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Nonparametric estimation of structural labor supply and exact welfare change under nonconvex piecewise-linear budget sets

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ABSTRACT

This paper contributes to the literature in both the estimation of structural labor supply and the calculation of exact welfare effects. It proposes a nonparametric method to estimate labor supply with nonconvex piecewise-linear budget sets. Different from previous literature such as Blomquist and Newey (2002) and Soest, Das, and Gong (2002), our method focuses on a nonparametric specification of an indirect utility function. We find that working with the indirect utility function is very useful in simultaneously addressing the labor supply problems with nonconvex budget sets, unobserved heterogeneity, labor nonparticipation, and measurement errors in working hours that previous literature was unable to account for. Further, two methods are developed to calculate exact welfare effects due to reforms of a nonlinear tax system. This paper also includes applications to the 1986 tax reform and 2001 Bush tax cut.

1. Introduction

This paper contributes to the literature in both the estimation of structural labor supply and the calculation of exact welfare effects. It proposes a nonparametric method to estimate labor supply with nonconvex piecewise-linear budget sets. Different from previous literature such as Blomquist and Newey (2002) and Soest et al. (2002), our method focuses on a nonparametric specification of an indirect utility function. We find that working with the indirect utility function is very useful in simultaneously addressing the labor supply problems with nonconvex budget sets, unobserved heterogeneity, labor nonparticipation, and measurement errors in working hours that previous literature was unable to account for. Further, two methods are developed to calculate exact welfare effects due to reforms of a nonlinear tax system.

A big concern when estimating labor supply is nonlinear taxation. Typically, tax systems and transfer programs in the real world generate piecewise-linear budget sets for individuals. To tackle this problem, a line of literature accounts for the complete form of the budget constraint. A non-exhaustive list includes Burtless and Hausman (1978), Hausman (1981b, 1985), Moffitt (1986, 1990), Triest (1990), Blomquist (1996), Blomquist and Newey (2002), Soest et al. (2002), Fullerton and Gan (2004), Kumar (2008), Heim (2009), and Gan et al. (2013). Recently, nonparametric estimation of labor supply and welfare effects of tax reforms has drawn attention of economists and econometricians who follow this line of studies. For many reasons, nonparametric specification is preferred to a linear one. First, economic theories demand a nonlinear labor supply function. For example, Brown and Walker (1989) argued that the unobserved heterogeneity in preferences should enter the basic labor supply function in a nonlinear form.[1] Otherwise, the Slutsky matrix becomes asymmetric, violating the axioms of rationality. Second, empirical evidence suggests that a linear specification may bias the estimation of labor elasticities. For instance, Blomquist and Newey (2002) found that nonparametric estimation of wage elasticity is only 60% of that based on a linear method. Third, the functional specification also matters for evaluating welfare effects. Hausman (1981a) showed that the "second

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[1] Blomquist (1988) called the labor supply functions that would be generated by linear budget constraints the basic labor supply functions.

order'' properties of the labor supply curve is critical in measuring deadweight loss. In a word, nonparametric methods become increasingly important. However, taxes create a lot of difficulties for a nonparametric estimation.

First, nonconvex budget sets are difficult to handle in a nonparametric framework. If taxes are regressive, the budget set is concave. For example, in the United States, the upper limit of the social security tax and the upper limit of the phase-out stage of Earned Income Tax Credit (EITC) create concave points on the budget sets. In a utility optimization problem with a nonconvex budget constraint, there may be more than one local optimum choice. To derive the best choice, we need to compare the utility levels of all the local optimum choices. Traditionally, this is done by specifying a simple parametric labor supply function and solving the corresponding closed-form direct utility function.[2] The labor supply function is useful to derive all the local optimum choices while the utility function is used to determine the globally optimal choice. However, if the labor supply function is nonparametrically specified, it is difficult to obtain the closed-form direct utility function. Actually, for most labor supply functions, the closed forms of their corresponding direct utility functions do not exist at all.

In the literature, two attempts have been made in nonparametric estimation of labor supply under piecewise-linear budget sets. Blomquist and Newey (2002) proposed a nonparametric method that treats the labor supply as a function of the entire budget set. They showed that, if the budget set and preference are convex, the conditional mean time of working given the budget set is simply the sum of integrated working hours on all segments and kink points. However, their technique does not work in a general context. In the presence of a nonconvex budget set, the desired working hours is discontinuous with respect to unobserved heterogeneity and parts of the budget set around the concave kink points do not contribute to the conditional mean working hours. It is difficult to correctly determine these non-contributing parts. As a consequence, the conditional mean working hours given nonconvex budget sets might be incomputable. Soest et al. (2002) presented an alternative nonparametric method in which a direct utility function is specified and the budget set is replaced by a finite number of discrete points. This discretization method is able to address the nonconvexities on the budget sets, but the labor supply has to be estimated approximately.

Another problem in a nonparametric estimation with taxation is how to account for unobserved heterogeneity in preferences. The importance of unobserved heterogeneity is widely recognized in the labor supply literature. Also, unobserved heterogeneity is indispensable for a simulation-based policy evaluation (see Fullerton and Gan, 2004). However, in a traditional nonparametric regression model, the unobserved heterogeneity in preferences is usually integrated out, as in both Hausman and Newey (1995) and Blomquist and Newey (2002). Thus, the regression component in these models can be explained as the labor supply function of a representative individual. However, the aggregation often leads to biased estimates of welfare effects, because tax reforms may differ in influencing the aggregated agent and individuals with heterogeneous preferences.

Other common problems in a nonparametric estimation of labor supply include labor nonparticipation and measurement errors in working hours. In Soest, Das, and Gong's (2002) method of budget discretization, labor supply censoring is easy to address. But, an unresolved challenge is measurement errors in the working hours which enter the direct utility function in a nonlinear fashion. These errors, as Soest et al. (2002) pointed out, can have a detrimental effect on the estimates of policy relevant parameters. The method by Blomquist and Newey's (2002) was initially unable to deal with labor nonparticipation. Recently, this problem has been solved by Liang (2012).

This paper presents a new method to nonparametrically estimate labor supply. Instead of specifying functions of working hours or direct utility, we focus on a nonparametrically specified ordinary indirect utility function. Then, the mongrel labor supply is written as a function of three arguments: the entire budget set, the ordinary indirect utility function, and the heterogeneity of preferences for working.[3] In contrast to Blomquist and Newey (2002), we maintain the preference heterogeneity as an argument of the nonparametrically specified indirect utility function.

When indirect utility function is specified, the basic labor supply is easily obtained using Roy's identity. Then the basic labor supply function can be used to determine all the local optimal choices which fall on a segment or a kink point. If the budget set is nonconvex, probably more than one choice is locally optimal. We then utilize the indirect utility functions to compare their utility levels.

A key technique involved in the above global algorithm is how to derive the utility at a kink point. Our simple idea is to work out the supporting line that is tangent to the indifference curve passing through this kink point (see Blundell et al., 1988).[4] We design an efficient numerical algorithm to solve the tangent line. Once the supporting line is available, the utility at the kink point can be calculated by substituting the slope and intercept of the tangent line into the ordinary indirect utility function. We call the maximum indirect utility derived among all the segments and kink points generalized indirect utility.

Given the estimate of the ordinary indirect utility function, it is convenient to accurately evaluate welfare effects of tax reforms. We define a generalized indirect utility function which takes the entire budget set, the ordinary indirect utility function form, preference heterogeneity as its arguments. This tool enables us to numerically compute compensating variation (CV) and deadweight loss (DWL) in a framework with piecewise-linear budget sets.

In the literature, Hausman and Newey's (1995) is the first to examine the exact welfare changes in a nonparametric framework. Their approach is a two-step procedure. In the first step, they applied nonparametric regression models to the estimation of ordinary demand curves. Then, in the second step, Vartia's (1983) numerical methodology was employed to approximate the welfare measures. However, this method is only valid with linear budget sets, which impedes its applications to a context with complex taxes and tax reforms. Kumar (2008) proposed an ex post evaluation method using panel data based on Blomquist and Newey (2002)'s and Hausman and Newey (1995)'s approaches. Kumar (2008) takes into account piecewise-linear budget sets when estimating labor supply, but nonlinear budget constraints are neglected when applying Vartia's method (1983) to calculate welfare effects. In this paper, we show that a direct application of Vartia's method results in biased estimation of welfare effects whenever piecewise-linear budget constraints are present but ignored. In Appendix A, we extend Vartia's welfare evaluation method to deal with nonconvex piecewise-linear budget sets. Unfortunately, the

2 The closed-form utility function can be obtained through a two-step procedure. In the first step, obtain the closed-form indirect utility function by solving a differential equation. In the second step, the closed-form direct utility function can be derived from the indirect utility function by solving an optimization problem.

3 Blomquist (1988) called labor supply functions that would be generated by nonlinear budget constraints mongrel labor supply functions.

4 Blundell et al. (1988) searched for the supporting line by minimizing the indirect utility function. They applied a grid search method.