Multi-agent Bargaining under Asymmetric Information: Retrofitting an Elevator

Marcus Asplund
Copenhagen Business School

David Genesove
Hebrew University of Jerusalem

December 7, 2016

Abstract

It is well know that asymmetric information might lead to underprovision of public goods. To test the theoretical prediction, we study the decision to retrofit an elevator into an old apartment building, in which each owner has to agree on how the investment cost is split. The asymmetric information aspect is due to partly unobserved individual valuations of an elevator. We tailor Hellwig (2003) to the features of the retrofitting problem and use this to predict which building characteristics should make it easier for owners to agree. Data from Copenhagen broadly support the model's predictions. We use transaction data to estimate the market value of an elevator and conclude that for approximately 30-40 percent of the buildings without an elevator the aggregate increase in value exceeds the investment cost.

1 Introduction

In contrast to many other cities, Copenhagen apartments at higher floors typically don't command a significant premium. This can be easily explained as only 7 percent of the pre-war buildings have an elevator. For buildings with an elevator, price increases with a few percent for each floor. The interesting observation is that it is almost always possible to retrofit an elevator at a modest cost and simple calculations suggest that in many buildings the overall increase in value of apartments vastly exceed the investment cost. We ask whether bargaining under asymmetric information explore this apparent underinvestment.

The investment cost - however modest - has to be covered by owners' payments and at issue is how it should be split. Owners at higher floors will obviously benefit to a greater extent than those further down, and for someone on the ground floor an elevator is of virtually no value. The problem in bargaining is that each owner has the right to refuse the investment and any suggested sharing rule. Had each owner's valuation of an elevator been common knowledge the bargaining under symmetric information should result in an efficient outcome where the investment is undertaken as long as the aggregate valuation exceeds the investment cost.

The problem is that each agent knows his/her own valuation but has only some notion of others'. Such bargaining under asymmetric information has been shown to possibly result in an inefficient outcome.[1] Mailath and Postlewaite (1990) show that this bargaining problem worsens with the number of agents. The intuition is that with more agents, each agent's likelihood to be pivotal decreases and thus the incentive to underreport the willingness to pay increases. However, Hellwig (2003), who in analyzing the fixed cost (or at most cost slowly rising in number of agents) case considers a situation much like that of retrofiting an elevator, finds that spreading the costs over more agents tends to dominate the incentive to underreport, and thus the likelihood of efficient outcomes increases with the number of agents.[2]

2 Model

Multiple agents have to decide on whether to invest in a public good, where each agent can veto the investment. The investment decision is whether or not to retrofit an elevator in a building with multiple apartments. The elevator will affect the market value of all apartments and will also have user value to the owners until they sell. Each owner knows his valuation of the elevator but has only incomplete information on others'. Since the cost of the elevator has

[1] E.g. Myerson and Satterthwaite(1983) and Rob(1989).

[2] We focuse on the setting in which each agent has veto power and no-one can be excluded. In Norman (2004), the investment might be undertaken if there are sufficently large contributions from a set of agents that have also have the right to exclude those that have reporte too low valuations. Even if exclusion is inefficient (the cost of an extra user is zero) it might lead to higher probability of investment. Exclusion by means of requiring a key to access the elevator is possible but is apparently rarely used in this mearket.

to be covered by contributions from the owners each one would like to have the elevator but wants to contribute as little as possible. Thus, each owner has an incentive to understate his valuation if he believes that his contribution is positively linked to it and the investment might be made anyway.

In the following we derive the optimal mechanism to link an owner's valuation to a contribution, then examine how the probability an elevator is built depends on the number of apartments, the value of individual apartments, the value of the building, and asymmetries in how an elevator is valued by owners at different stories.

The model follows Hellwig (2003) closely. Let $c > 0$ be the fixed investment cost to provide a pure public good to $N \geq 2$ agents. Agent i's valuation of the good, θ_i , is drawn from a continuous distribution $F_i(\theta_i)$ with density $f_i(\theta_i)$ on the bounded support $\left[\underline{\theta}_i, \overline{\theta}_i\right]$. The utility of agent i if the good is provided is $\theta_i - t_i$, where t_i is the payment; the utility is 0 if there is no investment. Agent i observes θ_i but knows only the distribution of the others' θ's. Let θ be the vector of valuations $(\theta_1, \theta_2, \ldots, \theta_N)$ with support $\Theta = \prod_i \left[\underline{\theta}_i, \overline{\theta}_i\right]$. The cumulative distribution function is $F(\theta)$ with density $f(\theta)$. To make the problem non-trivial we assume that $\sum_{i=1}^{N} \underline{\theta}_i < c < \sum_{i=1}^{N} \overline{\theta}_i$.

2.0.1 A note on the interpretation of the theta distribution

We allow for different distributions F_i as it is plausible that the value of an elevator depends on varying apartment and owner characteristics that are observed by other owners in the building. For instance, the value should be increasing (in a first order stochastic dominance sense) in the apartment's floor level, perhaps in its size, and in the number of young children and the owner's age (if sufficiently great). These distributions are non-degenerate, as other owners will not know the given owner's sensitivity to these factors, and, in general, the owner's disutility of walking up and down stairs, financial situation, as well as his expected time until selling, which determines the extent that the owner discounts the future housing market return on the presence of an elevator.

The empirical specification θ_i is implictly based on some uncertain component ε_i being multiplicative with the fundamental value of the apartment m_i such that $\theta_i = m_i \varepsilon_i$.[3]

2.1 Second best mechanism

Define a direct mechanism to be the functions $q : \Theta \to \{0, 1\}$ and $t_i : \Theta \to \mathbb{R}$, such that q is the decision and t_i are transfers. It is well known (e.g. Myerson

[3] In principle it would be more correct to model it as the $\theta_i = m_i \varepsilon_i + v_i e_i$, where v_i is a fundamental disutility of walking the stairs and and e_i the agent's idiosyncratic view on this.

and Satterthwaite (1983)) that, in a setting such as ours, no direct mechanism can implement the first best outcome, $q = 1$ if $\sum_{i=1}^{N} \theta_i \geq c$ and $q = 0$ otherwise.

By the revelation principle, the second best mechanism has the property that each agent is at least as well off reporting his true θ_i rather than someone else's $\widetilde{\theta}_i$ (I.C. constraints) and that each agent should get at least a non-negative surplus (I.R. constraints).

Clearly the first best rule is to build the project when the sum of the utilities exceeds the cost. Hellwig shows that the rule under the second best mechanism is to undertake the project when a weighted average of the sum of utilities and the sum of virtual utilities exceeds cost. Under the assumption that the F_i are some Generalized Pareto Distribution, $1 - F_i(\theta_i) = (1 - (\theta_i - \underline{\theta}_i)/k\sigma_i)^k$, the virtual utility is linear in the utility, so that the second best investment rule can be stated as undertaking the investment when the sum of the utilities exceeds some threshold exceeding cost. This threshold is defined by the condition that the expected revenue conditional on the project being undertaken, according to the second best rule, equals the project's cost. Since the expected revenue equals the sum of the virtual utilities, this condition can be manipulated to state that the conditional expectation of the sum of the utilities equals some function of cost, and parameters of the F_i. Standardizing the sum of the utilities and invoking the Central Limit Theorem, we obtain that the probability of undertaking the project under the second best mechanism is approximately

$$1 - \Phi(J^{-1}(\frac{k}{1+k}[c - \sum_{i=1}^{N} \underline{\theta}_i]/\sigma\sqrt{N}))$$

where Φ is the standard normal distribution, $J(x) \equiv \Phi'(x)/1 - \Phi(x)$, i.e., the expectated value of a standard normal variate conditional on exceeding x, $\sigma^2 \equiv \sum_{i=1}^{N} \sigma_i^2/N(1+k^{-1})\sqrt{1+2k^{-1}}$).

Clearly, shifting any distribution i to the right by increasing $\underline{\theta}_i$ increases the probability of undertaking the project. There is an incentive problem only if $c > \sum_{i=1}^{N} \underline{\theta}_i$, so assuming that, we see that an increase in any σ_i,decreases the probability. We also see that increases in N when the new distribution has a location and spread the same of the average increases the probability.

2.1.1 Expected contributions and expected cost

The expected contribution is, summing over all agents,

$$R(s) = \int_{\Theta} q(\theta) \left[\sum_{i=1}^{N} \left(\quad \theta_i - \frac{1 - F_i(\theta_i)}{f_i(\theta_i)} \quad \right) \right] f(\theta) d\theta = \int_{\Theta} q(\theta) \left[\sum_{i=1}^{N} \left(\, 2\theta_i - \overline{\theta}_i \quad \right) \right] f(\theta) d\theta \tag{1}$$

The expected cost of investment is

$$C(s) = c\int_{\Theta} q(\theta)f(\theta)d\theta \tag{2}$$

We look for a mechanism that is budget balanced i.e. $D(s) = R(s) - C(s) = 0$. This will give us $s^*(c)$, which is the lowest aggregate valuation that is needed in order to undertake an investment c.

We are primarily interested in $s^*(c) - c$ (the implied inefficiency) but also in $\int_{\Theta} q(\theta)f(\theta)d\theta$ (the probability that the investment is undertaken given the second best mechanism) expressed as a function of c rather than s.

2.2 Numerical results

We consider buildings with two or three floors, with one apartment per floor where the distribution of valuations are as follows:

$$\begin{matrix} F_2^2(\theta_2) \\ F_1^2(\theta_1) \end{matrix} \qquad\qquad \begin{matrix} F_3^3(\theta_3) \\ F_2^3(\theta_2) \\ F_1^3(\theta_1) \end{matrix} \tag{3}$$

Consider four stylized buildings A-E with the following supports.

$$A: \begin{matrix}[0,1.0]\\ [0,1.0]\end{matrix} \quad B: \begin{matrix}[0,1.5]\\ [0,1.5]\end{matrix} \quad C: \begin{matrix}[0,2.0]\\ [0,1.0]\end{matrix} \quad .... D: . \begin{matrix}[0,1.0]\\ [0,1.0]\\ [0,1.0]\end{matrix} \quad E: \begin{matrix}[0,1.5]\\ [0,1.0]\\ [0,0.5]\end{matrix} \tag{4}$$

Assume for the moment that $\theta_i = m_i\varepsilon_i$,where m_i is some observable characteristic of the apartment (e.g. size and its floor location) and ε_i the unobserved valuation of an elevator.

Taking m_i to be the size of apartment i, building B has larger apartments and overall size than A. Buildings A and D have the same apartments sizes but D has an additional floor and thus larger overall size. B and D have the same overall size, but in D the apartments are smaller. B and C have the same overall size but apartments in C are of different sizes. If one instead relate m_i to the floor location, with higher floors placing a greater value on an elevator, then the comparison is between A and C.

2.2.1 Symmetric valuations

The first case we consider is where $F_i(\theta_i) = F_j(\theta_j)$ for $\forall i, j$.

First, consider the effect of changing the total size of the building, holding the number of apartments constant. For $N = 2$, we compare the effect of changing the support of θ_i from $[0, 1]$ to $[0, 1.5]$.

In Figure 1, the first best solution is given by the straight line c=$\theta_1 + \theta_2$. The difference $s^*(c) - c$ shows the inefficiency of the second best solutions. The first point to note is that for $c \to \underline{\theta}_1 + \underline{\theta}_2$ and $c \to \overline{\theta}_1 + \overline{\theta}_2$, $s^*(c) - c \to 0$. The reason is that for these extreme values there is not much to gain from reporting $\widetilde{\theta}_i$ lower than the true θ_i. It is for intermediate values of c that the likelihood that agent i is pivotal is highest and thus it is necessary to induce truthful reporting by keeping t_i substantially below θ_i. The second point is that holding c fixed, the inefficiency is greater when the support is larger. However, this comparison is somewhat misleading when we are interested in the probability that an investment is made. Figure 2 shows this. Holding c fixed, the probability that the investment will be made is greater when the support is greater. This is not surprising as the probability of investment is equal to zero if $c > \overline{\theta}_1 + \overline{\theta}_2$, (e.g. if $c > 2$ in case that $\overline{\theta}_i = 1$). And obviously, the probability that an investment is undertaken is decreasing in c.

Figures for $N = 3$ simply mirror those of $N = 2$, and interpretations are the same.

Figures 3 and 4 are for $F_i(\theta_i) = F_j(\theta_j)$ for $\forall i, j$, but for $N = 2$ or $N = 3$. The point to note here is that although the necessary aggregate valuation needed is greater for $N = 3$, the likelihood that the investment will be undertaken is greater. This is the insight of Hellwig (2003), who argues that, conditional on an investment cost that is independent of N, the aggregation over more individuals dominates the I.C. and I.R. constraints.

However, one can do a different comparison by holding the expected aggregate valuation fixed and consider changing N. Figures 5 and 6 are comparisons of $s^*(c)$ and $\text{prob}(\sum_{i=1}^{N}\theta_i \geq s^*(c))$ for $N = 2$ and $N = 3$ when the supports differ. For $N = 2$ the support is $[0, 1]$, and for $N = 3$ the support is $[0, 2/3]$. First, the curve $s^*(c)$ for $N = 3$ is above the one for $N = 2$, indicating that for a given total maximum valuation the inefficiency is more pronounced as the number of agents is larger. This is mapped into probabilities which are lower for $N = 3$.

In our setting this corresponds to the experiment where we have a given floor space and slice it up in smaller units. Assume for the sake of the argument that the price per square meter is independent of an apartment's size. Thus a floor of a given size with two equal sized apartments is more likely to have an elevator than if there were three smaller equal sized apartments. This shows that it is necessary to condition on both building size and number of apartments in the building.

2.2.2 Asymmetric valuations

In this section we consider the effect of asymmetric supports within a building and for brevity only show the results for $N = 3$. The comparison is between $\theta_i \in [0, 1]$ for $i = 1, 2, 3$ and $\theta_1 \in [0, 1/2]$, $\theta_2 \in [0, 1]$, and $\theta_3 \in [0, 3/2]$. Note that in this case the expected valuations are the same in both cases. It turns out that there is an effect of asymmetry but it tends to be "small" compared to the effects of changing N and the distribution of θ_i in the case where everyone draws from the same distribution.

The setting here is comparable to one where apartments on higher floors have valuations that FOSD those on lower floors.

The key insight here is that in the asymmetric case the probability to make the investment is higher than in the symmetric case (Figures 7 and 8). This is also true for $N = 2$.

One way to understand this for e.g. $N = 2$, is to think about the difference in the area spanned by the valuations. With symmetric valuations the shape is a square but in the asymmetric case it is a rectangle, which has less area. (For $N = 3$ think about the volume of a cube.) However, the investment will only take place if draws are "good". This means that there is relatively less to gain from reporting $\widetilde{\theta}_i$ lower than the true θ_i. Another way of looking at this is to see that someone with a low valuation will rarely not be pivotal but those with high valuation will often be. The higher valuation agent will therefore be more inclined to report truthfully, which limits the asymmetric information problem.

In terms of our probit specification, this would suggest that buildings with more variation in the size of the apartments should be more likely to have elevators (conditional on building size). A simple measure is the (somehow normalized) standard deviation of apartments in a building. Moreover, the buildings with more floors should be more likely to have elevators, conditional on floor size and number of apartments. This is also why it is difficult to say what is the best way to normalize the standard deviation - apartments of different sizes take draws from different distributions. The conjecture is that it will, in any case, be difficult to capture the effect of different apartment sizes within a building simply because they will tend to be of the same size (it is rarely the case that there is e.g. one apartment on one floor and two on another floor). Nevertheless the asymmetry gives us a motivation for including the number of floors in the probit and also the standard deviation effect.

3 Empirics

The first step in the analysis is a probability model for whether a building has an elevator as a function of its characteristics. The characteristics (number of apartments, total floor size, number of floors, distribution of apartment sizes) are motivated by the model of multi-agent bargaining under asymmetric information above. The second step is a hedonic model to estimate the expected price of an apartment using transaction data. The apartment characteristics that we are particularly interested in putting a value on is the existence of an elevator in the building. From the hedonic model, we will impute the value of all apartments (i.e. including those that were never traded) to examine the distribution of the value-added of an elevator in the population of apartments. These values are then aggregated to the level of the building to allow us to examine the distribution of the value added for the population of buildings, which will be compared to an approximate cost of retrofitting an elevator to a building without one. This step allows us to provide bounds on the possible inefficiency.

A more subtle point is that there is an element of self-selection into apartments. Those that buy an apartment on the fifth floor in an elevator-less building may not mind the stairs too much. This implies that their $u_{i,t}$ might tend to be low, which would go against the assumption that those at the top floors value an elevator more than others. However, even if the stairs weren't daunting when the apartment was bought, the individuals' age and health status may have changed since. One might also think that there is a degree of randomness in exactly which floor agent i buys an apartment if there are, at any point in time, relatively few apartments for sale of the size and in the neighbourhood that the agent idiosyncratically prefers. Moreover, living higher up means both more stairs to walk (negative) and better views and more light (positive) and the relative weights agents puts on these elements may differ. All of these arguments would tend to mitigate the problem of self-selection and the potential negative association between $u_{i,t}$ and the floor the individual lives. It should finally be noted that the expected market value added, $p^E_{i,T} - p^{NE}_{i,T}$, depends on the market's valuation of an elevator and this is independent of agent i's own views on walking the stairs.

3.0.3 Retrofitting an elevator

Before turning to the data it is worthwhile to describe the process of retrofitting an elevator, based on interviews with both firms providing the product and owners of apartments in buildings where an elevator has been added. Typically some of the owners of apartments in a building takes the initiative to contact one of the handful of firms that do the work (some of which are integrated into production of elevators) and invite it to a meeting with all the owners. At the meeting, the company representative will explain the various options (e.g. where the elevator can be placed, technical specifications) that are available for the particular building. The sales pitch for from the company is that an elevator both increase the accessability for owners and guests, and that it will increase the value of the apartments. Regarding total costs it is said to be around DKK 1.5m (including VAT) for most placements and specifications, where the cost is almost exclusively fixed (the extra cost of adding one more floor is approximately DKK 30000).[4] The investment cost is slightly lower if it can be fitted inside the main stairway and substantially higher if the requirement is that each apartment has direct access (which means establishing a shaft through the floors). Normally the question of how the costs should be split arise early and the representative outlines some examples that have been used elsewhere. One model for splitting the costs is "solidaric" in which each owner pays the same amount, another the "proportional" is where the split is based on the apartment size. More recently, the "Finnish model" has somtimes been adopted.[5] This is a simple sharing rule that in a typical five floor building amounts to the fourth floor apartments jointly pay 40 percent, the third floor 30 percent, the second floor 20 percent, the first floor 10 percent, and the ground floor pays nothing.

Following the meeting, the idea is discussed further among owners and, if there is sufficent interest, they ask for an offer from the company. To make a decision, the historical rule in most building associations is that the decision has to be unanimous. Some associations have made changes to the statues and require only a qualified majority to undertake the project. If that is the case they can not force the minority to pay for any of the costs, and there are simple technical solutions to block use of the elevator (e.g. a key or a code to the elevator door).

3.1 Data and descriptive statistics

Our data relates to owner-occupied apartments in Copenhagen municipality, Denmark. We use two data sources, both obtained from Statistics Denmark. As a cross-check we have a register of all elevators that are in existence as of 2015.

3.1.1 Data

The first data set contains transaction prices for all owner occupied apartments traded 1993-2010. For each apartment there are both characteristics of the individual apartment and of the building. The apartment specific characteristics include floor area, number of bathrooms, floor level, rental income (if any), and the assessed property value. There is a vast array of building characteristics recorded but for our purposes only a few will be relevant. The most important

[4] The costs for maintainance and eletricity amount to less than DKK 5000/year.

[5] The "Finnish model" has been developed by the Finnish Ministry of Finance and is the suggested splitting rule for elevator retrofitting projects. There are various modifications to the splitting rule that owners can make based on e.g. relative sizes of apartments. There is a spreadsheet available at www.korjaustieo.fi/sv/hisskalkylator. See also the sales material from the largest provider in Denmark http://alevator.dk/wp-content/uploads/Finansieringsplakat-opdateret-20141.pdf

ones are year of construction, number of floors, total floor space, and whether there is an elevator in building.

The second data set is a register (BBR) with all apartments as of 2010. This data contains the same apartment and building characteristics as the previous, but also has this information on apartments that were not traded 1993-2010. Table 1 gives the variable definitions and summary statistics for the subsamples we are focusing on.

Table 1 about here

The subsample we use are owner-occupied apartments in Copenhagen municipality, in residential-only buildings from the period 1860-1939 with 4-6 floors (including the ground floor). For owner-occupied apartments, the owner is free to set price and transaction prices are public information, while for apartments in co-operatives prices are regulated by the rules of co-operative and transaction prices are not officially recorded.[6] Apartments in buildings with commercial activites are excluded since often the incomes from renting out space is distributed among the owned apartments which implies that transaction prices will partly reflect unobservable rental income.

The period 1860-1939 is chosen as it contains the period when buildings were typically built without an elevator but where retrofitting one is possible. Buildings from before 1860 rarely had more than 3 floors and many of those that remain are historical and face stringent regulations on what can be altered. Over the period 1940-1960 there was little construction activity and towards the end of this period most buildings with four or more floors were built with an elevator; after 1960 virtually all have elevators. While most buildings constructed between 1860 - 1939 share a common architectual style and were built with bricks, the post war era marked a sharp break with the previous architectual style and were often in concrete. We restrict attention to building with 4-6 floors as, for the pre war buildings, there are almost no lower buildings with an elevator and is less than a handful of buildings with more than six floors (over the sample period there are only 29 transactions). Buildings with 4-6 floors without an elevator is were retrofitting might be an issue.

The central parts of Copenhagen municipality can be divided into seven postal codes that differ in both income levels and property values.[7] The two

[6] In Denmark there is a distinction between owner-occupied apartments ("ejerlejligheder") and apartments in co-operatives ("andelsboliger"). In the case of owner-occupied apartments the important entity is the individual apartment while it for the other category it is the co-operative. For co-operatives, apartments are owned by the co-operative and occupants pay for the right to use the apartment. The occupants share the responsibility for any debts of the co-operative. The right to use the apartment can be sold, but prices are normally set by the co-operative and typically don't reflect market valuations and no transaction prices are recorded. In contrast, for owner-occupied apartments the owner has the right to freely set the price and all transactions are public information (see e.g. http://www.boligsiden.dk/salgspris).

[7] Postal codes are not classifications for which official demographic statistics are published. The average income figures for 2010 reported below are found in Juul (2012), and are based on data complied by Statistics Denmark.

postal codes CPH K ("City") and CPH Ø ("East") have the highest average incomes, 251' and 234' as of 2010. CPH V ("West") and CHP S ("South") have average incomes of 212' and 206'. The remaining three postal codes, CPH N ("North"), CPH NV ("North-West"), and CPH SV ("South-West") are all considered poor with average incomes of 173', 187', and 196', respectively.[8]

In the following we examine the presence of elevators by area and apartment characteristics. In Table 2, there is information for the apartments that were traded on the mean selling prices (in thousands Danish kroner with base year 2000), the price per square meter, and the floor space in square meters. The data is broken down by postal code and floor level. [9]

In total, there are about 37000 transaction prices, out of which 26595 are for K, Ø, V, and S which is the sample we concentrate on.

Table 2 – Descriptive Statistics by Area and Floor

Focus to begin with on the bottom rows that condition on the postal area. Unsurprisingly there is a clear positive relation between prices and the average income level in the postal code. Prices per square meter, for apartments without elevator, are 11 and 16 percent higher in K than in Ø and V, respectively, and between 19 and 34 percent higher than in the remaining areas.

Elevators are rare in prewar buildings in all areas. Even in the three richest areas (K, Ø, and V) there are only 8-13 percent of the traded apartments that had an elevator. In S the figure is 2 percent, and among the three poorest areas, N has 0.2 percent and in SV and NV there has been no apartment with elevator traded over the period.

Within each of the areas K, Ø, V, and S, apartments with elevator are between 11 and 47 percent larger on average than those without. The price per square meter is on average 4-12 percent higher in K, V and S. Surprisingly, the price per square meter is about 4 percent lower in Ø, something that might be partly attributable to the large size differential, given that prices are non-linear functions of size.

Next, the last columns yield the totals conditioning on the floor at which the apartment is located. Here again prices are higher and sizes larger for the elevator apartments. Apartments at the ground floor are significantly cheaper per square meter than those at higher floors, but there is no obvious price effect as we compare across higher floors for those without an elevator.

By conditioning on both area and floor, the pattern with elevator apartments having higher prices and being larger continue to hold. In most areas the elevator

[8] The three postal codes with the lowest incomes are very poor compared to the rest of the country. Indeed, they all have lower incomes than all of Denmarks 98 municipalites (Juul, 2012). According to an official Ghetto List, these are also the only three postal codes to include areas classified as "ghettos" in Copenhagen.

[9] According to rules set by Statistics Denmark, information based less than 10 observations can not be reported. This means that sixth floor apartments have to be discarded and some cells have been left blank in Table 2.

apartments are also more expensive per square meter, but in Ø the situation is the opposite.

3.2 Probit model

We will first estimate a parsimonius probability model for whether there is an elevator in a building as of 2010. The sample contains all buildings in K, Ø, V and S that are residental-only, have at least four floors (including ground floor), and were built 1860-1939. This results in approximately 1500 buildings.

As dependent variable we use the dummy variable $ELEVATOR$ and as explanatory variables we use area dummies $AREA\_a$, $a \in \{K, \varnothing, , V, S\}$ and the building's age, $BUILDYEAR\_b$, $b \in \{1860-1879, 1880-1899, 1900-1919, 1920-1939\}$, and four variables based on the model described above.

First $\ln(APARTMENTS)$is the log of the number of apartments in the building. Splitting a building of a given size into more but smaller units should make it less likely that an elevator is present, as the asymmetric information problems are more severe. Second, $\ln(BUILDING\_M^2)$ is the log of the aggregate number of square meters of all apartments in the building. Holding the number of apartments constant and increasing the building size effectively increases the size of the apartments which should increase the value of the elevator and thus make it more likely that one is present. Third, $FLOORS$ is the number of floors in the building. If the value of an elevator is higher for apartments on higher floors then it is more likely that an elevator is present. Finally, $STDEV(\ln(APARTMENT\_M^2)$, is the standard deviation of the log apartment size of all the apartments in the building. The bargaining problems are easier to overcome if the valuations of an elevator are more dispersed which suggest that a building with more unequal distribution of apartment sizes is more likely to have an elevator.

There is an issue of multicollinearity as the number of apartments, number of floors, and building area are postively correlated. The raw correlations are xxx.

Table 3 - Probit model

Focusing on the last column, which includes all explanatory variables, the predictions from the model are broadly supported. The variables motivated by theory are jointly significant at the 1 percent level.

As expected from the theory, buildings with many apartments tend not to have an elevator. Increasing the mean number by one standard deviation corresponds to reduction in the probability by xxx. Large and high buildings are more likely to have an elevator. This is consistent with theory but would also hold under symmetric information. In line with the predictions from the asymmetric information bargaining model the coefficient on $STDEV \ln(APARTMENT\_M^2)$ is positive but it is not statistically significant.

Compared to the CPH S, it more likely to find an elevator in K, Ø, and V. This might reflect both that CPH S has lower property prices and lower income (liquidity constraints). Finally, the probability that there is an elevator in a building is decreasing in its age. This is likely due to the fact that some of the newer buildings were built with an elevator. Further examinations of the separate elevator register will allow us to restrict the sample to include only buildings that were not originally fitted with an elevator.

3.3 Hedonic model

To estimate the hedonic model we use $\ln(PRICE)$, where we among the regressors include a third order polynomial of log apartment size, $\ln(M^2)$, to capture any non-linearites of prices in apartment size. In all regressions there are year fixed effects, μ_t, to account for the fact that the property prices in Copenhagen have changed considerably over sample period. In addition, we include dummy variables for area, $AREA\_a$, $a \in \{K, V, \varnothing, N, S, NV, SV\}$ and the building's age, $BUILDYEAR\_b$, $b \in \{1860-1879, 1880-1899, 1900-1919, 1920-1939\}$. The variable $RENTED$, is a dummy variable taking the value one if the apartment is rented out. The motivation for including it is that rents are regulated and tenants have the right to stay in the apartment even if the ownership change and thus we expect these rented apartments to trade at a discount.

To test whether apartments with elevator sell at a premium, we include dummy variables for the floor at which the apartment is located, $FLOOR\_f$, where $f = 0, \ldots, 5$, and an interaction between $FLOOR\_f$ and a dummy for whether there is an elevator, $FLOOR\_f \times ELEVATOR$. Our prior is that the presence of an elevator should add value to the apartment, and that the value added should increase with the floor of the apartment, $\delta_j < \delta_k$ for $k > j$.

$$\ln(PRICE_{i,t}) = \beta_0 + \boldsymbol{\beta}\boldsymbol{X}_{i,t} + \sum_{f=1}^{5} \gamma_f FLOOR\_f_{i,t} + \sum_{f=0}^{5} \delta_f FLOOR\_f_{i,t} \times ELEVATOR_{i,t} + \mu_t + \epsilon_{i,t}, \tag{5}$$

where $\boldsymbol{X}_{i,t}$ a set of control variables.

As a starting point we take $ELEVATOR_{i,t}$ to be exogenous but below we treat it as endogenous and use theory to find instruments. The first three columns in Table 4 give the results for the full sample as well as two subsamples. The first subsample excludes the areas N, SV and NV where there elevators are virtually non existent, and the second subsample in addition excludes V and S which have on average significantly lower prices than the remaining K and Ø. The standard errors are clustered at the building level.

Table 4 - Hedonic Model

The least squares results show that apartments on the ground floor are 6-10 percent lower than those on higher floors, but among these there is quite limited price variation. More interestingly, the existence of an elevator is associated with higher prices above the ground floor. For the full sample, the premium is 3.5

percent at the first floor, and rises to 7.5 percent at the fourth floor and is 8.1 percent at the fifth floor. If one concentrates on the most expensive areas (K and Ø) the premium at the top is close to 11 percent.

The price is of course a function of the apartment's size. A closer examination of the polynomial shows that the price per square meter is monotonically decreasing in the apartment size for the range represented in the sample. For the other control variables it can be noted that, compared to CPH K, prices in CPH Ø are about 5 percent lower and prices in the other areas between 16 and 26 percent lower. The build year is also important for prices with the apartments in the oldest buildings selling at the highest prices. If there is a tenant in the apartment it reduces the price by some 4-5 percent.

In the three last columns in Table 4 we show the two stage least squares results. The variable that we wish to instrument for is $ELEVATOR$, and as instruments we use the various building characteristics described above. The argument for using e.g. the number of floors in the building is that theory suggest that higher buildings should be more likely to have an elevator but that the price of an apartment should be determined by its size, which floor it is at, etc. Likewise, buildings with more asymmetric apartment sizes should be likely to contain an elevator but the variation in apartment sizes is not expected to drive the price of a specific apartment. The first stage regression is a probit model with $ELEVATOR$ as the dependent variable. For the second stage hedonic model, the fitted probabilites are instead of $ELEVATOR_{i,t}$.[10]

For the probit model the instrumens are valid (joint significant at 1 percent level) and the variables that relate to area and building age have the same sign and signifance level as in Table 3. The variables that relate to apartment attributes are mostly insignificant (exlduing $RENTAL$ they are jointly insignificant at 1 percent level) which is not surprising as there is little reason to believe that e.g. apartments with elevators are traded more frequently.

For the hedonic model the results are broadly similar to those of the least squares. For the sample with K,V, Ø, and S, the premium for an elevator is around 10-11 percent at the top floors. which is somewhat higher than in the second column. Restricting the sample further to only K and Ø gives even higher premia, but the small sample together with few elevators mean that the results are IV results are probably less reliable and a 15 percent premium appears to high at the top floor.

3.4 Market value added at the building level

The final step is to aggregate all results to the building level. To do so, we use all apartments in the 1530 buildings in K, V, Ø, and S and calculate the expected selling price as of 2010 for each of these with and without an elevator. That is, we

[10] There are some econometric issues in correcting the standard errors with dummy endogenous variables that we have yet to sort out. In the tables, the standard errors are those of the least squares estimator.

use the coefficients in the second column of Table 4 and set $ELEVATOR_i = 0$ and $ELEVATOR_i = 1$ and sum up the values of all apartments in the building.

Figure 1a and 1b show the distribution of the aggregate market value of an elevator in buildings that do not have an elevator and in the buildings with an elevator as of 2010. The market value added is in DKK with base year 2000, so accounting for inflation the cost of a standard elevator approximately DKK1.1m (the nominal cost is DKK1.5m in 2015).

In Figure 1a, the buildings without an elevator that have an aggregate value exceeding 1.10m make up about 30-40 percent of the total. For some 15 percent of the buildings the market value added is about twice the investment costs. This is clearly evidence that there is underinvestment in elevators.

In Figure 1b, the buildings with an elevator tend to have higher market value added than in Figure 1a. There are, however, buildings where the market value added is less than the 1.1m, which would indicate either overinvestment or that market value added is only one component of the full value of an elevator. There is, however, a possibility that some of these buildings were fitted with an elevator at the time they were built. To sort this out we need to check with the separate elevator register.

3.5 Robustness

TBC (liquidity constraints, excludability, interviews, survey evidence, statutes in building association, value added as fixed amount v. proportional)

4 Conclusion

Not even close...

5 References

Felix J. Bierbrauer and Martin F. Hellwig, 2016, Robustly Coalition-Proof Incentive Mechanisms for Public Good Provision are Voting Mechanisms and Vice Versa, *The Review of Economic Studies* (2016) 0 (2016).

F.J.Bierbrauer, 2011, Incomplete contracts and excludable public goods, *Journal of Public Economics*, Volume 95, Issue 7-8, August 2011, Pages 553-569.

T.Börgers and P.Norman, 2009, TA note on budget balance under interim participation constraints: The case of independent types, *Economic Theory,* Volume 39, Issue 3, June 2009, Pages 477-489.

J.A. Dearden, 1997, Efficiency and exclusion in collective action allocations, *Mathematical Social Sciences* , Volume 34, Issue 2, 1 October 1997, Pages 153-174.

Martin F. Hellwig, 2003, Public-Good Provision with Many Participants, *The Review of Economic Studies* (2003) 70 (3): 589-614.

M.F.Hellwig, 2007, The provision and pricing of excludable public goods: Ramsey-Boiteux pricing versus bundling, *Journal of Public Economics,* Volume 91, Issue 3-4, April 2007, Pages 511-540.

George J. Mailath and Andrew Postlewaite, 1990, Asymmetric Information Bargaining Problems with Many Agents, *Review of Economic Studies* (1990) 57 (3): 351-367.

George J. Mailath and Andrew Postlewaite, 1990, Workers versus firms: Bargaining over a firm's value, *Review of Economic Studies,* Volume 57, Issue 3, July 1990, Pages 369-380.

D.Martimort, P.De Donder, and E.B. de Villemeur, 2005, An incomplete contract perspective on public good provision, J*ournal of Economic Surveys,* Volume 19, Issue 2, April 2005, Pages 149-180.

Roger B Myerson, Mark A Satterthwaite, 1983, Efficient mechanisms for bilateral trading, *Journal of Economic Theory*

Volume 29, Issue 2, April 1983, Pages 265-281.

Z.Neeman, 2004, The relevance of private information in mechanism design, *Journal of Economic Theory*, Volume 117, Issue 1, July 2004, Pages 55-77.

Peter Norman, 2003, Efficient Mechanisms for Public Goods with Use Exclusions, *The Review of Economic Studies* (2004) 71 (4): 1163-1188.

Rafael Rob, 1989, Pollution claim settlements under private information, *Journal of Economic Theory*, Volume 47, Issue 2, April 1989, Pages 307-333.

6 Appendix

The second best rule is a rule of the type: produce the public good if and only if

$$\sum_{i=1}^{N}\{\theta_i - \beta\frac{1-F_i(\theta_i)}{f_i(\theta_i)}\} \geq c$$

The actual second best rule corresponds to the lowest β in $(0,1)$ such the expected sum of virtual utilities conditional on the above conditon holding equals the cost. We assume that the distribution of valuation for any agent is a General Pareto distribution, all of them of the same shape:

$$1 - F_i(\theta_i) = (1 - \frac{\theta_i - \underline{\theta}_i}{k\sigma_i})^k$$

This implies that the inverse hazard is linear: $\frac{1-F_i(\theta_i)}{f_i(\theta_i)} = \sigma_i - k^{-1}(\theta_i - \underline{\theta}_i)$. That allows us to write the rule as

$$\begin{aligned}
\sum_{i=1}^{N}\{\theta_i - \beta[\sigma_i - k^{-1}(\theta_i - \underline{\theta}_i)]\} &\geq c \\
\sum_{i=1}^{N}\theta_i &\geq (1+k^{-1}\beta)^{-1}c + (1+k^{-1}\beta)^{-1}\beta\sum_{i=1}^{N}[\sigma_i + k^{-1}\underline{\theta}_i] \\
&= \frac{k}{k+\beta}(c + \beta\sum_{i=1}^{N}[\sigma_i + k^{-1}\underline{\theta}_i]) \equiv s
\end{aligned}$$

Thus the second best rule is characterizable as a threshold rule in the sum of valuations: build if the sum of valuations is greater than some value s. Since there is a one to one relationship between β and s, we can write the second best rule as: produce the public good if and only if

$$\sum_{i=1}^{N}\theta_i \geq s \tag{6}$$

where s is such that

$$E\{\sum_{i=1}^{N}\{\theta_i - \frac{1-F_i(\theta_i)}{f_i(\theta_i)}|\sum_{i=1}^{N}\theta_i \geq s\} = c \tag{7}$$

Substiting in the equation for the inverse hazard under the Generalized Pareto distribution, equation (7) becomes

$$E\{\sum_{i=1}^{N}\{\theta_i - [\sigma_i - k^{-1}(\theta_i - \underline{\theta}_i)]|\sum_{i=1}^{N}\theta_i \geq s\} = c$$

which can be rewritten as and $E\theta_i = \underline{\theta}_i + \frac{k}{1+k}\sigma_i$,

$$\begin{aligned}
(1+k^{-1})E\{\sum_{i=1}^{N}(\theta_i - E\theta_i)|\sum_{i=1}^{N}(\theta_i - E\theta_i) &\geq s - \sum_{i=1}^{N}E\theta_i\} = c + \sum_{i=1}^{N}[\sigma_i + k^{-1}\underline{\theta}_i] - (1+k^{-1})\sum_{i=1}^{N}E\theta_i \\
E\{\sum_{i=1}^{N}(\theta_i - E\theta_i)|\sum_{i=1}^{N}(\theta_i - E\theta_i) &\geq s - \sum_{i=1}^{N}E\theta_i\} = \frac{k}{1+k}[c + \sum_{i=1}^{N}(\sigma_i + k^{-1}\underline{\theta}_i) - \sum_{i=1}^{N}(\frac{1+k}{k}\underline{\theta}_i + \sigma_i)] \\
&= \frac{k}{1+k}[c - \sum_{i=1}^{N}\underline{\theta}_i]
\end{aligned}$$

noting $E\theta_i = \underline{\theta}_i + \frac{k}{1+k}\sigma_i$.

Define

$$Y \equiv \frac{1}{\sigma\sqrt{N}}\sum_{i=1}^{N}(\theta_i - E\theta_i)$$

where

$$\sigma \equiv \sqrt{N^{-1}h(k)\sum_i \sigma_i^2}$$

and $h(k)$ is the varaince of a standard $GPD(k)$ variable. Then equation (6) can be written as

$$E[Y|Y \geq w] = \frac{k}{1+k}[c - \sum_{i=1}^{N}\underline{\theta}_i]/\sigma\sqrt{N}$$

with

$$w \equiv \frac{1}{\sigma\sqrt{N}}(s - \sum_{i=1}^{N}E\theta_i)$$

By the Central Limit Theory, Billingsey (), Y is distributed approximately normally for sufficiently large N, so that $E[Y|Y \geq w]$ is approximately equal to $J(w)$, where $= \phi(x)/[1 - \Phi(x)]$. Inverting this, we obtain,

$$w \approx J^{-1}(\frac{k}{1+k}[c - \sum_{i=1}^{N}\underline{\theta}_i]/\sigma\sqrt{N})$$

Rewriting equation(6) in terms of Y and w as well, we then obtain that the probability of undertaking the public good is approximately

$$1 - \Phi(J^{-1}[\frac{k}{1+k}\frac{c - \sum_{i=1}^{N}\underline{\theta}_i}{\sigma\sqrt{N}}])$$

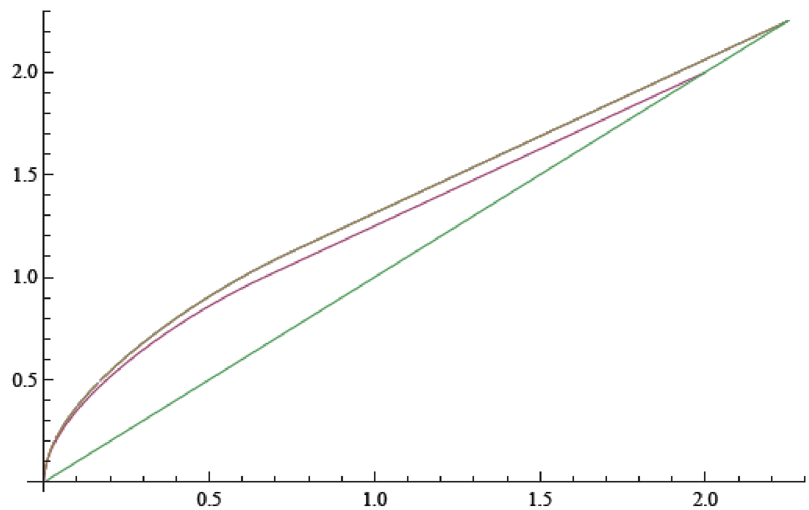

Figure 1: Minimum aggregate valuation to invest ($N = 2$): $s^*(c)$ for $\theta_i \in [0, 1]$ and $\theta_i \in [0, 1.125]$.

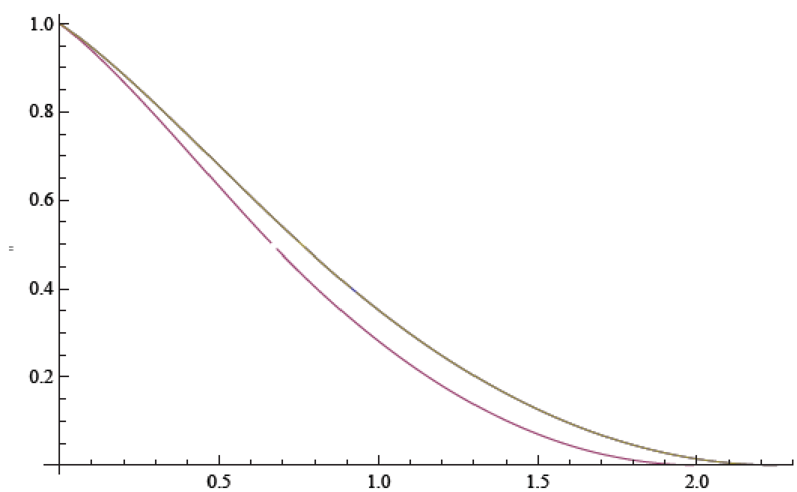

Figure 2: Probability of investment ($N = 2$): prob$(\sum_{i=1}^{N} \theta_i \geq s^*(c))$ for $\theta_i \in [0, 1]$ and $\theta_i \in [0, 1.125]$.

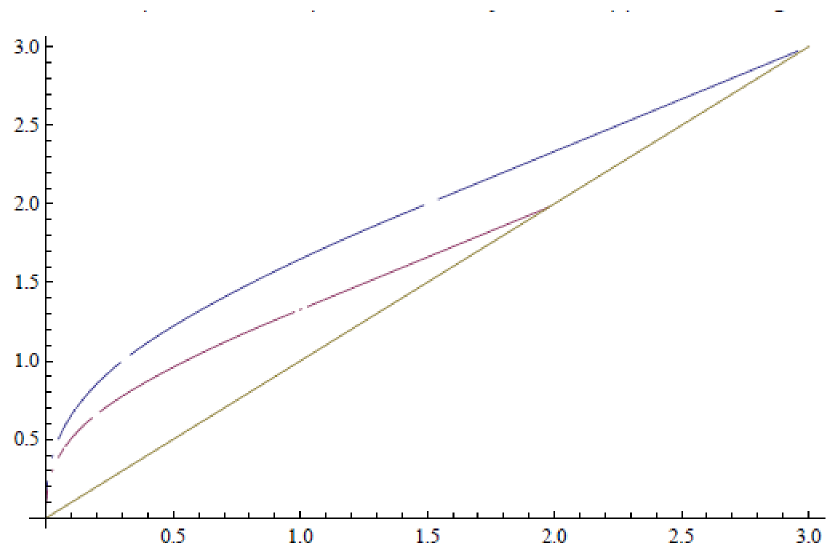

Figure 3: Minimum aggregate valuation to invest ($N = 3$): $s^*(c)$ for $\theta_i \in [0, 1]$ and $\theta_i \in [0, 0.666]$.

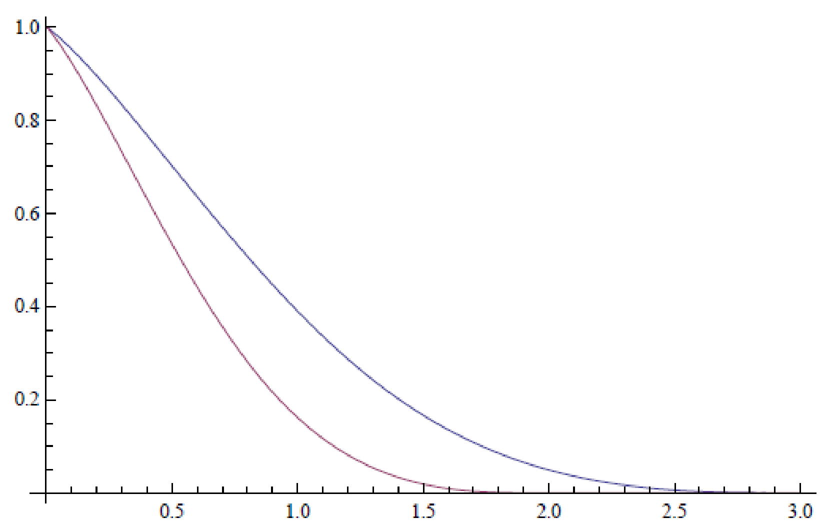

Figure 4: Probability of investment ($N = 3$): prob($\sum_{i=1}^{N} \theta_i \geq s^*(c)$) for $\theta_i \in [0, 1]$ and $\theta_i \in [0, 2/3]$.

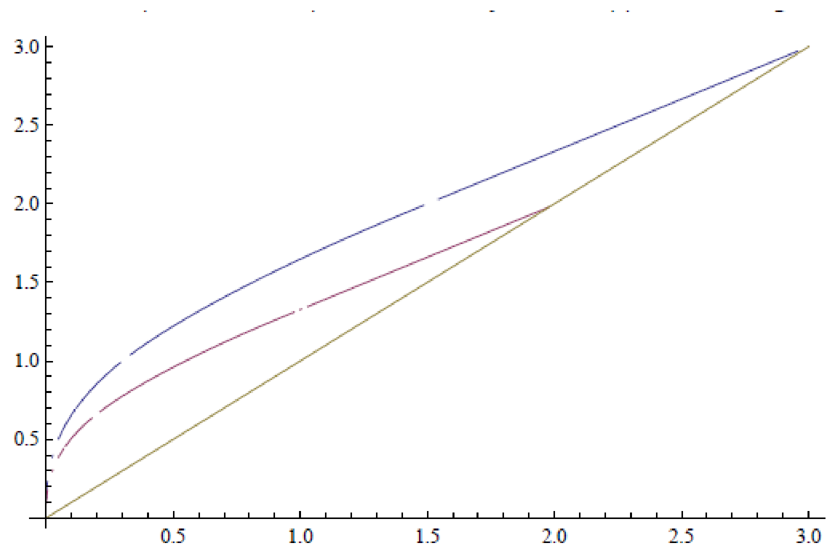

Figure 5: Minimum aggregate valuation to invest ($N = 3$): $s^*(c)$ for $\theta_i \in [0, 1]$ and $\theta_i \in [0, 0.666]$.

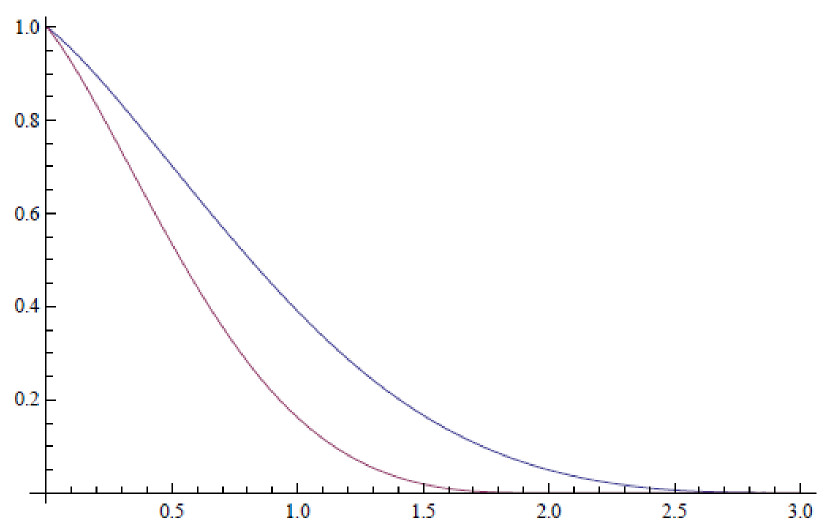

Figure 6: Probability of investment ($N = 3$): $\text{prob}(\sum_{i=1}^{N} \theta_i \geq s^*(c))$ for $\theta_i \in [0, 1]$ and $\theta_i \in [0, 2/3]$.

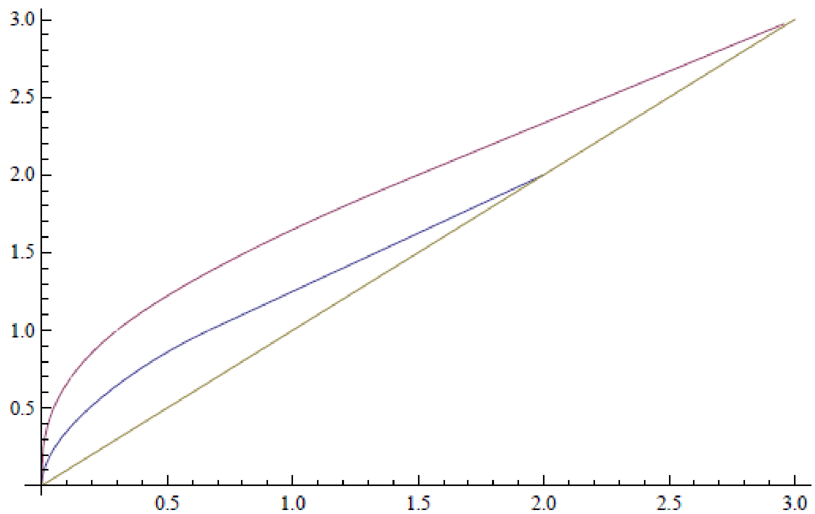

Figure 7: Minimum aggregate valuation to invest ($N = 2, 3$): $s^*(c)$ for $\theta_i \in [0, 1]$.

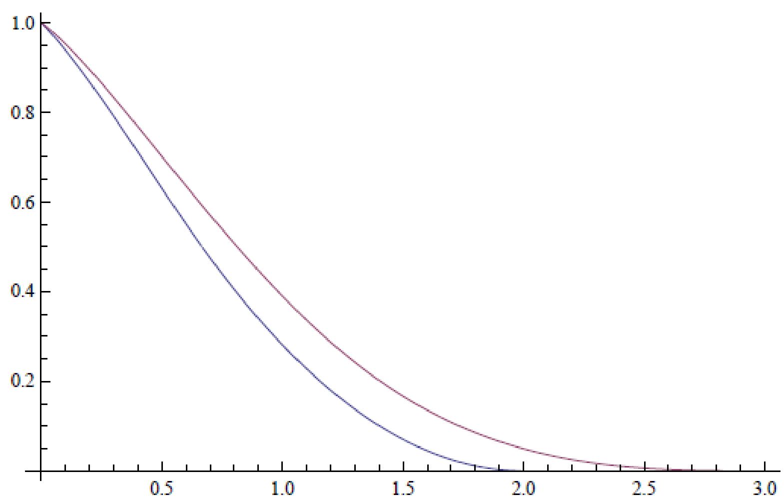

Figure 8: Probability of investment ($N = 2, 3$): prob($\sum_{i=1}^{N} \theta_i \geq s^*(c)$) for $\theta_i \in [0, 1]$.

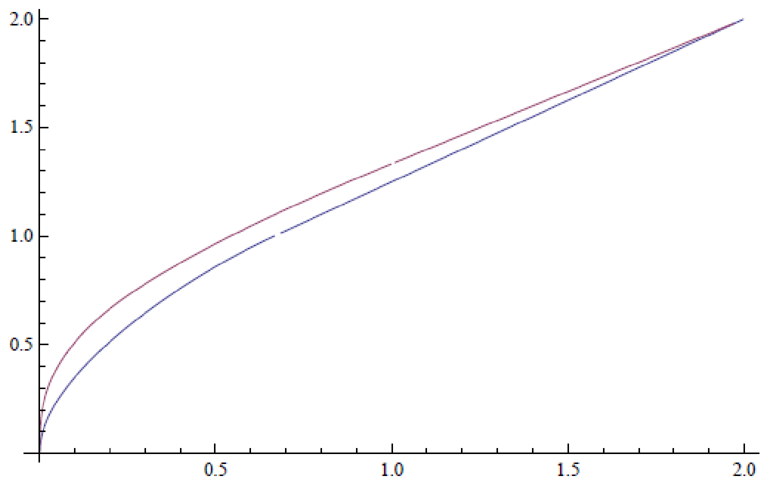

Figure 9: Minimum aggregate valuation to invest ($N = 2, 3$): $s^*(c)$ for $\theta_i \in [0, 1]$ and $\theta_i \in [0, 2/3]$.

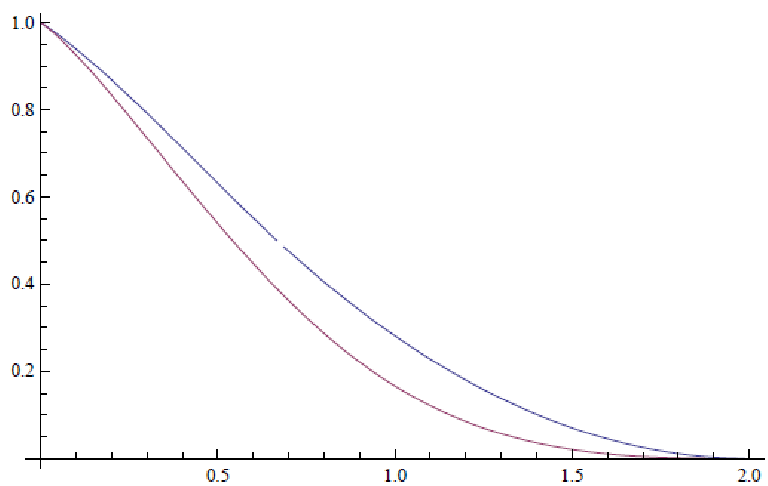

Figure 10: Probability of investment ($N = 2$ and $N = 3$): prob($\sum_{i=1}^{N} \theta_i \geq s^*(c)$) for $\theta_i \in [0, 1]$ and $\theta_i \in [0, 2/3]$.

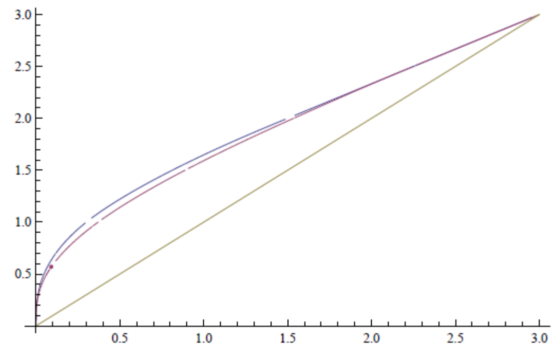

Figure 11: Minimum aggregate valuation to invest ($N = 3$): $s^*(c)$ for $\theta_i \in [0, 1]$ and $\theta_1 \in [0, 0.5]$, $\theta_2 \in [0, 1]$, $\theta_3 \in [0, 1.5]$

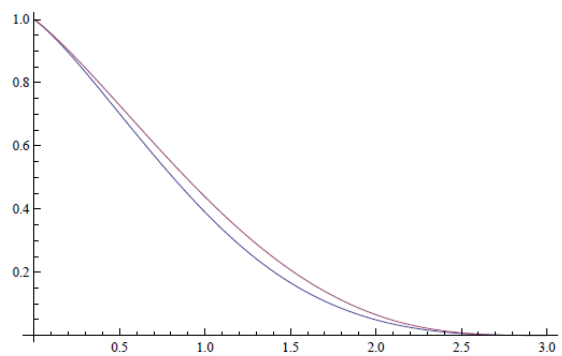

Figure 12: Probability of investment ($N = 3$): prob($\sum_{i=1}^{N} \theta_i \geq s^*(c)$) for $\theta_i \in [0, 1]$ and $\theta_1 \in [0, 0.5]$, $\theta_2 \in [0, 1]$, $\theta_3 \in [0, 1.5]$

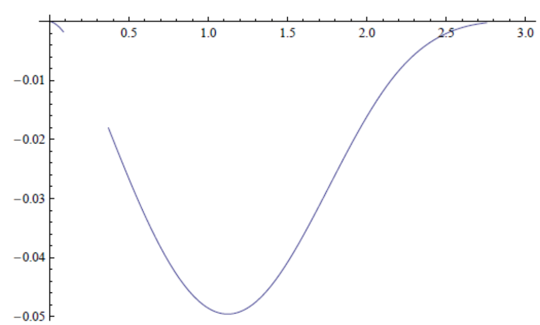

Figure 13: Difference in probability of investment ($N = 3$): prob($\sum_{i=1}^{N} \theta_i \geq s^*(c)$) - prob($\sum_{i=1}^{N} \theta_i \geq s^*(c)$) for $\theta_i \in [0, 1]$ and $\theta_1 \in [0, 0.5]$, $\theta_2 \in [0, 1]$, $\theta_3 \in [0, 1.5]$

Figure 1a. Market value-added of an elevator in buildings <u>without</u> an elevator. Aggregate over all apartments in building. Value added measured in DKK with base year 2000.

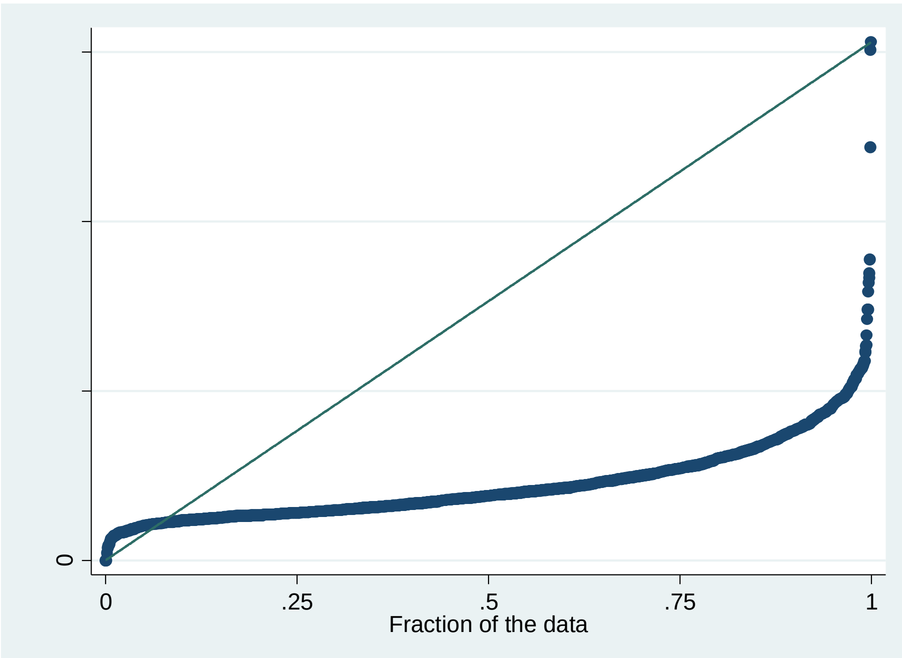

Figure 1b. Market value-added of an elevator in buildings <u>with</u> an elevator. Aggregate over all apartments in building. Value added measured in DKK with base year 2000.

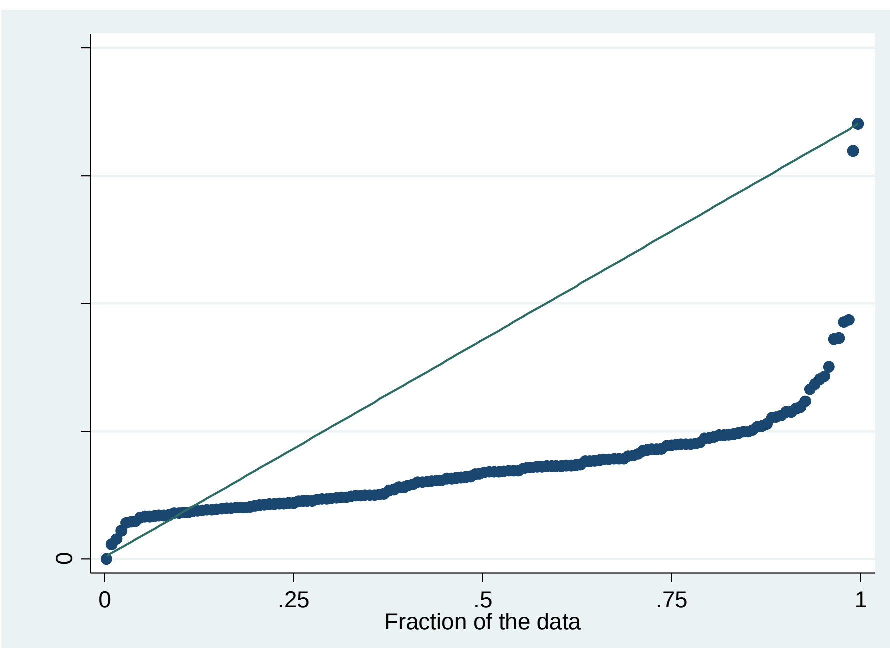

Table 2. Distribution of elevators across areas and floors.

	Area	Inner city		West		East		North		South		North-west		South-west		TOTAL	
Floor	Elevator	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Ground	PRICE	1234	1171	1014	1458	1132	1541	859		811	819	730		779		950	1399
	PM2	15.7	14.9	13.8	16.5	13.9	13.6	13.1		12.9	13.3	13.0		12.9		13.5	14.5
	M2	80	80	75	88	83	112	67		64	67	58		60		71	98
	BuildYr	1878	1932	1896	1922	1908	1926	1906		1923	1918	1932		1936		1911	1927
	Freq	418	75	487	55	1430	151	1067	0	1365	13	502	0	75	0	5344	294
First	PRICE	1416	1769	1069	1761	1274	1851	952		873	1189	772		776		1053	1737
	PM2	16.5	18.9	14.4	17.2	14.9	14.7	13.9		13.3	14.0	13.2		12.8		14.2	16.2
	M2	88	98	76	112	88	128	70		66	90	59		61		75	113
	BuildYr	1874	1908	1896	1914	1907	1926	1906		1922	1918	1931		1936		1909	1918
	Freq	633	84	643	58	1692	136	1424	0	1543	36	576	0	99	0	6610	314
Second	PRICE	1482	1872	1143	1809	1330	1820	986		878	993	779		789		1092	1758
	PM2	16.9	17.7	14.5	15.4	15.2	14.8	14.1		13.5	13.5	13.3		13.0		14.5	15.6
	M2	90	106	81	123	88	130	71		65	78	59		61		76	117
	BuildYr	1874	1918	1895	1912	1907	1927	1905		1922	1918	1931		1936		1908	1921
	Freq	710	108	720	71	1730	174	1428	<10	1679	35	601	0	94	0	6962	388
Third	PRICE	1477	1888	1135	1898	1374	1733	985		866	1055	773		717		1096	1733
	PM2	16.8	18.0	13.9	16.0	15.4	14.1	14.0		13.3	14.2	13.2		12.1		14.3	15.6
	M2	92	105	83	124	90	124	72		65	75	60		59		77	113
	BuildYr	1872	1921	1895	1915	1908	1927	1905		1921	1918	1931		1936		1908	1922
	Freq	659	104	786	74	1795	145	1442	<10	1706	42	578	0	106	0	7072	365
Fourth	PRICE	1492	1808	1151	1737	1336	1876	1034		879	1196	797		691		1100	1767
	PM2	16.7	19.8	14.4	16.3	15.5	15.1	14.4		13.3	15.0	13.5		11.7		14.5	16.6
	M2	94	97	81	115	88	128	73		66	86	60		59		76	113
	BuildYr	1877	1920	1896	1917	1908	1925	1904		1922	1918	1931		1936		1909	1921
	Freq	663	86	780	65	1688	137	1466	<10	1678	29	611	0	107	0	6993	317
Fifth	PRICE	1278	1649	1104	1950	1225	1817	828		980	1168	674				1092	1684
	PM2	17.0	19.8	15.2	17.2	15.4	14.7	14.2		14.2	12.8	12.1				15.2	16.5
	M2	76	85	75	120	81	129	61		69	99	57				73	108
	BuildYr	1885	1935	1892	1921	1903	1920	1901		1919	1918	1905				1901	1924
	Freq	344	64	362	54	811	60	481	<10	378	39	18	0		0	2394	217
TOTAL	PRICE	1420	1720	1110	1776	1289	1766	960		868	1097	771		747		1066	1687
	PM2	16.6	18.2	14.3	16.4	15.0	14.5	14.0		13.3	13.8	13.2		12.4		14.3	15.8
	M2	87	95	79	110	87	122	70		65	78	59		60		75	108
	BuildYr	1876	1921	1895	1917	1907	1926	1905		1922	1918	1931		1936		1908	1922
	Freq	3427	521	3778	377	9146	803	7308	29	8349	194	2886	0	481	0	35375	1895

Table 3. Probit regression with ELEVATOR as dependent variable.

	Elev.	Elev.	Elev.	Elev.	Elev.	Elev.
ln(#Apartments)	-0.128	-0.797***	-1.085***	-2.112***	-1.905***	-1.976***
ln(BuildingM2)		1.133***	1.308***	2.105***	1.952***	1.880***
#Floors			0.577***	0.661***	0.633***	0.632***
Build 1860-1879				-2.544***	-3.213***	-3.220***
Build 1880-1899				-1.859***	-2.291***	-2.326***
Build 1900-1919				-1.471***	-1.593***	-1.592***
CPH K					1.427***	1.407***
CPH V					1.339***	1.324***
CPH Ø					0.643***	0.627***
St.Dev ln(Apartment M2)						0.773
Constant	-0.984***	-7.165***	-10.68***	-13.28***	-13.12***	-12.55***
Observations	1533	1533	1533	1533	1533	1526

Table 4. Least squares and two stage least squares regressions. First stage probit regression (only reported for areas K, V, E, and S). All regressions have fixed year effects. 2SLS statistical significance based on least squares (i.e. not adjusted for endogenous dummy variable ELEVATOR).

	ln(Price)	**ln(Price)**	**ln(Price)**	**Elevator**	**ln(Price)**	**ln(Price)**
	LS FE	LS FE	LS FE	Probit FE	2SLS FE	2SLS FE
Elev.*Floor0	-0.00138	-0.00331	0.0212		-0.0228	0.0619*
Elev.*Floor1	0.0215	0.0094	0.0104		0.0118	0.019
Elev.*Floor2	0.0511**	0.0390*	0.0398		0.0777**	0.0727*
Elev.*Floor3	0.0432*	0.0318	0.0303		0.0603*	0.0739*
Elev.*Floor4	0.0727***	0.0639***	0.0861***		0.109***	0.138***
Elev.*Floor5	0.0683***	0.0467**	0.0982***		0.102**	0.150***
Floor== 1	0.0628***	0.0701***	0.0872***	-0.005	0.0687***	0.0907***
Floor== 2	0.0715***	0.0789***	0.101***	0.003	0.0750***	0.102***
Floor== 3	0.0740***	0.0837***	0.110***	-0.0003	0.0806***	0.111***
Floor== 4	0.0831***	0.0902***	0.113***	-0.013**	0.0864***	0.114***
Floor== 5	0.0855***	0.110***	0.105***	-0.001	0.102***	0.103***

Table 4 (continued). Least squares and two stage least squares regressions. First stage probit regression (only reported for areas K, V, E, and S). All regressions have fixed year effects. 2SLS statistical significance based on least squares (i.e. not adjusted for endogenous dummy variable ELEVATOR).

	ln(Price)	**ln(Price)**	**ln(Price)**	**ELEVATOR**	**ln(Price)**	**ln(Price)**
	FE	FE	FE	Probit	2SLS FE	2SLS FE
ln(M2)	0.0261***	0.0258***	0.0246***	-6.09**	0.0257***	0.0245***
ln(M2^2)	-0.0001000***	-0.0000957***	-0.0000883***	1.21*	-0.0000959***	-0.0000880***
ln(M2^3)	0.000000131***	0.000000121***	0.00000108***	-0.077*	0.000000122***	0.000000108***
CPH V	-0.176***	-0.177***		-0.061*	-0.176***	
CPH Ø	-0.0494***	-0.0575***	-0.0506***	-0.124**	-0.0547***	-0.0457***
CPH N	-0.158***					
CPH S	-0.218***	-0.227***		-0.188***	-0.222***	
CPH NV	-0.235***					
CPH SV	-0.256***					

Table 4 (continued). Least squares and two stage least squares regressions. First stage probit regression (only reported for areas K, V, E, and S). All regressions have fixed year effects. 2SLS statistical significance based on least squares (i.e. not adjusted for endogenous dummy variable ELEVATOR).

	ln(Price)	**ln(Price)**	**ln(Price)**	**ELEVATOR**	**ln(Price)**	**ln(Price)**
	FE	FE	FE	Probit	2SLS FE	2SLS FE
Build 1860-1879	0.0716***	0.0421*	0.0657***	-0.310***	0.0503**	0.0839***
Build 1880-1899	0.0569***	0.0341***	0.0568***	-0.252***	0.0405***	0.0715***
Build 1900-1919	0.0103	0.0157	0.0227*	-0.163***	0.0194*	0.0350**
Rental	-0.0477**	-0.0444**	-0.0562**	0.021**	-0.0448**	-0.0568**
ln(APARTMENTS)				-0.090***		
ln(BUILDING_M2)				0.021***		
FLOORS				0.082***		
STDEV(APARTMENT_M2)				0.099		
Constant	12.35***	12.36***	12.36***	9.98**	12.36***	12.35***
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Areas	K.V.E.N.S.NV.SV	K.V.E.S	K.E	K.V.E.S	K.V.E.S	K.E
Observations	34766	24481	12487	24475	24475	12483