Hold out in land assembly for residential development *

Thomas Boogaerts & Geert Goeyvaerts

Wednesday 15th December, 2021

Abstract

Using the universe of construction permits, sales and land use in Flanders (Belgium), we present new evidence on frictions in the land market. First, developed parcels for assembly projects are bought at a premium of 17%. This premium is not the result of differences in land use restrictions, local prices, reservation prices nor the quality of the existing structure. Second, parcels in assembly projects are less likely to be (re)developed than similar parcels in single-plot projects. The results from three tests suggest that holdout by landowners might be one of the frictions: i) the last acquired plot is sold at an additional premium of 9%, ii) smaller parcels receive a higher premium and are less likely to be (re)developed and iii) assembly projects with more parcels face a higher average premium. Lastly, we document an important difference between developed and undeveloped parcels. While undeveloped parcels in assembly projects are also less likely to be (re)developed, they are bought without a premium.

*Boogaerts: Department of Economics, KU Leuven. E-mail: thomas.boogaerts@kuleuven.be. Goeyvaerts: Department of Economics, KU Leuven. E-mail: geert.goeyvaerts@kuleuven.be. Funding from Research Foundation Flanders (FWO), project number S005718N, is gratefully acknowledged. We are grateful to the participants of the 2021 North American and European meeting of the Urban Economics Association.

1 Introduction

When the demand to live at already densely populated locations rises, developers can provide room for more households by building taller buildings.[1] However, taller buildings often require larger plots (Ahlfeldt and McMillen, 2018) and the supply of large plots can be limited at these locations, e.g. urban centers. Developers can address a lack of large plots by piecing smaller plots together, a process called land assembly. Yet there might be frictions that hinder this process. A prominent example is strategic holdout by landowners who, driven by local monopoly power, try to maximize their profits.

Frictions in land assembly can have a large effect on the development of cities and the welfare of its residents. They constrain housing supply and thereby increase house prices and rents making cities less affordable to live.[2] They restrict the density of a city since the increased cost of assembling land will push developers towards the urban fringe (Miceli and Sirmans, 2007), which will reduce a city's welfare as density seems to be a net-amenity (Ahlfeldt and Pietrostefani, 2019). To the extent that the opportunity to assemble different parcels increases the value of redeveloping them, these frictions will also lower the rate of redevelopment which would negatively affect the welfare of the surrounding residents (Rossi-hansberg et al., 2010) and possibly of the whole neighborhood (Brueckner and Rosenthal, 2009; Rosenthal and Ross, 2015).

Despite these potentially large negative welfare effects, empirical research on frictions in the land market is scarce.[3] In this paper, we provide new evidence on frictions and examine whether strategic holdout by landowners might be one of these frictions. Combining the universe of construction permits, transactions and the complete land register of Flanders, the largest region of Belgium, we construct a sample of parcels for which a multifamily housing permit has been issued. A unique permit identification key indicates which parcels belong to the same project. In other words, we know which projects aim to assemble several plots and which projects want to develop a single parcel.

In the first part of this paper, we look for evidence of frictions in the land market. Comparing the sale price of parcels while accounting for differences in property characteristics and census tract fixed effects, we find that parcels for assembly projects are bought at a 10% premium in comparison to similar parcels for single-plot projects. However, this average premium hides a stark difference between developed and undeveloped plots. While developed plots trade at a 15% to 17% premium, undeveloped plots for assembly projects are bought at the same price as similar undeveloped plots bought for single-plot projects. This difference in the premia for developed and undeveloped parcels holds for assembly projects using only undeveloped plots as well mixed assembly projects combining both type of plots.

There are several possible explanations for the difference in the assembly premium of developed and undeveloped parcels. One such explanation is that the premium for developed plots is the

[1] See Baum-Snow and Hartley (2020), Couture and Handbury (2020), Couture et al. (2020) and Su (2019) for an analysis of the drivers behind the revival of U.S. cities in the recent decades.

[2] Constraints on housing supply can eventually lead to spatial misallocation of labor and lower economic growth (Hsieh and Moretti, 2019).

[3] The existing evidence is limited to three papers by Brooks and Lutz (2016), Cunningham (2013) and Yuming et al. (2002).

result of differences in unobserved attributes. However, exploiting additional data from the land registry and Energy Performance Certificates (EPC), we show that this premium does not capture within-tract variation in floor-to-area restrictions or house and apartment prices, nor differences in reservation prices or the quality of the existing property. Nor do differences in these attributes mask a premium for undeveloped plots.

An alternative explanation is that undeveloped parcels are located in areas where frictions do not hamper the supply of land as much. For example, landowners will have less bargaining power if there are many possible sites for developers to choose from. The significant lower population density, higher share of undeveloped land and greater distance to the CBD of these areas all support this hypothesis. However, while the different nature of the locations might be the driver of the difference in the premium of developed and undeveloped plots in non-mixed assembly projects, the difference between developed and undeveloped parcels in mixed assemblies cannot be attributed to this difference since they lie at the exact same location. The latter difference might be the result of asymmetric bargaining power of owners of developed and undeveloped plots, but we leave a closer examination of the possible drivers of these differences for future research.

The significant difference in the sales price of developed plots suggests there are frictions that prevent developers from assembling smaller parcels into larger parcels. In a frictionless market, developers will assemble land until the difference in the price of small and large parcels reflects reasonable conversion costs (Brooks and Lutz, 2016). In a follow-up analysis, novel to this literature, we find that parcels in assembly projects are less likely to be (re)developed than similar parcels in single-plot projects. We consider this finding as suggestive evidence that frictions cause assembly projects to fail. While there is a significant difference in the premia, the results from this analysis suggest that both developed and undeveloped parcels in assembly projects are less likely to be (re)developed. This finding does not, however, contradict the results for prices. Even if there are frictions that cause some assembly projects to fail, the unit price of small and large plots will be similar as long as the market can supply a sufficient amount of large plots when demand increases.

In the second part of this paper, we look whether there is any evidence that holdout by landowners might be one of the frictions. Given that land is limited in supply, landowners will be able to extract a certain share of the surplus created by an assembly project. The size of the surplus will depend on their bargaining power. Landowners might engage in strategic holdout to maximize their share of the surplus. We test three predictions that stem from the theoretical literature on holdout behavior as developed by Eckart (1985) and Strange (1995). First, we find that the last developed parcel is sold at an additional premium of around 9%, suggesting landowners engage in strategic delay and are rewarded for it. Second, we find that the average premium decreases in the relative size of the parcels within the assembly project. Owners of smaller parcels will be more inclined to holdout since an increase in their premium will only have a small effect on the total price the developer has to pay. Third, we find that the premium for developed plots increases in the number of parcels of the assembly project. However, this increase is not significantly different from zero. Overall, our results point to holdout as one of the frictions that increase the cost of assembling land.

While landowners engage in strategic holdout to maximize their share of the surplus, such behavior might also cause assembly projects to fail. We find that smaller parcels in assembly projects are less likely to be redeveloped. However, there is no evidence that the probability of (re)development decreases in the number of parcels in an assembly project.

We add to a limited list of studies that examine frictions and holdout in the land market using observational data. Yuming et al. (2002) look for evidence of frictions in Hong Kong, Brooks and Lutz (2016) in Los Angeles County and Cunningham (2013) for Seattle. All three studies find that developed properties are sold at a premium. Moreover, the estimates in these papers and ours are of a very similar magnitude. Yuming et al. find a premium between 14 to 20 percent, the estimates from Brooks and Lutz range from 15 to 42 percent and that of Cunningham around 18 percent.[4] Furthermore, the results from the three holdout analyses are in line with those from Yuming et al. (2002) and Cunningham (2013).

Aside from presenting the first evidence of frictions in the land market of a region in Europe, we make two important contributions. First, we document a significant difference in the premia for developed and undeveloped plots. Second, we present the first, albeit suggestive, evidence from observational data that frictions are causing assembly projects to fail. Both findings are not only novel for the empirical literature, but also confirm some of the results in a large experimental literature that studies land assembly and holdout in particular. This literature, which is reviewed in Winn and McCarter (2018), finds that landowners can increase their share of the surplus by holding out and that this behaviour can cause negotiations to fail. Our first finding relates to the work of Isaac et al. (2016), who show that more competition between landowners significantly increases the number of successful negotiations.

This paper is organised as follows. In Section 2, we discuss the theoretical framework and formulate three testable hypotheses from the theory on strategic holdout. In section 3 we describe the data and construction of our sample that we use in the empirical analyses. Section 4 present the evidence of frictions in the land market and the robustness checks. Section 5, we test the three hypotheses to see whether hold out might be one of these frictions. We conclude and discuss avenues for future research in Section 6.

2 Theoretical framework

We refer to the theoretical framework from Brooks and Lutz (2016) and apply it to our setting. In this section we give a concise overview of their model. We investigate the market for land that can be used for residential projects, more precise apartment buildings. A land market in equilibrium, free of frictions, would at the same location lead to the same market price per squared meter for small and large parcels. If we assume that the land is divided in parcels of size a and size $2a$, then the value of two parcel of size a should be equal to the value of a parcel with size $2a$.

[4] Brooks and Lutz (2016) find a premium between 34 and 42 percent using a hedonic pricing model while a repeat sales model renders premium estimates of 15 to 21 percent.

Hence, the following condition would hold if we define $V(.)$ as the value function of the parcels, $V(2a) = 2V(a)$.

Over time, the demand for large parcels may increase. For example, due to population growth, the optimal level of density at the city center increases. This leads to an increase in the demand for apartment buildings, which in turn translates in the demand for larger parcels. Developers of apartment buildings prefer larger plots, this allows them to divide the fixed costs (e.g., an elevator) over more units. Furthermore, high buildings typically require larger footprints. The shortage of large parcels leads to a convex value function for the plots by size, hence, $V(2a) > 2V(a)$. If a convex value function is in place, assemblies are economically feasible. Until the equilibrium is restored a surplus s, defined as $s = V(2a) - 2V(a)$, can be gained by assembling land. In a well functioning market free from frictions, assemblies would occur until this surplus is arbitraged to 0 and the equilibrium is restored. However, there are costs of assembling land, such as regulatory costs, transaction costs and the additional work effort required to make an offer to multiple landowners instead of one. We assume that these costs are inevitable. In the presence of these costs, a small imbalance will remain in place. If we define these costs as δ, then land will be assembled until the surplus that can be gained is equal to this cost. Therefore, the following equilibrium would be obtained, $V(2a) - 2V(a) = s = \delta$.

Besides these costs of an assembly, undesirable frictions, with too few assemblies as a results, could prevent the equilibrium from restoring. If these frictions, such as holdouts, are present, then the remaining surplus must exceed the assembly costs. Thus, $s = V(2a) - 2V(a) > \delta$. This equation provides us with a testable prediction. As stated by Brooks and Lutz (2016), a large estimate of the surplus s, indicates the existence of frictions in the market of assembling land if there is free entry for developers and when the frictions are supply driven. The authors show that under these conditions, the difference between the land price per squared meter for to-be-assembled plots and unassembled plots represents the remaining surplus. Hence, in a market without frictions this surplus should be arbitraged away, such that there are no significant differences between the sales price of both plots. If entry restriction are in place, then part of the surplus will be absorbed by the developers. Frictions at the buyers side would reduce the willingness to pay for the plots. Both would lead to an underestimation of the assembly surplus.

To investigate the origin of these frictions we formulate three testable predictions with regard to hold out. First, landowners have an incentive to delay the acquisition of their parcel to increase their share in the project's surplus. The work of Menezes and Pitchford (2004), Miceli and Segerson (2007) and Miceli and Sirmans (2007) show that the last landowner to hold out will be able to extract all the remaining surplus of the project. These strategic delays happen at the expense of the developers who are faced with the costs of the lost time. If these delays are in place, then the first developers to undertake an assembly, facing a larger surplus, can compensate for these costs. However, if more assemblies happen, then the surplus will diminish until the developers can no longer compensate the time costs and the higher asking prices of the delaying landowners. As a consequence, these projects will not be realized as developers undertake projects at locations with less dispersed ownership. Therefore, the last acquired parcels of the realized assemblies must be bought by the developer at a premium.

Second, Eckart (1985) and Strange (1995) show that relatively smaller parcel demand larger sales prices. They argue that smaller landowners are aware that their asking prices are less likely to jeopardize the projects than large parcels. More so, large landowners may be willing to demand lower prices to make sure that the project is successful. This allows them to extract at least some part of the projects surplus. We can test this hypothesis by estimating if smaller parcels extract a relatively larger surplus in comparison with the larger parcels. If this form of hold out is in play, then we argue that the first assembly projects, which can generate the largest surplus, can compensate the smaller landowners. However, when the surplus diminishes, developers are forgoing the projects with smaller parcels and undertake projects at places where larger parcels are available. As with the strategic delay this could lead to urban sprawl, as larger parcels are typically located further away from the city center.

Third, the number of different inputs that are required for the projects, increases the possibility of hold out. The average size of the parcels relative to the total project drops when the number of required parcels increases. Therefore, more parcels will demand relatively large sales prices. The smaller relative parcel sizes will reduce the incentive for large landowners to demand lower asking prices to compensate for the smaller parcels. Eckart (1985) and Strange (1995) offer the testable prediction that projects that require more inputs pay a larger price. If the surplus of the project at a location with dispersed ownership is not large enough to compensate for the larger sales prices, then developers will move to locations where ownership is less dispersed.

3 Data

We test two hypotheses to see whether there are frictions in the land market. The first hypothesis states that parcels for projects that assemble two or more parcels are bought at a premium. The second hypothesis is that parcels in assembly projects are less like to be (re)developed than parcels in single-plot projects. To test these two hypotheses, we construct a sample of parcels by combining data from three sources: i) the construction permits in Flanders between 2007 and mid 2017, ii) the land register of Belgium from 2006 to 2020 and iii) the transactions in Belgium from 2006 to 2020.[5] We summarize each of these data sets and discuss how and why we link one to another in this section. More details on the data cleaning process can be found in the Appendix.

3.1 Construction permits

The main data set is a list of all the parcels for which a construction permit has been issued in Flanders between 2007 and mid 2017.[6] It reports the year and municipality where the permit has been issued and the type of the building that will be constructed. In addition to this basic information, the data set also contains a unique identification number of the construction permit.

[5] All three data sets comprise the entire population of construction permits, properties and transactions within their respective geographical area and time period.

[6] The data set stops in June 2017 as the Flemish municipalities switched to a digital permit platform.

In other words, we know which parcels belong to a project that will (re)develop a single parcel and which belong to a project that aims to (re)develop two or more parcels. We will refer to these two groups as the single-plot projects and assembly projects.[7]

We focus on multifamily housing projects for two reasons.[8] First, frictions in the land market have a larger impact on the development of multifamily housing than single family housing. The demand for larger parcels, and thus the need to assemble land, is strongly driven by the desire to build taller buildings (Ahlfeldt and McMillen, 2018). The latter is reflected in the share of assembly projects across the two building types: 43% of the multifamily housing projects comprise two or more parcels, while only 19% of the single-family housing projects are assembly projects. Second, a certain degree of homogeneity of the sample will help us to credibly identify the estimands of interest, i.e. the differences in the sales prices and probability of (re)development. The sample contains a total of 35,147 individual parcels that are related to 17,875 construction permits for multifamily housing projects.[9]

3.2 Land register

We use the Belgian land register to get more information on the parcels and projects as a whole. The land register reports several attributes of each individual property in Belgium. If a parcel is undeveloped, it is considered as a single property and will only have one record in the register. However, if a parcel is developed then each property on that parcel will have its own record, e.g. all the individual apartments in an apartment building.[10] In order to be able to match the relevant information to the parcels in our sample, we transform the land register from a data set at the property-level to a data set at the parcel-level by aggregating the attributes of the different properties on that parcel. For example, we sum the floor space of all the individual properties to get the total floor space of the entire building. After linking the data to the parcels using the unique identification key, we further aggregate the parcel-level information to the project-level.

We obtained the land register for the years 2006 to 2020.[11] The time span of the land register data allows us to track what happened on the parcels before and after the permit was issued. Checking whether a parcel has been (re)developed is, however, not a trivial exercise. In the extreme case in which a developer demolishes an entire building and replaces it with an exact similar one, only a single attribute might change, e.g. the construction year. We therefore assume the parcel is not (re)developed if none of the attributes of the parcel or the building changed after the permit was issued.[12]

Furthermore, developers are allowed to file as many permits requests as they like for one or more parcels, whether they own these parcels or not. There are several parcels and sets of parcels

[7] While we do not know whether the different parcels will effectively be assembled into a single large plot, we assume that at least they want to (re)develop these different parcels as a single project.

[8] We will use the terms project and permits interchangeably.

[9] We drop permits that were rejected after an appeal.

[10] Parcels of apartment buildings usually have a separate record in the land register.

[11] As attributes of properties change, the land register is updated regularly over the year. The annual cross-sections we received reflect the situation of the property stock on the first of January of that year.

[12] We start from the attributes in 2006 in order to have the oldest information on the parcels.

for which more than one permit was issued over the sample period.[13] The number of permits is, however, probably endogenous. Developers will request permits for the projects with the highest expected profits (Murphy, 2018). The latter depends, among other things like costs and prices, on the probability that the project will effectively be executed. However, price-taking developers in a competitive market do not coordinate. If expectations with regard to costs, prices and feasibility are homogeneous, many developers will want to pursue the same project and thus request a permit for the same parcel or sets of parcels. But parcels can only be (re)developed once and so many of the permits for the same project will not be executed.

Considering all but one permit as a failed attempt to (re)develop the parcel will not capture what we are interested in, namely whether parcels in assembly projects are less likely to be (re)developed due to frictions like holdout. On the contrary, it will bias our results as parcels in projects that were expected to be very feasible will have many failed attempts and thus a low probability of (re)development, while parcels in projects that did not seem feasible for many developers might have a high probability of (re)development. We adjust for this bias by considering all permits with the same set of parcels as a single observation. For example, if two developers received a permit to redevelop plots A and B, and both are indeed redeveloped in 2020 then this will show up as one successful assembly project in our data. However, if one developer received a permit to redevelop plots A and B and another developer got a permit to redevelop plots B and C then these will show up as one successful and one unsuccessful project.[14]

In addition to the adjustment to address the endogeneity problem, we make a couple of additional adjustments. First, if more than one permit has been issued for a certain parcel in the last year before the parcel is (re)developed, then we do not know which permit has been executed. We therefore drop all permits that are issued in the same year and have a 'common' parcel independent of whether this parcel is eventually (re)developed or not. Second, there might be permits in two consecutive years before the parcel is (re)developed. It is then also not certain which project has been executed. However, in this case we assume it was (re)developed following the last permit that has been issued.

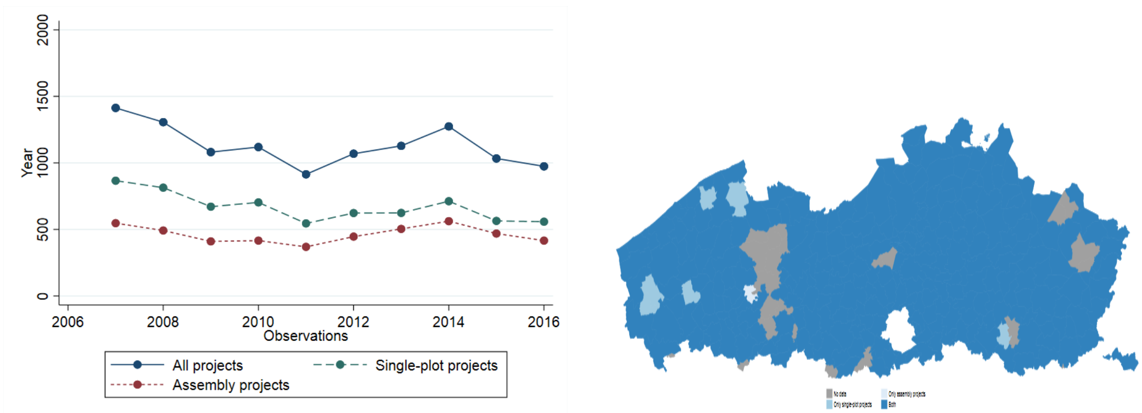
Applying these adjustments to the data and some additional cleaning and filtering which is described in detail in the Appendix, the sample reduces to 21,197 parcels from 11,747 permits. While the majority of the parcels are related to an assembly project (14,264 or 67.29%), the majority of the projects are single-plot projects (6,933 or 59%). Figure 1 shows the distribution of projects over time (a) and across space (b). The number of projects is relatively stable over the sample period and the majority of municipalities issued permits for both assembly and single-plot projects.

Table 1 presents descriptive statistics on projects and parcels in the redevelopment sample. Panel A presents a breakdown of the sample of parcels based on the type of parcels that are linked to the permits. Single-plot projects aim to (re)develop either an already developed parcel or an undeveloped parcel, while some of the assembly projects (re)develop both. We will refer to this latter category as the 'mixed' projects. Panel B presents descriptives on some of the key

[13]Recall that we do not observe the identity of the firm or person that received the permit.

[14]Parcels might therefore still end up more than once in the redevelopment sample, but only if they are accompanied by different parcels.

Figure 1. Distribution of projects over time and across space, Flanders 2007 to 2016



(a) Number of projects per year

(b) Projects by municipalities

attributes of the projects: the number of parcels, the total surface of the project and the floor-to-area ratio of the existing structure, if there is one. Panel C presents descriptives on similar attributes of the parcels like the surface, the floor-to-area ratio and distance to the CBD. The last row of Table 1 shows that 94% of the parcels in single-plot projects have been (re)developed in 2020 while this is 91% of the parcels in assembly projects. The 3 percentage points difference is statistically different from zero.

Table 1. Descriptive statistics: the redevelopment sample

	Single-plot projects		**Assembly projects**		
A. Type of project	Number	Share	Number	Share	
Developed	4,809	69.36%	2,694	55.96%	
Undeveloped	2,124	30.64%	355	7.37%	
Mixed	0	0	1,765	36.66%	
Total	6,933	100%	4,814	100%	
B. Projects	Mean	Std. dev.	Mean	Std. dev.	Difference
Number of parcels	1	0.00	2.98	1.96	-1.98***
Total surface	978.88	1517.48	1,793.28	2320.47	-814.40***
Floor-to-area ratio	0.42	0.65	0.46	0.59	-0.04***
C. Parcels	Mean	Std. dev.	Mean	Std. dev.	Difference
Surface	978.88	1517.48	598.74	1034.44	380.14***
Floor-to-area ratio	0.42	0.65	0.47	0.58	-0.05***
Distance to CBD	1.67	1.38	1.56	1.38	0.11***
Success	0.94	0.24	0.91	0.29	0.03***

Note: This table presents descriptive statistics on the characteristics of the projects and the parcels in the redevelopment sample. Information on the characteristics comes from the land register of Belgium from 2006.

3.3 Transactions

While the land registers provide us the parcels' attributes and the outcome for the second test on frictions, i.e. the probability of success, we use the transactions data set for information on the outcome for the first test, i.e. sales prices. This data set contains all the transactions in Belgium from 2006 to 2020.

Just like the land register, the transactions data set is a data set at the property-level and not at the parcel-level. We need to exclude sales of multifamily housing units because the dependent variable in the empirical analysis is the price per square meter of the parcel and apartment buildings are seldom sold as a whole. Nonresidential buildings are also dropped to increase the homogeneity of the sample. The sample of sales therefore only includes single family housing and undeveloped parcels.

We match our sample of parcels to the transactions using a unique parcel identification key. The goal is to find sales that are related to the specific development projects. However, we do not know the identity of the developer for whom the permit is issued nor the identity of the person who bought the parcel. We only know the year the permit was issued and the date the parcel was sold. We assume that all sales less than five years before or two years after the permit was issued are related to the project. While the former threshold is somewhat arbitrary, the latter is a natural boundary since developers need to start the development within two years after the permit was issued.[15]

Based on these selection criteria, we find a sale for 3,152 parcels which are related to 2,883 development projects. Six out of ten parcels in our sample were bought in the years preceding the year the permit was issued. The majority of these sales happened in the two years before the permit was issued (80%). Less than one out of ten of the transactions took place in the two years after the permit was issued. The rest in the same year the permit was issued. Given that we do not know the exact date the permit was issued, we do not know whether these sales happend before or after it was issued. Figure 2 shows an overview of the matched parcels. The majority of the parcels are developed plots (57%) and about one third (36%) are related to an assembly project.

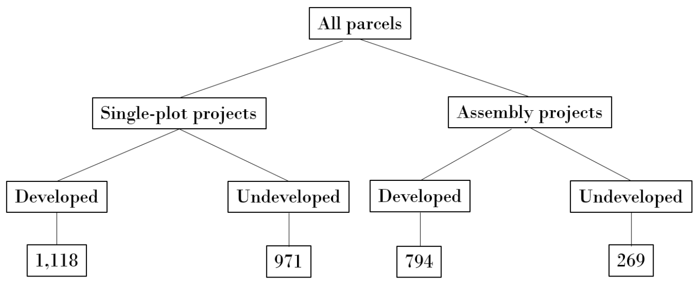


Figure 2. Overview of sales matched to parcels in permit data

Table 2 presents the descriptive statistics on the characteristics from the sales data for both groups of parcels separately. Panel A presents descriptives on the characteristics of the parcel. Parcels for single-plot projects are sold at a significantly lower price than parcels for assembly projects. The latter are however, on average, smaller and located closer to the CBD. Panel B reports similar numbers on the characteristics of the house if the plot is developed. In line with the parcel characteristics, we see that the parcels for single-plot projects have, on average, larger houses with more garages and facades but a lower floor-to-area ratio. However, there does not seem to be any significant difference in the characteristics related to the quality of the structure like the construction year, the number years since the last renovation and the number of bathrooms.

[15]They will have to request a new permit if the development has not starter after two years.

Table 2. Descriptive statistics: sales sample

	Single-plot projects		**Assembly projects**		
	Mean	Obs.	Mean	Obs.	Difference
A. Characteristics of the parcel					
Price per m^2	584.86	2,089	1024.68	1,063	-439.82***
	(19.49)		(36.38)		
Surface	683.32	2,089	438.73	1,063	244.59***
	(14.60)		(16.96)		
Distance to CBD	1.70	2,089	1.54	1,063	0.16***
	(0.03)		(0.04)		
B. Characteristics of the house					
Useful surface	204.92	1,118	175.03	794	29.89***
	(2.75)		(2.74)		
Floor-to-area ratio	0.66	1,118	0.91	794	-0.25***
	(0.02)		(0.02)		
Construction year	1926.23	1,118	1923.79	794	2.43
	(0.99)		(1.23)		
Bathrooms	0.72	1,118	0.70	794	0.02
	(0.02)		(0.02)		
Garages	0.65	1,118	0.46	794	0.19***
	(0.02)		(0.02)		
Number of facades	2.62	1,118	2.35	794	0.27***
	(0.02)		(0.02)		
Years since last renovation	25.07	228	24.02	169	1.05
	(0.49)		(0.58)		

Note: This table presents descriptive statistics on the characteristics of the parcels for which we found a sale in the transactions data set. Standard deviation in parentheses.

4 Evidence on frictions in the land market

In this section, we present evidence on frictions in the land market from two empirical analyses. In the first analysis, we find that developed parcels for assembly projects are bought at a premium. The results from the second analysis show that parcels in assembly projects are less likely to be (re)developed in 2020. Together, these findings suggest that there are frictions which prevent developers from assembling enough land to meet a rise in demand for larger parcels. We discuss the empirical strategy and results of each analysis in detail in the following sections.

4.1 Prices

4.1.1 Empirical strategy

The descriptives in Table 2 show that the price of parcels for assembly projects is 75% higher than the average price of parcels for single-plot projects. However, developers do not randomly assemble parcels but select them based on their location and specific attributes. Parcels for assembly project are, on average, smaller and located closer to the central business district (CBD). The difference in the average sales price might thus reflect differences in these attributes rather than a premium that developers are willing to pay for parcels they want to assemble.

In order to get an unbiased estimate of the price differential, we estimate a hedonic price model in which we adjust the price for differences in characteristics of the parcel and, in case the parcel is developed, the structure upon it:

$$log\left(\frac{Price}{Surface\ plot}\right)_{i,j,l,t} = \beta_1 \times Assembly_j + \lambda' X_i + \phi' Z_i + \alpha_l + \tau_t + \epsilon_{i,j,l,t} \quad (1)$$

The dependent variable in this linear regression model is the natural logarithm of the sales price per square meter of parcel i. $Assembly_j$ is a dummy variable that takes the value of one if project j aims to (re)develop two or more parcels. The vector of parcel-specific characteristics X_i includes the surface of the plot and a dummy variable indicating whether or not the parcel is developed. The vector Z_j contains characteristics of the house, if one is in place, including useful surface, floor-to-area ratio, construction year, years since last renovation, number of bathrooms and garages, and whether the house is detached, semi-detached or closed.[16]

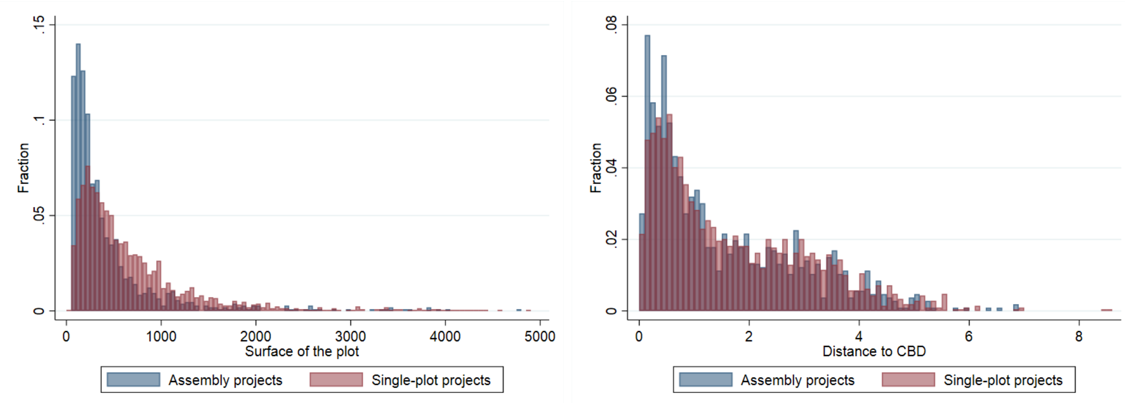
Location fixed effects (α_l) capture time-invariant location-specific heterogeneity. We use municipality fixed effects in the baseline specification. There were 308 municipalities in Flanders during the sample period. These municipalities had an average size of 44 square kilometers and an average population of 19,000 inhabitants.[17] However, some of the municipalities are quite large cities. The largest municipality is Antwerp with almost 500,000 inhabitants covering an area of 205 square kilometers. There might be a lot of unobserved variation within these municipalities which would be left unaccounted for. We therefore re-estimate each specification with census tracts fixed effects.[18] Flanders is divided in 9,182 tracts. With an average size of 1.47 square kilometers and an average population of 671 inhabitants, census tracts are considerably smaller geographical areas than municipalities.

Despite their size, there may still be factors which vary within census tracts. We therefore add a couple of additional measures regarding the location to the vector of parcel characteristics (X_i): i) distance to the CBD, ii) distance to the nearest train station, iii) nearest school and iv) park. Quarter of the year fixed effects (τ_t) capture quarterly changes in unobserved variables that affect the price of all sales such as fluctuations in the interest rate.

We have to make two assumptions in order to interpret $\hat{\beta}_1$ as an unbiased estimate of the average

[16] All of these variables are set to zero for undeveloped parcels.
[17] The source here is the Census of 2001.
[18] These tracts are referred to as the 'statistical sectors' in Belgium.

Figure 3. Distribution of the characteristics of the plot



(a) Surface of the plot

(b) Distance to CBD

premium at which parcels for assembly projects are bought (Imbens and Wooldridge, 2009). The first and main identifying assumption is that of unconfoundedness. We need to assume that there are no unobserved covariates that are associated with both the outcome (the price of the parcel) and its selection into treatment (assembly). While this is arguably a strong assumption, our data are exceptionally well suited for this exercise. First, the construction permit data makes it possible to select a very homogeneous group of parcels, i.e. parcels for which a multifamily housing construction permit has been issued. Second, the sales data include a large set of characteristics of the parcel and, for developed plots, of the existing structure.

The second assumption is that there are both parcels for assembly and single-plot projects for all possible values of the characteristics we adjust for in the hedonic model. This is referred to as the overlap assumption. Note that this assumption does not require the average characteristics of the parcels in both groups of projects to be equal.[19] It only requires that there is sufficient overlap in the covariate distribution. Figures 3a and 3b plot the distribution of the size of the parcel and its distance to CBD. While the average size and CBD distance of the parcels for assembly projects is significantly different from the average size and distance of the parcels for single-plot projects (see Table 2), there is substantial overlap in the distributions for both covariates.

Not only should the distributions of the characteristics overlap, but there should also be sufficient overlap in the location of the parcels. After all, the price differential is identified by comparing parcels for assembly projects with parcels for single-plot projects that are located in the same municipality or census tract. Table 3 presents the number of the parcels in the sales sample that are located in a municipality or census tract with sales for both single-plot and assembly projects. At the municipal level, 91.78% of the parcels are located in a municipality with sales for both type of projects. This share drops to 39.21% at the tract-level.

[19] If a perfectly balanced treatment and control group in observed covariates there would be no need to adjust for characteristics as there are no differences.

Table 3. The geographical overlap of the observations in the sample of sales

		Single-plot project	**Assembly project**	**Total**
A. Municipality	Only one	237	22	259
		(11.35%)	(2.07%)	(8.22%)
	Both	1,852	1,041	2,893
		(88.65%)	(97.93%)	(91.78%)
B. Census tract	Only one	1,488	428	1,916
		(71.63%)	(40.59%)	(61.21%)
	Both	601	635	1,236
		(28.77%)	(59.74%)	(39.21%)

Note: This table provides an overview of the geographical overlap in transactions for single-plot projects and transactions for assembly projects at the municipal- and tract-level. Column shares in parentheses.

4.1.2 Main results

The estimates in the first two columns of Table 4 show that parcels for an assembly project are bought at a premium of, on average, 8% to 10% relative to similar parcels bought for single-plot projects. The finding that parcels for assembly project are sold at a higher price suggests there exists frictions which prevent developers from assembling enough land into larger parcels.

Next, we study heterogeneity in the premium along two dimensions. First, we look whether the premium differs between developed and undeveloped parcels. Second, we look whether the premia for developed and undeveloped plots are any different if they are assembled jointly in a mixed project. To examine heterogeneity along the first dimension, we include an interaction between the assembly dummy and the dummy indicating whether the parcel is undeveloped.[20] For the second dimension, we add a dummy variable which equals one if the assembly project is a mixed project and an interaction between this dummy and the undeveloped dummy. Including all these additional dummy variables and the interactions gives us the following specification:

$$\begin{aligned} log\left(\frac{Price}{Surface\ plot}\right)_{i,j,l,t} =& \beta_1 \times Assembly_j + \beta_2 \times Assembly_j \times Undeveloped_i + \beta_3 \times Mixed_j \\ &+ \beta_4 \times Mixed_j \times Undeveloped_i + \lambda' X_i + \phi' Z_i + \alpha_l + \tau_t + \epsilon_{i,j,l,t} \end{aligned} \quad (2)$$

The estimates in the third and fourth column point to a large difference in the premia for developed and undeveloped plots. The estimate of β_1 suggests developed parcels for assembly projects are bought at a 17% premium.[21] Although the estimate of the interaction effect is larger in absolute size, a t-test rejects the hypothesis that the difference between $\hat{\beta}_1$ and $\hat{\beta}_2$ is statistically different from zero. This suggests that undeveloped parcels for assembly projects are bought at a

[20] Note that the undeveloped dummy is already included in the vector of parcel characteristics in the baseline specification.

[21] Note that including the interaction between the $Assembly_j$ and $Undeveloped_i$ changes the interpretation of β_1. It now captures the difference in price of developed plots.

Table 4. The difference in the sales price of parcels for assembly projects and single-plot projects

	(1)	(2)	(3)	(4)	(5)	(6)
Assembly (β_1)	0.082***	0.101**	0.169***	0.169***	0.152***	0.156***
	(0.025)	(0.041)	(0.025)	(0.041)	(0.028)	(0.045)
Assembly × undeveloped (β_2)			-0.267***	-0.252**	-0.232***	-0.226*
			(0.063)	(0.109)	(0.074)	(0.137)
Mixed (β_3)					0.057	0.051
					(0.044)	(0.078)
Mixed × undeveloped (β_4)					-0.039	-0.020
					(0.110)	(0.194)
Adj. R^2	0.740	0.775	0.743	0.778	0.743	0.777
Observations	3,152	3,152	3,152	3,152	3,152	3,152
Assembly	1,063	1,063	1,063	1,063	1,063	1,063
Single-plot	2,089	2,089	2,089	2,089	2,089	2,089
Location FE:						
Municipality	X		X		X	
Census tract		X		X		X

Note: This table presents the estimates of the coefficients β_1 to β_4 from Equations 1 and 2. The dependent variable in these regressions is the natural logarithm of the price per square meter. All specifications include quarter of the year fixed effects along with the following characteristics of the parcel (X_i) and structure (Z_i): surface of the plot, useful surface, floor-to-area ratio, construction year, years since last renovation, number of bathrooms and garages, whether the house is detached, semi-detached or closed and lastly the distances to CBD, nearest train station, school and park. Robust standard errors are reported in parentheses.

similar price as the undeveloped parcels for single-plot projects.[22] The estimates of β_3 in the last two columns are positive but not significantly different from zero, suggesting that the premium for developed plots does not vary across project types. This finding also holds for undeveloped plots since $\hat{\beta}_4$ is statistically insignificant as well.

We offer a couple of potential explanations for the difference in the assembly premium for developed and undeveloped inputs. The first explanation is that projects using undeveloped parcels are located in areas where there are less frictions hampering the supply of large parcels. Specifically, these projects might be located in areas where there are more large parcels or more possible combinations of smaller plots to assemble. More alternative parcels, or combinations, means more competition among landowners. More competition implies less bargaining power and might reduce strategic holdout behaviour. Isaac et al. (2016), for example, show that the success rate of assemblies more than doubles when the number of potential assemblies increases

[22] Given that we include a parcel-type fixed effect ($Undeveloped_i$) in X_i, β_1 and β_2 are identified using solely within parcel-type variation. Estimates of β_1 using the developed and undeveloped parcels separately are in line with the estimates in Table 4. They are reported in Table B.2 in the Appendix.

from one to four. Descriptive statistics on the attributes of developed and undeveloped plots support the hypothesis that they are located in very different areas. First, the descriptive statistics in Table B.1 in the Appendix show that the undeveloped parcels in the sales sample are located 320m farther from the CBD than the developed plots. The difference in the distance to CBD between developed and undeveloped parcels is twice as large as the difference between the parcels for single-plot projects and assembly projects (see Table 2). Furthermore, we find that undeveloped plots are located in census tracts with a significant lower population density and a higher share of undeveloped land.[23]

The estimates of β_3 and β_4 suggest there is also a difference in the premia for developed and undeveloped parcels in mixed assembly projects. This difference cannot be the result of differences in location-related attributes because the parcels lie at the exact same place. We argue that it might be the result of a difference in the bargaining power of the respective landowners. It seems reasonable that owners of developed parcels will demand a larger share of the surplus than the owners of the undeveloped plots in the mixed assemblies. However, we leave a detailed analysis of the potential drivers for future research.

The second explanation is more general and states that one or more estimates in Table 4 are biased. The premium at which developed parcels for assembly projects are bought might be the result of differences in unobserved characteristics. At the same time, differences in the same or other unobserved characteristics might mask a premium for undeveloped plots. While we cannot rule out the threat of an omitted variable bias, we check several potential confounders in the next section.

4.1.3 Robustness checks

In this section, we present four robustness checks using additional data that is not available for all sales in the main sample. The results of these robustness checks show that the main estimates in Table 4 are not the result of differences in land use regulation, the value of the parcels' locations, whether the property is listed nor the quality of the existing building as proxied by its energy performance.

Variation within census tracts: land use regulation and location effects

While census tracts are small geographical areas, there might be unobserved factors that influence the price of parcels and vary across locations within tracts. Comparing the price of parcels for assembly projects with the price of parcels for single-plot projects can arguably render a credibly identified estimate of the assembly surplus if the projects take place at fundamentally different locations. The price differential will then reflect a difference in the value of the locations where assembly and single-plot projects occur rather than a difference in the price of small and large plots at a similar location. In the first two robustness checks, we look whether the price differential might be driven by unobserved heterogeneity within census tracts.

[23] These descriptive statistics are available upon request.

Land use regulation - In a first robustness check, we look whether the premium is the result of differences in land use regulation. Land use regulation in Flanders is for a large part determined at the municipal level and can vary from street to street. Given that the demand for larger plots is driven by the willingness to construct taller buildings, developers might want to assemble in areas with less stringent floor-to-area restrictions. Using information from the land register of 2020, we are able to compute the floor-to-area ratio (FAR) of the newly developed buildings in the projects. The average FAR of buildings in assembly projects (1.45) is indeed significantly larger than those in single-plot projects (1.14). Parcels with less stringent land use regulation are, however, more valuable on average.[24] The difference in the average price might thus reflect a difference in the average stringency rather than a premium for large plots.

In order to test whether the premium reflects a difference in floor-to-area restrictions, we add the FAR of the newly developed building as a control variable and re-estimate Equations 1 and 2. However, we do not observe the FAR for each sale in the main sample since we can only compute this variable for parcels that are (re)developed in 2020. In order to check whether a difference in the estimates is the result of adding the FAR rather than the change in sample, we first estimate the two specifications using the selected sample without the FAR as a control variable.[25] The estimates in the first three columns of Table 5 are in line with the corresponding estimates in Table 4 except for $\hat{\beta}_2$ in the third column, which is now smaller in absolute size and no longer significantly different from zero. However, as with the estimates in Table 4, we have to reject the hypothesis that the difference between $\hat{\beta}_1$ and $\hat{\beta}_2$ is different from zero.

The estimates in columns four to six of Table 5 show that the coefficients of interest do not change significantly when we add the FAR of the new building as a control variable. The coefficient estimate on FAR is positive and significantly different from zero. It suggests that the value of the parcel increases with 1 percent if the floor-to-area increases with 10 percentage points. This result is in line with the finding that parcels with less stringent land regulation are more valuable. Note that, in addition to the census tract fixed effects, we also control for variation in land use regulation by selecting solely multifamily projects.

Location effect - In the second robustness test, we look whether the price of houses and apartments systematically differ across the locations of assembly and single-plot projects. First of all, assembly projects might occur more often in areas where the demand for houses is lower. To the extent that lower demand for houses results in a lower price of smaller plots, assembly projects might be more profitable. Secondly, assembly projects might occur more often in areas where the demand for apartments is higher. To the extent that small frictions increase the cost of assembly projects relative to single-plot projects, e.g. the time cost of negotiating with two or more persons instead of one, developers will start assembling in areas with higher apartment prices.

To test this hypothesis, we estimate the difference in the price of houses and apartments located near the projects that were sold around the time the permit was issued. Specifically, we take all

[24] See for example Ihlanfeldt (2007) and Turner et al. (2014).

[25] Table 5 reports the estimates of the coefficients from Equations 1 and 2 with census tract fixed effects. We did the same exercise with city fixed effects and the estimates were quantitatively similar. As were the estimates when we estimated both equations for the developed and undeveloped plots separately. All these results are available upon request.

Table 5. Is difference in prices driven by differences in floor-to-area restrictions?

	(1)	(2)	(3)	(4)	(5)	(6)
Assembly (β_1)	0.104**	0.169***	0.149***	0.106**	0.166***	0.154***
	(0.050)	(0.050)	(0.055)	(0.049)	(0.056)	(0.054)
Assembly $\times$ undeveloped (β_2)		-0.251*	-0.162		-0.272**	-0.197
		(0.134)	(0.172)		(0.133)	(0.169)
Mixed (β_3)			0.073			0.076
			(0.113)			(0.111)
Mixed $\times$ undeveloped (β_4)			-0.124			-0.082
			(0.238)			(0.238)
FAR new building				0.112***	0.115***	0.114***
				(0.037)	(0.038)	(0.037)
Adj. R^2	0.786	0.789	0.789	0.792	0.794	0.794
Observations	2,313	2,313	2,313	2,313	2,313	2,313
Assembly	806	806	806	806	806	806
Single-plot	1,507	1,507	1,507	1,507	1,507	1,507

Note: This table presents the estimates of the coefficients β_1 to β_4 from Equations 1 and 2. The dependent variable in these regressions is the natural logarithm of the price per square meter. All specifications include quarter of the year and census tract fixed effects along with the following characteristics of the parcel (X_i) and structure (Z_i): surface of the plot, useful surface, floor-to-area ratio, construction year, years since last renovation, number of bathrooms and garages, whether the house is detached, semi-detached or closed, and distance to the CBD, nearest train station, school and park. Robust standard errors are reported in parentheses.

sales of houses and apartments located within 100 meters of the single-plot and assembly projects for which we found one or more sales in the transactions data. We exclude the sales that took place more than three years before the permit was issued.[26] Using this sample, we then estimate the following hedonic price model:

$$log(Price)_{i,t} = \beta \times \mathbb{1}\{\text{Assembly<100m}\} + \lambda' X_i + \phi' Z_i + \tau_t + \alpha_l + \epsilon_{i,t} \quad (3)$$

With $\mathbb{1}\{\text{Assembly<100m}\}$ a dummy variable which takes the value of one if the housing unit is located within 100m of an assembly project and the value of zero if the unit is located within 100m of a single-plot project. As in the previous specifications, the vectors X_i and Z_i contain the characteristics of the parcel and the construction respectively, while τ_t and α_l capture quarter of the year and census tract fixed effects.

The estimates of β in columns one and three of Table 6 suggest that the average price of houses nor apartments significantly differs across the locations of the two projects types. This conclusion does not change when we allow the difference in prices to vary across the three types of assembly projects in columns two and four.[27]

Table 6. Does the premium capture differences in house or apartment prices within tracts?

	Houses		**Apartments**	
	(1)	(2)	(3)	(4)
Assembly<100m	-0.017		-0.003	
	(0.018)		(0.016)	
Assembly of developed<100m		-0.032		-0.009
		(0.022)		(0.017)
Assembly of undeveloped<100m		0.041		0.058
		(0.037)		(0.047)
Mixed<100m		-0.020		-0.001
		(0.059)		(0.060)
Adj.R^2	0.574	0.574	0.530	0.530
Observations	6,738	6,738	6,732	6,732
Assembly<100m	1,781	1,781	2,274	2,274
Single-plot<100m	4,957	4,957	4,458	4,458

Note: This table presents the estimates of β from Equation 3. The dependent variable in these regressions is the natural logarithm of the sales price of houses or apartments. All specifications include quarter of the year and census tract fixed effects along with the following characteristics of the parcel (X_i) and structure (Z_i): surface of the plot, distance to the CBD, useful surface, floor-to-area ratio, construction year, years since last renovation, number of bathrooms and garages, and lastly whether the house is detached, semi-detached or closed. Robust standard errors are reported in parentheses.

[26] To avoid capturing any spillover effects of the new development, we exclude all sales after the permit was issued. Our results are robust for different time periods and different distances.

[27] Table B.4 in the Appendix presents the estimates from Equation 3 using city fixed effects. While the estimates in columns one and two are line with the results in Table 6, the estimates in column three and four are now all statistically significantly.

Reservation prices and construction quality

The following two robustness checks focus on the assembly premium for developed parcels because the data that we will use is only available for developed plots and, in the last case, also only relevant for developed plots.

Reservation prices - In the third robustness check, we look whether the premium for developed plots reflects a difference in reservation prices. Winn and McCarter (2018) argue that sellers who were approached directly by developers (passive sellers) have higher reservation prices than sellers who have put their house up for sale (active sellers). The authors state that the number of passive sellers will be higher in assembly projects than in single-plot projects since it is less likely to find adjacent plots that are all listed for sale than to find one listed parcel. Parcels for assembly projects might thus be bought at higher prices because more are owned by passive sellers with higher reservation prices and not because of frictions.

We use data on Energy Performance Certificates (EPC) to see which parcels in the sample of sales were publicly listed before they were sold. In 2008, it became mandatory to disclose the energy performance of a dwelling. However, it was only required when the house was publicly listed for sale. We obtained the universe of EPC's together with the address of the housing units. We assume that parcels for which we find a matching EPC were publicly listed, while the parcels without an EPC were not. The EPC sample of sales differs from the main sample because of two reasons. First, all undeveloped plots are dropped since these do not have an EPC. Second, the EPC data starts in 2009. All sales before 2009 are therefore dropped. We find an EPC for about 60% of the sales for single-plot projects, which is slightly lower than the share for assembly projects (62%). The difference is, however, not significantly different from zero.

In order to check whether the premium captures a difference in reservation prices, we add a 'listed' dummy variable to Equation 1 and re-estimate the hedonic model. Just like for the robustness check using the floor-to-area ratio, we first run the specification using the selected sample of sales but without the additional control variable. The estimate in the first column of Table 7 is not significantly different from the corresponding estimate in Table 4. The main estimate in column two shows that the premium does not capture a difference in price between listed and unlisted parcels. These two results suggest that the premium is of similar magnitude in the full and selected samples and, more importantly, that the premium is not driven by differences in reservation prices. Note that the coefficient estimate on the listed dummy variable is positive but not statistically significant. There is no consensus, to our knowledge, on whether passive sellers have indeed higher reservation prices than active sellers. Active sellers might have higher reservation prices because they have better knowledge of the market.

Construction quality - In the fourth and last robustness check, we look whether the premium is driven by a difference in quality. Developed parcels that are torn down, are assumed to be bought at the price of vacant land (Rosenthal and Helsley, 1994). We therefore expect the existing houses to be strongly deteriorated. However, it seems implausible that this is the case for all the houses on the different adjacent parcels in every assembly project. In other words, the average price of developed parcels for assembly project might be higher than the price of developed parcels for

Table 7. Is the premium a result of differences in reservation prices or quality of the structure?

	Reservation prices		**Energy performance**	
	(1)	(2)	(3)	(4)
Assembly (β_1)	0.181**	0.173**	0.256***	0.251**
	(0.072)	(0.072)	(0.124)	(0.118)
Listed		0.094		
		(0.066)		
Energy efficiency				-0.001**
				(0.000)
Adj. R^2	0.769	0.771	0.789	0.802
Observations	1,344	1,344	814	814
Assembly	510	510	314	314
Single-plot	834	834	500	500

Note: This table presents the estimates of β_1 from Equation 1. The dependent variable in these regressions is the natural logarithm of the price per square meter. All specifications include quarter of the year and census tract fixed effects along with the following characteristics of the parcel (X_i) and structure (Z_i): surface of the plot, useful surface, floor-to-area ratio, construction year, years since last renovation, number of bathrooms and garages, whether the house is detached, semi-detached or closed, and distance to CBD, nearest train station, school and park. Robust standard errors are reported in parentheses.

single-plot parcels because the quality of the houses on these parcels is, on average, better.

We already control for a number of quality-related attributes in the main specification like the number of bathrooms, the construction year and years since renovation. While none of these attributes pointed to a significant difference in quality, the energy performance scores on the EPC's suggest that the houses on the parcels for assembly projects are, on average, of better quality than those for single-plot projects. The latter have a significant higher energy performance score than the former (685 vs. 592). Given that this measure indicates the energy usage of a building, a lower value corresponds to a more energy efficient house.

In order to see whether the premium does not merely reflect this difference in quality, we re-estimate the main specification with the energy performance score as a control variable. However, we first present the results using the selected sample. The estimate in the third column of Table 7 is larger than the estimate in Table 4, but the difference is not significantly different from zero. This estimate changes marginally when we adjust for the energy efficiency of the houses, suggesting that the premium does not capture differences in quality. The coefficient estimate on energy efficiency measure is negative and significantly different from zero. As expected, less energy efficient houses are sold at lower prices all else equal.

4.2 (Re)development

4.2.1 Empirical strategy

A significant difference in the price of small and large plots can only hold over time if there are frictions in the land market which prevent smaller plots from being assembled into larger plots. In a frictionless market, smaller plots would be assembled into larger plots until the difference in prices reflects 'reasonable' costs such as conversion costs and good-institutions transactions costs (Brooks and Lutz, 2016). The estimates in the previous section show that developed parcels for assembly projects are bought at a premium of 17% in comparison to similar parcels for single-plot projects. These results therefore suggests that not enough smaller parcels are assembled to bring prices back in line.

While the experimental literature consistently finds some fraction of the negotiations for assembly projects to fail, there does not exist - to our knowledge at least - any evidence of assembly projects failing in real life.[28] While we do not observe negotiations between buyers and sellers, the time span of the land register data allows us to see what happened with the parcels after the permit has been issued. In this section, we look whether parcels in assembly projects are less likely (re)developed than parcels in single-plot projects.

The descriptive statistics in Table 1 showed that 94% of the parcels in single-plot projects have been (re)developed in 2020 while this is 91% of the parcels in assembly projects. In other words, the probability that a parcel is not (re)developed, is 50% higher for parcels in assembly projects. However, this difference in the average (re)development rate might be the result of differences in alternative drivers rather than frictions preventing developers from executing an assembly project. For example, a common practice among developers is to first try to sell some fraction - often more than half - of the apartments before actually constructing the apartment building. The reasons why parcels remain unaltered might be correlated with the parcels' attributes and therefore differ between the average parcels in single-plot and assembly projects. We try to control for some of these alternative drivers by estimating the difference in the probability of (re)development using a linear probability model in which we adjust for differences in parcel-level characteristics[29]:

$$\begin{aligned}(Re)developed_{i,j,l,t} =& \beta_1 \times Assembly_j + \beta_2 \times Assembly_j \times Undeveloped_i + \beta_3 \times Mixed_j \\ &+ \beta_4 \times Mixed_j \times Undeveloped_i + \lambda' X_i + \phi' Z_i + \alpha_l + \tau_t + \epsilon_{i,j,l,t}\end{aligned} \tag{4}$$

The dependent variable $(Re)developed_{i,j,l,t}$ is a dummy indicating whether parcel i of project j has been (re)developed in 2020. Like in the previous models, $Assembly_j$ is a dummy variable taking the value of one if the project is an assembly project. The vectors X_j and Z_j now contain the following set of characteristics of the parcel and building: the size of the parcel, the floor-to-area ratio of the existing building and the same set of distances. The vector τ_t now consists of year of permit fixed effects and α_l is a vector of municipality or census tract fixed effects to account

[28] About 10% of all the negotiations in the laboratory experiments Winn and McCarter (2018) reviewed, failed.

[29] We prefer a linear probability model over a probit or logit model because of the large set of geographical fixed effects. However, our results are robust for different types of models.

for unobserved location-specific variation. As before, we can interpret the coefficient estimates as unbiased estimands of the difference in the (re)development probability under the assumptions of unconfoundedness and overlap.

4.2.2 Main results

The estimate in column one of Table 8 suggests that parcels in assembly projects are less likely to be (re)developed than parcels in single-plot projects. The coefficient estimate is 2.9 to 3.3 percentage points. The probability that a parcel will not be (re)developed is thus still 30% larger for parcels in assembly projects even after controlling for potentially confounding observables like location.

Contrary to the estimates of the difference in sales prices, the difference between $\hat{\beta}_1$ and $\hat{\beta}_2$ in column four is significantly different from zero at the 5% level. This suggests that undeveloped parcels in assembly projects have a lower probability of being (re)developed than undeveloped parcels in single-plot projects. Note that this finding does not contradict the lack of a price premium for undeveloped plots. Frictions that keep assembly projects from succeeding do not lead to higher prices if there are enough assembled or existing parcels to meet the increase in demand for larger plots.

Finally, the estimates in columns five and six point out that developed parcels in mixed assembly project have an even lower probability of being (re)developed than the developed parcels in assembly projects using solely developed parcels. The difference between all four coefficient estimates is also significantly different from zero. Undeveloped parcels have a similar probability to be (re)developed as developed parcels, whether they are part of a pure undeveloped assembly project or a mixed project.

The estimates in Table 8 show that the probability that a parcel gets (re)developed, is significantly lower for parcels in assembly projects. In line with the results regarding the assembly premium, this finding suggests that frictions in the land market cause assembly projects to fail or at least not being executed as initially planned. There are, however, some possible threats to the identification of the estimates in Table 8. We discuss these threats and how we deal with them in the next section.

Table 8. The difference in the probability that the parcel is (re)developed

	(1)	(2)	(3)	(4)	(5)	(6)
Assembly (β_1)	-0.033***	-0.029***	-0.037***	-0.032***	-0.033***	-0.027***
	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
Assembly × undeveloped (β_2)			0.013	0.012	0.020*	0.015
			(0.009)	(0.010)	(0.012)	(0.015)
Mixed (β_3)					-0.011*	-0.018**
					(0.006)	(0.007)
Mixed × undeveloped (β_4)					-0.004	0.004
					(0.013)	(0.015)
Adj. R^2	0.029	0.140	0.029	0.140	0.030	0.140
Observations	21,197	21,197	21,197	21,197	21,197	21,197
Assembly	14,264	14,264	14,264	14,264	14,264	14,264
Single-plot	6,933	6,933	6,933	6,933	6,933	6,933
Location FE:						
Municipality	X		X		X	
Census tract		X		X		X

Note: This table presents the estimates of the coefficients β_1 to β_4 from Equation 4. The dependent variable in these regressions is a dummy variable indicating whether the parcel is (re)developed in 2020. All specifications include year of permit along with the following characteristics of the parcel (X_i) and structure (Z_i): parcel size, floor-to-area ratio of the existing buildings and the distance to the CBD, nearest train station, school and park. Robust standard errors are reported in parentheses.

4.2.3 Robustness checks

In this section we consider two potential threats to the identification of the difference in the probability of being (re)developed between parcels from single-plot and assembly projects.

The first threat is related to the way we check whether a parcel is (re)developed. The downside of our approach is that parcels in projects that are still under construction in 2020 might be wrongfully labeled as not (re)developed. There are clear incentives to start a development sooner than later. First, there is a financial incentive to demolish existing buildings on the parcels to reduce the property tax burden.[30] Second, and more important, developers are required to start the development within 2 years after the permit has been issued otherwise they have to request a new permit. Yet while changes in a parcel's attributes as a result of the development sometimes show up in the land register, e.g. the demolition of the existing building, this seems more the exception than the rule.

Given that it can take many years for projects to finish, several parcels will therefore show

[30]However, the properties that are considered to be redeveloped might be eligible for a temporary reduction in the property tax due to inactivity.

up as not (re)developed while they are in fact under construction. Figure 4 plots the share of (re)developed parcels in single-plot and assembly projects by permit year. There are two take-aways. First, and unsurprisingly, the share of parcels that are (re)developed is lower for projects that received their permit in later years. Second, the decline in the share of (re)developed parcels differs across both groups of projects. While the decline in the overall share of (re)developed parcels will not form a threat to the identification of the difference in success, since it will be absorbed by the permit year fixed effects, the difference in the decline for both groups will bias the estimate to the extent that it reflects differences in the average duration of the development rather than a difference in the probability of being effectively (re)developed.

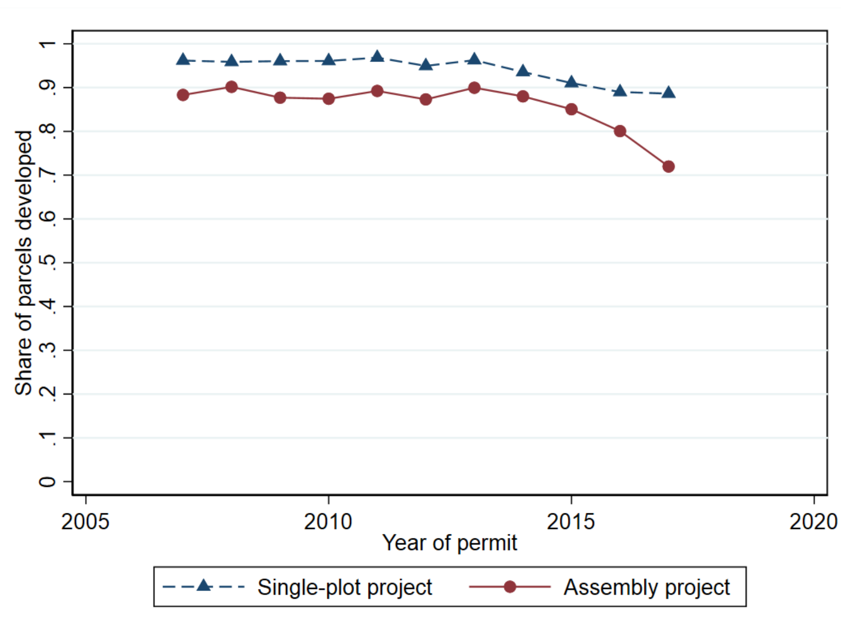


Figure 4. Share of parcels (re)developed in 2020 by permit year and project type

The decline in the share of (re)developed parcels seems to start from 2014 onward. We therefore re-estimate Equation 4 with the parcels for which the permit has been issued no later than 2013. The estimates in the first two columns of Table C.1 in the Appendix are in line with those in Table 8, but are larger in absolute size. The most striking difference is the change in the sign of β_2 which is now negative, suggesting that undeveloped plots in assembly projects are even less likely to be (re)developed in 2020 than developed plots.

A second and more fundamental threat to identification is that developers might not intend to (re)develop one or more undeveloped parcels in assembly projects despite that they are included in the permit. Parcels might be used as garden, parking space or as a way to provide access to other buildings. These land uses might not lead to a change in one of the parcels' attributes. The probability that one or more parcels in assembly projects are not (re)developed might therefore be larger even if frictions were completely absent. We try to tackle this problem in two ways. First, we removed projects with extreme small plots. Second, we perform a robustness check in which we only use parcels from two-plot assembly projects. This is the group of projects for which we think the probability that an undeveloped was never intended to be (re)developed is lowest. The estimates in Table C.2 are more less in line with those from 8 except for the estimate of β_3, which is now positive and no longer significantly different from zero. Combining both robustness checks, i.e. sample of two plot assembly project no later than 2013, in one analysis also does not affect the results (See Table C.3).

A last possible source of bias in the estimates is the lack of information on the ownership of the parcels. We cannot rule out that all parcels in an assembly project belong to the same owner. Some of the frictions that cause projects to fail, like strategic holdout, will be less of an issue if all parcels are owned by the same person. However, there is no immediate solution to tackle this problem. Yet, if anything, this would bias the estimates upward so the results in Table 8 can then be interpreted as a lower bound.

5 Are landowners holding out?

This section presents evidence on hold out in the land market. We test three hypotheses concerning hold out behavior by landowners that are based on theoretical work by Eckart (1985) and Strange (1995).[31] The results support the view that hold out is one of the frictions that prevent developers from assembling land into larger parcels.

5.1 Is the last parcel sold at a premium?

The first hypothesis concerning hold out states that landowners undertake strategic delays and are rewarded for it. To test this hypothesis in the data, we check whether the last acquired parcel in an assembly project trades at a higher premium. In most cases, all parcels of an assembly project were bought on the same day. However, 285 assembly projects have parcels that were bought on different dates. This within-project variation in the sales date allows us to test the prediction.

We add a dummy variable to Equation 1 indicating whether the parcel was bought last. This variable takes the value zero for all other observations and for all single-plot sales. The estimates of the last sale coefficient in columns one and two of Table 9 are positive but not statically different from zero. However, we find a significant last sale premium of 9% for developed plots in the specification with the municipality fixed effects where we allow this additional premium to vary across parcel types.[32] Moreover, the estimates are statistically significant in both specifications when we estimate the model for developed and undeveloped parcels separately.[33] While the estimates are borderline significant, they indicate that the developed parcels that are sold last in an assembly, are bought at a higher premium than those that are sold earlier. These results thus suggest that landowners engage in strategic delay to maximize their share of the surplus.

[31]See Menezes and Pitchford (2004), Miceli and Segerson (2007) and Miceli and Sirmans (2007) among others for more recent theoretical work on hold out.
[32]See Table D.1 in the Appendix for the full results.
[33]See Table D.2 in the Appendix

Table 9. Is the last parcel sold at a higher premium?

	(1)	(2)	(3)	(4)	(5)	(6)
Last sale	0.055	0.039				
	(0.054)	(0.066)				
Last sale ×			0.087*	0.092	0.090*	0.094
developed			(0.047)	(0.063)	(0.046)	(0.064)
Last sale ×			-0.064	-0.151	-0.063	-0.146
undeveloped			(0.167)	(0.202)	(0.167)	(0.199)
Adj. R^2	0.741	0.775	0.744	0.778	0.744	0.778
Observations	3,152	3,152	3,152	3,152	3,152	3,152
Assembly	1,063	1,063	1,063	1,063	1,063	1,063
Single-plot	2,089	2,089	2,089	2,089	2,089	2,089
Location FE:						
Municipality	X		X		X	
Census tract		X		X		X

Note: This table presents estimates of the coefficient on a last sale dummy and its interaction with parcel type from Equations 1 and 2. The dependent variable in these regressions is the natural logarithm of the price per square meter. All specifications include quarter of the year and census tract fixed effects along with the following characteristics of the parcel (X_i) and structure (Z_i): surface of the plot, useful surface, floor-to-area ratio, construction year, years since last renovation, number of bathrooms and garages, whether the house is detached, semi-detached or closed, and the distance to the CBD, nearest train station, school and park. Robust standard errors are reported in parentheses. The full results are presented in Table D.1 in the Appendix.

5.2 Are landowners of smaller parcels holding out?

The second hypothesis states that owners of small parcels are more likely to bargain for a higher premium because a higher premium for a relatively small parcel has only a relatively small effect on the total price of the land. Conversely, owners of relative large parcels are expected to be more restrained because their premium has a large effect on the total price the developer has to pay. We test this hypothesis by looking whether relatively small parcels trade at a higher premium.

We add the parcel's share in the total surface of the project to Equation 1.[34] The estimates in columns one and two in Panel A of Table 10 are negative, suggesting owners of smaller plots are indeed able to negotiate a higher premium relative to owners of larger plots. However, both estimates are not significantly different from zero. In columns three to six, we allow the effect to vary across parcel type. The estimate of the interaction effect of surface share with the developed dummy is negative and statistically significant, while the estimate for undeveloped plots is significantly positive.

Combining the full set of estimates in column 6 in Table D.3 in the Appendix shows that developed parcels with a share in the total surface above 66% are sold without a premium. Undeveloped

[34]The share equals zero for parcels of single-plot projects. Figure D.1a in the Appendix plots the distribution of this variable.

parcels, on the other hand, are sold at a premium if they take up at least 35% of the total surface of the project.[35] The finding that large undeveloped plots in an assembly project are sold at a premium seems contradictory, but is in fact in line with basic theory on land assembly. Indeed, developers will only start assembling land if the price of large parcels is higher than the price of small parcels. The latter result thus merely shows that developers do not assemble undeveloped parcels randomly across space, but in areas where land prices start to become convex. However, in areas with a small number of existing large plots and sets of parcels that can be assembled, landowners can get enough bargaining power to counteract these convex prices and get higher prices for small lots.

If owners of small parcels hold out to maximize their share of the surplus, then this might cause negotiations between developers and landowners to fail. Relatively small parcels might therefore have a lower probability of getting (re)developed. We test this hypothesis by adding the share in the total surface to Equation 4. The estimates in Panel B in Table 10 suggest that the probability a parcel is (re)developed increases with its share in the total surface of the project. While these results are in line with those in Panel A, we consider them as suggestive evidence at best. There might be other reasons, aside from hold out, due to which smaller parcels are less likely to be (re)developed.[36]

[35]Estimates from the regressions using the sample of developed and undeveloped plots separately are in line with those in Panel A in Table 10 except for the estimates for undeveloped plots with census tract fixed effects, which are much smaller in size and statistically insignificant. These results are presented in Table D.4 in the Appendix.

[36]Note that we already filter out projects with very small parcels.

Table 10. Are smaller parcels sold at a higher premium and less likely (re)developed?

	(1)	(2)	(3)	(4)	(5)	(6)
A. Sales prices						
Surface share	-0.073	-0.114				
	(0.100)	(0.166)				
Surface share ×			-0.516***	-0.557***	-0.537***	-0.567***
developed			(0.092)	(0.152)	(0.094)	(0.152)
Surface share ×			1.690***	1.766***	1.729***	1.795***
undeveloped			(0.254)	(0.445)	(0.260)	(0.454)
Adj. R^2	0.741	0.771	0.751	0.782	0.751	0.782
Observations	3,106	3,106	3,106	3,106	3,106	3,106
Assembly	1,017	1,017	1,017	1,017	1,017	1,017
Single-plot	2,089	2,089	2,089	2,089	2,089	2,089
B. (Re)development						
Surface share	0.046***	0.043***				
	(0.010)	(0.011)				
Surface share ×			0.037***	0.039***	0.035***	0.034***
developed			(0.011)	(0.012)	(0.012)	(0.013)
Surface share ×			0.070***	0.057***	0.068***	0.056***
undeveloped			(0.020)	(0.021)	(0.020)	(0.021)
Adj. R^2	0.030	0.140	0.030	0.140	0.031	0.141
Observations	21,197	21,197	21,197	21,197	21,197	21,197
Assembly	14,264	14,264	14,264	14,264	14,264	14,264
Single-plot	6,933	6,933	6,933	6,933	6,933	6,933
Location FE:						
Municipality	X		X		X	
Census tract		X		X		X

Note: This table presents the estimates of the coefficient on surface share and its interaction effects from Equations 1, 2 and 4. The dependent variable in these regressions in panel A is the natural logarithm of the price per square meter. In panel B the dependent variable is a dummy variable indicating whether the parcel is (re)developed in 2020. All specifications include quarter of the year and census tract fixed effects along with the following characteristics of the parcel (X_i) and structure (Z_i): surface of the plot, distance to the CBD, useful surface, floor-to-area ratio, construction year, years since last renovation, number of bathrooms and garages, and lastly whether the house is detached, semi-detached or closed. Robust standard errors are reported in parentheses. The full results are presented in Tables D.3 and D.5 in the Appendix.

5.3 Does holdout increase in the number of parcels that need to be assembled?

In the third and last analysis of holdout, we test the hypothesis that the price of parcels increases with the number of required parcels. The assembly dummy in equation 1 is replaced by a categorical variable indicating the number of parcels the developer intends to use in the project.[37] We then estimate the hedonic model for developed and undeveloped parcels separately.[38] Figure 5a plots the coefficient estimates along with the 95% confidence intervals from the sample of developed parcels. The premium for developed plots increases with the number of inputs in the model with municipality fixed effects. This trend is, however, less pronounced in the model with census tract fixed effects and the confidence bands are much wider. Figure 5b plots the estimates from the sample of undeveloped plots. There is no visible trend and none of the estimates is significantly different from zero.

We perform the same analysis with the probability of (re)development as outcome. In contrast with our previous analysis, we can now use the full sample of parcels from the multifamily housing projects.[39] Figure 5c shows somewhat of a downward trend in the estimates for developed plots. This suggests that the probability that the parcel will effectively be (re)developed decreases with the number of parcels in the assembly. The downward trend is, however, only visible in the estimates from the model with census tract fixed effects. The estimates for undeveloped plots fluctuate around zero and have quite large confidence bands.

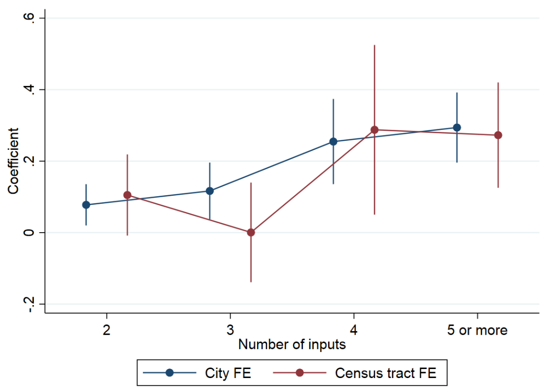
Overall, the empirical evidence in this section does not strongly point to holdout as a friction in land assembly. However, the lack of a clear effect might be due to the fact that the number of parcels in the permits does not necessarily equal the number of parcels required to make the project feasible.

[37]Due to a lack of observations, we truncate the categorical variable at 5 parcels. Panel A in Table D.6 in the Appendix presents the distribution of the projects for which we were able to find a sale of one of the parcels.

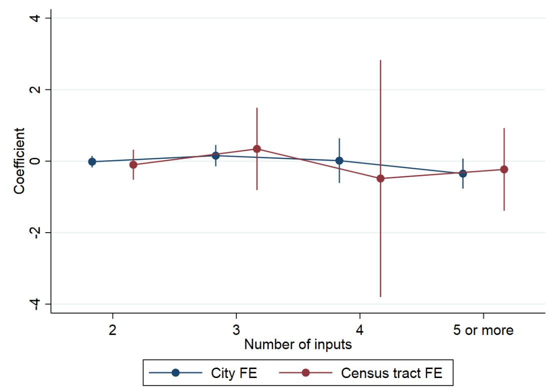
[38]Figure D.2a in the Appendix plots the same estimates for the full sample.

[39]Panel B in Table D.6 presents the distribution of the full sample of parcels in multifamily housing projects.

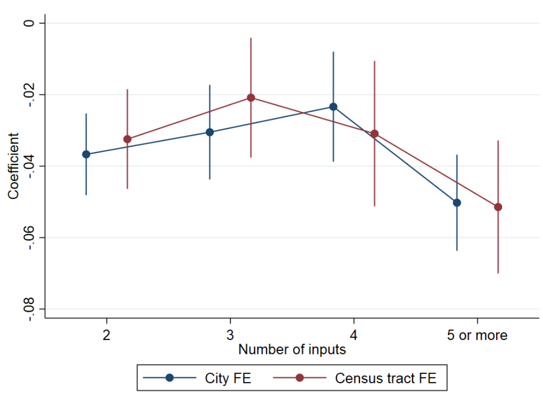
Figure 5. The difference in sales price and the probability that the parcel is (re)developed between single-plot and assembly projects by the number of parcels in the project



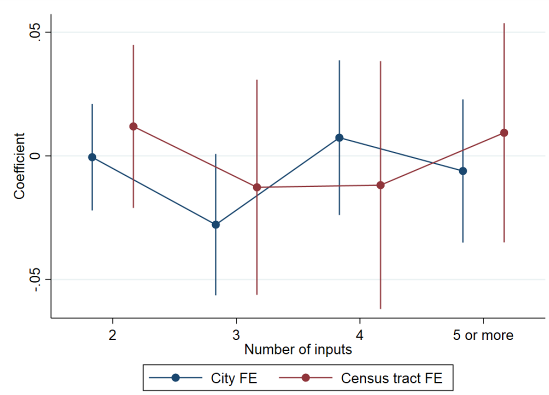
(a) Sales price: developed parcels



(b) Sales price: undeveloped parcels



(c) (Re)development: developed parcels



(d) (Re)development: undeveloped parcels

6 Conclusion

In this paper, we provide evidence of frictions in land assembly. Using a sample of parcels for which a multifamily housing construction permit has been issued, we find that developed parcels are bought at a premium of 17% if they are to be assembled. This premium is not the result of differences in floor-to-area restrictions, local house and apartment prices, reservation prices nor construction quality.

Contrary to developed parcels, undeveloped parcels are not sold at a premium. The absence of a premium suggests that undeveloped parcels are located in areas where the supply of large plots can increase sufficiently to bring the price of small and large parcels back in line. The data supports this view since undeveloped parcels plots are located further away from the city center in less densely populated areas with a higher share of undeveloped land. However, a different location cannot explain the difference in the premia of developed and undeveloped parcels within the same mixed assembly project. We argue that the latter difference might be driven by asymmetric bargaining power of the respective landowners.

In a novel analysis, we find that parcels in assembly projects are less likely to be (re)developed than parcels in single-plot projects. This suggests that there are frictions that cause assembly projects to fail. Contrary to the difference in prices, the difference in the (re)development probability is similar for developed and undeveloped parcels. These two sets of results do not, however, contradict each other since assembly projects can fail without raising the price of large parcels if there are enough alternative parcels, or sets of parcels, available in the area.

In the second part of this paper, we present the results from three tests which, together, suggest that strategic holdout behavior by landowners is one of these frictions. First, the last acquired developed parcel in an assembly is sold at a higher premium which indicates that landowners undertake strategic delays and are rewarded for it. Second, relatively smaller developed plots receive a higher premium suggesting that owners of relatively small parcels are aware that their premium has only a limited effect on the total price of the assembly project. Third, the premium increases slightly in the number of developed plots.

Although estimating the difference in prices as a test of frictions still has its merits, we think that other avenues of research using observational data would be more valuable. First, future research could focus more on whether there is evidence of assemblies failing in real life. We provide some of the first evidence on this topic, but there are many questions left unanswered. For example, do many negotiations between developers and landowners fail? The average failure rate in the experimental research of 10% seems rather low to lead to such price differences (Winn and McCarter, 2018). However, an important difference between laboratory experiments and real life is that landowners might expect a next developer coming along if the negotiations with a first developer fail.[40] Another important question is whether many developers pass on assembly projects beforehand because they expect such projects to become very costly and have a low probability to succeed? A second avenue for future research could focus on some of the hypotheses from the theoretical and experimental literature that have not been tested yet. For example, Isaac et al. (2016) find that more competition between landowners raises the success rate of assembly projects. In this paper, we document an important difference in the assembly premia for developed and undeveloped plots which might be considered as suggestive evidence on the effect of increased competition.

References

Ahlfeldt, G.M., McMillen, D.P., 2018. Tall buildings and land values: Height and construction cost elasticities in Chicago, 1870 to 2010. Review of Economics and Statistics 100, 861–875.

Ahlfeldt, G.M., Pietrostefani, E., 2019. The economic effects of density: A synthesis. Journal of Urban Economics 111, 93–107.

[40]These kind of expectations are hard if not impossible to create in a laboratory experiment.

Baum-Snow, N., Hartley, D., 2020. Accounting for central neighborhood change, 1980â2010. Journal of Urban Economics 117, 103228.

Brooks, L., Lutz, B., 2016. From today's city to tomorrow's city: An empirical investigation of urban land assembly. American Economic Journal: Economic Policy 8, 69–105.

Brueckner, J.K., Rosenthal, S.S., 2009. Gentrification and Neighborhood Housing Cycles: Will America's Future Downtowns Be Rich? Review of Economics and Statistics 91, 725–743.

Couture, V., Gaubert, C., Handbury, J., Hurst, E., 2020. Income Growth and the Distributional Effects of Urban Spatial Sorting.

Couture, V., Handbury, J., 2020. Urban revival in America. Journal of Urban Economics 119.

Cunningham, C., 2013. Estimating the Holdout Problem in Land Assembly.

Eckart, W., 1985. On the land assembly problem. Journal of Urban Economics 18, 364–378.

Hsieh, C.T., Moretti, E., 2019. Housing constraints and spatial misallocation. American Economic Journal: Macroeconomics 11, 1–39.

Ihlanfeldt, K.R., 2007. The effect of land use regulation on housing and land prices. Journal of Urban Economics 61, 420–435.

Imbens, G.W., Wooldridge, J.M., 2009. Recent Developments in the Econometrics of Program Evaluation. Journal of Economic Literature 47, 5–86.

Isaac, R.M., Kitchens, C., Portillo, J.E., 2016. Can buyer mobility reduce aggregation failures in land assembly? Journal of Urban Economics 95, 16–30.

Menezes, F., Pitchford, R., 2004. The land assembly problem revisited. Regional Science and Urban Economics 34, 155–162.

Miceli, T.J., Segerson, K., 2007. A bargaining model of holdouts and takings. American Law and Economics Review 9, 160–174.

Miceli, T.J., Sirmans, C.F., 2007. The holdout problem, urban sprawl, and eminent domain. Journal of Housing Economics 16, 309–319.

Murphy, A., 2018. A Dynamic Model of Housing Supply. American Economic Journal: Economic Policy 10, 243–267.

Rosenthal, S.S., Helsley, R.W., 1994. Redevelopment and the urban land price gradient. Journal of Urban Economics 35, 182–200.

Rosenthal, S.S., Ross, S.L., 2015. Change and persistance in the economic status of neighborhoods and cities, in: Handbook of Regional and Urban Economics. Elsevier. 5, pp. 1047–1120.

Rossi-hansberg, E., Sarte, P.D., Owens III, R., 2010. Housing Externalities. The Journal of Political Economy 118, 1–8.

Strange, W.C., 1995. Information, Holdouts, and Land Assembly. Journal of Urban Economics 38, 317–332.

Su, Y., 2019. The Rising Value of Time and the Origin of Urban Gentrification. Federal Reserve Bank of Dallas, Working Papers 2019.

Turner, M.A., Haughwout, A., van der Klaauw, W., 2014. Land Use Regulation and Welfare. Econometrica 82, 1341–1403.

Winn, A.M., McCarter, M.W., 2018. Who's holding out? An experimental study of the benefits and burdens of eminent domain. Journal of Urban Economics 105, 176–185.

Yuming, F., Mcmillen, D.P., Somerville, T., 2002. Lans Assembly: Measuring Holdup.

APPENDIX

A Data cleaning

Here we discuss how we clean the sample of parcels for which a construction permit for multi-family housing has been issued.

A.1 Construction permits and the Land Register

First, we drop parcels that did not exist in 2006. The reason is that these parcels might have underwent several changes. An example is the 'Green Quarter' in Antwerp South where some parcels are demolished, split, assembled, split again, etc... over our sample period. We want to avoid that the results are biased by very 'active' projects. All the parcels related to a permit are dropped if one of the parcels did not exist in 2006. This amounts to 8,777 parcels belonging to 3,943 construction permits. Second, we drop parcels for which we did not find the coordinates in the so called cadastral maps (CADMAPS). Third, we drop permits with extreme values in the characteristics at the project-level. There are assembly projects with very small parcels. A permit is dropped if it has a parcel of which the share in the total project's surface is smaller than the first percentile. Permits with a total surface smaller than the first percentile and larger than 99th percentile are also dropped. We do the same based on the floor-to-area ratio.

A.2 Transactions

First, we only keep arm's length sales so we drop transfers of property through donations, inheritances and public auctions. Second, we drop sales if they are part of a transaction of several pieces of real property because, in most cases, the price covers the entire transaction and not the individual properties. Third, we only keep sales for which the surface in the deed matches the surface in the cadaster and if both are not missing nor zero. Additionally, we excluded sold parcels with extreme values. Parcels with a recorded sales price, useful surface, plot surface, number of bathrooms, number of garages below or above the first and 99th percentile, respectively, are excluded.

B Additional results on prices

Table B.1. Descriptives sales: undeveloped versus developed parcels

	Undeveloped		**Developed**		
	Mean	Obs.	Mean	Obs.	Difference
Price per m^2	349.67	1,240	981.91	1,912	-632.24***
	(9.78)		(27.88)		
Surface	736.84	1,240	512.63	1,912	224.21***
	(21.23)		(12.45)		
Distance to CBD	1.83	1,240	1.52	1,912	0.32***
	(0.04)		(0.03)		

Note: This table presents descriptive statistics on the characteristics of the sales sample for the developed and undeveloped parcels separately.

Table B.2. The difference in sales price: by type of parcel

	Developed parcels		**Undeveloped parcels**	
	(1)	(2)	(3)	(4)
Assembly (β_1)	0.156***	0.165***	-0.054	-0.065
	(0.025)	(0.048)	(0.062)	(0.162)
Adj. R^2	0.804	0.787	0.468	0.586
Observations	1,912	1,912	1,240	1,240
Assembly	794	794	269	269
Single plot	1,118	1,118	971	971
Location FE:				
Municipality	X		X	
Tract		X		X

Note: This table presents estimates of β_1 from Equation 1. The dependent variable in these regressions is the natural logarithm of the price per square meter. All specifications include quarter of the year fixed effects along with the following characteristics of the parcel (X_i) and structure (Z_i): surface of the plot, distance to the CBD, nearest school, park and train station, useful surface, floor-to-area ratio, construction year, years since last renovation, number of bathrooms and garages, and lastly whether the house is detached, semi-detached or closed. Robust standard errors are reported in parentheses.

Table B.3. The geographical overlap of the sales sample: developed vs. undeveloped parcels

		Developed			Undeveloped		
		Single-plot	Assembly	Both	Single-plot	Assembly	Both
A. Municipality	Only one	158	35	193	365	30	395
		(14.13%)	(4.41%)	(10.09%)	(37.59%)	(11.15%)	(31.85%)
	Both	960	759	1,719	606	239	845
		(85.87%)	(95.59%)	(89.91%)	(62.41%)	(88.85%)	(68.15%)
B. Census tract	Only one	769	372	1,141	879	186	1,068
		(68.78%)	(46.85%)	(59.68%)	(90.53%)	(70.26%)	(86.13%)
	Both	349	422	771	92	80	172
		(31.22%)	(53.15%)	(40.32%)	(9.47%)	(29.74%)	(13.87%)

Note: This table provides an overview of the geographical overlap in transactions for single-plot projects and transactions for assembly projects at the municipal- and tract-level.

Table B.4. Does the premium capture differences in locations within municipalities?

	Houses		Apartments	
	(1)	(2)	(3)	(4)
Assembly<100m	-0.003		-0.026**	
	(0.011)		(0.012)	
Assembly<100m × developed		-0.005		-0.030**
		(0.014)		(0.013)
Assembly<100m × undeveloped		0.012		0.063**
		(0.023)		(0.031)
Assembly<100m × mixed		-0.028		-0.138***
		(0.039)		(0.047)
Adj.R^2	0.517	0.517	0.450	0.451
Observations	6,738	6,738	6,732	6,732
Assembly<100m	1,781	1,781	2,271	2,274
Single-plot<100m	4,957	4,957	4,458	4,458

Note: This table presents the estimates of β from Equation 3. The dependent variable in these regressions is the natural logarithm of the sales price of houses or apartments. All specifications include quarter of the year and municipality fixed effects along with the following characteristics of the parcel (X_i) and structure (Z_i): surface of the plot, distance to the CBD, useful surface, floor-to-area ratio, construction year, years since last renovation, number of bathrooms and garages, and lastly whether the house is detached, semi-detached or closed. Robust standard errors are reported in parentheses.

C Additional results on development

Table C.1. The difference in the probability that the parcel is (re)developed: permits up to 2013

	(1)	(2)	(3)	(4)	(5)	(6)
Assembly (β_1)	-0.041***	-0.033***	-0.038***	-0.029***	-0.033***	-0.022***
	(0.005)	(0.006)	(0.005)	(0.007)	(0.006)	(0.007)
Assembly ×			-0.011	-0.014	-0.010	-0.020
undeveloped (β_2)			(0.010)	(0.012)	(0.014)	(0.018)
Mixed (β_3)					-0.016**	-0.020**
					(0.007)	(0.009)
Mixed ×					0.008	0.016
undeveloped (β_4)					(0.015)	(0.019)
Adj. R^2	0.041	0.131	0.041	0.131	0.041	0.131
Observations	14,270	14,270	14,270	14,270	14,270	14,270
Assembly	9,424	9,424	9,424	9,424	9,424	9,424
Single-plot	4,846	4,846	4,846	4,846	4,846	4,846
Location FE:						
Municipality	X		X		X	
Census tract		X		X		X

Note: This table presents the estimates of the coefficients β_1 to β_4 from Equation 4. The sample only includes parcels from projects for which the permit has been issued no later than 2013. The dependent variable in these regressions is a dummy variable indicating whether the parcel is (re)developed in 2020. All specifications include year of permit along with the following characteristics of the parcel (X_i) and structure (Z_i): parcel size, floor-to-area ratio of the existing buildings and the distance to the CBD, nearest train station, school and park. Robust standard errors are reported in parentheses.

Table C.2. The difference in the probability that the parcel is (re)developed: 2 plot projects

	(1)	(2)	(3)	(4)	(5)	(6)
Assembly (β_1)	-0.031***	-0.026***	-0.037***	-0.032***	-0.038***	-0.035***
	(0.005)	(0.006)	(0.006)	(0.007)	(0.006)	(0.008)
Assembly $\times$			0.022*	0.022	0.023	0.023
undeveloped (β_2)			(0.011)	(0.014)	(0.015)	(0.019)
Mixed (β_3)					0.007	0.014
					(0.012)	(0.013)
Mixed $\times$					-0.008	-0.009
undeveloped (β_4)					(0.020)	(0.023)
Adj. R^2	0.022	0.094	0.023	0.095	0.022	0.095
Observations	12,387	12,387	12,387	12,387	12,387	12,387
Assembly	5,454	5,454	5,454	5,454	5,454	5,454
Single-plot	6,933	6,933	6,933	6,933	6,933	6,933
Location FE:						
Municipality	X		X		X	
Census tract		X		X		X

Note: This table presents the estimates of the coefficients β_1 to β_4 from Equation 4. The sample only includes single-plot and two plot assembly projects. The dependent variable in these regressions is a dummy variable indicating whether the parcel is (re)developed in 2020. All specifications include year of permit along with the following characteristics of the parcel (X_i) and structure (Z_i): parcel size, floor-to-area ratio of the existing buildings and the distance to the CBD, nearest train station, school and park. Robust standard errors are reported in parentheses.

Table C.3. The difference in the probability that the parcel is (re)developed: 2 plot projects up to 2013

	(1)	(2)	(3)	(4)	(5)	(6)
Assembly (β_1)	-0.042***	-0.029***	-0.042***	-0.029***	-0.037***	-0.024**
	(0.006)	(0.008)	(0.007)	(0.009)	(0.007)	(0.010)
Assembly × undeveloped (β_2)			-0.001	-0.001	-0.009	-0.011
			(0.013)	(0.017)	(0.017)	(0.023)
Mixed (β_3)					-0.026*	-0.023
					(0.015)	(0.018)
Mixed × undeveloped (β_4)					0.033	0.028
					(0.025)	(0.028)
Adj. R^2	0.023	0.086	0.023	0.085	0.023	0.086
Observations	8,459	8,459	8,459	8,459	8,459	8,459
Assembly	3,613	3,613	3,613	3,613	3,613	3,613
Single-plot	4,846	4,846	4,846	4,846	4,846	4,846
Location FE:						
Municipality	X		X		X	
Census tract		X		X		X

Note: This table presents the estimates of the coefficients β_1 to β_4 from Equation 4. The sample only includes single-plot and two plot assembly projects for which the permit has been issued no later than 2013. The dependent variable in these regressions is a dummy variable indicating whether the parcel is (re)developed in 2020. All specifications include year of permit along with the following characteristics of the parcel (X_i) and structure (Z_i): parcel size, floor-to-area ratio of the existing buildings and the distance to the CBD, nearest train station, school and park. Robust standard errors are reported in parentheses.

D Additional results on holdout

Table D.1. Is the last parcel sold at a higher premium: full results.

	(1)	(2)	(3)	(4)	(5)	(6)
Assembly (β_1)	0.074***	0.095**	0.156***	0.156***	0.138***	0.141***
	(0.025)	(0.041)	(0.025)	(0.041)	(0.029)	(0.046)
Assembly ×			-0.245***	-0.212*	-0.210***	-0.191
undeveloped (β_2)			(0.066)	(0.111)	(0.078)	(0.143)
Mixed (β_3)					0.059	0.054
					(0.044)	(0.079)
Mixed ×					-0.037	-0.010
undeveloped (β_4)					(0.110)	(0.191)
Last sale	0.055	0.039				
	(0.054)	(0.066)				
Last sale ×			0.087*	0.092	0.090*	0.094
developed			(0.047)	(0.063)	(0.046)	(0.064)
Last sale ×			-0.064	-0.151	-0.063	-0.146
undeveloped			(0.167)	(0.202)	(0.167)	(0.199)
Adj. R^2	0.741	0.775	0.744	0.778	0.744	0.778
Observations	3,152	3,152	3,152	3,152	3,152	3,152
Assembly	1,063	1,063	1,063	1,063	1,063	1,063
Single-plot	2,089	2,089	2,089	2,089	2,089	2,089
Location FE:						
Municipality	X		X		X	
Census tract		X		X		X

Note: This table presents estimates of the coefficient on a last sale dummy and its interaction with parcel type from Equations 1 and 2. The dependent variable in these regressions is the natural logarithm of the price per square meter. All specifications include quarter of the year and census tract fixed effects along with the following characteristics of the parcel (X_i) and structure (Z_i): surface of the plot, useful surface, floor-to-area ratio, construction year, years since last renovation, number of bathrooms and garages, whether the house is detached, semi-detached or closed, and the distance to the CBD, nearest train station, school and park. Robust standard errors are reported in parentheses. Robust standard errors are reported in parentheses.

Table D.2. Is the last parcel sold at a premium: developed vs. undeveloped

	Developed parcels		**Undeveloped parcels**	
	(1)	(2)	(3)	(4)
Assembly	0.143***	0.122***	-0.041	-0.043
	(0.026)	(0.042)	(0.067)	(0.168)
Last sale	0.090*	0.111*	-0.087	-0.109
	(0.046)	(0.058)	(0.173)	(0.238)
Adj. R^2	0.805	0.837	0.468	0.585
Observations	1,912	1,912	1,240	1,240
Assembly	794	794	269	269
Single plot	1,118	1,118	971	971
Location FE:				
Municipality	X		X	
Census tract		X		X

Note: This table presents the estimates of the assembly premium (β_1) from Equation 1. The dependent variable in these regressions is the natural logarithm of the price per square meter. All specifications include quarter of the year fixed effects along with the following characteristics of the parcel (X_i) and structure (Z_i): surface of the plot, useful surface, floor-to-area ratio, construction year, years since last renovation, number of bathrooms and garages, whether the house is detached, semi-detached or closed, and the distance to the CBD, nearest train station, school and park. Robust standard errors are reported in parentheses. Robust standard errors are reported in parentheses.

Table D.3. Are smaller parcels sold at a higher premium: full results.

	(1)	(2)	(3)	(4)	(5)	(6)
Assembly (β_1)	0.107**	0.143*	0.338***	0.371***	0.356***	0.380***
	(0.046)	(0.079)	(0.041)	(0.070)	(0.045)	(0.075)
Assembly ×			-0.886***	-0.951***	-0.936***	-1.003***
undeveloped (β_2)			(0.128)	(0.236)	(0.148)	(0.278)
Mixed (β_3)					-0.035	-0.016
					(0.045)	(0.078)
Mixed ×					0.051	0.063
undeveloped (β_4)					(0.109)	(0.199)
Surface share	-0.073	-0.114				
	(0.100)	(0.166)				
Surface share ×			-0.516***	-0.557***	-0.537***	-0.567***
developed			(0.092)	(0.152)	(0.094)	(0.152)
Surface share ×			1.690***	1.766***	1.729***	1.795***
undeveloped			(0.254)	(0.445)	(0.260)	(0.454)
Adj. R^2	0.741	0.771	0.751	0.782	0.751	0.782
Observations	3,106	3,106	3,106	3,106	3,106	3,106
Assembly	1,017	1,017	1,017	1,017	1,017	1,017
Single-plot	2,089	2,089	2,089	2,089	2,089	2,089
Location FE:						
Municipality	X		X		X	
Census tract		X		X		X

Note: This table presents the estimates of β_1 to β_4 from Equations 1 and 2 together with the estimates of the coefficient on surface share and its interaction effects. The dependent variable in these regressions is the natural logarithm of the price per square meter. All specifications include quarter of the year and census tract fixed effects along with the following characteristics of the parcel (X_i) and structure (Z_i): surface of the plot, useful surface, floor-to-area ratio, construction year, years since last renovation, number of bathrooms and garages, whether the house is detached, semi-detached or closed, and the distance to the CBD, nearest train station, school and park. Robust standard errors are reported in parentheses. Robust standard errors are reported in parentheses.

Table D.4. Are smaller parcels sold at a higher premium: by type of parcel.

	Developed parcels		**Undeveloped parcels**	
	(1)	(2)	(3)	(4)
Assembly (β_1)	0.335***	0.358***	-0.495***	-0.441
	(0.042)	(0.067)	(0.119)	(0.310)
Share of total	-0.531***	-0.608***	1.172***	0.890
	(0.094)	(0.150)	(0.244)	(0.570)
Adj. R^2	0.806	0.838	0.501	0.595
Observations	1,886	1,886	1,220	1,220
Assembly	768	768	249	249
Single plot	1,118	1,118	971	971
Location FE:				
Municipality	X		X	
Census tract		X		X

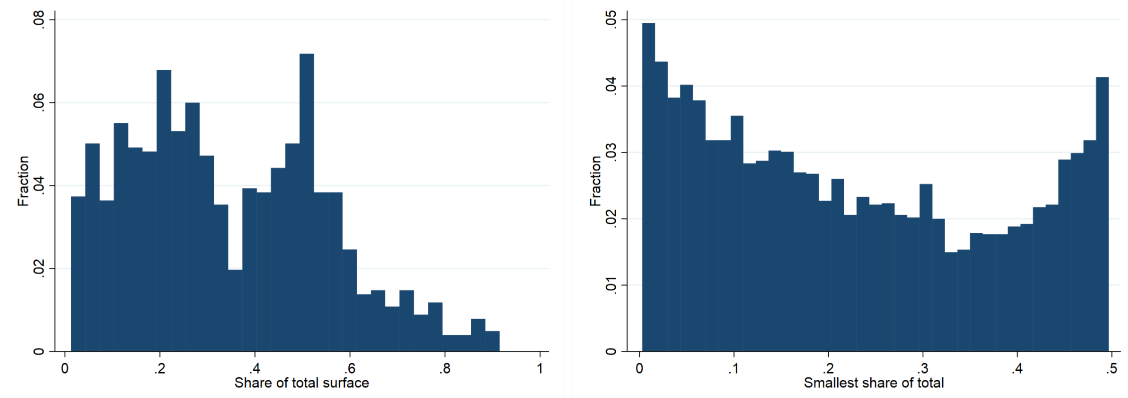
Note: This table presents the estimates of the assembly premium and the coefficient on the share in the total surface of the project. The dependent variable in these regressions is the natural logarithm of the price per square meter. All specifications include quarter of the year fixed effects along with the following characteristics of the parcel (X_i) and structure (Z_i): surface of the plot, useful surface, floor-to-area ratio, construction year, years since last renovation, number of bathrooms and garages, whether the house is detached, semi-detached or closed, and the distance to the CBD, nearest train station, school and park. Robust standard errors are reported in parentheses. Robust standard errors are reported in parentheses.

Table D.5. Are smaller parcels less likely (re)developed: full results.

	(1)	(2)	(3)	(4)	(5)	(6)
Assembly (β_1)	-0.050***	-0.046***	-0.050***	-0.047***	-0.047***	-0.041***
	(0.006)	(0.007)	(0.006)	(0.007)	(0.007)	(0.008)
Assembly × undeveloped (β_2)			0.001	0.005	0.005	0.004
			(0.013)	(0.014)	(0.016)	(0.018)
Mixed (β_3)					-0.008	-0.015**
					(0.006)	(0.007)
Mixed × undeveloped (β_3)					-0.001	0.007
					(0.013)	(0.015)
Surface share	0.046***	0.043***				
	(0.010)	(0.011)				
Surface share × developed			0.037***	0.039***	0.035***	0.034***
			(0.011)	(0.012)	(0.012)	(0.013)
Surface share × undeveloped			0.070***	0.057***	0.068***	0.056***
			(0.020)	(0.021)	(0.020)	(0.021)
Adjusted R-squared	0.030	0.140	0.030	0.140	0.031	0.141
Observations	21,197	21,197	21,197	21,197	21,197	21,197
Assembled	14,264	14,264	14,264	14,264	14,264	14,264
Unassembled	6,933	6,933	6,933	6,933	6,933	6,933
Location FE: Municipality	X		X		X	
Census tract		X		X		X

Note: This table presents the estimates of β_1 to β_4 from Equation 4 together with the estimates of the coefficient on surface share and its interaction effects. The dependent variable in these regressions is a dummy variable indicating whether the parcel is (re)developed in 2020. All specifications include year of permit along with the following characteristics of the parcel (X_i) and structure (Z_i): parcel size, floor-to-area ratio of the existing buildings and distance to the CBD. Robust standard errors are reported in parentheses.

Figure D.1. Distribution of the relative size of parcels within assembly projects



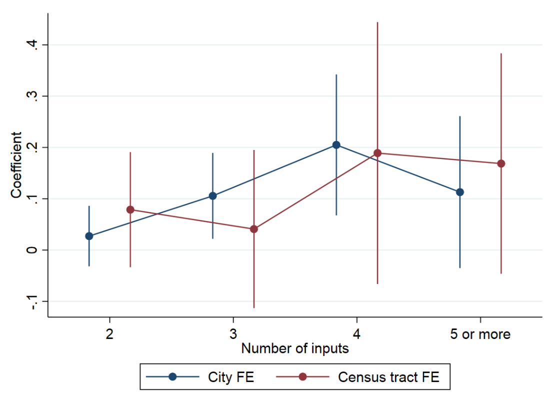
(a) Share of total surface (b) Smallest share of the total surface

Table D.6. Number of parcels in projects

	All	Developed	Undeveloped	Mixed
A. Sale sample				
1	2,089	1,118	971	
2	477	326	151	
3	200	163	37	
4	141	116	25	
≥ 5	245	189	56	
B. Redevelopment sample				
1	7,784	5,389	2,395	0
2	3,098	1,935	330	833
3	1,186	607	56	523
4	584	251	28	305
≥ 5	684	229	15	440

Note: This Table presents the number of parcels per project size (in number of parcels per project).

Figure D.2. The effect of the number of parcels in a project on the sales price of parcels



(a) Full sample