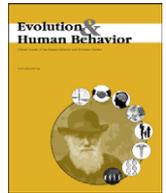




Contents lists available at ScienceDirect

## Evolution and Human Behavior

journal homepage: [www.ehonline.org](http://www.ehonline.org)

## Original Article

# Why household inefficiency? An experimental approach to assess spousal resource distribution preferences in a subsistence population undergoing socioeconomic change<sup>☆,☆☆</sup>

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## ARTICLE INFO

## Article history:

Initial receipt 6 March 2016

Final revision received 12 July 2016

Available online xxx

## Keywords:

Intra-household distribution

Sexual division of labor

Family

Marriage

Bargaining

Tsimane

## ABSTRACT

Two disparate views of the sexual division of labour have dominated the representation of intra-household resource allocations. These *joint* and *separate* interests views differ in their interpretation of the relative roles of men and women, and make different predictions about the extent to which marriage promotes economic efficiency (i.e. maximized household production). Using an experimental “distribution task” stipulating a trade-off between household efficiency and spousal equality in allocating surpluses of meat and money, we examine factors influencing spousal distribution preferences among Tsimane forager-horticulturalists of Bolivia ( $n = 53$  couples). Our primary goal is to understand whether and how access to perfectly fungible and liquid resources – which increases with greater participation in market economies – shifts intra-household distribution preferences. We hypothesize that greater fungibility of money compared to meat results in greater squandering of money for individual fitness gain at a cost to the family. Money therefore requires costly strategies to insure against a partner’s claims for consumption. Whereas nearly all Tsimane spouses prefer efficient meat distributions, we find a substantially reduced efficiency preference for money compared to meat controlling for potential confounders (adjusted OR = 0.087, 95% CI: 0.02–0.38). Reported marital conflict over paternal disinvestment is associated with a nearly 13-fold increase in odds of revealing a selfish money distribution preference. Selfish husbands are significantly more likely than other husbands to be paired with selfish wives. Lastly, Tsimane husbands and wives are more likely than Western Europeans to prefer an efficient money distribution, but Tsimane wives are more likely than Western European wives to exhibit a selfish preference. In sum, preferences for the distribution of household production surplus support joint and separate interests views of marriage; a hybrid approach best explains how ecological-, family-, and individual-level factors influence spousal preferences through their effects on perceptions of marginal gains within and outside the household.

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## 1. Introduction

Intra-household resource distribution determines energy budgets available for growth, reproduction and survival, and is thus central to understanding trade-offs underlying human life history allocations. The sexual division of labor and resources – perhaps the most basic form of human economic specialization and exchange (Murdock,

1949) – is also a highly complex social relationship, entailing frequent cooperation and altruism but also defections and spite. Spouses face numerous barriers to generating economic surplus and allocating resources efficiently among family members, despite generally having more opportunities and willingness to share information than dyads in non-sexual relationships. Barriers include conflicting reproductive interests (Bird, 1999; Borgerhoff Mulder & Rauch, 2009; Gurven, Winking, Kaplan, von Rueden, & McAllister, 2009; Maynard Smith, 1977; Parker, Baker, & Smith, 1972; Smith, Bird, & Bird, 2003; Stieglitz, Blackwell, et al., 2012; Stieglitz, Kaplan, Gurven, Winking, & Vie, 2011; Trivers, 1972; Winking, Kaplan, Gurven, & Rucas, 2007), asymmetric information and unobservable action (Ashraf, 2009; Ashraf, Field, & Lee, 2014; Ligon, 2011). These barriers can result in reduced marital quality, verbal and/or physical disputes over appropriate levels of work effort and use of time and resources (Flinn, 1988; Hewlett & Hewlett, 2008; Stieglitz,

☆ **Conflict of Interest:** None reported.

☆☆ **Role of the Funding Source:** Funding sources had no direct involvement in study design, data collection, analysis, interpretation of data, or manuscript preparation or submission.

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<http://dx.doi.org/10.1016/j.evolhumbehav.2016.07.002>

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Please cite this article as: Stieglitz, J., et al., Why household inefficiency? An experimental approach to assess spousal resource distribution preferences in a subsistence populati..., *Evolution and Human Behavior* (2016), <http://dx.doi.org/10.1016/j.evolhumbehav.2016.07.002>

Gurven, et al., 2012), and can contribute to the development and maintenance of patriarchal social norms that reinforce and exacerbate these barriers.

A goal of this paper is to examine factors influencing intra-household resource distribution preferences of spouses using an experimental approach in a small-scale forager-horticultural society, the Tsimane of Bolivia. Given that Tsimane and other subsistence-level societies worldwide are witnessing rapid changes in livelihood and increasing access to cash-based economies, another goal is to examine whether and how spousal resource distribution preferences vary across populations differing in their reliance on cash and the extent to which spousal labor is more substitutable versus complementary. Despite the complexity highlighted above that emphasizes both cooperation and conflict among spouses, two disparate views of the sexual division of labor have dominated the representation of intra-household resource allocations.

According to a **joint interest** view, the origins of the nuclear family are rooted in a sexual division of labor where men hunt wild animals and women gather plant foods (Lovejoy, 1981; Murdock & Provost, 1973). The pair bond between sexes is viewed as a cooperative endeavor aimed at joint production of altricial offspring, where women “trade” paternity certainty for long-term provisioning and protection by men (Isaac, 1978a; Lancaster & Lancaster, 1983; Washburn & Lancaster, 1968; Wood & Marlowe, 2013). Marriage enables men and women to achieve fitness benefits by producing economies of scale such that the production of the pair exceeds the summed production of adults working alone (Gurven & Hill, 2009; Gurven et al., 2009; Kaplan & Lancaster, 2003). Spouses thus meet consumption demands by drawing from “pooled energy budgets” (Kramer & Ellison, 2010; Reiche et al., 2009). This view is analogous to the “unitary” model of household decision-making in economics, where the household behaves as if it were a single unit with a single set of distribution preferences. Spouses either have identical preferences or only one spouse makes allocation decisions (Becker, 1991). Because partner-specific labor proceeds are pooled in the joint budget, efficient intra-household labor allocation should be that which maximizes joint production; resource distributions should be efficient regardless of whether a husband or wife produces the resource.

An alternative **separate interests** view posits that fitness gains from economic efficiency alone cannot account for marriage. According to this view men’s work effort in foraging societies is not primarily motivated by a desire to provision offspring because men’s game acquisition is unpredictable or unreliable, and once acquired, game is shared widely with non-household members and not reciprocated (Hawkes, 1991; Hawkes & Bliege Bird, 2002). This view proposes that men hunt because of the desirable social attention and mating benefits that come from providing meat, which is a widely shared public good. Because hunting is difficult and requires substantial skill, strength, endurance and knowledge, successful hunting is difficult to fake and serves as an honest signal of underlying male quality to potential allies, mates and competitors (Bird, Smith, & Bird, 2001). This signaling is effective because visibility of returning with a kill is high, and group members pay careful attention to men’s hunting returns in order to obtain shares for themselves. Here men’s work is viewed as a form of mating effort or status competition, rather than familial provisioning, so marriage is interpreted as a convention of publicly recognized property rights designed to reduce male mating competition, rather than a cooperative union designed to achieve economic efficiency. Women therefore choose good hunters because of their presumed genotypic or phenotypic quality, not because of their willingness to provide household resources. Intra-household distributions are thus expected to be inefficient (e.g. characterized by a spouse’s selfishness) due to imperfect enforceability of marital contracts or informational asymmetries among spouses (cf. Bloch & Rao, 2002; Ligon, 2011; Lundberg & Pollak, 1993; Mazzocco, 2007).

Joint and separate interests views differ in their interpretation of the relative roles of men and women in the energetics of reproduction and

in the life history adaptation. While it is often acknowledged that household decision-making contains elements of both joint and separate interests views, empirical studies usually conclude by supporting one view or the other. The topic has thus generated much controversy in anthropology, with much of the debate focusing on production decisions (e.g. why hunters target large vs. small game) and less emphasis on how spouses distribute production surplus. However, hybrid approaches containing elements of both joint and separate interests views have a long history in household economics (e.g. Bobonis, 2009; Chiappori, 1988; Manser & Brown, 1980; McElroy & Horney, 1981). A key tenet of a joint interest view is that a sexual division of labor and resources characteristic of marriage facilitates efficiency and maximization of household economic surplus. Yet an inefficient non-cooperative equilibrium within marriage can still be more advantageous (in terms of utility or fitness) for both spouses than divorce, as supported by experimental research indicating that spouses are willing to reject joint surplus maximization for greater personal control over resources (Ashraf, 2009; Mani, 2011; Munro, Kebede, Iversen, Jackson, & Verschoor, 2006), and the observation that spouses pool income for some but not all categories of consumption (Phipps & Burton, 1998). But even if divergent spousal interests are explicitly acknowledged (Almas, Armand, Attanasio, & Carneiro, 2016; Anderson & Baland, 2002; Basu, 2006; Duflo & Udry, 2004; Gurven et al., 2009; Heath and Tan under review; Lundberg & Pollak, 1993; Schaner, 2015), the question of whether spousal preferences yield efficient outcomes, and what factors contribute to household inefficiency remain unresolved. Answering these empirical questions is essential to advance theoretical models of household behavior (Del Boca & Flinn, 2014; Munro et al., 2006).

Field experiments are uniquely poised to offer insight into these questions by manipulating intra-household distribution choices to reveal spousal preferences. Experiments provide novel inferences about whether and why preferences deviate from efficiency in ways that prior observational studies cannot. Field experiments also permit more controlled comparisons of intra-household preferences across diverse societies.

### 1.1. The distribution task

Here we assess Tsimane spousal preferences regarding intra-household allocations using a “distribution task” (Beblo, Beninger, Cochard, Couprie, & Hopfensitz, 2015; Cochard, Couprie, & Hopfensitz, 2014) among spouses from the same marriage. In this task spouses must decide between two allocations of a resource between themselves and their partner. Each of five decisions provides the choice between option A (equally divided between partners) and option B (unequal division between partners but always efficient in terms of maximizing joint payoffs). Spouses thus face a trade-off between equality and efficiency (see Table 1). This equality-efficiency trade-off characterizes various allocation decisions regarding food, money and other household resources (e.g. Behrman, 1988; Engle & Nieves, 1993; Farmer & Tiefenthaler, 1995). The task is not designed to examine spousal production decisions per se (e.g. who acquires what), but rather how spouses distribute production surplus. The task permits identification of spouses who maximize joint payoffs (i.e. efficient), maximize their own payoff (extreme selfish), maximize their partner’s payoff (extreme altruistic), or who are concerned with partner equality (inequality averse). No communication between partners is allowed during this one-shot exercise and one cannot deduce a partner’s revealed preferences. While spousal interactions are obviously repeated and communication is possible outside of the experiment, many household decisions are made independently and provide incentives to free-ride on a partner. It must also be noted that participants have the possibility to choose the unequal but efficient payoff (option B) and then pool and distribute this payoff equally with a partner after the task. Inequality aversion thus does not necessarily prevent one from choosing option B, and the number of those choosing option A is only a lower bound estimate of the

**Table 1**

A) Distribution task design. The task consists of three rounds and five questions/round. Respondents choose option A or B for each question. Spouses face a trade-off between equality and efficiency for every question except #3, where options A and B both offer equal divisions but B is also efficient. In round one respondents indicate their preferences for actual shares of dried meat ( $X = 0.67$  kilograms), and responses determine compensation. Round two choices concern hypothetical shares of money (unincentivized;  $X = 30$  Bolivianos). Round three choices concern hypothetical shares of fresh meat (unincentivized;  $X = 0.67$  kilograms). Rounds, questions and options are presented in random order (not as shown here). B) Classification of individuals based on their aggregate preferences. Efficient individuals maximize joint payoffs. Selfish individuals retain a disproportionate share ( $>0.5$ ) of joint payoffs for themselves, whereas altruists retain  $<0.5$  for themselves. Symmetric individuals choose equality instead of efficiency at least once, retaining an equal share (0.5) of joint payoffs as a partner.

A) Question # in a given round	Option A		Option B	
	Payoff for self	Payoff for partner	Payoff for self	Payoff for partner
1	$X*0.33$	$X*0.33$	0	X
2	$X*0.33$	$X*0.33$	$X*0.25$	$X*0.75$
3	$X*0.33$	$X*0.33$	$X*0.5$	$X*0.5$
4	$X*0.33$	$X*0.33$	$X*0.75$	$X*0.25$
5	$X*0.33$	$X*0.33$	X	0

B) Classification of individuals based on aggregate preferences	Preference (#'s below indicate question #'s above)		Consistent with which view of marriage?
	Option A	Option B	
EFFICIENT (maximize joint payoff)		1–5	Joint interest
EXTREME ALTRUISTIC (max. Spouse's payoff)	4–5	1–3	Hybrid
EXTREME SELFISH (max. Own payoff)	1–2	3–5	Separate interests
ASYMMETRIC- ALTRUISTIC	Multiple possibilities		Hybrid
ASYMMETRIC - SELFISH	Multiple possibilities		Hybrid
SYMMETRIC-INEQUALITY AVERSE	Multiple possibilities		Hybrid
IRRATIONAL	3		Neither

number of inequality averse participants. If pooling and distribution of payoffs after the task is in fact common among spouses, then one would expect a bias toward maximizing joint payoffs.

Individual preferences elicited by this task help determine the extent to which these patterns are consistent with joint and separate interests views, or a hybrid approach. A joint interest view predicts that spouses should always prefer to maximize joint payoffs (option B) regardless of whether inequality favors a husband or wife because partner-specific incomes are pooled. A separate interests view suggests that personal gains matter more than the pair's total joint gains. A "selfish" individual should choose option A for decisions where their own payoff is smaller than their partner's (Table 1A, questions 1–2), and choose option B when inequality favors oneself (Table 1A, questions 4–5). An "altruistic" individual should do the opposite. An "inequality-averse" individual should always choose option A. Any combination of pure individual preferences is possible. Degree of selfishness is related to the number of A choices in questions 1–2; degree of altruism is related to the number of A choices in questions 4–5. A separate interests view predicts that conditions increasing spousal conflict over optimal levels of household investments should promote inefficient, particularly selfish distribution preferences. A hybrid approach predicts that evidence consistent with both joint and separate interests views will be found, and that distinct preferences may be explained by factors impacting perceptions of gains within and outside the household, and relative bargaining power (Heath and Tan, under review).

## 1.2. Study goals and predictions

We determine spousal distribution preferences for two resource types, meat and money, which have been central to economic exchange throughout human history and thus central to models of intra-household distribution in anthropology and economics. Money, unlike meat, serves as an abstract store of value, can be easily converted into other valuable goods or services, can be easily divided into small or large values, and has only recently (past few millennia) emerged in human economic exchanges (Davies, 1994). The greater fungibility and liquidity of money have been linked to diminished risk-seeking behavior than when food is used as experimental currency (Rosati & Hare, 2015). Because money is more fungible, storable, and easier to conceal than meat, it can more easily be squandered (e.g. on other sexual

relationships, luxury goods, recreation) by a partner at substantial cost to the family, and our prior work suggests that Tsimane husbands' diversions of sporadic wages away from the family for individual fitness gain (one indicator of paternal disinvestment) are a principal cause of verbal disputes and physical violence among spouses (Stieglitz et al., 2011). The Tsimane represent an informative case study, relative to fully market-integrated populations, of how reliance on a mixed economy based primarily on subsistence but with increasing market involvement and reliance on cash can influence intra-household distribution preferences. Understanding variability in these preferences informs evolutionary economic models of the family by examining their basic predictions (e.g. whether household production surplus is maximized), and builds on a growing body of psychological and experimental economic research into how different resource types influence decisions underlying production and distribution (Rosati & Hare, 2015).

We hypothesize that greater resource fungibility increases paternal disinvestment, thus favoring strategies employed by either spouse to protect fungible resources against a partner's claims for consumption (e.g. Anderson & Baland, 2002). If these strategies are internalized then we should expect revealed preferences in the distribution task for equality over efficiency for fungible resources that are most vulnerable to exploitation by either spouse. We test whether greater resource fungibility (i.e. money vs. meat) is associated with reduced preference for joint efficiency (P1). This prediction is inconsistent with a joint interest view that spouses are unequivocally motivated to maximize household production surplus.

In the distribution task distinct motivations can underlie one's preference for spousal equality (i.e. household inefficiency) including inequality aversion, selfishness (if efficiency entails less for oneself than equality), altruism (if efficiency entails less for one's spouse than equality) or irrationality (Table 1). These alternatives highlight the fact that equal but inefficient distribution preferences may still exist in harmonious marriages where spousal interests converge. To tease apart these alternatives and examine whether potentially divergent spousal interests affect revealed preferences, we test whether for a perfectly fungible resource like money, lower self-reported marital quality is associated with inefficient distribution preferences (P2). Specifically, reported marital conflict over paternal disinvestment – indicating differential consumption choices between spouses – should be associated with selfish money distribution preferences by either spouse (P2a).

In a stable marriage market, where spouses provide complementary investments, resource distribution preferences of spouses should be correlated (Becker, 1991) such that efficient spouses are assortatively paired. This assortment may reflect either one's preference for a partner with similar characteristics, consensus preferences in the market for desired characteristics (e.g. with desirable spouses choosing each other, and less desirable spouses "settling" for each other), propinquity effects, or convergence (i.e. the tendency for spouses to become more similar over time). We thus test whether distribution preferences of spouses are correlated (P3).

Lastly, we hypothesize that population-level differences in economic organization and the nature and degree of spousal interdependence are associated with population-level differences in revealed distribution preferences. We test whether Tsimane exhibit a greater preference for efficiency relative to a comparative Western European sample (P4). Tsimane reliance on a mixed hunting/foraging/horticultural economy coupled with their high fertility favors greater sex-specific economic specialization, generating a complementarity where hunted foods complement gathered/farmed foods, and men's focus on hunting increases women's time spent in childcare or subsistence efforts compatible with childcare (Kaplan & Lancaster, 2003). In contrast, competitive labor/consumer markets and greater labor market participation and income earned by women can reduce the value of a sexual division of labor by making men's and women's parental investments more substitutable and less complementary. When investments are less complementary and more substitutable, as more commonly occurs in market-integrated Western Europe versus subsistence-level Tsimane, then spousal resource distribution preferences are expected to be less efficient (all else equal).

## 2. Material and methods

### 2.1. Study population

Tsimane are semi-sedentary forager-horticulturalists living in the Bolivian Amazon. They inhabit 90+ villages ranging in size from ~50–550 individuals. They cultivate plantains, rice, corn, sweet manioc and other crops in small swiddens, and regularly fish and hunt. These foods comprise >90% of the diet, with the remainder purchased from market stores or obtained from trade with itinerant merchants. Tsimane live in extended family clusters, where the majority of food and labor sharing occurs. Modern contraceptives are rarely used and total fertility rate is high (9 births per woman) (Kaplan, Hooper, Stieglitz, & Gurven, 2015; McAllister, Gurven, Kaplan, & Stieglitz, 2012).

There are no formal marriage ceremonies and a couple is considered married when they sleep together in the same house. Mean  $\pm$  SD age at first marriage for men and women in the present sample is  $20.8 \pm 2.9$  and  $17.4 \pm 4.0$ , respectively. Post-marital residence rules are flexible but emphasize matrilocality early in marriage and patrilocality thereafter. Tsimane marriages are generally stable: men and women aged 45+ report a mean of 1.3 lifetime marital partners (Stieglitz, Blackwell, et al., 2012). Polygyny is infrequent (<10% of married adults) and usually sororal (Winking, Stieglitz, Kurten, Kaplan, & Gurven, 2013). Important characteristics of long-term mates for both sexes include industriousness and a good character (Gurven et al., 2009). Despite a lack of patriarchal norms and limited residential privacy, physical wife abuse is not uncommon and when it occurs is often triggered by verbal disputes over paternal disinvestment (Stieglitz, Gurven, et al., 2012; Stieglitz et al., 2011). Within marriage there is a belief that a husband's infidelity leads to his children's sickness and potentially death.

"Modernization", defined here as a trend toward urban residence and participation in the market (cash) economy, takes several forms: visits to the closest market town (San Borja), sale of horticultural and other products, itinerant wage labor (e.g. with ranchers) and schooling. Most wage opportunities are only available to men, are low income and sporadic. Many villages now have elementary schools (up to 5th grade)

taught by bilingual (Spanish-Tsimane) teachers, many of whom are Tsimane trained by missionaries. Secondary schools now exist in several larger villages, and young Tsimane adults are starting to become high school graduates. Generally, however, school attendance rates are low or inconsistent and adult literacy rate is low (34% in the present sample). Fluency in the Tsimane language (which is unrelated to Spanish) is universal as Tsimane remains the native language; 39% of adults (76% male) are fluent in Spanish. Mean  $\pm$  SD years of schooling for men and women is  $6.6 \pm 4.7$  and  $3.8 \pm 3.8$ , respectively.

### 2.2. Experimental assessment of spousal resource distribution preferences

A "distribution task" consisting of 15 questions was completed by husbands and wives from the same monogamous marriage ( $n = 53$  couples). Neither literacy nor Spanish fluency was required to participate, as respondents could either state their response and/or point toward a relevant image depicted on a laminated card to respond (see Electronic Supplementary Material [ESM] for additional experimental details including examples of images presented to respondents [Fig. S1], available on the journal's website at [www.ehonline.org](http://www.ehonline.org)). The experiment was conducted in two villages by JS and an assistant in the Tsimane language to increase informants' comfort levels. Basic numeracy was required to participate, and all respondents possessed this ability.

For each question, a respondent selects one of two options specifying his/her preferred allocation of a resource between him/herself and a partner (see Table 1 and Beblo et al., 2015 and Cochard et al., 2014 for details on the original implementation of this task among French and German couples). Tsimane respondents were queried about their distribution preferences for meat (dried and fresh) and money (Western Europeans were only queried about money). The task thus consisted of three rounds with five questions per round: round one choices concerned actual shares of dried meat, where responses determined participant compensation (see ESM, available on the journal's website at [www.ehonline.org](http://www.ehonline.org) and this section, below); round two choices concerned hypothetical shares of money (unincentivized); and round three choices concerned hypothetical shares of fresh meat (unincentivized). Round three was included to assess whether incentivizing options affects preferences for the same resource type (by comparing round three vs. round one preferences), and serves as a more natural comparison of preferences across resource types (by comparing round three vs. round two preferences, neither of which were incentivized). Across rounds, values of meat (dried or fresh) and money presented to respondents in each image are equivalent (e.g. 0.67 kg of actual dried meat = 30 Bolivianos [Bs] depicted in the image = 23.6 oz. of fresh meat depicted in the image). Any difference in preferences for meat versus money therefore cannot be attributed to a difference in value across resource types. Rounds, questions and options are presented in random order (i.e. not as shown in Table 1).

To recruit study participants, a radio message<sup>1</sup> was first presented in the Tsimane language that briefly introduced study objectives and logistics (e.g. participating villages, sampling restriction to married adults only, participant compensation). The following day the researchers held a village meeting, during which study objectives and protocols were explained in greater detail and any married meeting attendee was invited to participate with his/her spouse. The first village meeting was well attended since it was also held, coincidentally, to discuss plans for well construction by an independent engineering organization. High meeting attendance increased the pool of potential study participants, and limited self-selection by demographics, schooling and other factors (e.g. marital quality).

<sup>1</sup> A former Protestant Mission maintains a radio station in San Borja which communicates messages to listeners at fixed hours each day. Most Tsimane hear these messages (or have a neighbor who hears messages and then informs non-listeners) on their personal home radios.

During both village meetings and individual trials we explained to participants that they would receive two pay-outs of dried meat: 1) a show-up gift of 0.67 kg for each participant (worth 30 Bs or US \$4.30), and 2) up to another 0.67 kg (but as little as 0 kg) based on their distribution task responses in round one. We explained that compensation would be provided after all couples in the village participated. We selected dried meat as compensation because meat is always in high demand, regardless of market involvement, and because it is storable (~1 month). Participants thus did not feel pressure to consume the meat immediately and could freely choose whether and how to distribute it. Money was not used as compensation to avoid commodification and to minimize sample bias (e.g. money may appeal more to individuals with greater market involvement, thus potentially biasing participation rates). The total value of compensation per respondent was equivalent to one-half to one day's worth of wage labor, as has been used in economic experiments worldwide (Henrich et al., 2005). To incentivize decisions and ensure anonymity, one response in round one for each couple was randomly selected for the second pay-out. This pay-out was determined by two dice rolls: one to select whether the husband's or wife's round one response would be used, and another to choose the response. We repeatedly emphasized that responses were private and that a spouse would have no opportunity to discover one's own responses even after receiving compensation. Each participant received both pay-outs of dried meat simultaneously (i.e. in the same plastic bag), and could not deduce a partner's responses from the weight of the bag. During the experiment participants could not communicate with others, including spouses.

Distribution task instructions were translated into Spanish and then Tsimane by a bilingual Tsimane research assistant and JS. To test translation accuracy the Tsimane instructions were then back-translated into Spanish by a different Tsimane researcher, and discussions among the two Tsimane and JS ensued until an effective translation was found. Considerable care was taken to explain the instructions simply, both verbally and using the laminated cards (see ESM, available on the journal's website at [www.ehbonline.org](http://www.ehbonline.org)). After explaining instructions to each respondent in private, the respondent was asked two questions to test their comprehension. All respondents correctly answered both questions before beginning the study. Respondents were informed that there was no right or wrong way to complete the task, and were repeatedly encouraged to ask questions if anything was unclear. To further ensure comprehension we explained to participants how a given resource was actually distributed between spouses while the participant was presented with each question (15 questions\*2 options/question\*2 partners/option = 60 explanations/respondent). This combination of simultaneous visual presentation and verbal explanation ruled out the possibility that individuals were responding by rote without actually considering the efficiency-equality trade-off. Indeed, for each question most participants were observed to be correctly "doing the math" prior to responding. Participants were encouraged to carefully consider each option before responding, and to use as much time as needed. Once a response was provided the participant was asked if he/she was certain, while also being reminded of the implications for not having chosen the alternative. Participants were also asked to explain their responses using an open-ended format (i.e. "Why did you choose option A and not B?"). From these open-ended questions it was clear that respondents understood the task and actively considered the alternative on a question-by-question basis. The experimenter looked only at the laminated card (or bowls of dried meat) when participants responded to avoid inadvertent social cuing.

To gain insight into respondents' task perception, respondents were asked post-experiment whether task decisions resembled those encountered in daily life (unrealistic = 0, slightly realistic = 1, realistic = 2) and whether decisions were difficult (easy = 0, slightly difficult = 1, difficult = 2). Over half of respondents (62% men, 55% women) perceived decisions as realistic; 68% of men and 66% of women perceived decisions as easy.

### 2.3. Self-reported marital quality and socio-demographics

After the experiment, participants were queried about the frequency of serious verbal disputes with their spouse in the past three months (0 = none, 1 = once per month, 2 = once per week, 3 = several per week, 4 = daily). Participants then reported, without prompts, the cause of their most frequent serious verbal disputes in the past three months. This open-ended, free-listing technique was used because it does not force respondents into selecting preconceived categories and allows for a more thorough account than otherwise possible. We focused on the most serious disputes because we reasoned that they would provide the most accurate recall. No restriction was placed on the number of disputes that one could mention. After each dispute was reported, we systematically queried participants about the relevance of other potential causes (Stieglitz, Gurven, et al., 2012; Stieglitz et al., 2011). For example, if a wife reported a dispute over a husband's excessive alcohol consumption (one indicator of paternal disinvestment), we then asked the wife whether this dispute was also caused by the husband's neglect of particular subsistence tasks, childcare or domestic tasks, the husband's excessive social visitation, or other causes (see ESM for additional details, available on the journal's website at [www.ehbonline.org](http://www.ehbonline.org)).

Age and marital duration were estimated based on a combination of methods described elsewhere (Winking et al., 2013). Parity, schooling, Spanish fluency and literacy were assessed during annual census updates conducted by the Tsimane Health and Life History Project. After the experiment husbands were asked about their wage labor involvement (i.e. time elapsed since the last wage opportunity, and daily earnings from this opportunity) to gain further insight into market participation.

Mean  $\pm$  SD age of husbands and wives is  $34.8 \pm 12.2$  and  $30.9 \pm 12.0$ , respectively. Mean  $\pm$  SD marital duration is  $12.4 \pm 10.5$  years (range: 1 month–46 years), and mean  $\pm$  SD number of joint children is  $3.2 \pm 3.5$  (range: 0–13).

Procedures for all methods were approved by the UNM Human Subjects Review Board, Tsimane government, village leaders and study participants.

### 2.4. Data analysis

Outcomes include responses to individual distribution task questions, and aggregate responses in a given round (see electronic appendix). The latter are used to classify respondents as follows: always maximize joint payoffs (efficient), always maximize a partner's payoff (extreme altruist), or always maximize own payoff (extreme selfish) (see Table 1). To classify other respondents whose aggregate preferences are not represented, we calculate a ratio of "own payoff" to "couple payoff" summed over the five questions in a round. We calculate for the five questions the sum of own payoff divided by the sum of couple payoffs, which corresponds to the share of the total payoff retained by the respondent. If this share equals 0.5 then respondents are classified as "symmetric-inequality averse" (i.e. their preference is symmetric around question #3); if this share is greater (or lower) than 0.5 respondents are classified as "asymmetric selfish" (or "asymmetric altruist"). Respondents who did not select option B for question #3 are classified as "irrational".

We utilize both within- (P1) and between-subjects (P2–P4) comparisons to test predictions. Chi-square and Mann–Whitney *U* tests are used for descriptive analyses. Generalized estimating equations (GEE) analyses are used to model effects of resource type on the probability of choosing an efficient distribution. This method accounts for the correlated structure of a dependent variable arising from repeated measures on the same individual (Liang & Zeger, 1986). There is no standard absolute goodness-of-fit measure with the GEE method (Pan, 2001), which does not make distributional assumptions and uses a quasi-likelihood rather than full likelihood estimation approach (see Pan, 2001 for a general formulation). Logistic regression is used for

between-subjects analyses to model the probability of being classified as efficient (or selfish, etc.) based on aggregate preferences. A stepwise approach is used to fit regression models. Parameter estimates are reported as odds ratios (ORs) or predicted probabilities. GEE and logistic regressions assume that between-subjects measurements are independent, which may not be realistic if spousal distribution preferences are correlated (P3). We therefore repeated analyses after including a random intercept for couple ID in mixed effects logistic regressions, although couple ID did not yield a significant variance estimate or affect results. Fixed effects of village ID and distribution task question number (indicating degree and direction of inequality) were also not significant and omitted. For all continuous predictors we tested for non-linear associations using quadratic or cubic terms. To test for population-level differences in money distribution preferences we merged French and German samples into one “Western European” sample; differences between French and Germans have been reported elsewhere (Beblo et al., 2015) and are not of primary interest here.

### 3. Results

#### 3.1. Classification of Tsimane spouses based on aggregate distribution task preferences

No respondent is classified as “extreme selfish” or “irrational” for either resource type (meat [dried or fresh] or money). When meat distribution options are incentivized (dried meat), all respondents choose efficiency (Fig. 1). When meat distribution options are not incentivized (fresh meat), all husbands and nearly all wives (96%) still choose efficiency, indicating that incentivizing options does not strongly affect preferences for the same general resource type.

For money, most husbands (87%) and wives (70%) choose efficiency. Wives not consistently preferring efficiency are either asymmetric selfish (hereafter “selfish” unless otherwise noted, 13%), asymmetric altruistic (8%), symmetric-inequality averse (hereafter “symmetric”, 6%) or extreme altruistic (4%). Selfish wives are more likely than other wives to report a spousal dispute over paternal disinvestment (86% vs. 17%, Fisher's Exact  $p = 0.001$ ) (Table S1, available on the journal's website at [www.ehbonline.org](http://www.ehbonline.org)), but do not differ from other wives in terms of demographics, indicators of modernization or task perception. Husbands not consistently preferring efficiency are either selfish (6%), symmetric (6%) or extreme altruistic (2%)<sup>2</sup> (Fig. 1). Efficient husbands are more likely than other husbands to be fluent in Spanish (63% vs. 29%, Fisher's Exact  $p = 0.096$ ) and earn more per day from their last wage opportunity (mean = 68 vs. 57 Bs, Mann–Whitney  $U p = 0.081$ ) (Table S2, available on the journal's website at [www.ehbonline.org](http://www.ehbonline.org)). Wives are less likely than husbands to choose efficiency ( $\chi^2 = 4.50$ ,  $p = 0.034$ , 106 individuals), are more likely to be asymmetric altruistic (Fisher's Exact  $p = 0.059$ ), but are not more likely to be selfish ( $\chi^2 = 1.77$ ,  $p = 0.184$ ).

#### 3.2. Is greater resource fungibility (i.e. money vs. meat) associated with reduced preference for joint efficiency (P1)? Yes

Tsimane respondents selected the inefficient option for 6.1% of observations,<sup>3</sup> and 90.4% (47/52) of inefficient responses occur with money as the resource type. Probability of choosing efficiency is much lower for money (adjusted  $OR_{Money} = 0.087$ , 95% CI: 0.02–0.38,  $p = 0.001$ ) after controlling for potential confounders including demographics and indicators of marital quality, modernization and task perception (Table S3,

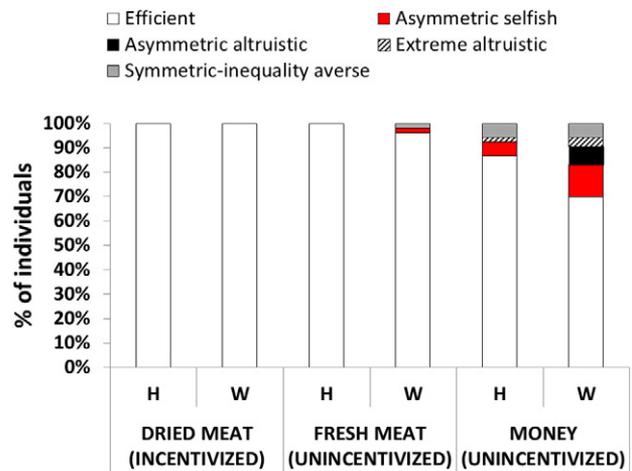


Fig. 1. Classification of husbands (H) and wives (W) based on aggregate distribution task preferences for each resource type ( $n = 53$  husbands and wives from the same marriage).

available on the journal's website at [www.ehbonline.org](http://www.ehbonline.org)). Holding significant confounders constant (at the sample mean), the predicted probability of choosing efficiency is 0.99 for meat and 0.92 for money; these probabilities do not change after including fixed effects of village ID and distribution task question number (indicating degree and direction of inequality), which are not significant. Across resource types, inefficient responses of both husbands and wives are equally prevalent based on whether a husband or wife receives the greater resource share (i.e. half of inefficient responses [husbands: 8/16, wives: 18/36] occur when a wife receives the greater share, and half occur when a husband receives the greater share) (Fig. S2, available on the journal's website at [www.ehbonline.org](http://www.ehbonline.org)). Resource type effect size is therefore similar if regressions are restricted to question #'s 1–2 (inequality favors wife) or to question #'s 4–5 (inequality favors husband). Inclusion of separate interaction terms between resource type and either age, sex or number of joint children does not yield significant parameter estimates.

#### 3.3. Is lower self-reported marital quality associated with inefficient – particularly selfish – money distribution preferences (P2)? Yes

Inefficient preferences can result from selfishness, altruism or inequality aversion, but analyses in Section 3.2 do not distinguish between these alternatives. To test P2 it is therefore necessary to conduct between-subjects analyses using aggregate responses.

Sixty-nine percent of respondents (66% husbands, 72% wives,  $\chi^2 = 0.396$ ,  $p = 0.529$ ) reported having a serious verbal dispute with a partner in the past three months. Respondents who reported having a dispute are more likely paired with someone who likewise reported a dispute ( $\chi^2 = 6.324$ ,  $p = 0.012$ ), indicating spousal consistency in reporting. Further, respondents who reported having a dispute over paternal disinvestment (15% husbands, 26% wives,  $\chi^2 = 2.065$ ,  $p = 0.151$ ) are more likely paired with someone who also reported this same type of dispute (Fisher's Exact  $p = 0.023$ ). Disputes over paternal disinvestment are among the most commonly free-listed disputes by both sexes (Fig. S3, available on the journal's website at [www.ehbonline.org](http://www.ehbonline.org)).

As predicted, those reporting paternal disinvestment disputes are more likely to be selfish ( $OR_{Disinvestment} = 12.6$ , 95% CI: 2.93–54.28,  $p = 0.001$ ). Respondents reporting any disinvestment dispute trend toward being less efficient ( $OR_{Disinvestment} = 0.38$ , 95% CI: 0.14–1.07,  $p = 0.067$ ), but this negative effect weakens slightly after including demographic controls ( $OR_{Disinvestment} = 0.47$ , 95% CI: 0.16–1.39,  $p = 0.172$ , controlling for age, age<sup>2</sup> and sex). However, respondents reporting any recent dispute are not less likely than other respondents to choose efficiency, but trend toward being less altruistic after controlling for potential confounders (adjusted  $OR_{Dispute\ Reported} = 0.258$ , 95%

<sup>2</sup> Total  $\neq 100$  due to rounding.

<sup>3</sup> For consistency the sample is restricted to distribution preferences for fresh meat and money (both of which are unincentivized and elicited using hypothetical resources); preferences for dried meat (which are incentivized and elicited using the actual resource) are omitted from analyses. Moreover, for each resource type responses to question #3 (where there is no efficiency–equality trade-off) are omitted because no respondent selected the irrational option A. The analysis sample is thus 848 observations (2 resource types [fresh meat and money]\*4 questions/type\*106 respondents).

**Table 2**

Determinants of being classified as efficient, selfish, altruistic, or symmetric-inequality averse based on aggregate money distribution preferences (n = 53 husbands and wives from the same marriage). Logistic regression coefficients are presented as odds ratios.

Predictor	Bivariate models				Stepwise models			
	Efficient	Selfish	Altruistic <sup>h</sup>	Symmetric	Efficient	Selfish	Altruistic <sup>h</sup>	Symmetric
<i>Indicator of reduced marital quality</i>								
Any dispute reported <sup>a</sup> (vs. not reported)	1.237	1.061	0.311*	2.353	-----	-----	0.258*	-----
Any dispute over paternal disinvestment <sup>b</sup> (vs. not reported)	0.380*	12.600***	----- <sup>i</sup>	0.752	-----	12.600***	----- <sup>i</sup>	-----
<i>Demographic</i>								
Age <sup>c</sup> (years)	0.806	0.982	5.928*	1.009	0.743*	-----	-----	-----
Age <sup>2</sup> (years)	1.003*	-----	0.969*	-----	1.004*	-----	-----	-----
Sex = male	2.842**	0.394	0.151*	1.000	3.314**	-----	0.108*	-----
# joint children < age 10 <sup>d</sup>	0.669**	1.184	2.122**	1.146	-----	-----	2.148**	-----
<i>Indicator of modernization</i>								
Schooling <sup>e</sup> (years)	1.012	1.063	0.666*	1.057	-----	-----	-----	-----
Fluent in Spanish (vs. not or partially)	2.066	0.654	0.246	0.782	-----	-----	-----	-----
Partner schooling <sup>f</sup> (years)	0.916*	1.113*	1.013	1.080	-----	-----	-----	-----
Time since H's last wage opportunity <sup>g</sup> (months)	1.033	0.973	0.993	0.905	-----	-----	-----	-----
H's daily wage from last opportunity <sup>g</sup> (2014 Bs)	1.012	0.984	0.994	0.992	-----	-----	-----	-----
<i>Task perception</i>								
Realistic (vs. not)	1.739	0.437	0.943	0.695	-----	-----	-----	-----
Easy (vs. not)	2.253*	0.289*	1.250	0.471	-----	-----	-----	-----

<sup>a</sup> Refers to serious verbal disputes with a partner in the past three months. <sup>b</sup>Dispute causes were free-listed by respondents without prompts. Paternal disinvestment includes excessive alcohol consumption, infidelity (perceived or real) or irresponsible use of money (see Stieglitz et al., 2011; Stieglitz, Blackwell, et al., 2012; Stieglitz, Gurven, et al., 2012). <sup>c</sup>Marital duration is strongly correlated with age (Pearson  $r = 0.83, p < 0.001$ ) and is not a significant predictor in univariate models; marital duration is thus omitted. Spousal age difference (H-W, years) is also not a significant predictor and is omitted. <sup>d</sup>Whether a respondent has any living children from prior unions (vs. none) is not a significant predictor and is omitted (# of children from prior unions [total or < age 10] is also not significant). <sup>e</sup>Literacy (vs. none or partial) is not a significant predictor and is omitted. <sup>f</sup>Neither partner literacy nor partner Spanish fluency are significant predictors and are omitted. <sup>g</sup>As reported by husband; logged value also yields a nonsignificant result. <sup>h</sup>Includes both "asymmetric altruistic" and "extreme altruistic" classifications. <sup>i</sup>No altruist reported a dispute over paternal disinvestment.

\*  $p \leq 0.1$  \*\* $p \leq 0.05$  \*\*\* $p \leq 0.01$ .

CI: <0.01–2.02,  $p = 0.1$ ) (Table 2). No indicator of modernization or task perception is significantly associated with aggregate distribution task preferences in bivariate or stepwise regressions, thus ruling out these potential confounders. The fact that preferences for inefficiency and greater selfishness are associated with paternal disinvestment disputes – but not any dispute (Table 2) – reduces the possibility that other types of marital conflicts influence this association. Indeed, in separate analyses (not shown) aggregate distribution task preferences among respondents reporting disputes other than paternal disinvestment (e.g. over a wife's "neglect" of domestic work, see Fig. S3, available on the journal's website at [www.ehonline.org](http://www.ehonline.org)) are not significantly different from respondents reporting no such disputes. We find no significant interaction effect of

sex and dispute reports (over paternal disinvestment or other causes) on preferences. Similarly, no indicator of modernization interacts with dispute reports to affect preferences.

3.4. Are distribution preferences of spouses correlated (P3)? Partially

To test P3 we restrict analyses to money distribution preferences given limited variance in meat distribution preferences. Seventy-four percent of efficient husbands (n = 46) are paired with efficient wives, compared to 33% of selfish (n = 3), 0% of altruistic (n = 1) and 67% of symmetric husbands (n = 3) (Fig. 2). Efficient husbands are less likely than other husbands to be paired with selfish wives ( $OR_{\text{Husband efficient}} =$

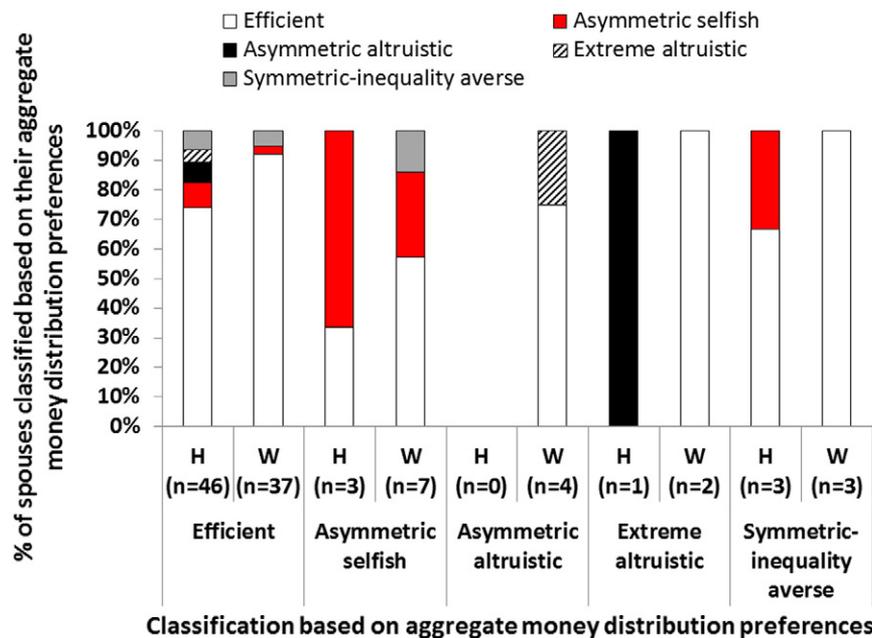


Fig. 2. Marital assortment by money distribution preferences among Tsimane (n = 53 couples).

0.127, 95% CI: 0.02–0.78,  $p = 0.026$ ,  $n = 53$ ), and efficient husbands are more likely (albeit not significantly) paired with efficient wives (OR<sub>Husband efficient</sub> = 3.778, 95% CI: 0.74–19.38,  $p = 0.11$ ). Sixty-seven percent of selfish husbands are paired with selfish wives, compared to 9% of efficient, 0% of altruistic and 33% of symmetric husbands (Fig. 2). Selfish husbands are more likely paired with selfish wives (OR<sub>Husband selfish</sub> = 18.000, 95% CI: 1.38–235.69,  $p = 0.028$ ). These results – while based on a small sample size – do not change controlling for schooling of each spouse, which is moderately positively correlated (Pearson  $r = 0.37$ ,  $p = 0.006$ ). Results also do not change controlling for task perception of each spouse, which is positively correlated for one but not both indicators (agree task easy:  $\chi^2 = 4.02$ ,  $p = 0.045$ ; agree task realistic:  $\chi^2 = 0.29$ ,  $p = 0.591$ ). Spousal distribution preferences are not more strongly correlated with increasing marital duration, suggesting minimal/no convergence in preferences over time.

### 3.5. Are efficient money distribution preferences more common among Tsimane than western Europeans (P4)? Yes

We restrict analyses of P4 to money distribution preferences since Western Europeans were not queried about preferences for other resource types. Tsimane husbands and wives are more likely than Western Europeans to choose efficiency (husbands: 87% vs. 56%,  $\chi^2 = 15.87$ ,  $p < 0.001$ ,  $n = 209$ ; wives: 70% vs. 53%,  $\chi^2 = 4.80$ ,  $p = 0.028$ ,  $n = 209$ ) (Fig. 3; Table S4, available on the journal's website at [www.ehbonline.org](http://www.ehbonline.org)). The group-level difference is significant controlling for age and sex (adjusted OR<sub>Tsimane</sub> = 2.631, 95% CI: 1.56–4.45,  $p < 0.001$ ,  $n = 418$ ), and is not attenuated after including other demographic covariates (marital duration, spousal age difference or number of co-resident children). Inclusion of a group-by-age interaction term yields a significant parameter estimate (interaction  $p = 0.01$ , controlling for sex), indicating that Western Europeans but not Tsimane are less likely to choose efficiency with age (Fig. S4, available on the journal's website at [www.ehbonline.org](http://www.ehbonline.org)). Inclusion of additional interaction terms between group and other demographic predictors does not yield significant parameter estimates.

Despite no Tsimane being classified as “extreme selfish”, Tsimane wives are more likely than Western Europeans to exhibit selfish preferences (asymmetric selfish or extreme selfish) (wives: 13% vs. 3%, Fisher's Exact  $p = 0.007$ ; husbands: 6% vs. 7%, Fisher's Exact  $p = 0.506$ ). There is a significant group-by-sex interaction effect on the probability of exhibiting any selfish preference (interaction  $p = 0.033$ , controlling for age) (Fig. S5, available on the journal's website at [www.ehbonline.org](http://www.ehbonline.org)). Inclusion of other demographic predictors as either main effects or interacting with group does not yield significant parameter estimates.

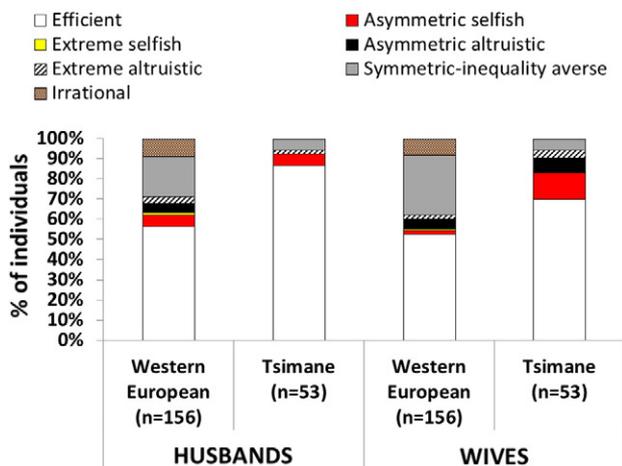


Fig. 3. Money distribution preferences of Western European and Tsimane spouses ( $n = 209$  couples).

There are no group-level differences in the probability of exhibiting altruistic preferences (asymmetric altruist or extreme altruist) (Fig. 3; Table S4, available on the journal's website at [www.ehbonline.org](http://www.ehbonline.org)). Tsimane husbands and wives are less likely than Western Europeans to prefer a symmetrical distribution (husbands: 6% vs. 20%,  $\chi^2 = 5.87$ ,  $p = 0.015$ ; wives: 6% vs. 30%,  $\chi^2 = 12.51$ ,  $p < 0.001$ ). These group-level differences are significant controlling for age and sex (not shown); inclusion of other demographic predictors as either main effects or interacting with group does not yield significant parameter estimates.

## 4. Discussion

Using an experimental approach stipulating a trade-off between household efficiency and spousal equality in distributing production surplus, we find that Tsimane spouses strongly prefer efficient meat distributions. Meat distribution preferences are similar for unincented responses (Fig. 1), and are consistent with a joint interest view that marriage in small-scale societies achieves economic efficiency and maximization of household production surplus (Isaac, 1978b; Kaplan & Lancaster, 2003; Lancaster & Lancaster, 1983; Lovejoy, 1981; Murdock & Provost, 1973). The efficiency preference is apparent even though our distribution task does not specify who acquired the resource, which could in principle minimize salience of the perceived benefits provided by sex-specific economic specialization and complementarities between spouses' distinct productive efforts. The fact that Tsimane women in particular prefer household efficiency – regardless of whether a wife or husband possesses meat – is not compatible with a separate interests view that women's mate choice is indifferent to men's willingness to provide acquired game for household consumption.

Consistent with P1 we find a much stronger efficiency preference for meat compared to money, despite the fact that both resources are almost exclusively acquired by men in this population. Including numerous potential confounders does not influence the strong effect size of resource type, equivalent to an 11-fold increase in odds of choosing efficiency for meat compared to money. While most spouses prefer efficiency over other distributions (Fig. 1), inefficient preferences result from a combination of selfishness, altruism and inequality aversion. This variability in preferences is consistent with a hybrid approach containing elements of both joint and separate interests views of marriage (Table 1B) (also see Gurven et al., 2009). The preference for household inefficiency may be related to intra-household inequality aversion since no Tsimane prefers to maximize his/her own monetary payoff (extreme selfishness) and only 3% prefer to maximize a partner's payoff (extreme altruism). Despite the possibility of post-experiment payoff pooling resulting in an equal distribution regardless of revealed preferences, 22% of Tsimane (13% men, 30% women) prefer the inefficient but equal money distribution option at least once (47/530 round two observations [8.9%]), providing a lower bound prevalence of inequality aversion.

Our finding that meat and money elicit different preferences is broadly consistent with prior experimental and neuroimaging research indicating that people make value-based decisions differently when faced with decisions about money versus either food or other concrete inedible payoffs (Rosati & Hare, 2015). People exhibit fewer risk-seeking preferences and reduced reward discounting for money, even in small amounts, compared to desirable food or inedible prizes. Distinct brain regions also appear to underlie value-based decisions based on whether payoffs are monetary or not (Clithero & Rangel, 2014). It has thus been suggested that different psychological processes motivate decisions about abstract compared to concrete payoffs of similar value. Money may uniquely influence decision-making because of its fungibility and liquidity, as people exhibit fewer risk-seeking preferences in experiments when money can be freely exchanged for other payoffs compared to when this ability is constrained (Rosati & Hare, 2015). Taken together, this prior research – usually conducted in Western populations and in contexts where payoffs are not divided with others –

suggests that expectations about resource fungibility and liquidity directly affect consumption decisions. The present study generalizes to a non-Western subsistence-level population the finding that money elicits different preferences for use compared to food, and provides an ultimate explanation for why resource fungibility and liquidity is central to understanding consumption and distribution preferences within households.

We hypothesized that the greater fungibility of money compared to meat, and as a result the greater potential to squander money for individual fitness gain at a cost to the family (Stieglitz, Blackwell, et al., 2012), favors unique individual strategies to protect money against a partner's claims for consumption (e.g. Anderson & Baland, 2002). As expected if these strategies are internalized, we find that spouses are more likely to reject household efficiency for an equal distribution of the highly fungible resource most vulnerable to exploitation by a partner. This finding is not compatible with a joint interest view that spouses are unequivocally motivated to maximize household production regardless of resource type. Resource fungibility may be one of several resource characteristics (e.g. in addition to variance in daily acquisition, degree of complementarity with other household investments) that influence perceptions of the marginal gains from individual consumption and distribution (Kaplan & Gurven, 2005).

Consistent with P2 we find that reported marital conflict over paternal disinvestment is associated with a nearly 13-fold increase in odds of revealing a selfish money distribution preference (Table 2). Greater preference for costly selfishness is uniquely associated with recent paternal disinvestment disputes, but not any other recent marital disputes, which is broadly consistent with prior research indicating that paternal disinvestment is the principal cause of intense verbal and physical conflict among Tsimane spouses (Stieglitz, Gurven, et al., 2012). Paternal disinvestment thus presents a principal barrier to allocating household resources efficiently, as suggested by a separate interests view that spousal disagreement over appropriate use of household resources leads to costly selfish actions (Bloch & Rao, 2002; Borgerhoff Mulder & Rauch, 2009; Mani, 2011; Munro et al., 2006). Experimental research in rural Kenya demonstrates that greater spousal heterogeneity in discounting preferences – similarly indicating differential consumption choices – leads to inefficient and selfish savings behavior, whereas greater spousal homogeneity in preferences facilitates household efficiency in savings (Schaner, 2015). Our results suggest that greater resource fungibility per se can promote costly selfish actions even among spouses with homogenous allocation preferences, and that actions are explained by factors impacting perceptions of individual fitness gains within and outside of marriage.

Despite a small sample size, we find partial support for P3, as selfish husbands are significantly more likely than other husbands to be paired with selfish wives. Marital assortment may result from “market forces”, i.e., consensus in the marriage market regarding desirable partner characteristics. If selfishness is a characteristic that most find undesirable in a partner, then selfish individuals should attract fewer partners and thus pair with the less desirable (in this case, other selfish individuals). Similar logic may explain why efficient husbands are less likely paired with selfish wives, although we cannot rule out alternative explanations (e.g. propinquity effects, preference for a partner with similar characteristics as oneself). Among Tsimane, work effort and productivity are important mate choice criteria for both sexes, spouses engage in similar levels of work effort, and time allocation to work for each spouse is positively associated with fertility (Gurven et al., 2009). Positive assortment by personality is also evident for traits such as agreeableness and conscientiousness (unpublished data), which may facilitate household coordination and efficiency. Spousal distribution preferences are not more strongly correlated with increasing marital duration, which ranges from one month to 46 years in the present sample. Assortment may therefore be due to initial preferences upon union formation rather than preference convergence over time. Odds of being paired with an efficient wife are nearly four-fold higher for efficient versus inefficient

husbands, although the effect is not significant because of the small sample size of inefficient husbands ( $n = 7$ , see Fig. 2). Given the percentage of efficient and inefficient husbands paired with efficient wives (74% and 43%, respectively), a post-hoc power analysis indicates that a sample size of 125 husbands (a 136% increase from the current sample size) would be required to attain 80% power at an alpha of 0.05 with an identical unbalanced design. Obtaining this larger sample would have entailed visiting multiple additional Tsimane villages, which was not possible given various constraints. Nevertheless, prior experimental studies with larger sample sizes in rural Africa find that spouses with similar characteristics (e.g. level of schooling) generate greater household surplus (Munro et al., 2006; Schaner, 2015), which is broadly consistent with the findings reported here.

Consistent with P4, we find that Tsimane are more likely than Western Europeans to choose efficiency (Fig. 3). We suggest that group-level differences in economic organization and degree of complementarity in parental investments motivate the observed differences in distribution preferences. Multiple lines of evidence (Henrich et al., 2005) indicate that common economic tasks affect basic values underlying preference formation, and that these values in turn affect temperament and behavior. If these values are internalized, generalized and expressed, and if learning processes are adaptive and flexible, then the greater preference for monetary efficiency among Tsimane in a novel experimental situation may not be so surprising in light of their comparatively limited market exposure. Specialization in household production by sex that is characteristic of forager-horticulturalists can inform one's expectations of a spouse's preferences, such that even in an experiment Tsimane may expect a partner to behave in a similarly efficient manner. These expectations can sustain a high degree of cooperation throughout marriage, which may help explain why Tsimane efficiency preferences vary little with age (unlike for Western Europeans, see Fig. S4, available on the journal's website at [www.ehbonline.org](http://www.ehbonline.org)). At the same time, a greater preference for selfishness among Tsimane women compared to Western European women (Fig. S5, available on the journal's website at [www.ehbonline.org](http://www.ehbonline.org)) suggests a willingness to sacrifice household efficiency for greater personal control of fungible and liquid resources. This preference can indicate a broader adaptive strategy employed by Tsimane women to protect money against a husband's claims for consumption, especially because monetary access is often male-dominated and can result in costly paternal disinvestment.

#### 4.1. Strengths and limitations

The research design minimizes response and sampling biases. Data are obtained independently from both spouses instead of only one spouse, permitting assessment of spousal consistency in reporting. Indeed, we find consistency in reporting recent verbal disputes in marriage (Section 3.3). Study recruitment and participant compensation (Section 2.2) also limited self-selection by demographics, degree of modernization and marital quality. Moreover we can rule out potential “contamination effects”, which are expected if Tsimane participants, after completing the study, informed others of what to expect and thus biased others' distribution task responses. To test for such effects we examined whether distribution preferences within a village changed over time but found no such evidence. Regarding external validity, a majority of respondents indicated that distribution task questions resembled the types of decisions encountered in daily life (Section 2.2). Variability in task perception did not significantly affect any outcome or modify effect sizes of primary predictors. The fact that no Tsimane exhibited an irrational distribution preference and the fact that all Tsimane correctly answered both pre-task comprehension questions suggests that Tsimane understood the task. Results of cross-population analyses (Section 3.5) are not affected if irrational Western Europeans are omitted from analyses. Our study is the first to our knowledge to systematically compare resource distribution preferences among couples in

subsistence-level and fully market-integrated populations using a common experimental framework.

Nevertheless, resource transfers outside of the “laboratory” obviously cannot be prevented in experiments among spouses. If post-experiment transfers are indeed common then this affects our ability to correctly classify spouses based on their aggregate preferences (e.g. an “asymmetric-selfish” wife may transfer half of her resources to a husband post-experiment and thus prefer inequality aversion to selfishness). Relatedly, there are other possible explanations of altruistic preferences; altruistic spouses may allow or expect a partner to divide a resource equally among co-resident kin, and thus altruism could be a sign of partner respect even at the expense of household efficiency. Perhaps this helps explain why degree of offspring dependency is associated with inefficient distributions (see Table S3, available on the journal’s website at [www.ehbonline.org](http://www.ehbonline.org), Table 2). Alternatively, altruism could be a form of extra-pair mating effort, as predicted by a separate interests view of marriage, if reputational benefits of altruism entail extra-pair mating opportunities or other social benefits. Our inability to validate revealed preferences with subsequent behavioral measures represents a significant study limitation that hinders stronger interpretation of observed empirical patterns. Another study limitation is the small sample size, especially for testing P3.

#### 4.2. Conclusion

Examination of spousal preferences for distributing household production surplus reveals evidence for both joint and separate interests views of marriage (cf. Anderson, Kaplan, Lam, & Lancaster, 1999). Shared and distinct spousal preferences are explained by ecological-, family-, and individual-level factors impacting perceptions of marginal gains within and outside the household. A hybrid approach explains intra- and inter-population variation in distribution preferences. Determining whether such preferences predict marital behavior and outcomes should be a focus of future research.

#### Supplementary materials

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.evolhumbehav.2016.07.002>.

#### Acknowledgments

We thank the Tsimane couples that participated in this study, and Miguel Mayer Vie for assistance with study implementation. We thank Maguin Gutierrez Cayuba for assistance with translation, and Tsimane Health and Life History Project personnel for logistical support. We also thank participants of the 4th Behavioral and Experimental Economics (BEE) workshop at the Université de Lyon for providing useful comments that improved the quality of the manuscript. Two anonymous reviewers also provided constructive comments that improved the manuscript. Funding was provided by the Agence Nationale de la Recherche (ANR) – Labex IAST, and by ANR grant SINT (ANR-15-CE33-0005-01).

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