GENDER ROLES AND NON-COOPERATIVE BEHAVIOR: FIELD EXPERIMENT ON THE EFFECT OF ASYMMETRIC INFORMATION ON INTRA-HOUSEHOLD ALLOCATION IN GHANA

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Abstract:

We present a simple model of intra-household bargaining relations in rural Ghana, a context in which men and women hold separate economies and spending patterns differ by gender. The model shows how when there is asymmetric information over monetary transfers between spouses, the incentives to hide income depend on the role spouses play within the household. Specifically, the obligation incumbent on men in Akan tradition to make transfers to their wives gives them a strategic advantage which may induce wives to hide income from their husbands. We then test the model's predictions using data from a unique field experiment in rural Ghana, where participants in a household survey had a chance to win public and private lottery prizes. These prizes were allocated at random to husbands or wives. The household survey data capture how these prizes were subsequently used. We find significant differences in the use of prize money depending on its visibility. Public prizes were spent in more visible ways, such as on food, household assets or health. There is evidence that husbands and wives both hid private prize money, but in different ways. Wives were more likely than husbands to save their private cash prizes. Both spouses also invested prize winnings in their social network in the form of gifts or loans. To the extent that there is a distortion in the allocation of private income, we find that it is intertemporal rather than product-specific, and biased towards greater saving.

Key words: incomplete information, income hiding, non-cooperative family bargaining.
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"The family is the basic building block in the edifice of institutions that govern social and economic interactions. How the family allocates resources across its members has important implications both for individual outcomes, as well as for public policy on issues such as property rights and income transfers" (Mani, 2010).

1. Introduction

Although an extensive literature dating back to Becker examines the dynamics of resource allocation within the family, fundamental questions about the family unit remain unresolved. Are family members, with repeated interaction over a long time, able to eliminate the frictions we observe in contracting? Do spouses actually have access to better information about each other's income? And if they don't, do they exploit their private information? If spouses choose to exploit their information advantages by concealing money from each other, this may have consequences for resource allocation and welfare. Within a cooperative marital contract, spouses must allocate resources away from goods that can easily be monitored, which can result in underinvestment in household public goods.

In a development setting, such behavior may contribute to an intergenerational poverty trap. Since child human capital investments, such as education and nutrition, are easily monitored, spouses who conceal income may spend less on such investments. This limits their children's productivity later in life (Duflo, 2001; Rosenzweig, 1990). It might also have consequences for the strength of the observed relationship between female earnings and investment in children: women who conceal their income from their husbands may invest less in their children than those who do not.

The allocation of resources within the household has historically been viewed as either the result of a single household member (unitary or common preference model) or the result of a cooperative decision among the collective of household members (which model?). It is often argued that, because families involve long-term, repeated interactions and caring, households will realize there are opportunities for Pareto improvement and thus cooperation will evolve over time (see Browning et al., 2008, for a review of the literature on the subject). However, these opportunities may diminish if asymmetric information over money exists between spouses, that is, if it is the case that one spouse is able to conceal income without risk of detection. Recent empirical evidence has documented inefficient allocations (Udry, 1996) and non-cooperative behavior as a result of asymmetric information within the household (Chen (2009); de Laat (2009); Ashraf, (2009); Castilla (2011)).

Households living under the same roof can be subject to asymmetric information (Pahl (1983; 1990); Boozer et al. (2009); Bursztyn and Coffman, (2010); Castilla (2011)), and the literature on the response of household members to having informational advantages over own income is scarce. Ashraf (2009) conducted field experiments in the Philippines to examine the effect of the information environment on savings decisions among married couples. She finds that when husbands have private information over their own resources, they deposit the money into their private accounts. Because Ashraf's experiments end at the point when spouses choose to deposit the money in a certain account we cannot determine the effect of asymmetric information outside of the laboratory environment. Castilla (2011) finds that husbands hide farm income from their spouses in the form of gifts to extended family; however, the data used does not allow her to compare the likelihood of hiding when wives have information advantages.

In this paper we expand upon the findings of Castilla (2011) to examine the effect of asymmetric information over money on expenditure. In order to do this, we use data from a field experiment in Southern Ghana in which subjects participated in a lottery. Half of the prizes were given out in public (in front of the entire village) and the remaining half were distributed in private. Husbands and wives had the same probability of winning a prize, which allows us to compare spouses' responses to prize-winning by gender. Further, using baseline data collected before the experiments were conducted, and follow-up data collected afterwards, we can test the effect of asymmetric information on actual household expenditure[3].

Southern Ghana is an ideal setting for analyzing intrahousehold resource allocation because of the extent to which the standard marital contract deviates from the commonly assumed unitary model. In Ghanaian households men and women maintain separate economies, such that no spouse has control over all of the household's resources, and spending patterns differ by gender (Goldstein, 2004). Nonetheless, it is common for spouses to exchange resources formally through intra-household transfers called "chop money" (usually flowing from husband to wife), as well as irregular gifts and loans. It seems then that either the intra-household allocation of resources is non-cooperative (each spouse controls his/her own resources), or that the fall-back alternative when household members cannot reach a bargaining agreement (the threat point) corresponds to a non-cooperative equilibrium within marriage where the husband makes positive transfers to his wife. In the unitary model, or in a separate-spheres model where preferences are identical, transfers are of little interest because the redistribution of resources between spouses has no effect on consumption decisions. However, when household bargaining is non-cooperative, utility functions differ and there is asymmetric information, there can be incentives to hide unobservable resources. These incentives differ depending on the role each spouse plays within the marital contract and on the patterns of intra-household transfers.

We present a simple model of intra-household allocation to show that when the quantity of resources available to the household is not perfectly observed by all household members, the

[3] We use data on individual spousal expenditure, as well as aggregate household expenditure on different items.

incentives to hide income depend on the role spouses have within the resource management contract. We follow the assumption used in Lundberg and Pollak's (1993) separate spheres model that spouses do not commit to any binding agreements, and extend the framework in Castilla (2010). In Ghana, the marital contract obliges husbands to provide chop money to their wives to pay for food and household items (Ogbu, 1978). Wives, on the other hand, are allowed to choose how to spend the chop money. In equilibrium, the husband has no incentives to hide money because through his chop money allowance he can indirectly determine the household public good allocation. Conversely, when the wife has private information over her own money, she has an incentive to hide from her husband in order to keep him from reducing the chop money allowance. Two testable hypotheses fall out of the model: (1) hiding of money occurs when observable resources do not respond to changes in unobservable money, while unobservable resources do; (2) the spouse in charge of deciding the chop money allowance has no incentives to hide, while the spouse responsible for household public good provision does.

We test these predictions on the Ghanaian survey data, exploiting the fact that household income was experimentally and randomly perturbed using the lottery prizes. The model predicts that winning a prize will have differential effects on resource allocations depending on the gender of the winner, and the ease with which the prize is observed by his or her spouse. In line with the model's predictions, we find that spending patterns in response to prize winning differ by gender and by the publicity of the prize. Publicly won prizes were spent on household public goods that are highly visible, such as food, utilities, and assets. Meanwhile, private prizes were invested in relatively more concealable goods such as public transportation and gifts. Wives appear to have spent their prize money more slowly, suggesting that they were able to save the money until needed. Both husbands and wives also invested some of their prize winnings in the social network, in the form of gifts or loans. Inter-household transfers responded mostly to private prizes, indicating that sharing was voluntary rather than induced by social pressure. The investment of prize money in the social network – especially in the form of interest-free loans, common among women – can be interpreted as a form of savings that keeps the money out of the hands of the other spouse.

2. Intra-Household Decision-Making under Asymmetric Information

In Ghanaian households, it is not the norm for men and women to pool resources (Chao, (1998); (Clark, 1999)). The responsibility for day-to-day maintenance of the family, however, seems to be shared by both husbands and wives, while the majority maintains separate financial arrangements of spending, owning and saving (Oppong, 1974). Oppong observed that, as a result of the Akan matrilineal inheritance system, husbands and wives rarely own, manage or inherit property together.[4] She found that husbands were twice as likely to own property with their kin as with their wives, and only ten percent of households had joint accounts. Although these observations are dated, the 2009 survey data affirm that asset ownership and inheritance patterns remain distinctly separate between spouses. As observed by Duflo and Udry (2004) in Cote d'Ivoire, men and women tend to have separate income streams, often with a traditional gender-based division of responsibilities for different type of expenditures (Chao, 1998). Generally, men are expected to contribute either staple grains from their farms for household consumption, or "chop money" for food and pay for children's school fees. Women bear primary responsibility for childrearing, cooking, washing and collecting fuel, wood and water. Thus additional

[4] Most of the respondents were of Akan heritage, although a small number are immigrants with a different clan heritage which is not matrilineal (e.g. the Ewe).

expenditures for children - such as clothes - are met by women, as are meal preparation and ingredients (Chao, 1998).

Reflecting the marital contract described above, we develop the following model. Consider a model with two family members, f and m, who each have preferences over consumption of a private (or personal) good, denoted x_i, $i \in \{f, m\}$, and one household public good, Q, whose quantity is chosen by f.[5] The household resource allocation decision is made in two stages. In the first stage household member *m* receives income, Y_m and household member f receives Y_f, which are both common knowledge to both spouses. Further, one spouse receives a lottery prize T which is not observed by the other household member. It is worth noting that households who receives the lottery prize can adjust effort, in which case his total income from all sources has the potential to remain constant.

The prize winner household member has to decide whether to reveal the unobserved income to his/her spouse or to keep it for private consumption. For simplicity *T* is assumed to be observable with probability zero and it is also assumed that *the uninformed spouse* cannot observe *the informed spouse* private consumption choices, nor does she invest in monitoring income[6], though *the uninformed spouse* can perfectly infer the presence of additional income through the public good allocation, which is perfectly observable. In the second stage, each household member makes his consumption choices conditional on the amount of the lottery prize that is revealed. The family decision-making process is solved by backwards induction. First, the

[5] Since some Ghanaians continue to practice polygamy, there are a small number of households with more than one wife. We exclude these households from the sample as the intra-household resource management contract in this case is considerably different.

[6] This assumption is not trivial, but it can be justified given that in the field experiment care was taken to guarantee that in one of the treatments whether the spouse had won the lottery was kept private both from his spouse and from the rest of the village. The model can be extended to incorporate both, time allocation decisions and a cost of monitoring.

consumption choices conditional on the amount of resources that become known are described, and then the circumstances under which it is optimal for *m* or *f* to hide income are determined.

Both family members face the same price for private goods which is normalized to 1 (one can think about the private good as discretionary expenditure), and p is the price of the public good. If both household members pool their income, the joint budget constraint is:

$$x_f + x_m + pQ = Y_f + Y_m + T \qquad (1)$$

If each member decides to allocate the income at his/her disposal separately between private and household public goods, their individual budget constraints are:

$$x_i + pQ = Y_i + T_i \pm s \quad \text{for } i = f,m \qquad (2)$$

where $T_i > 0$ for the lottery winner spouse, and $T_i = 0$ for the other spouse. Preferences over own consumption are represented by a money metric egotistic utility function, U_i. Utility depends on the aggregate level of consumption of household public goods, Q, and private goods, x_i, and is assumed to be separable in both:

$$U_i = U(Q, x_i) = u(x_i) + v(Q) \qquad \text{for } i = f,m \qquad (3)$$

The functions $u(\cdot)$ and $v(\cdot)$ satisfy the standard Inada conditions: $u' > 0$, $v' > 0$, $u'' < 0$, $v'' < 0$. Both spouses have the same functional form for simplicity. The characterization of goods as public or private depends on the nature of the good. The household public goods are assumed to be non-rival in utility, so they are of the Samuelson type. For instance, a clean house provides utility to both members of the household, while clothing provides utility only to the person who consumes it.

Separate Spheres Bargaining in Ghanaian Households

As mentioned earlier, in Ghanaian households men and women hold separate economies, such that no spouse has access to all of the household's resources, and spending patterns differ by gender[7]. Nonetheless, it is generally the case, and so it is observed in the data, for intra-household transfers to occur in the form of "chop money" (Udry and Goldstein, 1998), loans and farm produce, particularly from husbands to wives. It seems plausible to consider the possibility then that the intra-household allocation of resources is non-cooperative (each spouse controls his/her own resources)[8]. In the unitary model, or in a separate-spheres model where preferences are identical, transfers are of little interest because the redistribution of resources between spouses is fully offset by adjusting private consumption. However, when household bargaining is non-cooperative and strictly positive transfers occur between spouses, there can be incentives to hide unobservable resources.

In this section, we examine the incentives to hide when household bargaining is non-cooperative; when there is gender specialization in the household, such that the husband is in charge of providing chop money, while the wife specializes in the provision of the public good. We draw from the Lundberg and Pollak (1993) separate spheres model. Consistent with observations of Ghanaian households, we assume that under the marital contract the husband must pay for children's school fees and provide chop money to his wife.[9] Thus, upon marriage the husband makes a binding commitment to pay for school fees (and these are assumed to be

[7] This does not conflict with the assumption on the same functional form of the utility function as each spouse can spend money on different private items.
[8] Alternatively, it could be indicative that the fall-back alternative when household members cannot reach a bargaining agreement (the threat point) corresponds to a non-cooperative equilibrium within marriage where the husband makes positive transfers to his wife
[9] Among the Akan, the wife can divorce in the case lack of economic support by her husband (Ogbu, 1978). Husbands are also expected to pay for school fees (Chao, 1998).

given). This assumption is not unrealistic given that the individuals in the sample live in very small villages and it is unlikely that they have many schooling choices. The chop money allowance, *s*, however, is chosen by the husband. The marital contract stipulates that he must provide for his wife (Ogbu, 1978), but the amount is chosen by the husband. The wife, on the other hand, chooses the household public good allocation (Q). The public good can be thought of as child expenditures other than school fees, such as clothing and other schooling expenses, shared household goods, and common meals. We assume that spouses do not commit to any binding agreements regarding intra-household transfers and public goods expenditures. The non-cooperative game consists of 2 stages: in the first stage, one of the spouses has the opportunity to win a lottery. The lottery money (*T*) comes in the form of a cash transfer that may or may not be observable by the other spouse. In the second stage, the husband chooses the chop money allowance (*s*) he will give his wife (*f*) first; and then the wife decides the public good provision conditional on both *T* and *s*.

<u>Separate Spheres Bargaining in Ghanaian Households:</u> Husband wins Private Lottery Prize

We first consider the case when the husband (*m)* receives his regular income (Y_m) and also wins a private lottery prize (*T*). In this stage, if the lottery prize is unobserved, the husband chooses whether to reveal the chop money transfer (T) or to hide it (if it is observed, then this stage is trivial). In the second stage, the non-cooperative bargaining game consists of two stages. First, he chooses the chop money allowance (*s*) he will give his wife (*f*); and then the wife decides the public good provision, Q, conditional on both T and s. The model is solved by backwards induction. In the benchmark case, i.e. when T is observed (or revealed), the wife (*f*) solves the following optimization problem,

$$\max_{Q\geq 0;\, x_f\geq 0} U_f = v(Q) + u(x_f) \quad s.t. \quad x_f \leq Y_f + s - pQ \tag{4}$$

[10]

Substituting in the budget constraint, the first-order condition for Q is

$$v'(Q) - pu'(Y_f + s - pQ) \leq 0 \tag{5}$$

Conducting comparative statics on the above condition yields,

$$\frac{\partial Q}{\partial s} = \frac{pu''(Y_f+s-pQ)}{v''(Q)+p^2u''(Y_f+s-pQ)} > 0 \tag{6}$$

So, the chop money allowance is the husband's way to increase his household public good consumption, but the correspondence is not one-to-one because it depends on the wife's preferences. Note that, the public good allocation will be strictly positive, thus equation (5) holds with equality.

Taking spouse *f's* first-order condition as given, spouse *m* solves:

$$\max_{s\geq 0;\, x_m\geq 0; Q\geq 0} U_m = v(Q) + u(x_m)$$

$$s.t. \quad x_m \leq Y_m + T - s;\;\; v'(Q) - pu'(Y_f + s - pQ) = 0 \tag{7}$$

The Lagrangian is:

$$\mathcal{L} = v(Q) + u(Y_m + T - s) + \lambda\left[pu'(Y_f + s - pQ) - v'(Q)\right]$$

which yields the following Kuhn-Tucker first-order conditions,

$$\frac{\partial \mathcal{L}}{\partial Q} = v'(Q) - \lambda p^2 u''(Y_f + s - pQ) - \lambda v''(Q) \leq 0 \tag{8}$$

$$\frac{\partial \mathcal{L}}{\partial s} = -u'(Y_m + T - s) + \lambda pu''(Y_f + s - pQ) \leq 0 \tag{9}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = pu'(Y_f + s - pQ) - v'(Q) = 0 \tag{10}$$

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[10] Technically, the utility function is given by: $U_i = v(Q,t) + u(x_i)$ but since the schooling fees (t) are assumed fixed, it does not affect the outcomes. One can also think about Y_m as being the husband's disposable income after paying for school fees.

$$Q\left[\frac{\partial \mathcal{L}}{\partial Q}\right] = 0,\ s\left[\frac{\partial \mathcal{L}}{\partial s}\right] = 0;\ \lambda\left[\frac{\partial \mathcal{L}}{\partial \lambda}\right] = 0;\ Q \geq 0;\ s \geq 0$$

Solving the system of first-order conditions simultaneously yields the Subgame Perfect Nash equilibrium. There is a corner solution where the chop money allowance can be zero, as well as an interior solution. Proposition 1 specifies the conditions that must be met for an equilibrium with a strictly positive chop money allowance to exist.

<u>Proposition 1</u>: *Given $Y_m + T$, there exists a $\overline{Y_m}$ in the interval $(0, Y_f)$ such that if $Y_m + T \leq \overline{Y_m}$ a corner solution with $s = 0$ and $Q > 0$ is possible.*

Following Proposition 1, if $Y_m + T \leq \overline{Y_m} \in (0, Y_f)$, it is optimal for *m* to give a zero chop money allowance to *f*. Proposition 2 states the properties of the equilibrium with respect to changes of income for both cases, and provides the foundations as to why when household bargaining is non-cooperative there are no incentives for the husband to hide income.

<u>Proposition 2:</u> *When spouses behave non-cooperatively and all income is revealed:*

Case (i) If $Y_m + T \leq \overline{Y_m} \in (0, Y_f)$, $s = 0$ and $Q > 0$, then an increase in Y_f results in $\frac{\partial x_f}{\partial Y_f} > 0$; $\frac{\partial Q}{\partial Y_f} > 0$; $\frac{\partial s}{\partial Y_f} = \frac{\partial x_m}{\partial Y_f} = 0$, while an increase in Y_m or T results in $\frac{\partial x_m}{\partial Y_m} = \frac{\partial x_m}{\partial T} > 0$; $\frac{\partial s}{\partial Y_m} = \frac{\partial s}{\partial T} = 0$; $\frac{\partial Q}{\partial Y_m} = \frac{\partial Q}{\partial T} = \frac{\partial x_f}{\partial Y_m} = \frac{\partial x_f}{\partial T} = 0$.

Case (ii) If $Y_m + T > \overline{Y_m}$*,* $s, Q > 0$*, then an increase in* Y_f *results in* $\frac{\partial x_f}{\partial Y_f} > 0$; $\frac{\partial Q}{\partial Y_f} > 0$; $\frac{\partial x_m}{\partial Y_f} > 0$; $\frac{\partial s}{\partial Y_f} < 0$ *while an increase in* Y_m *or* T *results in* $\frac{\partial x_m}{\partial Y_m} = \frac{\partial x_m}{\partial T} > 0$; $\frac{\partial s}{\partial Y_m} = \frac{\partial s}{\partial T} > 0$; $\frac{\partial Q}{\partial Y_m} = \frac{\partial Q}{\partial T} > 0$; $\frac{\partial x_f}{\partial Y_m} = \frac{\partial x_f}{\partial T} > 0$.

If spouse *m* is not giving a positive housekeeping allowance to *f* (Case (i)), changes in husband's resources have no impact on *f's* allocations inframarginally. Now consider the case when *m* receives income that is unobservable to household member *f*. If the distribution of income is such that $Y_m + T \leq \overline{Y_m} \in (0, Y_f)$, hiding is indistinguishable from non-cooperative behavior under perfect information because in both cases a change in *m's* resources only impacts *m's* allocations[11]. This is intuitive because when all sources of cooperation fail between household members, the information asymmetries become irrelevant.

When $Y_m + T > \overline{Y_m}$, it is *m*'s best response to give a strictly positive chop money allowance to *f* in order to increase his household good consumption. In this case, an increase in *m's* resources increases his discretionary expenditure and his chop money allowance, and therefore the provision of the public good. However, it also increases *f's* private consumption. Thus in this case there could be incentives to hide income. To decide whether to reveal or to hide, *m* compares the utility per unit change of *T* in both cases.

Proposition 3: *Given* Y_f *and* Y_m *when* $Y_m + T > \overline{Y_m}$*, the Subgame Perfect Nash Equilibrium of the game is to always reveal.*

[11] There exists another case that is not being examined in this paper, corresponding to when *T* is such that, if revealed, it makes the interior equilibrium possible. In that case, comparisons cannot be made on the margin because the baseline utility is not the same across cases.

Propositions 2 and 3 imply that when household bargaining is non-cooperative, i.e. when they manage their resources independently, the husband does not hide income in equilibrium. When allocations default to separate spheres and no intra-household transfers occur, information asymmetries over household income are irrelevant. If strictly positive transfers occur between household members, the husband reveals his unobservable income, and first best can be attained. This contrasts with the case where the wife receives income that is unobservable to her husband, where hiding is the equilibrium if the unobservable income does not exceed a certain threshold.

Separate Spheres Bargaining in Ghanaian Households: Wife wins Private Lottery Prize

Now we consider the case when the wife receives the cash prize (*T*) that is unobservable to spouse *m* and chooses whether to reveal the transfer or to hide it; in the second stage, spouse *m* chooses the housekeeping allowance (*s*) he will give spouse *f*; and then, spouse *f* decides the public good provision conditional on both *T* and *s*.

In particular, spouse *f* solves the following optimization problem,

$$\max_{Q\geq 0;\, x_f\geq 0} U_f = v(Q) + u\left(x_f\right) \quad s.t. \quad x_f \leq Y_f + T + s - pQ \tag{11}$$

The first-order condition for Q is

$$v'(Q) - pu'\left(Y_f + T + s - pQ\right) \leq 0 \tag{12}$$

Conducting comparative statics on the above condition yields,

$$\frac{\partial Q}{\partial s} = \frac{pu''\left(Y_f+T+s-pQ\right)}{v''(Q)+p^2u''\left(Y_f+T+s-pQ\right)} > 0 \tag{13}$$

So, the housekeeping allowance is the husband's way to increase his household good consumption, but the correspondence is not one-to-one. Note that, the public good allocation will be strictly positive, thus equation (12) holds with equality.

Taking spouse *f's* first-order condition as given, spouse *m* solves:[12]

$$\max_{s\geq 0;\, x_m\geq 0; Q\geq 0} U_m = v(Q) + u(x_m)$$

$$s.t. \quad x_m \leq Y_m - s; \;\; v'(Q) - pu'\big(Y_f + T + s - pQ\big) = 0 \tag{14}$$

The Lagrangian is:

$$\mathcal{L} = v(Q) + u(Y_m - s) + \lambda\big[pu'\big(Y_f + T + s - pQ\big) - v'(Q)\big]$$

which yields the following Kuhn-Tucker first-order conditions,

$$\frac{\partial \mathcal{L}}{\partial Q} = v'(Q) - \lambda p^2 u''\big(Y_f + T + s - pQ\big) - \lambda v''(Q) \leq 0 \tag{15}$$

$$\frac{\partial \mathcal{L}}{\partial s} = -u'(Y_m - s) + \lambda p u''\big(Y_f + T + s - pQ\big) \leq 0 \tag{16}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = pu'\big(Y_f + T + s - pQ\big) - v'(Q) = 0 \tag{17}$$

$$Q\left[\frac{\partial \mathcal{L}}{\partial Q}\right] = 0,\, s\left[\frac{\partial \mathcal{L}}{\partial s}\right] = 0;\, \lambda\left[\frac{\partial \mathcal{L}}{\partial \lambda}\right] = 0;\, Q \geq 0;\, s \geq 0$$

Solving the system of first-order conditions simultaneously yields the Subgame Perfect Nash equilibrium. There is a corner solution where the housekeeping allowance can be non-positive, as well as an interior solution. Proposition 5 specifies the conditions that must be met for an interior solution to exist.

[12] This is equivalent to setting the optimization problem in the following way:

$$\max_{s\geq 0;\, x_m\geq 0; Q\geq 0} U_m = v\big(Q(s)\big) + u(x_m) \; s.t. \quad x_m \leq Y_m - s; \;\; Q(s) \geq 0$$

And then using equation (15) in the FOC to substitute for $\frac{\partial Q}{\partial s}$.

Proposition 4: *Given Y_f, there exists a $\overline{Y_m}$ in the interval $(0, Y_f)$ such that the Subgame Perfect Nash equilibrium is a corner solution with $s = 0$ and $Q > 0$ if $Y_m \leq \overline{Y_m}$.*

Following Proposition 4, if $Y_m \leq \overline{Y_m} \in (0, Y_f)$, it is optimal for *m* to give a zero chop money allowance to *f*. As shown by Lundberg and Pollak (1993), this yields an inefficient outcome that could be improved upon by bargaining. Proposition 5 states the properties of the equilibria with respect to changes in *f's* income.

Proposition 5:

Case (i): If $Y_m \leq \overline{Y_m} \in (0, Y_f)$ thus $s = 0$, an increase in Y_f or T results in $\frac{\partial x_f}{\partial Y_f} = \frac{\partial x_f}{\partial T} > 0$; $\frac{\partial Q_f}{\partial Y_f} = \frac{\partial Q_f}{\partial T} > 0$; $\frac{\partial s}{\partial Y_f} = \frac{\partial s}{\partial T} = \frac{\partial x_m}{\partial Y_f} = \frac{\partial x_m}{\partial T} = 0$, *while an increase in Y_m results in* $\frac{\partial x_m}{\partial Y_m} > 0$; $\frac{\partial s}{\partial Y_m} = 0$; $\frac{\partial Q}{\partial Y_m} = \frac{\partial x_f}{\partial Y_m} = 0$.

Case (ii): If $Y_m > \overline{Y_m}$.thus $s, Q > 0$, an increase in Y_f or T results in $\frac{\partial x_f}{\partial Y_f} = \frac{\partial x_f}{\partial T} > 0$; $\frac{\partial Q_f}{\partial Y_f} = \frac{\partial Q_f}{\partial T} > 0$; $\frac{\partial x_m}{\partial Y_f} = \frac{\partial x_m}{\partial T} > 0$; $\frac{\partial s}{\partial Y_f} = \frac{\partial s}{\partial T} < 0$, *while an increase in Y_m results in* $\frac{\partial x_f}{\partial Y_m} > 0$; $\frac{\partial Q_f}{\partial Y_m} > 0$; $\frac{\partial x_m}{\partial Y_m} > 0$; $\frac{\partial s}{\partial Y_m} > 0$.

If spouse *m* is not making a positive chop money allowance to *f*, changes in Y_f have no impact on *m's* allocations. Now consider the case when *f* receives a transfer (*T*) that is unobservable to household member *m*. Spouse *f* then has to decide whether to allocate the monetary transfer (*T*) between private and household public good consumption, thus directly or indirectly informing *m* about the increase in her resources, or to hide it and spend it all on private consumption. If the distribution of income is such that $Y_m \leq \overline{Y_m} \in (0, Y_f)$, then there is no incentive to hide the transfer because a change in Y_f only impacts *f's* allocations.[13]

When *m* gives a strictly positive housekeeping allowance to his wife, an increase in Y_f increases both *f* and *m's* private consumption and *f's* contribution to the public good, though it is likely to decrease *m's* supplementary transfer. This is the source of the incentive to hide income. If *f* reveals that her resources have increased, in order to increase her public good consumption, she will first have to compensate the reduction in spouse *m's* housekeeping allowance, and then supplement her private and household good consumption. If she hides, however, she can keep her household good consumption unchanged by preventing *m* from reducing his allowance, and increase her private consumption in the amount of the transfer.

Now consider the case when *f* receives a transfer (T) and has to decide whether to allocate T between private and household public good consumption, or to hide it and spend it all on private consumption. If the conditions described in Proposition 6 are met, *f* will hide the transfer from *m*.

<u>Proposition 6</u>*: Given Y_f, Y_m when $Y_m > \overline{Y_m}$, there exists a threshold level of transfer ($\bar{T}$) such that for any $T < \bar{T}$ the Subgame Perfect Nash Equilibrium of the game is to hide the transfer.*

As before, if the change in utility per unit change in the transfer is higher when *f* hides the transfer compared to when she reveals it, income-hiding is an equilibrium. The decision to hide depends not only on the relative change in marginal utility of private and public consumption for both household members, but on the size of the transfer as well, such that small transfers will be

[13] There exists another case that is not being examined in this paper, corresponding to when the transfer is such that, if revealed, it makes the interior equilibrium possible.

hidden. So far, we have shown that when spouses have independent accounts or when there is gender specialization, there is a threshold level of transfer such that income hiding is an equilibrium. It must be noted that the ease of hiding T depends on its volatility and observability of other income components. Also note that in the model we are assuming the decision to hide or reveal is all-or-nothing for ease of exposition. The model can be easily extended to a continuous decision, where for instance, a spouse that receives a prize T greater than $\bar{T}$ reveals only the proportion of the price that would put her above that threshold.

Testable Hypothesis 1:

Case (1): When spouse *f* cannot observe T, if x_m is not observed by spouse *f*, and Q and x_f are perfectly observable by spouse *f*, hiding occurs if $\frac{\partial x_m}{\partial T} \neq 0$, and $\frac{\partial Q}{\partial T} = \frac{\partial x_f}{\partial T} = 0$ and $\frac{\partial x_m}{\partial Y_m} \neq 0, \frac{\partial Q}{\partial Y_m} \neq 0, \frac{\partial x_f}{\partial Y_m} \neq 0$.

Case (2): When spouse *m* cannot observe T, if x_f is not observed by spouse *m*, and Q and x_m are perfectly observable by spouse *m*, hiding occurs if $\frac{\partial x_f}{\partial T} \neq 0$, and $\frac{\partial Q}{\partial T} = \frac{\partial x_m}{\partial T} = 0$ and $\frac{\partial x_m}{\partial Y_m} \neq 0, \frac{\partial Q}{\partial Y_m} \neq 0, \frac{\partial x_f}{\partial Y_m} \neq 0$.

Testable Hypothesis 2:

Following Propositions 3 and 6, the spouse in charge of deciding the chop money allowance, the husband in this case, has no incentives to hide when he has an information advantage. However, the wife (who is responsible for the household public good provision) does. Therefore, we expect to find hiding if the wife's prize is small enough.

The hypotheses derived from the model are tested through a field experiment conducted among households in 4 villages in Ghana. We collected data on spousal and household expenditure over 6 rounds and implemented a lottery experiment where spouses had the opportunity to win a prize that was either announced in public or in private. The details on the experimental design are presented in Section 3.

3. Survey and Experimental Design

The field experiments were conducted between March and October 2009 in conjunction with a year-long household survey in four communities in Akwapim South district of Ghana's Eastern Region. This district lies some 40 miles north of the nation's capital, Accra. Further details on the survey are provided in Walker (2011). The sample consists of approximately 70 households from each of the four communities. Slightly more than half of these 70 households were part of the initial 1997-98 sample, and the rest were recruited in January 2009 using stratified random sampling.[14] In the original sample, and in the 2009 re-sampling, households were selected only if headed by a resident married couple.[15] In some households from the 1997-98 sample, only one of the spouses remained. These 'single-headed households' account for between 7 and 15 of the households in each community. Thus the sample of individuals included in the experiment was around 150 individuals in each of the four communities (Table 1).

Each respondent was interviewed five times during 2009, once every two months between February and November. Each survey round took approximately three weeks to

[14] New sample members were selected randomly from the subset of households in the community headed by a married couple. The sample was stratified by age of the head into three categories: 18-29, 30-64 and 65+, so that the shares of households whose head was in each of these age categories corresponded to the community's population shares.
[15] Some men in the sample have two or three wives, all of whom were included.

complete, with the two survey teams each alternating between two villages. The survey covered a wide range of subjects including personal income, farming and non-farm business activities, gifts, transfers and loans, and household consumption expenditures. Each round, both the husband and wife in each household were interviewed separately on all of these topics. The expenditure module obtained detailed information on the quantities and values purchased of a long list of items. Referring to the week prior to the interview, each spouse was asked about his or her own expenditures, those of their partner, and about expenditures for the household as a whole. In the gifts and transfers module, respondents were asked to report any gifts (cash or kind) given and received during the past two months, obtaining information on the counterparty's location and relationship to the respondent, and the nature and value of the gift. The survey also included a detailed survey of respondents' in-sample social networks.

Table 1. Sample summary

	Village				
	1	**2**	**3**	**4**	**Total**
Husbands	70	67	69	68	274
Wives	77	71	73	68	289
Single males	4	3	1	4	12
Single females	7	5	6	11	29
Total	158	146	149	151	604

The first round of the survey was designed as a baseline, therefore no lottery took place in that round. One week before each subsequent round the survey team visited each village to distribute prizes to selected respondents. There were twenty prizes allocated in each community, in each of the four lottery rounds, so that in all 320 prizes were given. Over the four lotteries, approximately 42 per cent of individuals and 62 per cent of households won at least one prize. Ten of the prizes were allocated publicly by lottery, and the other ten (identical in type) were allocated in private, by lucky dip. The values of the prizes varied, as described in Table 2. The prizes were of a substantial size[16].

The livestock prizes were purchased by the survey team in Accra on the morning of the lottery, and transported to the community. The chickens were of a type intended for eating, and were chosen because their price was essentially fixed at GH¢10 throughout the year. The goats were bought individually by the team directly from traders at the main market near Accra. On the first visit, the size and quality of goats available was established for the three price points (GH¢35, GH¢50 and GH¢70). On every subsequent visit, the team endeavored to obtain goats of similar size and quality, subject to market price and supply fluctuations.[17] Female goats were obtained when possible because of their utility for breeding.

The lotteries and lucky dips took place one week before the commencement of the survey interviews. Great care was taken to make clear to participants that the allocation of prizes was random, and that each respondent had an equal chance of winning in each round. A village meeting was held in the community, and all respondents were invited to attend. A small amount of free food and drink was provided as an incentive to come. Attendance at the meetings was generally around 100 people; roughly half of the respondents appeared for each meeting.[18] There were usually a number of non-respondents at these meetings as well, including many children. At each gathering, the respondents were thanked for their continued participation in the survey. The team explained that respondents had a chance to win one of 20 prizes that day, framing the prizes

[16] During 2009, mean monthly per capita expenditure averaged around GH¢65. One Ghana cedi (GH¢) was worth about 70 US cents in mid 2009.

[17] There was little price movement in the goat market throughout the year, though the price of chickens slowly appreciated, rising perhaps 20 per cent over 2009. The additional cost of the broiler chickens was absorbed to maintain consistency of the prizes across rounds. The quality of goats varied slightly between rounds in line with supply and climatic conditions, but a concerted effort was made to keep the quality close to constant within rounds.

[18] Around 125 of the 150 respondents in each community appeared for the private lucky dip, some of them arriving before or after the public meeting.

as a gratuity for their participation in the survey.[19,20] Winners for the ten public prizes were then drawn (without replacement) from a bucket containing the names of the survey respondents. A village member not in the sample was chosen by the villagers to do the draw, so as to emphasize that the outcomes were random. Each winner was announced, and asked to come forward to receive their prize. The prizes were announced and displayed before being awarded. Respondents who were absent at the time of drawing were called to pick up their prize in person. Spouses or close family members were allowed to receive the public livestock prizes (but not cash prizes) on the winner's behalf. Unclaimed prizes were delivered in person to the winner after the lottery.[21]

After the lottery prizes were distributed, the lucky dip began. Respondents were asked to identify themselves to an enumerator, who took their thumbprint or signature and issued them with a ticket displaying their name and identification number. The respondents then waited to enter a closed school room, one at a time, where another enumerator invited them to draw a bottle cap without replacement from a bag. Care was taken to shuffle the bottle caps after each draw, and to prevent respondents from seeing into the bag. If a respondent inadvertently drew more than one bottle cap, those caps were shuffled and the respondent was asked to blindly select one of them. There was one bottle cap for each of the *n* respondents in the community. Of these, *n*-10 were non-winning tokens (red colored), and 10 were winning tokens, marked distinctively to indicate one of the ten prizes listed in Table 2.[22] Those who drew winning tokens were informed immediately that they had won a prize, which was identified to them, and were told that they did not have to tell anyone else that they had won. The survey team made clear that

[19] Respondents signed an informed consent form at the start of the survey, explaining how they would be remunerated for their participation in the survey.
[20] In addition to the chance of winning a prize, every respondent was given a small amount of cash at the time of interview as partial payment for their participation in the survey.
[21] We have data on these cases, including the dates on which the prizes were claimed and the identity of the recipient (if not the winner).
[22] Respondents were shown a sheet relating the tokens to the prizes; this sheet was used to explain what prize (if any) the respondent had won based on the token they drew.

they would not divulge the identities of the lucky dip prize winners. Cash prizes were given to the winners immediately. Livestock prizes were delivered one or two days later to the winner in person, or to another household member if they were absent.[23,24] At the conclusion of the day, tokens which had not been drawn were counted and the remaining prizes allocated randomly among the non-attending respondents using a computer. There were usually 25-30 non-attendees and less than three prizes remaining.

All of the winners collected or received their prizes within one month of the lottery, and in all but one case at least a week before the household survey interview. The interviews commenced one week after the lottery, deliberately delayed to allow winners to receive their prize and do something with it. The interviews took place in no specified order throughout the following three weeks, so that some winners were interviewed a week after winning, and others up to four weeks after winning.[25] Table 3 contains a summary of the balance of treatment information. The only statistically significant difference ex ante between the treatment groups is for gifts received, and it seems to be driven by an outlier.

Table 2. List of prizes distributed in each lottery and lucky dip

Cash	Livestock
GH¢10	One broiler chicken, worth GH¢10
GH¢20	Two broiler chickens, worth GH¢10 each
GH¢35	Small goat, worth GH¢35
GH¢50	Medium goat, worth GH¢50
GH¢70	Large goat, worth GH¢70

Note: Mean per capita consumption averaged around GH¢65 per month in the study communities.

[23] If anyone received the prize on behalf of the winner, the survey team made clear who the animal was intended for. In the follow-up survey, each winner was interviewed privately about their prize, and established that all of them ultimately received their prizes.

[24] Clearly, there was no way of keeping the livestock prizes completely secret. It should be assumed that members of the winner's household were all aware of those prizes. However, the delivery of the lucky dip livestock prizes was kept as low-key as possible. Thus there is a strong difference in publicity between the lottery and lucky dip prizes, at least with respect to non-household members.

[25] We have data on the dates of the lotteries and interviews, but thus far have not looked at them for this analysis.

Table 3. Balance of treatment for key round 1 variables (by prize type)

Variable	Non-winners	Public prize	Private prize
Demographic characteristics			
Male	0.484	0.448	0.475
	(0.500)	(0.499)	(0.501)
Years schooling	7.259	7.731	7.240
	(3.977)	(4.002)	(4.266)
Num. adults	3.141	3.122	3.271
	(1.594)	(1.564)	(1.835)
Num. kids	1.882	1.748	1.812
	(1.438)	(1.361)	(1.372)
Age of HH head	45.254	45.336	46.624
	(13.416)	(14.433)	(14.16)
SN size	91.35	92.233	91.194
	(39.947)	(40.075)	(38.409)
Friends given gift	31.367	30.552	32.201
	(28.837)	(28.846)	(30.575)
Coinsured	0.510	0.433*	0.475
	(0.501)	(0.497)	(0.501)
Coinsured (HH)	0.691	0.679	0.712
	(0.463)	(0.469)	(0.454)
Relatively rich	0.427	0.425	0.468
	(0.495)	(0.496)	(0.501)
Relatively rich	0.527	0.493	0.532
(household)	(0.5)	(0.502)	(0.501)
Relatively rich	0.854	0.873	0.914
(alt. measure)	(0.694)	(0.73)	(0.717)
Rel. rich HH	0.986	0.985	0.993
(alt. measure)	(0.688)	(0.715)	(0.717)

Variable	Non-winners	Public prize	Private prize	Non-winners	Public prize	Private prize
	Ex-ante variables (round 1)			**Ex-post variables (rounds 2-5)**		
Total expenditure	627.383	581.35	674.495	466.776	493.796	490.208
	(504.752)	(370.986)	(622.185)	(299.674)	(339.05)	(296.547)
Food expenditure	327.468	319.637	352.763	269.305	275.505	281.168
	(209.303)	(174.126)	(246.492)	(135.914)	(154.165)	(135.977)
Other expenditure	136.671	128.144	131.296	103.699	107.832	117.552**
	(105.962)	(96.204)	(106.083)	(83.369)	(88.317)	(83.839)
Asset expenditure	14.442	26.062	28.344	5.643	5.481	4.114
	(89.491)	(147.932)	(153.018)	(24.508)	(21.229)	(14.501)
Abnormal exp.	148.802	107.506*	162.092	88.13	104.978	87.375
	(338.216)	(182.476)	(441.616)	(187.31)	(201.062)	(171.277)
Farm expenses	17.906	15.917	19.176	17.387	33.648***	28.477**
	(52.361)	(56.338)	(67.05)	(54.177)	(122.119)	(123.197)
Log liquid assets	5.331	5.482	5.451	4.735	4.795	4.943*
	(1.48)	(1.41)	(1.462)	(1.566)	(1.51)	(1.636)
Log illiquid assets	6.610	6.640	6.618	6.749	6.770	6.803
	(0.986)	(0.904)	(1.047)	(0.778)	(0.675)	(0.816)
Gave transfer	0.507	0.560	0.46	0.381	0.44*	0.5***
	(0.501)	(0.498)	(0.5)	(0.486)	(0.498)	(0.502)
Amount given	16.438	14.451	28.027	9.336	7.898	10.63
	(36.648)	(24.224)	(131.189)	(23.798)	(16.676)	(28.373)
Received transfer	0.519	0.590*	0.532	0.462	0.520*	0.506
	(0.500)	(0.494)	(0.501)	(0.499)	(0.501)	(0.502)
Amount received	25.995	30.194	48.281***	23.082	19.360	28.966
	(42.709)	(46.301)	(123.214)	(52.548)	(28.139)	(60.313)
Gave transfer	0.350	0.328	0.302	0.271	0.327*	0.353**
(within village)	(0.478)	(0.471)	(0.461)	(0.445)	(0.471)	(0.479)
Amount given	9.382	5.175*	7.155	4.468	3.236	3.953
(within village)	(30.744)	(11.799)	(31.032)	(17.303)	(7.285)	(9.181)
Received transfer	0.246	0.306*	0.245	0.212	0.227	0.231
(within village)	(0.432)	(0.463)	(0.431)	(0.408)	(0.42)	(0.423)
Amount received	5.204	9.196**	24.132***	4.368	4.312	4.859
(within village)	(15.79)	(25.436)	(112.399)	(16.219)	(13.789)	(13.777)

4. Estimation and Empirical Results

The testable hypotheses in Section 2 indicate that hiding can be identified empirically if an unobservable cash prize has no effect on observable expenditure, while it has a significant effect on expenditure that is unobservable. In the experiment, we actually have random variation between private and public prizes, thus these hypotheses can be translated to match the experimental design as follows. Allow $x_{f,hr}^{g,Pr}$ to indicate expenditure on item g which is only observable to the wife (*f*), $x_{f,hr}^{g,Pu}$ to indicate expenditure on item g which is observable to both *f* and *m*; likewise for the husband, allow $x_{m,hr}^{g,Pr}$ to indicate expenditure on item g which is only observable to the husband (*m*), $x_{m,hr}^{g,Pu}$ to indicate expenditure on item g which is observable to both *f* and *m.* Then the hypotheses to be tested are:

<u>Testable Hypothesis 1</u>:

Case (1): Let T_{Pu} be the public prize and T_{Pr} be the private prize. If the wife wins a prize, $x_{m,hr}^{g,Pr}$ is not observed by spouse *f*, and $x_{m,hr}^{g,Pu}$, $x_{f,hr}^{g,Pr}$ and $x_{f,hr}^{g,Pu}$ are perfectly observable by spouse *f*, hiding occurs if $\frac{\partial x_{f,hr}^{g,Pr}}{\partial T_{Pu}} \neq 0$; $\frac{\partial x_{f,hr}^{g,Pu}}{\partial T_{Pu}} \neq 0$; $\frac{\partial x_{m,hr}^{g,Pu}}{\partial T_{Pu}} \neq 0$; $\frac{\partial x_{m,hr}^{g,Pr}}{\partial T_{Pu}} \neq 0$ and $\frac{\partial x_{f,hr}^{g,Pr}}{\partial T_{Pr}} = \frac{\partial x_{f,hr}^{g,Pu}}{\partial T_{Pr}} = \frac{\partial x_{m,hr}^{g,Pr}}{\partial T_{Pr}} = 0$; $\frac{\partial x_{f,hr}^{g,Pr}}{\partial T_{Pr}} \neq 0$.

Case (2): Let T_{Pu} be the public prize and T_{Pr} be the private prize. If the husband wins a prize, $x_{f,hr}^{g,Pr}$ is not observed by spouse *m*, and $x_{m,hr}^{g,Pu}$, $x_{m,hr}^{g,Pr}$ and $x_{f,hr}^{g,Pu}$ are perfectly observable by spouse m, hiding occurs if $\frac{\partial x_{f,hr}^{g,Pr}}{\partial T_{Pu}} \neq 0$; $\frac{\partial x_{f,hr}^{g,Pu}}{\partial T_{Pu}} \neq 0$; $\frac{\partial x_{m,hr}^{g,Pr}}{\partial T_{Pu}} \neq 0$; $\frac{\partial x_{m,hr}^{g,Pu}}{\partial T_{Pu}} \neq 0$ and $\frac{\partial x_{f,hr}^{g,Pr}}{\partial T_{Pr}} = \frac{\partial x_{f,hr}^{g,Pu}}{\partial T_{Pr}} = \frac{\partial x_{m,hr}^{g,Pu}}{\partial T_{Pr}} = 0$; $\frac{\partial x_{m,hr}^{g,Pr}}{\partial T_{Pr}} \neq 0$.

Testable Hypothesis 2:

We expect to find no differences in the effect of the husband winning a public or a private prize on the different expenditure categories, as he has no incentive to hide a private transfer. Conversely, we would expect to find different effects of winning public or private prizes on expenditure by degree of observability.

For both the husband and the wife, personal and clothing expenditures are considered, as well as the gifts granted to each social network, loans given and consumption of alcohol and/or tobacco which is only purchased by the husband. Clothing is easily observable, personal expenditure less so, while gifts, loans and alcohol consumption are harder to monitor. The gifts to each social network, as well as loans, are much harder to monitor because the money effectively leaves the household, and the recipients have an incentive to keep the gifts or loans private because otherwise, the giver would have to negotiate with his/her spouse over how the money is allocated. For household public goods we consider children schooling and clothing expenditures, as well as food and health spending and we assume these are observable.

To test these hypotheses, we estimate reduced-form demand equations for expenditure on observable household goods such as food purchased and from family farms, assets, schooling and health expenses, as well as goods attributable to either the husband or the wife. Private expenditures include clothing and personal care, alcohol and restaurant meals, and public transport. Finally, we consider money allocated towards gifts and loans. Because there exists the possibility of spending zero Cedis at any particular round on a given item, an unobserved random effects Tobit model is used. For spouse i, in household h, village v, and round r, the demand for good $x^g_{i,v,r}$ can be expressed as:

$$lnx^g_{i,h,v,r} = \sum_{j=0}^{1}\left[\delta_{1j}PuC_{i,v,r-j} + \delta_{2j}PrC_{i,v,r-j} + \delta_{3j}L_{i,r-j}\right] + \theta_1 lnTE_{h,1} + \theta_2 lnA^{liq}_{h,1}$$
$$+\theta_3 lnA^{ill}_{h,1} + \sum_{v=2}^{4}\alpha_v + \sum_{r=3}^{5}\sigma_r + \varepsilon_{i,v,r}$$

where $PuC_{i,v,r}$, $PrC_{i,v,r}$ and $L_{i,r}$ are the values of the public and private cash prizes, and livestock prizes, respectively, won by spouse i; $\sum_{\mathrm{h}=2}^{4}\alpha_{\mathrm{v}}$ are village fixed-effects; $\sum_{\mathrm{r}=3}^{5}\sigma_{\mathrm{r}}$ are round fixed-effects; $TE_{h,1}$ is total household expenditure; and $A^{liq}_{h,1}$ and $A^{ill}_{h,1}$ are household liquid and illiquid assets in round 1 respectively. We use assets rather than income (as in the usual Engel specification) because the income data proved too noisy to reliably capture households' living standards. The results are presented in Table 4 for the effect of intent to treat effects of private and public cash prizes on household public goods which would be observable to both spouses, in Table 5 for the effect on private observable expenditures of each spouse, and in Table 6 for the effect on gifts and loans, which are easier to conceal.

The first notable aspect of these results is the lack of any significant response of public good spending to private prizes (current or lagged) except the reduction on asset expenditure by husbands. Meanwhile, there are clear responses to public prizes and livestock. The second observation is that the responses of spending to public prizes are clearly gender-differentiated. Husbands' public cash prize is spent on assets and equipment, as well as home goods (utilities, household items, etc) and health, while schooling expenditure in the round following the prize decreases. Wives who win spend less on food, using up more of the produce from their farms. Livestock prizes won by wives increase asset expenditures, indicating that some livestock were kept for breeding or later consumption. Livestock prizes won by the husband decrease health expenditure in the following months, suggesting health payments were done in kind or that there was an increase in nutrition. This may reflect the non-discretionary nature of the expense.

In Table 5 we present the results for regressions where the dependent variable is spending on private, observable goods. Since the survey asked each spouse separately about their private goods spending, we present results for spending reported by each spouse. (We tried this also for public goods, but the data by spouse were too sparse to be separated since in most cases the purchase of public goods is assigned to only one spouse.)

Expenditure on assignable private goods responds to both public and private prize winning, but in different ways. Husbands spend public prize money on men's clothing; wives on personal care and decrease women's clothing. This indicates that the other spouse knew about these purchases. It is interesting also that public prizes won by wives had no significant impacts on spending in the month immediately following the lottery; instead, the effects are lagged. This suggests that wives were inclined to save some of their prizes, and were successful in doing so for up to three months after their win. Meanwhile, husbands spent private prizes on public transport, while wives did not cause significant changes in expenditure, nor differences relative to public prizes.

In Table 6, we present the results for regressions where gifts and loans are the dependent variable. The first thing to note is that both spouses responded to prize-winning by increasing gifts or loans, but also that the response varies by type of prize. Wives also shared some of the prize money with others as cash gifts, while for husbands gifts in kind increased. Livestock prizes given away register as an increase in in-kind gifts. Livestock and private cash winnings by husbands significantly increase their in-kind gifts and there are no lagged effects. Also, when the husband wins a livestock prize, wives' in-kind gifts decrease in a similar amount as the increase observed in husbands gifts. Livestock prizes were awarded in front of the entire village, thus they may be driven by social pressure. However, cash prizes are only known by others if the recipient chooses to share, which is consistent with Walker's (2011) risk sharing findings, suggesting that inter- household transfers are driven by investment motives, rather than social pressure. Importantly, the fact that both husbands and wives make gifts and loans from private prizes as well as public prizes provides evidence against the hypothesis that gifts are induced by social pressure. Rather, it suggests a conscious decision to invest in social networks.

Wives' private prizes increase cash gifts in the immediate round (at the 15% level in the linear specification). Recall that follow up surveys were conducted a week after the lotteries, suggesting the wife commits the prize towards an allocation that is both difficult to monitor and cannot be easily recovered if the husband were to find out she won. Public prizes won by wives significantly increase loans in the immediate round, and both cash and in-kind gifts in following rounds. The differences in the timing of committing the private prizes towards cash gifts, and lagged public prizes towards both kinds of gifts is consistent with differing motives. The wife commits the private prize to cash gifts immediately. On the other hand, she shares (probably what is left from) public prizes from previous rounds. The effect on cash gifts is larger than the effect on in-kind gifts, further strengthening the argument of an intention to conceal from her husband, as in-kind gifts are easier to monitor. Furthermore, wives made gifts out of lagged public prizes, more than two months following their win. This does not align with the notion of public prize-winning inducing immediate sharing.

Loans may be a form of concealment, or at least an effort by wives to preserve their prize money out of their husbands' reach. Collins et al. (2009) find evidence that spouses in Ghana lend money to agents called "money guards", who offer the chance to hold the money aside until it is needed for expenditures not sanctioned by the other spouse, or for transfers to the spouse's family. This interpretation is also consistent with Udry's (1990) definition of loans in West Africa as a form of contingent claim; loans are almost universally interest-free and with flexible repayment terms, thus lending serves the creditor as a relatively costless store of value and future insurance. Given wives have less regular and reliable flows of income than their husbands, loans may therefore be an attractive short-term investment option where bank accounts are not readily available.

Thus our results lend support to the model's prediction that spouses conceal private windfalls from each other in the form of less visible spending, savings or gifts and loans to other households. Public prizes, on the contrary, are spent in visible ways: on food, and physical assets. This behavior was observed among both husbands and wives. Interestingly, husbands were inclined to spend their private prizes on vice goods such as alcohol or entertainment.

One interesting behavioral difference between the sexes was that wives tended to save more out of private prizes and spend them over the few months following the win. These results are consistent with Ashraf (2009), who found higher degrees of savings out of private windfalls in a lab experiment. This difference in inter-temporal allocation induced by the form of the prize is interesting, since it suggests that the degree of publicity of the income affects its efficient allocation. Yet which allocation is more optimal (spending a public prize quickly, or a private prize slowly) is not clear. One might interpret the private windfall as more efficient in the sense that it encourages saving, especially among women.

Table 4. Treatment Effects of Asymmetric Information on Household Public Goods Expenditure

	Household Public Goods											
	Dependent Variable: Ln (Expenditure)						Dependent Variable: Expenditure					
	Home Expenses	Assets	Schooling	Health	Child Clothing	Purchased Food	Home Expenses	Assets	Schooling	Health	Child Clothing	Purchased Food
Husband												
Public Cash Prize	0.008	0.028**	-0.006	0.011*	0.002	-0.001	0.181*	0.464**	-0.514	0.147	0.013	-0.474*
	(0.005)	(0.013)	(0.014)	(0.006)	(0.012)	(0.001)	(0.100)	(0.231)	(0.557)	(0.189)	(0.079)	(0.290)
Private Cash Prize	0.001	-0.038**	0.012	0.000	-0.027*	0.001	-0.049	-0.533	0.257	0.045	-0.176*	-0.073
	(0.005)	(0.018)	(0.012)	(0.006)	(0.016)	(0.001)	(0.104)	(0.337)	(0.496)	(0.193)	(0.105)	(0.291)
Livestock Prize	0.000	-0.000	0.001	-0.007**	0.004	0.001	0.044	-0.069	-0.114	-0.052	0.015	0.249
	(0.003)	(0.009)	(0.008)	(0.003)	(0.007)	(0.000)	(0.063)	(0.173)	(0.329)	(0.123)	(0.048)	(0.179)
Public Cash Prize	0.007	0.029*	-0.040**	0.008	-0.005	-0.000	0.180	0.284	-1.323*	0.076	-0.067	-0.113
(Lag)	(0.007)	(0.017)	(0.019)	(0.007)	(0.017)	(0.002)	(0.124)	(0.309)	(0.748)	(0.242)	(0.111)	(0.362)
Private Cash Prize	0.004	-0.000	-0.008	0.004	-0.007	-0.000	0.179	0.045	-0.474	0.018	-0.078	-0.056
(Lag)	(0.007)	(0.018)	(0.016)	(0.007)	(0.018)	(0.002)	(0.129)	(0.324)	(0.663)	(0.245)	(0.119)	(0.369)
Livestock Prize	-0.001	0.016	0.003	0.000	-0.001	-0.001	0.062	0.160	0.144	0.065	-0.009	-0.185
(Lag)	(0.004)	(0.010)	(0.009)	(0.004)	(0.009)	(0.001)	(0.077)	(0.176)	(0.378)	(0.141)	(0.060)	(0.214)
Wife												
Public Cash Prize	-0.001	-0.023	0.009	0.000	-0.003	-0.002**	0.139	-0.140	0.182	-0.068	-0.009	0.076
	(0.005)	(0.014)	(0.011)	(0.005)	(0.010)	(0.001)	(0.088)	(0.244)	(0.444)	(0.161)	(0.066)	(0.245)
Private Cash Prize	-0.002	0.004	0.010	0.000	-0.012	-0.000	0.036	0.014	0.985**	-0.007	-0.057	-0.158
	(0.005)	(0.013)	(0.012)	(0.006)	(0.013)	(0.001)	(0.104)	(0.248)	(0.481)	(0.185)	(0.081)	(0.280)
Livestock Prize	0.002	-0.010	-0.000	-0.002	-0.003	0.001	0.013	-0.174	-0.041	-0.111	-0.028	0.003
	(0.003)	(0.009)	(0.008)	(0.003)	(0.007)	(0.001)	(0.065)	(0.177)	(0.326)	(0.122)	(0.050)	(0.184)
Public Cash Prize	-0.000	-0.009	0.012	0.000	0.003	-0.001	-0.047	-0.143	-0.186	-0.069	0.037	-0.090
(Lag)	(0.005)	(0.013)	(0.010)	(0.005)	(0.010)	(0.001)	(0.090)	(0.236)	(0.437)	(0.165)	(0.065)	(0.249)
Private Cash Prize	0.002	0.016	0.018	0.003	0.015	-0.001	-0.009	0.189	0.438	0.306	0.083	-0.218
(Lag)	(0.006)	(0.014)	(0.013)	(0.006)	(0.012)	(0.001)	(0.115)	(0.262)	(0.519)	(0.207)	(0.078)	(0.313)
Livestock Prize	0.001	0.018**	-0.003	-0.004	-0.013	0.000	0.031	0.362**	-0.070	-0.096	-0.084	-0.014
(Lag)	(0.003)	(0.009)	(0.008)	(0.004)	(0.009)	(0.001)	(0.070)	(0.163)	(0.352)	(0.135)	(0.058)	(0.201)
Uncensored	826	342	484	854	376	1069	826	342	484	854	376	1069
N	1070	1070	1070	1070	1070	1070	1070	1070	1070	1070	1070	1070

Note: Results include controls for total expenditure, initial assets, village and round fixed effects. Standard errors in parentheses.

For the logarithmic specification we use the following transformations: ln(Expenditure+1) and lnx_i^ =ln[x_i^ +(x_i^2+1)^(1/2)]

*** p-value<0.001, ** p-value<0.05, * p-value<0.15

Table 5. Treatment Effects of Asymmetric Information on Observable Private Expenditure

	Dependent Variable: Ln (Expenditure)								Dependent Variable: Expenditure							
	Husband				Wife				Husband				Wife			
	Public Transp.	Personal Care	Clothing	Alcohol	Public Transp.	Personal Care	Clothing	Chop Money	Public Transp.	Personal Care	Clothing	Alcohol	Public Transp.	Personal Care	Clothing	Chop Money
Husband																
Public Cash Prize	0.001	-0.002	0.024	-0.008	-0.002	0.000	-0.004	0.003	0.041	-0.011	0.352**	-0.111	-0.048	0.009	-0.005	0.030
	(0.004)	(0.003)	(0.016)	(0.009)	(0.005)	(0.002)	(0.013)	(0.004)	(0.052)	(0.013)	(0.114)	(0.104)	(0.124)	(0.023)	(0.087)	(0.049)
Private Cash Prize	0.005	0.001	0.017	0.012	-0.008	0.004	0.025**	-0.001	0.119**	0.011	0.103	0.117	-0.132	0.021	0.148*	-0.015
	(0.004)	(0.003)	(0.018)	(0.008)	(0.005)	(0.002)	(0.013)	(0.004)	(0.052)	(0.014)	(0.135)	(0.085)	(0.129)	(0.022)	(0.082)	(0.049)
Livestock Prize	-0.001	-0.006**	0.012	0.005	-0.003	-0.001	0.001	0.000	-0.027	-0.015	0.092	0.052	-0.048	-0.010	0.018	0.006
	(0.003)	(0.002)	(0.013)	(0.005)	(0.003)	(0.001)	(0.008)	(0.003)	(0.037)	(0.010)	(0.094)	(0.059)	(0.076)	(0.014)	(0.055)	(0.032)
Public Cash Prize	0.001	-0.001	0.003	-0.033*	-0.008	-0.004	0.001	0.002	0.017	-0.014	0.058	-0.301	-0.175	-0.033	0.025	-0.037
(Lag)	(0.006)	(0.004)	(0.025)	(0.017)	(0.006)	(0.003)	(0.018)	(0.005)	(0.070)	(0.017)	(0.180)	(0.185)	(0.163)	(0.029)	(0.113)	(0.063)
Private Cash Prize	0.002	-0.000	-0.057	0.011	0.003	0.001	0.008	-0.009	0.103	-0.010	-0.402	0.083	0.022	0.012	0.054	-0.082
(Lag)	(0.005)	(0.004)	(0.038)	(0.010)	(0.006)	(0.003)	(0.018)	(0.006)	(0.065)	(0.017)	(0.277)	(0.112)	(0.154)	(0.028)	(0.115)	(0.065)
Livestock Prize	-0.002	-0.001	0.002	0.005	-0.005	-0.001	0.005	0.002	-0.011	-0.011	0.013	0.034	-0.089	-0.011	0.015	-0.000
(Lag)	(0.004)	(0.002)	(0.016)	(0.006)	(0.003)	(0.002)	(0.010)	(0.003)	(0.044)	(0.011)	(0.120)	(0.069)	(0.091)	(0.016)	(0.066)	(0.036)
Wife																
Public Cash Prize	-0.002	0.000	-0.008	0.001	0.005	0.004*	-0.029*	-0.005	-0.037	0.001	-0.086	-0.020	0.048	0.026	-0.190*	-0.053
	(0.004)	(0.002)	(0.017)	(0.007)	(0.004)	(0.002)	(0.015)	(0.003)	(0.048)	(0.012)	(0.132)	(0.079)	(0.099)	(0.019)	(0.100)	(0.041)
Private Cash Prize	0.009*	-0.001	0.033*	0.007	-0.001	0.002	0.001	-0.001	0.080	-0.012	0.213	0.056	-0.030	0.013	-0.004	-0.005
	(0.005)	(0.003)	(0.018)	(0.008)	(0.004)	(0.002)	(0.013)	(0.004)	(0.054)	(0.014)	(0.134)	(0.087)	(0.117)	(0.021)	(0.088)	(0.047)
Livestock Prize	0.003	-0.001	-0.009	0.000	0.000	-0.000	0.011	0.006**	0.045	-0.014	-0.073	0.017	-0.003	-0.008	0.075	0.103***
	(0.003)	(0.002)	(0.013)	(0.005)	(0.003)	(0.001)	(0.008)	(0.002)	(0.035)	(0.009)	(0.098)	(0.060)	(0.078)	(0.014)	(0.053)	(0.030)
Public Cash Prize	-0.001	-0.001	0.009	-0.002	0.006	0.006**	-0.001	-0.004	-0.018	-0.005	0.042	-0.067	0.056	0.046**	0.043	-0.058
(Lag)	(0.004)	(0.003)	(0.016)	(0.007)	(0.004)	(0.002)	(0.012)	(0.004)	(0.048)	(0.012)	(0.121)	(0.084)	(0.101)	(0.019)	(0.074)	(0.042)
Private Cash Prize	0.003	0.001	-0.064	0.005	0.000	0.000	0.007	0.000	-0.018	-0.004	-0.489	0.040	-0.033	-0.017	0.058	-0.015
(Lag)	(0.005)	(0.003)	(0.052)	(0.008)	(0.005)	(0.003)	(0.015)	(0.005)	(0.061)	(0.016)	(0.406)	(0.094)	(0.130)	(0.024)	(0.097)	(0.053)
Livestock Prize	0.000	-0.002	0.006	-0.001	-0.000	0.000	0.013	0.000	-0.023	-0.013	0.030	-0.014	-0.036	-0.001	0.070	0.019
(Lag)	(0.003)	(0.002)	(0.013)	(0.005)	(0.003)	(0.001)	(0.009)	(0.003)	(0.038)	(0.010)	(0.096)	(0.063)	(0.084)	(0.015)	(0.059)	(0.034)
Uncensored Obs.	830	839	197	470	845	1009	291	863	830	839	197	470	845	1009	291	863
N	1027	1027	1027	1027	1070	1070	1070	1100	1027	1027	1027	1027	1070	1070	1070	1100

Note: Results include controls for total expenditure, initial assets, village and round fixed effects. Standard errors in parentheses.

For the logarithmic specification we use the following transformations: ln(Expenditure+1) and lnx_i^ =ln[x_i^ +(x_i^2+1)^(1/2)]

*** p-value<0.001, ** p-value<0.05, * p-value<0.15

Table 6. Treatment Effects of Asymmetric Information on Concealable Private Expenditure

	Dependent Variable: Ln (Expenditure)						Dependent Variable: Expenditure					
	Husband			Wife			Husband			Wife		
	Cash Gifts	Inkind Gifts	Lending	Cash Gifts	Inkind Gifts	Lending	Cash Gifts	Inkind Gifts	Lending	Cash Gifts	Inkind Gifts	Lending
Husband												
Public Cash Prize	-0.002	-0.049	-0.019	-0.011	-0.011	0.033	-0.154	-0.296	-0.714	-0.141	-0.072	0.380
	(0.015)	(0.029)	(0.056)	(0.023)	(0.013)	(0.032)	(0.298)	(0.183)	(1.520)	(0.239)	(0.083)	(0.475)
Private Cash Prize	0.003	0.022*	-0.128	0.014	-0.005	0.035	0.040	0.148**	-3.192	0.120	-0.035	0.505
	(0.014)	(0.011)	(0.113)	(0.019)	(0.014)	(0.034)	(0.275)	(0.066)	(3.026)	(0.196)	(0.091)	(0.486)
Livestock Prize	0.000	0.020**	0.005	-0.009	-0.029**	-0.019	-0.081	0.118**	-0.081	-0.067	-0.194**	-0.302
	(0.010)	(0.008)	(0.030)	(0.013)	(0.011)	(0.027)	(0.196)	(0.048)	(0.811)	(0.133)	(0.072)	(0.393)
Public Cash Prize	-0.019	-0.012	-0.100	0.019	-0.003	-0.147	-0.437	-0.083	-2.529	0.153	-0.036	-2.225
(Lag)	(0.026)	(0.022)	(0.141)	(0.023)	(0.017)	(0.155)	(0.510)	(0.136)	(3.661)	(0.236)	(0.111)	(2.397)
Private Cash Prize	-0.002	-0.007	0.039	-0.046	-0.042	0.034	-0.037	-0.010	0.901	-0.385	-0.235	0.308
(Lag)	(0.020)	(0.018)	(0.056)	(0.041)	(0.029)	(0.048)	(0.378)	(0.103)	(1.507)	(0.394)	(0.181)	(0.725)
Livestock Prize	0.001	-0.003	0.032	0.005	-0.012	0.012	-0.020	-0.023	0.697	0.035	-0.082	0.286
(Lag)	(0.012)	(0.012)	(0.033)	(0.015)	(0.011)	(0.026)	(0.238)	(0.069)	(0.882)	(0.151)	(0.075)	(0.368)
Wife												
Public Cash Prize	-0.007	-0.005	0.048	0.003	0.014	0.057**	-0.115	-0.043	1.090	-0.027	0.075	0.721**
	(0.011)	(0.011)	(0.034)	(0.015)	(0.009)	(0.024)	(0.222)	(0.069)	(0.886)	(0.153)	(0.061)	(0.351)
Private Cash Prize	0.001	0.004	-0.044	0.032**	0.007	-0.002	-0.006	0.004	-1.243	0.218	0.030	0.335
	(0.014)	(0.012)	(0.063)	(0.015)	(0.011)	(0.035)	(0.273)	(0.075)	(1.685)	(0.151)	(0.074)	(0.474)
Livestock Prize	-0.005	0.008	0.038	-0.015	0.011	0.009	-0.087	0.056	0.891	-0.207	0.098**	0.224
	(0.010)	(0.008)	(0.025)	(0.013)	(0.007)	(0.024)	(0.186)	(0.048)	(0.664)	(0.140)	(0.048)	(0.345)
Public Cash Prize	-0.002	-0.006	0.001	0.041**	0.020**	-0.008	-0.127	-0.022	0.301	0.389**	0.109*	-0.206
(Lag)	(0.012)	(0.012)	(0.044)	(0.013)	(0.010)	(0.033)	(0.238)	(0.073)	(1.118)	(0.135)	(0.063)	(0.500)
Private Cash Prize	0.001	0.001	-0.116	0.012	-0.043	0.040	0.031	0.015	-2.718	0.053	-0.273	0.499
(Lag)	(0.016)	(0.015)	(0.129)	(0.020)	(0.027)	(0.032)	(0.308)	(0.089)	(3.287)	(0.213)	(0.181)	(0.476)
Livestock Prize	-0.007	0.011	0.007	0.012	-0.004	-0.003	-0.204	0.050	0.412	0.068	-0.042	-0.097
(Lag)	(0.011)	(0.009)	(0.030)	(0.012)	(0.009)	(0.028)	(0.216)	(0.054)	(0.775)	(0.128)	(0.063)	(0.423)
Uncensored	335	270	97	182	292	116	334	270	97	182	292	116
N	1048	1048	1048	1100	1100	1100	1048	1048	1048	1100	1100	1100

Note: Results include controls for total expenditure, initial assets, village and round fixed effects. Standard errors in parentheses.

For the logarithmic specification we use the following transformations: ln(Expenditure+1) and lnx_i^ =ln[x_i^ +(x_i^2+1)^(1/2)]

*** p-value<0.001, ** p-value<0.05, * p-value<0.15

5. Conclusions

We present a simple model of intra-household allocation to show that when the quantity of resources available to the household is not perfectly observed by all household members, the incentives to hide income depend on the role spouses have within the resource management contract. We draw from the Lundberg and Pollak (1993) separate spheres model in assuming that spouses do not commit to any binding agreements. The main focus is on the equilibrium where strictly positive intra-household transfers exist as this is what we observed among almost all households in the survey. Two testable hypotheses were derived from the model: (1) hiding of money occurs when observable resources do not respond to changes in unobservable money, while observable resources do; (2) the spouse in charge of deciding the chop money allowance has no incentives to hide, while the spouse responsible of the household public good provision does. We test the model through a field experiment in Ghana. The field experiments were conducted between March and October 2009 in conjunction with a year-long household survey in four communities in Akwapim South district of Ghana's Eastern Region. It consisted on four lotteries where all survey respondents were invited to participate. Participants were randomly allocated to one of two treatments: public or private prize. Half of the prizes were allocated publicly by lottery, and the other half were allocated in private, by lucky dip.

We find that winning an unanticipated monetary transfer has differential effects depending on the role spouses play within the household contract, as well as depending on the ease by which it can be observed. These differences highlight the gender roles of the spouses, which are clearly borne out in spending patterns. Public windfalls were spent publicly, on food, health and household assets. Meanwhile, we found evidence that husbands and wives both hid private windfalls by purchasing less visible goods and services. But we also noted that this hiding equally often took the form of saving and investment in social networks. Especially among wives, loans and delayed spending of prize money suggest that the information asymmetry may have a greater effect on intertemporal allocations than on inter-good allocations, possibly in a way which counteracts the power balance within the household and increases women's capacity to save and self-insure. Whether this outcome is more optimal than the spending of public windfalls on immediate consumption is unclear, and could be the subject of future research.

Appendix I: Proofs

Husband has Information Advantage:

Proof of Proposition 1:

Let Q=0, then (5) implies:

$$v'(0) < pu'(Y_f + s) \qquad \textit{(P1.1)}$$

But by assumption $v'(0) = \infty$, so (5) binds and Q>0.

Equation (9) implies that *s=0* for some Q>0 as long as:

$$\lambda pu''(Y_f - pQ) < u'(Y_m) \qquad (P1.2)$$

Which only holds *iff* $\lambda < 0$. We have shown that (5) binds, therefore the constraint on *m's* problem binds as well, so $\lambda \neq 0$. Since Q>0, from (8) we know:

$$v'(Q) = \lambda[p^2u''(Y_f - pQ) + v''(Q)] \qquad \textit{(P1.3)}$$

given the concavity assumption, is only possible if $\lambda < 0$.

If $Y_m + T = 0$, ($P3.2$) holds because $u'(0) = \infty$.

$$\lambda pu''(Y_f - pQ) < u'(0) \qquad \textit{(P1.4)}$$

If $Y_m + T = Y_f$, due to the concavity assumption we know that $u'(Y_f - pQ) > u'(Y_f)$, and from (5) and (8) we know that:

$$pu'(Y_f - pQ) = v'(Q) = \lambda[p^2u''(Y_f - pQ) + v''(Q)] \qquad \textit{(P1.5)}$$

So,

$$pu'(Y_f) < pu'(Y_f - pQ) = \lambda[p^2u''(Y_f - pQ) + v''(Q)] \tag{P1.6}$$

So, following from (9), and multiplying (*P3.4*) by *p* on both sides:

$$\lambda p^2u''(Y_f - pQ) < pu'(Y_f) < \lambda[p^2u''(Y_f - pQ) + v''(Q)] \tag{P1.7}$$

when $\lambda v''(Q) \rightarrow 0$, *(P1.7)* will generally won't hold, though there exists the possibility of a small interval where *(P1.7*) holds.

Proof of Proposition 2:

Case (i) If $Y_m + T \leq \overline{Y_m} \in (0, Y_f)$, $s = 0$, such that the value of Q is obtained from (5)

$$v'(Q) - pu'(Y_f - pQ) \leq 0 \tag{P2.1}$$

Differentiating *(P2.1)* and *f's* budget constraint with respect to Y_f *and T* yields the results stated in the proposition.

$$\frac{\partial Q}{\partial Y_f} = \frac{\partial Q}{\partial T} = \frac{pu''(x_f)}{v''(Q)+p^2u''(x_f)} > 0 \tag{P2.2}$$

$$\frac{\partial Q}{\partial Y_m} = 0 \tag{P2.3}$$

$$\frac{\partial x_f}{\partial Y_f} = \frac{\partial x_f}{\partial T} = \frac{v''(Q)}{v''(Q)+p^2u''(x_f)} > 0 \tag{P2.4}$$

$$\frac{\partial x_f}{\partial Y_m} = 0 \tag{P2.5}$$

$$\frac{\partial x_m}{\partial Y_f} = \frac{\partial x_m}{\partial T} = 0 \tag{P2.6}$$

$$\frac{\partial x_m}{\partial Y_m} = 1 \tag{P2.7}$$

Case (ii) If $Y_m + T > \overline{Y_m}$,. $s, Q > 0$.

Solving (8) and (9) for λ and substituting in, yields the following system for *s* and *Q:*

$$u'(Y_m + T - s)\left[u''\left(Y_f + s - Q\right) + v''(Q)\right] - v'(Q)u''\left(Y_f + s - Q\right) = 0 \qquad (P2.8)$$

$$u'\left(Y_f + s - Q\right) - v'(Q) = 0$$

Totally differentiating the system in (*P2.8*):

$$\begin{bmatrix} -u'(x_m)u'''\left(x_f\right) + u'(x_m)v'''(Q) - v''(Q)u''\left(x_f\right) + v'(Q)u'''\left(x_f\right) & -u''(x_m)u''\left(x_f\right) + u'(x_m)u'''\left(x_f\right) - u''(x_m)v''(Q) - v'(Q)u'''\left(x_f\right) \\ v''(Q) + u''\left(x_f\right) & -u''\left(x_f\right) \end{bmatrix} \begin{bmatrix} dQ \\ ds \end{bmatrix}$$

$$= \begin{bmatrix} v'(Q)u'''\left(x_f\right) - u'(x_m)u'''\left(x_f\right) & -u''(x_m)u''\left(x_f\right) - u''(x_m)v''(Q) & -u''(x_m)u''\left(x_f\right) - u''(x_m)v''(Q) \\ u''\left(x_f\right) & 0 & 0 \end{bmatrix} \begin{bmatrix} dY_f \\ dY_m \\ dT \end{bmatrix}$$

Let *D* denote determinant of the Hessian which is equal to:

$$D = det \begin{bmatrix} -u'(x_m)u'''\left(x_f\right) + u'(x_m)v'''(Q) - v''(Q)u''\left(x_f\right) + v'(Q)u'''\left(x_f\right) & -u''(x_m)u''\left(x_f\right) + u'(x_m)u'''\left(x_f\right) - u''(x_m)v''(Q) - v'(Q)u'''\left(x_f\right) \\ v''(Q) + u''\left(x_f\right) & -u''\left(x_f\right) \end{bmatrix}$$

$$= u''(x_m)\left[u''\left(x_f\right) + v''(Q)\right]^2 + \lambda v''(Q)u'''\left(x_f\right)v''(Q) - u'(x_m)u''\left(x_f\right)v'''(Q) + v''(Q)u''\left(x_f\right)^2 < 0$$

(P2.9)

Recall from FOC's: $v'(Q) - pu'(x_m) = \lambda v''(Q)$

$$= u''(x_m)\left[u''\left(x_f\right) + v''(Q)\right]^2 + \left[v'(Q) - pu'(x_m)\right]u'''\left(x_f\right)v''(Q) - u'(x_m)u''\left(x_f\right)v'''(Q) + v''(Q)u''\left(x_f\right)^2 < 0$$

So, the comparative statics are,

$$\frac{\partial Q}{\partial Y_m} = \frac{\partial Q}{\partial T} = \frac{\partial Q}{\partial Y_f} = \frac{u''(x_m)u''\left(x_f\right)^2 + u''(x_m)u''\left(x_f\right)v''(Q)}{D} > 0 \qquad (P2.11)$$

$$\frac{\partial x_f}{\partial Y_f} = \frac{\partial x_f}{\partial Y_m} = \frac{\partial x_f}{\partial T} = \frac{u''(x_m)v''(Q)^2 + u''(x_m)u''\left(x_f\right)v''(Q)}{D} > 0 \qquad (P2.12)$$

$$\frac{\partial s}{\partial Y_f} = \frac{u'(x_m)u''\left(x_f\right)v'''(Q) - \lambda v''(Q)u'''\left(x_f\right)v''(Q) - v''(Q)u''\left(x_f\right)^2}{D} < 0 \qquad if$$

$$u'(x_m)u''\left(x_f\right)v'''(Q) > \lambda v''(Q)u'''\left(x_f\right)v''(Q) + v''(Q)u''\left(x_f\right)^2 \qquad (P2.13)$$

$$\frac{\partial s}{\partial Y_m} = \frac{\partial s}{\partial T} = \frac{u''(x_m)\left[u''(x_f)+v''(Q)\right]^2}{D} > 0 \qquad (P2.15)$$

$$\frac{\partial x_m}{\partial Y_m} = \frac{\partial x_m}{\partial T} = \frac{\partial x_m}{\partial Y_f} = \frac{-u'(x_m)u''(x_f)v'''(Q)+\lambda v''(Q)u'''(x_f)v''(Q)+v''(Q)u''(x_f)^2}{D} > 0 \qquad (P2.16)$$

<u>*Proof of Proposition 3:*</u>

Assumptions:

(i) Spouse *f* can observe T with probability zero.

(ii) Spouse *m's* private consumption, or discretionary expenditure, is not monitored by *f*.

If *m* chooses to reveal T and $Y_m > \overline{Y_m}$ the change in utility per unit change in T is given by:

$$\left.\frac{\partial U_f}{\partial T}\right|_R = \frac{\partial v}{\partial Q}\frac{\partial Q}{\partial T} + \frac{\partial u}{\partial x_f}\frac{\partial x_f}{\partial T} \qquad (P3.1)$$

$$=$$

$$\frac{v'(Q^R)}{D}\left[u''(x_m^R)u''(x_f^R)^2 + u''(x_m^R)u''(x_f^R)v''(Q^R)\right] +$$

$$\frac{u'(x_m^R)}{D}\left[-u'(x_m^R)u''(x_f^R)v'''(Q^R) + \lambda v''(Q^R)u'''(x_f^R)v''(Q^R) + v''(Q^R)u''(x_f^R)^2\right]$$

Substituting in *f's* FOC$u'(x_f^R) = v'(Q^R) = \lambda\left[u''(x_f^R) + v''(Q^R)\right]$, and $u'(x_m^R) = \lambda u''(x_f^R)$

$$\left.\frac{\partial U_f}{\partial T}\right|_R =$$

$$\frac{u'(x_m^R)}{D}\left[u''(x_m^R)\left[u''(x_f^R) + v''(Q^R)\right]^2 - u'(x_m^R)u''(x_f^R)v'''(Q^R) + \lambda v''(Q^R)u'''(x_f^R)v''(Q^R) + v''(Q^R)u''(x_f^R)^2\right] = u'(x_m^R)$$

since $D = u''(x_m^R)\left[u''(x_f^R) + v''(Q^R)\right]^2 - u'(x_m^R)u''(x_f^R)v'''(Q^R) + \lambda v''(Q^R)u'''(x_f^R)v''(Q^R) + v''(Q^R)u''(x_f^R)^2$

If *m* decides to hide then *m* spends all the unobservable income on private consumption. Thus, the change in utility per unit change in the transfer is give by:

$$\left.\frac{\partial U_m}{\partial T}\right|_H = u'(x_m^H) \qquad (P3.2)$$

where x_m^H is the allocation when T is hidden, and x_m^R is the allocation when T is revealed. Note that $x_m^H > x_m^R$.

Spouse *m* hides money from *f* if and only if

$$\frac{\partial U_m}{\partial T}\bigg|_R = u'(x_m^R) < u'(x_m^H) = \frac{\partial U_m}{\partial T}\bigg|_H \qquad \textit{(P3.3)}$$

Which is never true due to the concavity assumption. Thus in a non-cooperative outcome, even when the husband makes positive transfers to his wife, he never hides.

Wife has Information Advantage:

Proof of Proposition 4:

First, it is important to show that (12) binds. Let Q=0, then (14) implies:

$$v'(0) < pu'\big(Y_f + s\big) \qquad \textit{(P4.1)}$$

But by assumption $v'(0) = \infty$, so (12) binds and Q>0.

Equation (16) implies that *s=0* for some Q>0 as long as:

$$\lambda u''\big(Y_f - Q\big) < u'(Y_m) \qquad (\textit{P4.2})$$

Which only holds *iff* $\lambda < 0$. We have shown that (12) binds, therefore the constraint on *m's* problem binds as well, so $\lambda \neq 0$. Since Q>0, from (15) we know:

$$v'(Q) = \lambda\big[u''\big(Y_f - pQ\big) + v''(Q)\big] \qquad \textit{(P4.3)}$$

Which, given the concavity assumption, is only possible if $\lambda < 0$.

If $Y_m = 0$, (*P4.2*) holds because $u'(0) = \infty$.

$$\lambda u''\big(Y_f - Q\big) < u'(0) \qquad \textit{(P4.4)}$$

If $Y_m = Y_f$, due to the concavity assumption we know that $u'(Y_f - Q) > u'(Y_f)$, and from (12) and (15) we know that:

$$u'(Y_f - Q) = v'(Q) = \lambda[u''(Y_f - Q) + v''(Q)] \qquad \textit{(P4.5)}$$

So,

$$u'(Y_f) < u'(Y_f - Q) = \lambda[u''(Y_f - Q) + v''(Q)] \qquad \textit{(P4.6)}$$

So, following from (16):

$$\lambda u''(Y_f - Q) < u'(Y_f) < \lambda[u''(Y_f - Q) + v''(Q)] \qquad \textit{(P4.7)}$$

Dividing by $\lambda < 0$:

$$u''(Y_f - Q) > [u''(Y_f - Q) + v''(Q)] \qquad \textit{(P4.8)}$$

Which is always going to hold due to concavity assumption.

Proof of Proposition 5:

It suffices to derive the comparative statics only for a change in Y_f which is also the comparative statistic of interest for the propositions that follow.

Case (i): If $Y_m \leq \overline{Y_m} \in (0, Y_f)$ thus $s = 0$, so the value of Q is obtained from (12)

$$v'(Q) - u'(Y_f - Q) \leq 0 \qquad \textit{(P5.1)}$$

Differentiating *(P5.1)* and *f's* budget constraint with respect to Y_f yields the results stated in the proposition. Note that neither x_m nor s change with Y_f. In particular,

$$\frac{\partial Q}{\partial Y_f} = \frac{u''(x_f)}{v''(Q) + u''(x_f)} > 0 \qquad \textit{(P5.2)}$$

$$\frac{\partial x_f}{\partial Y_f} = \frac{v''(Q)}{v''(Q) + u''(x_f)} > 0 \qquad \textit{(P5.3)}$$

Case (ii): If $Y_m > \overline{Y_m}$.thus $s, Q > 0$.

Solving (15) and (16) for λ and substituting in, yields the following system for s and Q:

$$u'(Y_m - s)\left[u''\left(Y_f + s - Q\right) + v''(Q)\right] - v'(Q)u''\left(Y_f + s - Q\right) = 0 \qquad \textit{(P5.4)}$$

$$u'\left(Y_f + s - Q\right) - v'(Q) = 0$$

Totally differentiating the system in (*P5.4*):

$$\begin{bmatrix} -u'(x_m)u'''(x_f) + u'(x_m)v'''(Q) - v''(Q)u''(x_f) + v'(Q)u'''(x_f) & -u''(x_m)u''(x_f) + u'(x_m)u'''(x_f) - u''(x_m)v''(Q) - v'(Q)u'''(x_f) \\ v''(Q) + u''(x_f) & -u''(x_f) \end{bmatrix} \begin{bmatrix} dQ \\ ds \end{bmatrix}$$

$$= \begin{bmatrix} v'(Q)u'''(x_f) - u'(x_m)u'''(x_f) & -u''(x_m)u''(x_f) - u''(x_m)v''(Q) \\ u''(x_f) & 0 \end{bmatrix} \begin{bmatrix} dY_f \\ dY_m \end{bmatrix}$$

Let D denote determinant of the Hessian which is equal to:

$$D = det \begin{bmatrix} -u'(x_m)u'''(x_f) + u'(x_m)v'''(Q) - v''(Q)u''(x_f) + v'(Q)u'''(x_f) & -u''(x_m)u''(x_f) + u'(x_m)u'''(x_f) - u''(x_m)v''(Q) - v'(Q)u'''(x_f) \\ v''(Q) + u''(x_f) & -u''(x_f) \end{bmatrix}$$

$$= u''(x_m)\left[u''(x_f) + v''(Q)\right]^2 + \lambda v''(Q)u'''(x_f)v''(Q) - u'(x_m)u''(x_f)v'''(Q) + v''(Q)u''(x_f)^2 < 0 \qquad \textit{(P5.5)}$$

So, the comparative statics are,

$$\frac{\partial Q}{\partial Y_f} = \frac{u''(x_m)u''(x_f)^2 + u''(x_m)u''(x_f)v''(Q)}{D} > 0 \qquad \textit{(P5.6)}$$

$$\frac{\partial Q}{\partial Y_m} = \frac{u''(x_m)u''(x_f)^2 + u''(x_m)u''(x_f)v''(Q)}{D} > 0 \qquad \textit{(P5.7)}$$

$$\frac{\partial x_f}{\partial Y_f} = \frac{u''(x_m)v''(Q)^2 + u''(x_m)u''(x_f)v''(Q)}{D} > 0 \qquad \textit{(P5.8)}$$

$$\frac{\partial s}{\partial Y_f} = \frac{u'(x_m)u''(x_f)v'''(Q) - \lambda v''(Q)u'''(x_f)v''(Q) - v''(Q)u''(x_f)^2}{D} < 0 \quad \textit{if} \quad u'(x_m)u''(x_f)v'''(Q) > \lambda u'''(x_f)v''(Q)^2 + v''(Q)u''(x_f)^2 \qquad \textit{(P5.9)}$$

$$\frac{\partial x_m}{\partial Y_f} = \frac{u'(x_m)u''(x_f)v'''(Q) - \lambda v''(Q)u'''(x_f)v''(Q) - v''(Q)u''(x_f)^2}{D} > 0 \qquad \textit{(P5.10)}$$

$$\frac{\partial s}{\partial Y_m} = \frac{u''(x_m)\left[u''(x_f) + v''(Q)\right]^2}{D} > 0 \qquad \textit{(P5.11)}$$

$$\frac{\partial x_m}{\partial Y_m} = \frac{-u'(x_m)u''(x_f)v'''(Q) + \lambda v''(Q)u'''(x_f)v''(Q) + v''(Q)u''(x_f)^2}{D} > 0 \qquad \textit{(P5.12)}$$

Recall from FOC's: $v'(Q) - u'(x_m) = \lambda v''(Q)$

Proof of Proposition 6:

If f chooses to reveal the transfer and $Y_m > \overline{Y_m}$ the demands are obtained from solving the following system of equations:

$$u'(Y_m - s)\left[u''\left(Y_f + s - Q\right) + v''(Q)\right] - v'(Q)u''\left(Y_f + s - Q\right) = 0 \qquad (P6.1)$$

$$u'\left(Y_f + s - Q\right) - v'(Q) = 0$$

$$u''(x_m^R)u''\left(x_f^R\right)v''(Q^R)$$

Thus, if *f* receives a transfer *T* and decides to reveal it, the change in Q, s, x_f, x_m per unit change in *T* are equivalent to those corresponding to changes in Y_f described in proposition 5.

The change in utility per unit change in the transfer is given by:

$$\left.\frac{\partial U_f}{\partial T}\right|_R = \frac{\partial v}{\partial Q}\frac{\partial Q}{\partial T} + \frac{\partial u}{\partial x_f}\frac{\partial x_f}{\partial T} \qquad (P6.2)$$

$$= \frac{v'(Q^R)}{D}\left[u''(x_m^R)u''\left(x_f^R\right)^2 + u''(x_m^R)u''\left(x_f^R\right)v''(Q^R)\right] + \frac{u'(\widetilde{x_f})}{D}\left[u''(x_m^R)v''(Q^R)^2 + u''(x_m^R)u''\left(x_f^R\right)v''(Q^R)\right]$$

Substituting in *f's* FOC $u'\left(x_f^R\right) = v'(Q^R)$,

$$\left.\frac{\partial U_f}{\partial T}\right|_R = \frac{u'\left(x_f^R\right)}{D}\left[u''(x_m^R)u''\left(x_f^R\right)^2 + u''(x_m^R)u''\left(x_f^R\right)v''(Q^R) + u''(x_m^R)v''(Q^R)^2 + u''(x_m^R)u''\left(x_f^R\right)v''(Q^R)\right]$$

If f decides to hide the transfer then f spends all the transfer on private consumption and the household good allocation doesn't change compared to before the transfer, nor do *m's* allocations. So it must be that $u\left(x_f\right) < u\left(x_f^R\right) < u\left(\overline{x_f}\right)$ $where\ \overline{x_f} = x_f + T$ where x_f is the pre-transfer private consumption optimal allocation and $\widetilde{x_f}$ is the post-transfer private consumption optimal allocation if the transfer is revealed. Thus, the change in utility per unit change in the transfer is give by:

$$\left.\frac{\partial U_f}{\partial T}\right|_H = u'\left(x_f^H\right) \qquad \textit{(P6.3)}$$

Spouse *f* hides money from *m* if and only if

$$\left.\frac{\partial U_f}{\partial T}\right|_R = \frac{u'\left(x_f^R\right)}{D}\left[u''(x_m^R)u''\left(x_f^R\right)^2 + u''(x_m^R)u''\left(x_f^R\right)v''(Q^R) + u''(x_m^R)v''(Q^R)^2 + u''(x_m^R)u''\left(x_f^R\right)v''(Q^R)\right] <$$

$$u'\left(x_f^H\right) = \left.\frac{\partial U_f}{\partial T}\right|_{NR} \qquad \textit{(P6.4)}$$

Multiplying through by D<0,

$$u'(x_f^R)\left[u''(x_m^R)u''(x_f^R)^2 + 2u''(x_m^R)u''(x_f^R)v''\left(Q^R\right) + u''(x_m^R)v''\left(Q^R\right)^2\right] > u'(x_f^H)\left[u''(x_m^R)[u''(x_f^R) + v''(Q)]^2 + \right.$$

$$\left. v''\left(Q^R\right)u'''(x_f^R)\left[v'\left(Q^R\right) - u'(x_m^R)\right] - u'(x_m^R)u''(x_f^R)v'''\left(Q^R\right) + v''\left(Q^R\right)u''(x_f^R)^2\right]$$

Which simplifies to,

$$\left[u'\left(x_f^R\right) - u'\left(x_f^H\right)\right]u''(x_m^R)\left[u''\left(x_f^R\right) + v''(Q^R)\right]^2 < u'\left(x_f^H\right)\left[v''(Q^R)u'''\left(x_f^R\right)[v'(Q^R) - u'(x_m^R)] + v''(Q^R)u''\left(x_f^R\right)^2 - \right.$$

$$\left. u'(x_m^R)u''\left(x_f^R\right)v'''(Q^R)\right] \qquad \textit{(P6.6)}$$

Recall from *(P5.9)* that,

$$\frac{\partial s}{\partial Y_f} < 0 \;\; \textit{if} \;\; u'(x_m^R)u''\left(x_f^R\right)v'''(Q^R) > v''(Q^R)u'''\left(x_f^R\right)[v'(Q^R) - u'(x_m^R)] + v''(Q^R)u''\left(x_f^R\right)^2$$

So, when $\frac{\partial s}{\partial Y_f} > 0$ (*P6.6*) doesn't hold because left-hand-side is negative and right-hand-side is positive, so *f* never hides the transfer. However, when $\frac{\partial s}{\partial Y_f} < 0$ both sides of the equation are negative, and the decision to reveal depends on relative preferences and the size of the transfer.

Consider the extreme case where *f* doesn't hide and allocates all of the transfer towards the household public good, such that $T = Q^R$. As the transfer increases ($T \to \infty$), $\lim_{T\to\infty} u'\left(x_f^R\right) = \lim_{T\to\infty} u'\left(Y_f + T + s - Q^R\right) = \lim_{T\to\infty} u'\left(Y_f + T + s - T\right) = u'\left(Y_f + s\right)$. If she does hide, then her only option is to allocate it towards private consumption to avoid detection, thus $\lim_{T\to\infty} u'\left(x_f^H\right) = \lim_{T\to\infty} u'\left(x_f + T\right) = u'(\infty) \to 0$. The right-hand side of (*P6.6*) is negative and the left-hand side tends to zero, so in this case the equilibrium would be not to hide.

Now consider the other extreme case where the transfer tends to zero. If f reveals the transfer: $\lim_{T\to 0} u'\left(x_f^R\right) = \lim_{T\to 0} u'\left(Y_f + T + s - Q^R\right) = u'\left(x_f\right)$, if she hides it $\lim_{T\to 0} u'\left(x_f^H\right) = \lim_{T\to 0} u'\left(x_f + T\right) = u'\left(x_f\right)$, so (*P6.6*) simplifies to $0 > u'(x_f)$, which always holds. Thus there exists a threshold level of transfer ($\bar{T}$) such that for any $T < \bar{T}$ the Subgame Perfect Nash Equilibrium is to hide.

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