Rent assistance and housing demand

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Rent Assistance and Housing Demand

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Abstract

We examine the effect of a rent subsidy program, Rent Assistance, on the demand for rental housing in The Netherlands. Low-income households with a rent that exceeds a norm rent, but is smaller than a maximum rent are eligible for this subsidy, that is equal to a fraction of the difference between the rent and the norm rent. The RA program lowers the marginal price of housing services, but in order to get this price reduction households have to pay an implicit entry fee. To estimate the effect of the program we develop a structural model of housing demand. This model takes account of the partial take-up of the subsidy. We estimate a reduced form that is compatible with the structural model and we test the restrictions that the structural model imposes on the reduced form. We find that if we allow for application costs the structural restrictions are not rejected by the data. We use the model to decompose the observed difference in housing demand into income-, price and preference heterogeneity effects, to examine the effect of application costs and to study the total effect of RA on housing demand.

1 Introduction

In most developed nations the government intervenes in the housing market, and The Netherlands is no exception (see *e.g.* Ball, Harloe and Maartens (1988)). Some of the policies pursued by the Dutch government stimulate the supply of (low-cost) housing, *e.g.* subsidies for the construction of housing for low-income households. Other policies stimulate the demand for housing, *e.g.* (full) deductibility of interest payments on mortgages for owner-occupiers and direct rent-subsidies for low-income renters. In this paper, we study the effect of direct rent subsidies on housing demand.

The rent subsidy program in The Netherlands is called Individuele Huursubsidie (IHS) which we shall translate as Rent Assistance (RA). In the program year 1985/86[1] 777 thousand households received RA, that is 25% of all renting households[2]. They received Dfl. 1344 million (approximately U$ 675 million) in RA subsidies, *i.e.* Dfl 1729 per household that is 33% of the average rent paid by an RA recipient. The RA program was introduced in 1970 in order to bring good quality housing within reach of low-income households. It was felt that the consumption of housing services should be subsidized, because housing was considered to be a merit good having external effects on the health and ability to work of household members. Moreover, under the assumption that rents can be controlled—and indeed in The Netherlands price controls on the rental market are pervasive—the RA program increased the real income of eligible households. Although there is little discussion of the goal of the RA-program, it seems that recently the merit good argument has lost ground to distributional considerations[3].

The RA program affects the relative price of housing services for eligible households in a rather complicated way. The resulting budget set, when choice is restricted to housing services and other consumption, is non-convex. In this paper we propose a utility maximizing model of

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[1] The program year for RA runs from July 1 to June 30. The year 1985/6 started on July 1, 1985 and ended on June 30, 1986. All our data pertain to this year.

[2] In 1985/86 56% of all households were renters.

[3] The policy intentions of the Dutch government are summarized in *Volkshuisvesting in de jaren negentig* (Housing in the Nineties).

housing demand, that takes account of the budget constraint as implied by RA. In specifying this model, we can draw on the extensive experience of applied econometricians with demand analysis in the presence of non-linear budget sets (see *e.g.* Pudney (1989) for an introduction). An additional complication is that about 40% of households that are eligible for RA do not apply for the subsidy. For that reason, we shall specify a joint model of RA take-up and housing demand.

By making a distinction between household preferences and constraints, including the perceived costs of application for RA, we hope to isolate the parameters of the preference structure. If we succeed, we can simulate the effect of changes in the RA program. A structural model is better suited to policy analysis, because its parameters are invariant under policy changes. In particular, we can investigate whether RA achieves its stated goals.

The paper is organized as follows. In section 2 we discuss the rules of the RA program. Section 3 introduces a structural model for housing demand. The data are discussed in section 4. The model is estimated in section 5, and section 6 contains some implications of the estimates. In section 7 we summarize the results.

2 The Rent Assistance Program and Rental Housing Supply

2.1 The Rent Assistance Program

The eligibility for RA and the amount of the subsidy are determined by three parameters: household income, household composition and rent[4]. We refer to the relevant measure of rent paid as the RA rent. The RA rent includes some service charges, such as charges for heating and cleaning of communal space in an apartment building (but not of the apartments), but it excludes charges for cleaning windows or the rent of a garage that sometimes are paid with the rent.

[4]The administration of the RA program is in the hands of the municipalities (in Dutch: gemeenten).

A household is eligible for RA if the RA rent exceeds the norm rent, but is lower than the maximum rent. The norm rent is the rent that the household is supposed to be able to pay, given its composition and income. It depends on household taxable income in the calendar year preceding the program year[5], and on household composition. Household taxable income is the sum of the taxable incomes of the household members. The norm rent increases with household taxable income, but decreases with family size. The only distinction made in household composition is between households having one member and households having two or more members. To be eligible for RA in the program year 1985/6 taxable income in 1984 had to be less than Dfl. 35000 for households with two or more members or Dfl. 31000 for households with only one member[6]. The maximum rent in 1985/6 was equal to Dfl. 8040 per year for households with two or more members and Dfl. 6360 for households with one member. The household received no RA, if the RA rent exceeded the maximum rent. A household did also not qualify for RA, if its RA rent was less than Dfl. 2960 per year. This is the lower bound on the norm rent[7].

The amount of the subsidy is determined by the difference between the RA rent and the norm rent. The computation is illustrated in figure 1. The numbers refer to a household with two or more members. The computation is similar for households with one member. The lower boundary of the region in figure 1 is the norm rent[8]. The lowest norm rent is Dfl. 2780 per year and the highest norm rent is Dfl. 7540 per year.The norm rent is a step function of taxable household income. It is constant on intervals of width Dfl. 500 (taxable household income less than Dfl. 28000) or Dfl. 1000 (taxable household income between Dfl. 28000 and Dfl. 35000). The regions A to E correspond to different

[5] If taxable income is expected to change by more than 25% in the program year, an estimate of taxable income is used to compute the RA entitlement.

[6] A household is not eligible for RA, irrespective of its income, if the value of its assets exceeds Dfl. 107000.

[7] To be precise, the lower bound on the norm rent in 1985/6 was Dfl. 2780, but RA was only paid if the subsidy exceeded Dfl. 180 per year.

[8] In figure 1 the relation between household taxable income and norm rent is somewhat simplified.

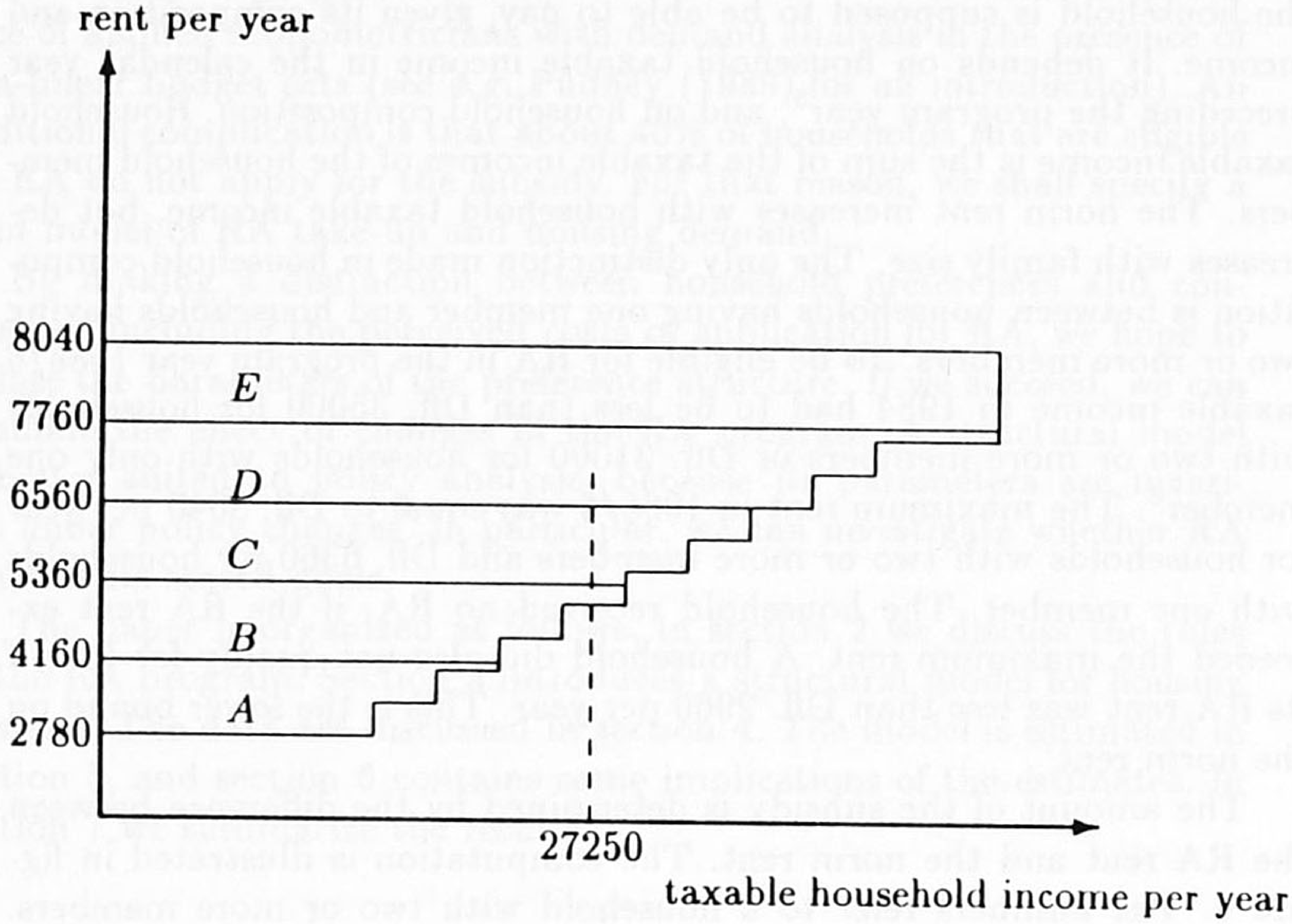

Figure 1: Determination of RA

subsidy rates. In region A, the subsidy rate is 100%, in region B 90%, and in regions C, D and E it is 80%, 70% and 60% respectively. The subsidy rates are applied to the difference between the RA rent and the norm rent that is in the relevant region. Consider *e.g.* a household with a taxable income of Dfl. 27250 and an RA rent of Dfl. 7000. The norm rent for this household is Dfl. 4600, so that the RA computation is based on the difference, Dfl. 2400. This difference is in the regions B, C and D, Dfl. 760 in B, 1200 in C and 440 in D. Hence, the subsidy is equal to $0.90 \times 760 + 0.80 \times 1200 + 0.70 \times 440 =$ Dfl. 1952. The subsidy is rounded to a smaller integer multiple of Dfl. 60, so that the subsidy is Dfl. 1920, 27% of the RA rent.

From figure 1 it is clear that the marginal price of housing services is not constant. Depending on household taxable income and the RA rent a household pays 0% (if the RA rent is in region A) to 100% (if the RA rent is not in the regions A to E) of an additional guilder spent on housing.

Note that the dependence of the norm rent on taxable income also increases the income tax rate, in particular for low-income families. Hence, the RA program could have an effect on the work effort. We neglect possible simultaneity of the labour supply and housing demand decision. In general, RA is a non-negligible part of disposable income. In the data used in this paper, the average fraction of household disposable income derived from RA is 10% for RA recipients. For families in the first quartile of the income distribution, this fraction is 13%.

2.2 Rental Housing Supply

The most important suppliers of rental housing are housing corporations (Dutch: woningbouwvereniging) and real-estate agents. The allocation of rental housing with rents below the rent limit (Dutch: huurgrens) [9] is regulated by the municipalities. Households that are searching for a rental dwelling below the rent limit may register with the municipalities and state their preferences concerning rent, size of the dwelling, district, etc. As soon as a suitable dwelling is available, this is offered to the household. The household then either accepts the dwelling or waits for another offer. Households can also search themselves, and indeed many dwellings are found that way. However, they still need approval of the local authorities to move in. Although this allocation system puts some restrictions on the choices of households, we assume that on average potential RA recipients are able to satisfy their demand for housing services at the given unit price.

Almost all rental housing below the rent limit is owned by housing corporations. The rents are determined by rules (prescribed by the government) which take into account size and other amenities of the

[9] Rent limits are determined by municipalities and are higher than the maximum rent.

dwelling, year of construction and building costs[10]. Because of these rules, it is not possible for letters to charge higher rents to households that receive RA in order to benefit from the program.

Since our empirical analysis is based on a cross-section survey, we abstract from intertemporal considerations in housing demand and supply. In the segment of the rental market where demand is affected by RA, government policy aims at satisfying demand at a unit price that the government considers to be reasonable. As a consequence our assumption that the observed distribution of rents is closely related to the distribution of quantities demanded is reasonable.

3 A Model of Housing Demand with Rent Assistance

3.1 Household Utility Maximization

In this section we propose a model of housing demand in the presence of RA. We assume that the household is the decision making unit, and that its preferences can be described by a single utility function. The household divides its income between housing services and other consumption. The price of a unit of housing services is the same for all dwellings, and without loss of generality we set it to Dfl. 1[11]. Hence, the rent equals the quantity of housing services provided by the dwelling. We assume that the household maximizes its utility function subject to a budget constraint that is affected by the RA program. We also must take account of the partial take-up of RA benefits. First, we discuss the budget constraint. Next, we specify household preferences and we consider the household maximization problem. Finally, we propose a model for the take-up of RA.

[10] These rules are referred to as the point system (Dutch: puntenstelsel).

[11] As pointed out before the purpose of the rent guidelines of the Dutch government is to reduce dispersion of unit prices. Moreover, if the household faces unit price dispersion it may use the expected unit price to determine its demand for housing services.

3.2 The Budget Constraint with RA

The budget constraint of the household is

$$R + X = Y + S, \tag{1}$$

where R denotes the rent, X the consumption of other goods, Y is disposable income and S is the RA subsidy, which may be 0. For R we shall use the RA rent.

S is determined by the difference between the RA rent R and the norm rent $R_n(Y_T, H)$ that depends on household taxable income Y_T and household composition H. Although the subsidy rate δ depends on R and $R - R_n(Y_T, H)$ (see figure 1), we apply a constant subsidy rate to the difference. We set $\delta = 0.823$, which is the average rate for RA recipients in our sample. Using this simplification, we can compute the RA subsidy by

$$S = \begin{cases} \delta(R - R_n(Y_T, H)) & R_n(Y_T, H) \leq R \leq R_{max}(H), \\ 0 & R < R_n(Y_T, H) \text{ or } R > R_{max}(H), \end{cases} \tag{2}$$

where $R_{max}(H)$ is the maximum rent, that depends on the household composition.

Substitution of equation (2) in equation (1) and some rewriting gives the budget constraint

$$\begin{array}{ll} R + X = Y & R < R_n(Y_T, H) \text{ or} \\ & R > R_{max}(H) \\ (1-\delta)R + X = Y - \delta R_n(Y_T, H) & R_n(Y_T, H) \leq R \\ & \leq R_{max}(H) \end{array} \tag{3}$$

If we set $R_n = R_{max}$ for households that do not qualify for RA because their taxable income is too high, then equation (3) applies to all households in the population.

Equation (3) makes clear that RA has two effects on the budget constraint. First, it reduces the (marginal) price of housing services from 1 to $1 - \delta$. Second, it has a negative effect on disposable income. To be eligible for RA the household must consume an amount of housing services that exceeds the norm rent. A fraction $1 - \delta$ of R_n has to be paid anyway, but the amount δR_n is the household contribution to the 'entry fee' for RA. In other words, δR_n can be considered as a fixed cost, which has to be incurred in order to be eligible for RA. Following e.g. Blomquist (1983) we define virtual income Y_v by

$$Y_v = Y - \delta R_n(Y_T, H).$$

Hence we can rewrite the second line in equation (3) as

$$(1-\delta)R + X = Y_v \qquad R_n(Y_T, H) \leq R \leq R_{max}(H).$$

The fixed cost is on average Dfl. 2735 per year which equals 14% of average disposable household income.

The budget constraint of an RA recipient is drawn in figure 2. It is evident that the budget set of an RA recipient is non-convex. The slope of the segments YA and $A''Y'$ is 1, while the slope of the segment AA' is $1-\delta$, reflecting the lower marginal price of housing services under RA.

From figure 2 we see that households that would choose an (R, X) combination on the segment AA'' in the absence of RA move to AA' after introduction of RA. Moreover, some households that give housing low priority move from YA to AA' and some households with strong relative preferences for housing services move from $A''Y'$ to AA'. Without knowledge of the preferences of the household we can not make more precise predictions.

3.3 Preferences and Utility Maximization

We assume that household preferences can be represented by the utility function

$$u(R, X) = \left(\frac{R}{\beta_1} + \frac{\beta_2}{\beta_1^2}\right) \exp\left(\frac{\beta_1^2 X - \beta_1 R + \beta_0 \beta_1}{\beta_2 + \beta_1 R}\right). \tag{4}$$

If we maximize (4) subject to a linear budget constraint

$$pR + X = Y, \tag{5}$$

we obtain the indirect utility function

$$\nu(p, Y) = \left(Y + \frac{\beta_2}{\beta_1}p + \frac{\beta_2}{\beta_1^2} + \frac{\beta_0}{\beta_1}\right) \exp(-\beta_1 p), \tag{6}$$

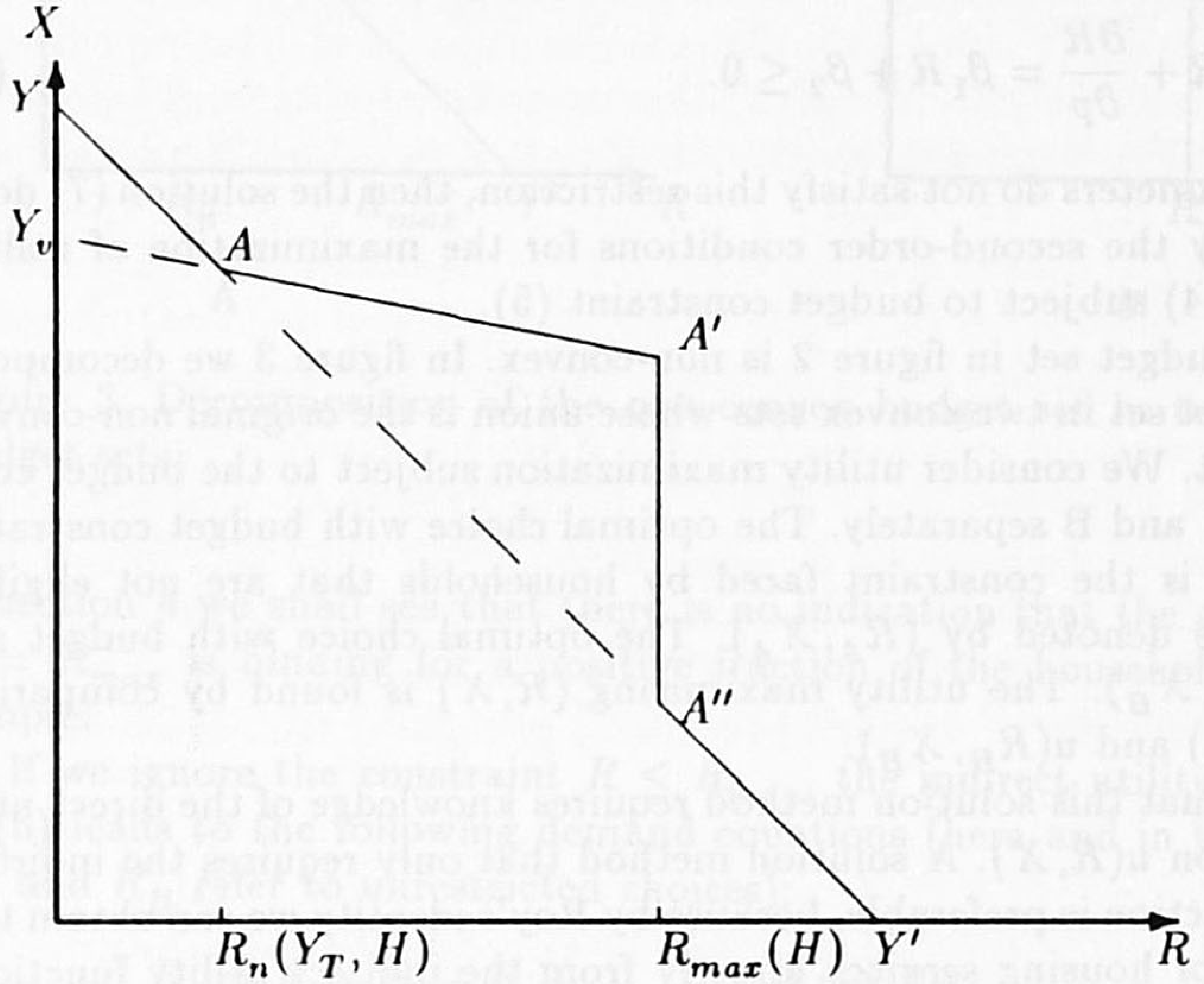

Figure 2: Budget set of RA recipient

and the demand for housing services

$$R = \beta_0 + \beta_1 Y + \beta_2 p. \tag{7}$$

We are somewhat restricted in our choice of preference structure, because we need an explicit expression for either the direct or the indirect utility function.

According to the Slutsky condition, the parameters of demand equation (7) have to satisfy the following restriction:

$$\frac{\partial R}{\partial Y} \cdot R + \frac{\partial R}{\partial p} = \beta_1 R + \beta_2 \leq 0. \tag{8}$$

If the parameters do not satisfy this restriction, then the solution (7) does not satisfy the second-order conditions for the maximization of utility function (4) subject to budget constraint (5).

The budget set in figure 2 is non-convex. In figure 3 we decompose this budget set in two convex sets whose union is the original non-convex budget set. We consider utility maximization subject to the budget constraints A and B separately. The optimal choice with budget constraint A, which is the constraint faced by households that are not eligible for RA, is denoted by (R_A, X_A). The optimal choice with budget set B is (R_B, X_B). The utility maximizing (R, X) is found by comparing $u(R_A, X_A)$ and $u(R_B, X_B)$.

Note that this solution method requires knowledge of the direct utility function $u(R, X)$. A solution method that only requires the indirect utility function is preferable, because by Roy's identity we can obtain the demand for housing services directly from the indirect utility function. Hence, expressing the decision to apply for RA in terms of the indirect utility function gives us additional flexibility in the selection of functional forms, because an explicit solution for the direct utility function is not required. If we ignore the constraint $R \leq R_{max}(H)$ in figure 3B, *i.e.* if we assume that the preferences are such that optimal choice under RA is always on the interior of $Y_v A'$, then an eligible household will choose a dwelling with RA if and only if

$$\nu(1 - \delta, Y_v) > \nu(1, Y). \tag{9}$$

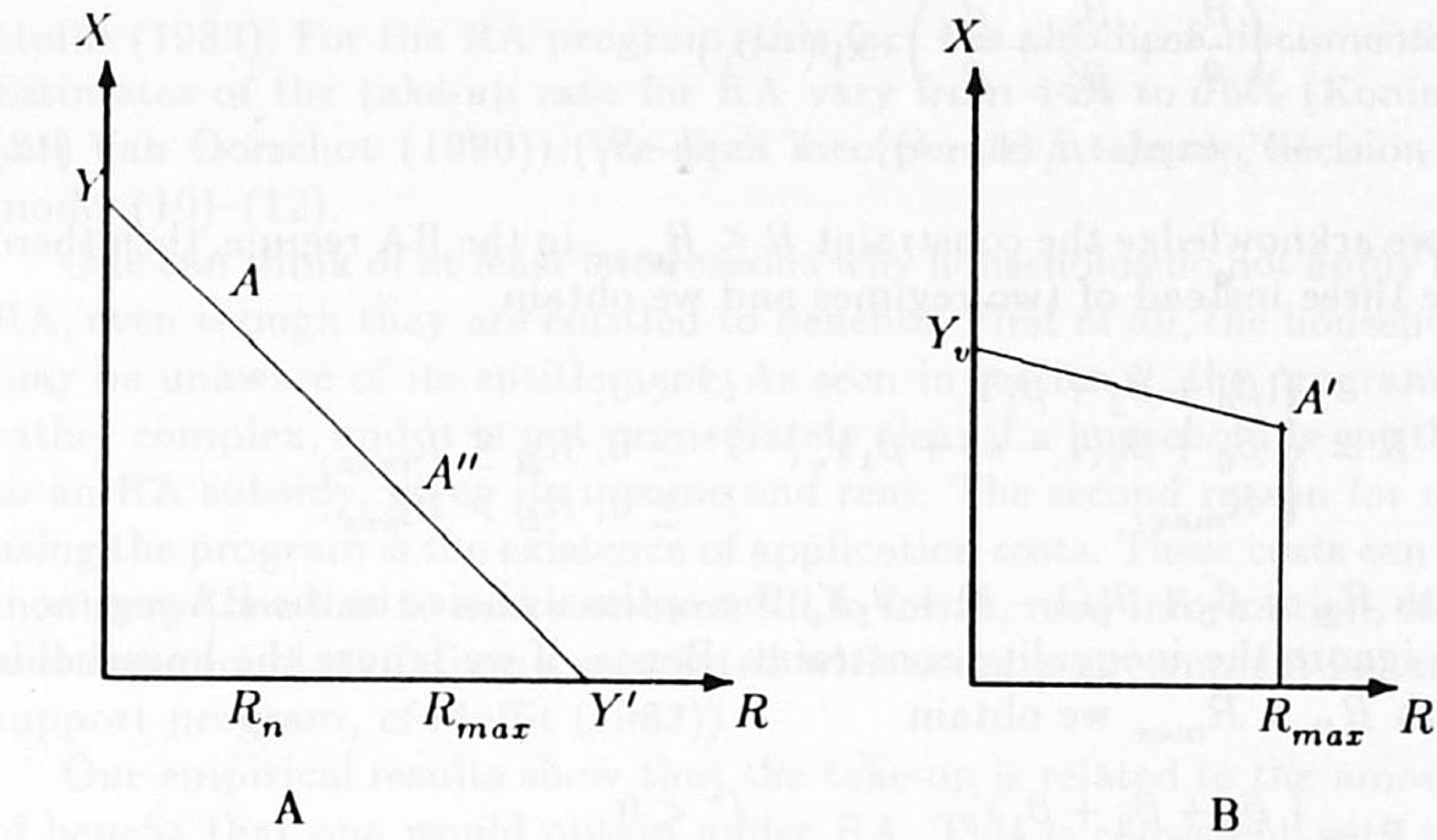

Figure 3: Decomposition of the non-convex budget set in two convex budget sets

In section 4 we shall see that there is no indication that the constraint $R = R_{max}$ is binding for a positive fraction of the households in our sample.

If we ignore the constraint $R \leq R_{max}$, the indirect utility function in (6) leads to the following demand equations (here and in the sequel R_A and R_B refer to unrestricted choices):

$$R = \begin{cases} R_A = \beta_0 + \beta_2 + \beta_1 Y & \text{if not RA,} \\ R_B = \beta_0 + \beta_2(1-\delta) + \beta_1 Y_v & \text{if RA,} \end{cases} \tag{10}$$

with according to equation (9)

$$\text{RA} \;\Leftrightarrow I^* = \nu(1-\delta, Y_v) - \nu(1, Y) > 0, \tag{11}$$

where

$$I^* = \left(\frac{\beta_2}{\beta_1}(1-\delta) + \frac{\beta_2}{\beta_1^2} + \frac{\beta_0}{\beta_1}\right) \exp\left(-\beta_1(1-\delta)\right)$$

$$-\left(\frac{\beta_2}{\beta_1}+\frac{\beta_2}{\beta_1^2}+\frac{\beta_0}{\beta_1}\right)\exp(-\beta_1)$$
$$+Y_v \exp\left(-\beta_1(1-\delta)\right) - Y\exp(-\beta_1). \qquad (12)$$

If we acknowledge the constraint $R \leq R_{max}$ in the RA regime, then there are three instead of two regimes and we obtain

$$R = \begin{cases} \beta_0+\beta_2+\beta_1 Y, & I^* < 0, \\ \beta_0+\beta_2(1-\delta)+\beta_1 Y_v, & I^* \geq 0,\ R_B \leq R_{max}, \\ R_{max}, & I^* \geq 0,\ R_B > R_{max}, \end{cases}$$

with $R_B = \beta_0+\beta_2(1-\delta)+\beta_1 Y_v$ the optimal choice in the RA regime if we ignore the inequality constraint. Hence, if we ignore the households with $R_B > R_{max}$ we obtain

$$R = \begin{cases} \beta_0+\beta_2+\beta_1 Y, & I^* < 0, \\ \beta_0+\beta_2(1-\delta)+\beta_1 Y_v, & I^* \geq 0,\ R_B \leq R_{max}, \end{cases}$$

The household does not receive RA if the optimal choice lies on either one of the segments YA or $A''Y'$ in figure 2. In the empirical analysis we ignore the observations corresponding to $A''Y'$ (see also section 4.1). This amounts to the imposition of an inequality constraint in the non-RA regime. Hence, if $R_A = \beta_0+\beta_1+\beta_2 Y$ is the optimal choice in the non-RA regime, then the full demand equation is (we ignore the households with $R_B > R_{max}$):

$$R = \begin{cases} R_A = \beta_0+\beta_2+\beta_1 Y, & I^* < 0,\ R_A \leq R_{max} \\ R_B = \beta_0+\beta_2(1-\delta)+\beta_1 Y_v, & I^* \geq 0,\ R_B \leq R_{max}, \end{cases}$$

Whether the additional restrictions on R_A and R_B complicate the empirical analysis depends on the stochastic specification of the econometric model. If we add disturbances to the demand equation, we obtain a switching regression Tobit model.

3.4 Modelling the Take-up of RA

It is well known, that the take-up of income-support programs is in general less than 100%, see for instance Blundell, Fry and Walker (1988) and

Moffit (1983). For the RA program, this fact has also been documented. Estimates of the take-up rate for RA vary from 44% to 76% (Konings and Van Oorschot (1990)). We shall incorporate a take-up decision in model (10)-(12).

One can think of at least two reasons why households do not apply for RA, even though they are entitled to benefits. First of all, the household may be unaware of its entitlement. As seen in section 2, the program is rather complex, and it is not immediately clear if a household is entitled to an RA subsidy, given its income and rent. The second reason for not using the program is the existence of application costs. These costs can be monetary (one has to make xeroxes, fill in forms, read information, etc.) and non-monetary (stigma associated with using a government income-support program, *cf* Moffit (1983)).

Our empirical results show that the take-up is related to the amount of benefit that one would obtain under RA. This is consistent with the presence of application costs, and hence we model the take-up by introducing such costs.

Let the costs be denoted by C'. Household income under RA is now $Y_v - C'$, with indirect utility $\nu(1-\delta, Y_v - C')$. Hence, a household will choose a dwelling with RA, if $\nu(1-\delta, Y_v - C') > \nu(1, Y)$. In this approach we can also take account of non-monetary indirect utility costs. Suppose these non-monetary costs are $\bar{\nu}$ (measured in utils). Then, the household will choose a rent with RA, if

$$\nu(1-\delta, Y_v - C') - \nu(1, Y) > \bar{\nu},$$

which with specification (6) can be rewritten as

$$\nu(1-\delta, Y_v) - \nu(1, Y) > C' \exp(-\beta_1(1-\delta)) + \bar{\nu}. \tag{13}$$

If we redefine the costs incurred as $C = C' + \bar{\nu}/\exp(-\beta_1(1-\delta))$, one sees that a household will choose a rent with RA if

$$\nu(1-\delta, Y_v - C) - \nu(1, Y) > 0. \tag{14}$$

The non-monetary costs $\bar{\nu}$ are valued at the marginal utility of income. In the present model, monetary and non-monetary application costs reduce virtual income Y_v under RA.

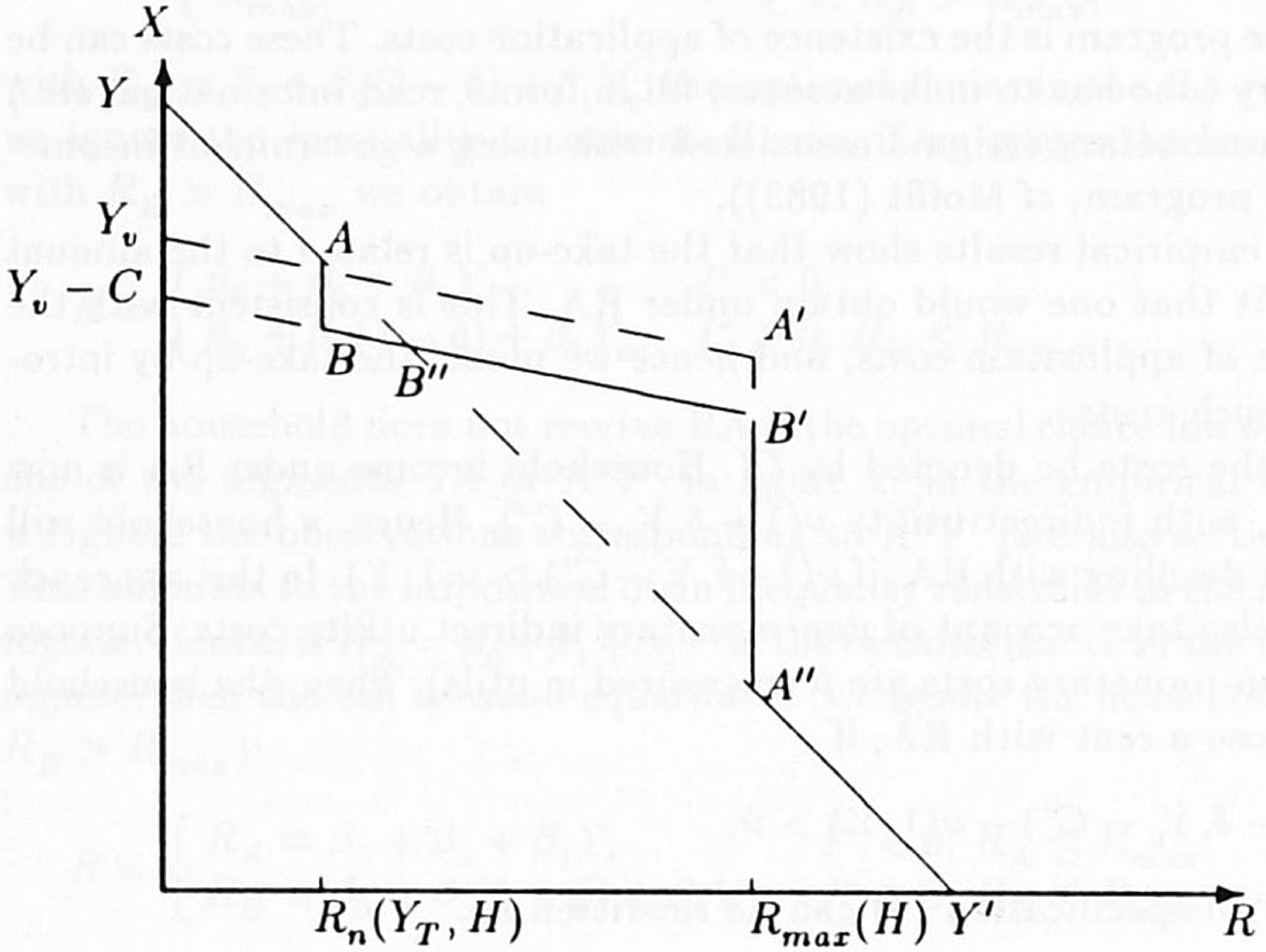

Figure 4: The consequences of application costs

The effect of application costs on the budget constraint is illustrated in figure 4. The budget constraint with application costs is $YABB'A''Y'$. The effect of RA on households with rents on AA'' is different with and without application costs. In both cases households on $B''A''$ will apply for RA. However, if $C = 0$ all households on AB'' will apply, but whether a household on AB'' will apply if $C > 0$ depends on its relative preference for housing services. Households with low relative preferences will choose not to apply. Hence, if there are application costs then application for RA is positively related to the amount of the entitlement.

4 The Data

4.1 Description of the Data and Descriptive Statistics

The empirical analysis used data from the Housing Needs Survey 1985/86 (to be abbreviated as HNS 85/6). This survey is based on a large sample from the Dutch population (54342 responding households, with the sample size being 70816). The sample and the sample design are described in detail in CBS (1990). For our purposes, we can consider the sample as a random sample of households. The survey contains detailed information on the dwelling of the households, as well as on their socio-economic characteristics.

We do not use all sample households in the analysis. We restrict ourselves to renters who satisfy certain criteria. These criteria are listed in Appendix A. Most selections are made to ensure that the utility-maximizing model is a reasonable description of household behaviour. We retain only households of which either the head of the household or his/her partner are interviewed. Moreover, we only consider households with a taxable income that entitles them to RA. Whether a potential RA recipient actually receives RA is another matter.

There are three reasons why a potential RA recipient does not receive RA: the rent paid is smaller than the norm rent, the rent paid is higher than the maximum rent or the household is eligible for RA, but it does not apply for the subsidy. In the sample we find that very few households do not receive RA because their rent exceeds the maximum rent. Moreover, there is no indication that households in the RA regime are constrained by the restriction that the rent should not exceed the maximum rent. If this were the case, we would observe a clustering of observed rents at and slightly below the maximum rent, which we do not. For these reasons, we select only those households whose rent is below the maximum rent and for these households we neglect the constraint that the rent should not exceed the maximum rent. This selection facilitates the empirical analysis.

We want to include only households that are utility maximizers. A standard approach in the literature is to select households that have moved recently (see, *e.g.* Ball and Kirwan (1977)). Households that moved a long time ago may no longer be in equilibrium, because adjustment costs may prevent them from moving to another dwelling. By retaining only those households that have moved recently, we hope that the observed consumption of housing services is close to the utility maximizing level of consumption. Of course, we could use all households, but then we would need to model the effect of adjustment costs on housing consumption explicitly. Our approach circumvents this problem.

We use some additional information to identify utility-maximizing households. In the HNS 85/6, households were asked if they intended to move within two years and whether they were satisfied with their dwelling and neighbourhood. We select those households which claimed to have no intentions of moving within two years and which were reasonably happy with their dwelling and neighbourhood. Even though this selection is based on intentions and not on observed behaviour, we think that it improves the correspondence between the data and the model.

A problem in analyzing housing demand is that we only observe housing expenditures. Housing expenditures are the product of the unit price of housing services and the quantity of housing services. However, price and quantity are not observed separately. For that reason we assume that the unit price of housing services is the same for all rental dwellings. In other words, differences in rents reflect differences in the quantity of housing services rather than differences in the price of housing services. We normalize the price component to 1. Every other normalization would do, because it merely changes the units of measurement of the quantity of housing services. Hence, the only price variation we allow for is the price variation due to the RA program.

For each household in the sample we computed its RA entitlement using information on household taxable income and family composition. The income measure needed for the calculation of the RA benefit in the year July 1 1985 - June 30 1986 is taxable household income in 1984. However, taxable income in the HNS 85/6 is measured over the year 1985. We assumed that taxable wage income increased by 2% from 1984 to 1985[12], and we assumed that social security benefits remained constant. This enabled us to estimate taxable household income in 1984.

We present some summary statistics in table 1. All variables have been introduced before, except SIZE and AGE. SIZE is the size of the household and AGE is the age of the head of the household. All monetary variables are measured in thousands of guilders. The variable Rent assistance in table 1 is the computed RA subsidy, *i.e.* the outcome of our computation of the RA benefits. The household may or may not take up these benefits.

Note that RA recipients spend, on average, more on housing than non-recipients. This may be due to the lower price of housing in the RA regime, but it may also be a consequence of the threshold, *i.e.* the norm rent, in the RA program. We also see that the fixed cost of entering the program (the difference between Y and Y_v, see section 3.2) is higher for non-recipients than for recipients. The differences in household size and age between the two groups are small.

Note that the average computed RA subsidy is not zero for households who do not receive RA. This means that there are households who are entitled to an RA benefit, but who do not receive the benefit. In fact, in our sample the take-up is 63.9%. The partial take-up of RA benefits will receive explicit attention in our empirical model.

[12]See Central Planning Bureau (1986), table IV.8.

Variable	Full sample	RA recipients	non RA recipients
Income (Y)	22.93	20.83	24.28
	(6.00)	(5.32)	(6.03)
Virtual Income (Y_v)	19.48	18.02	20.42
	(5.07)	(4.78)	(5.03)
Rent (R)	4.84	5.62	4.34
	(1.52)	(1.23)	(1.48)
Norm rent (R_n)	4.12	3.36	4.61
	(1.47)	(0.90)	(1.56)
Rent assistance (S)	1.08	2.01	0.48
	(1.20)	(1.05)	(0.86)
Entitled to RA	61.4%	100%	36.5%
Price (p)	0.68	0.18	1.00
Size	2.35	2.40	2.32
	(1.31)	(1.28)	(1.32)
Age	43.72	45.73	42.42
	(18.75)	(19.50)	(18.14)
Observations	1809	710	1099

Table 1: Means of variables, standard deviations in parentheses

4.2 A Preliminary Analysis

From table 1 we can obtain crude estimates of the price and income elasticity of housing demand. We estimate the price elasticity by

$$\hat{\eta}_p = \frac{(\bar{R}_B - \bar{R}_A)/\bar{R}}{(\bar{p}_B - \bar{p}_A)/\bar{p}} = -0.22,$$

where $\bar{R}_A$ is the average rent paid by non RA-recipients, $\bar{R}_B$ the average rent paid by RA-recipients, $\bar{R}$ the average rent paid in the sample, etc. If the income elasticity of housing demand is positive, this is an underestimate because the average income of RA-recipients is lower than that of non-recipients. However, if we use a similar procedure to estimate the income elasticity of housing demand, we obtain $\hat{\eta}_Y = -1.76$. This counterintuitive result is a direct consequence of the stronger incentives of the RA program for lower income households.

We can avoid the use of between-regime income variation by a slightly more sophisticated analysis in which we regress the rent on price and income. The resulting price and income elasticities are $\hat{\eta}_p = -0.27$ and $\hat{\eta}_Y = 0.43$.

It must be stressed that these estimates may still be biased. First, the norm rent may have an upward effect on the rents paid in the RA regime, resulting in an upward bias in the absolute value of the price elasticity. Moreover, its dependence on income may induce an upward bias in the estimate of the income elasticity. Second, the price may be endogenous, e.g. because RA-recipients may have a relatively strong preference for housing services causing an upward bias in the absolute value of the price elasticity. Third, we have not distinguished between non-recipients with and without entitlement to RA. Fourth, for RA-recipients the appropriate income measure is virtual income Y_v that includes the fixed costs of RA. The structural model of the next section will deal with these potential biases.

One implication of our theoretical model is that there is a positive relationship between the take-up of the RA-benefits and the amount of the benefit (see subsection 3.4). We examine this by estimating a probit model for households entitled to RA, with the dependent variable being 1 if the households exercises its entitlement to RA and 0 otherwise, and with independent variables the amount of RA (S) and income (Y). The estimation results and standard errors are:

constant	S	Y
−0.30	0.40	−0.00076
(0.19)	(0.040)	(0.0075)

Only the coefficient of S is significant at a 5% level. We conclude that there is a significant positive relation between take-up and the amount of the benefit, as is predicted by the model in section 3.4.

5 An Empirical Model of Rental Housing Demand

In this section, we first discuss our estimation strategy, that we then use to obtain estimates of the parameters of the model. The estimation strategy consists of three steps. First, we choose a stochastic specification for the structural model of rental housing demand. Next, we note that the structural model can be obtained by restricting the parameters of a reduced form model. We derive the likelihood function of this reduced form model. Finally, we obtain the structural form parameters from the reduced form parameters by the minimum distance method. This estimation procedure is computationally simpler than and asymptotically equivalent to maximum likelihood estimation of the structural model. In section 5.2 we present our empirical results.

5.1 Stochastic Specification and Estimation Strategy

The model of the previous section is not suited to estimation. It assumes that every household has the same preference structure, *i.e.*, the same β. One can model variation in preferences by making β dependent on demographic characteristics, but not all variation can be explained by a few variables. Moreover, we have seen in the last section that with respect to demographic variables as household size and age of the head, households that receive RA do not differ much from households that do not receive RA. Therefore, it is unlikely that the difference in average housing demand between RA recipients and other households can be attributed to differences in demographic characteristics. We model heterogeneity of preferences by making β_0 a random variable that varies over the population. The marginal rate of substitution between housing services and other goods is $-\frac{\beta_1 X - R + \beta_0}{\beta_2 + \beta_1 R} = u'_R / u'_X$. If the Slutsky condition is satisfied, the denominator is negative and the marginal rate of substitution increases linearly with β_0. Households with a large β_0 strongly prefer housing over other goods.

Let β_0 be normally distributed with mean δ_0 and variance σ_ζ^2: $\beta_0 \sim \mathcal{N}(\delta_0, \sigma_\zeta^2)$. The deviation of β_0 from its mean is denoted by ζ. If all variation in housing demand is due to preference and income variation, the stochastic version of our demand model becomes:

$$R = \begin{cases} \delta_0 + \beta_2 + \beta_1 Y + \zeta & I = 0 \\ \delta_0 + \beta_2(1-\delta) + \beta_1 Y_v + \zeta > R_n & I = 1 \end{cases} \tag{15}$$

$$\begin{aligned} I^* = & \left(\frac{\beta_2}{\beta_1}(1-\delta) + \frac{\beta_2}{\beta_1^2} + \frac{\delta_0}{\beta_1} \right) \exp(-\beta_1(1-\delta)) \\ & - \left(\frac{\beta_2}{\beta_1} + \frac{\beta_2}{\beta_1^2} + \frac{\delta_0}{\beta_1} \right) \exp(-\beta_1) \\ & + \exp(-\beta_1(1-\delta)) Y_v - \exp(-\beta_1) Y - \exp(-\beta_1(1-\delta)) C \\ & + \left(\frac{\exp(-\beta_1(1-\delta)) - \exp(-\beta_1)}{\beta_1} \right) \zeta, \end{aligned} \tag{16}$$

$$I = \begin{cases} 0 & I^* < 0 \\ 1 & I^* \geq 0 \end{cases}$$

Since rents in the RA-regime ($I = 1$) necessarily exceed the norm rent R_n, the distribution of rents in this regime is truncated from below. In equation (15), and later on, this is indicated by '$> R_n$' after the demand equation. Note that if $\beta_1 > 0$, then I^* is increasing in ζ, *i.e.* households with a relatively strong preference for housing are more likely to receive RA.

Of course, it is overly restrictive to allow only for preference heterogeneity. Another source of variation in the demand equation is the difference between the realized consumption of housing services and the desired consumption of these services. At the moment of the decision the desired type of dwelling may not be available, and the household must settle for a dwelling that either provides a larger or smaller amount of housing services. We assume that on average households realize their desired level of consumption. Because it may be easier to find a dwelling with the desired level of housing services in either the RA- or non-RA regime, the variance of this optimization-failure disturbance term need not be equal in both regimes. Households that prefer the RA regime face a restriction when choosing a particular dwelling. Even if the desired level of housing services provided by the dwelling is not equal to the desired level, it must exceed the level corresponding to the norm rent. We assume that households in the RA regime are aware of this restriction, so that the rents in the RA regime are truncated at the norm rent. Households that prefer the non-RA regime do not face a similar restriction, because there is no obligation to take up the RA benefits. Note that the truncation in the RA regime only is needed if we allow for optimization errors. In (15) the rent in the RA regime necessarily exceeds R_n. We also allow for additional variation in the regime allocation equation.

The complete stochastic specification of our model is now:

$$R = \begin{cases} \delta_0 + \beta_2 + \beta_1 Y + \zeta + v_1 & I = 0 \\ \delta_0 + \beta_2(1-\delta) + \beta_1 Y_v + \zeta + v_2 > R_n & I = 1 \end{cases} \tag{17}$$

$$\begin{aligned} I^* = {} & \left(\frac{\beta_2}{\beta_1}(1-\delta) + \frac{\beta_2}{\beta_1^2} + \frac{\delta_0}{\beta_1}\right)\exp(-\beta_1(1-\delta)) \\ & - \left(\frac{\beta_2}{\beta_1} + \frac{\beta_2}{\beta_1^2} + \frac{\delta_0}{\beta_1}\right)\exp(-\beta_1) \\ & + \exp(-\beta_1(1-\delta))Y_v - \exp(-\beta_1)Y - \exp(-\beta_1(1-\delta))C \\ & + \left(\frac{\exp(-\beta_1(1-\delta)) - \exp(-\beta_1)}{\beta_1}\right)\zeta + v_3, \end{aligned} \tag{18}$$

$$I = \begin{cases} 0 & I^* < 0 \\ 1 & I^* \geq 0 \end{cases}$$

We assume that the preference heterogeneity ζ is independent of the optimization errors v_1, v_2 and v_3. The variances of these terms will be denoted by σ_ζ^2, σ_1^2, σ_2^2 and σ_3^2 respectively.

If we ignore the parameter restrictions on (17) and (18), the corresponding reduced form model is:

$$R = \begin{cases} \alpha_0 + \alpha_Y Y + \varepsilon_1 & I = 0 \\ \alpha_1 + \alpha_{Y_v} Y_v + \varepsilon_2 > R_n & I = 1 \end{cases} \tag{19}$$

$$I^* = \gamma_0 + \gamma_{Y_v} Y_v + \gamma_Y Y + \eta \tag{20}$$

$$I = \begin{cases} 0 & I^* < 0 \\ 1 & I^* \geq 0 \end{cases}$$

For future reference, we define $\bar{R}_A$ to be the systematic part of the first equation, *i.e.* $\bar{R}_A = \alpha_0 + \alpha_Y Y$. $\bar{R}_B$ and $\bar{I}$ are defined analogously as the systematic parts of the second demand equation and the regime allocation equation.

The distribution of the disturbances is

$$\begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \eta \end{pmatrix} \sim \mathcal{N}\left(0, \begin{pmatrix} \sigma_{\varepsilon_1}^2 & \cdot & \sigma_{\varepsilon_1 \eta} \\ & \sigma_{\varepsilon_2}^2 & \sigma_{\varepsilon_2 \eta} \\ & & 1 \end{pmatrix}\right).$$

We impose the conventional normalization $\sigma_\eta^2 = 1$.

The identification of the structural parameters from the reduced form parameters proceeds as follows. First, β_1 is equal to α_Y or α_{Y_v}. The equality of α_Y and α_{Y_v} is an overidentifying restriction on the demand equations. Secondly, $\alpha_0 - \alpha_1 = \beta_2 \delta$ and hence this difference identifies β_2. Because we have identified β_1, we can identify σ_ζ^2 from either $\operatorname{cov}(\varepsilon_1, \eta)$ or $\operatorname{cov}(\varepsilon_2, \eta)$. The equality of these covariances is a second overidentifying restriction. In the regime allocation equation the ratio of γ_{Y_v} and γ_Y identifies β_1. This is a third overidentifying restriction:

$$\alpha_Y (= \alpha_{Y_v}) = \frac{1}{\delta} \log\left(-\frac{\gamma_{Y_v}}{\gamma_Y}\right). \tag{21}$$

Because δ_0, β_1 and β_2 are identified from the demand equations the constant of the regime allocation equation just identifies C. Hence, there are three overidentifying restrictions. If we set the application costs C to zero, then there is an additional overidentifying restriction. Since all parameters in the regime allocation equation are identified from the parameters of the demand equations, the variance of η is identified as well. Since σ_ζ^2 is identified, this in turn identifies the variance of v_3.

On the assumption that the regime choice precedes the choice of a dwelling, the loglikelihood of this model is given by

$$
\begin{aligned}
\ell(\theta) &= \sum_{I_i=0} \log f(R_i, I_i) + \sum_{I_i=1} \log f(R_i \mid I_i, R_i \geq R_{ni}) f(I_i) \\
&= \sum_{I_i=0} \log \int_{-\infty}^{-\bar{I}_i} f_{\varepsilon_1\eta}(R_i - \bar{R}_{Ai}, \eta) d\eta \\
&\quad + \sum_{I_i=1} \log \frac{\int_{-\bar{I}_i}^{\infty} f_{\varepsilon_2\eta}(R_i - \bar{R}_{Bi}, \eta) d\eta}{\Pr(R_{Bi} \geq R_{ni}, I_i^* \geq 0)} \int_{-\bar{I}_i}^{\infty} f_\eta(\eta) d\eta \\
&= \sum_{I_i=0} \Big(\log f_{\varepsilon_1}(R_i - \bar{R}_{Ai}) + \log \Pr(\eta < -\bar{I}_i \mid \varepsilon_1 = R_i - \bar{R}_{Ai}) \Big) \\
&\quad + \sum_{I_i=1} \Big(\log f_{\varepsilon_2}(R_i - \bar{R}_{Bi}) \\
&\qquad + \log \Pr(\eta \geq -\bar{I}_i \mid \varepsilon_2 = R_i - \bar{R}_{Bi}) \\
&\qquad - \log \Pr(\eta \geq -\bar{I}_i, \varepsilon_2 \geq R_{ni} - \bar{R}_{Bi}) + \log \Pr(\eta \geq -\bar{I}_i) \Big)
\end{aligned} \tag{22}
$$

Here, $f_{\varepsilon_1\eta}$ denotes the bivariate density of (ε_1, η), f_{ε_1} the marginal density of ε_1, etc., and θ is the vector of identified parameters:

$$\theta' = (\, \alpha_0 \quad \alpha_Y \quad \alpha_1 \quad \alpha_{Y_v} \quad \gamma_0 \quad \gamma_{Y_v} \quad \gamma_Y \quad \sigma_{\varepsilon_1\eta} \quad \sigma_{\varepsilon_2\eta} \quad \sigma_{\varepsilon_1}^2 \quad \sigma_{\varepsilon_2}^2 \,).$$

The loglikelihood function does not depend on cov $(\varepsilon_1, \varepsilon_2)$. Since we only observe housing demand in one of the two possible regimes, it is hardly surprising that this parameter is not identified.

The structural model in equation (17) follows from the reduced form model by imposing parametric restrictions. Let these restrictions be given by:

$$\theta = \pi(\psi).$$

The exact form of the restrictions is given in Appendix B. We estimate the structural parameters ψ by the minimum distance method (see, for instance, Chamberlain (1984)). An estimate of ψ is obtained by minimizing the quadratic form

$$S_N = \left(\hat{\theta} - \pi(\psi)\right)' A_N \left(\hat{\theta} - \pi(\psi)\right), \tag{23}$$

with A_N a possibly stochastic, symmetric weighting matrix and $\hat{\theta}$ the maximum likelihood estimator of θ. Under certain regularity conditions, the asymptotic distribution of $\hat{\psi}$ is

$$\sqrt{N}(\hat{\psi} - \psi) \sim \mathcal{N}\left(0, (F'AF)^{-1}F'A\left(\text{var}\,\hat{\theta}\right)AF(F'AF)^{-1}\right)$$

where $A = \text{plim}A_N$ and $F = \frac{\partial \pi(\psi)}{\partial \psi'}$. It is easily seen that choosing the weighting matrix $A_N = \left(\text{var}\,\hat{\theta}\right)^{-1}$ yields the estimator for ψ with the smallest variance. However, the minimand of (23) is a consistent estimator for ψ, regardless of the choice of A_N. If the restrictions are true, then minimum distance estimation with weighting matrix $\left(\text{var}\,\hat{\theta}\right)^{-1}$ yields an estimator which has the same asymptotic distribution as the maximum likelihood estimator.

If the structural model is just identified, $\psi(\cdot)$ will be one-to-one and the minimum of the quadratic form (23) is 0. On the other hand, if the structural model is overidentified, then S_N can be used to test these restrictions. To be precise, under the null hypothesis that the restrictions are satisfied, we have that $S_N \overset{asy}{\sim} \chi^2(p)$, with p the number of overidentifying restrictions.

5.2 Empirical Results

The estimation results for the reduced form model in equations (19) and (20) are given in table 2. All calculations were performed using the MAXLIK- and OPTMUM-routines of GAUSS386VM on a 486-personal computer.

Parameter		Parameter	
α_0	2.26	$\sigma_{\varepsilon_1\eta}$	0.16
	(0.27)		(0.15)
α_Y	0.089	$\sigma_{\varepsilon_2\eta}$	0.37
	(0.0088)		(0.25)
α_1	4.11	σ_{ε_1}	1.37
	(0.26)		(0.030)
α_{Y_w}	0.058	σ_{ε_2}	1.28
	(0.011)		(0.051)
γ_0	1.12		
	(0.13)		
γ_{Y_w}	0.75		
	(0.054)		
γ_Y	-0.71		
	(0.047)		
$\ln(\ell)$	-3973.52		
Observations	1809		

Table 2: Estimation results, reduced form model (standard errors in parentheses)

The empirical results of the reduced form are in accordance with our expectations: the income effect is positive and significantly so in both demand equations. The price effect is negative, as can be seen from the difference between the intercepts. The estimates of γ_{Y_w} and γ_Y have an opposite sign, as in the regime allocation equation (18). Moreover, γ_{Y_w} is slightly larger in absolute value than γ_Y, which was expected from the theoretical model as well. The covariances between the disturbance of the regime allocation equation and those of the demand equations are small and positive, though not significantly different from 0. The implied correlations are $\hat{\rho}_{\varepsilon_1\eta} = 0.14$ and $\hat{\rho}_{\varepsilon_2\eta} = 0.33$. Two restrictions implied by the structural model can be imposed on the reduced form directly, viz. $\alpha_Y = \alpha_{Y_w}$ and $\text{cov}(\varepsilon_1, \eta) = \text{cov}(\varepsilon_2, \eta)$. The resulting reduced form estimates are very similar to the ones reported in table 2 and the restrictions are not rejected as is seen from the likelihood-ratio test statistic $(LR = 4.70, \chi^2_{0.95}(2) = 5.99)$.

Parameter	Application costs	No application costs
δ_0	4.08	3.89
	(0.13)	(0.13)
β_1	0.079	0.065
	(0.0063)	(0.0069)
β_2	-1.50	-0.83
	(0.23)	(0.23)
C	1.03	-
	(0.050)	
σ_ζ	0.59	0.88
	(0.12)	(0.085)
σ_1	1.24	1.09
	(0.061)	(0.070)
σ_2	1.11	1.03
	(0.068)	(0.075)
σ_3	1.23	4.15
	(0.087)	(0.55)
S_N	4.74	265.95
Overidentifying restrictions	3	4

Table 3: Estimation results, structural model (standard errors in parentheses)

The parameter estimates for the structural model, obtained by minimum distance estimation, are given in table 3. The weighting matrix used is $A_N = \left(\operatorname{var}\hat{\theta}\right)^{-1}$.

We give estimates of the structural model both with and without application costs. If we estimate the structural model with $C = 0$ then the restrictions are rejected $(S_N = 265.95, \chi^2_{0.95}(4) = 9.47)$. Allowing for application costs yields larger estimates for the price and income effects and the remaining restrictions on the reduced form are not rejected ($S_N = 4.74, \chi^2_{0.95}(3) = 7.81$). The reason that the restrictions for the structural model without application costs are rejected is that the overidentifying restriction on the intercept of the regime allocation equation is rejected. As indicated above, no problems arise from the restrictions $\alpha_Y = \alpha_{Y_*}$ and $\text{cov}(\varepsilon_1, \eta) = \text{cov}(\varepsilon_2, \eta)$. Moreover, note that the estimate for the income effect based on γ_{Y_*} and γ_Y (see equation (21)) is 0.067, which is neatly between $\hat{\alpha}_Y$ and $\hat{\alpha}_{Y_*}$. Hence, the rejection of the restrictions is caused by rejection of the restriction on γ_0 and hence, by the restriction that there are no application costs ($C = 0$).

The implied price elasticity evaluated at the average rent and price ($R = 4.84$ and $p = 0.68$) equals -0.21[13] and the income elasticity evaluated at $R = 4.84$ and $Y = 22.93$ is 0.37. These estimates are both somewhat smaller in absolute value than the crude estimates obtained in section 4.2 but the differences are remarkably small. This can be partly explained by the small estimates of $\sigma_{\varepsilon_1\eta}$ and $\sigma_{\varepsilon_2\eta}$, since these imply that the biases due to self-selection are small.

The application costs C are large and significantly positive, as was expected. The estimated costs are Dfl. 1031, which is 18% of the average rent paid by RA-recipients and 51% of the average RA subsidy received. The estimates imply that 18% of the residual variance in the non-RA regime and 22% in the RA regime is explained by preference variation. We now turn to some implications of the estimates of the structural model.

6 Implications of the Estimates

In this section we use the structural model to

[13]In section 3.4 we introduced application costs to explain the partial take-up of RA-benefits. Strictly speaking application costs affect the demand for housing services in the RA regime, because they reduce the virtual income of the household. As a consequence the constant of the demand equation in the RA regime is $\delta_0 - \beta_1 C + \beta_2(1 - \delta)$. Hence, the estimate of the price effect reported in table 3 may be too small in absolute value. Because $\beta_1 C$ is very small, the potential bias is negligible.

1. Decompose the difference in average rent paid by RA and non-RA recipients observed in table 1.

2. Study housing consumption in the absence of RA.

3. Examine the effect of application costs.

Rents in counterfactual situations refer to utility-maximizing levels of housing consumption. On the assumption that the policies of the Dutch government are aimed at the satisfaction of demand at a fixed unit price of housing services, we can consider the outcomes as long-run equilibria.

The calculations in this section are refer to typical households, which represent subgroups in the population. These subgroups are identified by their regime choice and for the exogenous variables we take the average values in the chosen regime. For example RA-recipients are identified by $I = 1$ and have $Y = 20.83$ and $Y_v = 18.02$. Hence we may calculate the probability that a household with these average values of the income variables chooses a dwelling which entitles it to RA and the expected utility maximizing rent. Below, the subscript A indicates non-RA recipients, the subscript B indicates RA recipients and $\tilde{Y}$ and $\tilde{Y}_v$ indicate the income and virtual income in the regime allocation equation respectively.

6.1 Decomposition of the Difference

We first decompose the differences between the rents paid by a representative household which receives RA and a representative household which does not. These households differ in a number of ways. First, the RA household pays a lower price for housing services, but it also has a lower income due to the implicit entry fee. Moreover, an RA household is restricted in its choice to rents that exceed the norm rent R_n. These three differences reflect the incentives of the RA program. Second, as noted in table 1 the income of RA households is lower than that of non-RA households. Third, RA households have a stronger preference for housing services than non-RA households. We decompose the difference of the expected (utility-maximizing) rents between the two representa-

Price effect
$E\left(R_B \mid p=1-\delta, Y=\bar{Y}_{vB}, R_B > R_n, I=1, \tilde{Y}=\bar{Y}_B, \tilde{Y}_v=\bar{Y}_{vB}\right)$
$-E\left(R_B \mid p=1, Y=\bar{Y}_{vB}, R_B > R_n, I=1, \tilde{Y}=\bar{Y}_B, \tilde{Y}_v=\bar{Y}_{vB}\right)$
Entry fee
$E\left(R_B \mid p=1, Y=\bar{Y}_{vB}, R_B > R_n, I=1, \tilde{Y}=\bar{Y}_B, \tilde{Y}_v=\bar{Y}_{vB}\right)$
$-E\left(R_B \mid p=1, Y=\bar{Y}_B, R_B > R_n, I=1, \tilde{Y}=\bar{Y}_B, \tilde{Y}_v=\bar{Y}_{vB}\right)$
Truncation effect
$E\left(R_B \mid p=1, Y=\bar{Y}_B, R_B > R_n, I=1, \tilde{Y}=\bar{Y}_B, \tilde{Y}_v=\bar{Y}_{vB}\right)$
$-E\left(R_B \mid p=1, Y=\bar{Y}_B, I=1, \tilde{Y}=\bar{Y}_B, \tilde{Y}_v=\bar{Y}_{vB}\right)$
Income difference
$E\left(R_B \mid p=1, Y=\bar{Y}_B, I=1, \tilde{Y}=\bar{Y}_B, \tilde{Y}_v=\bar{Y}_{vB}\right)$
$-E\left(R_B \mid p=1, Y=\bar{Y}_A, I=1, \tilde{Y}=\bar{Y}_A, \tilde{Y}_v=\bar{Y}_{vA}\right)$
Preference heterogeneity
$E\left(R_B \mid p=1, Y=\bar{Y}_A, I=1, \tilde{Y}=\bar{Y}_A, \tilde{Y}_v=\bar{Y}_{vA}\right)$
$-E\left(R_A \mid p=1, Y=\bar{Y}_A, I=0, \tilde{Y}=\bar{Y}_A, \tilde{Y}_v=\bar{Y}_{vA}\right)$
Total difference
$E\left(R_B \mid p=1-\delta, Y=\bar{Y}_{vB}, R_B > R_n, I=1, \tilde{Y}=\bar{Y}_B, \tilde{Y}_v=\bar{Y}_{vB}\right)$
$-E\left(R_A \mid p=1, Y=\bar{Y}_{vA}, \tilde{Y}=\bar{Y}_A, \tilde{Y}_v=\bar{Y}_{vA}\right)$

Table 4: Decomposition of rent difference

Price effect	5.78 - 5.15	0.63
Entry fee	5.15 - 5.24	-0.09
Truncation effect	5.24 - 4.44	0.80
Income difference	4.44 - 4.83	-0.39
Preference heterogeneity	4.83 - 4.15	0.68
Total difference	5.78 - 4.15	1.63

Table 5: Results of the rent difference decomposition

Probability of using RA $\Pr\left(I=1 \mid C, \bar{Y}, \bar{Y}_v\right)$	0.35
Expected rent	4.66
Probability of RA, no transaction costs ($C=0$)	0.66
Expected rent	5.02
Probability of RA, no transaction costs ($\sigma_3^2=0$)	0.87
Expected rent	5.18

Table 6: Probability of taking up RA for an average household in the sample, and the expected utility maximizing rent

tive households which is equal to Dfl. 1630[14], into a program effect, that consists of three parts, an income effect and a preference heterogeneity effect. The results are reported in table 5. We see that quantitively the most important effect is the truncation effect, which exerts a large upward effect on the rents in the RA regime. The other most important effects are the preference heterogeneity effect (hence, the RA recipients have a relative preference for housing) and the price effect.

6.2 Housing Consumption in the Absence of RA

The effect of the elimination of RA on a representative RA household is equal to the sum of the three program effects reported in table 4. Housing consumption would be reduced by Dfl. 1340 (23%), from Dfl. 5780 to Dfl. 4440. The fraction of income spent on housing would change from 25.3% to 21.3%. It is clear that the RA program has a large positive effect on housing demand.

6.3 The Effect of Application Costs

In section 3 we discussed the effects of application costs on housing demand. Armed with the estimates of our structural model, we are able to quantify the effect of application costs. In table 6 we consider the average household in our sample, *i.e.*, the household with average values of Y and Y_v. We find the effect of application costs by setting $C = 0$. If we interpret v_3 as unobserved heterogeneity in C, then elimination of application costs would also imply $v_3 \equiv 0$. Hence, in table 6 we also compute the probability of taking up RA if $\sigma_3^2 = 0$. In that table, we also give the expected rents under these hypotheses, computed by

$$\begin{aligned} E(R) &= E(R_A \mid I = 0)\Pr(I = 0) \\ &+ E(R_B \mid R_B > R_n, I = 1)\Pr(I = 1). \end{aligned}$$

[14]This difference is larger than that reported in table 1. The measurement of the effects is listed in table 4. This is due to the non-linearity of the model. To obtain the difference of table 1 we have to simulate over the sample.

Probability of RA $\Pr\left(I=1 \mid C, \bar{Y}, Y_v, R_A > R_n\right)$	0.44
Probability of RA, no transaction costs ($C=0$)	0.74
Probability of RA, no transaction costs ($\sigma_3^2=0$)	0.97

Table 7: Probability of taking up RA for a household with income equal to the average income of households which do not take up their benefit

In table 7 we concentrate on households with rents that entitle them to RA. If application costs were eliminated, almost all these households would use their entitlement.

7 Summary and Conclusions

We have developed and estimated a structural model of rental housing demand, and we have used this model to study the impact of a rent subsidy program on the demand for rental housing. Recently, the credibility of structural estimates of program effects has been questioned. Some researchers have taken the position that only (quasi-) experimental approaches can yield valid estimates of effects. Although this discussion has focused correctly on the weak points of structural methods, it is our opinion that the structural approach, if applied carefully, can yield valuable insights into the working of social programs.

For that reason we have chosen not to impose the restrictions implied by our structural model. Instead, we have tested these restrictions against a reduced form, and we have concluded that the restrictions are not rejected by the data. The only assumptions we have not tested are the distributional assumptions with respect to the parameter heterogeneity and the disturbances in the demand and regime allocation equations. However, before we test these it is important to study the identifiability of these distributions. The problem is somewhat similar to the identification problem in the Roy model that has been studied recently by Heckman and Honoré (1990). We leave this to future work.

In section 6 we have shown that the structural model allows us to study a variety of interesting questions related to the Rent Assistance program. In that section we have only taken a first step. An open question, which has not been answered, is how effective RA is in stimulating housing consumption or as a income support program, both stated goals of the program.

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A Selection of Households

In the empirical analysis, we did not use all cases of the Housing Needs Survey 1985/86. The cases used satisfied the following criteria:

1. the household is the main occupant of the dwelling;
2. the dwelling is not used for business purposes (not a farm, shop, etc.);
3. the respondent is reasonably satisfied with the dwelling and the neighbourhood;
4. the household has no intentions of moving within the next two years;
5. the household is a single person household or a couple with or without with children;
6. the head of the household is not self-employed;
7. the household occupies a rental dwelling;
8. the income data of the household are valid as checked by the Central Bureau of Statistics;
9. taxable income of the household in 1984 exceeds Dfl. 10000;
10. rent in 1985 exceeds Dfl. 1200;
11. the household has moved in the period 1982-1986;
12. on the basis of its income the household is eligible for RA;

13. rent paid is less than the maximum rent;
14. the household does not receive RA while our simulation program indicates that the household is not entitled to RA;
15. the respondent is either the head of the household or his/her partner;
16. households taxable income in 1984 was below Dfl. 31000 for households with one member or Dfl. 35000 for households with two or more members.

B Restrictions Implied by the Structural Model

Let θ be the vector of parameters of the reduced form model and ψ be the vector of parameters of the structural model:

$$\theta = (\alpha_0 \quad \alpha_Y \quad \alpha_1 \quad \alpha_{Y_v} \quad \gamma_0 \quad \gamma_{Y_v} \quad \gamma_Y \quad \sigma_{\varepsilon_1\eta} \quad \sigma_{\varepsilon_2\eta} \quad \sigma_{\varepsilon_1} \quad \sigma_{\varepsilon_2})'$$
$$\psi = (\delta_0 \quad \beta_1 \quad \beta_2 \quad C \quad \sigma_\zeta \quad \sigma_1 \quad \sigma_2 \quad \sigma_3)'$$

The relations between the reduced form parameters and the structural parameters are given by:

$$\alpha_0 = \delta_0 + \beta_2 \tag{B-1}$$
$$\alpha_Y = \beta_1 \tag{B-2}$$
$$\alpha_1 = \delta_0 + \beta_2(1-\delta) \tag{B-3}$$
$$\alpha_{Y_v} = \beta_1 \tag{B-4}$$
$$\gamma_0 = \left(\left(\frac{\beta_2}{\beta_1}(1-\delta) + \frac{\beta_2}{\beta_1^2} + \frac{\delta_0}{\beta_1} \right) \exp(-\beta_1(1-\delta)) - \left(\frac{\beta_2}{\beta_1} + \frac{\beta_2}{\beta_1^2} + \frac{\delta_0}{\beta_1} \right) \exp(-\beta_1) - \exp(-\beta_1(1-\delta))C \right) \Bigg/ \sqrt{\sigma_\zeta^2 \left(\frac{\exp(-\beta_1(1-\delta) - \exp(-\beta_1)}{\beta_1} \right)^2 + \sigma_3^2} \tag{B-5}$$

$$\gamma_{Y_w} = \frac{\exp(-\beta_1(1-\delta))}{\sqrt{\sigma_\zeta^2\left(\frac{\exp(-\beta_1(1-\delta)-\exp(-\beta_1)}{\beta_1}\right)^2+\sigma_3^2}} \tag{B-6}$$

$$\gamma_Y = -\frac{\exp(-\beta_1)}{\sqrt{\sigma_\zeta^2\left(\frac{\exp(-\beta_1(1-\delta)-\exp(-\beta_1)}{\beta_1}\right)^2+\sigma_3^2}} \tag{B-7}$$

$$\sigma_{\varepsilon_1}^2 = \sigma_\zeta^2 + \sigma_1^2 \tag{B-8}$$

$$\sigma_{\varepsilon_2}^2 = \sigma_\zeta^2 + \sigma_2^2 \tag{B-9}$$

$$\sigma_{\varepsilon_1\eta} = \sigma_\zeta^2\left(\frac{\exp(-\beta_1(1-\delta)) - \exp(-\beta_1)}{\beta_1}\right) \tag{B-10}$$

$$\sigma_{\varepsilon_2\eta} = \sigma_\zeta^2\left(\frac{\exp(-\beta_1(1-\delta)) - \exp(-\beta_1)}{\beta_1}\right) \tag{B-11}$$

C Details of the Loglikelihood

The demand model in section 5 is

$$R_i = \begin{cases} \alpha_1' z_{1i} + \varepsilon_{1i} & I_i = 0 \\ \alpha_2' z_{2i} + \varepsilon_{2i} > R_{ni} & I_i = 1 \end{cases} \tag{C-1}$$

$$I_i^* = \gamma' z_{3i} + \eta_i \tag{C-2}$$

$$I_i = \begin{cases} 0 & I_i^* < 0 \\ 1 & I_i^* \geq 0 \end{cases}$$

where the vector z_{1i} contains the regressors of the demand equation for non-recipients, etc.

The vector $(\,\varepsilon_{1i} \quad \varepsilon_{2i} \quad \eta_i\,)'$ is normally distributed:

$$\begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \eta \end{pmatrix} \sim \mathcal{N}\left(0, \begin{pmatrix} \sigma_1^2 & \cdot & \sigma_{\varepsilon\eta} \\ & \sigma_2^2 & \sigma_{\varepsilon\eta} \\ & & 1 \end{pmatrix}\right).$$

The loglikelihood is now given by:

$$\ell(\theta) = \sum_{I_i=0} \left(\log f_{\varepsilon_1}(R_i - \bar{R}_{Ai}) + \log \Pr(\eta < -\bar{I}_i \mid \varepsilon_1 = R_i - \bar{R}_{Ai})\right)$$

$$
\begin{aligned}
&+\sum_{I_i=1}\Big(\log f_{\varepsilon_2}(R_i-\bar{R}_{Bi})\\
&\quad+\log \Pr(\eta\geq -\bar{I}_i \mid \varepsilon_2=R_i-\bar{R}_{Bi})\\
&\quad-\log \Pr(\bar{R}_{Bi}+\varepsilon_2\geq R_{ni},\eta\geq -\bar{I}_i)+\log \Pr(\eta\geq -\bar{I}_i)\Big)\\
&=\sum_{I_i=0}\Bigg(\log \frac{1}{\sigma_1}\phi\left((R_i-\bar{R}_{Ai})/\sigma_1\right)\\
&\quad+\log\Phi\left(\frac{-\bar{I}_i-\frac{\sigma_{\varepsilon\eta}}{\sigma_1^2}(R_i-\bar{R}_{Ai})}{\sqrt{1-\rho^2}}\right)\Bigg)\\
&\quad+\sum_{I_i=1}\Bigg(\log \frac{1}{\sigma_2}\phi\left((R_i-\bar{R}_{Bi})/\sigma_2\right)\\
&\quad+\log\Phi\left(-\frac{-\bar{I}_i-\frac{\sigma_{\varepsilon\eta}}{\sigma_2^2}(R_i-\bar{R}_{Bi})}{\sqrt{1-\rho^2}}\right)\\
&\quad-\log\left[1-\Phi((R_{ni}-\bar{R}_{Bi})/\sigma_2)-\Phi(-\bar{I}_i)\right.\\
&\quad\left.+\Phi_2\left((R_{ni}-\bar{R}_{Bi})/\sigma_2,-\bar{I}_i;\rho\right)\right]+\log\Phi(\bar{I}_i)\Bigg).
\end{aligned}
\tag{C-3}
$$

Here, $\phi(\cdot)$ denotes, the standard normal density function, $\Phi(\cdot)$ the standard normal distribution function and $\Phi_2(\cdot,\cdot;\rho)$ is the bivariate standard normal distribution function with correlation parameter ρ.

D Conditional Expectations

The conditional expectations in both demand regimes are given by:

$$
E\left(R_A \mid \eta<-\bar{I}\right)=\bar{R}_A+E\left(\varepsilon_1 \mid \eta<-\bar{I}\right)=\bar{R}_A-\sigma_{\varepsilon\eta}\frac{\phi(\bar{I})}{\Phi(\bar{I})} \tag{D-1}
$$

$$
\begin{aligned}
&E\left(R_B \mid \eta\geq -\bar{I},\varepsilon_2\geq R_n-\bar{R}_B\right)\\
&\quad=\bar{R}_B+E\left(\varepsilon_2 \mid \eta\geq -\bar{I},\varepsilon_2\geq R_n-\bar{R}_B\right)\\
&\quad=\bar{R}_B+\sigma_2\frac{\phi\left(\frac{R_n-\bar{R}_B}{\sigma_2}\right)}{\Pr(\eta\geq -\bar{I},\varepsilon_2\geq R_n-\bar{R}_B)}\times
\end{aligned}
$$

$$
\left(1-\Phi\left(\frac{-\bar{I}-\rho_{\varepsilon_2\eta}\frac{R_n-\bar{R}_B}{\sigma_2}}{\sqrt{1-\rho^2_{\varepsilon_2\eta}}}\right)\right)
$$

$$
+\sigma_{\varepsilon\eta}\frac{\phi(-\bar{I})}{\Pr(\eta\geq-\bar{I},\varepsilon_2\geq R_n-\bar{R}_B)}\times
$$

$$
\left(1-\Phi\left(\frac{\frac{R_n-\bar{R}_B}{\sigma_2}-\rho_{\varepsilon_2\eta}\cdot(-\bar{I})}{\sqrt{1-\rho^2_{\varepsilon_2\eta}}}\right)\right)
$$

$$
=\bar{R}_B+\sigma_2\frac{\phi\left(\frac{R_n-\bar{R}_B}{\sigma_2}\right)}{\Pr(\eta\geq-\bar{I},\varepsilon_2\geq R_n-\bar{R}_B)}\Phi\left(\frac{\bar{I}+\rho_{\varepsilon_2\eta}\frac{R_n-\bar{R}_B}{\sigma_2}}{\sqrt{1-\rho^2_{\varepsilon_2\eta}}}\right)
$$

$$
+\sigma_{\varepsilon\eta}\frac{\phi(-\bar{I})}{\Pr(\eta\geq-\bar{I},\varepsilon_2\geq R_n-\bar{R}_B)}\Phi\left(-\frac{\frac{R_n-\bar{R}_B}{\sigma_2}+\rho_{\varepsilon_2\eta}\bar{I}}{\sqrt{1-\rho^2_{\varepsilon_2\eta}}}\right) \quad \text{(D-2)}
$$

(see Pudney (1989), Appendix 2, equation (A2.57)). Of course, the last equation contains two correction terms, the first reflects the truncation $R_B > R_n$ and the second reflects the endogeneity of the regime.

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