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## **Modeling transfers of unpaid resources by age and sex within the framework of input-output models**

### 1. INTRODUCTION

Intergenerational transfers of financial and unpaid resources are strongly affected by population aging. Changes in population age structure affect the fraction of the population in each stage of the life course (e.g. school attendance, childbearing, retirement, etc.). Thus, demographic change has relevant macro social and economic consequences (Lee and Mason, 2011).

The National Transfer Accounts (NTA) project, a collaborative initiative led by Ronald Lee and Andrew Mason, has substantially improved our understanding of the generational economy. Members of the NTA network have generated the first estimates of economic flows across age, in a manner consistent with National Income and Product Accounts, for a large number of countries (Mason *et al.*, 2009). The NTA database has been used for a number of applications, including the evaluation of the macroeconomic consequences of population aging, the economic cost of childbearing, and care for the elderly (Lee and Mason, 2011).

One of the main limitations of the NTA project is that unpaid productive activities are not fully taken into account yet. A large quantity of goods and services are produced by household members for their own consumption, without involving market transactions. Despite the economic and social importance of unpaid work, these productive activities are largely invisible to traditional national economic accounts. As a consequence, standard measures of intergenerational transfers typically ignore household production, and thus underestimate the overall value of goods and services produced over the life cycle, in particular, the economic contribution of women. The challenge of estimating transfers of unpaid resources and the related consequences of population change is a longstanding one (Lee and Lapkoff, 1988). The increasing availability of time use surveys in a number of countries has made possible the estimation of non-market productive activities in a comparative perspective. Recently, there have been some efforts to evaluate the extent of household production, and to integrate it into national accounts (Abraham and Mackie, 2005; Donehower and Mejia-Guevara, 2012; Zagheni and Zannella, 2013; Zagheni *et al.*, 2015).

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The recent literature on time transfers, within the general context of the National Transfer Accounts project, has focused on generating estimates of profiles of consumption and production of unpaid household work, by age and sex. These profiles highlight important features of patterns of time transfers and can be used to develop summary statistics and indicators. The main limitation of existing profiles of time transfers is that they do not provide an explicit and complete picture of time flows between age/sex groups in the population. Dukhovnov and Zagheni (2015) started to address the issue by estimating matrices of time transfers related to caregiving activities in the United States. Each entry of the matrices provides an estimate of flows of time from an age/sex group in the population to another age/sex group during a defined period of time.

This article builds on the recent literature about estimating flows of unpaid work to develop a modeling framework that uses matrices of time transfers as input in order to evaluate the potential consequences of changes in population age structure on flows of caregiving time. Section 2 provides some background on matrices of time transfers, summarizes the descriptive results for the matrices obtained in Dukhovnov and Zagheni (2015), and provides estimates of Gini coefficients as summary indicators of the matrix structure. Section 3 is the core component of the article: it offers a novel methodological framework. More specifically, we propose a new modeling approach, based on the theory of input-output models, to evaluate the impact of demographic change on time transfers. Section 4 provides an illustrative application of the model, using matrices of time transfers in the form of caregiving for the United States. The last section discusses the results and the implications for future work.

## 2. MATRICES OF TIME TRANSFERS BY AGE AND SEX

This section summarizes key features of matrices of care time transfers, by age and sex, and shows estimates of the Gini index as an indicator of structural characteristics of the matrices. In previous work, we estimated matrices of time transfers, in terms of caregiving activities, by age and sex, for the US (Dukhovnov and Zagheni, 2015). We used data from the American Time Use Survey (ATUS), 2011-2013, the major study of how people spend their time in the US. The data are collected from a representative sample of about 26,400 participants selected annually from the respondents to the Current Population Survey (CPS) conducted by the US Census Bureau. The respondents are asked to provide a chronological account of the activities that they did during a randomly selected day, as well as additional information about who was present, the duration of the activities and where the activities took place.

Matrices of intra-household flows of caregiving time can be estimated directly from time use diaries, since the respondents record the time dedicated to various caregiving activities as well as the unique identifiers of household

members that benefited from the time. Inter-household transfers of caregiving time cannot be estimated directly, since the respondents do not record the age and sex of care recipients. We estimated inter-household flows indirectly by combining available information about time dedicated to inter-household caregiving activities, by age and sex, as they are reported in diaries, with frequencies of care recipients in various age and sex groups listed by the caregivers in the ATUS “Eldercare Roster.” The matrices of intra- and inter-household time transfers were then combined into a single tabulation of overall time transfers in terms of caregiving activities, by age and sex. More details about the methodology can be found in Dukhovnov and Zagheni (2015).

Figure 1 – *Graphic representation of matrices of time transfers related to caregiving activities in the US, estimated from the American Time Use Survey (2011-2013). In each panel, the color-coded values indicate average per-capita time transfers from the age groups on the rows to the age groups on the columns.*

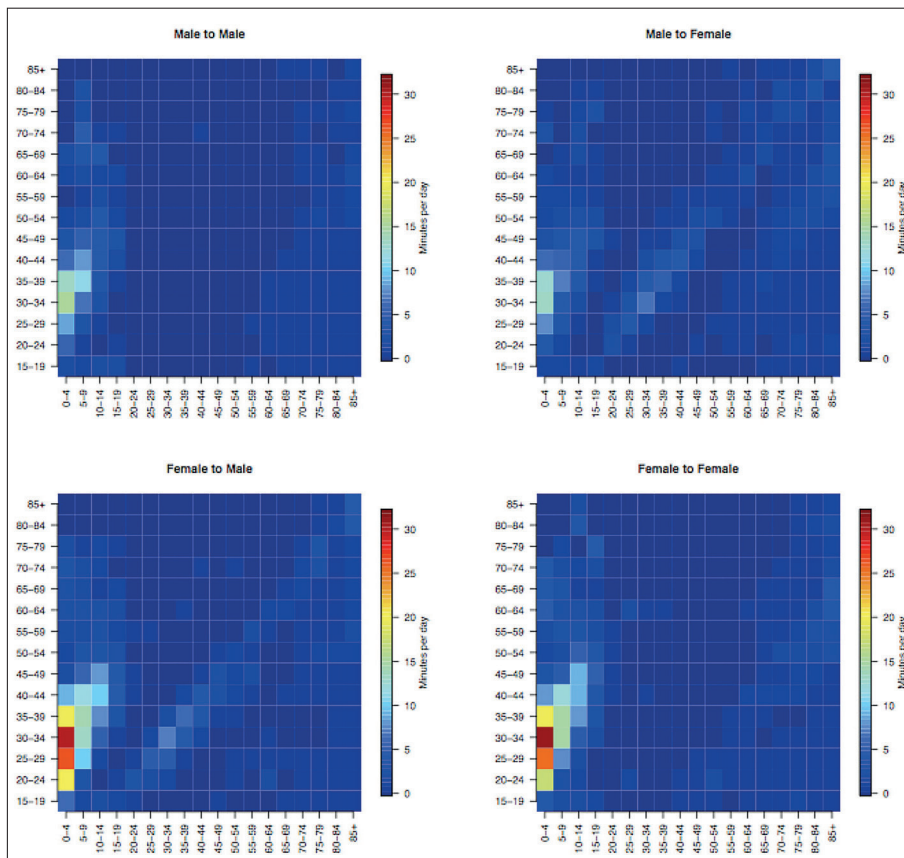


Figure 1 shows our estimates of overall flows of caregiving time by age and sex. Several important features emerge. First, we observe that the large majority of time transferred is from parents to young children, with notable sex differences: women spend about twice as much time as men caring for young children. Second, transfers from grandparents to grandchildren are noticeable. In particular, it is relevant to observe that gender differences emerge, with grandfathers spending more time with grandsons and grandmothers spending more time with granddaughters. Third, we observe a ridge along the main diagonal of the matrices of transfers to people of the opposite sex. This indicates substantial transfers to spouses. Finally, there are some sex differences in time dedicated to the elderly, and time needed by the elderly. Elderly women seem to have slightly higher care needs than elderly men. Middle-aged women spend slightly more time with the elderly than middle-aged men.

As Figure 1 graphically shows, patterns of transfers are unevenly distributed across the life course, with some age intervals during which people feel a “time squeeze”, in the sense that they may have large care commitments towards family members. These commitments may be concentrated over a relatively short period of time or phase of the life course. Hence the name “time squeeze”.

In order to assess structural characteristics of the distribution of time flows, the Gini coefficient is an appropriate summary measure. The Gini coefficient was proposed by Corrado Gini as a measure of inequality of income or wealth. The Gini coefficient has become a standard and influential measure of inequality. Here we use the coefficient to summarize features related to the inequality in the distribution of flows. We computed the Gini coefficient for the matrices of flows represented in Figure 1. More specifically, for each matrix, the values of flows were placed in ascending order in a vector  $y$ . In other words, the value  $y_i$  has rank  $i$ . Then the Gini coefficient was computed as:

$$G = \frac{2 \sum_{i=1}^n i(y_i - \bar{y})}{n^2 \bar{y}}$$

where  $n$  is the number of entries in the matrix considered.

The results indicate that the highest Gini coefficients are for matrices of transfers to the same sex (0.78 for male to male and 0.8 for female to female). The lowest value of the Gini coefficient is for the matrix of flows from male to female (0.65). The Gini coefficient for flows from female to male is 0.77. In this context, the Gini coefficient is a measure of inequality in the distribution of flows. Flows to the same sex are highly “unequal” in the sense that the highest values are related to childbearing only. Flows to the opposite sex are more diffuse, as they include not only childcare, but also peaks related to care for spouses.

3. THE THEORETICAL FRAMEWORK: MODELING TIME TRANSFERS WITH INPUT-OUTPUT MODELS

We can use matrices of time transfers as input for models for the evaluation of the impact of demographic change on structural patterns of time flows. This section outlines the main steps that we propose to develop an input-output model inspired by classic input-output economic models (Leontief, 1953, 2011).

Consider a population with  $m$  age groups, indexed by  $i$ . Total time production for age group  $i$ ,  $t_i$ , is written as:

$$t_i = z_{i1} + z_{i2} + \dots + z_{im} + d_i \quad [1]$$

where  $z_{ij}$  is the time flow from group  $i$  to group  $j$  and  $d_i$  is the size of a demographic shock that affects the total unpaid production for group  $i$ , but not the relative size of flows between groups in the population.  $d_i$  can be thought of as the exogenous impact of a change in population age structure that requires an adjustment in time production for group  $i$ . For instance, an increase in  $d_i$  may be driven by an increase in the demand for unpaid services produced by the age group  $i$ .

The model can be re-written to represent the flows between groups as a percentage of the transfers from the receiving group. Thus, if we write  $q_{ij} = (z_{ij} / t_i)$ , then the model can be expressed as

$$t_i = q_{i1}t_1 + q_{i2}t_2 + \dots + q_{im}t_m + d_i \quad [2]$$

or, equivalently

$$-q_{i1}t_1 - \dots + (1 - q_{ii})t_i - \dots - q_{im}t_m = d_i \quad [3]$$

By letting  $Q$  be the  $m \times m$  matrix containing all the coefficients  $q_{ij}$ ,  $T$  the  $m \times 1$  vector containing all the time production  $t_i$  terms, and  $D$  the  $m \times 1$  vector of shocks in ‘demand’ for time produced by age group  $d_i$ , the model can be expressed in a more compact form as:

$$[I - Q]T = D \quad [4]$$

This way, given the vector of final demand, and the matrix of coefficients  $Q$ , the vector of time production by age is obtained as:

$$T = [I - Q]^{-1}D \quad [5]$$

Equation [5] is the core methodological contribution of this paper. It provides a framework to evaluate the leverage effect of changes in demand

for age-specific production of unpaid resources. The underlying intuition is analogous to the idea behind economic input-output models. In the context of an economy where a number of sectors are interdependent, changes in the final demand for a specific sector imply an increase in the size of the specific sector with chain effects on a number of other sectors that produce input material and services for the sector considered. In the informal economy of unpaid production and transfers, equation [5] models age groups as “sectors”.

An increase in the size of unpaid services produced by a certain age group can be thought of as an increase in the size of the demographic group considered, holding per-capita production constant. The change in the size of a specific age group would have a chain effect on the flows of unpaid services produced by other age groups that support the demographic group considered. We expect that an increase in the size of a demographic group that is more dependent on others in terms of transfers (e.g., children and the elderly) would have a larger impact on the overall size of transfers compared to an expansion in the size of the population of young adults.

#### 4. AN EMPIRICAL APPLICATION ON MATRICES OF CARE TRANSFERS

This section offers an illustrative empirical application of the theoretical model described in the previous section. More specifically, the approach summarized in equation 5 is applied to the matrices of time transfers in the form of caregiving described in section 2.

Figure 2 – *Illustrative example of values of the vector  $T$  of time production, expressed in percentage values, obtained from a uniformly distributed vector of demands  $D$  and coefficients  $Q$  evaluated from the matrices of transfers described in section 2.*

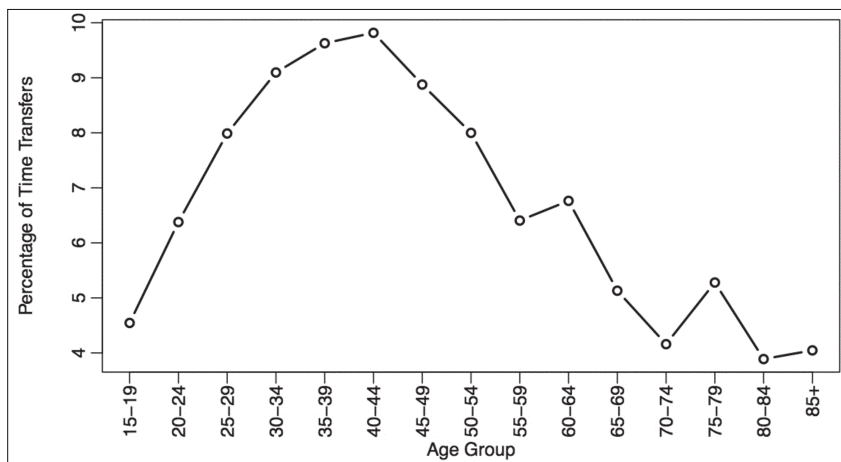


Figure 2 shows the values of the vector  $T$ , expressed in percentages, obtained from a uniformly distributed vector of demands  $D$ . The coefficients  $Q$  are estimated from the overall matrix of time transfers obtained by averaging transfers from males and females in Figure 1. The coefficients  $Q$  for this example are computed only for the square matrix of time transfers from and to people who are at least 15 years old.

As an experiment to mimic population aging, we can consider a situation in which the exogenous demand for time for specific age groups doubles. This is analogous to increasing the population of a specific age group while keeping their per-capita time production constant. Within our framework, the overall sum of produced and transferred time would increase substantially more if the size of the elderly increases, compared to an increase in the population of young adults. For example, doubling the total production for people who are 75 and older would lead to an increase in total production that is about 12 times bigger than what would result from doubling the population in the age group 25-39. The underlying idea is that, in the overall structure of flows between adults, an increase in the size of the elderly population has a large indirect effect on the whole system of transfers as they are receivers of transfers from a number of age groups. Thus the direct effect (increased production of the elderly) complements the indirect effects (increased production of other age groups). For the young adults, the direct effects are complemented by relatively smaller indirect effects, since young adults tend to be net producers rather than net consumers. In an analogy to an economy, young adults are the ‘raw’ material for the transfer system. An increase in demand from other groups would have a multiplier effect on demand for young adults.

It is important to note that this is a simplified model that does not account for potential behavioral changes. Population aging would affect behaviors and how people allocate their limited time to various activities. The input-output model does not account for individual-level decisions. Instead it gives a sense of the projected impact of changing age structure if people continued to behave in the same way. Analogously, the model tells us the extent to which behavior has to change in order to compensate for potential transformations in the population age structure.

## 5. CONCLUSIONS

This article presented a methodological contribution to model time transfers. This study builds on previously estimated matrices of time transfers for the US and develops a framework to include those matrices in input-output models. As an illustrative example, the new model is used to evaluate the impact of a hypothetical scenario of changing population age structure on time production and transfers. The model allows us to estimate the effect of



demographic change. One of the main results is that, all else being equal, doubling the population of people who are 75 years and older in the US would have an impact on care production that is about 12 times as big as the effect of doubling the population in the age group 25-39.

In this article, the empirical analysis focuses on the US and on time dedicated to caregiving activities. Given the increasing availability of detailed time use surveys for a large number of countries, the scope of the analysis could be expanded, in future research, to include more activities that potentially generate transfers of unpaid resources, and to perform comparative analyses across countries, in particular in the European context.

The model does not account for behavioral changes. It can be used to evaluate the extent to which changes in behavior are needed in order to compensate for modification in population age structure. Given that time is a limited resource, increasing demand for care may not result in a larger supply of unpaid caregiving. It may lead to a more prominent role of the market. Similarly, changes in technology and in health might affect the extent of time requirements.

This article offers a first step to further develop models that fully use the information contained in matrices of time transfers. The legacy of Corrado Gini includes a number of contributions where empirical analyses combined with formal models contributed to advances in our understanding of population processes. I hope that this study would stimulate the development of demographic models and empirical analyses of patterns of transfers for a number of countries, contexts and purposes.

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