessens the financier's cost in the case of default (interview citations appear after the bibliography). In addition, selling an assembled parcel, rather than multiple unassembled parcels, reduces paperwork and uncertainty in future transactions. Thus, our interviews suggest that the combination of substantial benefits and low costs results in developers choosing legal assembly over informal assembly in most cases.

To give a sense of the prevalence of assembly, Figure 2 presents the total number of assemblies in Los Angeles County divided by the total number of permits issued for residential construction by year from 1999 to 2010. We expect that this number

[24] Information in this section comes primarily from an interview with Wolfgang Krause, chief planner, city of Glendale, May 2010. To the best of our knowledge, these two circumstances do not vary across regulatory jurisdictions in the county.

[25] In such cases, with multiple owners, owners usually write legally binding easement agreements across properties.

[26] However, the bias from misclassification could be positive if more valuable parcels were selected into legal assembly, and less valuable parcels were selected into informal assembly and then misclassified as teardowns; and such misclassified assemblies account for a substantial share of teardowns.

[27] Interview citations appear in the online Data Appendix.

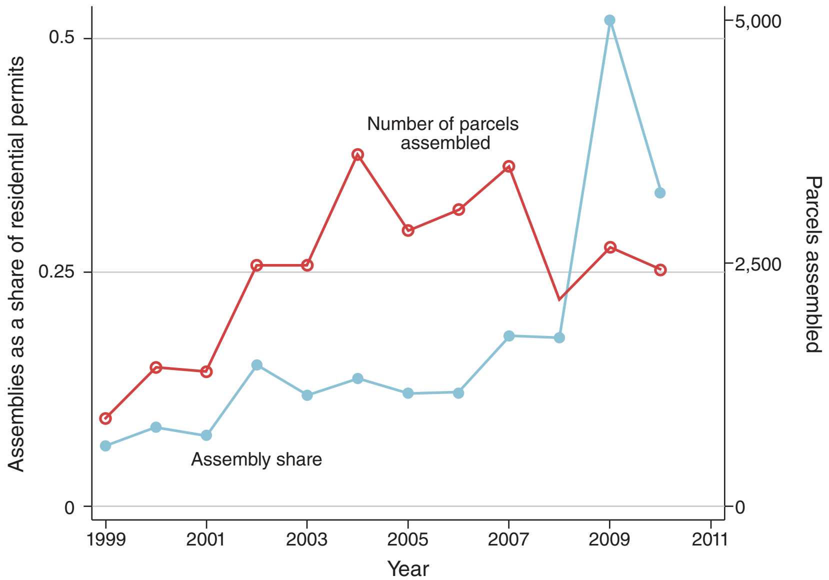

Figure 2. Prevalence of Assembly: Assembled Parcels Relative to Building Permits

Notes: While the Census Bureau counts one permit for each new unit, one assembly (in our terms) may result in more than one unit. This means that our measure in the chart may understate the importance of assembly. However, the Census Bureau counts residential permits only, while our measure of assemblies includes assemblies that result in nonresidential construction. In this sense, our measure overstates the importance of assembly. Because we do not have a cross section of properties from 2003, we attribute all assemblies in 2002 and 2003 to 2002; for the purposes of this chart, we split the assemblies in 2002 evenly between 2002 and 2003. Though our assembly information continues through 2011, this chart ends in 2010 when the permit data end.

Sources: Permit data from Census Bureau, assemblies calculated from authors' dataset. See online Data Appendix for details.

actually underestimates the importance of land assembly. While one permit allows for construction of one unit, one assembly may (and frequently does) result in more than one unit. For instance, three parcels of land may be assembled to construct a multistory 30-unit condo building. Thus, while three parcels are assembled, permits are given for 30 units. It is also possible that this number overstates the impact of assembly, since permits include only residential construction and our data include all land for assembly. However, the majority of assembly land (like all land) is used for residential purposes. Even given this likelihood of underestimation, assemblies account for roughly 7 to 20 percent of residential permits per year from 1999 to 2008 and account for a substantially larger share in 2009 and 2010.

This evidence from Los Angeles County is not obviously generalizable to the United States as a whole. Prices in the county are substantially higher, recent price changes are somewhat larger (see Appendix Figure A2 for details), and regulation is more stringent (Gyourko, Saiz, and Summers 2008). Given this, our results are likely most applicable to large coastal metropolitan areas, which tend to be both expensive and highly regulated. However, these metros account for a substantial share of the US population and economic activity, and are critical centers of innovation (e.g., Glaeser 2011). Indeed, 1 in 30 US residents lives in Los Angeles County.

Further, if current trends in land use regulation continue, the rest of the country will eventually look more like today's Los Angeles than vice versa. Thus, Los Angeles County's experience can also be interpreted as a harbinger.

IV. Data

Our project relies on multiple sources of data. We summarize the data here, and refer interested readers to our lengthy online Data Appendix for full details on all data inputs and data construction details. The three key components of our data are the annual property-level data for Los Angeles County, sales data for properties, and census neighborhood measures.

Our annual property data consist of 3 key parts: 12 annual cross-sectional observations of the 2.3 million parcels in the County of Los Angeles; an administrative dataset from the county assessor listing all parcels that change, and the identification numbers of the parcel(s) to which they change; and electronic maps with geographic information on all properties.

The annual cross sections are the heart of the dataset. In each year from 1999 to 2011 (except for 2003, which we have been unable to obtain; thus, we have a sample that spans 13 years but contains only 12 cross sections), we observe attributes about each individual piece of property in the 88 cities and the large unincorporated area of Los Angeles County. We observe too many attributes to list here, but briefly the data include attributes about the property itself (e.g., size, location, and current use) and attributes about the building on the property (e.g., building size). Thus, this part of the dataset includes somewhat more than 24 million observations with many descriptive variables.

The second part of the data is a file that allows us to take the 12 cross sections and make them into a true panel by linking property identification numbers over time. Though most properties retain a constant identification number throughout the sample, some properties split or merge. Our dataset of all property identification number changes allows us to follow each initial piece of land to its current, perhaps aggregated or disaggregated, form. While this task is conceptually simple, in practice it has been exceedingly difficult, and the bulk of our data assembly has been devoted to making sure that we have built these linkages correctly.

The third and final part of the annual property data is electronic maps of all parcels. These maps, which we have from 2006 onward, allow us to pinpoint the exact location of each individual property and calculate distances from one property to another, or from a given property to key urban amenities, such as light rail stops or freeways. These maps also allow us to assign each property to a unique census block group.

We combine this panel of all properties in the county with all property transactions by property identifier. Specifically, we observe the last three sales on each property as of 2006, and sales in the last two years each year from 2009 to 2011. This leaves a small gap of sales in 2006. We limit the sample of transactions to include only arms' length transactions and make other small adjustments as described in the online Data Appendix.

We measure neighborhood economic and demographic factors with data from the 1990 and 2000 decennial censuses at the block group level. To use the 1990 block group data, we use GIS mapping to make a correspondence from 1990 to 2000 census block groups.

Finally, we define a property as a teardown if the structure's age changes in our panel. Specifically, we require that the replacement structure be newer than the old structure, that the new structure is built after 1998, and that the old structure was built before 1990.[28]

We identify approximately 40,000 parcels that are inputs into an assembly and 14,000 parcels with structures that are torn down. Of these properties, there are 2,700 sales of assemblies and 6,800 sales of teardowns that are "close" to the time of assembly or teardown (see our definition of "close" in Section II).[29]

V. Results

This section presents results from our test for the existence of surplus. It also contains robustness checks, which aim to demonstrate that the estimated surplus reflects neither the endogeneity of assembly location nor high reservation prices.

A. *Existence of Surplus*

We motivate our comparison of assembly to teardown parcels by presenting their mean characteristics in columns 1 and 2 of Table 1. As a reminder, the sample contains only sales of assembly and teardown parcels that occur shortly before assembly or teardown. In order to provide context, column 5 displays means for non-assembly and non-teardown parcels. Overall, assemblies (column 1) and teardowns (column 2) are located in similar types of neighborhoods. Although there are statistically significant differences between the groups—column 3—the magnitude of the differences are economically small (e.g., a black neighborhood share of 5.3 percent for assemblies versus 6.0 percent for teardowns). Moreover, regression-adjusted mean differences that condition out census tract fixed effects, presented in column 4, generally show extremely small and imprecise differences. This similarity is advantageous for our primary test given its requirement that assemblies and teardowns be comparable in the unobserved determinants of price.

A glaring exception to the comparability is the average parcel's use before the assembly or teardown occurs: teardown parcels are much more likely to be single family than are assembly parcels. We take great care below to address this difference. All specifications include a control for use type and we allow the coefficients on the year by quarter of sale controls to differ by residential and nonresidential status. We also present specifications that restrict the sample to only single family

[28] We observe structure age at only a single point in time each year (in July). We therefore omit teardown sales in year *t* when the new structure appears in year *t* because we cannot determine if the structure was built before or after the sale. Thus, our sample surely omits some teardowns that should be included.

[29] Not surprisingly, teardowns are more likely to have a sale in our estimation sample than are assemblies. Assemblies often involve the purchase of parcels over a long period. In contrast, teardowns are a single, discrete event. Thus, restricting to sales "close" in time to assembly or teardown filters out relatively more assemblies than teardowns.

Table 1—Covariates of Assembly and Teardown Properties Are Similar

	Primary estimation sample: Assembly and teardown sales				
	Assembly (1)	Teardown (2)	Difference (3)	Difference conditional on tract FE (4)	Non-assembly and non-teardown sales (5)
ln(price per square foot)	3.897	4.104	−0.207	0.643	4.069
	[1.790]	[1.273]	(0.031)	(0.067)	[1.251]
Single family	0.204	0.736	−0.532	−0.335	0.634
	[0.403]	[0.441]	(0.009)	(0.019)	[0.482]
Poverty rate	0.106	0.114	−0.008	0.001	0.133
	[0.111]	[0.118]	(0.003)	(0.002)	[0.114]
Neighborhood share black	0.052	0.060	−0.008	0.004	0.084
	[0.094]	[0.121]	(0.003)	(0.002)	[0.148]
Neighborhood share Hispanic	0.232	0.242	−0.010	−0.003	0.338
	[0.253]	[0.266]	(0.006)	(0.003)	[0.272]
Neighborhood share of housing units vacant	0.039	0.046	−0.007	0.003	0.042
	[0.052]	[0.046]	(0.001)	(0.002)	[0.042]
Median household income	63,001	72,431	−9,430	230	55,445
	[27,623]	[43,627]	(881)	(605)	[28,373]
Observations	2,797	7,979	N/A	N/A	1,819,021

Notes: Columns 1, 2, and 5 display means. Column 3 displays the difference between columns 1 and 2 and the standard error for an equality of means test. Column 4 displays coefficient estimates from a regression of the variable in the row on an indicator variable for assembly and a set of census tract fixed effects. [ ] denotes standard deviation and ( ) denotes standard error. The standard errors in column 4 are clustered by city. Demographic characteristics, such as the poverty rate, are from the census and are measured at the block group level. Price per square foot in column 5 is not directly comparable to the other columns because it includes the value of capital and is therefore not comparable to the prices displayed in columns 1 and 2, which capture only the value of the land.

Source: See online Data Appendix for complete information.

parcels or only nonresidential parcels to make teardowns and assemblies as comparable as possible.

Table 2 presents the results for our test of surplus—absent frictions, the price of teardowns and assembly parcels should equate—implemented by estimating equation (2) on the sample of teardown and assembly sales. The first column of this table shows the results from a regression without any controls. This raw comparison shows that, on average, parcels sell into assembly for an insignificant 1 percent lower price than parcels sold for teardown.

In Table 2, column 2, we include tract fixed effects. The coefficient estimate indicates that being sold into an assembly is associated with a roughly 40 percent price premium relative to being sold for redevelopment without a change in parcel boundary. The extremely large magnitude of the assembly surplus suggests substantial frictions in the market for assembly.[30] However, this large estimate is not inconsistent with a simple, plausible example. Suppose that unassembled, two parcels can house two single family homes (one each) and that assembled,

[30] We use the test developed in Oster (2013) to assess the sensitivity of our estimate to unobservables based on coefficient movement and R^2 s across columns 1 and 2 in Table 2. Compared to the estimation with no covariates in column 1, we find a relatively tight bound on our estimate in column 2 of (0.42, 0.64).

Table 2—Excess Value of Land in Assembly

	Full sample							Single family
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1 if parcel is in an assembly	−0.01	0.42	0.38	0.35	0.39	0.34	0.37	0.36
	(0.18)	(0.06)	(0.06)	(0.05)	(0.06)	(0.10)	(0.13)	(0.04)
Observations	10,776	10,776	10,762	10,776	10,776	10,776	8,610	6,442
Assemblies	2,797	2,797	2,783	2,797	2,797	2,797	631	570
Teardowns	7,979	7,979	7,979	7,979	7,979	7,979	7,979	5,872
Geographic fixed effects								
Tract		X		X			X	X
Block group					X			
Tract × year						X		
Additional covariates								
Year-quarter of sale	X	X	X	X	X	X	X	X
Year-quarter of sale × nonresidential	X	X	X	X	X	X	X	
Use classifications	X	X	X	X	X	X	X	
Cubic in lot size	X	X	X	X	X	X	X	X
Capital controls			X					
Capital controls × nonresidential			X					
Neighborhood demographics				X			X	X
Distance to key amenities				X			X	X
Assembly teardowns							X	

Notes: The dependent variable is log(real sales price per square foot). We use the largest consistent sample of sales in the three years before teardown or assembly, where the teardown or assembly occurs between 1999 and 2011. Standard errors clustered at the city level are in parentheses. Capital controls are the value of improvements to the land per square feet, the ratio of the value of improvements to the land to the value of the land, and a full set of interactions of indicators for decile of structure age with indicators for decile of structure square feet divided by lot square feet (a measure of the quantity of capital). For both deciles an 11th indicator variable is added to denote missing values. Neighborhood demographics include the following variables in both 2000 level form and as changes between 1990 and 2000 levels: poverty rate, neighborhood share black, neighborhood share Hispanic, share of housing units vacant, and share of housing units owner-occupied. Use classifications include indicator variables for single family, non-condo multifamily, condo, vacant, and other. Distance to key amenities include measures for the shortest distance from each parcel to three amenities: a highway entrance or exit, a metro-link stop (commuter rail), and a metro-rail stop (subway or light rail).

Source: See online Data Appendix for complete information.

the parcels can house a six story condo building; such a situation would not be uncommon in parts of Los Angeles. Further, assume that the houses sell for \$500,000 each and condos sell for \$300,000 each. Assume that each house's capital value is \$300,000 and each condo's capital value is \$200,000. In this case, the premium to assembly is 50 percent: $(6 \times (\$300{,}000 - \$200{,}000) - 2 \times (\$500{,}000 - \$300{,}000))/2 \times (\$500{,}000 - \$300{,}000))$.

Columns 3 through 7 of Table 2 present alternative specifications. Column 3 adds controls for the value of capital in place at time of sale.[31] In principle, this capital should not affect the sales price, as the capital is slated to be scrapped shortly after

[31] We control for the presence of capital in a relatively nonparametric manner by including the full set of interaction terms between indicator variables for the decile of the vintage of the existing capital (year built) and indicator variables for the decile of the quantity of the capital (square feet of structure per square foot of land). This approach fails to account for both differences in depreciation across properties and differences in the initial quality of the capital. We therefore also control for the capital to land ratio (assessed improvements/assessed land value), and the value of capital per square foot of land (assessed improvements/lot size). We allow all of the coefficients on the capital variables to vary by residential and nonresidential pre-assembly use.

sale. Consistent with this, the inclusion of the capital controls has little effect on the estimated premium to assembly. Column 4 addresses within neighborhood variation by adding neighborhood demographic controls at the block group level and controls for local amenities. Column 5 further addresses intra-neighborhood variation by replacing the tract fixed effects with very finely grained block group fixed effects. Column 6 controls for the evolution in price specific to each tract by including tract-year terms. This is an extremely saturated and demanding specification: identification of the assembly premium comes solely from comparing assemblies to teardowns within census tracts in the same year.[32] Regardless of specification, the magnitude of the surplus estimate varies little, ranging from around 35 to 40 percent.

It is possible that assemblies occur with the aim of future, rather than immediate, redevelopment. If so, the sales price of the to-be-assembled parcels may reflect the expected return to any existing capital over the period before redevelopment (McMillen and O'Sullivan 2011). Such a scenario would bias our surplus estimates upward. To address this possibility, in column 7, Table 2 we restrict our sample to only assemblies where the existing capital is immediately torn down. (Due to the structure of our data, we under-identify these parcels. See Section 3 of the online Data Appendix for details.) The magnitude of the surplus estimate is virtually the same as the unrestricted sample.

To address the concern that assembled parcels are systematically less likely to be single family than are teardowns, column 8 of Table 2 restricts the sample to single family parcels. The restriction makes the teardown and assembly samples comparable in terms of pre-assembly use. The surplus estimates remain similar to those produced by the full sample.[33]

These surplus results are credible only insofar as we control for the endogenous location of assembly, and show that the results are not driven by owners' high subjective valuation of their homes. We deal with each of these issues in turn, starting with a falsification exercise and a repeat sales analysis that address the issue of endogenous location.

Intuitively, our falsification check asks whether land very near an assembly is more valuable than land very near a teardown. Such a difference would suggest that teardown areas differ systemically from assembly areas and that teardowns may not be an appropriate control group for assemblies. Stated differently, we estimate whether there is surplus to assembly for the non-assembly neighbors of assemblies. A positive estimate of assembly surplus for non-assembled parcels would suggest the estimates on Table 2 are spurious. We focus on the years just before the assembly to avoid any direct influence of the assembly on the value of neighboring parcels. Such spillovers would contaminate the falsification check. (We explore the possibility of spillovers to assembly in Section VC.)

[32] With the inclusion of the tract-year fixed effects in column 6, the identification of the assembly premium comes solely from tract-years with both an assembly and a teardown. There are 172 such tract-years. Nonetheless, the estimate of the assembly premium with the inclusion of tract-year fixed effects is reasonably robust to alternative specifications (available from the authors upon request).

[33] Our results also depend on observing both teardown and assembly parcels. The relative share of these parcels is stable after 2003; in 2002 and before, we observe low levels of teardowns. Results in Table 2 are robust to omitting teardowns and assemblies before 2003.

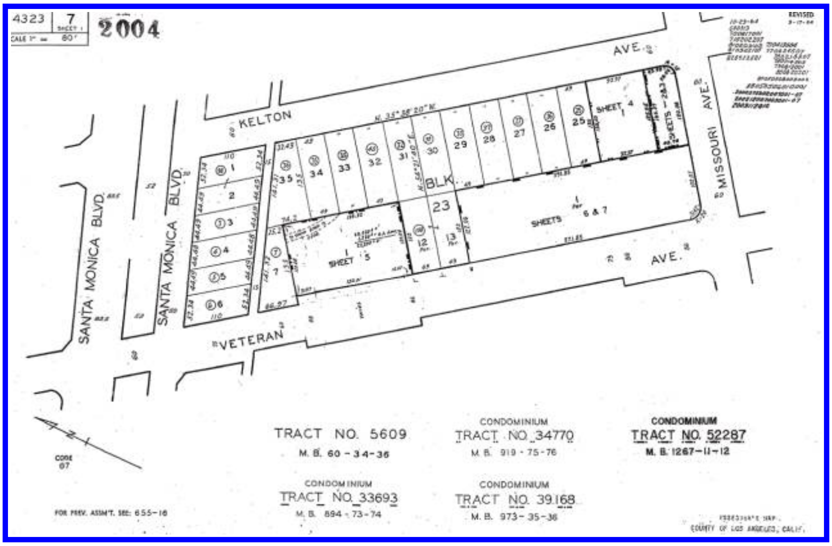

FIGURE 3. MAP BOOK PAGES ARE SMALL AREAS

Notes: This picture shows a "map book page." The assessor organizes all land in the county into map books. Each very small neighborhood is referenced by its page in such a map book.

Source: Los Angeles County Assessor website

Specifically, we estimate

$$
(3) \qquad \log\left(\frac{\textit{real sale price}}{\textit{lot square footage}}\right)_{i,g,t}
$$

$$
= \lambda_0 + \lambda_1 1\{\textit{pre-assembly very close neighbor}\}_{i,t}
$$

$$
+ \sum_{t=1}^{T} \textit{year-quarter}_t + \sum_{g=1}^{G} \textit{neighborhood}_g
$$

$$
+ \lambda_2 \mathbf{X}_{i,t} + \lambda_3 \mathbf{K}_{i,t} + \epsilon_{i,g,t},
$$

where $\mathbf{K}_{i,t}$ is a vector measuring the value of capital on parcel i at time t and $1\{\textit{pre-assembly very close neighbor}\}_i$ is an indicator variable equaling one if parcel i is a very close neighbor of an assembled parcel and t is one to three years prior to the start of the assembly. The sample for this estimation is the very close neighbors of teardowns and assemblies three years before assembly or teardown.

We define very close neighbors as parcels located on the same "map book page" as assembled parcels. Map book pages are geographical units defined by the county assessor's office. They are quite small, containing an average of only 26 parcels, and typically encompass a single square block. Figure 3 displays a representative example.

The coefficient λ_1 therefore captures the "surplus" to being a very close assembly neighbor relative to being a very close teardown neighbor. If the estimated premium

Table 3—Falsification Check—Do Future Assemblies Move the Current Price of Immediate Neighbors?

	Full sample				Single family
	(1)	(2)	(3)	(4)	(5)
1 × {Pre-Assembly Map Book Page}	−0.005	−0.01	−0.004	−0.033	−0.006
	(0.019)	(0.013)	(0.010)	(0.016)	(0.012)
Observations	150,849	150,849	150,849	150,849	84,761
Geographic fixed effects					
Tract	X	X			X
Block group			X		
Tract-year				X	
Additional covariates					
Year-quarter of sale	X	X	X	X	X
Year-quarter of sale × nonresidential	X	X	X	X	
Use classification	X	X	X	X	
Cubic in lot size	X	X	X	X	X
Distance to amenities	X	X			X
Neighborhood demographics	X	X			X
Capital controls		X	X	X	X
Capital controls × nonresidential		X	X	X	X

Notes: The dependent variable in these regressions is log(real sales price per square foot). 1 × {Pre-Assembly Very Close Neighbor} equals one for parcels that share a map book page with a parcel that will assemble within three years. We use the largest consistent sample of sales in the three years before teardown or assembly, on map book pages where the teardown or assembly occurs between 1999 and 2011; however, we exclude all teardown and assembly sales. Standard errors clustered at the city level are given in parentheses. Use classifications, amenities, and demographics are as given in the note on Table 2. Capital controls are the value of improvements to the land per square feet, the ratio of the value of improvements to the land to the value of the land, and a full set of interactions of indicators for decile of structure age with indicators for decile of structure square feet divided by lot square feet (a measure of the quantity of capital). For both deciles an 11th indicator variable is added to denote missing values.

Source: See online Data Appendix for complete information.

to assembly reflects bias from very localized unobserved amenities—those whose effect on property values is more geographically limited than a block group—these amenities should be reflected in the price of the assembled parcels' very close neighbors. Thus, a positive and precise λ_1 indicates that the Table 2 results may be biased. A zero estimate of λ_1 suggests no bias, and a negative λ_1 suggests potential negative selection in assembly relative to teardown.[34]

Table 3 presents the results. Column 1 suggests that there is virtually no difference in price between very close assembly neighbors pre-assembly and very close teardown neighbors pre-teardown. The 95 percent confidence interval is bounded by

[34] This falsification test is cleanest when the decision to assemble or tear down certain parcels within a map book page is determined by idiosyncratic factors unrelated to unobservable determinants of parcel value. For example, imagine two very similar neighboring houses. The owner of one house has a child in 10th grade who wishes to graduate at his current school and the other neighbor has no children. These owners may have very different subjective costs of moving. Unlike this example, it is possible that parcels, even within a map book page, may be selected into assembly or teardown. For example, positive selection into assembly could occur if developers avoided parcels with unobservable negative characteristics. Negative selection into assembly could occur if houses on inferior parcels were less well maintained and were therefore cheaper to scrap in a redevelopment. Any such positive or negative selection into either assembly or teardown would be problematic for the falsification check. However, if the selection is the same for both assemblies and teardowns, the selection would difference out.

−4.2 percent and 3.2 percent. Unlike the prices for teardowns and assemblies, the market value of neighboring parcels likely includes the value of capital. Column 2 therefore controls, in a very flexible manner, for the parcel's capital, as defined in Table 2. The discount falls a bit and remains imprecise. Using block group fixed effects produces an even smaller point estimate—column 3. Including tract-year fixed effects in column 4 produces a small and significant negative effect. Restricting the sample to single family parcels produces an extremely small, imprecise estimate—column 5.

Overall, these results suggest that there is little bias involved in comparing assemblies to teardowns and they strongly suggest that there is no upward bias in the comparison: the upper 95 percent confidence interval for the estimate in column 3 is a mere 0.016.

In order to further address the endogenous location of assembly, we now turn to a repeat sales approach, which we estimate using the following specification

$$(4) \quad \log\left(\frac{\textit{real sale price}}{\textit{lot square footage}}\right)_{i,t} = \beta_0 + \beta_1 1\{\textit{redevelop}\} \times 1\{\textit{ever assembly}\}_{i,t} + \beta_2 1\{\textit{redevelop}\}_{i,t} + \beta_4 \mathbf{K}_{i,t} + \beta_5 \mathbf{K}_{i,t} \times 1\{\textit{redevelop}\}_{i,t} + \sum_{i=1}^{I} \textit{parcel}_i + \sum_{t=1}^{T} \textit{year-quarter}_t + \varepsilon_{i,t}.$$

We restrict the sample to teardown and assembly parcels which have, in addition to the teardown or assembly sale, a previously occurring sale (after 1985). The indicator $1\{\textit{redevelop}\}_{i,t}$ equals one when the observation is the sale immediately before either an assembly or teardown. The indicator $1\{\textit{ever assembly}\}_{i,t}$ is one if the parcel is ever sold into an assembly in our sample; it is not included as an uninteracted, main effect because it is collinear with the parcel fixed effect. Thus, $1\{\textit{redevelop}\}_{i,t} \times 1\{\textit{ever assembly}\}_{i,t}$ equals one if this sale is the final sale before assembly, and β_1 is the coefficient of interest.

This repeat sales estimation can be viewed as a double difference: relative to the same parcel over time, and relative to teardowns, is there a premium for being the last sale before an assembly? The principle advantage of the approach is that the parcel fixed effect, $\sum_{i=1}^{I} \textit{parcel}_i$, controls for any time-invariant feature of the parcel such as greenery, freeway access, proximity to commercial strips, etc. However, if assemblies are anticipated, sales before the final assembly sale may partially reflect the value of the parcel as used in an assembly. In this case, the repeat sales estimates is downward biased.

While the "redevelopment" sales values should not reflect the value of capital, the earlier sales values likely do (i.e., the earlier sale buyers likely intended to use

Table 4—Premium to Assembly in Repeat Sales Framework

	(1)	(2)	(3)
1{Redevelopment} × 1{Assembly}	0.13	0.15	0.21
	(0.05)	(0.06)	(0.07)
Observations	6,837	6,837	6,837
No. unique assembled parcels	853	853	853
No. unique teardown parcels	2,133	2,133	2,133
Redevelopment and capital covariates			
1{Redevelopment}	X	X	X
Capital controls		X	X
1{Redevelopment} × capital controls		X	X
Geographic fixed effects			
Parcel fixed effect	X	X	X
Additional covariates			
Year-quarter of sale	X	X	X
Year-quarter of sale × nonresidential	X	X	X
Use classifications	X	X	X
City × year fixed effects			X

Notes: The dependent variable in these regressions is log(real sales price per square foot). We use the largest consistent sample of repeat sales in the three years before teardown or assembly, where the teardown or assembly occurs between 1999 and 2011. Standard errors clustered at the city level are given in parentheses. 1{Redevelopment} is an indicator variable equal to one when the sale is an assembly or teardown sale. Use classifications are as given in the note on Table 2. The capital controls (which are more parsimonious than the set used on Tables 2 and 3) include capital per lot square foot (assessed improvements/lot size), the capital to land ratio (assessed improvements/assessed land value), quadratics in structure square feet per lot square foot, structure age (set to zero if missing), an indicator variable for structure age missing, the interaction of structure square feet per lot square foot with structure age, and the interaction of structure square feet per lot square foot with the indicator for structure age missing. Coefficients on the capital variables are allowed to vary by residential and nonresidential pre-assembly use. The city × year effects include a category for unincorporated portions of LA county.

Source: See online Data Appendix for complete information.

the capital located on the parcels). We therefore include controls in equation (4) for capital, $\mathbf{K}_{i,t}$, and capital on the final sale ($\mathbf{K}_{i,t} \times 1\{redevelop\}_{i,t}$).[35]

Table 4 presents the repeat sales results. From the smaller numbers in the observation rows, it is clear that the data requirements of the approach yield a substantially thinner sample than that used for the initial test in Table 2. This is particularly true for the number of unique assemblies and teardowns. The repeat sales approach thus places significant demands upon the data. Column 1 presents a specification which lacks the capital controls and column 2 adds in these controls. Both specifications yield an assembly surplus of about 15 percent. Unlike the initial test, these estimates are sensitive to controlling for the geographic-specific evolution in prices. Controlling for city-year effects in column 3 boosts the surplus estimate to

[35] Given the much smaller sample size, we use a more parsimonious set of capital controls than for Table 3's falsification check. See the note on Table 4 for a complete list of the capital control variables.

Table 5—Do Reservation Prices Explain the Premium to Assembly?

	Non-single family (1)	Nonresidential (2)	Single family (3)
1{Parcel in an Assembly}	0.33	0.32	0.44
	(0.13)	(0.16)	(0.09)
1{Parcel in an Assembly}			−0.17
× 1{Owner Occupied}			(0.11)
Observations	4,334	3,573	4,225
Assemblies	2,227	1,887	406
Owner-occupied			241
Teardowns	2,107	1,686	3,819
Geographic fixed effects			
Tract	X	X	X
Additional covariates			
Year-quarter of sale	X	X	X
Year-quarter of sale × nonresidential	X		
Use classifications	X	X	
Cubic in lot size	X	X	X
Neighborhood demographics	X	X	X
Distance to key amenities	X	X	X

Notes: The dependent variable in these regressions is log(real sales price per square foot). We use the sample of sales in the three years before teardown or assembly, where the teardown or assembly occurs between 1999 and 2011. Standard errors clustered at the city level are given in parentheses. Use classifications, amenities, and demographics are as in the note to Table 2.

Source: See online Data Appendix for complete information.

21 percent.[36] While smaller than the surplus estimate produced by our principal approach, 21 percent remains a sizable surplus to assembly. Moreover, as we note above, these estimates may be biased downward if assembly is anticipated when the parcel sells before the final assembly sale.[37]

We conclude our analysis of surplus by considering whether our estimates of surplus are driven by high subjective valuations. Subjective valuations should be particularly high for single family homes (Ellickson 1973). Therefore, in order to assess the importance of reservation prices in determining surplus, we examine the difference in surplus between single family and non-single family parcels. Column 1 of Table 5 presents results from our surplus estimation (Table 2) using a sample that excludes single family homes. The surplus estimate of 33 percent is extremely similar to the analogous estimate of 36 percent for single family homes (column 7 of Table 1). Similarly, Table 5, column 2 further restricts the sample to nonresidential parcels, which we expect would have lower subjective valuations, on average, than single family homes. The result is again quite similar to the estimate for single family homes. Finally, single family owner-occupants would likely have higher subjective valuations than absentee owners. In Table 5, column 3, we restrict the sample

[36] The tract-year terms used elsewhere in the paper cannot be employed here given the thinness of the estimation sample.

[37] If we re-estimate the specifications in Table 2 with this sample; results are similar to those in Table 2. Therefore, differences between the results in this table and Table 2 are a function of the estimation strategy, not the sample.

to single family homes and allow the assembly premium to vary by owner status. If reservation prices were the primary factor driving the surplus estimate, owner-occupied homes should have a higher surplus. The results suggest the opposite, but are quite imprecise. In sum, the patterns of surplus by parcel use and ownership status are not consistent with surplus consisting primarily of high reservation prices.

B. *Causes of Assembly Surplus*

Broadly, we construe the results from Tables 2 through 5 as jointly offering reasonably strong support for the existence of an economically significant premium to assembled land. Given this, we now turn to a consideration of the sources of this surplus. Surplus can be driven by both public and private market frictions. Public frictions that yield surplus are regulations on the use of land. Private market frictions include problems of holdouts and other bargaining issues. We use two tests to assess whether private market failures contribute to the surplus.[38] The results point toward an important role for private market failures in creating assembly surplus. We cannot rule out the possibility, though, that public market failures may also play an important role.

Starting with the first test: in a well functioning market, smaller parcels should be more likely to assemble than larger parcels due to the convexity of the land value function in areas undergoing land assembly. Alternatively, in a poorly functioning market, small parcels are particularly prone to market frictions such as holding out and strategic delay. We therefore examine the influence of parcel size on assembly probability. To do so, we use the cross section of all 2 million county parcels from the first year of the sample (1999).[39] The estimating equation is

$$(5) \quad assembly_{i,g} = \gamma_0 + \gamma_1 \log(lot\ square\ footage_i) + \sum_{g=1}^{G} neighborhood_g + \gamma_2 \mathbf{amenities}_i + \gamma_3 \mathbf{K}_{i,t} + \varepsilon_{i,g},$$

where $assembly_{i,g}$ equals one if the parcel is involved in an assembly over the following 13 years of the sample and zero otherwise, and $lot\ square\ footage_i$ is the size of the parcel. γ_1 captures the marginal effect of lot size on the probability of assembly and is the coefficient of interest.

The coefficient γ_1 is properly identified when lot size is uncorrelated with unobserved determinants of assembly, $\varepsilon_{i,g}$. There are at least three possible reasons to be concerned that this may not be the case. First, the likelihood of assembly may vary by location, and location may be correlated with parcel size. For example,

[38] A natural third test would examine the land assembly premium as a function of the time of sale, where later selling parcels would garner a larger premium. Unfortunately, the structure of our data precludes such an approach. Market participants told us that sales into assembly are frequently "contingent sales" so that no sale of any potentially assembled property occurs until the developer has gathered a sufficient amount of land. In such a case, all properties that sell into the assembly officially transact on the same date, even though the actual bargaining date may differ substantially. We observe only the official transaction date, which is frequently the same for parcels selling into a given assembly.

[39] Summary statistics for this sample are in Appendix Table A1.

Table 6—Effect of Lot Size on Likelihood of Assembly

	(1)	(2)	(3)	(4)
log(lot size)	0.012	0.011	0.010	0.010
	(0.003)	(0.003)	(0.004)	(0.003)
Observations	2,139,621	2,139,621	2,139,621	2,139,621
Share ever assembled	0.014	0.014	0.014	0.014
Geographic fixed effects				
Tract	X		X	
Block group		X		X
Additional covariates				
Use classifications	X	X	X	X
Neighborhood demographics	X		X	
Distance to key amenities	X		X	
Capital controls			X	X
Capital controls × nonresidential			X	X

Notes: The dependent variable is an indicator variable equal to one if the parcel is ever engaged in assembly from 1999 to 2011; results are estimated via OLS (linear probability model). The sample is the cross section of all parcels that exist in 1999, and excludes public land. Standard errors clustered at the city level are given in parentheses. Use classifications are as given in the notes to Table 2. Census demographic variables and amenities are as listed in the notes to Table 2. The capital controls include the value of improvements to the land per square feet, the ratio of the value of improvements to the land to the value of the land (i.e., capital to land ratio), and a full set of interactions of indicators for decile of structure age with indicators for decile of structure square feet divided by lot square feet (for both deciles an 11th indicator variable is added to denote missing values).

Source: See online Data Appendix for complete information.

parcels near the urban center may be ripe for assembly and redevelopment due to traffic congestion. These parcels may be relatively small, but it is their lower commute time, not their size, driving the assembly decision. As before, we net out such neighborhood-specific factors with tract or block group fixed effects, so that all our comparisons are made within a given, limited geographic area.

The second threat to the credibility of the identifying assumption is the possibility that large plots tend to have more valuable capital per square foot of land than smaller parcels. All else equal, the more valuable the capital on a parcel, the less likely the capital will be scrapped to allow for redevelopment and the less likely is assembly. We therefore control for the presence of capital on each parcel in a very flexible manner (see the note to Table 6).

A third reason lot size may be correlated with the error term is because not all lots are "assemble-able," and "assemble-ability" may be correlated with lot size. In general, larger parcels should be more likely to be unable to assemble because they have no contiguous neighbors. However, this possibility would bias our estimation toward small parcels being more likely to assemble, and hence make it less likely we will conclude that the market for assembly is inhibited by frictions.

Column 1 of Table 6 indicates that a 10 percent increase in the size of a parcel increases the probability of ever being assembled by 0.1 percent. This is a large effect, equal to around 10 percent of the sample mean probability of ever assembling (see the "Share Ever Assembled" row). The remaining columns use block group fixed effects (columns 2 and 4) and include the capital controls (columns 3 and 4). These permutations have little effect on the lot size coefficient.[40]

We believe that these results are unlikely to be driven exclusively by a correlation between reservation prices and lot size, or by land use regulations. Conditional on the right-hand side controls, which include the pre-assembly use of the parcel, there is no obvious reason why reservation prices should vary by lot size. Similarly, land use regulations are not likely to create an incentive to use large parcels in an assembly.[41] Thus, we interpret this evidence as suggesting that private market frictions are prevalent in the market for land assembly.

Our second test for the causes of assembly surplus relies on a similar logic to that of the previous test. In the absence of frictions, the convexity of the land value function requires that small parcels should not receive a premium relative to large parcels when they sell into an assembly. Alternatively, when market frictions are present, small parcels may command a premium. We implement this test by estimating

$$\text{(6)} \quad \log\left(\frac{\textit{real sale price}}{\textit{lot square footage}}\right)_{i,a,t} = \theta_0 + \theta_1 \log(\textit{lot square footage}_i) + \sum_{t=1}^{T} \textit{year-quarter}_t + \sum_{a=1}^{A} \textit{assembly group}_a + \theta_2 \mathbf{amenities}_i + \varepsilon_{i,g,t},$$

where $\sum_{a=1}^{A} \textit{assembly group}_a$ is a fixed effect for each assembly group—a set of contiguous parcels that are assembled together. The coefficient θ_1 captures the marginal effect of lot size on sales price and is the coefficient of interest. The sample is limited to assembly sales.

The $\sum_{a=1}^{A} \textit{assembly group}_a$ term ensures the influence of lot size on sales price is measured solely within groups of parcels assembled together. The identifying assumption required for equation (6)—that lot size is uncorrelated with the unobserved determinants of price—is therefore extremely plausible. To-be-assembled parcels are sold only for their land value. Within an assembly group parcels are contiguous and thus likely have very similar location value.

Table 7 presents the results. Column 1 shows that a 10 percent increase in parcel size reduces the sales price of a to-be-assembled parcel by roughly 8 percent. Column 2 includes the distance to amenities controls, which vary somewhat within a parcel group, and produces nearly identical results. There is little reason to think

[40] If we exclude the least dense quartile of parcels in terms of the population density of their block group from the sample, ensuring that our results are driven by outcomes in a dense urban setting, results are little changed.

[41] In fact, land use regulation may provide an incentive to assemble small parcels. Consider minimum setback requirements. Under a fixed setback requirement, assembling parcels relaxes the regulatory constraint as the adjoining borders of the input parcels become interior to the assembled parcel and do not require a setback (Shoup 2008). Hence, a higher percentage of the assembled land can have capital situated on it relative to the unassembled land. The gain along this dimension is greater for joining together several small parcels than it is for joining together a few large parcels.

Table 7—Elasticity of Sales Prices with Respect to Lot Size

	(1)	(2)
log(lot size)	−0.825	−0.801
	(0.191)	(0.166)
Observations	2,916	2,916
Number of assembly groups	1,358	1,358
Geographic fixed effects		
Assembly group	X	X
Additional covariates		
Year-quarter of sale	X	X
Year-quarter of sale × nonresidential	X	X
Use classifications	X	X
Distance to key amenities		X

Notes: The dependent variable in these regressions is log(real sales price per square foot). The sample is the same as in Table 2, but omits teardowns. Standard errors clustered at the city level are given in parentheses. Use classifications and distance to amenities are as given in the notes to Table 2.

Source: See online Data Appendix for complete information.

that reservation prices vary with lot size within a parcel group, conditional on use. Thus, the substantial premium to small parcels supports the hypothesis that the owners of these parcels tend to hold out and demand higher than average prices for their land—behavior which works to reduce the number of successful assemblies.[42] While it is possible that land use regulation differs within assembly groups in a manner correlated with lot size, we view this evidence as most consistent with private market failures.

C. *Welfare Implications*

Given that our evidence suggests a substantial deadweight loss associated with the inhibition of land assembly, it is natural to ask whether this inhibition causes an overall welfare loss. We explore this issue at length in the online Welfare Appendix and summarize our conclusion—that a welfare loss is likely but not certain—here. If an increase in land assembly decreases welfare, it must be that the negative external effects of assembly outweigh the reduction in direct deadweight loss (the shaded area in Figure 1, panel B). We divide the external effects of land assembly into local and nonlocal (that is, metropolitan area wide) effects. To estimate the local external effects of land assembly, we estimate a modified version of equation (3), where we replace $1\{\textit{pre-assembly very close neighbor}\}_i$ with an indicator for being on the same map book page as an assembly after the assembly, and we restrict the

[42] A similar logic yields an expectation that parcels geographically central to the assembly should receive a larger premium. Because we do not observe parcel maps until 2006, we are unable to implement such a test exactly. However, we can proxy for parcel centrality with the geographic center of the parcel (measured with substantial noise in the early years of our sample), and ask whether parcels "central" to the assembly receive a larger premium. We do not find any such evidence. Given the crudeness of our measure, we believe the role of centrality remains an open question.

sample to non-assembly and non-teardown sales. Intuitively, this specification estimates whether parcels very close to the assembly experience a price change after the assembly. In short, we observe no capitalization of assembly into nearby properties, suggesting no local externalities to land assembly.

Therefore, for additional land assembly to decrease welfare, metropolitan area externalities to assembly must be quite negative. We believe this is unlikely, but cannot rule out this possibility. Furthermore, assessing the welfare consequences of frictions is inherently difficult in an urban setting. Most urban models assume market failures that generate agglomeration and congestion. In such a second-best setting, removing a negative externality, such as land assembly frictions, need not improve overall welfare (e.g., Helpman 2007; Kanemoto 2013). Overall, though, we believe the combination of direct evidence of deadweight loss and the absence of evidence for negative local spillovers points toward the possibility of a large welfare loss from land assembly frictions.

VI. Conclusion

The results of this paper provide robust confirmation of the hypothesis that the market for land assembly is inhibited by frictions. We find that land selling into assembly garners a 15 to 40 percent premium. Because we find that smaller parcels are less likely to be assembled and fetch higher per square foot prices within a given assembly, we contend that at least part of the overall frictions we document are due to private market failures. Though the evidence is not conclusive, it is possible that the frictions inhibiting land assembly are associated with large and negative welfare effects.

While the problems we document are salient for the developed world, they are likely to be just as salient, if not more, for the developing world, where urban growth often confronts problems of assembly. Seshadri (2012) holds that problems in land assembly inhibit the growth of special economic zones in India, and media coverage of holdouts in Chinese land assembly is abundant (for examples, see French 2007 and Molloy 2012).

If the market for private land assembly operates as poorly as suggested by this work, it is natural to look to government for remediation. The most recent large-scale government action to assemble land is known as "urban renewal," a process in the United States, Canada, and in some parts of Europe in the 1960s and 70s. Urban renewal used the government's power of eminent domain to assemble small parcels of land, predominantly in the urban core. Urban renewal, however, ended amid charges of developer cronyism and racism and has largely been judged harshly by historians (Cord 1974). While our findings suggest that the land assembly portion of urban renewal would likely not have been achieved by the private market, our results from the private market have little to offer in understanding the potential value of government-driven assembly.

Alternatively, there may be a middle ground between the private exchange of land and direct government intervention. Under the practice of "land readjustment," redevelopment districts are formed and land assembly occurs if a majority of land owners in the district vote for it. The owners are given a stake in the new development as compensation. The practice has been successfully used in a number of countries, including Germany, South Korea, and Israel (Hong 2007). Land readjustment may provide a mechanism for overcoming the private market failures inherent in land assembly, while mitigating the costs associated with direct government intervention. Another possible middle ground approach is graduated density zoning, which awards the right to build at greater density to larger lots. The "density bonus" increases the value of large lots and encourages assembly. Although it does not eliminate holdouts, it may generate a fear of being left out and therefore reduce the prevalence of holdouts (Shoup 2008).

More broadly, our evidence argues that "tragedies of the anti-commons," in which problems of fragmented ownership impede socially optimal outcomes, are of economically significant magnitude. While we illustrate these problems in the context of land assembly, they apply in many contexts with fragmented ownership, such as spectrum rights or intellectual property.

Appendix

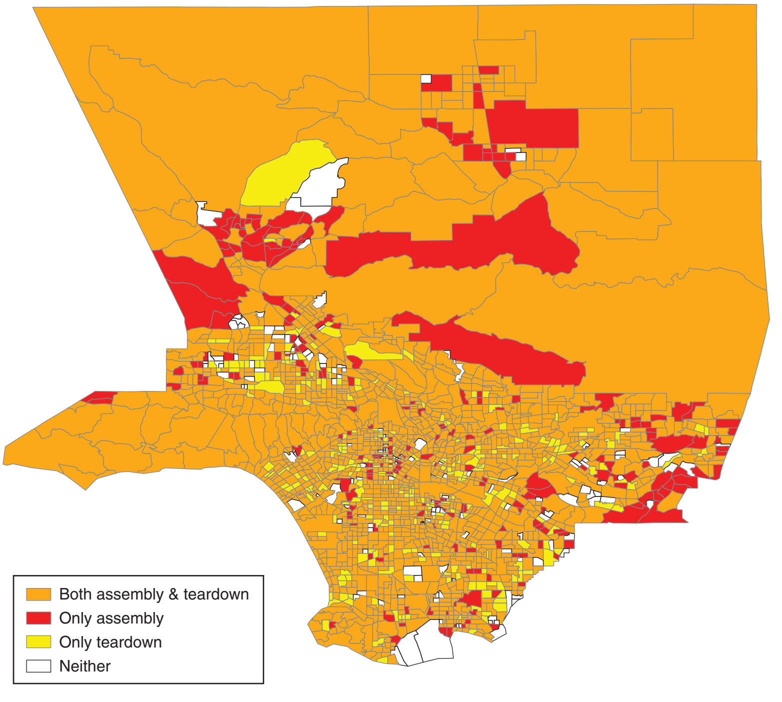

Figure A1. Map of Los Angeles County Census Tracts by Redevelopment Status

Note: Each polygon in this map is a census tract, which is defined to have roughly between 3,000 and 4,000 people.

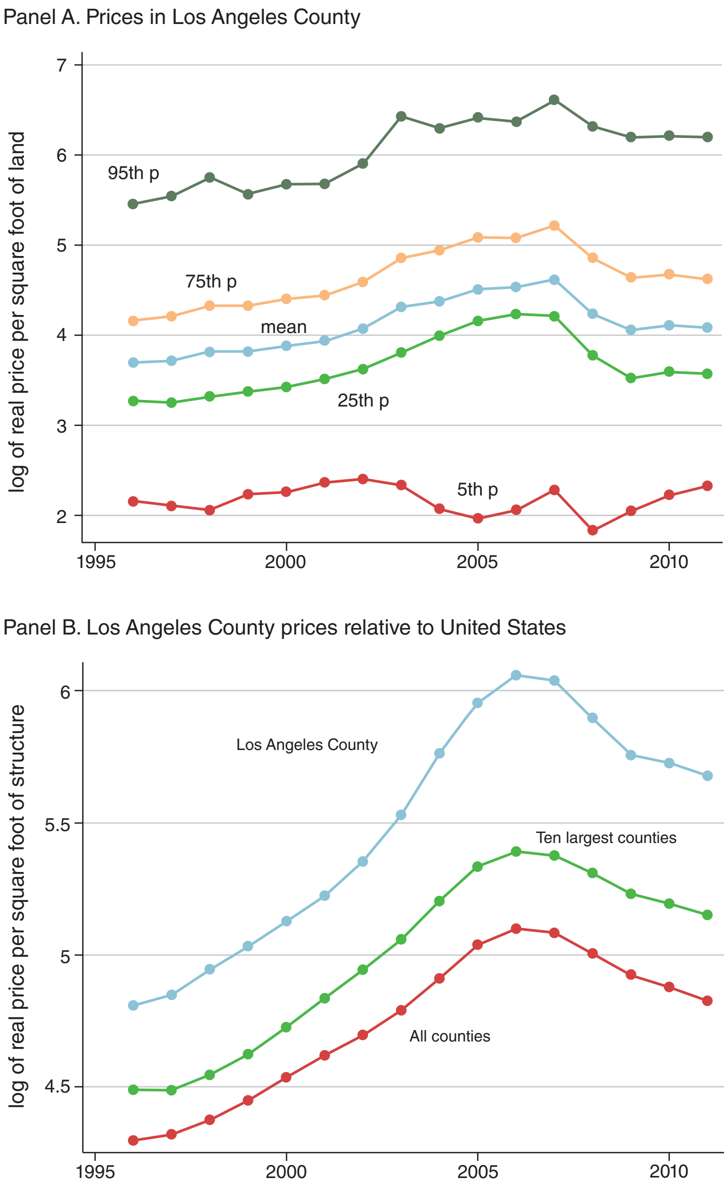

Figure A2. Los Angeles County Has Substantial Price Dispersion, and Higher Prices than Most of United States

Notes: The upper panel uses the assessor sales data to illustrate dispersion across the county over time. The top line in the figure reports the ninety-fifth percentile of the log real price per square foot of land per year; subsequent lines report the seventy-fifth percentile, the mean, the twenty-fifth percentile, and the fifth percentile. The bottom panel uses Zillow's estimates of mean price per square foot of structure by zip code and month to calculate annual averages by county and metropolitan area. The ten largest metros in the figure are the counties of New York, Chicago, Dallas-Fort Worth, Houston, Philadelphia, Washington, Miami-Fort Lauderdale, Atlanta, and Boston.

TABLE A1—SUMMARY STATISTICS FOR 1999 CROSS SECTION

	Maximal sample		Sample with full covariates	
	Ever assembled (1)	Never assembled (2)	Ever assembled (3)	Never assembled (4)
log(lot size)	9.728	8.912	9.667	8.783
	[1.569]	[1.093]	[1.393]	[0.848]
Improvement/land assessed value	36.878	3.937	59.933	4.285
	[2,156.9]	[864.9]	[2,751]	[902.7]
1 if single family	0.257	0.643	0.400	0.699
	[0.437]	[0.479]	[0.49]	[0.459]
Structure square feet in 100,000s	0.080	0.027	0.121	0.029
	[0.421]	[0.149]	[0.514]	[0.155]
Year structure was built	1960.0	1955.2	1960.4	1,955.2
	[28.881]	[21.613]	[28.565]	[21.612]
Census 2000 block group covariates				
Poverty rate	0.128	0.135	0.133	0.134
	[0.124]	[0.113]	[0.129]	[0.113]
Share black	0.068	0.086	0.072	0.088
	[0.119]	[0.162]	[0.122]	[0.166]
Share Hispanic	0.292	0.353	0.317	0.359
	[0.271]	[0.284]	[0.28]	[0.286]
Share housing units vacant	0.050	0.043	0.046	0.038
	[0.062]	[0.053]	[0.053]	[0.037]
Share housing units owner-occupied	0.619	0.606	0.605	0.600
	[0.296]	[0.262]	[0.308]	[0.264]
Distances to amenities				
Nearest highway entrance or exit	1.741	1.637	1.342	1.272
	[2.907]	[2.683]	[1.771]	[1.573]
Nearest subway or light rail	10.362	8.172	8.743	7.040
	[10.717]	[9.316]	[9.462]	[7.506]
Nearest commuter rail	5.919	6.195	5.552	5.929
	[4.891]	[4.982]	[4.414]	[4.703]
Observations	26,907	2,157,067	16,538	1,979,876

Source: See online Data Appendix.

REFERENCES

Asami, Yasushi. 1988. "A game-theoretic approach to the division of profits from economic land development." *Regional Science and Urban Economics* 18 (2): 233–46.

Bogart, Dan, and Gary Richardson. 2009. "Making Property Productive: Reorganizing Rights to Real and Equitable Estates in Britain, 1660–1830." *European Review of Economic History* 13 (1): 3–30.

Brooks, Leah, and Byron Lutz. 2016. "From Today's City to Tomorrow's City: An Empirical Investigation of Urban Land Assembly: Dataset." *American Economic Journal: Economic Policy*. http://dx.doi.org/10.1257/pol.20130399.

Brownstone, David, and Arthur DeVany. 1991. "Zoning, Returns to Scale, and the Value of Undeveloped Land." *Review of Economics and Statistics* 73 (4): 699–704.

Brueckner, Jan K. 1980a. "Residential Succession and Land-Use Dynamics in a Vintage Model of Urban Housing." *Regional Science and Urban Economics* 10 (2): 225–40.

Brueckner, Jan K. 1980b. "A Vintage Model of Urban Growth." *Journal of Urban Economics* 8: 389–402.

Cadigan, John, Pamela Schmitt, Robert Shupp, and Kurtis Swope. 2011. "The holdout problem and urban sprawl: Experimental evidence." *Journal of Urban Economics* 69 (1): 72–81.

Colwell, Peter F., and Henry J. Munneke. 1997. "The Structure of Urban Land Prices." *Journal of Urban Economics* 41 (3): 321–36.

Colwell, Peter F., and Henry J. Munneke. 1999. "Land Prices and Land Assembly in the CBD." *Journal of Real Estate Finance and Economics* 18 (2): 163–80.

Colwell, Peter F., and C. F. Sirmans. 1993. "A Comment on Zoning, Returns to Scale and the Value of Undeveloped Land." *Review of Economics and Statistics* 75 (4): 783–86.

Cord, Steven. 1974. "Urban Renewal: Boon or Boondoggle?" *American Journal of Economics and Sociology* 33 (2): 184–86.

Coulson, N. Edward. 1989. "The Empirical Content of the Linearity-as-Repackaging Hypothesis." *Journal of Urban Economics* 25 (3): 295–309.

Cunningham, Christopher. 2013. "Estimating the Holdout Problem in Land Assembly." Federal Reserve Bank (FRB) of Atlanta Working Paper 2013-19.

Duranton, Gilles, and Diego Puga. 2004. "Micro-Foundations of Urban Agglomeration Economies." In *Handbook of Regional and Urban Economics*, edited by J. V. Henderson and J. E. Thisse, 2063–2118. Amsterdam: North-Holland.

Dye, Richard F., and Daniel P. McMillen. 2007. "Teardowns and land values in the Chicago metropolitan area." *Journal of Urban Economics* 61 (1): 45–63.

Eckart, Wolfgang. 1985. "On the Land Assembly Problem." *Journal of Urban Economics* 18 (3): 364–78.

Ellickson, Robert C. 1973. "Alternatives to Zoning: Covenants, Nuisance Rules, and Fines as Land Use Controls." *University of Chicago Law Review* 40 (4): 681–781.

Fennell, Lee Anne. 2004. "Common Interest Tragedies." *Northwestern University Law Review* 98 (3): 907–90.

Field, Alexander James. 1992. "Uncontrolled Land Development and the Duration of the Depression in the United States." *Journal of Economic History* 52 (4): 785–805.

French, Howard W. 2007. "In China, Fight Over Development Creates a Star." *New York Times*, March 26. http://www.nytimes.com/2007/03/26/world/asia/26cnd-china.html?_r=0.

Fu, Yuming, Daniel P. McMillen, and Tsur Somerville. 2002. "Land Assembly: Measuring Holdup." Centre for Urban Economics and Real Estate (CUER) Working Paper 02-08.

Glaeser, Edward. 2011. *Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier.* New York: Penguin Books.

Glaeser, Edward L., and Joseph Gyourko. 2002. "The Impact of Zoning on Housing Affordability." National Bureau of Economic Research (NBER) Working Paper 8835.

Glaeser, Edward, Joseph Gyourko, and Raven Saks. 2005. "Why is Manhattan so Expensive? Regulation and the Rise in Housing Prices." *Journal of Law and Economics* 48: 331–69.

Grossman, Sanford J., and Oliver D. Hart. 1980. "Takeover bids, the free-rider problem, and the theory of the corporation." *Bell Journal of Economics* 11 (1): 42–64.

Grossman, Zachary, Jonathan Pincus, and Perry Shapiro. 2010. "A Second-Best Mechanism for Land Assembly." http://www.econ.ucsb.edu/papers/wp07-10.pdf.

Gyourko, Joseph, Albert Saiz, and Anita Summers. 2008. "A New Measure of the Local Regulatory Environment for Housing Markets: The Wharton Residential Land Use Regulatory Index." *Urban Studies* 45 (3): 693–729.

Harding, John P., Stuart Rosenthal, and C. F. Sirmans. 2003. "Estimating Bargaining Power in the Market for Existing Homes." *Review of Economics and Statistics* 85 (1): 178–88.

Heller, Michael A. 1998. "The Tragedy of the Anticommons: Property in the Transition from Marx to Markets." *Harvard Law Review* 111 (3): 621–88.

Heller, Michael A., and Rebecca S. Eisenberg. 1998. "Can Patents Deter Innovation? The Anticommons in Biomedical Research." *Science* 280 (5364): 698–701.

Helpman, Elhanan. 2007. "The Size of Regions." In *Topics in Public Economics: Theoretical and Applied Analysis*, edited by David Pines, Efraim Sadka, and Itzhak Zilcha, 33–56. Cambridge: Cambridge University Press.

Henderson, J. Vernon. 1977. *Economic Theory and the Cities.* Cambridge, MA: Academic Press.

Hong, Yu-Hung. 2007. "Assembling Land for Urban Redevelopment: Issues and Opportunities." In *Analyzing Land Readjustment: Economics, Law and Collective Action*, edited by Yu-Hung Hong and Barrie Needham, 3–36. Cambridge, MA: Lincoln Institute of Land Policy.

Hornbeck, Richard, and Daniel Keniston. 2014. "Creative Destruction: Barriers to Urban Growth and the Great Boston Fire of 1872." http://faculty.chicagobooth.edu/richard.hornbeck/research/papers/fire_hk_dec2014.pdf.

Hsieh, Chang-Tai, and Enrico Moretti. 2015. "Why Do Cities Matter? Local Growth and Aggregate Growth." National Bureau of Economic Research (NBER) Working Paper 21154.

Kanemoto, Yoshitsugu. 2013. "Second-best cost-benefit analysis in monopolistic competition models of urban agglomeration." *Journal of Urban Economics* 76 (1): 83–92.

Kominers, Scott Duke, and E. Glen Weyl. 2010. "Concordance Among Holdouts." http://home.uchicago.edu/weyl/Holdout_4_10.pdf.

Landis, John D., and Heather Hood. 2005. *The Future of Infill Housing in California: Opportunities, Potential, Feasibility and Demand.* Institute of Urban and Regional Development. Berkeley, CA, September.

Libecap, Gary D., and Dean Lueck. 2011. "The Demarcation of Land and the Role of Coordinating Property Institutions." *Journal of Public Economics* 119 (3): 426–67.

Libecap, Gary D., Dean Lueck, and Trevor O'Grady. 2010. "Large Scale Institutional Changes: Land Demarcation Within the British Empire." National Bureau of Economic Research (NBER) Working Paper 15820.

McDonald, John F. 2007. "What is Public Use? Eminent Domain and the Kelo Decision." *Cornell Real Estate Review* 5 (1): 10–25.

McMillen, Daniel, and Arthur O'Sullivan. 2011. "Option Value and the Price of Teardown Properties." http://www.pcb.ub.edu/xreap/aplicacio/fitxers/Option%20Value%20and%20the%20Price%20of%20Teardown%20Properties,%208-15-11.pdf.

Menezes, Flavio, and Rohan Pitchford. 2004. "The land assembly problem revisited." *Regional Science and Urban Economics* 34 (2): 155–62.

Merrill, Thomas W. 1986. "The Economics of Public Use." *Cornell Law Review* 72 (1): 61–116.

Miceli, Thomas J., and Kathleen Segerson. 2007. "A Bargaining Model of Holdouts and Takings." *American Law and Economics Review* 9 (1): 160–74.

Miceli, Thomas J., Kathleen Sergerson, and C. F. Sirmans. 2008. "Tax Motivated Takings." *National Tax Journal* 61 (4, Pt. 1): 579–91.

Miceli, Thomas J., and C. F. Sirmans. 2007. "The holdout problem, urban sprawl, and eminent domain." *Journal of Housing Economics* 16 (3–4): 309–19.

Molloy, Mark. 2012. "We shall not be moved: Road builders thwarted by elderly couple's home." Metro UK, May 2. http://metro.co.uk/2012/05/02/we-shall-not-be-moved-road-builders-thwarted-by-elderly-couples-home-411516/.

Munch, Patricia. 1976. "An Economic Analysis of Eminent Domain." *Journal of Political Economy* 84 (3): 473–97.

Nelson, Arthur C., and Robert E. Lang. 2007. "The Next 100 Million." *Planning* 73 (1): 4–6.

O'Flaherty, Brendan. 1994. "Land Assembly and Urban Renewal." *Regional Science and Urban Economics* 24 (3): 287–300.

Oster, Emily. 2013. "Unobservable Selection and Coefficient Stability: Theory and Validation." National Bureau of Economic Research (NBER) Working Paper 19054.

Pitchford, Rohan, and Mark L. J. Wright. 2008. "Holdouts in Sovereign Debt Restructuring: A Theory of Negotiation in a Weak Contractual Environment." Centre for Applied Macroeconomic Analysis (CAMA) Working Paper 37/2008.

Plassmann, Florenz, and T. Nicolaus Tideman. 2008. "Efficient Urban Renewal Without Takings: Two Solutions to the Land Assembly Problem." http://www.binghamton.edu/economics/research/old-working-papers/docs/WP0607.pdf.

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

Rosenthal, Jean-Laurent. 1990. "The Development of Irrigation in Provence, 1700–1860: The French Revolution and Economic Growth." *Journal of Economic History* 50 (3): 615–38.

Rosenthal, Stuart S. 2008. "Old homes, externalities, and poor neighborhoods: A model of urban decline and renewal." *Journal of Urban Economics* 63 (3): 816–40.

Rosenthal, Stuart S., and Robert W. Helsley. 1994. "Redevelopment and the Urban Land Price Gradient." *Journal of Urban Economics* 35 (2): 182–200.

Rosenthal, Stuart S., and William C. Strange. 2004. "Evidence on the Nature and Sources of Agglomeration Economies." In *Handbook of Regional and Urban Economics*, Vol. 4, edited by J. V. Henderson and J. E. Thisse, 2119–71. Amsterdam: North-Holland.

Seshadri, Triyakshana. 2012. "An Analysis of the Feasibility of Private Land Assembly for Special Economic Zones in India." *Urban Studies* 49 (10): 2285–2300.

Shoup, Donald. 2008. "Graduated Density Zoning." *Journal of Planning Education and Research* 28 (2): 161–79.

Special Investigations Section, Los Angeles County Assessor. 2013. Phone conversation.

Strange, William C. 1995. "Information, Holdouts, and Land Assembly." *Journal of Urban Economics* 38 (3): 317–32.

Tanaka, Tomomi. 2007. "Resource Allocation with Spatial Externalities: Experiments on Land Consolidation." *B. E. Journal of Economic Analysis and Policy* 7 (1).

United States Census Bureau. 2015. "Construction Length of Time Statistics, Table 3: Average Number of Months from Start to Completion for Private Multifamily Construction Projects, by Value and Number of Units, 2008-2009." http://www.census.gov/const/C30/t309.pdf.

Wheaton, William C. 1982. "Urban spatial development with durable but replaceable capital." *Journal of Urban Economics* 12 (1): 53–67.

Wheaton, William. 1983. "Theories of Urban Growth and Metropolitan Spatial Development." In *Research in Urban Economics*, Vol. 3, edited by J. V. Henderson, 3–36. Greenwich, CN: JAI Press.

Willis, Carol. 1995. *Form Follows Finance*: *Skyscrapers and Skylines in New York and Chicago*. New York: Princeton Architectural Press.