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A simple identification strategy for Gary Becker's time allocation model[☆]

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HIGHLIGHTS

- We focus on Gary Becker's time allocation model.
- This model is associated with an identification problem.
- We present a simple approach to solve this identification problem.
- The approach is based on the observability of a set of production shifters.

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ABSTRACT

The implementation of Gary Becker's (1965) time allocation model is hampered by the fact that values of the different time uses are usually not observed. In practice, one often assumes that the value of time is uniform across time uses by using market wages. This approach implies a fundamental identification problem. We demonstrate that the identification problem can be solved if production shifters are available.

1. Introduction

About half a century ago, Gary Becker published the classic paper "A theory of the allocation of time" in the *Economic Journal*. Together with Gorman (1956) and Lancaster (1966), this seminal work laid the foundations of household production theory. The key characteristic of Becker's time allocation model is that households combine market goods and time uses to produce nonmarket goods, which directly provide utility. This beautiful theory though is faced with an important empirical issue that is related to the lack of observability of the 'prices' of the different time uses. The usual approach then is to assume that the prices of female and male time uses are uniform and equal to their respective wages. However, also this approach is faced with a fundamental identification problem.

In this short note, we present a simple approach to solve this identification issue. The approach is based on the observability of a set of variables that are related to the total factor productivities associated with the production of nonmarket goods.

The rest of the note is structured as follows. We present Becker's (1965) time allocation model in Section 2. In Section 3, we present the identification problem associated with the empirical

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implementation of the theoretical model. We discuss our simple solution to obtain identification in Section 4. Section 5 concludes.

2. Becker's time allocation model

In what follows, we focus on Becker's (1965) setting in which households are assumed to behave as single decision makers with rational preferences. A household is assumed to derive utility from the consumption of nonmarket goods ('basic commodities' in Becker's words). Examples of such nonmarket goods are a clean home, eating or child rearing. Nonmarket goods are produced by means of market goods and time. Let us denote nonmarket goods by the vector $\mathbf{z} = (z^1, \ldots, z^k)'$. Market goods and time used in the production of nonmarket good i are denoted by the vectors $\mathbf{q}^i$ and $\mathbf{t}^i$ respectively, while they are associated with the price vector $\mathbf{p}^i$ and the vector $\mathbf{w}^i$ that captures the values of the different time uses. In what follows, we will denote the vector of time spent on market labor by $\mathbf{t}^m$ while $\mathbf{w}^m$ are the associated market wages. The former vector of time use consists of, for example, female and male time spent on market labor, or the time spent on various jobs. Market goods are financed by earnings $\mathbf{w}^{m\prime}\mathbf{t}^m$ and nonlabor income y. A household's preferences over nonmarket goods are represented by a utility function u, which is strictly increasing, twice continuously differentiable and quasi-concave in its arguments $\mathbf{z}$. Each nonmarket good i, with $i = 1, \ldots, k$, is associated with a production function f^i in the following way:

$$z^i = f^i(\mathbf{q}^i, \mathbf{t}^i), \tag{1}$$

where f^i is strictly increasing, twice continuously differentiable and concave in its arguments. Following Pollak and Wachter (1975), we further assume that there are constant returns to scale in the household technologies and that there is nonjointness in production: a given input can only be used for the production of a sole nonmarket good.

The household's maximization problem is then equal to:

$$\max_{\mathbf{z},\mathbf{q}^1,\ldots,\mathbf{q}^k,\mathbf{t}^1,\ldots,\mathbf{t}^k,\mathbf{t}^m} u(\mathbf{z}) \tag{2}$$

subject to

$$z^i = f^i(\mathbf{q}^i, \mathbf{t}^i) \quad \text{with } i = 1, \ldots, k, \tag{3}$$

$$\sum_{i=1}^{k} \mathbf{p}^{i\prime}\mathbf{q}^i = y + \mathbf{w}^{m\prime}\mathbf{t}^m, \tag{4}$$

$$\sum_{i=1}^{k} \mathbf{t}^i = \mathbf{T} - \mathbf{t}^m, \tag{5}$$

where $\mathbf{T}$ is a vector that gives the total time available (for females and males for example). An important insight by Becker (1965) is that time can be converted in market goods by using less time in the home production process and more time spent on the labor market. As a result, the constraints (4) and (5) can be rewritten as the single full income constraint:

$$\sum_{i=1}^{k} \mathbf{p}^{i\prime}\mathbf{q}^i + \mathbf{w}^{m\prime}\sum_{i=1}^{k} \mathbf{t}^i = y + \mathbf{w}^{m\prime}\mathbf{T}. \tag{6}$$

The implication of the constant returns to scale assumption in addition to nonjointness in production is that the cost function c, which gives the minimum outlay on inputs needed to produce a vector of nonmarket goods $\mathbf{z}$ for given prices $(\mathbf{p}^1, \ldots, \mathbf{p}^k)$ and wages $(\mathbf{w}^1, \ldots, \mathbf{w}^k)$ can be rewritten as:

$$c(\mathbf{p}^1, \ldots, \mathbf{p}^k, \mathbf{w}^1, \ldots, \mathbf{w}^k, \mathbf{z}) = \sum_{i=1}^{k} c^i(\mathbf{p}^i, \mathbf{w}^i, z^i) = \sum_{i=1}^{k} b^i(\mathbf{p}^i, \mathbf{w}^i)z^i, \tag{7}$$

where $\mathbf{q}^i = \frac{\partial c^i(\mathbf{p}^i,\mathbf{w}^i,z^i)}{\partial \mathbf{p}^i}$ and $\mathbf{t}^i = \frac{\partial c^i(\mathbf{p}^i,\mathbf{w}^i,z^i)}{\partial \mathbf{w}^i}$ equal the demand for market goods and time for a given z^i. Further, we have that $\frac{\partial c^i(\mathbf{p}^i,\mathbf{w}^i,z^i)}{\partial z^i} = b^i(\mathbf{p}^i, \mathbf{w}^i)$. This index can be interpreted as the full cost of one unit of the nonmarket good i, which depends on the prices of market goods and time uses needed in this good's production. Making the appropriate substitutions, we can rewrite the full income constraint (6) as:

$$\sum_{i=1}^{k} b^i(\mathbf{p}^i, \mathbf{w}^i)z^i = y + \mathbf{w}^{m\prime}\mathbf{T}. \tag{8}$$

The combination of the household's utility function u with the above full income constraint is now very similar to a standard consumption allocation problem that aims at choosing the utility maximizing bundle $\mathbf{z}$ for given prices $b^i(\mathbf{p}^i, \mathbf{w}^i)$, with $i = 1, \ldots, k$, and a given full income $y + \mathbf{w}^{m\prime}\mathbf{T}$. As Heckman (2015) noted, this is actually an instance of Gorman's (1959) separability analysis, where the utility function u is separable in the arguments to produce the nonmarket goods $\mathbf{z}$ and the production functions exhibit nonjointness and constant returns to scale. More specifically, in the first stage, households optimally allocate budgets $b^i(\mathbf{p}^i, \mathbf{w}^i)z^i$ to each nonmarket good, with $i = 1, \ldots, k$, where the budgets depend on the price indices $b^i(\mathbf{p}^i, \mathbf{w}^i)$ and the full income. In a second stage, the households maximize each z^i subject to the prices of market goods and time uses used in its production and the budget determined in the first stage.

3. A fundamental identification problem

A potential problem associated with the empirical implementation of the time allocation model is that the nonmarket goods $\mathbf{z}$ are usually unobserved. As we will demonstrate later, this is no real issue. A far more important problem is that the values of the different time uses are usually not observable. A popular approach to deal with this problem is to assume that each household member's possible time uses have a uniform price, which equals that individual's market wage. However, this approach is faced with a fundamental identification problem, in the sense that different structural models are observationally equivalent.[1]

This can be demonstrated as follows. Let us first focus on the optimal choice of inputs to produce given amounts of nonmarket goods $\mathbf{z}$. Recall that this is the second stage of Gorman's separability analysis that was described in Section 2. The household's optimal choices of the inputs in the household production technologies are observable functions of the total budget spent on nonmarket good i, denoted by y^i, the household members' market wages $\mathbf{w}^m$ and the prices $\mathbf{p}^i$ (with $i = 1, \ldots, k$):

$$\mathbf{q}^i = \mathbf{g}^i_q(\mathbf{p}^i, \mathbf{w}^m, y^i), \qquad \mathbf{t}^i = \mathbf{g}^i_t(\mathbf{p}^i, \mathbf{w}^m, y^i). \tag{9}$$

The observability of these functions implies that the household production functions f^i, with $i = 1, \ldots, k$, that give rise to the nonmarket goods $\mathbf{z}$, can be recovered up to a monotonically increasing transformation. This is a direct application of integrability results in standard demand analysis. More specifically, the observed Marshallian demand functions (9) can be rewritten as (with $i = 1, \ldots, k$):

$$\frac{\partial c^i(\mathbf{p}^i, \mathbf{w}^m, z^i)}{\partial \mathbf{p}^i} = \mathbf{g}^i_q(\mathbf{p}^i, \mathbf{w}^m, c^i(\mathbf{p}^i, \mathbf{w}^m, z^i)),$$

$$\frac{\partial c^i(\mathbf{p}^i, \mathbf{w}^m, z^i)}{\partial \mathbf{w}^m} = \mathbf{g}^i_t(\mathbf{p}^i, \mathbf{w}^m, c^i(\mathbf{p}^i, \mathbf{w}^m, z^i)),$$

[1] Obviously, the identification problem becomes even more difficult in the case when the shadow prices are assumed non-uniform but remain unobservable (see Chiappori and Lewbel, 2015).