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Marginal Tax Reform and the Specification of Consumer Demand Systems

by

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Abstract: This paper examines the conjecture that tax reform recommendations are not as sensitive to underlying consumer demand systems as are derived optimal tax rates. Tax reform recommendations for Ireland using the well-known Ahmad-Stern model of indirect tax reform with different underlying consumer demand systems are examined. Using Irish data, tax reform recommendations are found to exhibit little sensitivity to the underlying deterministic demand system, but they do display some sensitivity to the stochastic and dynamic assumptions made. Their greatest sensitivity is with regard to the imposition of the restrictions implied by utility maximisation, especially symmetry.

I am grateful to Peter Neary for helpful comments, but remain responsible for any errors. This is a preliminary draft and not for quotation without the permission of the author.

Marginal Tax Reform and the Specification of Consumer Demand Systems

1. Introduction

It is a well-established fact that optimal tax proposals are sensitive to the specification of the underlying consumer demand system and in particular to assumptions regarding separability. If the consumer demand system in question imposes restrictions on demand responses, then this will affect the derived optimal tax rates. This has been implicit in the optimal taxation literature for some time (e.g. the well-known results of Corlett and Hague (1953)), and has perhaps its most formal exposition in the paper by Deaton (1981), who shows that optimal tax rates are very sensitive to "small" variations in separability assumptions (his inverted commas). He states: "In consequence, it is likely that empirically calculated [optimal] tax rates, based on econometric estimates of parameters, will be determined in structure, not by the measurements actually made, but by arbitrary, untested (and even unconscious) hypotheses chosen by the econometrician for practical convenience." (Deaton (1981)). An empirical verification of Deaton's conjecture is given by Ray (1986), who compares optimal commodity tax rates for India using the well-known (and restrictive) Linear Expenditure System (LES) and the more flexible Restricted Non-Linear Preferences System of *Blundell and Ray (1984)*. *He finds considerable differences* between the optimal tax rates derived from the two tax systems and these differences tend to widen the greater the degree of inequality aversion assumed.

It has been conjectured that optimal tax reform might not be so sensitive to the underlying demand specification. Deaton (1987) points out that calculation of optimal tax rates requires knowledge of price and income responses at points quite different from the current position of the economy, or indeed from any position of the economy ever observed. On the other hand, tax reform requires knowledge only of the current position and of current price and income responses.

Ahmad and Stern (1984), in their analysis of the Indian indirect tax system, make the same point stating that tax reform analysis only requires aggregate demand derivatives and those only for the actual point at which the economy finds itself. Guesnerie, cited by Ahmad and Stern in the same paper, expressed this in a similar way, by maintaining that optimum taxes depend on derivatives of any order of utility functions, whilst tax reform depends only on second derivatives. In other words, calculation of optimal tax rates will require knowledge of such issues as how elasticities change in response to changes in taxes and/or redistribution, which involves knowledge of the second derivatives of demand functions and hence require third or higher order functional forms for the utility function; in contrast, tax reform merely requires knowledge of aggregate demand responses (i.e. first derivatives of demand functions). Ahmad and Stern maintain that estimates of first derivatives of demand functions obtained through econometric methods should be less sensitive to consumer demand specification than estimates of derivatives of higher order. This suggests that estimates from a second order flexible functional form representation of preferences may be sufficient for tax reform proposals. The need for aggregate responses only also implies that estimates from such flexible demand systems as the Rotterdam system (Theil, 1975), which is utility-consistent only for trivial cases, may also be suitable for tax reform (they would not be suitable for optimal tax design, however). The issue of the appropriateness of tax reform proposals using demand responses from demand systems which are either not utility-consistent or are not found to be utility-consistent at the point at which they are measured is taken up in the conclusion.

In the light of the above discussion, the empirical sensitivity of tax reform to underlying demand specification seems an issue worthy of investigation. Decoster and Schokkaert (henceforth DS, 1990) examine this using the well-known tax reform model of Ahmad and Stern (1984). They calculate marginal social costs (MSCs) of taxation for different goods using a variety of consumer demand

systems, applied to Belgian data.¹ They conclude that tentative support can be offered for the conjecture that sensitivity to the specification of the demand system is less severe for a tax reform exercise than for the calculation of optimal tax rates. However, they still note how sensitive tax reform is to the restriction of symmetry of the Slutsky matrix. Unlike Ray, they find that the degree of sensitivity is less the greater the degree of inequality aversion assumed. This is explained by the fact that, in tax reform models, inequality aversion affects only the weights attached to actual consumption patterns. An increase in the inequality aversion parameter increases the weight given to observed consumption, and hence reduces the dependence of the results on the underlying demand system.

The study of DS concentrates on the sensitivity of tax reform to what we call the deterministic specification of the consumer demand system i.e. the particular functional form chosen. However, tax reform may also be sensitive to what we may call the stochastic specification of the underlying consumer demand system and also to the inclusion of simple dynamic elements. If consumer demand systems are more sensitive to stochastic than to deterministic specification and are also influenced by dynamic factors (as appears to be the case for Ireland as documented in Madden (1992b)), then this suggests the same may be true for tax reform proposals. In fact, in confining sensitivity tests of tax reform (and tax design) proposals to deterministic specification, the literature has only partially attended to Deaton's warning, since if consumer responses to price changes are best modelled by the inclusion of dynamic factors, then this must also be taken into account in examining tax reform proposals.

The aim of this paper is to pursue this research agenda, making use of the estimates of consumer demand systems for Ireland by Madden (1992b). In

¹This model of tax reform is usually associated with indirect tax reform in developing countries. However, it has also been applied to developed countries e.g. Christiansen and Jansen (1978), Decoster and Schokkaert (1989), Craggs (1990) and Madden (1989, 1992a).

particular, we examine the sensitivity of tax reform proposals to three alternative dynamic structures: an Almost Ideal Demand System (AIDS) model estimated in levels, the same model estimated in levels but with the addition of a quadratic time trend, and the same system estimated in first differences. We also address the issue analysed by DS i.e. the sensitivity of tax reform recommendations to alternative deterministic specifications of consumer demand viz. different specification of the AIDS models, the Rotterdam model of Theil (1975) and the CBS² model of Keller and Van Driel (1985).

A further, potentially exciting, extension of our work would be the analysis of the sensitivity of tax reform proposals to the assumption of weak separability between goods and leisure, an assumption which is adopted in all the existing applications of the Ahmad-Stern approach of which we are aware. This would involve the inclusion of variable labour supply and the estimation of a jointly determined commodity demand-labour supply model. Such an analysis would get to the heart of exploring Deaton's conjecture for tax reform work, and it is an area we are currently working on for Ireland.

The layout of this paper is as follows: Section 2 gives a brief outline of the tax reform model used. Section 3 discusses the different consumer demand system results available for Ireland and examines the means and variances of the MSCs associated with the different demand systems. Section 4 examines how sensitive tax reform proposals are to the underlying demand system, while Section 5 offers some concluding comments.

²The acronym CBS comes from the Netherlands Central Bureau of Statistics where the authors⁴ were working at the time.

2. The Tax Reform Model.

The tax reform model we will be using in this paper is that of Christiansen and Jansen (1978) and Ahmad and Stern (1984). The crucial parameter of interest in these models is what is known as the marginal social cost (MSC) of raising revenue via an increase in tax on the i th good, often referred to as λ_i . A sufficient condition for optimality of the indirect tax system is that λ_i be equal to λ_j for all goods i and j . If this condition is not met, then it is always possible to increase welfare while keeping revenue constant, by lowering the tax on a good with a high MSC and raising the tax on a good with a low MSC (i.e. if $\lambda_i > \lambda_j$ then lower t_i and raise t_j). More formally, suppose we assume factor incomes to be fixed and untaxed. Producer prices $p_1 \dots p_N$ of the N commodities are also fixed and there are no pure profits. Indirect taxes are given by $t_1 \dots t_N$ and consumer prices by $q_1 \dots q_N$. Thus we have

$$q_i = p_i + t_i, \quad i=1, \dots, N. \quad (1)$$

There are H households in the economy and total consumption of commodity i is given by

$$X_i = \sum_h x_i^h, \quad i=1, \dots, N. \quad (2)$$

where x_i^h is the amount purchased by household h , and is a function of consumer prices and incomes (which are assumed to be fixed). The government collects revenue through indirect taxes R :

$$R = \sum_i t_i X_i \quad (3)$$

and wishes to find changes in tax rates which will raise social welfare, represented by the function $W[v^1(q), \dots, v^H(q)]$, where $v^h(q)$, $h=1, \dots, H$, refers to the indirect utility function of household h . λ_i is then defined as

$$\lambda_i = - \frac{\delta W / \delta t_i}{\delta R / \delta t_i} \quad (4)$$

Roy's Identity and some re-arranging gives

$$\lambda_i = \frac{\sum_h \beta^h q_i x_i^h}{q_i x_i + \sum_k \epsilon_{ki} \tau_k q_k x_k} \quad (5)$$

where β^h is the marginal social valuation of one unit of income accruing to household h i.e. its welfare weight, ϵ_{ki} is the uncompensated price elasticity and $\tau_k = t_k / q_k$ is the tax rate on good k expressed as a fraction of consumer price.

As can be seen from (4), the expression for λ_i is the ratio of a welfare effect, $\delta W / \delta t_i$, and a revenue effect, $\delta R / \delta t_i$. $\delta W / \delta t_i$ will always be negative. In general, we would expect $\delta R / \delta t_i$ to be positive, but, in principle, it can be greater than, less than, or equal to zero (the case of $\delta R / \delta t_i < 0$ could be regarded as a commodity specific Laffer effect)³. This can have implications for the value of λ_i . As $\delta R / \delta t_i$ becomes smaller, λ_i becomes larger. When $\delta R / \delta t_i = 0$, $\lambda_i = \infty$, and when $\delta R / \delta t_i < 0$, $\lambda_i < 0$. This introduces a discontinuity into the relationship between λ_i and $\delta R / \delta t_i$ and also raises the question of how to compare λ_i s between two goods when one

³Although the case of $\delta R / \delta t_i < 0$ appears unlikely, such a situation is by no means impossible, and as can be seen in the tables in the appendix $\delta R / \delta t_i < 0$ for a number of goods for certain demand systems. The study by Fitzgerald, Quinn, Whelan and Williams (1988) also examines the potential for such effects owing to the existence of cross-border trade.

has a positive MSC and the other a negative. From a policy point of view, a negative λ_i implies that a lowering of the tax on good i will not only increase welfare but will also increase revenue. Thus, *a fortiori*, we would recommend that the tax on good i should be lowered and we can also lower the tax on any other good j whose $\lambda_j > 0$, thus giving us an even greater welfare gain with no revenue change. This, of course, implies that the rule whereby the tax on the good with the higher λ_i be reduced does not hold when one of the λ_i is negative. As can be seen from the tables in the appendix, $\delta R / \delta t_i$ is negative for tobacco and/or durables for certain demand specifications.

To avoid any problems of discontinuity, goods can be ranked according to $1/\lambda_i$ (which for convenience we will refer to as ρ_i) with the general recommendation that if $\rho_i < \rho_j$, then the indirect tax on good i should be lowered and that on good j should be raised. Intuitively, ρ_i gives the marginal cost in revenue foregone when a tax is lowered so as to provide one extra unit in welfare (we can call this the marginal revenue cost, MRC). The expression for ρ_i is given in equation 6.

$$\rho_i = \frac{q_i X_i}{\sum_h \beta^h q_i X_i^h} + \frac{\sum_k e_{ki} \tau_k q_k X_k}{\sum_h \beta^h q_i X_i^h} \quad (6)$$

Expression (6) gives a more intuitive breakdown of MSC/MRC. We can see that ρ_i is a combination of two terms, one of them taking account of distributional issues and actual consumption patterns and the other taking account of revenue responses. If we adopt a purely utilitarian viewpoint i.e. $\beta^h = 1 \forall h$, then the first term on the right hand side of (6) becomes unity. This term is the inverse of Feldstein's "distributional characteristic" of a good (see Feldstein (1972)). Following Ahmad and Stern (1984) we also note that in the case of uniformly proportional indirect taxes, $t_k = \alpha p_k \forall k$, then Cournot aggregation implies that the numerator of the second term on the right-hand side is zero, and so goods are ranked solely by distributional considerations.

Once again, the existence of negative ρ_i does complicate our rule somewhat. However, note that for ρ_i the denominator can never be zero or negative, presuming every good under consideration is consumed. Thus the discontinuity problem associated with λ_i is avoided. The rule "lower t_i if $\rho_i < \rho_j$ " is always robust to whatever sign ρ_{ij} takes.

A further key point to remember is that the existence of negative $\delta R/\delta t_i$ and hence negative ρ_i can also have implications for carrying out tests on the sensitivity of the ranking of goods by ρ_i , and this is discussed below.

To actually calculate (5) and (6) a variety of information is required. Individual household and aggregate consumption of different commodities must be obtained from Household Budget Survey Data. The tax rates can be obtained from various sources, including the Revenue Commissioners' Reports and Budget booklets. This leaves the β^h and the ϵ_{ki} . The β^h are usually imposed via the use of a utility of income function such as that of Atkinson(1970)⁴. Using a normalisation of $\beta^1=1$, where 1 represents the poorest household, this leads to $\beta^h=(I^1/I^h)^e$, with I representing income (in fact, expenditure is usually used) and e is the inequality aversion parameter. A value of $e=0$ implies zero inequality aversion, in which case the numerator of (5) is simply the total consumption of good i , $q_i X_i$. The calculated values of ρ_i for the different demand systems are given in table A1.

Given that all the constituents of ρ_i except the ϵ_{ki} are either taken straight from data sources or imposed, the sensitivity of the ρ_i to the elasticity estimates is obvious. Note that only aggregate demand responses or elasticities are

⁴Alternatively, the β^h can be estimated under the hypothesis that the initial equilibrium is optimal i.e. all the λ_i , and hence ρ_i , are equal. In other words, we would be estimating the values of β^h implicit in the existing tax system, given that the existing tax system is optimal. This is a different exercise from identifying welfare-improving directions of reform and was the principal motivation behind the original Christiansen and Jansen (1978) paper.

required, thus ignoring such issues as preference heterogeneity arising from household composition etc. In the next section we review the elasticities implied by different demand systems estimated for Ireland.

3. Consumer Demand Estimates for Ireland.

For a comprehensive set of consumer demand responses, we use those of Madden (1992b). They have the advantage of being the most up-to-date available and also present estimates from five different demand specifications, each specification being estimated first unrestricted, second with homogeneity imposed and third with homogeneity and symmetry imposed, thus giving us fifteen different sets of demand responses. The different demand specifications estimated were the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980), the Rotterdam (ROTT) system of Theil (1975) and the CBS system of Keller and Van Driel (1985). The AIDS system was estimated in levels (AIDS), with a quadratic time trend included (TAIDS) and in first-differences (DAIDS). The three versions of the AIDS model and the ROTT and CBS models give the five different specifications.

The data used were annual data from National Income and Expenditure for the period 1958-88.⁵ The data were disaggregated into ten commodities: food, alcohol, tobacco, clothing and footwear, fuel and power, petrol, transport and equipment including travelling within the state, durables, other goods and services. For estimation purposes services were treated as a residual.

It is not intended to discuss the relative merits of the different specifications here. The interested reader is referred to Madden (1992b). In this paper we are concerned with the sensitivity of the rankings of goods by MRC to the underlying demand system. Nevertheless, it is still of some interest to take a broad look at the estimated demand systems, in particular to note the results of testing the

⁵I am grateful to John Fitzgerald for providing the data.

restrictions implied by utility maximisation, since this will indicate whether the utility function underlying the demand system is concave. This is of interest since we will also want to examine how sensitive tax reform proposals are to the imposition of the restrictions implied by utility maximisation. As mentioned above, the issue of the concavity of the utility function also has implications for both optimal tax design and tax reform and this is addressed in the conclusion.

Both equation-by-equation and system-wide tests for homogeneity were carried out for the five different specifications. On an equation-by-equation basis, homogeneity was rejected for four out of ten goods and was borderline for a fifth in the AIDS model. However, in the DAIDS, ROTT and CBS models, homogeneity is only rejected for food. In the TAIDS model it was rejected for only two goods, food and fuel and power. Straightaway, we can see that stochastic and/or dynamic specification matters for tests of homogeneity (as was pointed out by Deaton and Muellbauer in their original AIDS paper (1980) and has since also been explored by Anderson and Blundell (1983)).

Much the same story can be seen when we test on a system-wide basis. Using the conventional Wald and likelihood-ratio tests, homogeneity is decisively rejected for all specifications, but even more emphatically for AIDS than for DAIDS, ROTT or CBS, though curiously TAIDS rejects it most strongly. However, as Laitinen (1978) and Deaton (1986) have pointed out, such system-wide tests are biased towards rejection in the presence of small samples. Using Laitinen's suggestion of applying Hotelling's T^2 statistic, it is found that both ROTT and CBS fail to reject homogeneity at 99% as does DAIDS when the intercept is suppressed. Both AIDS and TAIDS continue to decisively reject homogeneity.

While the tests for homogeneity fail to reject it conclusively, the same cannot be said for symmetry. Symmetry is a cross-equation restriction and the test statistics, even allowing for the application of a small-sample correction factor, show decisive rejection. Interestingly, rejection is most decisive for AIDS and TAIDS and least decisive for DAIDS.

The final restriction tested was negativity. This was carried out by inspecting the eigenvalues of the Slutsky matrix of the systems with homogeneity and symmetry imposed. Once again, negativity was rejected, but again the degree of rejection was greater for AIDS and TAIDS than for DAIDS, ROTT or CBS.

To summarise briefly the results from Madden (1992b), tests of the restrictions implied by utility maximisation, namely homogeneity, symmetry and negativity, show that homogeneity was not rejected in a number of cases but that symmetry and negativity were rejected for a variety of consumer demand systems. However, the degree of rejection was quite sensitive to the dynamic specification adopted suggesting that tax reform results might exhibit the same sensitivity.

Before directly examining this issue there is a further point to be made. We are examining the question of sensitivity of tax reform proposals to both the deterministic and stochastic specification of the underlying consumer demand system, but we are not making any inferences regarding what is the "best" consumer demand system⁶. If we considered one consumer demand system to dominate the others, in the sense of giving the most accurate description of consumer behaviour, then the issue of sensitivity of tax reform proposals, while still of interest, would be less pressing, since presumably we would adopt the tax reform proposals derived from the "best" system. The different consumer demand systems we have been comparing are not nested, thus complicating the choice of any particular system as the "best". Of course, there are non-nested tests, for example Barten (1991), Barten and McAleer (1991) and the survey by Pesaran (1987) but, in general, there does not appear to be any well-established procedure which would allow one to unambiguously choose between non-nested models. Thus, the issue of sensitivity remains a pertinent one.

⁶In particular we are not addressing the question of whether it is preferable to estimate in levels or differences. For a discussion of this point, see Harvey (1981) and, for the Irish case, Madden (1992b).

While we cannot unambiguously choose any one demand system as being the "best", using the measure of ρ_i we can identify which demand system is associated with the lowest average MRC^{7,8}. Since the use of ρ_i overcomes the discontinuity problem, we can now examine the distribution of ρ_i associated with each demand system and compare means and variances. Table A1 gives the summary statistics for each demand system. The system with the highest MSC is AIDS3.

The measure of variance is also of interest. Recall that if all the ρ_i are equal, then we are at an optimum and there is no scope for a welfare-enhancing tax change which leaves revenue unchanged. Thus the greater the variance, the greater the scope for marginal tax reform. Table A2 identifies AIDS2 as the demand system with the greatest scope for tax reform, while DAIDS3 has the least.

We can also examine how the mean and variance of ρ changes with the imposition of homogeneity and symmetry across the different systems. The imposition of homogeneity and symmetry appears to cause little systematic difference to the distribution of ρ , with one exception. The imposition of homogeneity causes the mean ρ to fall in AIDS, DAIDS, ROTT and CBS (marginally), while it rises in TAIDS. The further imposition of symmetry lowers mean ρ for DAIDS, TAIDS, ROTT and CBS but raises it (substantially) for AIDS.

⁷In the discussion which follows it is important to bear in mind that in comparing the means and variances of the ρ_i associated with each demand system, we are at all times viewing the economy at a single point in time. We have different models of consumer demand, none of which can be unambiguously identified as the "best" representation of consumer behaviour. Thus while demand system 1 may have higher mean ρ_i than demand system 2, this is distinct from the issue of whether demand system 1 is a more accurate description of the economy at the particular point in time than demand system 2.

⁸Recall that ρ_i gives the gain in revenue if taxes are changed so that welfare falls by only one unit. Thus the higher is mean ρ then the lower is the welfare cost of raising a given amount of revenue.

Homogeneity raises the variance of ρ for AIDS and TAIDS, but lowers it for the other systems. Interestingly, the further imposition of symmetry lowers the variance of ρ for all demand systems, in some cases substantially. Intuitively, what this tells us is that the imposition of the restrictions implied by utility maximisation appears to reduce the scope for marginal tax reform. This result is difficult to interpret and it should be borne in mind that it is a result for a specific economy at a specific point in time.

4. Tax Reform Results and Consumer Demand Specification.

The methodology adopted to examine the question of sensitivity of tax reform prescriptions to the underlying consumer demand system is that of DS (1990). In the Ahmad and Stern model of tax reform, what matters most is the ranking of goods by ρ_i . Taxes should be raised on those goods with the highest ρ_i and lowered on those with the lowest ρ_i . Thus, the tax reform prescriptions will be sensitive to the underlying consumer demand system if the ranking of goods by ρ_i is likewise sensitive. DS thus examine Spearman rank correlation coefficients for the different consumer demand systems. The use of rank correlation coefficients is not without its drawbacks as has been pointed out by Madden (1992a). Rank correlation coefficients are non-parametric statistics and so are independent of the mean value of ρ_i and/or its standard deviation. In particular, given that ρ_i s are based on consumer demand estimates, they will have implicit standard errors, which will not be taken into account in the calculation of rank correlation coefficients.

Given these drawbacks, we can ask what other methodologies can be used. One method which immediately suggests itself and has the advantage of explicitly taking account of the values of the ρ_i apart from just the ranking is to regress the ρ_i from different specifications against each other. This is a useful approach, although it is not entirely straightforward. One of the first issues to be addressed concerns whether to estimate with an intercept term or not. Estimation with an

intercept term constrains the relationship between the two variables to go through the origin, thus implying that if ρ_i for one system is zero, then so too should be ρ_i for the other system. There seems no particular reason as to why we should wish this to be the case. The regression results obtained turn out to be quite sensitive to the inclusion or non-inclusion of an intercept.

More fundamentally, regression analysis implies some causal relationship between the two variables, in the sense that one has to be defined as the dependent variable and the other as the independent variable. When regressing without an intercept, the value of the R^2 and the estimated coefficients will be sensitive to the choice of dependent variable (when estimating with an intercept the R^2 is invariant to the choice of dependent variable but the estimated coefficient is not).

This discussion implies that when using regression analysis for the purposes of analysing sensitivity of tax reform results we should estimate with an intercept term and compare R^2 only which, of course, is equivalent to comparing simple correlation coefficients. Since we will be examining Spearman rank correlation coefficients, it seems most reasonable to present our regression results in the form of correlation coefficients.

The Spearman rank correlation coefficients are presented in Table A2.⁹ In analysing these results, there are essentially three issues we can look at. Firstly, there is the question of whether tax reform recommendations are sensitive to the underlying consumer demand system (what we call its deterministic specification). To do this, we have to isolate demand systems that have the same stochastic specification. Thus we address this question by looking at the first of our two rank correlation matrices i.e. that containing the three versions of DAIDS, ROTT and CBS. Secondly, we have to examine how sensitive tax reform

⁹Results are presented here for the purely utilitarian case i.e. $e=0$. Results for other values of e are available from the author on request.

recommendations are to the underlying stochastic specification, which we do in the second of our rank correlation matrices, where we have rank correlations between three different dynamic versions of the same deterministic system (AIDS). Finally, we examine how sensitive are recommendations to the imposition of the restrictions implied by utility maximisation. This we can do by comparing the rank correlations between the three different versions of each system e.g. AIDS1, AIDS2, AIDS3 etc.

To examine sensitivity to deterministic specification we examine correlations between DAIDS1, ROTT1 and CBS1 (and similarly those involving DAIDS2, ROTT2 etc). These correlations show complete consistency in the unrestricted case and those with homogeneity only imposed i.e. all rank correlations between any pair of DAIDS1, DAIDS2, ROTT1, ROTT2, CBS1 and CBS2 are unity. DS obtain near perfect correlation between ROTT1, ROTT2 and CBS1 but find correlations of around 0.6-0.7 between AIDS1 and ROTT1 and CBS1 and also between AIDS2 and ROTT2 and CBS2.

When symmetry is imposed in addition to homogeneity, the Irish correlations drop only very slightly to around 0.96. Given that the CBS system is a hybrid of the Rotterdam and AIDS models combining the price coefficients of the former and the expenditure coefficients of the latter (see Keller and Van Driel (1985)), the continuing high correlation between ROTT3 and CBS3 is not too surprising. What is slightly surprising is the continuing high correlation between DAIDS3 and the other two systems with homogeneity and symmetry imposed. This contrasts with the results for DS who obtained correlations of 0.3497 and 0.3357 between DAIDS3 and ROTT3 and CBS3 respectively.

We turn now to examine the question of sensitivity to the restrictions implied by utility maximisation. Here, the results are very similar to those obtained by DS. Taking firstly the three systems in differenced form, DAIDS, ROTT and CBS, in all cases the imposition of homogeneity leads to no changes in the rankings with all correlations unity. Broadly speaking this is identical to DS.

The further imposition of symmetry causes the correlation to fall to 0.539 for DAIDS, 0.527 for ROTT and 0.6 for CBS. The corresponding figures for DS were 0.2098, 0.6783 and 0.6503. Despite the slight difference between our figures and those of DS for the DAIDS system, it seems reasonable to suggest that our results and those of DS are consistent i.e. the imposition of symmetry does exert a significant influence on the ranking.

We can also examine this issue for the two other systems estimated for Ireland viz. AIDS (i.e. in levels) and TAIDS i.e. AIDS in levels with a quadratic time trend introduced to provide some simple dynamics. These results suggest that the sensitivity of rankings to the imposition of restrictions implied by utility maximisation is affected by the degree of dynamics introduced. In the simple AIDS in levels model the ranking between AIDS1 and AIDS2 is 0.770, while it is 0.976 for TAIDS and 1.0 for DAIDS. The further imposition of homogeneity causes the correlation to fall to 0.309 and 0.321 for AIDS and TAIDS respectively but only 0.54 for DAIDS.

Finally we can address the issue of how dynamic specification *per se* affects tax reform rankings i.e. correlations between AIDS1, TAIDS1 and DAIDS1 etc. These results suggest that stochastic specification is of greater importance than deterministic specification but only to a limited degree. For example, the DAIDS1/TAIDS1 correlation is 0.976 and the DAIDS1/AIDS1 and TAIDS1/AIDS1 correlations are 0.879 and 0.854 respectively, lower than those between DAIDS1/ROTT1, DAIDS1/CBS1 and ROTT1/CBS1 (all of which are unity). When homogeneity only is imposed, the DAIDS/TAIDS and DAIDS/AIDS correlations change to 0.976 and 0.515 respectively compared to unity once again for DAIDS2/ROTT2 and DAIDS2/CBS2. When symmetry is imposed, the correlations are both 0.77, compared to 0.987 for ROTT and 0.96 for CBS. Thus the DAIDS models show higher correlations with their corresponding ROTT and CBS models than with the AIDS and TAIDS models, suggesting that for this data set, at least, the ranking of goods by p_i is more sensitive to stochastic than deterministic specification.

Turning now to the regression analysis, table A3 shows the matrix of correlation coefficients for the p_i for the different demand systems. The results from this table are consistent with those from table A2. They do help to show more vividly the effect of imposing symmetry on the consumer demand model e.g. the correlation coefficient between AIDS1 and AIDS3 is -0.006 while between AIDS2 and AIDS3 it is -0.268. This confirms that tax reform recommendations are quite robust to the imposition of homogeneity, but that the further imposition of symmetry significantly undermines this robustness, more so for the AIDS model than the others.

As was the case with the Spearman correlations there appears to be slightly more sensitivity to stochastic than to deterministic specification. The DAIDS1/ROTT1 and DAIDS1/CBS1 correlation coefficients are 0.967 and 0.982 respectively, while the DAIDS1/AIDS1 and DAIDS1/TAIDS1 correlations are 0.879 and 0.987 respectively.

We can summarise the results of the correlation coefficients by saying that they support the findings of the Spearman correlations but even more strongly raise the issue of sensitivity to the imposition of symmetry, an issue discussed in the concluding remarks.

5. Conclusion

This paper started off by conjecturing that tax reform recommendations might be less sensitive to the underlying demand system than optimal tax design. We also conjectured that they may be more sensitive to what we termed stochastic specification and the introduction of simple dynamics than to the deterministic choice of demand system, an issue so far ignored in the literature. This paper also ranks goods according to the inverse of the usual MSC measure, since this parameter is more appropriate when some goods have negative MSC.

The results obtained here are consistent with the conjecture that tax reform is not very sensitive to the underlying demand system. Indeed our results bear this out even more strongly than the only other study in this area of which we are aware. As regards sensitivity of tax reform recommendations to such restrictions as homogeneity and symmetry, our results are consistent with the view that homogeneity matters little, but symmetry does affect rankings (in particular, in our results the ranking of alcohol is very sensitive to the imposition of symmetry). Moreover, not only does the imposition of symmetry affect rankings of goods by ρ_i , it also appears to lower the variance of the estimated ρ_i s, thus reducing the implied potential for tax reform. Our results also suggest that stochastic specification and dynamic factors do matter, and, for this data set at least, more so than deterministic specification. Thus, overall, these results are consistent with the general conjecture that tax reform recommendations are less sensitive to underlying assumptions regarding functional form than are derived optimal tax rates. It is tempting to go on and say that these results suggest that this finding could be extended to the underlying assumptions regarding stochastic and/or dynamic specification. However, we are not aware of any theoretical or empirical results concerning the sensitivity of derived optimal tax rates to the stochastic/dynamic specification of the underlying consumer demand system. Thus, for the moment, we merely report the empirical finding that stochastic/dynamic specification does affect tax reform recommendations, for this data set at least.

What appears to matter most, in terms of tax reform recommendations is the imposition of the restrictions implied by utility maximisation. This also raises the issue of whether we should feel comfortable making tax reform recommendations given that our underlying consumer cost function is non-concave (since symmetry and negativity are rejected) and that the imposition of symmetry appears to affect results. Here we are faced with the dilemma posed in DS and in Deaton and Muellbauer (1980b). From a strictly theoretical viewpoint it should matter that our results come from an underlying cost function that is not consistent with utility maximisation. However, it could be argued that this is not

as great a problem as it might at first seem. On a theoretical basis perhaps we should not be too worried about the rejection of restrictions on individual behaviour from an aggregate time-series data set, since it could be maintained that what is being rejected are the assumptions required for aggregation rather than the individual-behaviour restrictions. On this point Gilbert (1989, p20) states: "Theoretical restrictions should not be expected to hold precisely on aggregate data. This implies that classical rejections cannot *per se* be taken to imply rejection of the theories in question". Also, taking a purely pragmatic viewpoint we could argue that (a) even if our data set does suggest that symmetry is rejected and consumers are not maximising utility, then so be it, that is the way the world is and we should make our recommendations on the basis of the unrestricted results we have or, at least, only imposing those restrictions which are not rejected by the data; and (b) the results in this paper suggest that tax reform recommendations are not very sensitive to the imposition of symmetry and, in any event, that sensitivity arises principally from one particular good (alcohol), which we can always leave out of our tax reform package.

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Table A1: Rankings of Goods by MRC

AIDS1	AIDS2	AIDS3
1. Alc 1.836	1. Alc 2.560	1. Serv 1.114
2. F & P 1.187	2. C & F 1.079	2. Food 0.897
3. Serv 0.991	3. Serv 0.986	3. C & F 0.893
4. Oth G 0.834	4. F & P 0.942	4. F & P 0.891
5. Food 0.751	5. Food 0.783	5. Oth G 0.866
6. C & F 0.727	6. T & E 0.460	6. Petrol 0.591
7. Petrol 0.684	7. Oth G 0.449	7. T & E 0.508
8. T & E 0.680	8. Dura 0.397	8. Toba 0.451
9. Dura -0.420	9. Petrol 0.317	9. Dura 0.382
10. Toba -0.568	10. Toba -0.829	10. Alc -0.116
Mean ρ_i 0.670	Mean ρ_i 0.714	Mean ρ_i 0.648
Var ρ_i 0.499	Var ρ_i 0.716	Var ρ_i 0.129

DAIDS1	DAIDS2	DAIDS3
1. Oth G 1.202	1. Oth G 1.225	1. Oth G 1.127
2. Alc 1.169	2. Alc 1.181	2. Serv 0.947
3. F & P 1.028	3. F & P 1.014	3. Food 0.935
4. Serv 0.956	4. Serv 0.962	4. Petrol 0.784
5. Food 0.874	5. Food 0.875	5. F & P 0.745
6. T & E 0.725	6. T & E 0.725	6. C & F 0.688
7. Petrol 0.507	7. Petrol 0.490	7. T & E 0.632
8. C & F 0.427	8. C & F 0.442	8. Dura 0.632
9. Dura 0.150	9. Dura 0.152	9. Alc 0.428
10. Toba 0.014	10. Toba 0.043	10. Toba 0.380
Mean ρ_i 0.705	Mean ρ_i 0.711	Mean ρ_i 0.723
Var ρ_i 0.173	Var ρ_i 0.172	Var ρ_i 0.045

Table A1 (contd.)

TAIDS1	TAIDS2	TAIDS3
1. Oth G 1.127	1. Alc 1.163	1. Petrol 1.014
2. Alc 1.085	2. Oth G 1.095	2. Serv 1.000
3. Serv 1.020	3. F & P 1.086	3. C & F 0.926
4. F & P 0.983	4. Serv 1.008	4. Oth G 0.876
5. Food 0.856	5. Food 0.821	5. Food 0.872
6. T & E 0.722	6. T & E 0.745	6. F & P 0.818
7. Petrol 0.548	7. Petrol 0.659	7. T & E 0.643
8. C & F 0.536	8. C & F 0.537	8. Alc 0.586
9. Toba 0.294	9. Toba 0.081	9. Toba 0.382
10. Dura 0.023	10. Dura -0.210	10. Dura -0.108
Mean ρ_i 0.740	Mean ρ_i 0.699	Mean ρ_i 0.701
Var ρ_i 0.106	Var ρ_i 0.208	Var ρ_i 0.120

ROTT1	ROTT2	ROTT3
1. Oth G 1.077	1. Oth G 1.088	1. Oth G 0.961
2. Alc 0.964	2. Alc 0.970	2. Food 0.954
3. F & P 0.959	3. F & P 0.950	3. Serv 0.935
4. Serv 0.921	4. Serv 0.924	4. Petrol 0.750
5. Food 0.894	5. Food 0.893	5. F & P 0.745
6. T & E 0.729	6. T & E 0.728	6. C & F 0.667
7. Petrol 0.497	7. Petrol 0.487	7. T & E 0.661
8. C & F 0.375	8. C & F 0.383	8. Dura 0.641
9. Dura 0.365	9. Dura 0.366	9. Alc 0.397
10. Toba -0.083	10. Toba -0.067	10. Toba 0.272
Mean ρ_i 0.670	Mean ρ_i 0.672	Mean ρ_i 0.698
Var ρ_i 0.137	Var ρ_i 0.135	Var ρ_i 0.053

Table A1 (contd.)

CBS1	CBS2	CBS3
1. Oth G 1.070	1. Oth G 1.080	1. Oth G 0.973
2. Alc 1.052	2. Alc 1.057	2. Food 0.955
3. F & P 0.979	3. F & P 0.972	3. Serv 0.942
4. Serv 0.930	4. Serv 0.935	4. F & P 0.747
5. Food 0.888	5. Food 0.888	5. Petrol 0.737
6. T & E 0.735	6. T & E 0.730	6. T & E 0.668
7. Petrol 0.472	7. Petrol 0.462	7. C & F 0.667
8. C & F 0.421	8. C & F 0.427	8. Dura 0.647
9. Dura 0.286	9. Dura 0.287	9. Alc 0.416
10. Toba -0.113	10. Toba -0.100	10. Toba 0.264
Mean ρ_i 0.672	Mean ρ_i 0.674	Mean ρ_i 0.702
Var ρ_i 0.154	Var ρ_i 0.152	Var ρ_i 0.053

Table A2: Spearman Rank Correlation Coefficients

DAI1	1.00								
DAI2	1.00	1.00							
DAI3	.539	.539	1.00						
ROT1	1.00	1.00	.539	1.00					
ROT2	1.00	1.00	.539	1.00	1.00				
ROT3	.527	.527	.987	.527	.527	1.00			
CBS1	1.00	1.00	.539	1.00	1.00	.527	1.00		
CBS2	1.00	1.00	.539	1.00	1.00	.527	1.00	1.00	
CBS3	.600	.600	.960	.600	.600	.970	.600	.600	1.00
	DAI1	DAI2	DAI3	ROT1	ROT2	ROT3	CBS1	CBS2	CBS3

AID1	1.00								
AID2	.770	1.00							
AID3	.309	.309	1.00						
TAI1	.854	.503	.261	1.00					
TAI2	.903	.564	.164	.976	1.00				
TAI3	.309	.188	.721	.321	.224	1.00			
DAI1	.879	.515	.212	.976	.976	.261	1.00		
DAI2	.879	.515	.212	.976	.976	.261	1.00	1.00	
DAI3	.406	.103	.770	.551	.418	.770	.540	.540	1.00
	AID1	AID2	AID3	TAI1	TAI2	TAI3	DAI1	DAI2	DAI3

Table A3: Correlation Coefficients

DAI1	1.00								
DAI2	.999	1.00							
DAI3	.496	.489	1.00						
ROT1	.967	.962	.605	1.00					
ROT2	.970	.965	.602	.999	1.00				
ROT3	.503	.493	.988	.636	.632	1.00			
CBS1	.982	.977	.553	.995	.995	.584	1.00		
CBS2	.983	.980	.552	.994	.995	.581	.999	1.00	
CBS3	.527	.518	.986	.659	.656	.999	.610	.610	1.00
	DAI1	DAI2	DAI3	ROT1	ROT2	ROT3	CBS1	CBS2	CBS3

AID1	1.00								
AID2	.853	1.00							
AID3	-.01	-.27	1.00						
TAI1	.861	.616	.215	1.00					
TAI2	.919	.610	.217	.962	1.00				
TAI3	.616	.220	.588	.599	.741	1.00			
DAI1	.879	.660	.160	.987	.949	.553	1.00		
DAI2	.873	.657	.156	.989	.947	.548	.999	1.00	
DAI3	.242	0.00	.787	.485	.436	.587	.496	.489	1.00
	AID1	AID2	AID3	TAI1	TAI2	TAI3	DAI1	DAI2	DAI3