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Gender Norms and Network Structure: A Model of the Intra-Household Division of Labor

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Abstract

We study a bargaining model with endogenous gender norms. Agents are heterogeneous in their wage rates and preferences, but seek to conform to the behavior of their social reference group. In contrast to the previous literature, which assumes a homogeneous social norm, agents are connected through explicitly modeled social networks and thus face heterogeneous gender norms. In our model, social pressure to conform to gender norms exacerbates gender inequalities in the distribution of paid and unpaid labor resulting from a gender pay gap or gender-specific preferences. However, a heterogeneous norm causes agents to act significantly different from – and, on average, more egalitarian than -- a homogenous norm. The differences are particularly strong if agents are more likely connected with others who have similar preferences. Our findings suggest that technological revolutions such as social media could impact the intra-household division of labor by changing the social reference group of individuals.

Keywords: intra-household bargaining, social norms, agent-based model, social network

JEL-Codes: C63, C78, D13, J16, J22

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Endogenous Heterogeneous Gender Norms and the Distribution of Paid and Unpaid Work in an Intra-Household Bargaining Model

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Abstract

We study the impact of gender norms on the distribution of paid and unpaid labor between women and men in an intra-household bargaining model featuring endogenous social norms. In contrast to the previous literature, which assumes a homogeneous social norm, agents are connected via explicitly modeled social networks and accordingly face heterogeneous perceptions of gender norms. In our model, social pressure to conform to gender norms exacerbates gender inequalities in the distribution of paid and unpaid labor that may result from a gender pay gap or gender-specific preferences. However, we show that the behavior of agents connected in different standardized social networks is significantly closer to a situation in which agents face no social pressure than in a scenario in which the whole of society perceives homogeneous gender norms. This is particularly true if agents are more likely to form connections to other agents that have similar preferences.

Keywords: intra-household bargaining, social norms, agent-based model, social network

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1 Introduction

Although certain aspects of gender equality have improved in recent decades, numerous inequalities remain highly persistent. This is also true of 'economic' indicators such as women's participation in the labor market, which has increased in most industrialized countries, but still lags behind men's (OECD, 2017). In addition, female workers are more likely to be employed on a part-time basis and gender pay gaps persist (Meara *et al.*, 2020; European Institute for Gender Equality., 2021). The OECD (2023) reports a substantial gender wage gap for 2022, with the median female full-time employee earning 12% less than her male counterpart. Moreover, the division of 'care work' remains persistently unequal. Even in households where both parents work full-time, housework and care work are rarely shared equally, with gender differences increasing when the first child enters the household (OECD, 2017). This paper aims to contribute to the understanding of this last inequality in particular: the unequal distribution of paid and unpaid work.

To understand why inequalities in the division of paid and unpaid work are so persistent, and what might be done to accelerate progress towards greater equality[1], it is important to study the socially contingent intra-household mechanisms that produce them. Intra-household bargaining models can be valuable in this regard. In contrast to the 'unitary approach' first developed by Becker (1981), intra-household bargaining models explicitly recognize that intra-household decisions are made by two separate decision-makers who may have unequal bargaining power. This perspective has proven very useful for assessing the consequences of a wide range of family-related policies, such as tax laws or parental leave regulations (Chiappori & Mazzocco, 2017).

In this respect, Bina Agarwal (1997) already stresses that the distribution of bargaining power and the resulting inequalities are crucially influenced by the social

[1] It is crucial to emphasize that gender equality extends beyond the mere distribution of paid and unpaid work. Additionally, the impact of an equal distribution of labor on overall gender equality depends on specific contextual factors. In the subsequent discussion, the term "gender equality" refers specifically to the one-dimensional perspective of work distribution.

gender norms that prevail in societies. Recent models of gender bargaining, in addition to exploring the impact of gender wage differentials, also reflect this insight (Cudeville & Recoules, 2015) and show that the effect of social norms differs between bargaining models and the 'unitary approach' (Beal Cohen *et al.*, 2021). However, these models assume a society-wide, homogeneous gender norm to which all members of a given gender adhere. Since many studies have pointed to the prevalence of different, often conflicting gender norms, which in turn depend on social group belonging (Pearse & Connell, 2016), and to the importance of considering the social network when studying social influence (Noble *et al.*, 2004; Castellano *et al.*, 2003; Kiesling *et al.*, 2012), we aim to understand the impact of a heterogeneous gender norm and thus fill this gap in the literature.

Following Beal Cohen *et al.* (2021), we implement an intra-household bargaining model based largely on Cudeville & Recoules (2015) as a simulation model and study numerically approximated equilibrium outcomes over an extensive parameter space. Our aim is to relax certain assumptions made in these models in order to better understand their implications. This exercise is useful in itself, but will also facilitate the development of more complex models in this tradition in the future. More specifically, we focus on three aspects: *First*, in contrast to the use of a Cobb-Douglas utility function, we implement a CES utility function that allows for different degrees of substitutability between i) the 'private good' derived from paid work or spousal transfers and ii) the 'public good' produced by unpaid care work. We show that the impact of the gender pay gap on differences in the respective time allocation between men and women is strongly mediated by the parameters of the utility function, highlighting the need for a better empirical understanding of men's and women's preferences. *Second*, we experiment with two different ways of conceptualizing social norms: One in which agents only perceive the behavior of their same-gender peers as social norm (similar to Beal Cohen *et al.*, 2021), and one in which they additionally perceive the behavior

of their peers' spouses as part of the social norm. *Finally* and most importantly, we map social interactions according to different idealized network types to account for heterogeneous perceptions of social norms. Our analysis shows that the 'homogeneous norm' approach followed by Cudeville & Recoules (2015) and Beal Cohen *et al.* (2021) provides a good approximation for the *mean* outcomes of many different network configurations. However, we demonstrate that explicitly modeled network configurations result in agents being much less clustered around the mean behavior than in the 'homogeneous norm' approach. When we explicitly model the social network of agents, we observe that most agents tend to align with the 'optimal behavior' in terms of time allocation and defined by the specification without social pressure.[2] This optimal behavior corresponds to the allocation of time between paid and unpaid labor that leads to the highest degree of gender equality. In other words, when social pressure is not considered, the distribution of paid and unpaid work tends to be more equitable among genders. We find that a 'homophilic' network structure where agents are more likely to find their social reference group in other agents with the same preferences, is closest to a situation without any social pressure and hence more conducive to gender equality.

The remainder of this paper is organized as follows: Section 2 presents a brief overview of the literature on household decision making, social norms and the importance of the network structure of social interactions. Section 3 gives a detailed description of the model implementation, and section 4 presents the results from our simulations. Finally, section 5 concludes the paper.

[2]It is important to acknowledge that the implementation of the social norm in our model assumes that adherence to the norm cannot increase agents' utility per se; instead, agents lose utility if they deviate from the social norm. Consequently, outcomes reached without the influence of the social norm are considered optimal in this context. This is why we use the term 'social pressure' instead of a more neutral choice such as 'social influence'. We discuss this assumption in more detail in the conclusion.

2 Literature

This paper builds on three strands of the scientific literature. The first one deals with the analysis of household behavior and discusses how decisions are made within a household (e.g. Agarwal, 1997; Chiappori & Mazzocco, 2017). The second strand discusses social norms and their role in economic decision making, as well as the interplay between social norms and individual decisions (e.g. Pearse & Connell, 2016; Bicchieri *et al.*, 2018). Finally, we build on the literature on social networks where different mixing patterns or typologies of networks have an impact on the outcomes of social systems (e.g. Barrat *et al.*, 2013; Sen & Sen, 2010).

2.1 Intra-household decision making

The focus of this paper is on the analysis of intra-household decision-making, with an emphasis on men's and women's choices regarding time spent on paid and unpaid work. Household behavior, and in particular models of it, have been a focus of attention in economics since Gary Becker introduced his famous 'unitary' approach (Becker, 1981). He postulates that the household can be represented by a single altruistic household head who maximizes household utility with pooled household resources and incomes. Thus, this approach does not consider the distribution of household resources and any associated bargaining (Chiappori & Mazzocco, 2017; Agarwal, 1997; Haddad *et al.*, 1997). For this reason, the unitary approach has been widely criticized (Agarwal, 1997; Lundberg & Pollak, 1993, e.g.) and there has been extensive research on the subject in recent decades in which scholars have addressed the fact that households consist of separate entities, each with its own preferences and its own optimal strategies.

There are broadly three approaches to analyzing intra-household interactions, with Chiappori & Mazzocco (2017) arguing "that the choice of a specific model of household behavior is never irrelevant, and almost never innocuous" (Chiappori & Mazzocco, 2017, p. 986), especially in the context of policy evaluation. These are non-cooperative,

cooperative and collective approaches [3]. Non-cooperative and cooperative approaches rely on game-theoretic models that assume that households consist of more than one individual and that intra-household interactions are best described as a form of bargaining. They either use the concept of a non-cooperative Nash equilibrium and arrive at generally inefficient outcomes or use cooperative game theory and Nash bargaining postulating Pareto efficiency (McElroy & Horney, 1981; Manser & Brown, 1980, see Chiappori & Mazzocco (2017) for more details). Collective approaches also assume Pareto efficiency but seek to "uncover the decision-making rules and processes through empirical analysis" (Agarwal, 1997, p. 4). Both non-cooperative and cooperative bargaining models postulate that intra-household interaction involves cooperation and conflict (for an overview see Agarwal (1997)): There are different cooperative outcomes in terms of the division of labor and the allocation of resources, but they also differ in terms of the distribution of utility among household members, making the choice of any particular outcome conflictual. The relative bargaining power of the parties, represented for example by the outside-option or "threat point", determines the outcome (Agarwal, 1997).

Combining cooperative and non-cooperative aspects Lundberg & Pollak (1993) put forward the notion of "separate spheres": the threat-point for cooperative bargaining is not divorce and thus an absolute breakdown of the household arrangement, but rather non-cooperation constituted by withdrawal into separate spheres "denfined by, say, a division of labor based on socially recognized gender roles that emerge without explicit bargaining" (Agarwal, 1997, p. 5). Further, Carter & Katz (1997), with their "conjugal contract model", elaborate on Sen's notion of "cooperative conflict" by characterizing the "household economy as a site of independent preferences and resource allocation decisions bound together by various forms of interdependence" (Carter & Katz, 1997, p. 97), in which the conjugal contract consists of an income sharing arrangement. One partner transfers a portion of his or her income to the other. Basu (2006) and

[3] For an exhaustive overview see e.g. Agarwal (1997) and Chiappori & Mazzocco (2017).

Lundberg & Pollak (2003) go a step further by explicitly modeling bargaining power or position in the intra-household decision-making process as influenced by the choices made. Thus, not only does bargaining power determine intra-household decisions, but decisions also affect bargaining power.

Cudeville & Recoules (2015), on whose model this paper is based, extend the idea of interdependencies from Basu (2006) and respond to calls from Agarwal (1997) to consider the role of social norms in determining bargaining power. They model the influence of intra-household decisions on a conformism parameter that influences preferences for the design of the conjugal contract. Both intra-household decisions and conjugal social norms are endogenously determined in the model. Beal Cohen *et al.* (2021) implement an agent-based version of this model and impressively demonstrate the differences between a unitary modeling approach and an intra-household bargaining approach. We extend their model by introducing network effects to account not only for the heterogeneity of agents but also for the effect of social norms on them.

2.2 Social norms in economics

The second strand of literature on which this paper builds is concerned with the emergence and impact of social norms on economics behavior. Social norms in economics, and more specifically in household economics, have long been regarded as exogenous constraints on the choices of individuals. In their famous account of identity economics, Akerlof & Kranton (2000) discuss the impact of identity present in different social categories on economic outcomes. Bicchieri (2005) on the other hand, in a game theory account, identifies social norms as equilibria of strategic games that have the power to transform them into different types. Furthermore, evolutionary game theory has been used to understand the emergence of social norms and their evolution (see e.g. Burke & Young, 2011), thus explicitly endogenizing them. According to Guala (2007),

Bowles (2004) and Young (2007), among others, social norms can also be treated as coordination devices that select between multiple equilibria.

In the context of intra-household bargaining Agarwal (1997, p. 15) distinguishes four ways in which social norms can influence the bargaining process:

> "norms set limits on what can be bargained about; they determine or constrain bargaining power; they affect how bargaining is conducted (for example, covertly or overtly, aggressively or quietly); and they constitute a factor to be bargained over, that is, social norms can be endogenous, themselves subject to negotiation and change." (summarized by Pearse & Connell, 2016, p. 33).

She thus places particular emphasis on the endogeneity of social norms and is consistent with the endogenous treatment of Sen (1990) and Badgett (1999). This also highlights the interaction between economic conditions and social norms:

> "Some writers, while recognizing that social norms can be contested, locate the contestation perhaps too much in ideology and give inadequate weight to the links between gender ideologies and economic inequalities, or to economic inequalities as a signifcant (although not sole) determinant of relative male–female power within (and beyond) the household." (Agarwal, 1997, p. 21).

Similarly, Pearse & Connell (2016) argue that what matters is how "norms are materialized in social life" (Pearse & Connell, 2016, p. 37). They stress that social norms are embedded in institutional arrangements, such as the "separation of home from workplace" but also "different pay levels for men and women"; thus they are "not just embedded in personal attitudes and conduct" (Pearse & Connell, 2016, p. 41), but are constantly negotiated and mediated in the economic sphere. At the same time, they influence the economic sphere, so that changes in the gender order may originate not only from ideological but also the material factors (Pearse & Connell, 2016, p. 48) and "may also arise from the contradictions of gender relations themselves"(Pearse & Connell, 2016, p. 47). The causation can thus flow both ways. Most importantly for the purposes of the present paper, however, Pearse & Connell (2016) emphasize

that contradictory norms exist simultaneously in societies: role definitions and gender-related attitudes differ depending on the social group to which one belongs, which is in turn shaped by a number of factors, such as social class, gender and generation. The authors conclude that there is seldom a single, unambiguous, society-wide social norm, but rather a cluster of norms that are at work. Similarly, although ethnographic accounts of patriarchal communities find less pressure on boys and more pressure on girls to conform to norms, women show less support for "patriarchal opinion items than men as a group" in attitude surveys. (Pearse & Connell, 2016, p. 41).

Thus, other than in the models of Cudeville & Recoules (2015) and Beal Cohen *et al.* (2021) on which our model is based, the social norm in our approach is not global but for each individual depends on the social network he or she is part of. In the two models mentioned above the social norm is calculated as the average behavior of all agents. This is based on the assumption that individuals are homogeneously mixed, and agents perceive the behavior of all other agents. As recent studies have shown, this assumption is not valid for various social systems. In many cases the social interactions display a complex network structure (Easley & Kleinberg, 2010). Therefore, we implement different network algorithms to assess the impact of network topology on the behavior of the agents.

2.3 Relevance of the structure of social interaction

The third and final strand of the scientific literature deals with the impact of different mixing patterns or network topologies on system outcomes. Social networks consist of individuals of a population and the social ties or relations among them. In this literature, social interactions are modeled as 'links', also known as 'edges', and can represent various types of connections, depending on the particular research question: friendships, collaborations, sexual contacts, business relations etc. (Boccaletti *et al.*, 2006).

Empirical analysis of the structure of social networks revealed common properties and connection patterns and contributed to our understanding of a variety of processes ranging from the spreading of diseases to the emergence of consensus and knowledge diffusion in different kinds of organizations and social structures (Barrat *et al.*, 2013). A considerable body of literature recognizes the influence of mixing patterns and linkage rules on the outcome and dynamics of a system. Sen & Sen (2010) study the effect of network topology on the emergence of norms through interaction-based social learning. They find that the rate with which one behavior emerges as the norm from a set of acceptable behaviors differs for different network topologies. Noble *et al.* (2004) showed that information transmission in networks depends on the level of preferential attachment. Castellano *et al.* (2003) showed that the behavior of a voter model strongly differs for small world network topologies compared with a regular topology. In a review of various innovation diffusion models Kiesling *et al.* (2012) summarize the pronounced effects of network topology on the diffusion efficiency. Overall, these studies highlight that an approximation of the connectivity or mixing pattern with an all-to-all principle is inaccurate. Real world networks of social interactions are characterized by specific topological patterns far from an all-to-all mixing pattern, where each individual perceives the behavior of all other individuals as a homogeneous aggregated norm. One pervasive feature of real-world social networks is the mixing pattern that follows from the tendency of nodes to connect to other nodes with similar properties (Newman, 2003). In sociology this tendency is known as the concept of homophily, which states that people generally tend to associate with others who are similar to them in some way (Barrat *et al.*, 2013; Easley & Kleinberg, 2010); for instance, assortative mixing by language, race (Moody, 2001), age, income, educational level, etc. Newman (2003). Another prevalent mixing pattern is preferential attachment with respect to the node degree Barabási & Albert (1999). In this case, a node i is more likely linked to a node j, if j is already linked to many other nodes. From

this linkage rule result networks with a few highly connected hubs and a large number of nodes with only few connections, also called scale-free networks, as it is the case for example for scientific citation networks (Redner, 1998). This distribution also resembles the situation found on social media platforms whose content is dominated by relatively few 'influencers' that have a lot of followers. Another important topological feature observed in social networks is represented by the class of small-world networks Watts & Strogatz (1998). These networks are highly clustered and at the same time have relatively short path lengths between any two nodes. Clustering results from the fact that the neighboring nodes of a given node are more likely to establish a link between them than with other randomly selected nodes.

To address complex social questions, it is essential to consider the interplay between the behavior of individual humans and the specific structural organization of interactions between them (Will *et al.*, 2020). Agent-based simulations make it easy to implement an explicit network topology and allow to study macro-level dynamics that emerge from individual behavior on a micro-level; thus the structure of relations in the population can be considered explicitly. In order to assess the influence of the network topology on system outcomes and accordingly the main structural influences, the comparison of formalized artificial networks with very specific characteristics is a worthwhile approach. In that way, certain network properties might be identified as factors determining the system dynamics. In our case this exercise proves especially interesting since we can study how the emergence and evolution of heterogeneous gender norms are shaped by the patterns of social interactions of individuals.

3 Model

Our model builds, in particular, on the work of Cudeville & Recoules (2015) and Beal Cohen *et al.* (2021) and is populated by N_f artificial women and N_m artificial men, jointly called agents. In line with the literature, we explicitly focus on the

household dynamics of heterosexual couples, and hence assume that each woman is connected to exactly one man.[4] Each agent can allocate their time to the production of a private good (representing paid work) or a local public good (representing, e.g., care work); they optimize this decision based on their (heterogeneous) preferences, as well as on a 'conjugal contract' θ_i that they agree upon with their spouse after Nash bargaining. This 'conjugal contract' specifies how much of the private good (i.e. money) is transferred from one spouse to the other and can take any values between -1 (where the wife would transfer all of her income to the husband) and +1 (where the husband would transfer all of his income to his wife). In our model, the intra-household division of labor, as well as social norms are determined endogenously due to the (optimizing) actions taken by the agents based on the agents' preferences, wage rates, as well as the actions chosen by other agents. Hence, our model allows us to study the distributional consequences of i) the structure of the social network of the agents, ii) gender-specific differences in the wage rate (i.e. a gender pay gap), iii) gender-specific differences in the preferences for the private and public good (as induced, e.g., by gender-specific upbringing (Badgett, 1999) iv) the degree of conformism towards social norms, v) the elasticity of substitution between the two goods.

The following subsections provide a detailed description of the model. The model code is available at github[5].

3.1 Sequence of events

Each simulation run starts with the initialization phase, in which agents and their social network connections are created, and households are formed (see subsection 3.2). Afterwards, the following sequence of events is computed for a specified number of periods that is sufficient to numerically approximate an equilibrium meaning that agents cease to adapt their time allocation and the transfer between the spouses.

[4] This implies that $N_f = N_m$ and that we abstract from single individuals as well as homosexual and polyamorous relationships.
[5] https://github.com/patrickmellacher/gendernorms

- Agents observe the social norm based on their friends' decisions taken in the previous period (see subsection 3.4).
- Agents bargain for the optimal 'conjugal contract' and allocate their time accordingly (see subsection 3.5).
- Statistics are updated.

3.2 Initialization

At the beginning of each simulation run, N_f women and N_m men are created. Their wage rate ($w_i > 0$), conformism ($c_i >= 0$) and preference for the private good ($\alpha_i \in [0, 1]$) are drawn from normal distributions with a mean of w_g, c_g and α_g respectively where $g \in f, m$, and the standard deviation $\sigma_{w/c/\alpha}$. Then, men are linked with other men, and women are linked with other women to form their respective social reference group following one of the procedures described in the following subsection (3.3). Finally, each woman randomly forms a household with one man. [6]

3.3 Network topology

In contrast to the previous literature on gender norms in an intra-household bargaining model, we assume that agents only orientate towards an explicitly modeled social reference group that represents, e.g., friends or celebrities and influencers. To this end, agents in our model are connected to a social network. We experiment with four different algorithms for network construction. We rely on Netlogo's "nw" extension to produce i) a random network, ii) a Watts-Strogatz 'small-worlds' network, as well as a iii) preferential attachment network. Further, we develop our own algorithm to produce a iv) homophilic network, in which agents are more likely connected to each other if they are 'similar' in a specific characteristic. Finally, we compare our results with v) the homogenous norm baseline approach followed by Cudeville & Recoules (2015) and

[6] We are aware that a random assignment of partners is unrealistic and that humans tend to carefully select their mating partners. We plan to analyze the influence of different partner selection scenarios in a future paper.

Beal Cohen *et al.* (2021), where the social norm is determined as an aggregate over all individuals of the respective type, and vi) a scenario in which there are no social ties at all, and agents only take their own actions in the past as a point of reference for the social norm.

random: The random network construction algorithm uses the Erdős-Rényi model G(n,p) (Erdős & Rényi, 1960), where an edge between each distinct pair of nodes is included with a certain probability p, and n denotes the number of nodes in the whole social network.

small-world: To construct a small-world network as proposed by Watts & Strogatz (1998), nodes are arranged in a circle and then connected to o_w neighbors on either side. In the second step, shortcuts are introduced by rewiring links with a probability p_r. If $p_r = 0$, the network is a regular network, i.e. a network in which every node has exactly the same number of neighbors, whereas $p_r = 1$ corresponds to a random network.

preferential attachment: Uses an algorithm proposed by Albert & Barabási (2002) to create a scale-free network with a distribution of links that follows a Power law, i.e. some nodes have a lot of links, while most nodes have few links. Technically, the network is created by creating the agents one-by-one. Each new agent forms a specified number of links o_p to other agents, but the probability of forming a link to agent y depends on the number of links that agent y already has, thus favoring agents who already have relatively many links.

social homophily: This procedure reflects the tendency of agents, to link to other agents who are similar to them in a certain variable. We have used several features for comparison of the agents: their wage w_i, the preference for the private good α_i, and their degree of conformism c_i. In three set-ups, one feature each was used to make agents more likely to form links with an agent if they were more similar on the variable of interest. We implement this idea in the following way: Each agent forms k_h links

sequentially. The probability that an agent x creates one of these links to agent y of the same gender is given by the inverse of the absolute difference between the value of the variable of interest for agent x (v_x) and agent y (v_y) relative to the sum of the inverse of the absolute difference between the variable of interest for agent x and all other agents z, where z is an agent of the same gender as x, but $x \neq z$ (see eq. 1).

$$p_{x,y} = \frac{\frac{1}{|v_x - v_y|}}{\sum \frac{1}{|v_x - v_z|}} \quad , where \quad x \neq y \wedge x \neq z \tag{1}$$

3.4 Utility and social norm

Agents perceive a social norm Z_i that is given by the mean behavior chosen in the previous period by the agents with which they are connected (e.g., their friends) in any variable k (see eq. 2).

$$Z_i(k_i) = -\sum (k_i - \bar{k}_{i,t-1})^2 \tag{2}$$

We analyze two specifications: In the first one, which is highly similar to Beal Cohen *et al.* (2021), agents consider the mean time devoted to producing the private good $\bar{l}_{i,t-1}$ and the mean conjugal contract $\bar{\theta}_{i,t-1}$. In the second specification, they also consider the mean paid working time of the spouses of the agents to which they are connected to $\bar{l}_{j,t-1}$. This implies that, in the first specification, agents only care about whether their own actions deviate from the social norm perceived from their peer group. In the second specification, however, agents also lose utility if their spouse deviates from the actions chosen by their peers' spouses.

The individual utility function is different for donors (i.e., agents who transfer parts of their income in terms of the private good to their spouse) and receivers (i.e. agents who receive the transfer). The utility for a donor i with a spouse j is given by eq. 3 and depends on the wage rate w_i, conformism c_i and (paid) labor time of the agent l_i and (paid) labor time of their spouse l_j, as well as a substitution parameter ρ.

$$U_i(w_i, c_i, l_i, l_j, \alpha_i, \theta_i) = (\alpha(l_i w_i(1 - |\theta_i|))^\rho + (1 - \alpha)(2 - l_i - l_j)^\rho)^{1/\rho} e^{c_i Z_i} \quad (3)$$

The utility function for a receiver i with a spouse j, on the other hand, is given by eq. 4.

$$U_i(w_i, c_i, l_i, l_j, \alpha_i, \theta_i) = (\alpha(l_i w_i + l_j w_j |\theta_i|)^\rho + (1 - \alpha)(2 - l_i - l_j)^\rho)^{1/\rho} e^{c_i Z_i} \quad (4)$$

3.5 Intra-household bargaining

On a technical level, agents agree on a conjugal contract θ_i and allocate their labor time in a two-step procedure (largely following Beal Cohen *et al.*, 2021)[7]: First, agents optimize their allocation of labor between producing the public and the private good for each possible value of [-1,1], which we iterate in steps of 0.01. In doing so, they take θ_i, the social norm, as well as the optimized decision of their spouse into account and calculate the payoff according to eq. 5.

$$U_{i,j} = argmax((U_i(\theta_i) - U_i(0)) * (U_j(\theta_j) - U_j(0))) \quad (5)$$

$$where$$

$$U_i(\theta_i) > U_i(0)$$

$$U_j(\theta_j) > U_j(0)$$

$$\theta_i = \theta_j$$

[7] In contrast to Beal Cohen *et al.* (2021), we employ a 'hill climbing' mechanism for the optimization conducted by the agents that substantially increases the computational speed. This is possible due to the fact that the utility function of each agent contingent on the decision taken by their spouse is single-peaked, i.e. there is a single maximum.

3.6 Updating statistics

At the end of each period, the following aggregate statistics are computed: mean, first quartile, median, third quartile and standard deviation of i) paid working time for women and ii) men, iii) utility for women and iv) men, and v) transfer.

4 Results

We analyze our model by starting with a simple set-up and gradually increasing the model's complexity. The figures shown in this section are created using the ggplot2 package (Wickham, 2016) for the programming language R (R Core Team, 2022).

4.1 No social pressure

We begin our analysis in a world where social pressure does not exist. This allows us to understand how model outcomes are shaped by preferences and budget constraints alone, which are given by the substitution parameter ρ, the (relative) preference for the private good α, the wages of men and women (i.e. the gender pay gap), and the time budget which we normalize to 1. For this analysis, it is sufficient to consider a single representative household and its decisions, as households do not take into account the actions chosen by other households anyway. Fig. 1 shows the results of this exercise.

Previous work in the gender bargaining literature highlights the crucial role of relative wages (Cudeville & Recoules, 2015). However, our model illustrates that eliminating the gender pay gap may on its own not be a magic bullet in increasing women's time allocated to paid work and achieving gender equality in time allocation generally: First, (relative) preferences for the private good are crucial. We can see that the changes in the relative wage rate have only a limited impact if the preferences for the private good are not the same for the members of the household. Therefore, policies aimed at closing the gender pay gap may not be sufficient in themselves to achieve gender equality in the distribution of paid and unpaid work, even in the absence of explicit

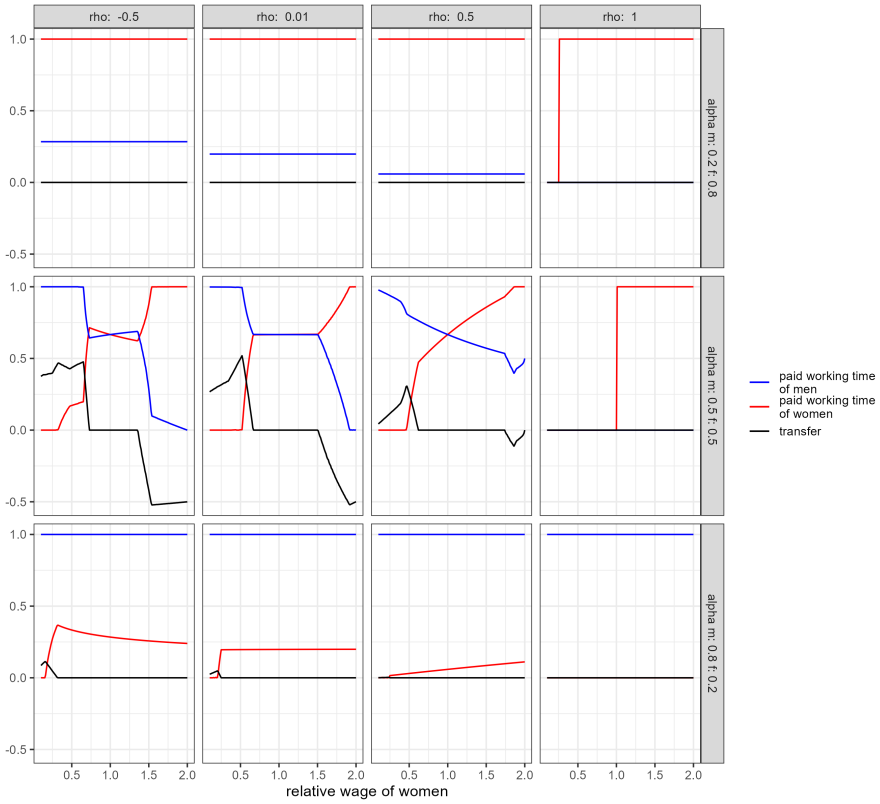

Figure 1 Paid working time of men and women, as well as transfer for different substitution parameters, preferences and relative wages without social pressure.

social pressure to align working hours with those of peers. Thus, socialized preferences, which might also be considered to be influenced by gender norms (Fernandez & Fogli, 2009), have their own influence in our model.

Second, if the private and the public goods are (imperfect) complements instead of (imperfect) substitutes (i.e. $\rho < 0$), an increase in the relative wage rate may even paradoxically cause a decrease in the paid working time of women, especially if the preference for the private good is relatively low; the two dynamics are hence intertwined.

Furthermore, we observe that the transfer level θ is almost always 0 if i) there are large differences between the genders with regard to the preference for the private

good, or ii) there is no (or only a low) gender pay gap. It is important to understand, however, that real-world transfers within households are often primarily utilized for family purchases, while the transfer recipient in our model uses the transfer to buy goods that only benefit herself or himself.

For the remainder of our analysis, we will focus on parameter combinations where both men and women have the same preference for the private good of 0.5 and the substitution parameter is 0.5, as these produce the most interesting results. However, we are aware that preferences are shaped by gender socialization (Fernandez & Fogli, 2009) and that it is unlikely that both men and women will have the same preferences.

4.2 Heterogeneity in social conformism

In this subsection, we test how social conformism influences the relative distribution of labor in our model. In order to isolate this mechanism, we focus on the analysis of a representative household that considers its actions chosen in the previous period as the social norm. We test two specifications: In the first setting, only the own actions are subject to the social norm. This specification is highly similar to the one chosen by Beal Cohen *et al.* (2021). In the second setting, each agent also considers the actions of their spouse (i.e. an agent's utility is also reduced if his/her spouse deviates too much from the social norm).

Fig. 2 illustrates these results in a scenario with a gender pay gap of 25%. We can see that when agents do not take into account the behavior of their spouse in relation to the social norm, women paradoxically have the highest relative paid working time *and* receive the highest transfer when they are non-conformist and their husbands are highly conformist. This result seems to be counterintuitive and is driven by the fact that a higher level of conformism implies a worse bargaining position. Agents perceive their outside option as a situation in which there is no transfer between the spouses, i.e. $\theta = 0$. In our case, highly conformist husbands gain utility from adhering to the

social norm which is characterized by transferring a large part of their income to their wives. Thus, they are gradually willing to accept a situation in which they work less than their spouse but still transfer money to them.[8] On the other hand, if agents also perceive the actions of their own spouse relative to their peers' spouses as part of the social norm, the counterintuitive result vanishes. In such a situation the paid working time of men and women is most equal if both are nonconformist, even though the impact is quite low.

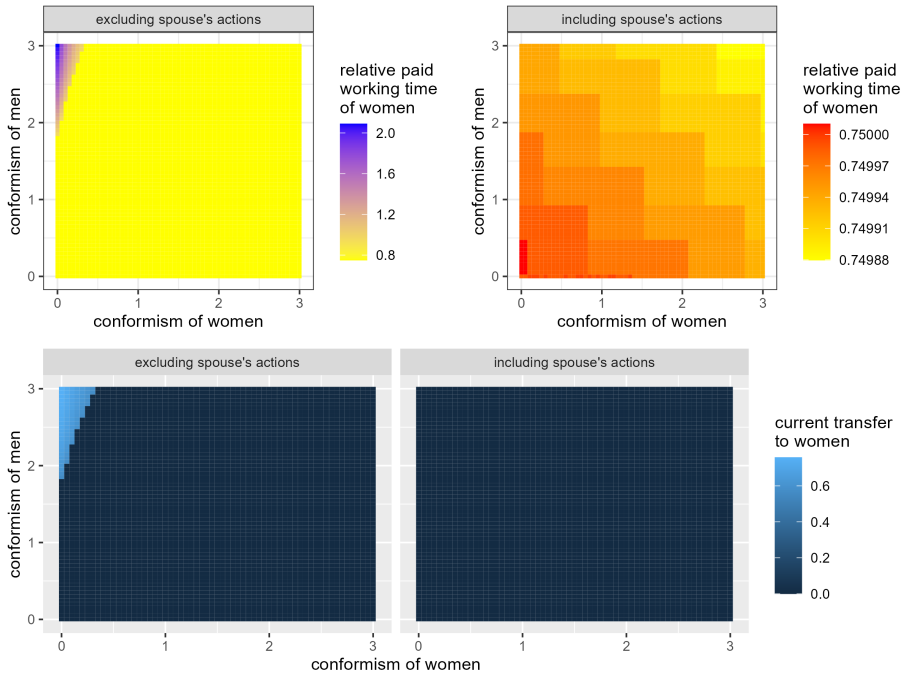

Figure 2 Relative paid working time of women (top) transfer (bottom) for different conformism parameters and settings (left: without taking the spouse's action into account).

Since the second specification produces more intuitive results we will use it for the remainder of our analysis. Furthermore, there is empirical evidence that husbands in highly patriarchal societies do consider the paid working time of women as part of

[8] A similar result, albeit less extreme, is shown by Beal Cohen *et al.* (2021), who illustrate that highly conformist men may decrease their paid working time and transfer most of their income to their wives in response to a wage increase for women.

their social norm and that these norms matter for the determination of the actual labor supply (Bursztyn *et al.*, 2020).

4.3 Different network structures

We now depart from our assumption of a representative household and study how agent heterogeneity and the structure of the social network interact.

4.3.1 Single runs

First, we look at a single population of agents and study how women allocate their time in nine different scenarios (see Fig. 3). In the "no social pressure" scenario, agents are initialized with conformism = 0 and hence do not consider the social norm in their decisions. Accordingly, the distribution of women's paid working time is the most fragmented. On the other hand, when agents take the aggregated actions of the whole society as the social norm, the distribution is the most condensed. Other network specifications – the Watts-Strogatz network, the preferential attachment network, the random network, and various homophilic networks – are not as fragmented as the "no social pressure" scenario, but not as condensed as the "whole society" scenario. This suggests that heterogeneous social norms as mediated by different social networks cause agents to behave more as if there were no social pressure, compared to the aggregated social norm given by the "whole society" scenario. The scenario that spawns the greatest level of fragmentation is the homophilic network where agents are linked according to their preferences for the private good.

4.3.2 Multiple runs

As stochastic processes govern the generation of agents and the social network in our model, it is not sufficient to look at a single run to reach final conclusions. In line with the literature on agent-based and simulation models (see, e.g., Dosi *et al.*, 2010), we

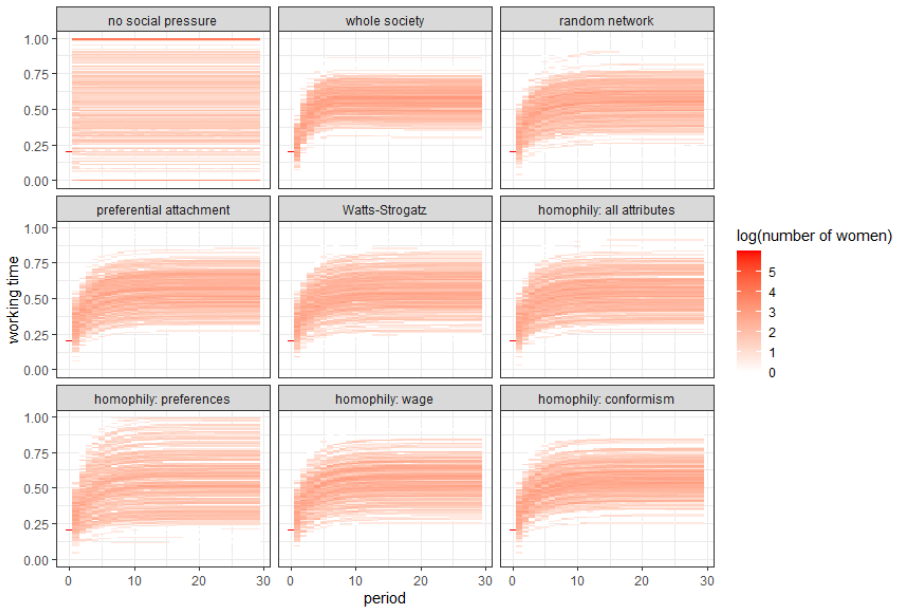

Figure 3 Evolution of the distribution of the paid working time of women in a single run for each network structure

hence run Monte Carlo simulations, i.e. a large number of simulations per parameter combination in order to analyze our model quantitatively.

Our computational setup allows us to create a clear experimental design to investigate causal inference within our model. In order to do so, we run 1,000 repetitions with fixed random seeds for each network type. This means that, in a first step, we create 1,000 different artificial populations of households. We then test the impact of each network configuration on each of the artificial populations. Since we are confronted with 9 scenarios (7 network types, as well as "no conformism" and "whole society" as baselines), our analysis is based on 9,000 simulation runs. The parameters of the artificial populations are described in Table 1.

The parameters of the different network structures are described in Table 2 and are set up in a way that the expected number of links/edges per network is the same for each of the seven network types.

Table 1 Parameters

Parameter	Symbol	Value
Number of agents of each type	N_f, N_m	401
Substitution parameter	ρ	0.5
Wage of women	w_f	$N \sim (0.75, 0.175)$
Wage of men	w_m	$N \sim (1, 0.175)$
Conformism of men	c_m	$N \sim (1, 0.2)$
Conformism of women	c_f	$N \sim (1, 0.2)$
Preference of women for the private good	α_f	$N \sim (0.5, 0.1)$
Preference of men for the private good	α_m	$N \sim (0.5, 0.1)$
Time women spend on the private activity in $t = 0$	$l_{f,t=0}$	0.2
Time men spend on the private activity in $t = 0$	$l_{m,t=0}$	0.8
Conjugal transfer in $t = 0$	θ	$N \sim (0.25, 0.05)$
Components of the social norm	k_i	l_i, l_j, θ

Table 2 Network parameters

Network	Parameter
no social pressure	no conformism ($c_i = 0$)
whole society	-
random network	connection probability $p = 0.01$
Watts-Strogatz network	links to neighbors (on each side) $k = 2$ rewiring probability $p = 0.1$
preferential attachment	min. number of links $k_{min} = 2$
homophilic mixing (various configurations)	min. number of links $k_{min} = 2$

We visualize the results with the help of notched box plots. As any box plot, they show the median, the first and third quartile of the respective variables as well as outliers. Furthermore, they incorporate 'notches', which show a confidence interval around the median which is given by the median $+/- 1.58 * \frac{IQR}{\sqrt{n}}$, as suggested by McGill *et al.* (1978) and implemented by the ggplot2 package for R. These notches help to better intuitively understand the results: If the notches of two boxes do not overlap, this is a strong indication that the median of the two boxes is significantly different.

Figure 4 shows the results of the 9,000 simulations. The mean relative paid working time of women is significantly higher in the "no social pressure" scenario and in the homophilic network where agents are linked according to their preferences for the private good, than in the "whole society" scenario. Furthermore, *all* social networks are significantly closer in terms of relative paid working time of women to the "no pressure"

scenario than to the "whole society" scenario at the 25th and 75th percentiles. Finally, the standard deviation of the paid working time of women in all explicitly modeled networks is significantly higher than in the "whole society" scenario.

Jointly, these results suggest that the network structure of the population indeed matters: While the aggregate norm approach (as represented by the "whole society" scenario) used by Cudeville & Recoules (2015); Beal Cohen *et al.* (2021) is a good approximation for mean outcomes in most network configurations, explicitly modeled networks cause more fragmentation in the distribution of relative paid working times *and* this fragmentation creates an outcome that is closer to a situation in which agents are free to optimize their decisions without any social pressure. Importantly, within our model, this fragmentation in the network structure also results in outcomes that are more favorable for gender equality in terms of the distribution of paid and unpaid work compared to the "whole society" scenario. Thus, explicitly considering the network dynamics provides a more nuanced understanding of how gender norms influence the allocation of paid and unpaid labor within households.

5 Conclusion

In conclusion, our study sheds light on the profound impact of gender norms on the division of labor within households, using an intra-household bargaining model that incorporates endogenous social norms. By considering explicitly modeled social networks and allowing for heterogeneity in agents' perceptions of gender norms, we have revealed significant deviations from the results found in the previous literature, which assumes homogeneous social norms. We have generalized and extended the intra-household bargaining models with endogenous gender norms by Cudeville & Recoules (2015) and Beal Cohen *et al.* (2021) by introducing i) a CES utility function and ii) heterogeneous norm perceptions shaped by different social networks. At the same time we, have rigorously explored the parameter space of the model leading to the following

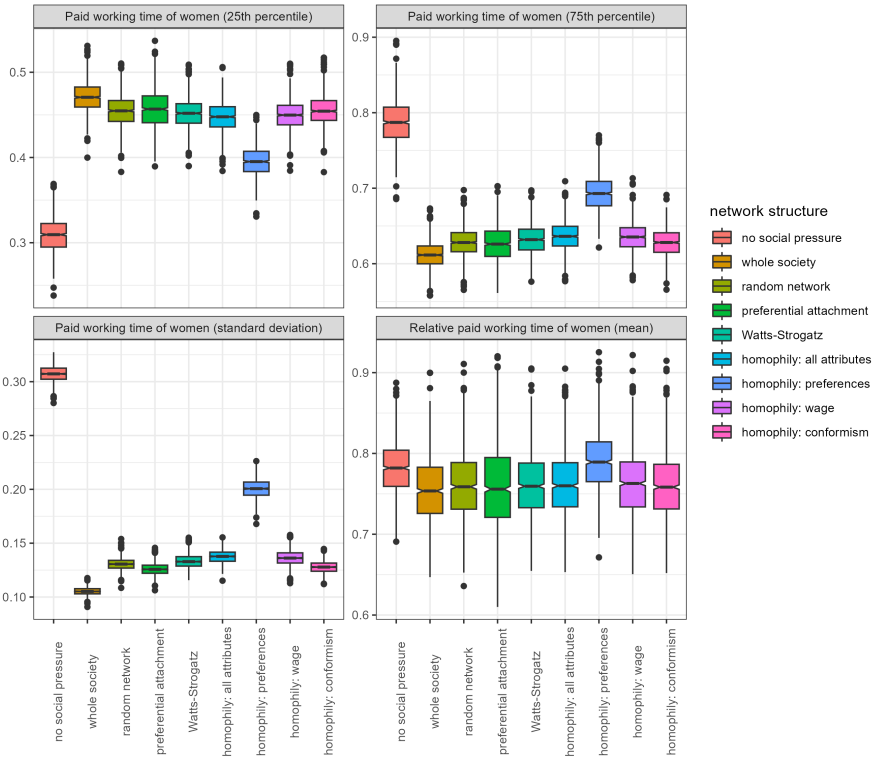

Figure 4 Notched box plots of the mean relative paid working time of women (top left), the 25th percentile (top right), 75th percentile (bottom left) and standard deviation (bottom right) of the paid working time of women for the different network structures.

conclusions: *First*, we showed that, depending on the relative preference for the private good of men and women, closing the gender pay gap may have no, or even a negative effect on women's paid working time (relative to men's paid working time). This finding highlights the importance of preferences which are mediated by upbringing and socialization in the decision to allocate time between paid and unpaid work.

Second, we demonstrated the effect of choice of the perception of social norms by exploring two different ways. In the first, used in the previous literature, agents only care about their own behavior relative to the behavior of their peers (who are agents of the same gender). In the second, however, they also care about their spouse's behavior relative to the behavior of their peers' spouses. We showed that the first mechanism

can produce counter-intuitive results when spouses differ in their conformism. For example, a non-conformist woman who is married to a highly conformist man may be more likely to work relatively more hours than a woman married to a non-conformist man. This is not the case for the second mechanism suggesting that the assumption that agents also care about their spouse's actions with respect to the social norm should be used in subsequent modeling efforts. The empirical evidence also points in this direction (e.g. Bursztyn *et al.*, 2020).

Finally, we relaxed the assumption that agents perceive the actions chosen by all other agents (of the same gender) as the social norm by Cudeville & Recoules (2015); Beal Cohen *et al.* (2021). Instead, agents perceive only a subset of other agents who are their social reference group (e.g. because they are their friends or family). We used four algorithms to create seven different stylized network types and compared them with two baseline scenarios: one in which there is no social pressure at all (i.e. the norm component does not play a role), and one in which the whole of society perceives the same gender norm (as used in the previous literature). We have shown that the *mean* behavior in most explicitly modeled networks is similar to the one in the homogeneous norm approach. However, looking at the 25th and 75th percentiles, we can see that the behavior of the agents is closer to a scenario where there is no social pressure. At the same time, the results of the simulations suggest that outcomes are more scattered when network structures are modeled, as shown by the significantly higher standard deviation. This is possible because, compared to the homogeneous norm approach, some women work more and others less. Thus, the ability to perceive heterogeneous norms also creates the reality of different 'norm clusters' within the population. Interestingly, this is true even if we do not assume *a priori* that agents are connected to agents who are 'like' them in any way, but rather that they are connected in well-known patterns, such as a Watts-Strogatz small worlds networks.

In particular, we found that a network in which agents are connected according to their preference for the private good (homophilic network with focus on preferences) also differs in the *mean* behavior from the standard approach; it is most conducive to gender equality in terms of the distribution of paid and unpaid work. This result again confirms the importance of socialized preferences mediated by upbringing.

There are several limitations to our model. Firstly, it is crucial to highlight that in our model, the inclusion of social norms can only lead to a decrease in utility. This assumption may suggest that any societal influence on individual behavior has detrimental effects, a viewpoint with which we strongly disagree. We acknowledge that individual behavior is inherently influenced by society, and it is not realistic for it to be completely independent. Social norms can also have positive effects, for instance by inducing coordination, but at the same time they often represent materialized power relations, especially in the context of gender inequalities. Secondly, we acknowledge that our use of utility as a concept in the study is not without its limitations. We are well aware of the longstanding feminist critique of rational choice theory, including its use of utility as a framework (e.g., England & Kilbourne, 1990). It is important to recognize that utility, as traditionally conceptualized, may not fully capture the multidimensional nature of individuals' well-being, particularly in relation to gender dynamics and social norms. Thirdly, in the utility function we use the conjugal contract is understood as regulating the transfer of a private good. However, in reality, conjugal transfers are often utilized for family expenses that both parties benefit from (such as rent or mortgage) rather than exclusively for the individual receiving the transfer. This discrepancy may explain why spouses choose a transfer of zero in many parameter combinations, particularly if they differ in their preferences for the private good, although cash transfers between spouses can often be observed in various situations in reality. Finally, in line with the literature we build on (Cudeville & Recoules, 2015; Beal Cohen *et al.*, 2021), we assume that both spouses have, in principle, the

same 'right' to bargain (even though they may differ in their outside option, which generally creates unequal outcomes). Other streams of the literature explicitly model differing bargaining powers of the spouses as a parameter (e.g. Vermeulen *et al.*, 2006)

By acknowledging these limitations, we can better contextualize the results of our study and encourage further research that addresses these complexities. Future studies could explore alternative models that incorporate a) a positive influence of the social norm on utility, b) explore in more detail the welfare implications of the different network types and c) use more nuanced concepts than utility.

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