A METHODOLOGY FOR CALCULATING THE STOCK-TRANSFER PRICE ELASTICITY OF SUPPLY
With An Application To The English Private Rented Sector

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Abstract:

This paper develops a methodology for estimating the stock transfer price elasticity of supply (STPES). Traditionally, housing supply has been viewed as arising from either additions/modifications to the existing stock, or from more intensive use of that stock. However, in countries like the UK where transfer of stock between tenures has been a critical element of market adjustment, an important component of supply response is overlooked by these traditional approaches. Using a two period model of supply adjustment through stock transfer, a formula is derived which allows STPES to be calculated from measurable parameters. The methodology is applied using the longitudinal element of the English House Condition Survey which traces the tenure movements of five thousand dwellings between 1991 and 1996. An econometric system is developed which controls for a variety of determinants of stock transfer and from which STPES is computed. A range of STPES estimates are presented, with a mean value of 0.6 for estimates derived from the preferred regressions. Policy implications of the results are discussed in the context of the anticipated outward shift of UK housing demand. It is concluded that the inelasticity suggested by the findings is likely to inhibit labor mobility, inflate the Housing Benefit bill, and reduce labour supply incentives of low income groups.

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Introduction

This paper presents a methodology for estimating the stock transfer price elasticity of supply (STPES), a component of the price elasticity of supply that has so far been overlooked in the real estate literature. Supply response has traditionally been viewed as arising either from more intensive use of the existing stock (Rydell, 1982), or from physical changes or additions to the housing stock, including repairs and improvements (Ingram and Oran, 1977; Arnott, Davidson and Pines, 1985; O'Zanne and Struck, 1978), and new construction (Whitehead, 1974; Mayes, 1979; Topel and Rosen, 1988; Meen, 1996; Bramley, 1993; Pryce, 1999a). However, an important element of total supply response is that of movements between tenures of the existing housing stock. Ignorance of this effect can only be justified if one is exclusively interested in the total housing stock, summed across all tenures. The great majority of econometric supply studies, however, have focused on a single housing tenure, and so this oversight cannot typically be justified.

A possible justification is that the transfer of stock relates only to temporary, short run movements, and so is of little significance. However, the UK experience has shown that stock transfer can have an important role in the long-run structure of housing tenure. For example, Kemp (1988) notes that 'between 1914 and 1975, 3.7 million dwellings were sold by private landlords to owner occupiers. This accounted for two thirds (67 per cent) of the loss of dwellings over the period and, conversely for about one third of the growth of owner occupation'.

Moreover, in countries where one form of tenure is so small as to constitute a residual sector, stock transfer may actually form the dominant component of supply response in that sector. In the UK the private rented sector (PRS) is now by far the smallest of the three main tenures, comprising less than 5 per cent of total tenure in some areas, with a national average of around ten per cent (Wilcox, 1998). Because of the diminutive scale of the PRS, the level of new construction specifically for private renting is now so small as to be barely detectable, and quantity adjustments to movements in PRS demand and supply arise almost entirely from stock transfer.

A methodology that allows the estimation of the stock transfer price elasticity of supply is therefore of greatest utility in countries where there exists a tenure for which there is little or no new construction. Where the tenure structure is more evenly balanced, the stock-transfer price elasticity of supply forms one component of the total PRS supply elasticity, to which other components (such as the new-construction price elasticity of PRS supply), can be computed separately using traditional methods, and added to the stock-transfer elasticity to construct a composite measure.

This paper aims to provide a new method for calculating the stock transfer that will facilitate empirical estimation, and to apply this method to the English PRS. I begin with a brief overview of the existing supply literature. A theory of stock transfer is then developed that yields an equation for the STPES. The theory demonstrates how *flow* elasticities (the responsiveness of the probability of inflow/outflow to rent) can be used to derive a *stock* elasticity (responsiveness of the stock of PRS dwellings to rent). The third section develops an econometric model that will estimate the components for calculating the STPES. The following two sections discuss the data and results, respectively, of the empirical application. Implications of the elasticity estimates for housing policy are then discussed and the main findings summarized.

Previous Literature

I shall not present a detailed analysis of the supply elasticity literature here since a number of recent reviews already exist (Bramley *et al* 1999; special issue of *Netherlands Journal of Housing and the Built Environment,* 1998; and Bartlett, 1989). It is suffice to say that these reviews demonstrate unequivocally the scarcity of supply side estimates as a whole, and the near famine of *PRS* supply estimates in particular. The bulk of supply research relates to the owner occupied sector, and the majority are for new housing construction, usually using UK or US data. The UK estimates (Whitehead, 1974: 0.5; Mayes, 1979: 0.55; Bramley, 1993: 0.8; Meen, 1996: 0.4; Pryce, 1999a: 0.58 to1.03) have tended to suggest that supply is inelastic, whereas the US estimates (Poterba, 1984: 2.3; Kearl, 1979: 1.6; Huang, 1973: 2.0; Topel and Rosen, 1988: 3.0) have tended to indicate relatively elastic supply. One commonly suggested explanation for the inelasticity of supply in the UK is that housing construction is particularly constrained by land availability problems, due in part to a sluggish planning system.

New construction elasticity estimates are of little use, however, in gauging the elasticity of PRS supply, particularly in countries such as the UK where changes in the PRS stock arise almost entirely from transfer of dwellings between tenures. Over the past fifty years the net transfer into the PRS has been negative in most years, partly due to the regulation of rents up to a decade ago, and the subsidization of owner occupancy, and partly due to unfavorable public perceptions of renting and the promotion of a 'property owning democracy' as a cornerstone of public policy. The fact that new construction elasticities are so dependent on the planning regime suggests that they have a tenuous and ambiguous link to the main sources of PRS supply: the decisions of owner occupiers to become landlords, and the decisions of existing landlords to increase or diminish their stock of properties, are only affected indirectly by new construction, through its impact on rents and prices. Although much work has been done elsewhere to explain the tenure decisions of households (Englund and Persson, 1982; Henderson and Ioannides, 1986; etc.), this literature focuses almost exclusively on the demand side. The selling or renting-out decisions of property owners are invariably overlooked, even though supply and demand simultaneously determine rents and quantity.

Few empirical estimates of the *private rented sector* supply elasticity currently exist. Crook et al (1995) offer a 'guestimate' of 0.2 for the UK, based loosely on the Scottish Landlord Survery. Preliminary regressions (which formed the starting point for the research presented here) listed in Bramley et al (1999) suggested an elasticity of less than 0.1. This contrasts with the assumed baseline value of 2.0 in the Social Housing Need model developed for the UK government by the University of Cambridge (DETR, 1997).

A number of PRS supply studies have been carried out in the US, including papers by De Leeuw and Ekanem (1971) and Di Pasquali and Wheaton (1992). The latter is a time series study from which a thirty year rental elasticity of new construction is estimated at 6.8. The techniques used by Di Pasquali and Wheaton, however, may not be directly applicable to many countries currently devoid of estimates because data limitations will preclude time-series estimation. In the UK, for example, the regulation of rents up to 1989 means that no meaningful time-series analysis can be done on data collected before this date, and there are insufficient data points to carry out the analysis on subsequent years.

For the foreseeable future, therefore, the only option for analysis of the private rented sector in the UK will be to use cross sectional and longitudinal data. Researchers using cross sectional methods, such as De Leeuw and Ekanem (1971, p. 806), have argued that data from cross sections of residential areas yield the required long run supply elasticity since "studying differences among cities amounts to studying how housing markets behave in the long run, in the sense of having had ample time to adjust to basic market forces. The reason is that differences among cities in size, costs, tax rates, real income and so on tend to persist for years or even decades". They arrive at supply elasticities ranging from 0.3 to 0.7, which is considerably lower than other ranges estimated in the US using time-series methods. Bartlett (1989, p.39) argues that the inelastic supply estimates may be due to the cross section method failing to capture "long-run" values of the variables: "it is rather implausible that all agents are operating at along run equilibrium values, and so the estimated equation is likely to be a hybrid measure of an unknown combination of short and long run effects."

Time series estimates of long run elasticities have their drawbacks of their own, however. It is ambiguous what the true long run elasticity means in practice, since it may never be reached within a given cyclical or policy time-frame, and so long run estimates may be of no practicable purpose. On this basis, Pryce (1999a) and others has argued that intermediate elasticities may actually be more relevant to policy makers. Although the elasticities calculated in this paper are based on longitudinal data, they are more akin to cross-sectional estimates than time-series, and so the arguments put forward by De Leeuw and Ekanem (1971) and Pryce (1999a) combine to provide an important motivation for their usefulness.

Two Period Model of the Stock Transfer Price Elasticity of Supply

STPES measures the responsiveness of the supply of dwellings in the PRS to rents, and can be calculated by dividing the proportionate change in the PRS stock *due to a rent change*, by the proportionate change in rent:

$$\eta = \frac{\%\Delta Q^{PRS:r}}{\%\Delta r}, \qquad [\ 1]$$

where,

$$\%\Delta Q^{PRS:r} = \frac{\Delta Q^{PRS:r}}{Q_2^{PRS*}} = \frac{\Delta \text{ PRS stock due to the change in rent between periods 1 and 2}}{\text{size of period 2 PRS stock if there were no rent change}}.$$

(An asterisk denotes that a variable relates to the hypothetical scenario that there is no rent change between the two periods – an essential component of the calculation of an elasticity). Note that $\Delta Q^{PRS:r}$ (the change in PRS stock due to the rent change) has to be distinguished from the total change in PRS stock between the two periods because some of the total change would have occurred even if there were no change in rents because of non-price determinants of supply. Therefore, sound calculation of $\Delta Q^{PRS:r}$ has to be based on a method which strips away perturbations of the PRS stock due to non-price factors. Achieving this in practice, however, is not straight forward.

One solution is to define the term, $\Delta Q^{PRS:r}$, as the difference between $Q^{PRS}{}_2$, the actual stock of private rented dwellings in period two (allowing for the influence of, *inter alia*, changes in rent), less $Q^{PRS*}{}_2$, what the stock of PRS dwellings would be in period two if there were no rent change:

$$\Delta Q^{PRS:r} = \quad Q^{PRS}{}_2 - Q^{PRS*}{}_2\,. \qquad [2]$$

The challenge now is to write $Q^{PRS*}{}_2$ as a function of variables and parameters that can be measured or estimated using longitudinal data sets. Defining $Q^{PRS*}{}_2$ as the period one PRS stock ($Q^{PRS}{}_1$) plus the inflow of dwellings that would have arisen if there were no rent change (f_i*) less the outflows if there were no rent change (f_o*), we have:

$$Q^{PRS*}{}_2 = Q^{PRS}{}_1 + f_i^* - f_o^*, \qquad [3]$$

I shall now show that f_i* and f_o* can be derived from measurable determinants.

Inflows and Outflows Assuming No Rent Change

First, consider f_i*, the inflow to the PRS stock if there were no rent change. Let p_i* be the probability (if there were no change in rent) that a standardised dwelling k, transfers from owner occupancy in period one to the PRS in period two:

$$p_i^* = \text{Prob}\ (k^{OO}{}_1 \rightarrow k^{PRS}{}_2 \mid \text{no change in rent}).$$

Similarly, p_i is the probability that a standardised dwelling k, transfers from owner occupancy to the PRS allowing for the effect of all changes in determinants, including rent:

$$p_i = \text{Prob}\ (k^{OO}{}_1 \rightarrow k^{PRS}{}_2).$$

One of the parameters that can be estimated from the application of econometric techniques to longitudinal dwelling data, is the inflow probability elasticity with respect to rent, η_{pi}. This measures the responsiveness of p_i to changes in rent. η_{pi} can be defined as the proportionate change in the inflow probability due to the change in rent ($\%\Delta p_{i:r}$), divided by the proportionate change in rent:

$\eta_{pi} \; = \; \%\Delta p_{i:r} \, / \, \% \, \Delta r.$

This is useful because we can write f_i* as a function of f_i and $\%\Delta p_{i:r}$, and then replace $\%\Delta p_{i:r}$ with $\%\Delta r \, \eta_{pi}$, to give a definition of f_i* that uses only measurable arguments (the mathematical workings are given in Appendix 1):

$$f_i^* = f_i \, / \, (1 \; + \; \%\Delta r \; \eta_{pi}). \qquad [4]$$

An equivalent procedure results in a comparable expression for outflows:

$$f_o^* \; = f_o \, / \, (1 \; + \; \%\Delta r \; \eta_{po}). \qquad [5]$$

These equations for f_i* and f_o* can then be substituted back into the equation for the no-rent change PRS stock in period 2 (equation [3]), which in turn can be substituted back into the equation for the change in PRS stock due changes in rent (equation [2]), and finally into the initial definition of the stock transfer own price elasticity of supply (equation [1]). Rearranging yields:

$$\eta = \frac{Q^{PRS}{}_2 - Q^{PRS}{}_1 - \dfrac{f_i}{(1+\eta_{pi}\%\Delta r)} + \dfrac{f_o}{(1+\eta_{po}\%\Delta r)}}{\%\Delta r\left(Q^{PRS}{}_1 + \dfrac{f_i}{(1+\eta_{pi}\%\Delta r)} - \dfrac{f_o}{(1+\eta_{po}\%\Delta r)}\right)}. \qquad [6]$$

This gives us an equation for η where all the variables and parameters on the RHS can be estimated from a longitudinal data set which traces dwellings over time.

The Econometrics of Stock Transfer

Consider, now, the derivation of empirical estimates of the various components of the stock transfer equation. Most of the parameters ($Q^{\mathrm{PRS}}{}_2$, $Q^{\mathrm{PRS}}{}_1$, f_i, f_o and $\%\Delta r$) can be computed directly from the data, but for the estimation of the inflow and outflow supply elasticities η_{pi} and η_{po}, an econometric model is needed that will yield estimates of the responsiveness of transfer probabilities p_i and p_o to changes in rent, whilst controlling for all other relevant factors. I shall first consider the determination of inflows, then of outflows, and then the possible structure of an econometric system that encapsulates both sources of stock transfer.

Inflow

In order for a dwelling to move from owner occupancy into the PRS, there has to be some economic incentive for the owner occupier of the dwelling in period one to change from being an implicit landlord (supplying housing services only to his/her household) to an explicit one (supplying housing services to an external household). Otherwise, owner occupiers who wish to move will sell their dwellings and the only way the property will enter the PRS is if it is purchased by an existing landlord. Figure 1 depicts the decision to by owner occupiers in period 1 whether to move and sell, *S;* to move and let , *L;* or to remain in their dwelling, $\varnothing$. p_1 is the probability that the owner occupier of dwelling k in period 1 decides to sell the dwelling; p_2 is the probability that the owner decides to move and let property k; p_3 is the probability that the owner remains in the dwelling (and hence does not sell or let); p_4 is the probability that, if the dwelling is offered for sale, the dwelling is purchased by a landlord, D_L. The remaining possibility is that, if the dwelling is offered for sale, it is purchased by another owner occupier, D_{OO} (probability = 1- p_4).

[Figure 1 pi :Inflow Probability (of *kOO1 → kPRS2)*]

It can be seen from the diagram that there are two possible final outcomes for dwelling k: either it remains in owner occupancy (because the owner decides not to move, or because she decides to sell and the dwelling is purchased by another owner occupier), or it transfers to the private rented sector. The probability of a dwelling k transferring from owner occupancy to private renting, $p_i = \text{Prob}(k_{\text{OO1}} \rightarrow k_{\text{PRS2}})$, is given by,

$$p_i = p_2 + p_1(p_4).$$

The expected utilities to j_{k1}, the initial owner occupier of dwelling k in period one, of selling, letting and staying are denoted by u_j^S, u_j^L, and $u_j^{\varnothing}$, respectively, and it is these which drive the probabilities associated with each of the outcomes:

$$p_1 = \text{Prob}(u_j^S > u_j^L) \cap \text{Prob}(u_j^S > u_j^{\varnothing}) = p_1(u_j^S, u_j^L, u_j^{\varnothing});$$

$$p_2 = \text{Prob}(u_j^L > u_j^S) \cap \text{Prob}(u_j^L > u_j^{\varnothing}) = p_2(u_j^S, u_j^L, u_j^{\varnothing});$$

$$p_4 = \text{Prob}(D_L) = p_4(u_j^S, u_j^L, u_j^{\varnothing}).$$

The utilities are in turn determined by a range of factors: $u_j^S = u_j^S(P, X, Z)$; $u_j^L = u_j^L(R, X, Z)$; $u_j^{\varnothing} = u_j^{\varnothing}(X, Z, M)$; where,

P = expected house price or expected capital gain,

X_j = characteristics of owner preferences/utility map,

Z_j = desire to move,

R = expected income stream in period 2 from renting,

It can be seen that the probability of a dwelling transferring into the PRS is ultimately dependent on these factors: $p_i = p_i(P, X, R, Z)$. However, p_i is not the only endogenous variable – P and R are also determined within the system:

$$P = P(P, X, R, Z, K^{PC}, Y^{PC}, L^M),$$

$$R = R(P, X, R, Z, K^{PC}, Y^{PC}, L^M),$$

where Y^{PC} is income per head, K^{PC} is the local stock of housing per head, and L^M denotes labour market characteristics.

Outflow

Now consider the possibility of dwellings moving out of the PRS into owner occupancy. This time we are interested in what determines the supply decision of landlords and how this interacts with local demand for OO and PRS tenures. Again there will be demand and supply factors to consider. The level of demand for owner occupied housing in an area will be driven by a range of variables including house prices, rents, household income, labour market factors, and the total number of dwellings per capita. Regarding supply, because the EHCS provides little data on the characteristics of private landlords, we are limited in the extent to which we can model the outflow supply decision. However, since we are only interested in how the outflow supply responds to rent, provided we can control for the effect of house prices and demand factors, it should be possible to arrive at a reliable estimate of the required elasticity. Outflow supply, then, is assumed to be determined by house prices, and rents. This is demonstrated in Figure 2 where it can be seen that p_o the probability of $k_{PRS1} \rightarrow k_{OO2}$ is given by,

$$p_o = q_2 + q_1 q_3$$

where q_1 is the probability that the landlord sells, S; q_2 the probability that he continues letting out the property, L; and q_3 is the probability of selling the property to an owner occupier once the property has been put on the market, D_{OO}. The expected profits to l_{k1} (the landlord of dwelling k in period one) are denoted by π_l^S and π_l^L, for selling and letting respectively, and it is these which drive the probabilities associated with each of the outcomes:

$$q_1 = 1\text{-}q_2 = q_1(\pi_l^S, \pi_l^L);$$

$$q_2 = \text{Prob}\,(\pi_l^L > \pi_l^S) = q_2(\pi_l^S, \pi_l^L),$$

$$q_3 = \text{Prob}(D_L) = p_4 = q_3(\pi_l^S, \pi_l^L),$$

The expected profits are determined as follows: $\pi_l^S = \pi_l^S\,(P)$; $\pi_l^L = \pi_l^L\,(R)$. Therefore, $p_o = p_o(P, R)$, where P and R are again endogenous.

[Figure 2 po: Outflow Probability (of *kPRS1* $\rightarrow$ *kOO2* = *q2* + *q1q3*)]

Having analyzed determination of p_i and p_o, we now need to construct an econometric system that will allow us to estimate η_{pi} and η_{po} – the responsiveness of p_i and p_o respectively to changes in rent, holding everything else constant.

Econometric System

Because p_i and p_o (along with rent), are both determined by demand and supply, an empirical model has to be developed that takes into account the interaction of both sides of the market for each probability. If we attempt to estimate either an inflow or outflow supply function directly, without controlling for demand, we will not be able to disentangle the effect of demand factors on the estimated parameters, and so the inferred elasticity of supply will be meaningless. Thus, the determination of p_o and p_i can be described in terms of two sets of demand and supply structural equations, and a common fifth equation for house prices/expected capital gain:

Inflow demand: $p_i = \alpha_0 + \alpha_1 R + \alpha_2 P + \alpha_3 K^{PC} + \alpha_4 \mathrm{Y}^{\mathrm{PC}} + \alpha_5 L^M;$

Inflow supply: $p_i = \beta_0 + \beta_1 R + \beta_2 P + \beta_3 Z + \sum_w \beta_w X_w;$

Outflow demand: $\mathrm{p}_o = \mathrm{a}_0 + \mathrm{a}_1 R + \mathrm{a}_2 P + \mathrm{a}_3 K^{PC} + \mathrm{a}_4 \mathrm{Y}^{\mathrm{PC}} + \mathrm{a}_5 L^M;$

Outflow supply: $p_o = \mathrm{b}_0 + \mathrm{b}_1 R + \mathrm{b}_2 P;$

House price: $P = \gamma_0 + \gamma_1 P + \gamma_2 X + \gamma_3 R + \gamma_4 Z + \gamma_5 Y^{PC} + \gamma_6 K^{PC} + \gamma_7 L^M.$

Estimation of the inflow and outflow structural supply equations will yield estimated coefficients on rent, from which η_{pi} and η_{po} (the inflow and outflow elasticities) can be calculated as follows: $\eta_{pi} = (\partial p_i / \partial R)(R/p_i)$; and $\eta_{po} = (\partial p_o / \partial R)(R/p_o)$. I now go on to apply this methodology to the UK private rented sector.

Data

The EHCS longitudinal data set traces 4,937 dwellings over time (two waves: 1991 and 1996), of which deregulated private renting constituted only 2.1% of the total stock in 1991 and 2.4% in 1992. Of the 119 deregulated PRS dwellings recorded in 1996, 44 of them had previously been OO in 1991. Of the 2,724 dwellings owner occupied in 1991, just under 2% transferred into private renting over the period. Thus, we know the net flows that have arisen between 1991 and 1996 in the presence of rent changes, but we do not know the size of flows that would have arisen if rents had been held completely constant, hence the need for the econometric methodology described above.

Table 1 shows the list of variables used in the econometric model and how they were constructed from the available data. Expected capital gains are used as a measure of the *P* variable rather than price because attempts at constructing a hedonic price variable proved unsuccessful. This is largely because creation of a hedonic index that reflects regional variations was hindered by the fact that the EHCS data is based on a survey, not transactions records, and so the current market price is not available. The EHCS does, however, record the original price paid and also the owner’s expected current price, but both of these proved to have only a very weak relationship with characteristics. Although variations in the price caused by errors in owner's estimate of the market value seem to dominate variations in the price caused by heterogeneous dwelling characteristics, errors in the owners estimate appear to be less deleterious to the measurement of estimated capital gain (estimated current price less original price paid). Thus, the average expected captial gain across localities produced more meaningful spatial variation than hedonic house prices. Attempts were also made to construct a hedonic house price using external data (Council for Mortgage Lenders 5% sample of mortgage lending) but this could only be meshed with the EHCS data at the level of English Regions, which meant that only ten values were possible. Unsurprisingly, this estimate of P also failed to produce meaningful results when entered in the inflow and outflow demand and supply system. Thus, owners' revealed estimate of expected capital gain was used to measure P in the regressions presented below.

Results

The results of the inflow and outflow supply regressions are presented in Table 2 and Table 3 respectively. The dependent variable is dichotomous in all the regressions because we are attempting to estimate the responsiveness of the transfer probabilities (p_i and p_o) to changes in rent, R. For the inflow supply regressions, the dependent variable equals one if the dwelling has transferred from owner occupancy in 1991 to private renting in 1996, and equals zero otherwise. Regressions (1) and (2) are simple one-stage logistic regressions that do not attempt to deal with the possible endogeneity of P and R.

The chi-square result suggests that we can reject the null hypothesis that all coefficients are zero, but with less confidence than in the two-stage regressions (5) and (6). The rent coefficients have the expected sign but are not statistically significant and are of much smaller magnitude than the two-stage estimates. The one-stage regressions also display negative coefficients on price, in contrast to the positive coefficients in the two-stage regressions. The pseudo R^2 measures the proportion of cases of the dependent variable correctly predicted by the regression and is high for all inflow regressions. This should be interpreted with care, however, given the small proportion of dwellings that actually transferred.

Much more statistically significant estimates of rent (the variable we are most interested in) are found in the two stage inflow regressions (5) and (6), with coefficients of 0.043 and 0.044, and Wald statistics of 4.28 and 4.16 respectively. The two-stage analysis is analogous to the Two Stage Least Squares methodology and has been shown to produce consistent estimates in systems dichotomous-dependent variable regressions (Maddala, 1983, chapter 8). Regressions (5) and (6) have the strongest Chi-square results and rent coefficients and are therefore judged to be the preferred regressions. In these regressions, the effect on the probability of dwelling transfer to PRS, of the owner occupier in 1991 being a senior manager, and married (X_1, and X_2 respectively) had had a negative impact, whereas being white (X_3) had a positive impact. Regressions (3) and (4) are also two-stage logistic regressions, but use the same estimates of expected capital gain and rent as the outflow regressions (i.e. $\hat{P}_a$ and $\hat{R}_a$) which do not include the exogenous variables that have missing values for all outflow observations (i.e. X_1, X_2, and X_3). These regressions yield similar (if slightly smaller) estimates of the rent coefficients (0.036 for both (3) and (4)).

[Table 2 Inflow Supply Regressions for the Computation of $\eta\iota$]

The outflow supply results (Table 2) are from logistic regressions where the dichotomous dependent variable is equal to one if the dwelling has transferred from private in 1991 to owner occupancy in 1996, and equal to zero otherwise. The diagnostics of the one-stage regressions (7) and (8) are poor, as are those of the two-stage regressions where both capital gain and rent variables are constructed from reduced form predicted values (regressions (9) and (10)). The non-quadratic two-stage regression that assumes capital gains to be exogenous (regression (11)) also has weak Chi-sqaure and Wald statistics. Regression (12) is therefore the superior of the outflow supply regressions, with a good Chi-square result and acceptable Wald statistic on rent. Despite the high variation in diagnostics between the two-stage regressions, the estimate of the rent coefficient is fairly stable, ranging from –0.014 to –0.086.

[*Table 3 Outflow Supply Regressions for the Computation of* η_o]

Stock Transfer Price Elasticity of Supply

Table 4 lists various estimates of STPES calculated using the formula for η developed in the first part of the paper (equation [6]). Estimates of η_{pi} and η_{po} were derived from the results of inflow and outflow supply regressions discussed above. Because the equations for p_i and p_o are estimated using logistic regression, the coefficients do not translate directly into first partial derivatives but have to be transformed as follows: $\partial p_i / \partial R = \Lambda_i(1-\Lambda_i)\beta_1$; and $\partial p_o / \partial R = \Lambda_o(1-\Lambda_o)b_1$; where $\Lambda_i = e^{\beta 1R} / (1+ e^{\beta 1R})$ and $\Lambda_o = e^{b1R} / (1+ e^{b1R})$ (Green, 1993, p. 639). The remaining parameters were computed directly from the data (note that $Q^{PRS}{}_2$, $Q^{PRS}{}_1$, f_i, f_o and $\%\Delta r$ do not require econometric estimation). The results suggest that the STPES is inelastic, with the estimates based on results from the two-stage inflow and outflow regressions yielding an average of around 0.7. Estimates based on results from the preferred regressions ((5), (6) and (12)) suggest an average of around 0.6.

Policy Implications

Implications for Social Housing Expenditure

Inelasticity of PRS supply has important implications for social housing provision. Government forecasts suggest substantial increases in the number of households in the UK over the next twenty years (due to relationship breakdown and smaller household size), resulting in future outward shifts in housing demand. Already owner occupied house prices in many parts of the country are such that only two-earner households can afford entry (due in part to the price inelasticity of supply of the owner occupied housing; see literature review above). Therefore, a reduction in the proportion of two-earner households will imply a rise in the proportion of households seeking to enter either public or private rented accommodation. How much of this outward shift in the demand schedule for renting will be met by the market, and how much by the social rented sector, is obviously of considerable policy importance and depends to a large extent on whether the outward shift in demand for private renting will result in a market adjustment that causes rent increases. Given that the estimates in this paper point to PRS supply being substantially less elastic than the current baseline assumptions of the DETR Social Housing Need Model, it is likely that social housing requirements will be considerably greater than anticipated.

Implications for Housing Benefit

The main UK tenant subsidy system, Housing Benefit, is essentially *ex post*, providing a reduction in the cost of housing based on the rents actually faced by the tenant[2] (as opposed to *ex ante* systems where the recipient receives an allowance which can be used to bid for housing – see Gibb, 1995, for a comparison of the two approaches). The *ex post* nature of Housing Benefit means that overall expenditure it is highly sensitive to rents. Kemp (1998) notes that there has been a "five fold increase in expenditure on rent allowances paid to private and housing association tenants, and a two-fold increase in expenditure on rent rebates paid to council tenants" (p. 158). The total number of housing benefit recipients has risen to 4.6 million, at a cost of £12 billion per annum – 12 per cent of all social secuirity expenditure and 1.5 per cent of UK GDP (*ibid*). Outward shifts of demand for PRS housing in the context of inelastic supply would imply further increases in the Housing Benefit bill.

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[2] Housing Benefit is not available to home owners.

Labor Mobility and Work Incentives

Maclennan (1994), amongst others, has argued that the diminutive scale of the PRS has implications for the wider economy, because it acts as a bottleneck to labour mobility. The unresponsiveness of supply to rising real rents indicated by the results presented above, suggests that it will take more than the relaxation of rent controls to revive the sector and so the residualization of private renting may continue to forestall the achievement of a truly flexible labour market for some time to come.

Another labour market implication is the impact on work incentives. Because increasing labour supply (and hence earnings) reduces Housing Benefit entitlement, the *ex post* nature of Housing Benefit means that an increase in rents effectively raises reservation wages. A sizeable literature now exists on the work-disincentive effects of Housing Benefit, most of which employ *a priori* simulations of threshold wage levels to demonstrate that rising rents have a powerful disincentive effect on the decision to work (Brown 1989; Department of Social Secuirity 1996; Ginsberg 1995; Marsh and McKay 1993; Social Security Advisory Committee 1995; Wilcox 1993a,b, 1994, 1995 Kearns *et al* 1996). The only research that has so far attempted actual empirical estimation of the relationship is the study by Pryce (1999b), which finds some evidence to support the disincentive argument, but less than the hypothetical models would suggest. Nevertheless, in the current system of benefits, a prolonged period of rising rents could have a real impact on the level of benefit dependency and strengthen the case for reforming the Housing Benefits system.

Summary

This paper has outlined a methodology of estimating the STPES (stock transfer price elasticity of supply), and has provided the first econometric estimate in the UK of the responsiveness of PRS supply to changes in rent. The paper began with a brief overview of the existing literature, and then proceeded to derive an expression of STPES that could be empirically estimated. This was followed by an elaboration of the theoretical rationale underlying stock transfer, leading to a formulation in terms of the demand and supply decisions of owner occupiers, and existing landlords. Changes in the PRS stock occur because of changes in the inflow of dwellings from the owner occupied sector relative to the outflow. The inflow supply function was modelled in terms of the probability of a dwelling transferring from OO to PRS, and the outflow supply function as the probability of a dwelling transferring from PRS to OO. By estimating the responsiveness of these two probabilities to changes in rent and controlling for demand factors, it was possible to deduce the responsiveness of the stock of PRS dwellings to rent changes. The stock elasticity was found to be less than one, with averages based on results from the preferred regressions suggesting a value of around 0.6. Although this estimate is much smaller than the Di Pasquali and Wheaton (1992) estimate for the US, it continues the established tendency for UK housing supply elasticities to be less than their US counterparts. The paper also discussed the policy implications of such a low PRS supply elasticity in the context anticipated outward shifts in demand. Such inelasticity is likely to inhibit labor mobility, inflate the Housing Benefit bill, and reduce labour supply incentives of low income groups.

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Appendix 1 Derivation of f^*_i in terms of Measurable Determinants

If we know the initial stock of owner occupied dwellings ($Q^{OO}{}_1$), and we know the probability of an owner occupied dwelling transferring to the PRS (p_i^*), then we can compute the inflow (assuming no change in rent) from the definition of p_i^*:

$$p_i^* = f_i^* / Q^{OO}{}_1$$

$$\Rightarrow \qquad f_i^* = p_i^* / Q^{OO}{}_1.$$

Similarly, f_i can be defined as, $f_i = p_i / Q^{OO}{}_1$, and from this we can write f_i in terms of $\%\Delta p_{i:r}$, p_i^* and $Q^{OO}{}_1$:

$$\begin{aligned}
f_i &= p_i / Q^{OO}{}_1, \\
&= \left(\frac{p_i * + (p_i - p_i *)}{p_i *} \right) p_i * Q_1^{OO}, \\
&= \left(1 + \frac{(p_i - p_i *)}{p_i *} \right) p_i * Q_1^{OO}, \\
&= (1 + \%\Delta p_i) p_i * Q_1^{OO},
\end{aligned}$$

Given that $f_i^* = p_i^* / Q^{OO}{}_1$, we can write this as,

$$f_i = (1 + \%\Delta p_i) f_i *.$$

Substituting $\%\Delta r \eta_{pi}$ for $\%\Delta p_{i:r}$, and rearranging in terms of f_i^*, yields,

$$f_i^* = f_i / (1 + \%\Delta r \eta_{pi}).$$

Since fi and $\%\Delta r$ are directly observable from the data and η_{pi} can be estimated using logit analysis, it can be seen that we have now derived f_i^* in terms of measurable determinants.

Table 1 Measurement of Variables and Expected Signs

R	hedonic rent: based on the coefficients from a hedonic rent regression with the following characteristics: type of dwelling; fitness of dwelling, main heating provision, number of rooms, floor space, surrounding land use (EHCS). *R* is expected to have a positive sign in inflow supply regressions, and a negative sign in outflow supply regressions.
P	expected capital gain: measured as the difference between the original price paid for the dwelling, and the owner's estimate of the value of house in 1996 (EHCS). Owners with large amounts of housing equity have a greater incentive to sell, and so this reduces the probability of owner becoming a landlord. However, properties which have made large gains in value over time may be seen as good investments to landlords and so may have a positive effect on the probability of transfer into private renting. Therefore, *P* has ambiguous expected sign in the inflow supply regressions and (for similar reasons) in the outflow supply regression.
Z	desire to move dummy: based on the question to respondents in 1991 as to whether they were hoping to move within the next five years (EHCS). Expected to have a positive effect on the inflow supply probability.
X_1	dummy variable: equals one if the head of household is a senior manager, zero if not (EHCS). Expected sign is ambiguous since senior employment status may reflect/determine entrepreneurship (positive effect on outflow supply) but may also reduce the likelihood to need to rent out the property to boost income.
X_2	dummy variable: equals one if the head of household is married, zero if not (EHCS). Expected to have a negative effect on the inflow supply probability by reducing risk taking behaviour of owner occupiers in period one.
X_3	dummy variable: equals one if the head of household is white, zero if not (EHCS). Ambiguous expected sign.
Y^{PC}	local median income per capita (Regional Trends) – demand variable.
K^{PC}	dwellings per capital: measured by stock of dwellings per 1,000 population in 1996 (Regional Trends) – demand variable.
L^M	labour market indicator: number of local vacancies at jobcentres in 1996 (thousands Regional Trends) – demand variable.

Figure 1 p$_i$:Inflow Probability (of $k_{OO1} \rightarrow k_{PRS2}$)

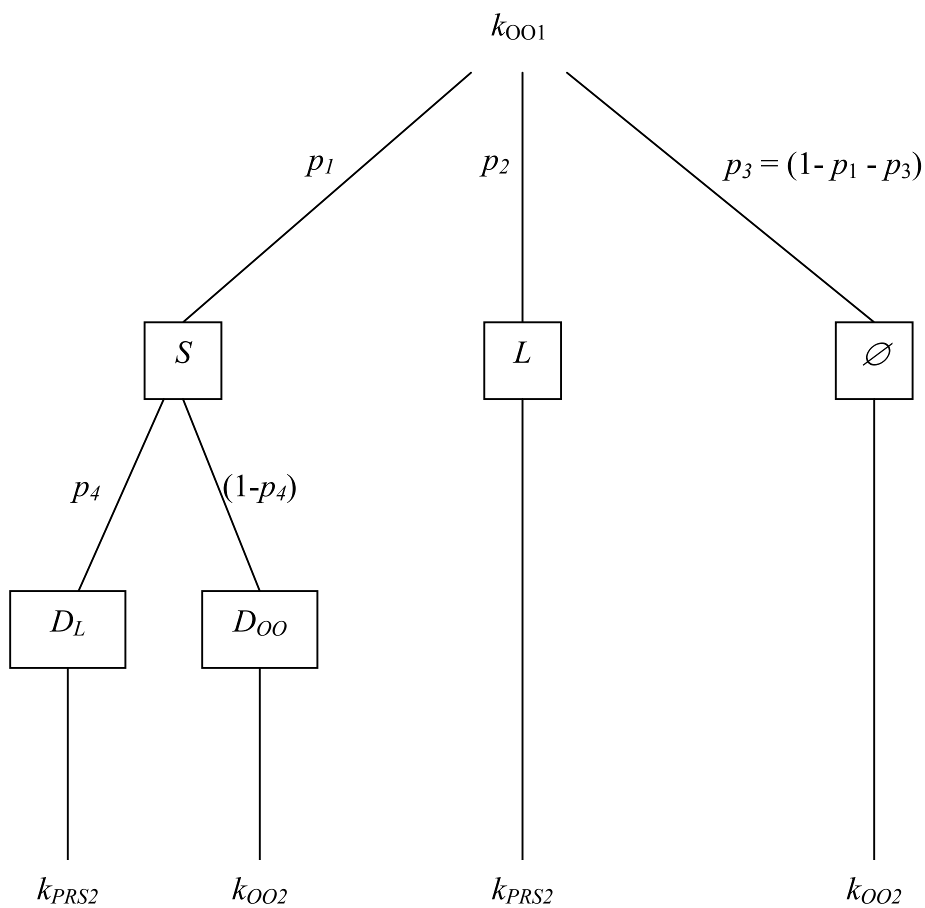

Figure 2 p_o: Outflow Probability (of $k_{PRS1} \rightarrow k_{OO2} = q_2 + q_1 q_3$)

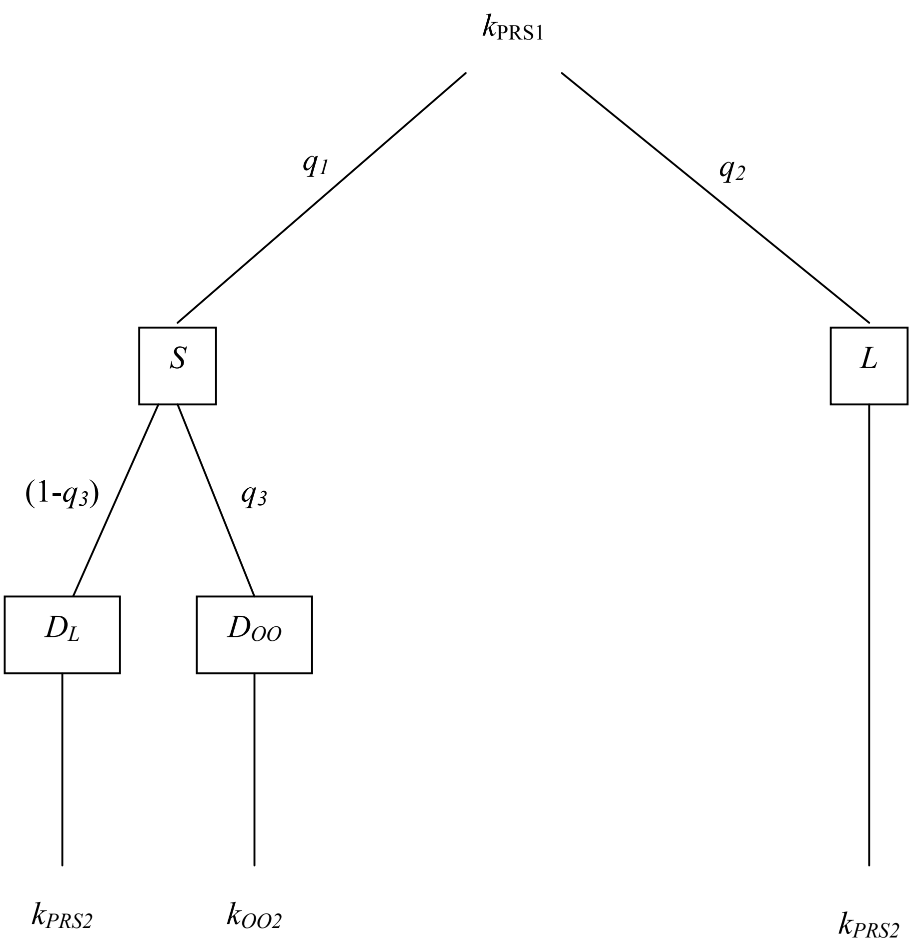

Table 2 Inflow Supply Regressions for the Computation of η_i

	Dependent Variable $= \begin{cases} 1 \text{ if } k_{\text{OO1}} \rightarrow k_{\text{PRS2}} \\ 0 \text{ if } k_{\text{OO1}} \rightarrow k_{\text{OO2}} \end{cases}$					
Variable	(1)# Rent = R Price = P	(2)# Rent = R Price = P	(3) Rent = $\hat{R}_a$ Price = $\hat{P}_a$	(4) Rent = $\hat{R}_a$ Price = $\hat{P}_a$	(5)* Rent = $\hat{R}_b$ Price = $\hat{P}_b$	(6)* Rent = $\hat{R}_b$ Price = $\hat{P}_b$
Constant	-2.302 (3.38)	-1.993 (1.88)	-13.9633 (8.50)	-13.0938 (5.50)	-15.2880 (7.20)	-14.6327 (5.54)
R	.0017 (.16)	.002 (.12)	.0355 (3.76)	.0366 (3.66)	.0429 (4.28)	.0440 (4.16)
P	-.120 (.22)	-.299 (.38)	2.2477 (4.07)	1.4093 (.25)	2.7481 (4.93)	2.0339 (.55)
P^2	-	.025 (.24)	-	.1692 (.10)	-	.1441 (.09)
Z	1.230 (9.39)	1.233 (9.43)	.7802 (6.11)	.7713 (5.90)	.7735 (6.01)	.7634 (5.77)
X_1	.022 (.002)	.028 (.003)	-	-	-.5272 (1.13)	-.5374 (1.14)
X_2	-1.176 (8.27)	-1.175 (8.23)	-	-	-1.8725 (18.44)	-1.8768 (18.14)
X_3	-1.411 (4.59)	-1.417 (4.63)	-	-	.3796 (.24)	.4561 (.30)
n	1,447	1,447	2,631	2,631	2,631	2,631
Pseudo R^2	98.20%	98.20%	98.33%	98.33%	98.33%	98.33%
Chi-Square	21.28 [.002]	21.43 [.003]	13.08 [.005]	13.18 [.010]	31.92 [.000]	32.01 [.000]

Figures in parentheses are Wald statistics. Figures in square brackets are significance levels. "Pseudo R^2" is the proportion of cases of the dependent variable correctly predicted by the regression.
* Diagnostics suggest that these are the preferred inflow supply regression.
\# These are simple logistic regressions without any two-stage procedure to deal with simultaneity.

This table presents the regression results of the inflow supply regressions. The dependent variable is dichotomous (equal to one if the dwelling has transferred from owner occupancy in 1991 to private renting in 1996, and equal to zero otherwise). Regressions (1) and (2) are simple one-stage logistic regressions that do not deal with the possible endogeneity of expected capital gain and rent. The remaining regressions are two-stage (the price and rent variables are constructed from the predicted values of regressions on all exogenous variables). Regressions (3) and (4) use the same estimates of expected capital gain and rent as the outflow regressions (i.e. $\hat{P}_a$ and $\hat{R}_a$) which do not include the exogenous variables that have missing values for all outflow observations (i.e. X_1, X_2, and X_3). Regressions (5) and (6) use estimates of expected capital gain and rent ($\hat{P}_b$ and $\hat{R}_b$) that are based on regressions which do include X_1, X_2, and X_3.

Table 3 Outflow Supply Regressions for the Computation of η_o

	Dependent Variable $= \begin{cases} 1 \text{ if } k_{\text{PRS1}} \rightarrow k_{\text{OO2}} \\ 0 \text{ if } k_{\text{PRS1}} \rightarrow k_{\text{PRS2}} \end{cases}$					
Variable	(7)[#] Rent = R Price = P	(8)[#] Rent = R Price = P	(9) Rent = $\hat{R}_a$ Price = $\hat{P}_a$	(10) Rent = $\hat{R}_a$ Price = $\hat{P}_a$	(11) Rent = $\hat{R}_a$ Price = P	(12)* Rent = $\hat{R}_a$ Price = P
Constant	-4.4320 (3.95)	5.7250 (.86)	2.4064 (.062)	14.8588 (.70)	.7279 (.07)	16.0496 (3.08)
R	.0136 (1.43)	-.0075 (.17)	-.0138 (.14)	-.0293 (.40)	-.0283 (1.32)	-.0864 (2.38)
P	.5543 (1.59)	-5.1163 (2.44)	-.7536 (.12)	-8.5151 (.94)	-.0121 (.001)	-7.7621 (3.85)
P^2	-	.8393 (3.01)	-	1.2930 (.89)	-	1.1288 (4.15)
n	31	31	48	48	31	31
Pseudo R^2 **	77.42%	80.65%	72.92%	72.92%	80.65%	80.65%
Chi-Square	2.175 [.3371]	6.062 [.1086]	.148 [.9285]	1.144 [.7665]	2.489 [.2881]	10.346 [.0158]

Figures in parentheses are Wald statistics, figures in square brackets are significance levels. "Pseudo R^2" is the proportion of cases of the dependent variable correctly predicted by the regression.
* Diagnostics suggest that this is the preferred outflow supply regression.
[#] These are simple logistic regressions without any two-stage procedure to deal with simultaneity.

This table presents the regression results of the outflow supply regressions. The dependent variable is dichotomous (equal to one if the dwelling has transferred from private in 1991 to owner occupancy in 1996, and equal to zero otherwise). Regressions (7) and (8) are simple one-stage logistic regressions that do not deal with the possible endogeneity of expected capital gain and rent. The remaining regressions are two-stage (the price and/or rent variables are constructed from the predicted values of regressions on all exogenous variables). Regressions (9) and (10) use reduced form predicted values for both expected capital gain and rent (i.e. $\hat{P}_a$ and $\hat{R}_a$), whereas (11) and (12) use reduced form predicted values only for rent.

Table 4 Stock Transfer Price Elasticity of Supply for the UK Private Rented Sector

Selected Source of Results Used to Calculate η		**η (STPES)**
Inflow Equation	***Outflow Equation***	
(1)[#]	(7)[#]	0.72
(2)[#]	(8)[#]	2.76
(3)	(9)	1.43
(3)	**(12)**	**0.45**
(4)	(10)	1.38
(4)	**(12)**	**0.42**
(5)	(10)	**1.15**
(5)	**(12)**	**0.26**
(6)	(10)	**1.11**
(6)	**(12)**	**0.23**
Mean of all η's:		.86
Mean of all η's that use results from Two-Stage Regressions:		.72
Mean of all η's that used results from any of the preferred regressions **(5)**, **(6), (12)**:		**.58**

Figures in bold indicate that are the elasticity was calculated using results from either of the preferred regressions, (6) and (12).
[#] These are simple logistic regressions without any two-stage procedure to deal with simultaneity.

This table presents stock transfer price elasticity of supply (STPES) estimates for the English private rented sector. These elasticities are calculated on the basis of the formula for STPES derived in the first part of the paper. This formula requires, amongst other things, the inflow and outflow elasticities of the probability of transfer with respect to changes in rent. These elasticities were estimated using logistic estimation of the inflow and outflow supply probabilities, the results of which are listed in the previous two tables. The preferred regressions were (6) and (12) for inflow and outflow supply respectively. The table also gives the average of estimates which used the results from either of these two regressions, along with the mean of estimates which used the two stage procedure, and the mean of all the estimates of STPES.