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PENSION WEALTH AND HOUSEHOLD SAVINGS: TESTS OF ROBUSTNESS

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Abstract

A substantial literature exists on the impact of pension schemes, both public and private, on the level of household saving. Yet there is no clear consensus on the impact of pensions on private saving. In this paper we show how beliefs about this displacement effect are modified by prior beliefs both about variables which might be relevant in an equation for private savings and about the magnitude of the displacement effect. Using data for 8,279 Canadian households, and estimates of pension wealth (both private and social security) which we construct for each household in the sample, the estimated displacement effects are found to be relatively robust with respect to both types of prior belief.

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Pension Wealth and Household Savings:

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1. Introduction

There is, by now, a substantial literature on the impact of pension schemes, both public and private, on the level of household savings.[1] Feldstein's (1974) time-series study of the impact of social security wealth in the US spawned numerous empirical studies using both time-series and cross-section data. Yet there is no clear consensus on the impact of pensions on private saving. In part, this results from the fact that theory does not yield unambiguous predictions about the response of household savings to the existence of pension wealth. At least four possible influences may be identified:

(a) If pension wealth is seen as a substitute for private accumulation there will be a displacement of the latter when the former is introduced or increased. In the limit, if other assets were perfect substitutes for pension wealth, the offset would be "one-for-one", an implied displacement of unity.

(b) There may be an induced retirement effect which would tend to raise household savings in order to finance consumption over a longer period of retirement (Feldstein 1974).

(c) Concern about future generations, upon whom the cost of meeting the pension commitment of unfunded schemes falls, may result in additional private savings for higher bequests in order to offset the increased tax burden. (Barro 1974, 1978). Alternatively, unfunded schemes may result in intergenerational transfers with both a wealth and a substitution effect.

(d) Imperfections in the capital market may undermine the relevance of the life-cycle model, at least to the behaviour of a minority of households (Diamond and Hausman 1982, King and Dicks-Mireaux 1982).

These ambiguities in the theoretical effects of pensions on private saving mean that we must turn to empirical evidence. It is clear, however, that the interpretation of existing evidence suffers from two defects. First, the absence of clear cut theoretical predictions does not mean that we examine and interpret the evidence free from the influence of prior beliefs. Theoretical introspection rarely leads to a completely diffuse prior. But since prior beliefs differ, we need to understand how important any given set of empirical results is for a range of priors, and it is useful to summarise the evidence in terms of a mapping from prior to posterior beliefs. Secondly, there is the suspicion that reported results may (for a variety of reasons which include the priors of referees and journal editors as well as space constraints) be reported selectively and may not be robust to minor changes in the specification of the model. In this paper we present some evidence on the displacement effect of pension wealth on private net worth, in the light of these two concerns, using data for 8,279 Canadian households.

We estimate the displacement effects for two types of pension, social security and private pension wealth, and this natural two-dimensional aspect allows us to present a geometric interpretation of the results. This diagrammatic representation is useful in any problem in which we are concerned mainly with the estimates of a pair of parameters, and may be of more general interest than the present context.

The basic model and our research strategy are set out in section 2 and the data employed in this study are described in section 3. The main results are presented in section 4. In section 5 we consider the effect of alternative estimates of pension wealth for these results. Our conclusions are summarised in section 6. We should be clear from the outset that we are not concerned here with the implications of social security for the total level of savings and investment because these depend upon the extent to which social security is funded.[2]

2. The Basic Model

We shall estimate a model for the behaviour of household net worth over the life cycle and its dependence, if any, on pension wealth. There are several strategies upon which such an investigation could be based. First, we could pursue an ad hoc approach of estimating alternative specifications and report the "best results" according to some criterion such as goodness of fit. This raises the problem of selective reporting. Secondly, we could estimate a very general model (which, in practice, would mean including a large number of explanatory variables) and use various statistical criteria to reduce the model by gradually eliminating some of the independent variables until a parsimonious representation is achieved. We call this a "contracting search". But, as with ad hoc regression strategies, the process of model selection entailed by a contracting search does not, in general, lead to inference under classical statistical theory.[3] Thirdly, we could construct the full Bayesian mapping from a given set of prior beliefs into a posterior distribution for the parameters of the model.

Although the Bayesian approach probably corresponds more closely to the way in which we absorb the results of empirical studies, it gives no feel for the sensitivity of the posterior distribution to changes in the prior. This is unfortunate because it is implausible to suppose that the consumers of the output of a research project would all agree on a precise specification for the prior. A more flexible approach is required. One of the contributions of Leamer (1978) is to show that we can say a good deal about the posterior distribution even though the prior distribution is not fully specified. Our research strategy is to examine the sensitivity of the displacement effects of pension wealth to changes in the type and amount of prior information we are willing to specifiy. These range from beliefs about which are the relevant explanatory variables to prior beliefs about the magnitude of the displacement effects. The posterior estimates of the displacement effects depend upon both the prior and the information in our data set, and we shall try to disentangle the relative contributions of the two for our conclusions about the impact of pension wealth on household net worth.

The framework for our analysis is the life-cycle model of household consumption (Modigliani and Brumberg 1954, Modigliani and Ando 1957). For a cross-section of households, the life-cycle model implies a nonlinear relationship between the ratio of wealth to permanent income and age. Permanent income is defined here as normal annual earnings. We condition on this variable because of the correlation between age and the other determinants of potential net worth, such as education and the differences in the lifetime prospects of different cohorts.[4] The life-cycle model itself places few a priori constraints on the function describing the age profile of household net worth, apart from a presumption of a "hump-shaped" pattern, once we allow for uncertainty about length of life, future earnings and rates of return.[5] There is, therefore, a good deal of latitude in the specification of the functional form to be estimated, and there are no convincing a priori grounds for choosing among alternative approximations to the true relationship. If we assume that households experience a period of retirement during which they expect to receive little or no labour income, then for most plausible earnings profiles we would expect the ratio of net worth (excluding the present value of future earnings) to permanent income to first increase with age and then to decline after retirement. Support for this stylised view is given by Figure 1. This shows the average ratio of wealth to permanent income for each 5-year age group over the life cycle for our sample of households. Wealth is defined as the value of non-human assets plus the present value of pension wealth. The construction of variables for pension wealth and permanent income, and details of the sample, are described in Section 3 below. Two profiles are shown in Figure 1 corresponding to total net worth (TW) and net worth excluding the value of equity in owner-occupied housing (TW'), respectively. A clear life-cycle pattern can be observed.[6]

To approximate the true age profile of wealth holdings, we shall use the nonlinear piecewise function employed in our earlier study (King and Dicks-Mireaux 1982) which consists of six pieces corresponding to pre-determined age ranges. It is then possible to estimate the model by the following linear regression

$$\ln\left(\frac{TW_i}{Y_i}\right) = a_o + \sum_{j=1}^{7} a_j v_{ji} + u_i \qquad (1)$$

where

TW_i is the total net worth of household i

Y_i is the permanent income of household i

v_{ji}, j = 1 ... 7, are age variables for the head of household i which are defined in Appendix 1. One of the variables (corresponding to the age range 60-75) is quadratic in age so that the data may determine whether or not there is a maximum for the level of household net worth.

The value of a_o is the natural logarithm of the ratio of wealth to permanent income at age 15; which is approximately the lowest age at which working life could begin. The values of a_1 to a_7 measure the average annual rates of accumulation of wealth in the various age ranges.

Equation (1) relates to total net worth including both social security and private pension wealth. We shall assume, however, that pension wealth is an exogenous variable beyond the control of an individual household. Although this is true of social security wealth, it may be possible to change the level of private pension wealth by choosing an occupation which offers an appropriate retirement compensation package. We shall ignore this possible source of endogeneity and take net worth excluding pension wealth as the dependent variable. Pension wealth becomes an explanatory variable thus enabling us to estimate displacement effects. Since pension wealth is an imperfect substitute for other forms of wealth, we assume that total wealth may be expressed in terms of net worth excluding pension wealth (W), social security wealth (SW) and private pension wealth (PW) by a loglinear approximation.

$$\ln\left(\frac{TW}{Y}\right) = \ln\left(\frac{W}{Y}\right) + \alpha_1 \ln\left(\frac{SW}{Y}\right) + \alpha_2 D \ln\left(\frac{PW}{Y}\right) \qquad (2)$$

where D = 1 if the household is eligible for a private pension plan, zero otherwise. From (1) and (2) we have

$$\ln\left(\frac{W_i}{Y_i}\right) = a_o + \sum_{j=1}^{7} a_j v_{ji} - \alpha_1 \ln\left(\frac{SW_i}{Y_i}\right) - \alpha_2 D \ln\left(\frac{PW_i}{Y_i}\right) + u_i \qquad (3)$$

The set of true explanatory variables is likely to be larger than those contained in equation (3). Unless these are orthogonal to pension wealth, their inclusion or exclusion will affect the estimates of the displacement effect. We divide these additional variables into two types. The first comprises variables that we would wish to include in the basic specification on a priori grounds. In this category we include permanent income (to test for homotheticity) and the number of persons in the household with life insurance coverage (because the data on net worth exclude the value of insurance policies). The second consists of variables which are less obvious candidates as explanatory variables, but which we are unwilling to exclude on a priori grounds. Since we regard (3) as a linearisation of the true relationship, we include in the second category higher order age terms, as well as regional and area dummies, the number of adults in the household, the number of persons in the household who are unemployed, and a farm family dummy.[7] The full list of variables in both categories is shown in Appendix 2. Although the distinction between the two categories is not clearcut, it represents our prior view about which are likely to be the relevant explanatory variables, and corresponds to Leamer's (1978) distinction between "focus" and "doubtful" variables. In section 4 we shall examine the robustness of the estimated displacement effects to alternative specifications of equation (3).

The second set of prior beliefs we shall examine concerns priors about the actual magnitudes of the displacement effects. The interpretation of published results is likely to be influenced by prior beliefs. Such priors may originate from a distillation of previous empirical evidence or from a theoretical model. To examine formally the sensitivity of conclusions to prior beliefs we consider two priors namely (a) a zero displacement effect for both social security and private pension wealth, and (b) a displacement effect of unity (a one-for-one effect) for both types of pension wealth.[8] This will allow us to examine the sensitivity of posterior beliefs about the displacement effect to various degrees of belief in the prior. How confident, for example, would we have to be in either of these priors not to modify significantly our beliefs about the impact of pension wealth on household savings?

The choice of the two priors is a deliberate attempt to set up "straw men" that encompass the full range of viewpoints which have been expressed about the size of the displacement effects. Empirical studies have produced differing estimates of the effect of pension wealth on savings. Cross-section studies in the U.S. by Kotlikoff (1979), Feldstein and Pellechio (1979) and Feldstein (1980) found this to be greater than 0.5. In contrast, magnitudes of less than 0.5 have been found by Munnell (1976) and Diamond and Hausman (1982); in the former study this was true also for private pensions. In one of the few studies using Canadian data, Boyle and Murray (1979) using aggregate time-series data found no significant impact of social security on savings.

The mapping of the coefficients α_1 and α_2 into displacement effects is given by

$$\frac{\partial W}{\partial (SW)} = - \alpha_1 \left(\frac{W}{SW} \right) \tag{4}$$

$$\frac{\partial W}{\partial (PW)} = - \alpha_2 \, D \left(\frac{W}{PW} \right) \tag{5}$$

For the prior of zero displacement, α_1 and α_2 therefore take values of zero. Imposing unitary displacement effects, computed at sample means at age 65, gives a prior for α_1 and α_2 equal to minus the reciprocal of the mean net worth to pension wealth ratio for the sample of all 65 year olds and those eligible for a private pension respectively.

In section 4, we examine the posterior distributions of the displacement effects corresponding to the three sets of priors described above, namely a prior about which are the relevant explanatory variables, a prior of zero for the displacement effects, and a prior for the displacement of unity at age 65.

3. The Data

The data used in this study refer to 8,279 Canadian families in 1977, and are taken from the Statistics Canada micro-data tape "Income (1976), Assets and Debts (1977) of Economic Families and Unattached Individuals" which contains data collected as a supplement to the 1977 Survey of Consumer Finances.[9] A household is defined as a group sharing a common dwelling and related by blood or marriage. The data on net worth refer to market values in May 1977 and the income data to the calendar year 1976. The survey data on net worth exclude pension wealth (which we discuss below), consumer durables other than cars, equity in life insurance policies and other "assets" such as the expected value of future inheritances and support from relatives or children.

There are 12,734 households in the data base. This number was reduced to 8,279 in two stages. First, we excluded all households headed by a woman. A substantial fraction of such households were headed by elderly women, probably widows, for whom permanent income is determined primarily by the life-time earnings of the deceased husband on which no information was available. Permanent income was computed as a minimum-variance estimate of normal age-adjusted annual earnings using the method proposed in King and Dicks-Mireaux (1982) to which the reader is referred for further details. This exclusion reduced the number of households to 10,118.[10] At the second stage a further 1,839 households with net worth less than $2,500 were excluded thus bringing the sample used in estimation down to 8,279. The reason for this exclusion is that in our earlier study (King and Dicks-Mireaux 1982) we found evidence of different types of savings behaviour among different groups of the population, and the truncation adopted here corresponds to that of the earlier paper. To correct for the truncation bias thus induced we used the two-stage procedure suggested by Heckman (1976, 1979) which involved estimating a probit model for low wealth-holdings (less than $2,500) and including the inverse of the Mills' ratio as an additional explanatory variable in the second stage regression for the ratio of net worth to permanent income. The results for the probit model are reported in our earlier paper (op. cit., Table 4).

The most important component of wealth for which we do not have direct observations is the value of the right to future private pensions and old age social security payments. Social security wealth is defined as that accruing from the public retirement income system, and comes from five sources: Old Age Security (OAS), the Guaranteed Income Supplement (GIS), the Spouses' Allowance (SPA), and the Canada and Quebec Pension Plans (CQPP). The OAS provides flat-rate benefits which are taxable, and were equal to $1,634.34 in 1976 to those aged 65 and over. Eligibility for GIS is based on receipt of OAS, and those who have no income other than OAS receive the maximum benefit of $1,146.30 and $2,035.80 (in 1976), for single and two-pensioner families respectively. The SPA is payable to a pensioners' spouse, provided he or she is 60-64 years old and would, except for age, qualify for OAS and the GIS at the two-pensioner family rate. Both these benefits are reduced, at different rates, if income is received from sources other than OAS. These benefits have been fully indexed to increases in the consumer price index (CPI) since 1972, and are all financed from general tax revenue.

The Canada and Quebec pension plans, which are virtually identical with automatic transferability of benefit credits, were established in 1965 and cover almost the entire labour force. Both plans are contributory and earnings-related. Contributions are paid by individuals aged 18 to 70 years and not receiving plan benefits, at a rate of 3.6% shared equally by employers and employees and paid in full by the self-employed, on earnings between a lower and upper bound. Both plans provide three types of benefits: retirement pensions, survivors' benefits, and disability benefits. Since 1976 the eligible age for receipt of retirement benefits has been sixty-five. The benefit level is calculated as 25% of adjusted career average earnings (ACAE), multiplied by the average value of the yearly maximum pensionable earnings (YMPE) in the final three working years. The ACAE is the mean value of the ratio (with a maximum value of one) of earnings to YMPE in the best 85% of earning years. The intent of the system appears to be to index the YMPE to the average wage and salary index, although in practice it has on occasion failed to achieve this. Benefit payments are indexed to the CPI. Survivors' benefits include death benefits, surviving spouses' pensions, disabled widowers' pensions, and orphan benefits. The surviving spouse's pension, (the one of most concern to us), is 60% of that which would have been paid to the deceased contributor if the spouse is 65 years old or older, plus a flat-rate component if aged 45 to 65. For those of age less than 45 the pension level is determined by age, the number of dependent children, and disability.

The recent nature of the plan, and the transitional arrangements used to introduce it, has added a further source of variation in the value of pension rights across individuals. Those persons aged 55 and less in 1966 were to be eligible for full pensions at age 65; in effect the closer an individual was to age 55 in 1966 the greater the "bonus" or net benefit received. Those of age 56 or more, contributing for less than ten years would receive a pro rated pension.

To calculate the benefit level of CQPP the eligibility rules described above were applied to individual age-earnings profiles. The profiles are those estimated for the purpose of constructing our measure of permanent income. The benefit accruing in each year of retirement was multiplied by the individual's probability of surviving until that year. To convert these survival-adjusted benefits into a present value the nominal discount rate was chosen to be equal to the rate of change of the wage and salary index. In other words the real discount rate was assumed to be equal to the rate of productivity growth. The age-earnings profile and so also the estimated benefit levels are in 1976 dollars. Therefore, because the yearly maximum pensionable earnings are effectively indexed to the nominal discount rate, for years up to retirement, a discount factor of one was applied to the survival-adjusted benefits. With benefit payments indexed to the CPI, for post-retirement years we use the real discount rate set at 2.5%. For wives allowance was made for non-participation in the labour force at various stages of the life cycle by adjusting the level of the age-earnings profile in a fashion identical to that used in estimating permanent income. In addition to the retirement pension only the surviving spouses' pension, for those over 45, was included in the calculation. In computing the flat-rate components of social security wealth everyone of at least 65 years of age was assumed to receive OAS. No allowance for SPA was made because the age-earnings profile implicitly assumes that spouses effectively work until they are 65. Current and future eligibility for the GIS was determined using the appropriate needs test.

In estimating the present value of private pension wealth, actual receipts were used for retirees, and an expected pension was imputed for those in pension plans who were below retirement age, (assumed to be 65). The imputation, expressed in 1976 dollars, was based on a regression for pension receipts of retirees in terms of permanent income, age and occupation. To allow for sample selection bias the inverse Mills' ratio computed from a probit model of positive pension receipts for retirees, was included as an explanatory variable. The pension was adjusted by survival probabilities. For the present value calculation it is necessary to make some assumption about current and future pre-and post-retirement indexation. Indexation provisions vary widely across pension plans and any assumption, (although we do take notice of what evidence is available), applied uniformly across households will only be an approximation. The heterogeneity of the pension plans across occupations will be captured to some extent in the imputation of pension receipts. We assume that prior to retirement, benefits are effectively indexed to the rate of growth of wages and salaries. Therefore, as was done for CQPP benefits, a discount factor of one is used for years pre-retirement. Post-retirement we assume the level of indexation is 60% of the CPI and also the rate of inflation to be 5%. This yields a discount rate for post-retirement years of 4.5%. With the information available, it was difficult to incorporate survivors' pensions. The procedure used assumes that any living spouse will be entitled to one-half of the households' pension income, regardless of whether he or she is widowed.

A more detailed description of the Canadian retirement income system, and of the construction of the wealth estimates is presented in Dicks-Mireaux (1981 b). Mean values of wealth in these various forms in the sample of 8,279 households were the following; for net worth recorded in the survey \$65,821, social security wealth \$74,363, and for the 3,832 households with private pension wealth \$61,349.

4. Robustness Analysis of Displacement Effects

We now turn to an analysis of the robustness of the estimated displacement effects. The model of equation (3) augmented by additional explanatory variables may be written as

$$\ln\left(\frac{W}{Y}\right) = Z_1\gamma_1 + Z_2\gamma_2 - \alpha_1 \ln\left(\frac{SW}{Y}\right) - \alpha_2 D \ln\left(\frac{PW}{Y}\right) + u \qquad (6)$$

where Z_1 is an N x J matrix of J basic explanatory varibles for the N households (listed in column 1 of Appendix 2) and γ_1 is the associated parameter vector. Z_2 is an N x K matrix of K "doubtful" variables (listed in column 2 of Appendix 2) and γ_2 the associated parameter vector. The disturbances u are assumed to be distributed $N(o,\sigma^2 I)$. To simplify notation rewrite (6) as

$$\underline{Y} = X\underline{\beta} + \underline{u} \qquad (7)$$

where $\underline{Y} = \ln\left(\frac{W}{Y}\right)$

X is the N x (J + K +2) data matrix

$\underline{\beta}$ is the (J + K + 2) x 1 parameter vector $(\gamma_1, \gamma_2, -\alpha_1, -\alpha_2)$

Estimation of (6) yields consistent estimates of $\underline{\beta}$, which we denote by $\underline{b}$, and of the sample data precision matrix H^{11}. Given the normality of $\underline{u}$, the estimator $\underline{\beta}$ is asymptotically normally distributed and we shall assume that our sample size (8,279) is sufficiently large that we may ignore deviations from normality. Suppose also that we have a multivariate normal prior for $\underline{\beta}$ of $\underline{b}^*$ with prior precision matrix H^*. Then the location of the posterior mean of $\underline{\beta}$ is given by the following matrix-weighted average of the prior location and the regression estimator (Chamberlain and Leamer 1976).

$$\underline{\beta}^* = (H + H^*)^{-1}(H\underline{b} + H\underline{b}^*) \tag{8}$$

Clearly, if we have specified both $\underline{b}^*$ and H^*, there is a unique posterior mean and implied preferred estimates for the displacement effects. But it is unlikely that we would be willing to specify fully a prior distribution for $\underline{\beta}$. Nevertheless, even in this case, the posterior can be shown to lie within a certain region, the size of which depends upon how fully the prior distribution is specified.

The first case is where we know the sample estimates of $\underline{\beta}$, $\underline{b}$, and the sample precision matrix H. But, although we are willing to specify a prior location for $\underline{\beta}$, $\underline{b}^*$, we wish the prior precision matrix to be completely arbitrary. Then from Leamer (1978, Theorem 5.11) we know that the posterior mean of $\underline{\beta}$ must lie in the ellipsoid

$$(\underline{\beta}^* - \underline{c})'H(\underline{\beta}^* - \underline{c}) < \frac{1}{4}(\underline{b} - \underline{b}^*)'H(\underline{b} - \underline{b}^*) \tag{9}$$

where $\underline{c} = \frac{(b + b^*)}{2}$

Equation (9) defines a region within which the posterior mean is located and can be used to provide extreme bounds on individual parameter values. Our interest, however, lies not in the whole ellipsoid but only in the restrictions it implies on the posterior means of the displacement effects. This natural two-dimensional feature of our study means that we can exploit an appealing geometric representation of our results. Instead of computing extreme bounds we may plot the projection of the ellipsoid given by (9) into displacement effect space. This projection, in terms of the (α_1, α_2) coefficient space, is an ellipse described by the following equation.

$$(\underline{\alpha} - \underline{c}_p)'Z(\underline{\alpha} - \underline{c}_p) = \frac{1}{4}(\underline{b} - \underline{b}^*)'H(\underline{b} - \underline{b}^*) \tag{10}$$

where $\underline{\alpha}$ is the vector $(-\alpha_1, -\alpha_2)$, $\underline{c}_p$ the subvector of $\underline{c}$ corresponding to the pension wealth variables, and Z is the matrix $(H^{-1})^{-1}_{SP}$, the inverse of the 2 x 2 submatrix formed by taking the rows and columns of the inverse of H corresponding to social security and private pension wealth. Using (4) and (5) we may convert (10) into an ellipse for the displacement effects, and we plot this ellipse for each of the three sets of prior beliefs described in section 2.

Prior 1

The first type of prior information we examine is a belief about which are the relevant explanatory variables. In section 2 we argued that these included the variables in the Z_1 matrix, in addition to the pension wealth variables, with the doubtful variables in the Z_2 matrix. Our prior for $\underline{\beta}$ is, therefore, the regression estimates for γ_1, α_1 and α_2 from the model with Z_2 excluded (which implies a prior for γ_2 of zero).[12] These estimates are shown in column 1 of Table 1. The priors for the displacement effects obtained from the restricted model are 0.171 for social security wealth (an extra dollar of social security wealth reduces household net worth by 17.1 cents) and 0.508 for private pension wealth. The regression estimates from the augmented model (including all the doubtful variables) are shown in column 2 of Table 1. They imply displacement effects of 0.208 for social security wealth and 0.276 for private pension wealth.

Using these estimates, we plotted the feasible ellipse corresponding to the first prior and this is shown in displacement effect space in Figure 2. The two sets of estimates are clearly close to each other, but, because they are matrix-weighted averages, the posterior means do not necessarily lie between the prior and the data points. This can be seen in Figure 2 in which the feasible ellipse contains values outside the range between the prior and regression estimates, particularly in the case of social security. The extreme bounds on the displacement effects defined by the ellipse in Figure 2 are 0.107 to 0.273 for social security wealth and 0.272 to 0.512 for private pension wealth.

We have interpreted the ellipse in Figure 2 as defining a feasible region for posterior beliefs about the displacement effects given a set of prior beliefs and a set of regression estimates for equation (6). An alternative interpretation is that it represents the locus of displacement effects implied by the regression estimates of (6) subject to linear constraints on the parameter vector of the form

$$R(\underline{\beta} - \underline{b}^*) = 0 \qquad (11)$$

Given <u>any</u> constraint of this type (i.e., a matrix R), the estimate of (6) subject to the constraint lies on the boundary of the ellipse shown in Figure 2.[13] When R = I we obtain the prior and when R = 0 we obtain the regression estimate (shown as the point DATA on Figure 2). Different R matrices trace out the ellipse and correspond to regression estimates for differing linear combinations of explanatory variables. In this way, the ellipse summarises the estimated displacement effects for a whole family of regressions.

<u>Prior 2</u>

The second prior is that the displacement effects are zero. With this prior the feasible ellipse for the posterior means of the pension wealth coefficients is given by

$$(\underline{\alpha} - \frac{\underline{a}}{2})'Z(\underline{\alpha} - \frac{\underline{a}}{2}) = k \qquad (12)$$

where $\underline{a}$ is the vector of regression estimates of α_1 and α_2, and the constant K can be determined by the condition that the ellipse must pass through the prior and the data points. It is, therefore, unnecessary to specify a prior for the other parameters of the model if we are projecting the feasible ellipsoid into two dimensions. The feasible ellipse for the second prior is shown in Figure 3 denoted by F. The bounds on the values of the posterior means for the displacement effects are -0.034 to 0.244 for social security wealth and -0.064 to 0.340 for private pension wealth. The introduction of prior information about the location of the parameters widens the bounds for the displacement effects compared with the case when prior beliefs concerned the set of explanatory variables. To narrow the range we need to know how much weight to place on the sample evidence and how much on the prior information. The information about displacement effects contained in the data may be summarized in the iso-likelihood contours. In pension wealth space these data confidence ellipses are defined by

$$(\underline{\alpha} - \underline{a})'Z(\underline{\alpha} - \underline{a}) = \ell^2 \qquad (13)$$

Similarly the iso-prior density contours lie on the ellipses

$$(\underline{\alpha} - \underline{a}^*)'Z^*(\underline{\alpha} - \underline{a}^*) = p^2 \qquad (14)$$

where Z^* is the matrix $(H^{*-1})^{-1}_{SP}$ and $\underline{a}^*$ is the prior vector for α_1 and α_2.

For any given prior density we could ask the question "which parameter values maximise the probability that they are consistent with the observed data?". The answer is the locus of points of tangency between the prior ellipses and the confidence ellipses, christened the information contract curve by Leamer (1978). It is defined by minimizing ℓ for a given value of p, and in two-dimensions is the following hyperbola

$$\underline{\alpha} = (Z + \lambda Z^*)^{-1}(Z\underline{a} + \lambda Z^*\underline{a}^*) \quad 0 \leq \lambda \leq \infty \qquad (15)$$

As λ varies from zero to infinity we trace out the information contract curve moving from the data point to the prior location. Given a prior covariance matrix (which we need to specify only up to a scalar multiple) the contract curve is defined. For the prior covariance matrix of displacement effects we choose a block diagonal matrix with the submatrix corresponding to the two pension wealth variables given by

$$\sigma_p^2 \begin{bmatrix} 1 & rk \\ rk & k^2 \end{bmatrix} \tag{16}$$

Because private pension wealth, as measured here, probably has more unobservable attributes than social security wealth, we take our prior standard error for the private pension wealth displacement effect to be larger than that for social security wealth. In the calculations below we assume that $k = 1.5$. Beliefs about the magnitude of one of the displacement effects are likely to be highly correlated with those about the others. For example, it would be unlikely that many people would have a prior belief of zero for one effect and unity for the other. We take a value for the correlation coefficient, r in (16), of 0.75. The contract curve is independent of the value of the scalar σ_p^2, but to calibrate the prior density ellipses we take a prior standard error for the social security displacement effect of 10 cents. In other words, for a given prior location the prior 95 per cent confidence interval is equal to the location plus or minus 20 cents.

The contract curve, CC, corresponding to the prior location of zero and prior covariance matrix (16), is shown in Figure 3 together with the 95 per cent data confidence ellipse, D, and 95 per cent prior density ellipse, P. The contract curve joins the prior location and the regression estimates.[14] Although the two 95 per cent ellipses intersect, the prior mean of zero is not contained in the confidence ellipse for this data set. Figure 3 shows that, in this case, the bounds on the displacement effects implied by the contract curve are only a little tighter than those given by the feasible ellipse. An alternative approach is to place a limit on the extent to which we wish to deviate from the estimates implied by the data. For example, suppose that we consider only those values of the displacement effects which lie within the 95 per cent data confidence ellipse, then the posterior location must be in the intersection of the feasible ellipse and the 95 per cent confidence ellipse. This is shown as the hatched area in Figure 3.

Prior 3

The final prior we consider is that the displacement effect is unity for both types of pension wealth. The feasible ellipse, the 95 per cent prior density and data confidence ellipses, and the contract curve are all plotted in Figure 4. With this prior the bounds on the displacement effects implied by the feasible ellipse are rather uninformative; they are 0.143 to 1.066 for social security wealth and -0.032 to 1.308 for private pension wealth. The data and the prior are well separated, and the 95 per cent prior and confidence ellipses do not intersect. The contract curve provides much tigher bounds than the feasible ellipse for the private pension wealth displacement effect. Tighter bounds still are obtained by looking at the intersection of the feasible ellipse and the 95 per cent confidence ellipse (the hatched area in Figure 4), and, in effect, this gives much greater weight to the data than to the prior. Alternatively, we might choose points on the contract curve which attach a specific weight to the prior. For example, if we wish to remain within the 95 per cent prior ellipse, then the point which maximises the likelihood of the observations from our sample (the intersection of the 95 per cent prior density ellipse and the contract curve) is 0.728 for social security wealth and 0.633 for private pension wealth.

We may summarize the role of prior information as follows. If we specify only prior values for the displacement effects, we know that our preferred (posterior) estimates lie in the feasible ellipse. This is shown in Figures 2, 3 and 4 for the three sets of priors which we have examined. If we are prepared to specify our relative prior uncertainty about the displacement effects (equivalent to defining a prior covariance matrix up to a scalar multiple) then we obtain the contract curve. A fully specified set of prior standard errors leads to a unique point on the contract curve. The uncertainty about the size of the displacement effects is summarised in Table 2 which shows the bounds on the two effects arising from different sources of uncertainty. First, we show the range of estimates resulting from sampling uncertainty in terms of the upper and lower bounds of the 95 per cent confidence interval for each effect. Secondly, we give the bounds determined by the feasible ellipse. Finally, we show the bounds which result from taking the intersection of the feasible ellipse and the 95 per cent confidence ellipse. In the case of the first prior concerning the choice of explanatory variables to be included in the model, sampling uncertainty is far greater than specification uncertainty. For the second prior the differences between the prior and data points result in uncertainty about the displacement effects of the same order of magnitude as the sample confidence interval. The overall picture is that the estimated displacement effects are rather robust with respect to the specification of the model. Moreover, if we restrict ourselves to estimates in the 95 per cent confidence ellipse, differing prior beliefs about the magnitude of the displacement effects do not lead to radically different posterior beliefs, particularly in the case of social security. The evidence suggests that there is a small but significant displacement effect of pension wealth on private saving.

We conclude with some caveats about the assumptions underlying our methodology. The priors for the displacement effects were assumed to be joint normally distributed. With this assumption the posterior is a matrix-weighted average of the prior and regression estimates. But prior beliefs may not be symmetrically distributed around their mean. For example, if the prior mean for the displacment effect is zero, we may not wish to attach equal probabilities to the effect being positive as to it being negative. In these circumstances an asymmetric prior distribution, such as the Beta distribution, might be more appropriate. It is no simple matter, however, to compute the convolution of a normal and Beta distribution, and the use of matrix-weighted averages is very straightforward. The issue of the appropriate prior distribution raises the question of full-scale Bayesian estimation. If we specified a purpose for the estimated displacement effects then we could write down a loss function in terms of estimation errors and use the appropriate estimator rather than a regression estimate.

5. Sensitivity of Displacement Estimates to the Measurement of Pension Wealth

The accuracy with which pension wealth is measured will affect the estimates of the displacement effects implied by the regression model of household net worth. In this section we examine the sensitivity of our estimates to alternative measures of pension wealth.

We consider three potential sources of measurement error. Firstly, there may be an error in the imputation of private pension benefits. In section 3 it was assumed that before retirement these benefits are indexed to wage and salary growth. This may not be true for several reasons. One is that even final earnings plans have an earnings base of several years which means that there may be substantial pre-retirement erosion of benefits by inflation. Another is that wage growth may not be exogenous, and the growth of pension benefits and wages may be inversely related. Finally, even if benefits are vested immediately, firms do not index pensions of terminated workers before retirement. The benefits imputed to pre-retirement pension plan members are based on an econometric model of the benefits received by current retirees, which predicts the level of benefits in terms of several socio-economic characteristics of the recipient. If one assumes that the nature of pension plans, including the features mentioned above, remains unchanged then the model of benefit levels captures these aspects. That is, given the structure of pension plans and the characteristics of plan members, the model does in fact impute the real value of the pension at age 65 that the recipient expects to receive. Because of their statutory nature, it is likely that any error in the construction of anticipated social security benefits will be small.

The two remaining possible sources of error reside in our choice of the real discount rate and the expected rate of inflation. Altering the assumed value of the real discount rate will change the discount factor used for both pre- and post-retirement years. Because social security is fully indexed, different values of the expected inflation rate will change only the discount factor for private pension wealth. In Table 3 the displacement effects based on regression estimates of the augmented model (given in column 2 of Table 1), are shown for different assumptions about the real discount and expected inflation rates. The first row, "Standard Assumptions," corresponds to the data point in Figure 2. Rows 2 and 3 show the effect of lowering or increasing the real discount rate given the "standard" expected inflation rate. Similarly, rows 4 and 5 show the consequence of alternative expected inflation rates given the "standard" real discount rate. These alternative assumptions lead to only small changes in the displacement effect for social security wealth. For private pension wealth this is true also of the different expected inflation rates, but not of the real discount rate. At a real discount rate of 4 per cent per annum, the estimated displacement effect is small and negative, although insignificantly different from zero. With this exception the estimated effects seem rather robust to deviations from the standard assumptions. Since the effect of these alternative assumptions on the structure of the relevant submatrix of the sample covariance matrix was also found to be minor, the analysis of section 4 appears also to be robust with respect to the construction of the data.

6. Conclusions

In this paper we have shown how estimates of the displacement effect of pension wealth on household net worth are affected by prior beliefs of different types. The estimated effects are robust with respect to the specification of the model, and, even for very different prior beliefs about the magnitude of the displacement effects, the posterior means suggest a small but significant impact of pension wealth on private saving. We have also shown that if there are two parameters of principal interest, then the results can all be presented succintly in a diagram. This allows the reader to observe the complete set of results rather than a table of a subset of points selected by the investigator. The projection of the ellipsoids (feasible, prior, and confidence) into two dimensions is simple to calculate and requires only six numbers, the priors for the two parameters, and the four elements of the appropriate submatrix of the prior precision matrix in addition to the regression estimates. For this reason we hope that the geometrical approach used here may have a wider application.

Appendix 1: Age Variables Employed in the Study

We define the following dummy variables where the age of the head of the household i is A_i

$$d_{1i} = 1 \text{ if } A_i < 30, \text{ zero otherwise}$$

$$d_{2i} = 1 \text{ if } 30 \leq A_i < 40, \text{ zero otherwise}$$

$$d_{3i} = 1 \text{ if } 40 \leq A_i < 50, \text{ zero otherwise}$$

$$d_{4i} = 1 \text{ if } 50 \leq A_i < 60, \text{ zero other wise}$$

$$d_{5i} = 1 \text{ if } 60 \leq A_i \leq 75, \text{ zero otherwise}$$

$$d_{6i} = 1 \text{ if } 75 < A_i, \text{ zero otherwise}$$

We now define the following age variables for each household

$$V_{1i} = d_{1i}(A_i - 15) + 15 \sum_{j=2}^{6} d_{ji}$$

$$V_{12i} = d_{1i}A_i - 15)^2 + 225 \sum_{j=2}^{6} d_{ji}$$

$$V_{2i} = d_{2i}(A_i - 30) + 10 \sum_{j=3}^{6} d_{ji}$$

$$V_{22i} = d_{2i}(A_i - 30)^2 + 100 \sum_{j=4}^{6} d_{ji}$$

$$V_{3i} = d_{3i}(A_i - 40) + 10 \sum_{j=4}^{6} d_{ji}$$

$$V_{32i} = d_{3i}(A_i - 40)^2 + 100 \sum_{j=4}^{6} d_{ji}$$

$$V_{4i} = d_{4i}(A_i - 50) + 10 \sum_{j=5}^{6} d_{ji}$$

$$V_{42i} = d_{4i}(A_i - 50)^2 + 100 \sum_{j=5}^{6} d_{ji}$$

$$V_{5i} = d_{5i}(A_i - 60) + 15d_{6i}$$

Appendix 1: Age Variables (continued)

$$V_{6i} = d_{5i}(A_i - 60)^2 + 225d_{6i}$$

$$V_{7i} = d_{6i}$$

Appendix 2: Variables Used in the Study

Basic Variables

1. Constant
2. V_1
3. V_2
4. V_3
5. V_4
6. V_5
7. V_6
8. V_7
9. ln Y
10. Number of Persons with Life Insurance
11. $\ln (\frac{SW}{Y})$
12. $\ln (\frac{PW}{Y})$
13. Inverse of Mills' ratio

Doubtful Variables

1. V_{12}
2. V_{22}
3. V_{32}
4. V_{42}
5. DIFF = Age of head of household minus age of spouse
6. $(DIFF)^2$
7. REG 1; dummy equals 1 if region of household in Quebec, zero otherwise*
8. REG 2; dummy equals 1 if region of household is Ontario, Prairies or British Columbia, zero otherwise*
9. AREA; dummy equals 1 if area of household is rural, zero otherwise**
10. Farm Family Dummy
11. Number of Persons Unemployed
12. Number of Adults in Household

* The default region is Atlantic.

** The default areas are large and small urban areas.

FOOTNOTES

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[1]A brief survey of the US literature may be found in Danziger, Haveman, and Plotnick (1981); for a more comprehensive survey see Dick-Mireaux (1981a).

[2]Funding of social security does not require a separate fund into which contributions are paid. Rather it refers to whether the benefits paid out could have been financed from the contributions and accumulated income.

[3]Another problem with this approach is the lack of an obvious criterion for the process of model selection. In contrast with time-series data where tests of dynamic misspecification may be used to generate the most parsimonious representation consistent with white noise error, cross-section data offer no such clear choice. In the former case it is conventional to assume a small and given number of exogenous variables and achieve parsimony by reducing the number of lags required to model the data generation process. With cross-section data there is no such natural ordering of variables.

[4]For further discussion of this point see King and Dicks-Mireaux (1982).

[5]In the case of certainty, and for particular assumptions about the utility function of households, the function relating net worth to age is very tightly parameterised and is determined by the optimal consumption plan (Blinder et al, 1980). But with uncertainty it is possible to obtain an explicit function for net worth only in special cases.

[6]The "hump-shaped" profile holds also for the behaviour of net worth excluding pension wealth.

[7]A farm family is one in which any member receives more than 50 per cent of his income from self-employment in farming. Such a variable is important in a country like Canada where farms are substantial and asset valuation problems particularly severe.

[8]These do not, however, represent the extremes of feasible values. A negative displacement effect is possible if pension wealth alerts people to the need to save for retirement (Cagan 1965, Katona 1965). A displacement effect in excess of unity could occur if the introduction of an unfunded pension scheme were announced well in advance.

[9] All computations on this data base were carried out by the authors and should not be attributed to Statistics Canada. Further details of the data may be found in Statistics Canada (1979).

[10] Also excluded were 139 "special family units," primarily those with high incomes, for whom data on age and other characteristics were not recorded on the tape to protect their identity. These families accounted for 7.3 per cent of the total value of assets held by the complete sample (using population weights to compute the share).

[11] These are derived from the two-step procedure described in section 3 with the corrected covariance matrix for such an estimator (Greene 1981).

[12] For an application of the "doubtful variables" approach to other empirical problems see McManus (1980) and Cooley and Le Roy (1981).

[13] To show this, simply substitute the expression for a constrained least-squares estimate into equation (9) defining the ellipse; see Leamer (1978, Theorem 5.1).

[14] Points on the contract curve need not, in general, lie between the prior and regression estimates because $\underline{\alpha}$, as defined by (15), is a matrix-weighted average of the two estimates. The ellipse shown in Figure 3 is the hull of all possible contract curves for different choices of Z*.

TABLE 1. NET WORTH REGRESSIONS: TRUNCATED SAMPLE $W \geq \$2500$

(standard errors in parentheses*)

Dependent Variable $\ln \frac{W}{Y}$

	(1)	(2)
Constant	4.592 (0.734)	5.468 (1.094)
V_1	0.073 (0.011)	-0.010 (0.084)
V_2	0.042 (0.007)	0.121 (0.026)
V_3	0.032 (0.007)	0.043 (0.020)
V_4	0.002 (0.007)	-0.003 (0.028)
V_5	0.013 (0.021)	0.034 (0.022)
V_6	-0.002 (0.002)	-0.003 (0.002)
V_7	-0.062 (0.127)	-0.027 (0.117)
ln Y	-0.501 (0.067)	-0.595 (0.094)
Number of Persons with Life Insurance	0.036 (0.015)	0.065 (0.014)
$\ln \frac{\text{Social Security Wealth}}{Y}$	-0.192 (0.058)	-0.234 (0.083)
$\ln \frac{\text{Private Pension Wealth}}{Y}$	-0.125 (0.029)	-0.068 (0.026)
V_{12}	-	0.003 (0.004)
V_{22}	-	-0.009 (0.003)
V_{32}	-	-0.0001 (0.0026)
V_{42}	-	-0.00002 (0.00269)

TABLE 1. NET WORTH REGRESSIONS (continued)

	(1)	(2)
DIFF	-	-0.006 (0.003)
$(DIFF)^2$	-	0.00008 (0.00004)
REG 1	-	0.082 (0.043)
REG 2	-	0.476 (0.036)
AREA	-	0.105 (0.033)
Farm Family Dummy	-	1.040 (0.061)
Number of Persons Unemployed	-	-0.034 (0.027)
Number of Adults in Household	-	0.043 (0.017)
Inverse of Mills' Ratio	-1.223 (0.051)	-1.080 (0.048)
Standard Error of Equation	1.132	1.031
$\bar{R}^2$	0.411	0.495
Degrees of Freedom	8266	8254

*These are the corrected asymptotic standard errors appropriate for a two-step estimator (Greene, 1981).

TABLE 2: BOUNDS ON DISPLACEMENT EFFECTS

	SOCIAL SECURITY WEALTH			PRIVATE PENSION WEALTH		
	LOWER	UPPER	DIFFERENCE	LOWER	UPPER	DIFFERENCE
1. Sampling Uncertainty (data point ± 1.96σ)	.064	.352	.288	.067	.485	.418
2. Posterior Means						
Prior 1	0.107	0.273	0.166	0.272	0.512	0.240
Prior 2	-0.034	0.244	0.278	-0.064	0.340	0.404
Prior 3	0.143	1.066	1.209	-0.032	1.308	1.340
3. Intersection of 95% Confidence and Feasible Ellipses						
Prior 1	0.107	0.273	0.166	0.272	0.512	0.240
Prior 2	0.008	0.244	0.236	-0.013	0.340	0.353
Prior 3	0.147	0.566	0.419	0.079	0.408	0.329

Source: Own Calculations.

TABLE 3: DISPLACEMENT EFFECTS FOR ALTERNATIVE MEASURES OF PENSION WEALTH

(standard errors in parentheses*)

	Assumptions		Displacement Effect	
	Real Discount Rate (%)	Expected Rate of Inflation (%)	Social Security Wealth	Private Pension Wealth
1. Standard Assumptions				
	2.5	5.0	0.208 (0.074)	0.276 (0.107)
2.	1.0	5.0	0.207 (0.067)	0.344 (0.080)
3.	4.0	5.0	0.196 (0.079)	-0.095 (0.134)
4.	2.5	3.0	0.209 (0.074)	0.293 (0.103)
5.	2.5	8.0	0.206 (0.074)	0.245 (0.111)

*These are the corrected asymptotic standard errors approriate for a two-step estimator (Greene, 1981).

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FIGURE 1: AGE PROFILE OF THE RATIO OF WEALTH TO PERMANENT INCOME

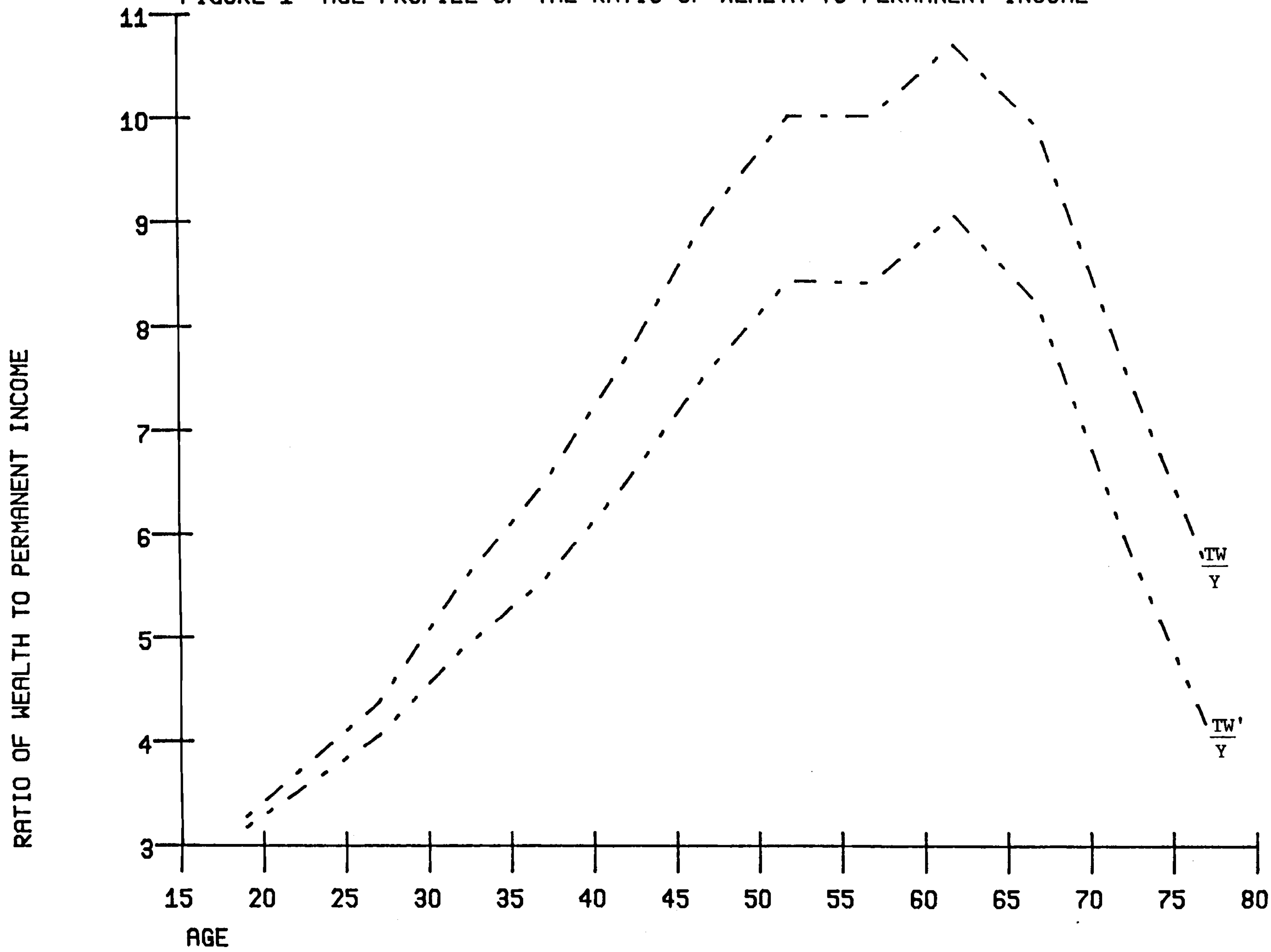

FIGURE 2: BOUNDS FOR DISPLACEMENT EFFECTS : PRIOR 1

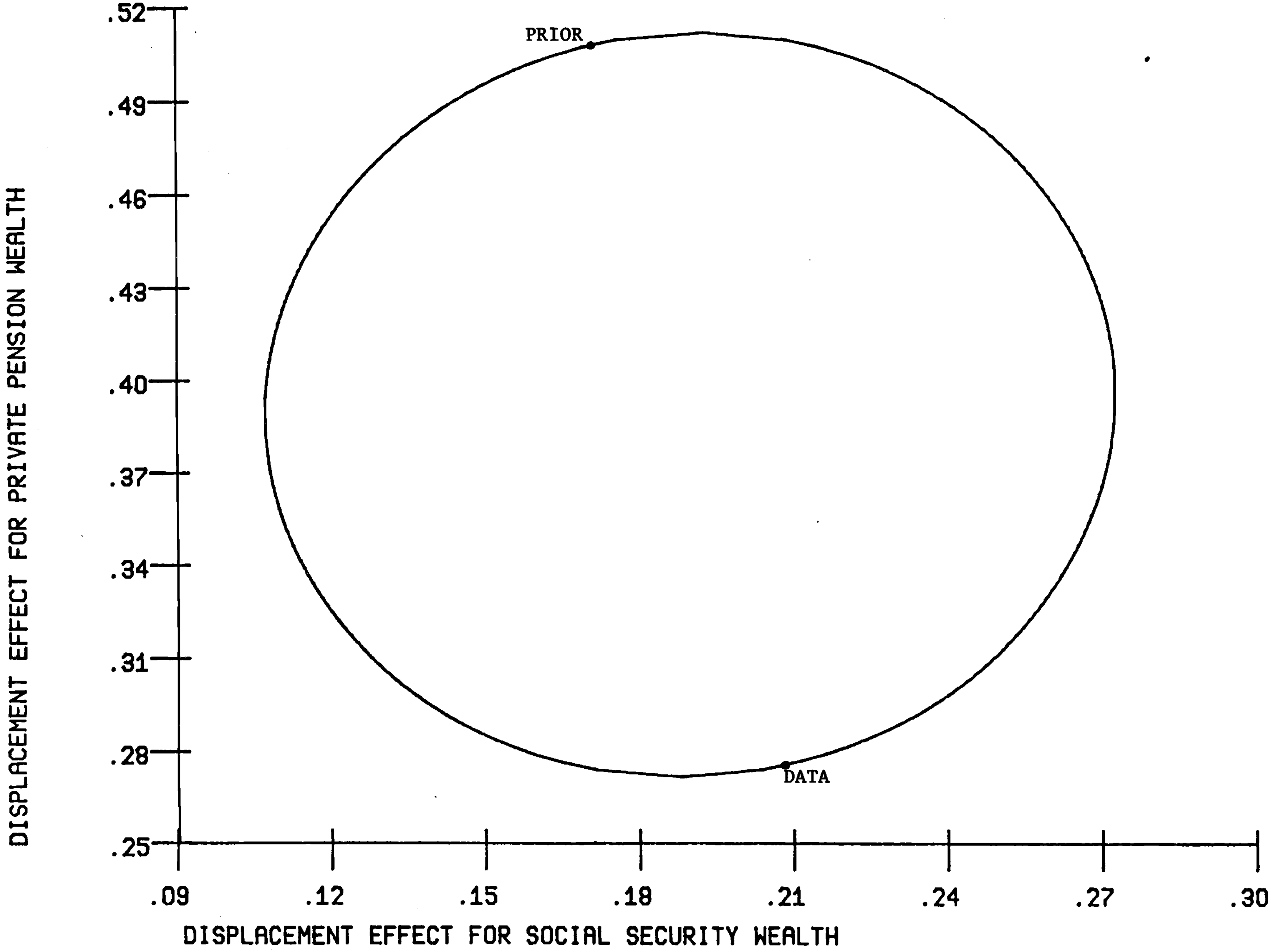

FIGURE 3: ELLIPSES AND CONTRACT CURVE : PRIOR 2

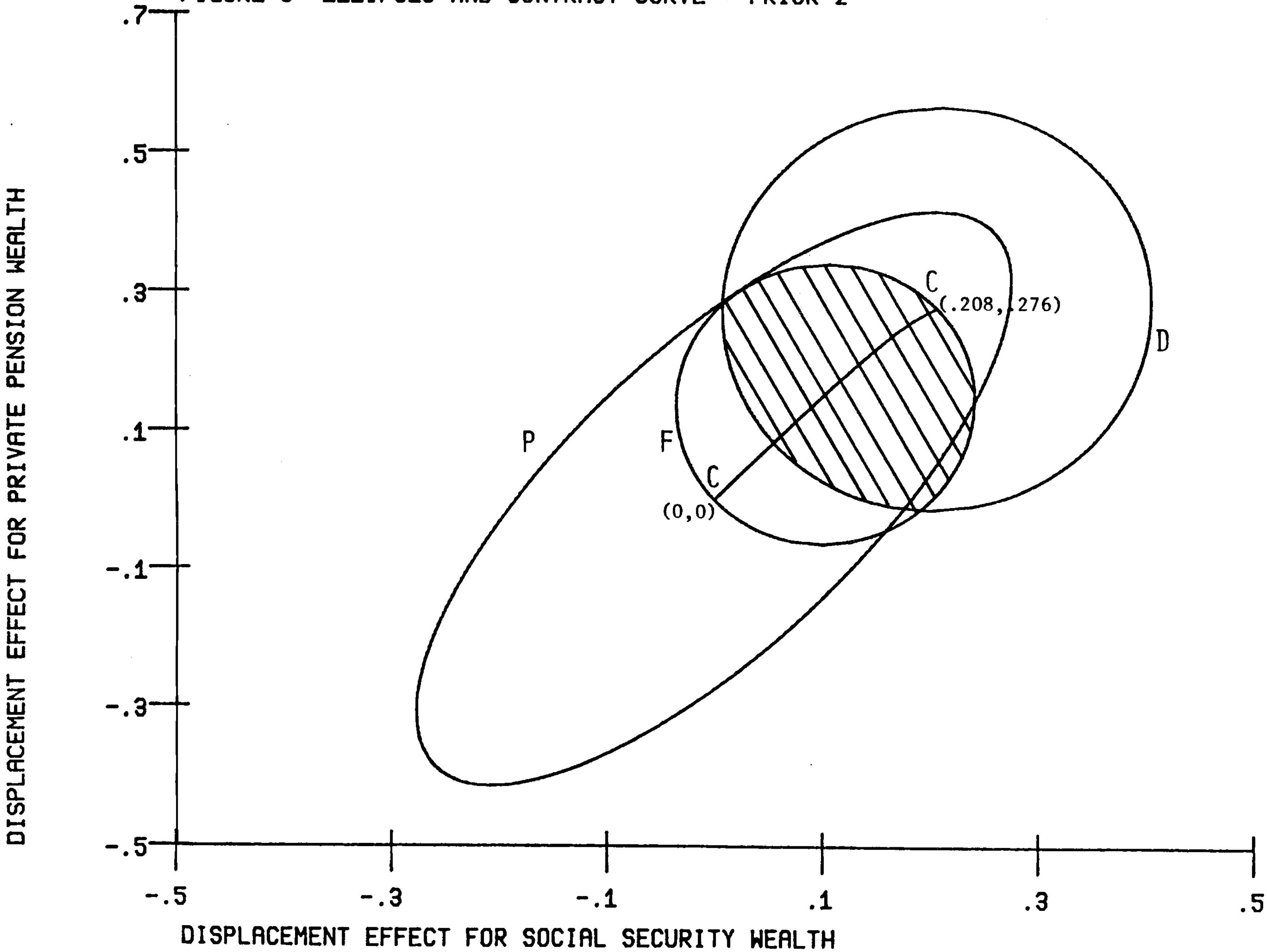

FIGURE 4: ELLIPSES AND CONTRACT CURVE : PRIOR 3