# Welfare Comparisons, Economies of Scale and Indifference Scale in Time Use

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# Equivalence Scale for Welfare Comparisons

Equivalence scales= tools to make interpersonal comparisons of welfare levels between members of households of different sizes and compositions.

$\Rightarrow$ "What is the expenditure level required by a single household to be as well off as if it was a household with several members?"

# Shortcomings in Traditional Equivalence Scale (I)

Welfare $\neq$ material standard of living

1. Zeckhauser (1973): Time is "*the ultimate source of utility*".
2. Time poor (Vicker 1977)
3. Time pressure has increased in the recent decades (Goodin 2005, Hamermesh2007).

# Shortcomings in Traditional Equivalence Scale (II)

Traditional definition of indifference scale
$\Rightarrow$ identification problems (Pollak and Wales 1979, 1992, Blundell and Lewbel 1991, Lewbel 1997)

1. Interpersonal utility comparison & utility cardinalization to compare the utility of an individual to that of a household.
2. The notion of a household utility is flawed.

# Browning, Chiappori, Lewbel (2004): Indifference Scale in HH Collective Model

**HH collective model** assumes that the household has a welfare function that is a weighted sum of the individuals' private utility functions

**Indifference scale** compares the same person's welfare in different living arrangements

# Literature Review

- BCL introduce a *consumption technology function*
- Cherchye, De Rock, Vermeulen (2008) analyze economic well-being and poverty among the elderly.
- Vermeulen and Watteyne (2006) define *a priori* goods that are privately or publicly consumed.
- Lewbel and Pendakur (2008) use a demand system reduced to a system of Engel curves.
- Bargain and Donni (2010) analyze the child cost.

**Identification assumption**: singles & individual living in a couple have the same preferences

# Contribution

1. Defining equivalence scale and economies of scale in a household collective model linked to time-uses
2. Defining the time poverty line
3. Theoretically: providing identification without price variation & new results on separability

# Results

Empirical application to UK Time Use Survey (2000):

- Economies of scale: 2 singles living apart need 6.3% free time more to achieve the same utility level as living together, about 2 hours more per day.
- Indifference scales: a woman (man) requires 54% (52%) of joint time-resources to attain the same utility level than she would have when she lived in a couple.
- 3% of our sample is time poor.

1 Theoretical Model

2 Empirical Strategy

3 Results

4 Shortcomings

5 Work in Progress

6 Conclusion

# Time Separability Assumption

- Two-stage budgeting process:
  1. At medium run: consumption-leisure trade-off
     = individual determines the demand for Consumption $C$, Leisure $\widetilde{T}$ and his Hours of work $H$
  2. At short run: individual allocates the daily spare time $\widetilde{T}$ to $k$ non-market activities $t$
     $\widetilde{T} = \Sigma_{k=1}^{K} t_k = 24 - H$

- Hours of work = given time constraint which impact daily time-allocation decisions only via an income effect.

# Time-use Technology Function

The time-use technology function incorporates all economies of scale induced by sharing and jointness activities

The time-use technology function = transformation function of time ($\mathbf{t}$) into private equivalent ($\mathbf{z}$):

$$\mathbf{z} = \mathbf{A}(\mathbf{t}_f, \mathbf{t}_m) \tag{1}$$

# Time-use Technology Function

The matrix **A**: its diagonal elements are 1 and other elements
$0 \leq \alpha^k \leq 1$ (Fong and Zang 2001)
$\alpha^k = 1$ for purely public time
$\alpha^k = 0$ for purely private time

$$\text{For singles } z_i^k = t_i^k$$

Singles

$$\text{For couples} \begin{cases} z_f^k = t_f^k + \alpha^k t_m^k \\ z_m^k = t_m^k + \alpha^k t_f^k \end{cases}$$

# Couple program

The collective HH program gives Pareto-efficient decisions

$$(P^c)\begin{cases} \max_{\mathbf{t}_f,\mathbf{t}_m} \mu.u_f\left(\mathbf{z}_f\right) + u_m(\mathbf{z}_m) \\ \text{st. } \sum_{k=1}^{K} t_i^k = \widetilde{T}_i \\ \text{st. } z_f^k = t_f^k + \alpha^k t_m^k \\ \text{st. } z_m^k = t_m^k + \alpha^k t_f^k \end{cases}$$

where $t_i^k \geq 0$, $t_i^k \leq T$ and $\mu(y, \mathbf{s})$ is the Pareto weight.

# Dual representation

To prove identification results & to facilitate empirical application: we derive a dual representation of the household's program.

$$(P^d)\begin{cases} \max_{\mathbf{z}_i} u_i(\mathbf{z}_i) \\ \text{st.} \sum_{k=1}^{K} \pi_i^k z_i^k = \eta_i \end{cases}$$

where $\boldsymbol{\pi}$ are the shadow prices and $\eta_i$ the shadow income.

# Economies of Scale and Indifference Scales

Economies of scale in time-use ($e$) represent the cost in time needed to consume the private equivalent times in comparison to what the HH spends:

$$e = \frac{\mathbf{p}'[\sum_{k=1}^{n}(z_f^k + z_m^k) - \tilde{T}]}{\mathbf{p}'\tilde{T}} = \frac{\sum_{k=1}^{n}(z_f^k + z_m^k)}{\tilde{T}} - 1$$

Indifference scales ($IS_i$) represent the fraction of HH time-resources that a single $i$ would require to consume the private equivalent times $z_i$ at market prices that put her on the same indifference curve that she attained as living in a couple:

$$IS_i = \frac{Min_{\mathbf{z}_i^*}(\mathbf{p}'\mathbf{z}_i^* | u_i(\mathbf{z}_i^*) = u_i(\mathbf{z}_i))}{\mathbf{p}'\tilde{T}}$$

# Identification

**Identification of price derivatives** (Deaton and Muellbauer 1980)
*Assumption 1:* Preferences are strongly separable and additive, and income effects vary across activities
⇒ Stone-Geary utility function allows to recover price and cross-price elasticities

**Generic Identification**
*Assumption 2*: Conditional on characteristics, commodity demands $h_f$ and $h_m$ are the same whatever the marital status
⇒ Preference parameters are identified using single individuals data.

*Assumption 3:*: The time-use technology parameters are generically identified, for $K \geq 1$, if there is an assignable time $j$ that is purely private, i.e. $\alpha^j = 0$.
⇒ Technology parameters are identified using couples data.

# Data

- UK Time Use Survey 2000
- 1,172 full-time workers between 16 and 65 years old without children
- Free-time conditional to hours of work is allocated between: sleeping, personal care, domestic work, “pure” leisure and commuting
- Weighted mean of 2 diaries: a working day and a non-working day

# Functional form

Stone-Geary utility function (additivity & strong separability):

$$U_i(t_i^1, ..., t_i^K) = \Pi_{k=1}^{K}(t_i^k - \gamma_i^k)^{\rho_i^k}$$

where $i = f, m$, $\gamma_i^k$ are the minimum expenditures and $\sum_{k=1}^{K} \rho_i^k = 1$

gives rise to Linear Expenditure System:

$$t_i^k = \gamma_i^k + \rho_i^k(\widetilde{T}_i - \Sigma_{j=1}^{K}\gamma_i^j) + \varepsilon_i^s$$

# Method & Parametrization

- GMM deals with simultaneity and endogeneity of spare time (endogenous hours of works): restrictions = management responsibilities, shift work, size of the firms and local unemployment rate
- Parameters $\gamma_i^k$ and $\rho_i^k$ are estimated using singles data including heterogeneity in income effects.
- As gains from living together and the degree of publicness of time-activity could vary across household, we include heterogeneity in technology parameters.

# Separability Test

A simple test of weak separability: $t_i^k$ depend on $C_i$?

| | Single female | Single male | Female in couple | Male in couple |
|---|---|---|---|---|
| Personal care | -0.06 | -0.09 | -0.09** | -0.05 |
| | (0.2) | (0.56) | (2.39) | (1.21) |
| Housework | -0.54 | 0.22 | -0.05 | 0.13** |
| | (1.15) | (0.95) | (0.73) | (2.4) |
| Leisure | 0.92 | -0.4 | -0.07 | -0.01 |
| | (1.83) | (1.24) | (1.15) | (0.01) |
| Commuting | -0.005 | -0.09 | -0.01 | -0.02 |
| | (0.02) | (0.45) | (0.33) | (0.63) |

Marginal effect of consumption on HH demands. t statistic in parentheses. **significant at the 5% level.

# Preference Parameters

| | Single Female | Single Male |
|---|---|---|
| Personal Care | 0.079** | 0.085*** |
| | (0.03) | (0.02) |
| Housework | 0.285*** | 0.168*** |
| | (0.04) | (0.03) |
| Leisure | 0.424*** | 0.431*** |
| | (0.05) | (0.05) |
| Commuting | 0.02** | 0.068** |
| | (0.01) | (0.03) |
| Sleeping | 0.192 | 0.248 |

Note that due to adding-up restriction, time devoted to sleeping is not estimated. Then the proportion of free-time devoted to sleeping is computed as follow:$1-\Sigma_{k=1}^{4}\rho k$. Absolute standard errors are in parentheses. *,**,*** significant at the 10, 5 and 1% level.

# Time-use Technology Parameters and Shadow Prices

| | $\alpha$ | $\pi_f$ | $\pi_m$ |
|---|---|---|---|
| Housework | 0.18*** | 5.08*** | 5.37*** |
| | (0.039) | (0.33) | (0.77) |
| Leisure | 0.22** | 4.08*** | 4.61*** |
| | (0.088) | (0.733) | (0.773) |
| Commuting | 0.08** | 7.31*** | 7.92*** |
| | (0.038) | (5.088) | (5.471) |

Standard errors are in parentheses. *,**,*** significant at the 10, 5 and 1% level.

# Economies of Scale & Indifference Scales

- Economies of Scale : 135.60 min (6.3 % )
  - Housework: 22.13 min (female) min; 17.49 min (male)
  - Leisure: 71.82 min (female) min; 58.71 min (male)
  - Commuting: 8.31 min (female) min; 6.95 min (male)
- Indifference Scale
  - Female Indifference Scale: 0.54 (% of household spare time)
  - Male Indifference Scale: 0.52 (% of household spare time)

# Time poverty-line

- Total expenditures on private time equivalent
- Individual with less than 60% of median equivalent time expenditures is considered to be time-poor
- 3% of our sample

# Sharing rule and Shadow prices Identification

Separability implies that demands are homogeneous of degree zero regarding individual wages
$\Rightarrow$ Sharing rule and Shadow prices cannot be identified simultaneously

Let's rewrite the model for couples starting from the BCL one:

$$\begin{cases} \max_{Z_f, Z_m} \mu . u_f(z_f) + u_m(z_m) \\ \text{st. } \sum_{k=1}^{K} \left( w_f t_f^k + w_m t_m^k \right) = \widetilde{FI} \\ \text{st. } Z_f^k = t_f^k + \alpha^k t_m^k \\ \text{and } Z_m^k = t_m^k + \alpha^k t_f^k \\ \text{st. } \sum_{k=1}^{K} t_i^k = \widetilde{T}_i \end{cases}$$

where $\widetilde{F}_i = w_i \widetilde{T}_i$

# Sharing rule and Shadow prices Identification

- Using the BCL model, i.e. the "time budget" constraint:

$$t_i^k = b_i^k(w_i, \widetilde{FI})$$

$\Rightarrow$ identification of $\pi$ and $\eta$, separately

- Whereas, using the "time" constraint:

$$t_i^k = t_i^k(\widetilde{T}_i)$$

$\Rightarrow$ time-use demands don't depend on wages: $\frac{\partial t_i^k}{\partial w_i} = 0$ that implies $\frac{\partial \eta_i}{\partial w_j} = 0$

$\Rightarrow$ time-use demand as a function of $\frac{\pi}{\eta}$
$\Rightarrow$ we cannot identify $\pi$ and $\eta$, separately

# Sharing rule and Shadow prices Identification

Implicitly, in the dual program: $\widetilde{FI}_i = \eta_i$

- identification of the shadow prices
- Pareto weights are known initially
- preceding estimates are conditional to a given Pareto weight

# Further research

This version requires:

1. Give out the separability assumption:
   - Computing economies of scale for time-use & consumption
   - Identification of the sharing rule

   ⇒ Work in progress: Using a Consumption-Leisure model with price variation
2. Generalization of the household production technology
   ⇒ Work in progress: Adding more structure and distinguishing economies of scale in pure leisure from housework

# HH member optimization program

$$(P^1)\begin{cases} \max_{c_i,l_i} U_i(c_i, l_i) \\ \text{st. } w_i l_i + c_i \leq w_i T + y_i = F_i \\ \text{st. } T - l_i > 0 \end{cases}$$

where $w$ is the opportunity cost of leisure time, i.e. individual wage, $T$ the total amount of time, $y$ the non-labor income, $F$ the full-income and $l$ the leisure, i.e. non-market activities.

# Technology functions

Adding a consumption technology function ala BCL (2004) and Cherchye et al. (2008)

$$\begin{cases} z_{lf} = l_f + \alpha_{lm} l_m \\ z_{lm} = l_m + \alpha_{lf} l_f \\ z_c = (1 + \alpha_c)\, c \end{cases} \qquad (2)$$

where $\alpha$ is the vector of publicness degrees comprised between 0 and 1.

# Identification

Using the same equal preferences assumption
and price variation
+ Combining childless singles and couples data

⇒ identification of all parameters
⇒ estimation of total welfare gain resulting from living together, including both C and L

# Preliminary Results

Using the same UK data base:

- The sharing rule = 0.63
- Overall scale economy: between 36% and 52% (BCL (2004) find 0.51%, Vermeulen and Watteyne (2006) 0.28% and Cherchye et al (2008) 0.38% focusing only on consumption)
- Indifference scale: a woman (men) requires 70% (66%) of joint income to be as well off single as she (he) was in couple (BCL (2004) estimates are about 83% for woman and 66% for man)
- Poverty line: 13% of our sample

# Conclusion

- HH decision-making process introduces a time technology function:
  • to identify equivalence scales and economies of scales
  • compare individual welfare in terms of time allocation between two marital situation
  • provide time poverty-line
- Extension (using LISS in which consumption data are detailed at the individual level)
  • Disaggregate consumption goods and non-market activities: using production shifters and consumption good price variations could help identification
  • Extension to model with children (Bargain and Donni, 2010)

THANK YOU FOR YOUR ATTENTION

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# Singles

Daily time-allocation program of the individual $i$:

$$(P^s)\begin{cases} max_{\mathbf{z}_i} U_i(\mathbf{z}_i) \\ \text{s.t} \sum_{k=1}^{K} t_i^k = \widetilde{T}_i \end{cases}$$

where $\mathbf{z}_i = \mathbf{t}_i$; $t_i^k \geq 0$, $t_i^k \leq T$, $h_i > 0$, $h_i \leq T$
Denoting $\mathbf{t} = (t_i^1, ..., t_i^K)$ the individual time-use vector and $\tilde{T}_i = 24 - h_i$ the daily spare time.

back