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## Deliverable 2.3: Implications of Measurement Error for Tax-Benefit Models

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**Implications of measurement error for tax-benefits models**

Maria Flevotomou

The backbone of any tax-benefit model is income survey data, which contains information on incomes, needs, assets, housing costs and other household characteristics, all necessary in order to simulate tax liabilities and benefit entitlements. The quality of the simulations and consequently the reliability of the model itself are therefore heavily dependent upon the scope and quality of the available data.

On the one hand, it is highly unlikely that the modeller will ever have access to the full information set required for a perfect simulation of the tax-benefit system. On the other hand, even if that were the case, the information available is most likely to be afflicted with measurement error.

In this note, we specifically address the relevance of measurement error for tax-benefit models with regard to the study of benefit non take up. We begin by briefly discussing possible sources of measurement error. We then consider how measurement error may be directly modelled in the study of non take up behaviour. Given the limitations inherent in such an approach, we suggest an alternative strategy whereby the implications of measurement error for tax-benefit models are explored through sensitivity analysis.

There are two broad levels at which we may identify measurement error afflicting our data. First, the benefit receipt information contained in the survey data may be inaccurate. This may happen, most obviously, if survey respondents fail to correctly report their actual benefit entitlement, e.g. because of old age. It may also occur if the time-period covering the survey question regarding benefit receipt is not the same as the time period per which the benefit is paid and input into the model. In that case, it is up to the survey conductor to convert a, say, annual amount into the appropriate monthly amount. Last but not least, one should not ignore the role of administrators' errors in the determination of benefit entitlements.

On a second level, measurement error impacts upon the quality of a tax-benefit model through the simulation of benefit entitlements. To begin with, it may be impossible to have access to all, especially qualitative, information necessary to perfectly simulate eligibility. But perhaps the most crucial problem, particularly in the study of means tested benefits, is whether respondents of the income survey truthfully and informatively reveal their income to the survey conductors. Further biases may stem from the fact that eligibility for certain benefits is judged upon incomes earned in years earlier to the year in which eligibility is being assessed and in which the survey is carried out. Needless to say, that additional factors entering simulated means tests, such as needs, assets, and housing costs, may all be subject to measurement error.

Jäntti (2007), based upon the methodology of Hernandez and Pudney (2006), presents the above-mentioned issues in the formal framework described below.

Let the true benefit entitlement of a unit be $B^*$, and let $B_g$ be the entitlement that the program administrator observes:

$$B_g = B^* + e_g \qquad (1)$$

where $e_g$ captures errors in the administrators determination of entitlement, such as administrative and assessment errors or possibly fraudulent behaviour by the claimants.

The take up analyst simulates an entitlement $B_a$ usually based on income survey information:

$$B_a = B_g + e_a \qquad (2)$$

where $e_a$ is the analyst's assessment error.

Then, the take up probability, conditional on the administrator's eligibility determination ($B_g$) and the set of household characteristics affecting the likelihood of take up (X), is:

$$\Pr(R = 1|X, B_g) = p(X, B_g) \qquad (3)$$

where R = 1 denotes benefit receipt.

In the presence of measurement error, the immediate difficulty facing the analyst is that he/she cannot observe $p(X, B_g)$ directly because of the random term $e_a$ in the specification of $B_g$. This, however, may be overcome following a method proposed by Hernandez and Pudney (2006), whereby the following likelihood function is formulated:

$$\Pr\left(R = 1, B_a \middle| X\right) = \int_{B_g} p\left(X, B_g\right) f\left(B_a \middle| B_g\right) dF\left(B_g \middle| X\right) \qquad (4)$$

where

$f(B_a|B_g)$ is the conditional density of the analyst's assessment of entitlement $B_a$, given the administrator assessment $B_g$, and

$F(B_g|X)$ is the distribution of the administrator's entitlement assessment, conditional on the characteristics X.

Still, a new challenge facing the analyst is the identification of equation (4). The complex functional form – based on latent variables, or underlying "true" variables being measured by "indicators" that contain measurement errors – is a first obstacle. In general, the analyst will need repeated measurements of the underlying true variables to be able to identify such models.

The analytical intractability of directly modeling measurement error cannot be doubted. As Jäntti (2009) pointed out:

> "In the absence of the kind of data that allow for the convincing modelling of take-up in multiple programs in the presence of measurement errors in both benefits and resources, it is not entirely clear what should be done." (p.29)

Given that intractability, a more fruitful alternative would be indirectly to account for the presence of measurement error through sensitivity analysis. Assuming that the observed income, needs and all other relevant information in the survey data underlying the simulation of benefit eligibility are all "true", the analyst may examine the effect of two types of measurement error upon non take up and beta error estimates.

For instance, to account for systematic measurement error, flat rate variations in incomes or needs may be introduced in any tax-benefit model, while to account for classical measurement error, random variations to such measures may be introduced separately or simultaneously[1]. The random component may be specified as a percent deviation from the underlying "true" measure that is normally distributed with an appropriately set mean and standard deviation. Repeated random draws then give distributions of non take up and beta error estimates which may be compared to our "true" baseline estimates to evaluate the impact of measurement error. Substantial differences alert the analyst that should measurement error afflict the underlying data, the validity of results will be undermined even if eligibility is perfectly simulated in the tax-benefit model.

To sum up, measurement error is most likely an inevitable aspect of any source of data. Insofar as it is relevant with respect to variables playing a key role in the take up analysis undertaken in the framework of a tax-benefit model, it may potentially introduce a bias in results. The econometric difficulties inherent in models with measurement error make a direct approach tackling the problem less appealing than an indirect treatment whereby its effects are studied through sensitivity analysis.

[1] Assuming independent errors.

## References

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