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Assessing individual skill influence on housework time of Italian women: an endogenous-switching approach

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Abstract

Using Italian data from the Time Use Survey (Istat) on the time devoted by Italian women to housework tasks, in this study we analyze how much individual ability of a woman employed in the market influences her housework time. To this aim we estimate a two-regime Endogenous-Switching model for both employed and not employed women. As a novelty, a ML estimation of this model provides also the point-estimation of the across-regime correlation parameter, that allows us to evaluate the individual skill effect on the time devoted to housework tasks by a woman and to calculate the probability of choosing one of the two regimes, corrected for the endogeneity of the choice. The estimation framework allows us to identify the role of individual skills of the Italian women in household decision-making.

Keywords Time use · Housework division between partners · Endogenous switching · Across-regime correlation · Employed and unemployed women

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1 Introduction

Reconciling domestic work, paid work and leisure time is particularly complicated for women living in couples, especially for those who work in the market. In the Italian families, the overall contribution in terms of time devoted to work (paid and domestic) of each partner remains constantly unbalanced and penalizing for the woman, especially if there are small children to care in the family (Anxo et al. 2011; Campolo et al. 2020).

One possible explanation is that Italian male partners have a strong bargaining power in the household and leave most of the housework commitments to their female partners. Several studies highlighted as the bargaining process between partners is a result of the influence of cultural factors, such as gender attitudes and other women's personality aspects, considered as particularly relevant in Italy (Mills et al. 2008; Anxo et al. 2011).

In this study, specifying the factors that influence the bargaining process, we analyse the role of the individual skills of the Italian woman in household decision-making. In particular, we aim at learning more about how individual ability influences the commitment of the women in housework tasks.

Usually, analysts identified the weight of each partner in the bargaining process with her/his earning profile (Eckstein and Wolpin 1989), or taking into account her/his economic dependency given by her/his contribution to the household labour income (Brines 1994; Gupta 2007). However, the aspects related to the influence of the individual skills on the time devoted to housework tasks by the woman have not been still sufficiently explored. This lack in bargaining's specification may be probably due to the difficulty of empirically identifying the effect of individual skills on the decision-making process within the family. Individual skills are obviously important; and they are (obviously) latent variables.

To fill this gap, in this study we suggest an estimation procedure of housework time that allows us to identify the impact of individual skills as part of the stochastic component of a two-regime "endogenous switching" model (e.g., Maddala 1983, 1986). In this model, we assume two regimes given, each one, by the decision of the women to work in the market or not. Then, we try to explain the time committed in housework by women belonging to each of these two regimes. We hypothesize that the choice of the regime by a woman (employed or unemployed) is endogenously influenced by latent factors given by her skills. Performing this model, we estimate simultaneously the time devoted to housework for both employed and unemployed women specifying an equation for each regime. In doing this, we adopt the maximum likelihood estimation procedure introduced by Calzolari and Di Pino (2017) and Calzolari et al. (2021), that allows to simultaneously estimate the regression coefficients of both equations and related variances and covariance. The proposed methodology improves over previous estimation methods of a two-regime switching model (Lee 1978; Maddala 1983; Vella and Verbeek 1999) that do not estimate the covariance (and correlation) between the two equations errors simultaneously with the other parameters. This parameter is particularly important because it allows to infer on how latent factors affect

the choice of the regime (namely, to be employed or unemployed). These factors are considered as related to the nature of the skill of the subject. In practice, the knowledge of the so-called "across-regime" correlation parameter provides information about the ability of the woman to "specialize" herself to operate in one of two regimes, or about the ability of the woman to operate in both regimes.

We perform our empirical analysis by using cross-sectional Time Use Data on Italian couples, provided by the Italian National Institute of Statistics (Istat) with reference to the years 2012–2013.[1]

Our estimation procedure allows us to estimate, not only the "expected" time of a woman's housework in both regimes (or sectors), but also the probability that a woman will choose one of the two regimes, namely that she decides to work on the market or not.

As a result of the estimation of the domestic work supply of the Italian women, we obtain a large positive value of the across-regime correlation that reveals how the attendance to housework of, respectively, employed and unemployed women is not affected by a different skill. This conclusion contrasts with the hypothesis that Italian women are naturally specialized in housework and supports the thesis that women generally seek ways to maximize time devoted to children and domestic chores, whether they are employed or unemployed. This result is reached by assuming the woman's skill as a latent variable included in the stochastic component of an endogenous switching model. We find, in particular, that the stochastic component in the two regimes follows a bivariate distribution (assumed to be normal) identifiable by estimating the across-regime covariance (or correlation). Identification of the stochastic component of an endogenous switching model and, as a consequence, of the latent woman's skill may be considered as the prevalent contribution, both methodological and empirical, of this study.

In the next section we present a brief survey on the findings of the most relevant studies about the influence of bargaining on intra-household allocation, and on the determinants of the "specialization" in housework activity. In the following sections we discuss, in sequence: the rationale of our two-regime model to identify the woman's ability in housework; the model specification and the properties of the adopted estimator; the characteristics of the dataset data of the Italian Time Use Survey and the sample composition, the estimation results. Finally, we conclude with final observations and remarks.

2 Partners' skills effect on housework-time allocation: problems of identification

The bargaining process in the division of housework time between partners is considered by researchers as influenced not only by the ability of each partner in income production, but also by other factors such as their respective personality traits and

[1] The Time Use Survey 2012–2013 provided by Istat (Italian National Institute of Statistics) is available in the public domain at: http://www.istat.it/it/archivio/4611.

levels of economic dependency, as well as by gender attitudes and social norms. However, as we will show below, in previous studies on bargaining, the effect of (latent) individual skills on the decision making process is not clearly identified. A common feature of the studies about the intra-household allocation of domestic work is to explicitly or implicitly assume that the nature of the agent's ability can be identified with her/his degree of ability to produce labour income. In general, several analysts assume that a larger commitment of the individual in domestic activity corresponds also to a greater skill in domestic work and to a lower skill to work in the market. In this reasoning, however, a counterfactual evaluation of the ability of the agent in the "sector" in which she/he is not employed is absent. This lack makes difficult to explain the nature of specialization frequently observed in intra-household allocation of domestic work.

The weight of partners' respective earnings ability in decision making is typical of the "collective models" explaining intra-household time allocation (Apps and Rees 1997; Chiappori 1998). A common feature to the studies based on collective-model approach is that individual ability in income production can be assumed as a proxy of the effect of individual skills on bargaining process. Along this line, for example, an empirical identification method of the determinants of sharing rule for specialization was proposed by Mangiavacchi and Rapallini (2014). They suggested to adopt, as a proxy of the respective ability in income production, an index of self-reported economic condition of the household members obtained from the responses to a questionnaire related to a Time Use Survey (TUS) in Italy. Basing the individual skills evaluation only on the produced income, however, does not allow us to distinguish between an agent endowed by a higher ability under a specific regime and an agent with higher ability whatever the sector in which she/he is employed.

Flinn, et al. (2018) suggested to use the agent's personality traits (jointly with education and cognitive ability) to determine the so-called "Pareto's weights", that allow to determine the extent to which a cooperative attitude prevails in the bargaining process between the partners. In practice, personality traits measure individual openness to experience, conscientiousness, extraversion, agreeableness, and emotional stability (see, in particular, Borghans et al. 2008).[2] In this approach, however, the Pareto's weights effect on labour division does not account for individual skill since the use of a cognitive ability measure is not sufficient to identify the "nature" of the ability of the agent.

The role of the individual skill remains unidentified even in the versions of the collective approach that derive a sharing rule modeled on a household welfare function in a cooperative context (e.g., Manser and Brown 1980; McElroy and Horney 1981) as well as in the version in which household members are assumed to act non-cooperatively (Lundberg and Pollak 1993). Other approaches suggest different ways to explain decision making, such as the models based on the "economic dependency rule". In this context a higher decisional weight is assigned to the household member prevalently committed in paid work activity (Brines 1994; Gupta 2007, among

[2] These are the so-called Big Five traits, the most commonly used measures of personality to study the interface between Psychology and Economics (Borghans et al. 2008).

others). This approach assumes that housework tasks are provided by one or more household members in return for economic support; that is money is exchanged for domestic labour under an implicit contract stipulating the rights and obligations for (dominant) breadwinners and (dependent) partners.

Gendered social norms is another factor considered by researchers in explaining division of labour within the family. Several socioeconomic analyses have investigated how social norms affect the division of labour between partners especially in Southern European countries, in which domestic work is carried out predominantly by women (Jurado Guerrero and Naldini, 1996; Saraceno, 1994). Note that, even in the approaches considering, respectively, economic dependency and social norms effects to explain bargaining process, analysts do not account for the influence of individual skills, or they assume that its proxy measure can be (endogenously) obtained by the amount of time prevalently employed by the agent in a specific type of work.

In general, from this brief survey on the models that study the determinants of the decision-making process between partners, one cannot obtain a convincing explanation on how the individual skills of each partner influence the allocation of working time, especially regarding the time dedicated to housework. Against this background, we suggest an original way to establish whether a partner's greater (lesser) commitment in housework tasks depends on her/his greater (lesser) ability in domestic work (hypothesizing a sort of specialization), or whether it rather depends on her/his greater (lesser) working ability regardless the regime which she/he has chosen (to work in the market or not). In doing this we suggest to adopt an endogenous switching approach based on the assumption that the agent (the woman living in couple), in choosing the regime, follows a sorting decision process depending, at least in part, on the nature of her own skills.

3 A two-regime switching model

We start by assuming that the time spent in paid work is less flexible than the time devoted to household chores,[3] and we assume also that the agent (the woman, in this specific study) may choose between two regimes: to work in the market or not. Therefore, the woman will choose the regime that allows her to minimize the time spent in housework considering, however, the constraints due to the influence of other factors, many of which are related to the bargaining power of the woman in decision making within the family (economic resources of the household, economic dependency, gender attitude, personality traits, availability of leisure time, etc.). Net of the impact of these factors, the woman chooses the regime in which the commitment in domestic activity is lower. Note that to simplify our approach, we do not

[3] In this study, we consider, in particular, the difficulties of Italian women to reconcile housework time and paid-work time in the context of the Italian labour market (see, among others, Del Boca 2002 and Del Boca and Vuri 2007).

take into account the possibiliy to introduce a third "intermediate" regime given by a part-time commitment in paid work.

The model is specified by two regression equations whose dependent variables (housework time of employed and unemployed women, respectively) are excluding each other in a cross-sectional framework, and where selection, given the other factors affecting the outcomes, y_{1i} and y_{2i}, is based on the choice of the lower housework time. The model may be represented as follows:

$$\begin{cases} y_{1i} = x'_{1i}\beta_1 + u_{1i} \\ y_{2i} = x'_{2i}\beta_2 + u_{2i} \\ \\ \text{if } y_{1i} < y_{2i} \text{ then } y_{1i} \text{ is observed and } y_{2i} \text{ is latent;} \\ \text{otherwise } y_{2i} \text{ is observed and } y_{1i} \text{ is latent.} \end{cases} \tag{1}$$

In model (1) y_{1i} and y_{2i} contain the value of the dependent variable (housework time) for i-th unit: Regime 1, if the woman works in the market and Regime 2 if the woman is not employed. The vectors x_{1i} and x_{2i} contain the observed variables that explain both the decision to work at home and the quantity of time spent in domestic work, β_1 and β_2 are column vectors including the coefficients of each equation. The unobserved components of both equations, u_{1i} and u_{2i}, also include the latent skill of the woman related to her ability in housework tasks.

We specify our model as a switching regression model with 'sample separation known' (cf. Maddala 1986 for a survey). The "agent" (woman) is assumed to compare the outcomes of the two equations (housework time), and to choose the smaller. The model is therefore a sort of 'two simultaneous censored equations' with endogenous censoring. For each individual, the contribution to the likelihood is given by the probability density of the observed variable (the smaller) and by the (conditional) probability that the other (latent) variable is higher. The (Gaussian) likelihood function includes coefficients, variances and also the across-equation covariance (correlation).

Usually, in estimating endogenous switching models, analysts integrate this model with a further selection equation explaining the choice of the regime. These extensions of the model adopt (rarely) maximum likelihood (ML) methods (Poirier and Ruud 1981; Maddala 1983) and (more frequently) a two-stage procedure (Lee 1978; Heckman 1990) providing also estimated coefficients of a third selection equation. In the two-stage version, the estimation of the outcome equations in both regimes accounts for the endogenous effect of the selection by introducing, in the respective regressors set, a correction term obtained by the "generalized residuals" of the selection equation, estimated at a first stage. Differently from these approaches, Calzolari and Di Pino (2017) and Calzolari et al. (2021) suggested a direct ML estimation of the model (1) specified as the "two-equation" Roy model rather than the "three-equation" generalized versions. This full-information approach is based on the assumption of joint normality of the error terms of the two outcome equations. A relevant novelty introduced by this "two-equation" ML approach, denominated

as "MLCAR" (Calzolari et al. 2021),[4] is that it is possible to estimate, simultaneously with coefficients and variances of both equations, an across-regime covariance, σ_{12}, or correlation parameter, ρ_{12}, between the error terms of both equations. This parameter is usually unidentified in most of the commonly adopted two-regime models because the selection rule implies that both dependent variables cannot be jointly observed in both regimes. The estimation method here adopted allows to estimate ρ_{12}, whose knowledge permits to derive the joint distribution of potential outcomes knowing only the outcomes of subjects observed into one of the two regimes (Heckman and Honoré 1990; Vijverberg 1993). Knowledge of this parameter (even partial) is necessary to obtain the predictive distributions of outcomes and the probability of the agent to choose one of two regimes (Poirier and Tobias 2003; Fan and Wu 2010).

The knowledge of ρ_{12} helps the analyst to assess the sorting process into the two regimes (employed and unemployed); the sign of the across-regime correlation, in particular, signals what criterion the agents follow to select the regime. When $\rho_{12} < 0$, the sector-specific skills, identified as part of the stochastic component of the two model's equations, are negatively correlated and we observe a comparative advantage structure. That is, on average those who perform well, relative to others, in one among the two regimes perform relatively worse in the other regime. Alternatively, $\rho_{12} > 0$ characterizes a hierarchical structure in which, on average, those individuals who perform well, relative to others, in one regime also perform relatively well in the other regime. (cf. Vijverberg 1993; Vella and Verbeek 1999; French and Taber 2010).

Therefore, considering the parameter ρ_{12} in our study, we improve our knowledge about the ability of a woman to operate in housework. In practice, the nature of the ability, identified by the sign ρ_{12}, can be of two types:

(1) if $\rho_{12} < 0$, the woman is more able in housework sector and less in paid work (or vice versa),
(2) if $\rho_{12} > 0$, the woman is equally able whatever the sector in which she spent her work.

However, the estimation methods adopted so far, such as those in the studies cited above, allow the analyst to obtain only a partial identification and estimation of the across regime correlation.[5] Differently from previous approaches, the MLCAR estimator here suggested provides a point estimation of ρ_{12} whose efficiency has been checked by Calzolari and Di Pino (2017) in comparison to that of alternative approaches based on a three-equation model specification.

[4] Calzolari et al. (2021) implemented a Stata command, denominated MLCAR, that provides a simultaneous ML estimation of coefficients, variances and across regime covariance, as well as a Conditional Moment based testing procedure for model specification. The procedure was originally developed in a context in which the regime corresponding to the largest value is observed. The approach can be easily generalized to the case in which the lowest-value regime is chosen. An updated procedure is available from the authors upon request.

[5] See, for example, Fan and Wu (2010) who obtained sharp bounds including ρ_{12}.

Calzolari and Di Pino (2017) also checked the robustness of the estimates obtained with the two-equation ML model by simulating the departure from the assumption of normality of the error distribution, showing that negligible bias emerges when the Student-t with 5 degrees of freedom is adopted in the data generating process (still estimating the model under the normality assumption).

3.1 ML estimation of the two-regime "endogenous switching" model

Consider the above specified Model (1). The additive error terms u_{1i} and u_{2i} are assumed to be normally distributed with zero mean and variances σ_1^2 and σ_2^2. Since, in this study, the selection rule is based on the choice of the lower outcome (housework time), identification and estimation of the across-regime covariance, σ_{12} (and across-regime correlation ρ_{12}), becomes possible by considering (as in a Tobit model) the probability density of the observed outcome multiplied by the conditional probability that the other outcome (latent) is higher than the observed. More in detail, the censoring rule in the model implies that:

$$\begin{array}{lll} y_{1i} \text{ observed} & \Rightarrow \; y_{2i} > y_{1i} & \Rightarrow \; x'_{2i}\beta_2 + u_{2i} > y_{1i} \\ y_{2i} \text{ observed} & \Rightarrow \; y_{1i} \geq y_{2i} & \Rightarrow \; x'_{1i}\beta_1 + u_{1i} \geq y_{2i} \end{array} \tag{2}$$

Hence, to build the likelihood, we need:

$$\begin{array}{l} f(u_{1i})\Pr(y_{2i} > y_{1i}) = f(u_{1i})\Pr(u_{2i} > y_{1i} - x'_{2i}\beta_2 | y_{1i} \text{ observed}) \\ f(u_{2i})\Pr(y_{1i} \geq y_{2i}) = f(u_{2i})\Pr(u_{1i} \geq y_{2i} - x'_{1i}\beta_1 | y_{2i} \text{ observed}) \end{array} \tag{3}$$

where $f()$ is a normal probability density function (pdf).

We consider also the conditional moments of the error terms; namely, $E(u_{1i}|u_{2i}) = \frac{\sigma_{12}}{\sigma_2^2}u_{2i} = \frac{\sigma_{12}}{\sigma_2^2}(y_{2i} - x'_{2i}\beta_2)$ and $\text{Var}(u_{1i}|u_{2i}) = \sigma_1^2 - \frac{\sigma_{12}^2}{\sigma_2^2}$ are, respectively, the conditional mean and variance of u_{1i} given u_{2i}. Analogously, $E(u_{2i}|u_{1i}) = \frac{\sigma_{12}}{\sigma_1^2}u_{1i} = \frac{\sigma_{12}}{\sigma_1^2}(y_{1i} - x'_{1i}\beta_1)$ and $\text{Var}\left(u_{2i}|u_{1i}\right) = \sigma_2^2 - \frac{\sigma_{12}^2}{\sigma_1^2}$ are, respectively, the conditional mean and variance of u_{2i} given u_{1i}.

Therefore we have

$$\Pr\left(u_{2i} > y_{1i} - x'_{2i}\beta_2 | y_{1i} \text{ observed}\right) = 1 - \Phi\left[\frac{(y_{1i} - x'_{2i}\beta_2) - \frac{\sigma_{12}}{\sigma_1^2}(y_{1i} - x'_{1i}\beta_1)}{\sqrt{\sigma_2^2 - \sigma_{12}^2/\sigma_1^2}}\right] \tag{4}$$

and analogously

$$\Pr\left(u_{1i} \geq y_{2i} - x'_{1i}\beta_1 | y_{2i} \text{ observed}\right) = 1 - \Phi\left[\frac{(y_{2i} - x'_{1i}\beta_1) - \frac{\sigma_{12}}{\sigma_2^2}(y_{2i} - x'_{2i}\beta_2)}{\sqrt{\sigma_1^2 - \sigma_{12}^2/\sigma_2^2}}\right] \tag{5}$$

with $\Phi()$ the standard normal cumulative distribution function (cdf) used to specify, in both Eqs. (4) and (5), the contribution to the likelihood of censoring of, respectively, y_{2i} and y_{1i}.

Using (4) and (5), finally, we obtain the following contribution of the i-th observation to the log-likelihood[6]:

$$\begin{aligned}\ln L_i(\theta) =& R_i\left\{-\frac{(y_{1i}-x'_{1i}\beta_1)^2}{2\sigma_1^2}-\frac{1}{2}\ln\sigma_1^2+\ln\Phi\left(-\xi_{1i}\right)\right\}\\&+(1-R_i)\left\{-\frac{(y_{2i}-x'_{2i}\beta_2)^2}{2\sigma_2^2}-\frac{1}{2}\ln\sigma_2^2+\ln\Phi\left(-\xi_{2i}\right)\right\}\end{aligned} \tag{6}$$

with

$$\xi_{1i}=\frac{(y_{1i}-x'_{2i}\beta_2)-\frac{\sigma_{12}}{\sigma_1^2}(y_{1i}-x'_{1i}\beta_1)}{\sqrt{\sigma_2^2-\sigma_{12}^2/\sigma_1^2}}$$

and

$$\xi_{2i}=\frac{(y_{2i}-x'_{1i}\beta_1)-\frac{\sigma_{12}}{\sigma_2^2}(y_{2i}-x'_{2i}\beta_2)}{\sqrt{\sigma_1^2-\sigma_{12}^2/\sigma_2^2}}$$

and $\theta=(\beta_1',\beta_2',\sigma_1^2,\sigma_2^2,\sigma_{12})'$, while R_i is a dummy variable equal to 1 if y_{1i} is observed (Regime 1), and equal to 0 if y_{2i} is observed (Regime 2). Applying maximum likelihood estimation, the parameter σ_{12} (and, consequently, ρ_{12}) can be directly estimated maximizing $\sum \ln L_i(\theta)$ (6). In addition, the probabilities to choose one of the two regimes can be obtained replacing the parameters with their estimates in Eqs. (4), for Regime 1, and (5) for Regime 2, respectively (see Calzolari et al. 2021).

As a complement to the estimation procedure, Calzolari et al. (2021) implement a conditional moment (CM) test to verify the normality assumption. The proposed test procedure extends, to the two-equation case, the CM test available in the literature to verify the normality assumption in the context of the Tobit model (e.g., Skeels and Vella 1999). In particular, the test is based on the comparison of the third and fourth moments of u_{1i} and u_{2i} with the theoretical values implied under the assumption of normally distributed error terms.

[6] Omitting $\sqrt{2\pi}$ and taking into account also the well-known property of the symmetry of a normal r.v., z, according to which, we have: $1-\Phi(z)=\Phi(-z)$.

3.2 Postestimation, individual skill and matching

In this section, we explain how the estimated parameters can be used to predict the woman's domestic work in both regimes and the probability, for a woman, to choose one of two regimes. In addition, we explain how the woman skill can be identified as a latent component included in the error terms of the equation in each regime.

We consider now the random variable $(u_{1i} - u_{2i})$ that, according to our assumptions, is normal, with expectation zero and variance $Var(u_{1i} - u_{2i}) = \sigma_1^2 + \sigma_2^2 - 2\sigma_{12}$ (thus requiring also σ_{12}).

The probability for a woman to choose Regime 1 is given, according to our model, by

$$\begin{aligned} P_{1i} = Pr[y_{1i} < y_{2i}] &= Pr[x'_{1i}\beta_1 + u_{1i} < x'_{2i}\beta_2 + u_{2i}] \\ &= Pr[(u_{1i} - u_{2i}) < (x'_{2i}\beta_2 - x'_{1i}\beta_1)] \end{aligned} \tag{7}$$

that is, the cumulative distribution function of the above mentioned normal variable evaluated at $(x'_{2i}\beta_2 - x'_{1i}\beta_1)$. It can be easily estimated as

$$\hat{P}_{1i} = \Phi\left[\frac{(x'_{2i}\hat{\beta}_2 - x'_{1i}\hat{\beta}_1)}{\sqrt{\hat{\sigma}_1^2 + \hat{\sigma}_2^2 - 2\hat{\sigma}_{12}}}\right] \tag{8}$$

Symmetrically, we can estimate the probability of the woman to choose Regime 2.

$$\hat{P}_{2i} = \Phi\left[\frac{(x'_{1i}\hat{\beta}_1 - x'_{2i}\hat{\beta}_2)}{\sqrt{\hat{\sigma}_1^2 + \hat{\sigma}_2^2 - 2\hat{\sigma}_{12}}}\right] \tag{9}$$

Each probability (P_{1i} and P_{2i}) can be interpreted as the probability to choose one regime regardless from the selection rule. Correction for endogeneity is implicit in the application of our model. This makes it possible to use the P_{1i} as propensity scores in a matching procedure that allows us to link each woman who belongs to Regime 1 with her corresponding counterfactual belonging to the alternative Regime 2 (and symmetrically for women belonging to Regime 2).[7]

Performing a matching procedure allows us to evaluate the extent to which the choice of the regime influences the time devoted to domestic work and how much part of domestic work spent by the woman depends on her own individual ability in the chosen regime. To this aim, we compare the housework time of a woman in her chosen regime with that of a counterfactual with the same propensity score value, but belonging to the alternative regime. Propensity score values can be obtained by

[7] Independence of propensity scores with respect to the selection rule ensures that the condition of *selection on observables* is not violated by the matching procedure (Heckman and Robb 1985). This condition implies that systematic differences in outcomes between treated and comparable individuals with the same values for covariates are attributable to treatment.

the probabilities estimated using the Eqs. 8 and 9. This Propensity Score Matching (PSM) procedure permits to evaluate two important effects due to the choice of one regime with respect to the alternative regime: (1) the differences in outcome (housework time spent in a day); and (2) the differences in individual skill effect (housework time influenced by individual skill). The PSM procedure allows to evaluate the differences in outcome and ability effect by estimating the Average Treatment effect on Treated (ATT) and the Average Treatment Effect on Untreated (ATU). In doing this, we consider as treated the women belonging to the regime of the employed; whereas we consider as untreated the women belonging to the alternative regime of unemployed. Another commonly used parameter measuring the impact of the choice is the Average Treatment Effect (ATE), measuring the effect of the choice on a woman who randomly belongs to one of the two regimes.

A method to identify the individual skill effect on housework time is required. This can be easily performed in the context of our model. Customarily, in the regression analysis, the error terms are considered as summarising the omitted explanatory variables. Suppose that the individual skill is the main omitted variable in explaining the time spent in housework (of course, it is a latent variable). If we could (only ideally, unfortunately) include into x_{1i} and x_{2i} all possible determinants "except" the individual skill, then in principle we could use directly the error terms as measures of the skill. Thus, in principle, we could directly use the residual $\hat{u}_{1i}$ if the woman is observed in Regime 1, otherwise $\hat{u}_{2i}$. This would be the ideal case. More realistically, let's think that the individual skill is not the entire error term, but an important (maybe the main) component of the error term. We could define as individual skill of woman i the part of the error term in the *observed* regime that would appear in the other equation if the same woman had chosen the other regime: thus, the conditional expectation of the *unobserved* error term. In other words, what we shall use as the "skill effect" for woman i is

$$\tilde{u}_i = \frac{\hat{\sigma}_{12}}{\hat{\sigma}_1^2}\hat{u}_{1i} \quad \text{if woman i is observed in Regime 1 (employed)} \tag{10}$$

or

$$\tilde{u}_i = \frac{\hat{\sigma}_{12}}{\hat{\sigma}_2^2}\hat{u}_{2i} \quad \text{if woman i is observed in Regime 2 (unemployed)} \tag{11}$$

We shall use $\tilde{u}_i$ as skill effect, while $\hat{u}_{1i}$ or $\hat{u}_{2i}$ is the residual in the observed regime.

4 Data and sample composition

Data are collected from the Time Use Survey 2013 provided by Istat (Italian National Institute of Statistics). Information on time use are surveyed using the "diary method" and allow us to analyze how people allocate their time during a day. The dependent variable is given by time (minutes) daily devoted to housework task and caregiving. In order to eliminate the influence of outliers of the dependent

variable on the results of the analysis, a trimming was applied on the observations of housework time, dropping out the observations below the fifth percentile and above the 95 percentile (763 observations in total). As a result, the sample is composed of 5012 working-age women, married or cohabiting, equitably distributed by area of residence. The age of the women ranges from 20 to 50 years. The sample does not include retired women or unable to work. Women are classified into two regimes based on their working condition: Regime 1 comprises No. 3094 employed women (self-employed included) and Regime 2 comprises No. 1918 unemployed women.

Explanatory variables used in the model provide demographic and socioeconomic information on the women such as age, education and indicators measuring the woman's earnings ability compared with that of partner. In addition, we introduced some personality aspects' proxies and a gender attitude indicator. In Table 1 we report the description of the variables used in the model and in Fig. 1 a graphical description of the distribution of the dependent variable.

In selecting the covariates we tried to specify the effect of the most important determinants of the individual housework commitment known in the literature. First, the woman age in years, *age*, is included among the regressors, as well as the number of sons/daughters living in the family (*sons/daughters*, with age ranging between 0 and 30 years, the average age being 17.4). A dummy variable for women living in the south (*dummy_south*) is included to account for geographic characteristics. As information on the use of time is collected with the diary method, the daily time devoted to housework varies significantly depending on whether the survey is conducted on a weekday or on a non-working day, especially for employed women. In order to take this effect into account, the dummy variable *dummy_weekend* is included in the equation in Regime 1 (employed women). As a proxy of the of woman's earnings contribution to household economic resources we adopted an index (*sharing_weight*) similar to that suggested by Mangiavacchi and Rapallini (2014), given by the logarithms of the ratios between economic satisfaction indicators of, respectively, female partner (numerator) and male partner (denominator). If this index is equal to zero, it means that each partner has the same weight in contributing to standard of living of the family. A positive sign indicates that the woman has a higher weight than man in earnings ability. The opposite occurs if the sign is negative.

Regarding to the influence of personality aspects, we apply the procedure by Mazziotta and Pareto (2016) to obtain an aggregation of categorical ordered responses of the subject's about her attitude in care activities towards family and home available in the Istat – Time Use questionnaire. A measure of woman's conscientiousness, *MPI_conscient*, takes into account the woman's importance of having a tidy and clean house, her assessment of the importance of caring and assisting children, elderly and sick family members, and looking after home. A further MPI composite indicator is introduced to measure the gender attitude of the subject (*MPI_g*). In particular, this index quantifies the extent to which the woman's behavior is influenced by the traditional social norms fixing different roles of, respectively, female partner and male partner in the family. An increasing value of the index, in this case, indicates that the woman's belief is not influenced by the traditional gendered mentality. Another variable is adopted as a proxy of extraversion

Table 1 Variables description

Variable	Description	Full sample (Obs. 5012)		Employed women (Obs. 3094)		Unemployed women (Obs. 1928)	
		Mean or %	Std. Dev.	Mean or %	Std. Dev.	Mean or %	Std. Dev.
Dependent variable							
homework	Time (minutes) daily spent in housework tasks	265.714	129.983	229.344	122.971	324.385	119.110
Explanatory variables							
dummy_weekend	Dummy: if the survey took place over the weekend	65.52%	47.53%	65.00%	47.71%	66.37%	47.26%
dummy_south	Dummy: if the family lives in Southern Regions	37.65%	48.46%	28.44%	45.12%	52.50%	49.95%
education	Woman's education: years of schooling	12.055	3.803	12.969	3.657	10.581	3.563
age	Woman's age	42.223	7.771	42.673	7.343	41.496	8.367
diff _age	Woman's age—male partner's age	− 3.978	6.081	− 3.662	5.876	− 4.489	6.364
paid_help	paid help received in housework (minutes in a day)	0.520	3.360	0.743	3.969	0.160	1.972
MPI_consc	Mazziotta-Pareto Index measuring woman's conscientiousness	100.245	6.978	100.791	8.017	99.363	4.727
extraversion	Score-indicator measuring woman's extraversion	7.202	1.514	7.259	1.427	7.110	1.641
leisure_sat	Categorical, measuring woman's leisure availability	2.410	0.761	2.272	0.716	2.632	0.778
MPI_g	Mazziotta-Pareto Index measuring woman's gender attitude	99.782	6.326	98.558	6.113	101.757	6.162
sons/daughters	No. of sons/daughters living in the family	1.443	0.917	1.360	0.889	1.575	0.946
sharing_weight	Woman's satisfaction in sharing rule (×100). If > 0 Woman is more satisfied than male partner	− 0.006	4.040	1.719	3.648	− 2.788	2.925

Fig. 1 Distribution of the dependent variable across the two regimes: Regime 1, if the woman works in the market and Regime 2 if the woman is not employed

of the woman (*extraversion*), on the basis of the values assigned by the interviewed woman to the satisfaction with her own life (score ranged 1 to 10). A brief explanation of the construction of the MPI index is reported in Appendix A, together with a detailed description of the indicators used to build the *MPI_conscient* and *MPI_g* indices. Finally, a categorical variable signaling availability of leisure time is introduced (*leisure_sat*), defined on the basis of the interviewee's satisfaction with the availability of free time, that we coded as 1 = Not at all to 4 = A lot (that is, larger values are associated with larger satisfaction).

5 Estimation results

In this section we discuss the estimation results obtained by applying our ML method to a two-regime switching model of Italian women's housework time. We estimated simultaneously the regression coefficients in both regimes, the variances of errors, and the across-regime correlation parameter (see Table 2). The results of the estimates partly confirm what has already been shown in previous studies (Anxo et al., 2011), namely that the amount of domestic work by women increases with the age and number of sons/daughters, both for working women and for non-employed women, while the woman's education level is negatively correlated with housework time in both regimes. Employed women increase their commitment in domestic tasks in the weekend (see coefficient of *dummy_weekend*). In addition, we found that housework time increases for both employed and unemployed women who live in the Southern regions. Two explanatory variables proxy of personality traits turn out to be significant in both regressions: *MPI_conscient* (conscientiousness)

Table 2 Housework time estimation for employed and unemployed women; Number of obs = 5,012; Dependent variable in both regimes: *homework*

Regressors	Coef.	Std.Err.	*z*	*p*-value
Regime 1: employed women				
dummy_weekend	5.011	1.615	3.102	0.002
education	− 4.474	0.496	− 9.013	0.000
age	2.110	0.237	8.919	0.000
diff_age	− 1.418	0.302	− 4.695	0.000
paid_help	− 1.733	0.533	− 3.248	0.001
dummy_south	37.284	3.804	9.802	0.000
MPI_conscient	0.383	0.255	1.505	0.132
extraversion	− 4.202	1.201	− 3.500	0.000
leisure_sat	13.580	1.479	9.180	0.000
MPI_g	2.199	0.297	7.410	0.000
sons/daughters	14.151	1.982	7.141	0.000
sharing_weight	− 6.807	0.570	− 11.948	0.000
Constant	− 58.900	43.822	− 1.344	0.179
Regime 2: unemployed women				
education	− 2.379	0.497	− 4.791	0.000
age	2.459	0.221	11.114	0.000
diff_age	− 0.895	0.279	− 3.213	0.001
paid_help	− 1.455	0.536	− 2.712	0.007
dummy_south	23.112	3.618	6.388	0.000
MPI_conscient	1.338	0.253	5.294	0.000
extraversion	− 2.813	1.100	− 2.558	0.011
MPI_g	1.423	0.284	5.005	0.000
sons/daughters	12.522	1.851	6.766	0.000
Constant	− 65.599	41.373	− 1.586	0.113
σ_1^2	15560.34	330.28		
σ_2^2	13081.43	289.93		
ρ_{12}	0.9673	0.0056		

and *extraversion*, respectively, with positive and negative sign. Only for employed women, the satisfaction with quality and availability of leisure time (*leisure_sat*) is positively related to housework time.[8] Again, for employed women, a proxy of bargaining power of woman in the household (*sharing_weight*) is significant and with negative sign: this signals a penalization of the woman in bargaining process. Finally, an index measuring the woman's adherence to gender role indicates

[8] In (unreported) preliminary estimation, the *leisure_sat* variable shows a positive coefficient also in the regime of non-working women (Regime 2), but at a much lower level than that reported in the regime of working women and with reduced significance. In any case, the inclusion or not of *leisure_sat* in regime 2 does not affect the robustness of the overall results of the estimates.

Table 3 Effect of choice of Regime 1 (employed) and skill impact on womens' housework time. PSM estimation using ML probabilities

	Treated	Controls	Difference	S.E.	*t*-stat
Outcome variable: homework time					
Unmatched	229.3439	324.3848	− 95.0409	3.5312	− 26.91
ATT	246.5176	317.2630	− 70.7455	5.3298	− 13.27
ATU	318.2918	245.1062	− 73.1856	4.8807	− 15.00
ATE			− 72.0524	4.9466	− 14.57
Outcome variable: skill effect					
	Treated	Controls	Difference	S.E.	*t*-stat
Unmatched	− 21.9930	20.8129	− 42.8058	3.2660	− 13.11
ATT	− 44.6018	21.1200	− 65.7217	4.9352	− 13.32
ATU	20.3918	− 40.4516	− 60.8434	4.6097	− 13.20
ATE			− 63.1089	4.6125	− 13.68
Common support assignment					
Assignment	Off support	On support	Total		
Untreated	835	1083	1918		
Treated	2155	939	3094		
Total	2990	2,022	5012		
Balancing statistics on propensity score					
	Mean				
	Treated	Control	% bias	*t*-stat	
Unmatched	0.7772	0.3570	178.2	62.30	
Matched	0.4709	0.4995	− 12.1	− 2.95	

a direct impact of gender attitude to increase commitment in domestic work of both employed and unemployed women. The high absolute level of the estimated coefficient ρ_{12}, equal to 0.9673, signals a strong endogeneity effect on the choice of the regime.

In order to evaluate the extent to which the decision of the woman to work in the market influences her housework time, we performed a matching procedure based on the propensity scores generated as post-estimation output of our model (see Section 3.2). To this aim, we applied a matching algorithm based on the correspondence of the propensity scores (PS) between the units belonging to a different regime. We imposed a one-to-one linking criterion and a noreplacement rule. In addition, units may be linked each one if they are included in a specific range (Caliper) equal to 25% of the standard deviation of the PS.[9] The particularly severe constraints here imposed to the matching procedure result in the exclusion of numerous observations from the common support (2990 cases dropped out using ML and 2835 using traditional PSM). However, linking the observations included in the common support,

[9] We perform matching procedure by implementing the Stata command PSMATCH2 (Leuven and Sianesi see 2003).

Table 4 Effect of choice of Regime 1 (employed) and skill impact on womens' housework time. PSM estimation using Probit

	Treated	Controls	Difference	S.E.	*t*-stat
Outcome variable: homework time					
Unmatched	229.3439	324.3848	− 95.0409	3.5312	− 26.91
ATT	246.8838	317.6854	− 70.8016	5.2647	− 13.45
ATU	318.5529	245.4333	− 73.1196	4.7561	− 15.37
ATE			− 72.0446	4.8478	− 14.86
Outcome variable: skill effect					
	Treated	Controls	Difference	S.E.	*t*-stat
Unmatched	− 21.9926	20.8129	− 42.8055	3.2660	− 13.11
ATT	− 42.9023	23.3891	− 66.2914	4.8426	− 13.69
ATU	23.2523	− 39.5560	− 62.8082	4.3692	− 14.38
ATE			− 64.4050	4.4387	− 14.51
Common support assignment					
Assignment	Off support	On support	Total		
Untreated	739	1179	1918		
Treated	2096	998	3094		
Total	2835	2177	5012		
Balancing statistics on propensity score					
	Mean				
	Ttreated	Control	% bias	t-stat	
Unmatched	0.7772	0.3570	178.2	62.30	
Matched	0.5083	0.4696	16.4	3.89	

we reduce the risk that results are affected by selection due to heterogeneity in covariates.

Matching results are reported in Table 3. We can observe as an employed woman (included in common support) spends, on average, 246.5 min in a day in housework tasks, while a woman with high propensity to be employed, but observed in the regime of unemployed, spends 317.3 daily minutes for domestic tasks. The difference is the estimated Average Treatment on Treated (ATT) parameter signaling that, because of the decision to work in the market, a woman reduces her housework time of 70.7 min in a day. In this reduction of domestic work, a relevant part is due to the effect of the individual skill, equal to 65.7 min per day, corresponding to the value of ATT parameter estimated by perform matching on the skill effects. In general, the skill effect involves a reduction of housework time even for unemployed women with high probability to be employed. In fact, the estimated Average Treatment on Untreated (ATU) parameter signals a reduction of housework time of 60.8 daily minutes due to the skill effect. Note that matching results, obtained using probabilities generated by our ML estimation procedure, are coherent with those obtained by applying a traditional PSM procedure based on Probit estimates of propensity scores (Table 4).

6 Final observations and remarks

A relevant aspect of this analysis is the confirmation that employed and non employed women are not characterized by different ability in housework production. A novelty in this study is the identification of the latent effect of the individual ability on the commitment in housework tasks as a part of the stochastic component of an endogenous-switching model. Key to this result is the point estimation of the across-regime correlation parameter. The knowledge of this coefficient allows us to acquire important information on the relation between woman's ability and choice of the regime and, consequently, it allows us to evaluate if the woman aims to specialize or not in domestic activity. In addition, note that, identifying ability as part of the stochastic component of the model, also allows us to distinguish its effect from that of bargaining and gender attitude, as shown by the results of our estimates.

The identification of skill in the stochastic component, however, implies that the non-stochastic part of the model, reproducing the effect of observed covariates, should be correctly specified. In order to avoid misspecification due to endogenous regressors, in particular, we decided to introduce, in the regressors set, a specific index of the relative level of satisfaction in labour division of each partner (*sharing_weight*), rather than introducing the housework time spent by the male partner and the time spent by the woman in paid work. Regarding this aspect, a further extension of our model could concern a simultaneous estimation of the domestic work of the two partners based on the (endogenous) decision of the woman to work or not in the market. In addition, to simplify model estimation (that would otherwise entail evaluation of multivariate normal variables) we do not distinguish between part-time and full-time commitment in paid work. The extension of the model proposed in this paper to a three-regime framework would be an interesting extension to be considered for further research. Finally, note that our estimation method also provides the estimated probabilities to choose one of the two regimes corrected for the endogeneity of the choice of the regime. This result, which could be of interest for the evaluation of the causal effects of a choice, needs to be further investigated in future researches.

Synthesis of indicators applying the Mazziotta-Pareto Index (*MPI*)

A brief description of the *MPI* index is here reported (see Mazziotta and Pareto 2016), jointly with the indicators (categorical variables drawn from the Istat–Time Use survey) synthesized as different dimensions of the measured phenomena.

The *MPI* is a composite index for summarizing a set of indicators. It is based on a non-linear function which, starting from the arithmetic mean, introduces a penalty for the units with unbalanced values of the indicators.

Given the matrix $\mathbf{X} = \{x_{ij}\}$ with $i = 1, 2, \ldots, n$ rows (statistical units) and $j = 1, 2, \ldots, m$ columns (indicators), we calculate the standardized matrix $\mathbf{Z} = \{z_{ij}\}$ as follows:

$$z_{ij} = 100 \pm \frac{\mathbf{X} - \mathbf{M}_{X_j}}{\mathbf{S}_{X_j}} 10$$

where $\mathbf{M}_{X_j}$ and $\mathbf{S}_{X_j}$ are, respectively, the mean and standard deviation of the indicator j and the sign $\pm$ is the 'polarity' of the indicator j, i.e., the sign of the relation between the indicator j and the phenomenon to be measured (that is + if the individual indicator represents a dimension considered positive and − if it represents a dimension considered negative).

Denoting with $\mathbf{M}_{z_i}$ and $\mathbf{S}_{z_i}$, respectively, the mean and standard deviation of the standardized values of the unit i, the generalized form of *MPI* is given by:

$$MPI_i = \mathbf{M}_{z_i} \pm \mathbf{S}_{z_i} \frac{\mathbf{M}_{z_i}}{\mathbf{S}_{z_i}} = \mathbf{M}_{z_i} \pm \mathbf{S}_{z_i}\, cv_{z_i}$$

where cv_{z_i} is the coefficient of variation for the unit i. The *MPI* may be decomposed in two parts: mean level, given by $\mathbf{M}_{z_i}$, and penalty, given by $\mathbf{S}_{z_i}\, cv_{z_i}$. The penalty is a function of the indicators' variability in relation to the mean value, and its function is to reward the units that, mean being equal, have a greater balance among the indicators. The sign $\pm$ depends on the kind of phenomenon to be measured. Increasing values of the index correspond to positive variations of the phenomenon (e.g., socio-economic development). In this case, $MPI_i = \mathbf{M}_{z_i} - \mathbf{S}_{z_i}\, cv_{z_i}$. On the contrary, if the composite index is 'decreasing' or 'negative', i.e., increasing values of the index correspond to negative variations of the phenomenon (e.g., poverty), then $MPI_i = \mathbf{M}_{z_i} + \mathbf{S}_{z_i}\, cv_{z_i}$ is used. In any cases, an unbalance among indicators will have a negative effect (penalty) on the value of the index.

In this analysis, we adopt the *MPI* index in order to obtain a composite measure of two phenomena: (1) the personality trait known as Conscientiousness, and (2) a gender-role attitude of the woman. In both cases we use as indicators the answers of the subjects to some specific questions of the Istat – Time Use questionnaire.

(1) *Conscientiousness* (*MPI_conscient*) - four questions:

i. How is important that the house is always tidy and clean (four ordered responses: "not at all", "little", "enough", "a lot");
ii. If it is a priority caring and assisting children (response: yes or no),
iii. If it is a priority caring and assisting elderly and sick family members (response: yes or no);
iv. If it is a priority looking after home (response: yes or no).

(2) *Gender-role attitude* (*MPI_g*)- reported level of agreement with the following five statements measuring each one a dimension of the gender-role attitude of the woman (to each statement, one of four ordered responses: "not at all", "little", "enough", "a lot"):

i. It is better for the family that the man devotes himself mainly to economic needs and the woman to take care of the house;
ii. If both spouses / partners work full-time, the man must carry out the same amount of housework as the woman (washing, ironing, tidying up, cooking, etc.);
iii. If both parents work and the child gets sick, the parents have to take shifts to stay at home and take care of the child;
iv. Men perform household activities just as well as women;
v. Fathers know how to take care of young children just as well as mothers.

We have reversed the polarity of the answer to the statement i) to make the corresponding response consistent with the other dimensions of the analyzed phenomenon.

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