Estimating the Income Reporting Function for the Self-Employed

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Abstract

There is considerable interest in measuring the underground economy using microeconomic data. One such method estimates income under-reporting by households by assuming a known, parametric form of the Engel curve and making the further parametric assumption that households under-report their income by a constant fraction, independent of income. This paper proposes a nonparametric approach which avoids functional form restrictions and enables the reporting function to vary across income levels and household characteristics. I illustrate by estimating the effect of the Canadian Goods and Services Tax on income under-reporting.

Keywords: Underground Economy, Income Under-reporting, Nonparametric Estimation, Engel Curve

JEL Classification: C14, D12, O17

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1. INTRODUCTION

There has been a recent resurgence in interest in measuring the underground economy and this interest has been stimulated predominantly by the perception that the underground economy is sizeable and growing. In broad terms, the phrase "underground economy" refers to output that is produced and income that is generated by agents who hide this fact from authorities. Knowledge of the size and structure of the underground economy is important for a number of reasons. First, because underground activities are unmeasured, they are not taken into account in the information-set that is used to assist economic policy-makers. Second, the underground economy effectively re-distributes both income and wealth in ways that are not necessarily consistent with the re-distributional goals of the taxation system. Third, the shortfall in income-reporting that is associated with underground activities leads to an erosion in the tax base and tax revenue with subsequent implications for both public expenditure and taxation policies. Finally, enforcement activities are unlikely to be successful (and may have counter productive consequences) without detailed knowledge of the characteristics and types of activities of underground economy participants.

To date, research that seeks to measure the underground economy has predominately employed macro-methods.[2] These macroeconomic measures, however, have been criticized for not being consistent with modern economic models of consumer behaviour, employing flawed econometric techniques, producing unreliable estimates, and providing limited guidance to policy makers (Thomas 1999). In particular, the macro-methods developed to date do not provide any information regarding the characteristics of those participating in the underground

[2] Such methods include: the *Currency-Ratio Approach* (Gutmann 1977); the *Monetary-Transactions Method* (Feige 1979); *Tanzi's Approach* (Tanzi 1980); *National Accounts/Judgmental Methods;* and the *Latent Variable/MIMIC model* (Frey and Weck-Hanneman 1984).

economy. In order to obtain this type of information, a method that utilizes microeconomic data is required.

One such approach, popularized by Pissarides and Weber (1989) and modified by Lyssiotou *et al.* (2004), utilizes household income and expenditure data to estimate the degree of income under-reporting (i.e. the amount by which household income should be scaled upwards to obtain true, or actual, income as opposed to reported income). The basic principle of this *Expenditure-Based Method* is that true household income can be imputed from reported household expenditures. The method is premised on variations of several key assumptions, namely: the reporting of expenditures on some items by all households is accurate; those who report zero self-employment income report income accurately while those who report non-zero self-employment income may under-report; and the marginal propensity to consume out of unreported income is equal to the marginal propensity to consume out of reported income. Actual, or true, self-employment income is then imputed by comparing the expenditure levels of households with positive self-employment income to the expenditure-income bundles of households with zero self-employment income and similar characteristics. In practice, the method is implemented by estimating reliable expenditure functions (i.e. Engel curves) for wage earners that are then inverted to estimate true income for the self-employed.

Previous studies have implemented the *Expenditure-Based Method* using highly parametric restrictions on: (1) an Engel curve (Pissarides and Weber 1989) or a system of Engel curves (Lyssiotou *et al.* 2004); and (2) an income reporting function. These restrictions imply that households under-report their income by a constant fraction, independent of income. There is no empirical evidence that supports this restriction and little, if anything, is actually known about the functional form of the reporting function. This paper considers an alternative way of implementing the *Expenditure-Based Method*. In particular, the parametric restrictions are relaxed and a nonparametric approach to the measurement of income under-reporting is explored.

Specifically, a two-step approach to estimating a variable-with-income reporting function is proposed, within the framework of the *Expenditure-Based Method*. The approach is essentially as follows. First, a nonparametric inverse food Engel curve is estimated for the sample of households that report zero self-employment income, to obtain an estimate of true income given (accurately) reported expenditures for every household in the sample (including those with self-employment income). Second, the nonparametric reporting function for self-employment income for households that report positive self-employment income is estimated. This approach improves on the implementation of the *Expenditure-Based Method* by minimizing the number of assumptions required for estimation. More particularly, the proposed framework avoids the usual functional form restrictions and enables the reporting parameter to vary across income levels.

The approach is illustrated by estimating the effect of the Canadian Goods and Services Tax (GST) on income under-reporting by married households with self-employment income. It is often argued that the implementation of this broadly based consumption tax increased the incentives and opportunities for tax evasion (e.g. Spiro 1993, and Hill and Kabir 1996) though the Government of Canada maintained that it would reduce the scope the tax evasion. The empirical analysis uses the Canadian Family Expenditure Survey (FAMEX), which contains household level information about income and expenditures.

Overall, this refinement to the *Expenditure-Based Method* produces results that demonstrate that income under-reporting does vary across household income levels. In particular, the gap between true and reported self-employment income is larger for households at the lower end of the self-employment income distribution. This result supports the fundamental results of Reinganum and Wilde (1985, 1986) that "…taxpayers with greater true income under-report less than those with lower true income…" (Reinganum and Wilde 1986, p. 741). Possible explanations of this finding are that households with more self-employment income may *think* they are more likely to be audited by the authorities, face higher utility costs if they are caught, and/or disproportionately benefit from legal tax avoidance (e.g. by exploiting various tax credits or loopholes). It is also found that some self-employed households, notably those households at the upper end of the self-employment income distribution, over-report their income. The parametric restrictions imposed previously masked this possible behaviour. Overall, the aggregate results neither support the hypothesis that the GST increased tax evasion nor the claim by the Canadian federal government that the GST would reduce tax evasion, at least for the self-employed.

The remainder of this paper is organized as follows. First, estimating income under-reporting from micro data is discussed, including a brief overview of the literature and details regarding the nonparametric approach proposed by this paper. The application of the approach is then described, including a description of the data, implementation details of the nonparametric approach (e.g. kernel and bandwidth selection), the results, and a discussion regarding the limitations. The paper ends with some concluding comments.

2. ESTIMATING INCOME UNDER-REPORTING FROM MICRO DATA

2.1.Previous Approaches

In this section, attention is focused on two critical aspects of the empirical work in this paper with the view of placing the empirical strategy in context. These aspects concern: (1) functional form restrictions; and (2) the treatment of permanent income.

2.1.1. Functional Form Restrictions

A critical aspect of the empirical work in this area is the specification of the expenditure and reporting functions. The pioneering work in the development of the *Expenditure-Based Method* was conducted by Pissarides and Weber (1989).[3] First, they categorize households as either being self-employed or wage earning. Second, they specify a log-log (in expenditures and income) form for the expenditure equation (i.e. the constant elasticity Engel curve) that is used to estimate the parameter θ in the linear reporting function for self-employed households, defined as

$$y_{SE}^{*} = \theta y_{SE} \tag{1}$$

where y_{SE}^{*} represents true self-employment income, y_{SE} denotes reported self-employment income, and θ is assumed to be > 1. This method of estimating income under-reporting consists of two steps. First, an expenditure function is estimated for wage earners. Second, the expenditure function is inverted to calculate θ, the amount by which reported self-employment income must be scaled up by in order to obtain true self-employment income.

[3] The *Expenditure-Based Method* was developed following work conducted by Dilnot and Morris (1981) who calculated the difference between reported household income and expenditures and arbitrarily classify households as "black economy" households if expenditures exceeded income by at least 20 percent. Smith *et al.* (1986) propose a framework similar to that of Pissarides and Weber (1989) except that the slope of the Engel curve was allowed to differ across wage earners and the self-employed and they make an assumption about the mean of true income.

Figure 1 provides a graphical representation of the approach. Constant-elasticity Engel curves for wage (or employee) and self-employed households are shown. A self-employed household reports expenditures, E*, and income, Y, but the reported level of expenditures is actually consistent with true income, Y*. The amount by which reported income must be scaled up to obtain true income is calculated by taking the ratio of the distance 0Y*/0Y which is equivalent to the parameter θ in equation (1) above. As the Engel curve for the self-employed is assumed to be parallel to that of wage earners, the distance is the same for every household (i.e. the reporting parameter is constant).

Lyssiotou *et al.* (2004) propose a systems approach to the *Expenditure-Based Method*. They specify a system of Engel curves of quadratic-in-(log)income Working-Leser form. They assume that durable and nondurable goods are separable and base their demand system on nondurable goods only, namely: food, alcohol, fuel, clothing, personal goods/services, and leisure goods/services. Lyssiotou *et al.* (2004) maintain the specification of the linear reporting function given in equation (1) above but avoid classifying households as either wage earners or self-employed.[4]

The functional form for the Engel curve that is specified by Lyssiotou *et al.* (2004) raises two concerns. First, there is an implicit assumption of the *Expenditure-Based Method* that the Engel curve(s) employed in the estimation must be monotonic in income. In reference to Figure 1, if this critical assumption is violated, then a unique value of true income associated with a

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[4] Lyssiotou *et al.* (2004) also allow for what they call "preference heterogeneity". They note that income from self-employment may not be spent in the same way as income from other sources. In particular, it could be that households spend wage income, which is predictable, on necessities and the self-employment income, which is subject to under-reporting and is unpredictable, on luxuries. Equally, the self-employed could just have different preferences. Pissarides and Weber (1989) assumed homogenous preferences among all households. Lyssiotou *et al.* (2004) allow for preference heterogeneity in their estimated system of budget shares through the inclusion of the self-employment proportion of reported income, which can enter the system nonlinearly. The preference heterogeneity term(s), however, are identified only by functional form and are not identified in the nonparametric framework proposed in this paper.

particular level of expenditures may not exist. The quadratic-in-(log)income Working-Leser form of the Engel curve specified by Lyssiotou *et al.* (2004) is not necessarily consistent with the monotonicity assumption, with particular goods, notably alcohol and clothing, known to violate this assumption (Banks *et al.* 1997). Second, the quadratic-in-(log)income Working-Leser form of the Engel curve is not invertible over all values due to the presence of asymptotes. While the presence of asymptotes is not a concern under the structure imposed by Lyssiotou et al. (2004) - the system of Engel curves is not (implicitly) inverted over all data points - it underscores the likelihood that the estimates are influenced, in whole or in part, by the parametric restrictions.

More generally, this approach still assumes a parametric Engel curve, albeit one that is more widely accepted than that implied by earlier constant-elasticity assumption. Perhaps more importantly, this approach continues to assume that households under-report their income by a constant fraction, independent of income. In fact, little is known about the form of the reporting function and it is plausible that under-reporting will differ with income and household characteristics. This paper proposes a nonparametric approach which avoids functional form restrictions. The proposed method also works directly with an inverse Engel curve, avoiding problems associated with inversion, and continues with the tradition of the single equation approach. The single equation approach also allows the analysis to be restricted to a good for which the Engel curve is widely acknowledged to be monotonic in income.

2.1.2. Permanent Versus Transitory Income

There is a general belief that households base expenditures on permanent rather than transitory income. This implies that households save when they have positive transitory income and dissave when they have negative transitory income. If the *Expenditure-Based Method* is implemented using transitory, or annual income, this may lead to biased estimates of income under-reporting. Pissarides and Weber (1989) acknowledge that permanent income is the measure of income that influences consumption decisions but stop short of requiring their expenditure function to conform exactly to the permanent income hypothesis, perhaps because the dataset used in their analysis (1982 British Family Expenditure Survey) did not contain information regarding household savings behaviour. They indicate that "…for given permanent income, the measured income of the self-employed may be more variable than the measured income of employees in employment. If this is correct, our measure of income under-reporting by the self-employed will have to be adjusted accordingly." (Pissarides and Weber 1989, pp. 20) Empirically, they implement this assumption by treating reported income as endogenous and then using instrumental estimation, which "…enables an independent estimate of the residual variance of reported income for each group which is exploited in the calculation of income under-reporting." (Pissarides and Weber 1989, pp. 22)

Whether Pissarides and Weber's (1989) Two-Stage Least Square (2SLS) approach is preferred to Ordinary Least Squares (OLS) depends on the quality of the instruments. Datasets that contain information on household expenditures and income may not contain relevant and suitable instrumental variables required for this analysis. Further, the approach requires the researcher to make additional and somewhat arbitrary assumptions which restrict the analysis. As a result, an alternative approach which addresses the issue of permanent income is desirable. This paper explores such an alternative.

2.2. A Nonparametric Approach

As outlined above, to date, the *Expenditure-Based Method* has been implemented by estimating Engel curves which are implicitly or explicitly inverted to obtain an average estimate of income under-reporting. A more direct approach to estimating income under-reporting is to utilize an inverse Engel curve (i.e. with income taking on the role of the dependent variable) and nonparametric methods. Within the framework of the *Expenditure-Based Method*, a two-step approach to estimating a variable-with-income reporting function is proposed that responds to the concerns raised in the previous section.

The first step nonparametrically estimates an inverse Engel curve, which can be consistently estimated for households that report zero self-employment income, to obtain true income for all households. The second step nonparametrically estimates the reporting function for households with positive self-employment income. The use of nonparametric methods has three advantages. First, it enables the reporting function to vary across income levels and household characteristics. Second, it avoids functional form restrictions on the Engel curve. Third, within this framework it is also possible to test the null hypothesis that the reporting function is linear, as has been assumed in the previous literature.

Estimating Engel curves using nonparametric techniques is quite common and demographic household characteristics, used to account for observable heterogeneity, are often included by specifying a partially linear additive semi-parametric specification using the Yatchew (1997) or Robinson (1988) approach. However, "restrictions from consumer theory are not innocuous both on the form of the Engel curve relationship and on the way in which observable heterogeneity (demographics in our case) can enter." (Blundell *et al.* 1998, pp. 436) In particular, Blundell *et al.* (1998) have demonstrated that "…the additive structure between demographic composition and income that underlies the partially linear semiparametric model implies strong and unreasonable restrictions on behaviour." (Blundell *et al.* 1998, pp. 459) Rather, to be consistent with consumer theory, the demographics that enter the Engel curve specification must also scale the income term. The nonparametric estimation strategy proposed here cannot be implemented if income and demographic terms enter non-additively, hence, semiparametric estimation was not pursued. Instead, estimation is conducted separately on an identified homogenous sub-population (i.e. married couples without dependent children present in household).[5]

To achieve estimation, some initial assumptions are required. The three fundamental assumptions of Pissarides and Weber (1989) are maintained and classifying households as either self-employed or not is avoided, following Lyssiotou *et al.* (2004). First, food expenditures are used in the analysis and it is assumed that the reporting of food expenditures by all households is accurate.[6] Second, only self-employment income can be under-reported.[7] Third, the marginal

[5] This is not to say that a semi-parametric approach cannot be pursued within the framework proposed but is beyond the scope of this paper.

[6] The arguments for using food as opposed to any other commodity or group of commodities are that: there is no social stigma associated with food consumption which could cause expenditures to be reported inaccurately (counter examples would include tobacco and alcohol); food expenditures are more likely to be reported accurately by households participating in the underground economy since individual expenditures on food are small and are unlikely to rouse suspicion; tastes for food are more likely to be uniform across employment groups and over time; it is very difficult for a household to postpone food consumption; most food purchases cannot be included as a business expense; and, the food Engel curve is widely acknowledged to be monotonic. However it should be noted that the self-employed in many countries are able to write-off for tax purposes food that is consumed in restaurants much more easily than wage employees.

[7] Taxes for most sources of income, particularly wage and salary income, and various "payroll" taxes are "pay as you earn". That is, income and payroll taxes are withheld at source from these payments to individuals. Self-employment income, on the other hand, is reported and taxed at year end (though many self-employed are required to make estimated tax payments during the year in order to ensure that they meet their tax obligation in a timely manner) by the individual who earned the income and there is no third party who also reports this income. That is, there is no check and balance within the system to ensure that the individual is accurately reporting their self-employment income. As a result, there is an opportunity for some self-employment income to be under-reported. That said, the assumption that only self-employment income is under-reported is likely not entirely accurate. For example, employers can pay their employees in whole or partially in cash as a way to evade income and payroll

propensity to consume out of unreported income is constrained to be equal to the marginal propensity to consume out of reported income.[8]

The estimation strategy is as follows. The object of interest is true household self-employment income, $y^*_{SE,h}$, which is assumed to be a function of reported household self-employment income, $y_{SE,h}$, plus a white noise disturbance term:

$$E(y^*_{SE,h} \mid y_{SE,h}, d = 1] = f(y_{SE,h}) + \xi_h \tag{2}$$

where h denotes an individual household and d is a dummy variable that takes a value of one if the household reports any self-employment income.

The first stage of the procedure is to nonparametrically estimate an inverse Engel curve to obtain true (permanent) income given (accurately) reported expenditures. The inverse Engel curve expresses income, in this case permanent income, for reasons discussed above, as a function of expenditures. For this exercise, the nonparametric representative of the inverse Engel curve is given by:

$$y^p_{TOTAL,h} = h(x_h) + \nu_h \tag{3a}$$

where x_h represents household reported (and assumed to be true) food expenditures, ν_h is a white noise disturbance term, and $y^p_{TOTAL,h}$ represents true (reported plus unreported) total permanent household income, defined as

taxes. The extent that this assumption is not valid will lead to the resulting estimate of the degree of under-reporting to be biased toward zero.

[8] The reader should be made aware that this assumption may not be accurate. It may not be true that the marginal propensity to consume out of unreported income is equal to the marginal propensity to consume out of reported income. Households may use all unreported income to boost expenditures. Alternatively, households may use unreported income to boost savings, though the inclusion of the net change in assets and liabilities in the analysis will likely account for this behaviour.

$$y^{p}_{TOTAL,h} \equiv y^{*}_{SE,h} + y_{OTH,h} - \Delta A_h. \tag{3b}$$

$y_{OTH,h}$ refers to household reported (and assumed to be accurately reported) other income and ΔA_h indicates household net change in financial assets and liabilities (a household that has positive (negative) transitory income will save (dissave) the additional money and ΔA_h>0 (<0)).

By assumption, x_h is accurately observed for all households but $y^{p}_{TOTAL,h}$ is only accurately observed for those households that have zero self-employment income ($y^{*}_{SE,h} = y_{SE,h}$=0). This implies that $h(x_h)$ can be consistently estimated for households that report zero self-employment income. The fitted values from the first stage regression, $\hat{h}(x_h)$, for households that report zero self-employment income are used to obtain an accurate estimate of total permanent income for households with positive self-employment income based on food expenditures. As a result, consistent estimates of total permanent household income, $\hat{h}(x_h)$, are obtained for every household.

As indicated in equation (3b) above, total permanent household income is comprised of three elements, namely the household's: true self-employment income, ($y^{*}_{SE,h}$); reported other income, ($y_{OTH,h}$); and net change in financial assets and liabilities, (ΔA_h). If $y_{OTH,h}$ is subtracted from and ΔA_h is added to the estimate of total permanent household income obtained in the first step, $\hat{h}(x_h)$, one obtains an estimate of true self-employment income, $y^{*}_{SE,h}$, for those households that report positive self-employment income. That is, $y^{*}_{SE,h}$ can be calculated as follows:

$$y^*_{SE,h} = \hat{h}(x_h) - y_{OTH,h} + \Delta A_h. \tag{3c}$$

This relationship is exploited in the second step of this approach.

The second step estimates the nonparametric form of the reporting function, the parametric form of which is given by equation (1), for those households that report positive self-employment income ($y_{SE,h}$>0). The nonparametric form of the reporting function is given by:

$$y^*_{SE,h} = f(y_{SE,h}) + \zeta_h. \tag{4}$$

The amount of self-employment income that is unreported by each household is calculated as the predicted value of true self-employment income, $\hat{f}(y_{SE,h})$, minus reported self-employment income, $y_{SE,h}$. Total unreported income is found by summing over households with positive reported self-employment income.

2.3. Testing Linearity of the Reporting Function

As indicated above, previous studies assumed that the reporting function took the form denoted in equation (1), where θ is assumed to be > 1. The nonparametric approach outlined above provides an opportunity to test the null hypothesis that the reporting function takes the linear form specified by equation (1) versus the alternative that the reporting function takes the nonparametric specification specified by equation (4).

To implement this test, a testing method described by Yatchew (1998, 2003) is utilized. The test statistic is given by

$$V = \frac{T^{1/2}(s^2_{res} - s^2_{diff})}{s^2_{diff}} \quad \sim \quad N(0,1) \tag{6}$$

where

$$s_{diff}^2 = \frac{1}{2T} \sum_{h=2}^{T} (y_{SE,h}^* - y_{SE,h-1}^*)^2 \tag{7}$$

$$s_{res}^2 = \frac{1}{T} \sum_{h=1}^{T} (y_{SE,h}^* - \hat{\theta} y_{SE,h})^2 \tag{8}$$

and T is the total number of households.

The testing procedure is as follows. First, the data is reordered such that $y_{SE,1} \leq \ldots \leq y_{SE,T}$. Second, s_{diff}^2 is calculated. Third, the restricted regression given by equation (1) is performed to obtain $y_{SE,h}^* - \hat{\theta} y_{SE,h}$. Fourth, s_{res}^2 is calculated. Finally, the test statistic, V, is calculated and a one-sided test is conducted, comparing the value of the test statistic to a critical value from a standard normal distribution.

2.4. Testing the Significance of the Change in Asset Term

It is also possible to test the significance of ΔA_h, the change in financial assets term, in equation (3) by employing the differencing method discussed in Yatchew (1998, 2003). To do so, note that equation (3) can be rewritten as

$$y_h^a = h(x_h) + \beta \Delta A_h + \nu_h \tag{9}$$

where y_h^a represents a household's annual income (where $y_h^a = y_{SE,h}^* + y_{OTH,h}$). Equation (9) is a partially linear model in ΔA_h. In equation (3) above, β was assumed to be equal to 1.

In order to test if β=0 or, alternatively, if β=1, the data must first be sorted such that $x_1 \leq \ldots \leq x_T$. The variables y_h^a and ΔA_h are then differenced (which, in heuristic terms, "removes" the direct effect, $h(x_h)$, of the nonparametric variables, x_h, that occurs through ΔA_h). The Ordinary Least Squares (OLS) estimator is then applied to the differenced data such that:

$$\hat{\beta}_{diff} = \frac{\sum_{h=2}^{T} (y_h^a - y_{h-1}^a)(\Delta A_h - \Delta A_{h-1})}{\sum_{h=2}^{T} (\Delta A_h - \Delta A_{h-1})^2}. \qquad (11)$$

The process of differencing the data, however, creates autocorrelation in the error term. Yatchew (2003) notes that the correction is simple if homoskedasticity is assumed: the standard errors simply need to be multiplied by the square root of 1.5. Following this correction, standard inference techniques can be employed.

3. APPLICATION

The nonparametric application of the *Expenditure-Based Method* outlined above is illustrated here by estimating the effect of the Canadian Goods and Services Tax (GST) on income under-reporting. The implementation of the GST in 1991 represents an interesting opportunity to explore changes in income under-reporting by the self-employed in Canada. The GST is a federal value-added tax that applies at a rate of 7% to the supply of most goods and services, including services offered by the self-employed[9], in Canada and replaced a less comprehensive manufacturers' sales tax (MST).

Prior to introducing the GST, the federal government argued that the GST would reduce the scope for tax evasion because it is applied successively at different stages of processing. That is, businesses, including the self-employed, are required to pay the GST on all its inputs but

[9] Most businesses, including the self-employed, are required to register for the GST (and collect and remit the GST or HST). However, "small suppliers" are not *required* to register for the GST. The Canada Revenue Agency defines a GST Small Supplier as a sole proprietor, partnership, or corporation whose total taxable revenues before expenses are $30,000 or less annually. However, the Small Supplier GST registration rule doesn't apply to all types of businesses; taxi and limousine operators, for instance, must always register for the GST. Additionally, even if a business does qualify as a GST Small Supplier, the business can still register for the GST. As a GST registrant, the business can reclaim the GST they have paid on business purchases, on everything from capital property through office supplies. The FAMEX data contains no information regarding the GST registrant status of the self-employed contained in the data sample.

this is credited against the GST it collects from its own customers. In order to obtain the credit, however, the business is required to produce receipts showing that it paid the GST on its inputs. For this reason, the tax is said to apply only to the value added by a business. Another promoted virtue of the GST was that, as a consumption tax, it is a tax that even the hard-to-tax (e.g. those earning their full income in the underground economy) would have to pay since they must purchase at least some of their goods and services in the observed economy. On the other hand, it is often argued that the implementation of the GST increased the incentives and opportunities for tax evasion. First, the business can choose not to report some fraction of their sales, avoiding both their income and GST tax liability, while still claiming their whole input tax credit. Second, the business and customer can collude and avoid collecting and paying the GST, respectively.

3.1. Data

The data used in this paper come from the public use Canadian Family Expenditure Surveys (FAMEX), which were conducted at irregular intervals between 1969 and 1996.[10] The FAMEX is a cross-sectional household recall survey that is intended to be representative of all persons living in private households in the ten Canadian provinces.[11]

Two previous studies applied the Pissarides and Weber (1989) variant of the *Expenditure-Based Method* to FAMEX data. Mirus and Smith (1997) find that the self-employed in Canada under-report their income by 12.5% for the year 1990. Schuetze (2002) pools FAMEX data for the period 1969 to 1992 and finds that the self-employed under-reported

[10] In 1997, the Survey of Household spending (SHS) replaced the FAMEX and has been conducted annually since. The SHS, however, does not provide detailed information regarding the sources of household income so this data cannot be used for this analysis.
[11] Households in the Territories are also surveyed but their data is not included in all the public use files.

their income by between 11-23% and that the self-employed in the construction and service occupations are more likely to be involved in tax non-compliance.

The sample for this analysis is limited to married couples (without children) and it is assumed that the household unit acts as a single decision maker regarding expenditure and income reporting. The sample is further restricted to households: where the head and spouse are of working age (25-64 years of age); which constitute one economic family; that have positive food expenditures; and for which the head's occupation is known and is not working in the primary occupation category. (This last restriction will exclude farm households, which are likely to have much different expenditure patterns on food than those in other occupations.) Households whose annual gross income was either in the top or bottom 1% of the income distribution were excluded from the analysis. In addition, households whose permanent gross income[12] was either in the top or bottom 1% of the income distribution were also excluded from the analysis. These last two exclusions are intended to avoid households with negative income and extreme positive income in both steps of the method described above. Finally, households with negative self-employment income were also excluded from the analysis.

To conduct the analysis, results from using FAMEX data for the years 1982 and 1986 will be compared to those obtained using data for the years 1992 and 1996. Pooling the data in this way attempts to ensure that there are sufficient observations included in each stage of the analysis. Each pooled sample contains one year during which the economy was sluggish (1982 and 1992) and one year in which the economy was in a growth period (1986 and 1996). The implicit restriction made by pooling the data in this way is that the marginal propensity to consume food is the same for each of the two years contained in each of the pooled samples.

[12] This is the dependent variable in the first stage regression and is defined as gross income less change in assets.

Two additional households in the pooled 1982/1986 sample were excluded from the analysis as well as one additional household in the pooled 1992/1996 sample. These households had self-employment income that exceeded average self-employment income by a factor of almost six. As there were no other observations within their vicinity it was not possible to obtain nonparametric estimates at these points by using any reasonable bandwidth. Pooling, along with the restrictions noted here and above, left a total of 1,907 households in the 1982 and 1986 pooled sample, of which 303 are self-employed and a total of 1,840 households in the 1992 and 1996 pooled sample, of which 369 are self-employed. The increase in the ratio of self-employed households to nonself-employed households between the two samples is not unexpected, given that the Canadian self-employment rate rose from 13% in 1979 to 18% by 1997 (Picot *et al.* 1998).

Expenditures are converted to real 1996 dollars using the food price index developed by Browning and Thomas (1999). Food expenditures, which includes expenditure on food consumed at home and in restaurants, are used in estimating equation (3).[13] Income terms and the change in asset term[14] are converted to real 1996 dollars using a general price index. All income terms are inclusive of income taxes because net income by source is not available in the FAMEX.[15]

Table 1 provides some summary statistics of the data. The top half of the table presents statistics for households with zero self-employment income, while the bottom half of the table presents statistics for households with positive self-employment income. The left column shows

[13] Similar estimates to those reported above were obtained when food expenditures were restricted to include only expenditures on food consumed at home.
[14] Net change in assets and liabilities includes total net change in assets (including cash held in banks, money owed to households, money deposited against future purchases, net contributions less withdrawals to Registered Retirement Savings Plans, financial assets, sales of personal property, real estate, and investments in unincorporated business or farms) less net change in debts (including loans with regular payments and other money owed).
[15] Pissarides and Weber (1989) use net income in their analysis.

statistics for the 1982/1986 pooled sample and the right column for 1992/1996. The two household groups report comparable average incomes, changes in assets, and expenditures on food in each of the two samples, but self-employed households have greater variability in their assets in the 1982/1986 sample.

3.2. Implementation Details of the Nonparametric Estimator

Nonparametric estimation of equations (3) and (4) is achieved by employing the locally-weighted least-squares procedure, using the Gaussian kernel, and adaptive bandwidth where the initializing bandwidth was selected by cross-validation (Härdle and Marron 1990). Equation (3), the inverse Engel curve, is estimated at every point in the data but assigns a weight of zero to households with positive self-employment income in the estimation process. The reporting function given by equation (4) is estimated only for those households which report positive self-employment income ($y_{SE,h}$>0).

3.3. Results

As outlined above, it is possible to test the significance of the ΔA_h term in equation (3a). The results of this test are outlined in Table 2. As before, the results for 1982/1986 are in the column on the right and 1992/1996 are presented in the left-hand column. The parameter estimates for β_{diff} , noted in the first row, are very close to unity in value. In both cases, the null hypothesis that $\beta_{diff} = 0$ is rejected with p-values of essentially zero, as is noted in the second row of the table. The results for testing the null hypothesis that β_{diff} =1 are shown in the third row. For the 1982/1986 pooled dataset, the null hypothesis that $\beta_{diff} = 1$ is not rejected at the

1% or 5% significance levels but would be rejected at a 10% significant level. For the 1992/1996 pooled dataset, the null hypothesis that $\beta_{diff} = 1$ is not rejected at any conventional significance level. Given the test results and the fact that the estimates for β_{diff} are economically no different from unity, it is concluded that the ΔA term should be included in the analysis as outlined above and proceed accordingly.

Figure 2 presents graphs of the inverse food Engel curve, estimated from equation (3a). Recall from above that equation (3a) can be consistently estimated on the sample of households that report zero self-employment income and provides an estimate of true household income for all households. The graph on the left is for the 1982/1986 pooled sample while the graph on the right is for 1992/1996. Reported food expenditure is plotted on the horizontal axis and gross household income, less changes in assets, is plotted on the vertical axis. For both samples, the inverse food Engel curve appears linear over most food expenditures, but takes on some curvature at higher levels of food expenditures, notably where the data becomes sparse.[16]

Figure 3 presents graphs of the nonparametrically estimated reporting function that were obtained using equation (4). Again, the graph on the left is for the 1982/1986 pooled sample while the graph on the right is for 1992/1996. Estimated true self-employment income is plotted on the vertical axis and reported self-employment income is plotted on the horizontal axis. Both axes use the log scale. Also shown are 90% bootstrapped confidence intervals obtained using the "wild" bootstrap procedure (Wu 1986) which allows for heteroskedastic errors. The forty-five degree line in the figures shows reported self-employment income. When the plot of estimated

[16] The inverse Engel curves obtained from equation (3) but without the change in asset term (where gross income is the dependent variable), are similar in shape to those shown in Figure 2 but are shifted vertically. Ignoring the change in asset term, therefore, leads to biased estimates of true gross income given reported food expenditures.

true self-employment income is above the forty-five degree line, a household is under-reporting their self-employment income. Each graph also presents three vertical lines, which represent the tenth, fiftieth, and ninetieth percentiles of the data. This information is presented to provide the reader with detail regarding the density of the data and its relation to the estimation of the reporting function.

The graphs in Figure 3 show that the reporting function appears to be nonlinear. For the 1982/1986 pooled sample, estimated true self-employment income is above reported self-employment income for households with less than almost $40,000 in reported self-employment income, but under-reporting decreases as reported self-employment income approaches approximately $40,000. For the 1992/1996 pooled sample, estimated true self-employment income is above reported self-employment income for households with less than just over $40,000 in reported self-employment income, but under-reporting decreases as reported self-employment income increases beyond approximately $40,000. While this result may appear to be counter-intuitive, it supports the primary result of the model of tax compliance proposed by Reinganum and Wilde (1985, 1986).

Beyond the approximate $40,000 threshold amount in both samples, the results indicate that households over-report self-employment income. It should be noted that the estimated number of married households that over-report is small in percentage terms. There are two possible explanations for the over-reporting finding. First, this particular result could be driven, at least in part, by data sparsity and a breakdown in the nonparametric procedures. In both pooled samples, the data are sparse beyond $40,000. In the 1982/1986 pooled sample, the ninetieth percentile occurs at approximately $46,800 ($55,000 in the 1992/1996 pooled sample). In both cases, the ninetieth percentile occurs in the vicinity of where estimated true self-employment income falls below reported self-employment income. Second, some self-employed households may over-report their income due to a misinterpretation of tax laws, to avoid a tax audit, to secure financing, and/or to exploit various tax deductions, credits and loopholes in an effort to reduce their tax bill. This is an issue that has not received a lot of attention in the tax evasion literature to date and the parametric restriction imposed on the *Expenditure-Based Method* previously masked this possible behaviour. It should be noted that Rice (1992), using the U.S. Internal Revenue Service's (IRS) Tax Compliance Measurement Program (TCMP) data, found that about 6% of firms overstate their taxable income to some extent, providing some support for this hypothesis.

As mentioned above, it is possible to test whether or not the reporting function, equation (4), is linear, as assumed previously in the literature. Table 3 summarizes the results of the test of null hypothesis, that the reporting function takes the form of equation (1), against the alternative, that the reporting function takes the nonparametric specification of equation (4). The results for the 1982/1986 pooled dataset are noted in the first column. The value of the test statistic is noted in the first row and the associated p-value is reported in the second row. A value for the test statistic of 1.306 is obtained with an associated p-value of 0.096; hence, the null hypothesis, $H_0: \; y^*_{SE,h} = \theta y_{SE,h}$, is rejected in favour of the alternative, $H_a : y^*_{SE,h} = f(y_{SE,h})$, at the 10% significance level. For the 1992/1996 pooled dataset, the results of which are reported in the column on the left of Table 3, a value for the test statistic of 2.863 is obtained, noted in the first row, with an associated p-value of essentially zero, shown in the second row. Therefore, the null hypothesis is rejected at all of the usual significance levels. However, some caution should be exercised in interpreting these results since this test statistic is known to suffer from severe size and power distortions.

Table 4 reports household population estimates of income under-reporting by the Canadian self-employed for 1982/1986, presented in the column on the left, and 1992/1996 in the column on the right. The total amount of income under-reporting is found by subtracting reported self-employment income from estimated household true self-employment income and summing up over households. The first row of table 4 shows the population estimates for total income under-reporting, obtained by using the FAMEX survey weights. Total income under-reporting almost doubled between the 1980's and the 1990's, amounting to just over \$0.619 billion in the 1982/1986 pooled sample and increasing to approximately \$1.198 billion in the 1992/1986 pooled sample. The associated 90% bootstrapped confidence intervals are noted in the parenthesis. There are two things to note with respect to the reported confidence intervals. First, for both samples, the confidence intervals indicate that total income under-reporting was statistically significantly greater than zero. Second, the overlapping of the confidence intervals suggests that total income under-reporting in 1992/1996 was not statistically significantly different from total income under-reporting in 1982/1986. Further statistical tests confirm that the difference is not statistically significant.

As the number of self-employed households increased between the two pooled samples, as shown in the second row of table 4, it could be that the increase in total income under-reporting was simply due to the increase in self-employed households over the sample period, rather than due to the implementation of the GST. In order to determine if there was a change in the amount of income under-reporting per household, the average per household income under-reporting is calculated.[17] Despite the fact that the number of self-employed households increased

[17] Average income under-reporting per married household with positive reported self-employment income is calculated by dividing total income under-reporting, reported in the first line of table 4, by the population size, also reported in table 4.

between these two pooled samples, there was an increase in the average amount of self-employment income that went unreported. Income under-reporting per married household, presented in the third row, amounted to $2,462.70 in the 1982/1986 pooled sample and $3,015.71 in the 1992/1996 pooled sample. The 90% bootstrapped confidence intervals for these per household amounts are presented in the final row of the table. Again, for both samples, the confidence intervals indicate that average income under-reporting is statistically significant, but the results are not statistically different from each other. That is, the results do not support the notion that the GST increased income under-reporting by married households with self-employment income. The results also do not support the claim that the GST would decrease tax evasion.

3.4. Limitations

The results presented above call into question many of the assumptions made in the parametric approach of the *Expenditure-Based Method*. That said, some caution needs to be exercised in interpreting these specific results, as the reliability of the estimate depends on the quality of the data. There are some notable features of the FAMEX that may bias the results reported in this paper.

First, by using survey data, only those households that elected to take part in the survey can be studied. Households that are heavily involved in underground activity, particularly those households that are involved in illegal activity (for example, drug trafficking, human smuggling, and prostitution), are unlikely to participate in the survey or may elect to modify their reported amount of expenditures to ensure they are not perceived to be living beyond their means.

Second, unlike household income and expenditure surveys conducted in other countries, the FAMEX is a recall survey. That is, the data for the FAMEX is collected in March/April of a given year, but covers expenditures for the previous year. It is possible that the expenditure data used in the analysis may suffer from recall bias.[18] In addition, data collectors make attempts to ensure that total expenditures are roughly equal to total income. In particular, income must balance expenditures to within 10% and records where expenditures exceed all sources of income by 20% or more are rejected. As a result, it is reasonable to assume that the estimates obtained for the underground economy using this method will be a lower bound estimate. The response rate for the FAMEX averages around 70%.

Third, income reported in the FAMEX may not be the same as income reported to the tax authority by households. Households are not required to produce any proof of income and there is no note in the FAMEX if the interviewer reviewed any such documents. To the extent that income reported in the FAMEX differs from that reported to the tax authority, the results outlined in this paper will be biased but it is unclear in which direction the results will be biased.

Finally, the unit of analysis, ideally, would be individuals, as it would avoid assuming households act as single decision makers and because in Canada, taxes are assessed on the individual rather than the household. In the FAMEX, however, expenditures are only surveyed at the household level and there are insufficient observations to conduct the analysis on single adult households. Additionally, as the FAMEX does not contain information regarding after-tax income by income source[19], the application was conducted using gross income. After-tax

[18] Ahmed *et al.* (2005) compare income and food expenditure information collected in a diary based survey (FOODEX) to those collect in a recall based survey (FAMEX) and find little difference.
[19] That is, the FAMEX contains information by household on total gross income and total net income but household self-employment income and other income is only available in gross terms. As household self-employment income

income is more desirable in this analysis as households are more likely to base their expenditures on after-tax income. Further, as previously mentioned, income tax in Canada is assessed on the individual rather than on the household. As a result, households with similar gross incomes, may not have comparable net income and hence may not have comparable expenditures, which would lead to a biased estimate of true gross income in the first step of the approach.

This analysis was also conducted on married households, living in both rural and urban areas. Limiting the analysis to households living only in urban areas, resulted in insufficient observations. It is extremely likely that households in urban and rural environments, have different levels of food expenditures at similar income levels for reasons that are unassociated with income under-reporting. For example, households in rural environments may be more likely to: grow food for consumption in a household garden; face reduced food prices due to the presence of local producers and suppliers; and engage in the trade of goods and services for food products. To the extent that this is true, food expenditures for rural households with no self-employment income will act as a poor counterfactual for urban households with positive self-employment income and vice versa.

Caution must also be exercised in interpreting and comparing the results presented here to those obtained by alternate methods. The results presented here, income under-reporting by married households with self-employment income, should not be interpreted as representing a measure of the total underground economy. Households with self-employment income but with different demographic characteristics (e.g. households with children, single person households etc.) may engage in income under-reporting at different rates than married households. Additionally, income under-reporting by the self-employed, represents only a portion of

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and other income is used to calculate true household self-employment income (shown in equation (3b) in the main text of this paper, the application described in this paper could only be conducted using gross income terms.

underground activity. Finally, the method presented in this paper, estimates income that is not reported to tax authorities, which is quite distinct from measuring production or income that is missed by the statistical offices when they calculate the value of the national product. Many methods employed in estimating underground activity use the latter calculation. Giles and Tedds (2002), updated by Tedds (2005), provide a summary of the available Canadian estimates of underground activity, arranged according to methodology and calculation employed, should additional, independent comparisons be desired.

4. CONCLUSION

This paper proposes a nonparametric approach for estimating income under-reporting by households with self-employment income. The use of nonparametric methods is shown to have several advantages over previous parametric approaches. First, it enables the reporting function to vary across income levels and household characteristics. Second, it provided the ability to test, and find evidence against, the previously held hypothesis that the reporting function takes the linear form. Third, the framework allowed for an alternative approach to addressing the issue of permanent income. A further advantage of this method is the ease in which population estimates can be generated. In particular, the total amount of unreported income in the population could be obtained directly, whereas previous studies could only extrapolate this information by using national accounts data. Overall, the approach outlined in this paper calls into question many of the assumptions made in the parametric applications of the *Expenditure-Based Method.*

The approach outlined in this paper is illustrated by estimating the effect of the Canadian Goods and Services Tax on income under-reporting by married households with self-employment income. The results indicate that income under-reporting by married households with self-employment income neither increased nor decreased following the implementation of the GST. The results indicate that income under-reporting increased, in real (1996) dollar terms, from \$2,462.70 per household in the 1980's to \$3,015.71 per household in the 1990's, following the implementation of the GST, but that this difference is not statistically significant. Caution needs to be exercised in interpreting these specific results, as the reliability of the estimate depends on the quality of the data and on the various assumptions made. Evidence is provided that supports the notion that the obtained estimates of income under-reporting reported in this paper are lower bound estimates.

The analysis presented in this paper indicates that further work is required in refining this method to improve consistency with available data and knowledge concerning participation in the underground economy. In particular, redefining the base group is warranted, as is exploring a relaxation of the assumption that requires the marginal propensity to consume out of unreported income to equal the marginal propensity to consume out of reported income. It may also be worthwhile to consider alternative forms of the reporting function. Finally, several shortcomings related to the use of the FAMEX were described in this paper, shortcomings that are shared by comparable data sets for other countries. The most important of these is that income reported in the FAMEX may not be the same as income reported to the tax authority by households because households are not required to produce any proof of income. Tax filer data, on the other hand, would have exact information regarding income and, hence, would provide more accurate estimates of income under-reporting. Unfortunately, tax filer data does not contain detailed information regarding expenditures. It does, however, contain information regarding expenditures on goods and services that are subject to tax credits and deductions and it may be possible to use this information and the method outlined in this paper to obtain more accurate estimates of income under-reporting.

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TABLES

Table 1: Data Summary[1]

	1982 & 1986 Pooled FAMEX				1992 & 1996 Pooled FAMEX			
	Households with zero self-employment income							
	Sample Size=1604				**Sample Size=1471**			
	Mean	Std dev	Min	Max	Mean	Std dev	Min	Max
Gross Income ($)	60,343	25,541	14,877	159,661	64,741	28,103	16,131	183,370
Self-Employ. Income ($)	0	0	0	0	0	0	0	0
All Other Income ($)	60,343	25,541	14,877	159,661	64,741	28,103	16,131	183,370
Food Expend. ($)	6,660	2,552	926	18,672	6,103	2,551	495	19,678
Net change in assets & liabilities ($)	6,046	12,275	-32,892	83,869	6,086	13,732	-56,120	88,171
	Households with positive self-employment income							
	Sample Size=303				**Sample Size=369**			
	Mean	Std dev	Min	Max	Mean	Std dev	Min	Max
Gross Income ($)	55,808	27,372	15,041	137,853	60,545	29,283	15,244	184,000
Self-Employ. Income ($)	19,612	20,080	56	94,436	22,019	24,453	1	126,356
All Other Income ($)	36,196	28,216	0	132,936	38,527	27,139	0	132,674
Food Expend. ($)	6,365	2,727	1,400	17,536	6,061	2,681	1,489	18,359
Net change in assets & liabilities ($)	5,785	16,020	-46,205	76,870	5,582	13,907	-42,619	61,211

Notes: [1]Amounts are in real (1996) Canadian dollars and are rounded to the nearest dollar.

Table 2: Testing the Significance of ΔA_h

	1982 & 1986 Pooled FAMEX	1992 & 1996 Pooled FAMEX
$\hat{\beta}_{diff}$ ($s.e.$)	1.053 (0.0408)[1]	1.047 (0.0440)[1]
Test: $H_0 : \beta_{diff} = 0$ **vs.** $H_a : \beta_{diff} \neq 0$	p-value=0.000	p-value=0.000
Test: $H_0 : \beta_{diff} = 1$ **vs.** $H_a : \beta_{diff} \neq 1$	p-value=0.098	p-value=0.143

Notes: [1]Standard errors corrected for autocorrelation as discussed in the text.

Table 3: Testing Linearity of the Reporting Function

	Test: $H_0 : y^*_{SE,h} = \theta y_{SE,h}$ **vs.** $H_a : y^*_{SE,h} = f(y_{SE,h})$	
	1982 & 1986 Pooled FAMEX	**1992 & 1996 Pooled FAMEX**
V	1.306	2.863
p-value	0.096	0.002

Table 4: Estimates of Income Under-Reporting[1]

	1982 & 1986 Pooled FAMEX	1992 & 1996 Pooled FAMEX
Total amount of Income Under-Reporting[2] (90% Bootstrapped Confidence Interval)	\$0.619 billion (\$0.116B; \$1.086B)	\$1,198 billion (\$0.612B; \$2.358B)
Population Size[2]	251,386	397,189
Income Under-Reporting[2] (90% Bootstrapped Confidence Interval)	\$2,463 (\$428; \$4,278)	\$3,016 (\$1,542; \$5,936)

Notes [1]Amounts are in real (1996) Canadian dollars and are rounded to the nearest dollar.
[2]Calculated for married households without dependent children present in the hosuehold that report positive self-employment income using the survey weights provided in the FAMEX by Statistics Canada to obtain population amounts.

FIGURES

Figure 1: Income Under-reporting in the Single Equation Expenditure-Based Method

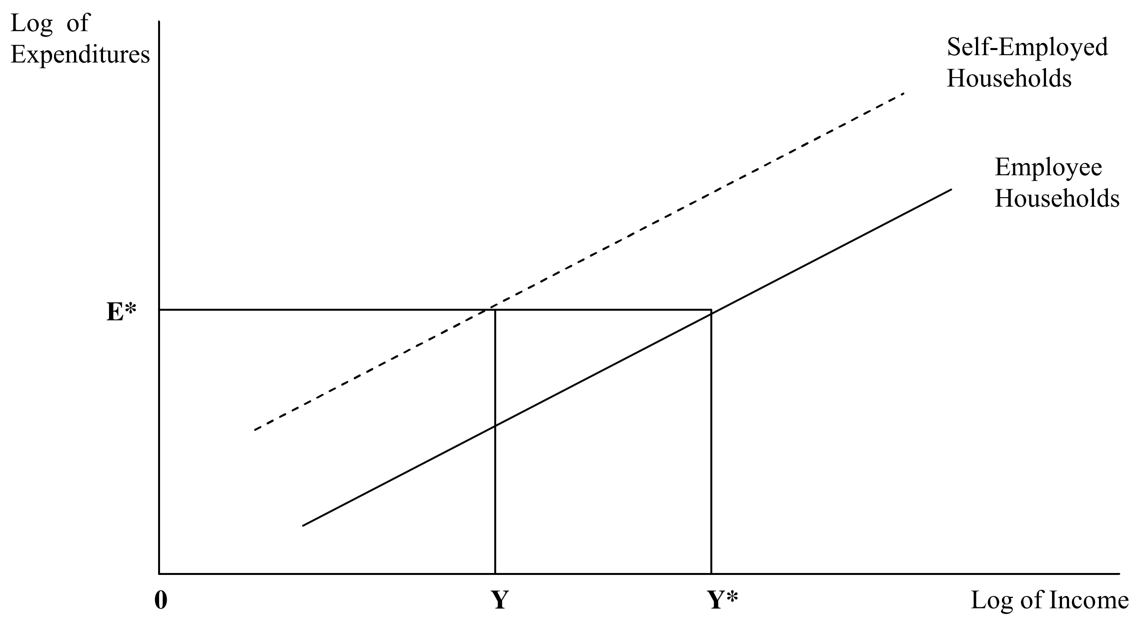
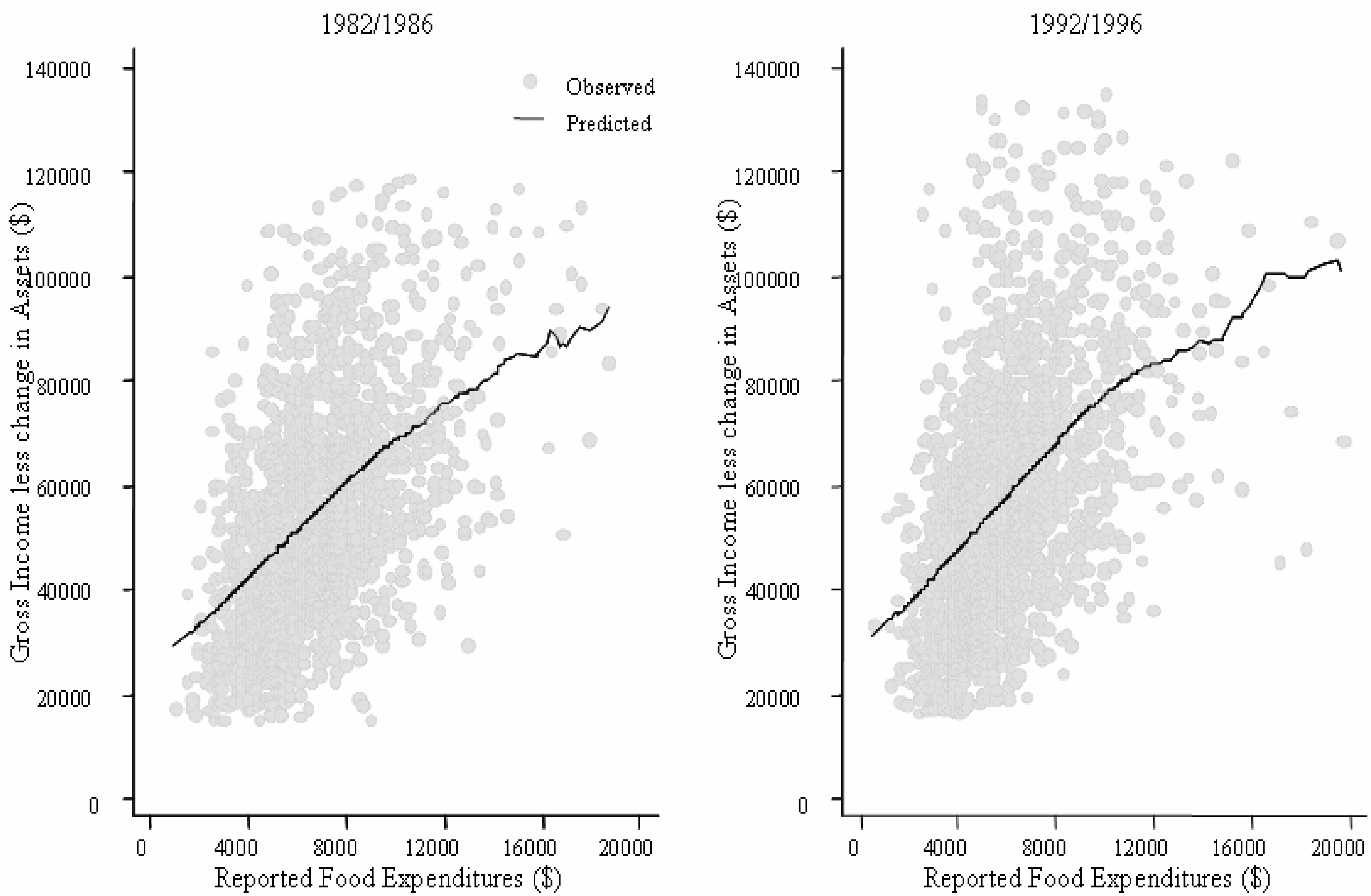
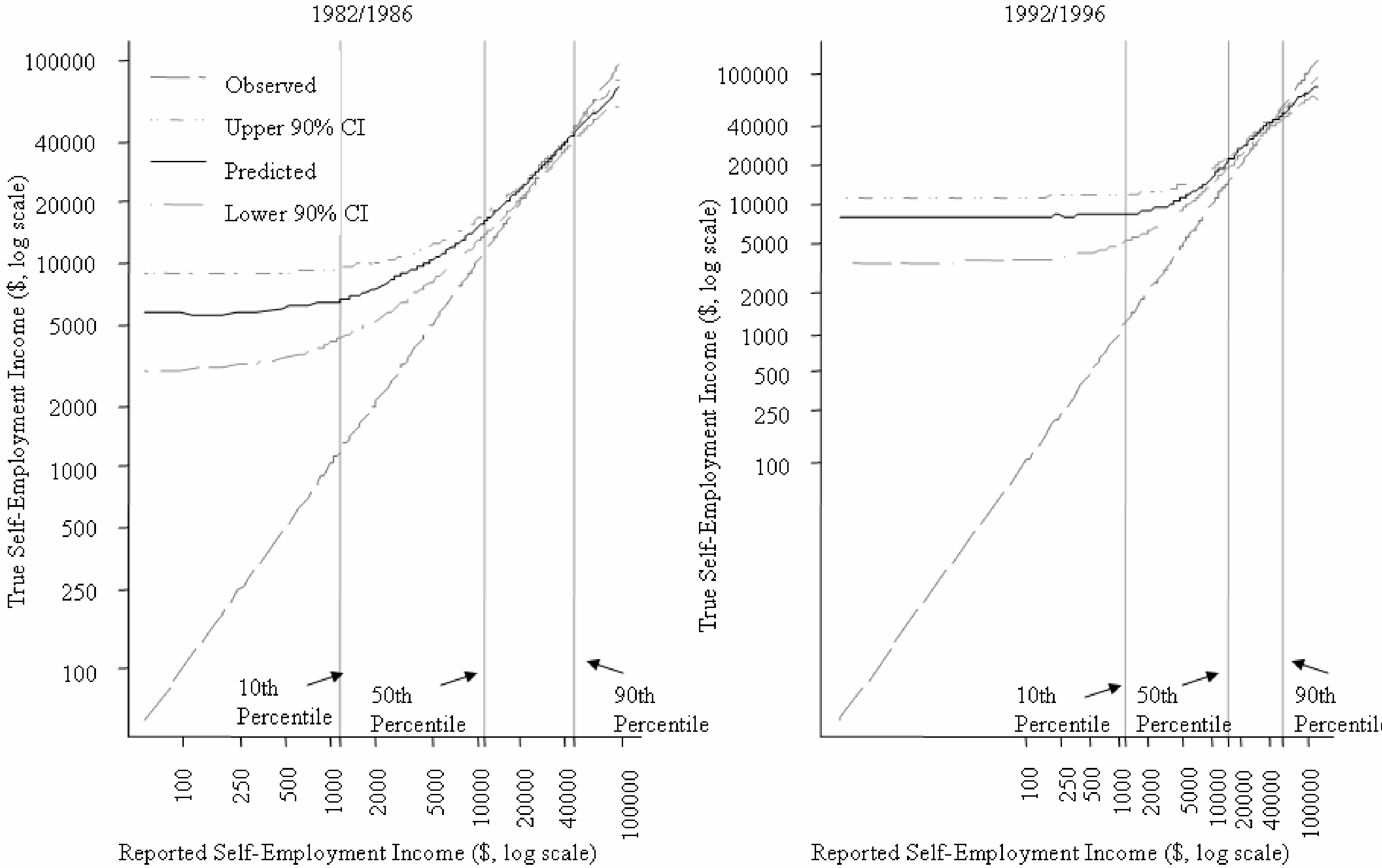


Figure 2: Inverse Food Engel Curves



Source: FAMEX, Real 1996 $, Married Couples

Figure 3: Estimated True Self-Employment Income (log scale)



Source: FAMEX, Real 1996 $, Married Couples