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Hide and Seek: A Theory of Efficient Income Hiding within the Household.

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Abstract

In many countries, spouses routinely hide income, consumption and assets from one another. In this paper, I provide a theoretical model in which hiding is costly and only some expenditure can be hidden. I characterise the set of ex ante Pareto efficient allocations and show by means of extended examples that in some cases it can be efficient for one or both partners to lie about their income. Examples also show that efficient hiding may not be a marker of power or weakness in the household decision-making process. As such, it may not be possible to make meaningful inference about the nature of the household simply by observing whether assets or income are hidden.

Keywords: C9; D9, efficient household, hiding income, family, couples

1. Introduction.

It is well-known and widely accepted that around the world, in many different cultures, spouses routinely keep some consumption and income from their partners. The pattern is documented in academic work by anthropologists, economists and other social scientists (Bruce (1989)) as well as being a frequent topic of popular culture. We can identify many motives for hiding spending from a spouse, but the central and most obvious reason is that within the partnership the goals of an individual may differ from those of the household of which they are a part. These varied motives suggest some value

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in developing theoretical models of hiding in marriage such as those recently and separately proposed by Malapit (2009) and Castilla and Walker (2013).

Observing the scattered evidence on assets prompts a number of questions, three of which will be the focus of this paper. First, can we equate hiding with inefficiency? It is tempting to interpret evidence of hiding as a sign of inefficiency because for one thing it is not immediately obvious why spouses who are engaged in a long-run relationship would draw up a marital contract that give incentives for dishonesty (Chiappori (1992)). Moreover, since hiding resources is usually costly, a contract that gives the hiding individual the correct incentive to reveal true income or wealth would seem to dominate an agreement based on deception. Now, this intuition, based perhaps on the well-known revelation principle is not necessarily correct and in fact, in a literature that has received intermittent attention, several authors have already shown that the revelation principle need not apply when the feasible message space (e.g. statements about income) depends on the state of the world (e.g. actual income) (Lacker and Weinberg (1989) Green and Laffont (1986)or Postlewaite (1979)).

A second, related question is this: can mutual hiding be efficient? The current theoretical work on dishonesty, such as Celik (2006) is not concerned with household relationships and more to the point the papers in the literature focus on one-sided uncertainty in their examples, leaving the issue of the optimality of mutual hiding so far unexplored. Meanwhile, on the empirical side, much of the evidence on intrahousehold behaviour that is available focuses on one gender or the other or provides only reports on aggregates or averages. It is not clear from this literature whether there is systematic and mutual hiding of assets within the same relationship and what mutual hiding would mean for identification of household models.

A third question naturally arises in combination with the first two: is hiding a sign of weakness or of strength in a relationship? In other words, are individuals with low bargaining strength in the household relationship more likely to resort to asset hiding or is it the case that the ability to hide assets gives individual spouses the power to extract more favourable terms from the household bargain?

Taking its cue from the mechanism design literature (e.g. Lacker and Weinberg (1989)), the general lesson from this paper is that hiding may be ex-ante Pareto efficient. Moreover, mutual hiding may be efficient. And, efficient hiding may not be linked to the power of a spouse: it may be the weak spouse or the strong spouse who hides. Finally, hiding may be optimal even when the utilities of spouses have equal weight in household decisions. It follows that observing hiding may tell us little about the efficiency of the household process or about the degree of equality in household decision-making. It is worth noting that I am not claiming that a cooperative model is necessarily the right one, only that hiding per se is compatible with ex-ante efficiency.

The plan of the paper is as follows: in the next section I provide some motivating background in the form of a survey of some of the worldwide evidence on spousal income, asset and consumption hiding.[1] The survey is incomplete, both in the sense that not all societies can be accommodated in one article, but also because much of the evidence on hiding is presented only tangentially in papers devoted to other aspects of relationships or household behaviour. I then present a basic cooperative model of the household in which income is stochastic, and income hiding is generally feasible but costly. In the model once income is privately revealed, each partner must make a declaration about their income. Ex ante, for each declared pair of incomes, the household agrees an allocation of resources and thereby a pair of publicly observed utilities. Partners who have hidden income may also receive additional, unobservable utility from that resource. We look for mechanisms that maximize ex ante household welfare, defined as a weighted sum of ex ante utility for each player. By definition, ex ante welfare is ex ante Pareto efficient, but the key question is whether hiding is part of that efficiency. As Lacker and Weinberg (1989) or Green and Laffont (1986) show, there are no clear general conditions under which the revelation principle does not hold. In the case of one sided potential hiding between principal and agent, Celik (2006) provides a sufficient condition for truth-telling to be optimal (see also Kartik (2009)'s model of a sender-receive game where the sender may lie at a cost).[2] I therefore use a series of examples to explore the issues.

[1]Hiding may refer to consumption, to income or to assets. In a dynamic model there must be a link between different forms of housing, though as the next section reveals the evidence on hiding is not thorough enough to show up this relationship in any detail.

[2]Where there is one sided asymmetric information a sufficient condition for truth-telling to be a feature of the optimum is nesting of types, meaning that if a type i can send a message that he or she is actually type j, then type i can also send any message that type j can send (Green and Laffont (1986)).

2. The Evidence on Hiding.

One common thread that links nearly all of the studies listed below and summarized in Table 1 is that their focus is only incidentally on hiding. Most often hiding behaviour is revealed when researchers ask questions about household money management or about the knowledge that one spouse has about the affairs and behaviour of the other spouse (Bennett (2013)). In many cases only one spouse is interviewed, making results partial. Generally then, the evidence is fragmentary and sometimes it is elusive.[3] One finding is that spouses often hide resources, but that there is shared awareness of this fact within the household, instanced by Dagnelie and LeMay (2008) report on a survey of 572 husbands and wives in Benin on the outskirts of the city of Cotonou (which has around 0.75m inhabitants). They find that 79% of respondents do not know their spouse's income and 76% believe that their partner does not know their income. They state that secrecy and a norm of not enquiring too deeply about a partner's income helps spouses hide their income and retain control over how it is spent. A similar pattern is reported in Gracia Clark's (1994) study of trading women in west African cities, where shared budgets between spouses were most unlikely. She states that amongst the Asante of Kumasi in Ghana, "virtual ignorance of the husband's amount and sources of income is not uncommon and some of the women openly recommended it. As long as he contributed adequately to the children's expense, it was better not to know about the rest. Besides, he was more likely to pay his share if he did not know the full extent of your own income." P. 340. She notes though some women stating that it was better to live with their husbands in order to monitor their income.

For the UK, Pahl (1990) cites historical evidence that many wives are unaware of their husband's earnings. She notes trends towards individual money management within households, but this does not say anything about whether tendencies are associated with greater hiding of spending and earning. More detailed evidence is available for Nigeria. Based on a sample of

[3]There are sources that are more or less anecdotal. For instance, writing about a small industry in Japan that facilitates hiding, George Mikes states that "Pay-packets are printed and supplied to order, showing the required smaller sums; replicas of the company's bags, typography, pay slips, etc. A man may open his pay-packet take out a few thousand yen for his own private use and still deliver a properly sealed and seemingly unopened pay-packet [to his wife]." p. 161, Land of the Rising Yen, Penguin London, 1970.

Yoruba women from 226 conjugal units in the urban setting of Lagos, Nigeria, Fapohunda (1988) finds that 80% of wives did not know their husband's income and 65% did not know his expenditure pattern. Similar results were found amongst traditional and modern self-styled families. According to the wives, only a small percentage of couples explicitly pooled their income, though often particular areas of expenditure were assigned to one partner's responsibility. In a companion piece, and using evidence from a number of countries, including Haiti and Nigeria, Bruce (1989) provides a wide-ranging survey of similar studies that also document the extent to which veils of ignorance partially obscured partner's understanding of their spouse's income, consumption and savings behaviour. Some of these conclusions draw on earlier work by Hill (1972), in rural Nigeria who noted the rearing of goats by Hausa women as assets "maintainable by children, removable on divorce, and safe (by tradition) from seizure by husbands, against whom there would be a right of appeal to the masu sarauta", p. 317 (see also Guyer (1988)). Studying a group of 187 households living in Mayur Vihar and Kalyanpuri colonies on the eastern edge of Delhi in India, Subramanian (2008) reports that, "women or children hide or stealthily put away small amounts of money for some personal use. The research does not identify whether men are aware of this hiding in some way or other. Often women may hide the money to pay a child's school fees or clear some debt." Page 106. She notes that men typically retain - which of course is not the same as hiding - a significant portion of their income for personal use and even when this is excessive women rarely complain, because "Fights may lead to the man asking his wife to leave the house and so women rarely complain. This fear is especially strong if they complain publicly, which is why most complaints are confined to members of their natal families and intimate female friends." P 107.

Side-by-side evidence from both husbands and wives is rare, but suggests that hiding consumptin or assets is concentrated in a limited number of goods. In an intriguing analysis of over 10,000 households drawn from two waves of the Indonesian Family Life survey, Matsumoto (2007) finds major discrepancies between self-reported ownership of assets amongst couples. Some of the differences at the individual household level may be random, due to recall biases or over-optimism about values. However Matsumoto finds that in particular, wives report significantly less ownership of jewellery and personal savings when interviewed in the presence of husbands, compared to situations where the wife is interviewed separately. For other assets such as housing, land and furniture no specific pattern emerges. Meanwhile, for men there are no systematic discrepancies across any of the assets. Eroglu (2009) interviews separately 17 spouses from low-income families in Ankara, Turkey. She reports that 8/17 wives had 'secret kitties' for hidden expenditure, with the mean size of the fund equal to around 3% of mean monthly household income. Kitties were common in households where women were responsible for handling money, but only occurred in one household where husbands actively monitored expenditure. Women accumulated these funds in various ways, not just from personal earnings but also through reducing claimed personal spending, "b) inflating claimed household expenditure, c) keeping the money saved from household shopping, and d) keeping the difference between home-made substitutes and their market equivalents." Eroglu (2009) p. 69. The money was used in different ways: to provide a buffer in household money management, as well as to pursue purchases (often for the household) that the wives felt husbands undervalued or would block.

Recent experimental data has provided further within household data. Iversen et al. (2006) conduct an experiment with 240 couples using variants of a simple voluntary contribution game in which the endowment of each partner is a secret. The location is Bufumbo sub-county and Sironko District on the slopes of Mt Elgon in south eastern Uganda, a densely settled rural area where livelihoods are predominantly agricultural, but still complex and diverse. In the games, despite the fact that there is a 50% premium for making public contributions to the pool, the authors discover that the majority of individuals keep back some money from the common account. In follow-up interviews with 51 couples that participated in the experiments, they find imperfect knowledge of spousal finances to be common, at least in wives' accounts. 72 percent of men claim full knowledge of wives' finances, and 92 percent that their wives fully know theirs. In wives' accounts these figures are startlingly different: 21 and 14 percent, respectively. In related studies for India, Nigeria and Ethiopia respectively, Kebede et al. (2011) , Munro et al. (2011) and Munro et al. (2010) find similar tales of hiding and ignorance. As with Matsumoto's study they also find differences in assets reported by the partners when they are questioned separately.

Ashraf (2009)'s experimental investigation of saving and consumption decisions in the Philippines is motivated by the practices of household. Individual spouses receive an endowment that must be invested in a joint account, in a private account or taken as a private gift certificate subject to alternative experimental conditions. She finds men's saving behaviour to be strategic: they are more willing to hide money in a private account or spend it on personal consumption if the decision is kept private from their spouse. Women's behaviour, in contrast, is largely invariant to changes in the experimental conditions. Further experimental evidence on hiding is provided by Jakiela and Ozier (2011). In this Kenyan based study, individuals had opportunities to hide (at a cost) experimental winnings. Women who had relatives present in the experiment were willing to pay more to hide. Another experiment based on 250 couples from the Siaya district of eastern Kenya, Hoel (2012) finds that both men and women give less to their partners in a dictator game, when the transfer is anonymous, compared to the situation where the source of transfers were identifiable. Interestingly, Hoel (2012) reports that individuals who state that their partners know their expenditures were more likely to behave strategically in the experiment.

Using data from the China Health and Nutrition Survey, Chen (2006) observes that women modify activities in the wake of their spouse's migration in a manner consistent with a switch towards harder to monitor activities that are personally favoured. With the father away, girls' household labour is higher and mothers' hours of work are lower. Meanwhile, choices that are more easily monitored by the father, namely children's schooling and health - are not affected by migration, controlling for changes in income. She argues that the data is not compatible with a unitary model, but would fit a non-cooperative model with costly monitoring. De Laat (2008) considers the other side of this asymmetric information problem, interviewing informal settlement dwellers in Nairobi, Kenya and finding that men who have migrated alone spend considerable resources in monitoring expenditure by their wives. Investments include co-location of spouses near the husband's siblings and frequent home visits. Husbands make more frequent visits home when wives live close to their own siblings. The men also attach conditions on remittances to ensure that they are spent on observable goods. Despite these efforts, only 30% of men in the sample report that they know how exactly how remittances are spent by their spouses.

While, Zelizer (1997) offers an intriguing round-up of historical evidence on hiding by wives, more recent or systematic evidence on the phenomenon in the USA is scant. Zagorsky (2003) uses five cohorts from the US National Longitudinal Survey which (sometimes) interviews spouses separately. He notes that husbands tend to give higher values for income assets and wives report higher figures for debts. Meanwhile both partners tend to give higher figures for their own income and lower figures for their partners (compared to their partner's answers). What is not clear is the reason for the widespread discrepancies – i.e. are they an artefact of the survey process, do they represent misunderstanding or do they represent the hiding of assets, debts and income by one or both partners. Lee and Pocock (2007) study saving by couples in South Korean where individual bank accounts are the norm and where the law provides strong protection to individual assets at the time of divorce. Using the Korean Household Panel Survey they find that where women have a relatively strong bargaining position savings are higher and women save relatively more in their own accounts. They note that the law in South Korea limits the ability of partners to know each other's financial affairs and this has been criticized for the protection it gives to (male) spouses who hide assets.

Most work on asset hiding has been empirical, but two pioneering papers which have theoretical models of spousal money hiding are Malapit (2009) and Castilla (2010) that build on earlier bargaining models (e.g. Manser and Brown (1980)) and non-cooperative models such as Aura (2002) and Lundberg and Pollak (1996) . In Malapit's model, spouses separately and non-cooperatively decide how much of their individual incomes to contribute to a household pool, out of which benefits are produced according to a function, G(.) which represents the household's agreed bargaining solution. In the specific form of the model G has the Cobb-Douglas form G = $\left(x^h\right)^\alpha$ $(x^w)^\beta$ where x^h and x^w represent the declared incomes of husband and wife respectively, and $\alpha + \beta < 1$, giving decreasing returns. Total benefits to the individual are a weighted sum of G and the income kept back from the spouse. There are two versions of the model. In one each person decides separately what share of income to contribute. This model produces the result that individual contribution rates are independent of the other spouse's income. Alternatively, she considers a case where one spouse has the power to choose a uniform contribution rate for both spouses.

The model is slightly different in Castilla (2010) which is applied to household data on income and expenditure for Ghana. In that model it is only the husband who has income to hide. In one version of the model, he must consider what income to give to his wife who, in turn, controls investment in a household public good. In the core version of the model, allocation decisions are ex post Pareto efficient, with bargaining powers determined by revealed income. Thus a husband has an incentive to reveal income (it raises bargaining power), but an incentive to keep income back (it can then be dedicated to private consumption). Together these papers form a useful point of comparison for the current exercise: their common starting point is a non-cooperative model of the household. The question I wish to address here is whether hiding can be a property of efficient models of the household.

3. A Basic Model of Efficient Hiding.

The previous section has set out some of the evidence on hiding within marriage from very different cultures. In this section, I propose a simple model in which hiding can be efficient. I set out the theory in three stages. The first stage involves an abstract model in utility space where individual incomes can vary. In the second stage I simplify this model to a situation where one agent only has risky income, which can produce one of three values. In the third stage some examples are considered in which both agents have stochastic income.

There are two individuals $k = 1, 2$ with utilities u and v, respectively. Agent k has possible states $j = 1, ...N^k$ all of which are equally probable. Thus there are $N^1 \times N^2$ possible states of nature, where I think of a state as being an income realisation for each agent. States are uncorrelated so that an agent learns nothing about the spouse's state from his or her own state.[4]

At the start of the game, each agent learns his or her own state, but remains in ignorance about the partner's state. Agent k sends a message θ^k. For each agent, the set of messages is potentially constrained. Specifically, let $M(j)$ be the feasible set of messages for an agent in state j. Suppose that $M(j) = \{k : \ j - 1 \leq k \leq j\}$. That is an agent in the lowest possible state cannot lie, while agents in higher states can pretend to have a state at most one below the true value. The idea of the restriction is that stating an income higher than the truth may be impossible because it could require a level of consumption that is not feasible. On the other hand it is possible to report a lower state, because some income can be consumed secretly. However there are limitations to the degree to which consumption and therefore income can be hidden. Allowing at most two possible messages per state simplifies the analysis that follows but is not essential to the argument.[5]

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[4]In some situations this may be unrealistic, especially when for instance, both spouses are agricultural workers in the same region. Nevertheless it is a useful starting point for an analysis of hiding.

[5]If agent in state j can send any message $k \leq j$ then for one-sided asymmetric information the nesting condition is satisfied (Green and Laffont (1986)). It is possible that in

Table 1: Summary of income hiding.

Country	Study	Main Points
Benin	Dagnelie and LeMay (2008)	79% of 572 survey subjects do not know their spouse's income and and 76% believe that their partner does not know their income.
PR China	Chen (2006)	Survey data. After spouse migration women switch towards harder to monitor activities that are personally favoured.
Ethiopia	Kebede et al. (2011)	1200 couples in a common pool experiment that takes place in several regions. Most spouses keep back (i.e. hide) money.
Ghana	Castilla (2010)	Survey amongst Asante women in Kumasi. Women commonly do not know spouses' income. Some recommended mural ignorance.
India	Subramanian (2008)	187 low income families in Delhi in a qualitative survey. Men and women hide money.
India	Munro et al. (2011)	1200 couples in an common pool experiment, when subjects may at a cost keep money private. Most spouses hide something from their partners.
Indonesia	Matsumoto (2007)	From the Indonesia Family Life Survey. Evidence of asset hiding by both sexes.
Kenya	De Laat (2008)	Survey evidence of investment in monitoring and controlling of wives by male migrants.
Kenya	Hoel (2012)	Experiment: spouses in a dictator game give less to partners when there is an opportunity to hide
Kenya	Anderson and Baland (2002)	Women using ROSCAS as a means to hide savings from spouses.
Kenya	Jakiela and Ozier (2011)	Experiment. Subjects, particularly women, pay more to hide lottery winnings if relatives are present in the experiment
Mali	Castle et al. (1999)	55 women in a qualitative study document high levels of hidden contraceptive use.
Nigeria	Fapohunda (1988)	Goats as easily hideable assets for rural Hausa women
Nigeria	Hill (1969)	226 Yoruba women, from which 80% of wives did not know their husband's income and 65% did not know his expenditure pattern.
Nigeria	Munro et al. (2010)	800 couples and 80 polygynous triples in a common pool experiment. Most spouses hide something from their partners.
Philippines	Ashraf (2009)	Subjects in an experiment and experts report hiding as commonplace.
South Korea	Lee and Pocock (2007)	Discusses ongoing criticism of a marital property law that allows spousal hiding of assets.
Turkey	Eroglu (2009)	In 41% of 17 low income families in Ankara, wives had 'secret kitties'
Uganda	Iversen et al. (2006)	240 couples in a common pool experiment. Around 45% couples hide income.
UK	Rake and Jayatilaka (2002)	Interview and qualitative evidence that some income hiding is common.
USA	Zelizer (1997)	Historical data on wives' hiding strategies.

Income that is hidden may be kept for private consumption. Because effective lying about the state is potentially costly, the reports made about the state of the world may affect the set of feasible utilities that can arise through some process of household bargaining. So each pair of states, (j,k) and each pair of reports (θ^1,θ^2) is associated with a *utility possibility set* (UPS) for the household, which I denote by $F(\theta^1,\theta^2 \mid j,k)$. The UPS is the set of feasible pairs (u,v) given actual and declared states of the world. I assume that

Definition 1. $\forall\ (j,k)$, (θ^1,θ^2) *the UPS is a compact, strictly convex, non-empty subset of* $\mathbb{R}^2_+$. *If* $(u,v) \in F(\theta^1,\theta^2 \mid j,k)$ *then* $(au,bv) \in F(\theta^1,\theta^2 \mid j,k)$ *for* $0 \le a \le 1$ *and* $0 \le b \le 1$. *Moreover* $F(j,k \mid j,k) \subseteq F(j',k' \mid j',k')$ *whenever* $j \le j'$ *and* $k \le k'$.

The utility possibility frontier (UPF) then consists of the subset of UPS elements that is undominated within the UPS. That is,

Definition 2. $UPF(\theta^1,\theta^2 \mid j,k) = \{(u,v) \mid v = \max\{v \mid (u,v) \in F(\theta^1,\theta^2 \mid j,k)\}\}$

I assume the following additional property for the UPS:

Definition 3. ***Costly hiding***: $\forall\ (j,k)$, $(\theta^1,\theta^2) \in M(j) \times M(k)$, $F(\theta^1,\theta^2 \mid \theta^1,\theta^2) \subseteq F(\theta^1,\theta^2 \mid j,k) \subseteq \quad F(j,k \mid j,k)$. ***Strictly costly hiding***: *costly hiding and* $\forall\,(u,v) \in F(\theta^1,\theta^2 \mid j,k) \quad \exists\,(u',v') \in \ F(j,k \mid j,k)$ *s.t.* $(u',v') > (u,v)$ *whenever* $(\theta^1,\theta^2) \neq (j,k)$.

This assumption says that lying about the true state may reduce the size of the UPS. However, lying can make the set no bigger than the feasible set available if the message sent were actually true. This amounts to saying that at worst, there is free disposal of income that is hidden from the spouse and at best this hidden income can be used as productively as income that is visible to all. The term *costless hiding* shall mean that $F(j,k \mid j,k) = F(\theta^1,\theta^2 \mid j,k)$ for feasible (θ^1,θ^2) and *completely costly hiding* is strictly costly hiding and

some cases a person can truly hide all their income if they make no attempt to consume it, but I claim it is much harder to hide some income but still use some of it for consumption. That said, the main purpose of the assumption on hiding adopted here is to show that there exists relatively simple and not unrealistic models in which hiding is efficient.

$F(\theta^1, \theta^2 \mid \theta^1, \theta^2) = F(\theta^1, \theta^2 \mid j, k)$ whenever $(\theta^1, \theta^2) \neq (j, k)$. Hiding may be *privately efficient* for player 1 if there exists, j, k, u, u', v, θ^2, such that, $(u, v) \in UPF(j, \theta^2 \mid j, k)$, $(u, v) \in UPF(j-1, \theta^2 \mid j, k)$ and $u' > u$. In other words, given the utility assigned to the spouse, player 1 could be better off misrepresenting his or her income. A similar definition can be made for player 2. Obviously costless hiding implies that hiding is privately efficient, but the converse is not necessarily true.

A *household allocation rule* is a mapping that relates messages to utilities (perhaps via the allocation of declared resources). Let u_{ij} and v_{ij} refer to the utilities when the state of the world is (i, j). The household seeks a household allocation rule to maximize *ex ante household welfare*, w:

$$w = \sum_i \sum_j \left(\alpha u_{ij} + (1-\alpha)\, v_{ij}\right)$$

where $0 \leq \alpha \leq 1$. The weight $\alpha$is the weight placed on each household member and is treated as exogenous here. In this context, the *first best* outcome is the result of maximizing household welfare subject to the following constraints:

$$(u_{ij}, v_{ij}) \in F(\theta^1, \theta^2 \mid i, j) \tag{1}$$
$$(\theta^1, \theta^2) \in M(i) \times M(j) \tag{2}$$

Explicit requirements that u_{ij} and v_{ij} are both non-negative for all i and j are redundant given the definition of F and the requirement that allocations should be in F. There is no assumption that the messages be truthful here, but I note in passing that the assumption of costly hiding implies that at the first best, $(\theta^1, \theta^2) = (i, j)$.

The (constrained) *optimum* is the result of maximization of household welfare with the additional pair of constraints on the equilibrium value of (θ^1, θ^2):

$$\sum_j u_{ij}\left(\theta^1\right) \geq \sum_j u_{ij}\left(\theta^{1'}\right), \qquad \forall \theta^{1'} \in M(i) \tag{3}$$
$$\sum_i v_{ij}\left(\theta^2\right) \geq \sum_i v_{ij}\left(\theta^{2'}\right), \qquad \forall \theta^{2'} \in M(j) \tag{4}$$

These constraints state that at an optimum, each individual sends the message that given the household allocation rule, maximizes his or her own expected utility.

I consider two sorts of potential optimum. The first is the standard one in which truth-telling is weakly optimal for each player at the equilibrium. I call this a *truthful equilibrium*. In the truthful equilibrium, the allocation rule also satisfies $(\theta^1, \theta^2) = (i, j)$, or:

$$\sum_j u_{ij}(i) \geq \sum_j u_{ij}\left(\theta^{1'}\right), \qquad \forall \theta^{1'} \in M(i) \tag{5}$$

$$\sum_i v_{ij}(j) \geq \sum_i v_{ij}\left(\theta^{2'}\right), \qquad \forall \theta^{2'} \in M(j) \tag{6}$$

These *truth-telling constraints* bind. In the second case, in at least one state, one or more players strictly prefers to lie about their true state at the optimum. I call this a *dishonest equilibrium*. Note that the definition of dishonest and truthful equilibria is disjunctive. The actual optimum is whichever is higher out of the honest and dishonest equilibria.

Proposition 1. *In any optimum, both players report honestly their highest and lowest states of the world.*

Proof. By construction it is not possible for a player in the lowest state to be dishonest. Suppose a player is dishonest about the highest state. Then the message(s) associated with this state are redundant. Then given the Costly Hiding assumption, we can rewrite the allocations associated with the highest states in such a way that the player receives as much from telling the truth as she or he does from being dishonest. □

Corollary 2. *When each player has at most two states of the world, then the optimum is a truthful equilibrium.*

Consider two problems, A and B, where $F(j, k \mid j, k)$ is the same in both A and B for all i and j. We say that B has a *higher cost of hiding*, if for all feasible $\theta^1, \theta^2, \quad j, \quad k, \quad F^B(\theta^1, \theta^2 \mid j, k) \subseteq F^A(\theta^1, \theta^2 \mid j, k)$

Proposition 3. *Suppose that for problem, A, the first best is optimal and that B has a higher cost of hiding compared to A. Then the first best is also optimal for B.*

Proof. If the optimum is the first best, then it is also truth-telling. Since, $F^B(j, k \mid j, k) = F^A(j, k \mid j, k)$, the first best outcome in B is the same as that in A. Suppose the truth-telling equilibrium that implements the first best in A was not truth-telling in B. In other words, there is some (j,k) and an associated feasible message such that either

$$\sum_k u\left(\theta^1\right) > \sum_k u\left(j\right), \qquad \theta^1 \in M(j)$$

$\square$

or,

$$\sum_i v\left(\theta^2\right) > \sum_i v\left(k\right), \qquad \theta^2 \in M(k)$$

Given that B differs from A only in that B has a higher cost of hiding, then a truthful equilibrium in A is also implementable in B. But that is the first best, so it is also the optimum in problem B.

Since, if hiding is completely costly the first best outcome is implementable, the proposition establishes the fact that for an underlying UPS, as the cost of hiding rises, there is a point beyond which the optimum is the first best. Incidentally, the proposition also shows that household utility in the truth-telling equilibrium rises as the cost of hiding rises. This suggests that if the truth-telling equilibrium is optimal in A then it is also optimal in B, but in fact a rise in cost of hiding may increase household utility in the dishonest equilibrium if there are some truth-telling constraints that bind in both problem A and B.

4. One sided hiding.

The propositions do not demonstrate that the optimum is dishonest. I now present a series of extended examples to show that dishonesty may be optimal. In the first example we consider a situation where agent 1 has three possible states, whereas the state and therefore income for person 2 is certain. This unilateral hiding case illustrates many of the main points of the theory. In the example, a player who reports state $i-1$ when the real state is i can obtain δ units of utility in addition to any utility obtained from the household allocation.

Let subscripts $i = 1, ..., 3$ denote states of the world and summarize the UPF in state i by the function, $f_i(u) = max(v \mid (u, v) \in UPF(i \mid i))$. Given that UPS is strictly convex, then f_i $i = 1, ..., 3$ is a strictly concave function.

In a truthful equilibrium the following incentive compatibility and feasibility constraints apply:

$$u_3 \geq u_2 + \delta \tag{7a}$$

$$u_2 \geq u_1 + \delta \tag{7b}$$

$$v_i \leq f_i(u_i) \qquad i = 1, ..., 3 \tag{7c}$$

In other words, the utility obtained by player 1 from truthfully announcing the state must be at least as great as the utility from reporting the next lower state.

In considering the dishonest equilibrium, I note first from the general propositions that it is state 2 that will be misreported. The following constraints apply:

$$u_2 = u_1 + \delta \tag{8a}$$

$$v_i \leq f_i(u_i) \qquad i = 1, 3 \tag{8b}$$

$$v_2 \leq f_1(u_2 - \delta) \tag{8c}$$

Collectively, label the first set of constraints as the truth-telling constraints and the second set as the dishonest constraints. Define $\{u_1^T, u_2^T, u_3^T\} = argmax\ v^T = v_1 + v_2 + v_3$ subject to $u_1^T + u_2^T + u_3^T \geq u$ and the truth-telling constraints and define $\{u_1^D, u_2^D, u_3^D\} = argmax\ v^D = v_1 + v_2 + v_3$ subject to the dishonest constraints and $u_1^D + u_2^D + u_3^D \geq u$. Meanwhile, let $u_i^* i = 1, .., 3$ and $v_i^*\ i = 1, .., 3$ represent the first-best solution.

The following will be true.

Proposition 4. *If $\alpha' > \alpha$, then, (i) $u^D(\alpha') \geq u^D(\alpha)$, $v^D(\alpha') \leq v^D(\alpha)$; (ii) $u^T(\alpha') \geq u^T(\alpha)$, $v^T(\alpha') \leq v^T(\alpha)$.*

Proof. Since the argument in both (i) and (ii) is the same we drop the superscripts on u and v. We also use u' to mean $u(\alpha')$ and so on. For the proof, first note that changes in α do not change the set of feasible values for u and v. It follows that, $\alpha' u' + (1 - \alpha')v' \geq \alpha' u + (1 - \alpha')v$ and $\alpha u + (1 - \alpha)v \geq \alpha u' + (1 - \alpha)v'$. Suppose that $u' < u$ and $v < v'$. Then, $0 > \alpha'(u' - u) \geq (1 - \alpha')(v - v')$. Since $\alpha < \alpha'$ then $0 > \alpha(u' - u) > (1 - \alpha)(v - v')$ but then, $\alpha u + (1 - \alpha)v < \alpha u' + (1 - \alpha)v'$ which is a contradiction. $\square$

Since the UPS is strictly convex then I can make the stronger claim that u is strictly increasing in α when u is in the interior of its feasible set.

Proposition 5. $\alpha' > \alpha \rightarrow$ *(i)* ${u_i^T}' \geq u_i^T$; *(ii)* ${u_i^D}' \geq u_i^D$ $i = 1, ..., 3$;

Proof. See appendix, but note by way of intuition that either $u_{i+1}^T = u_i^T + \delta$ in the Truthful solution or $u_i^T = u_i^*$. As a result, when the same truth-telling constraints are binding at both α' and α then by the same kind of revealed preference argument used in Proposition 4 the proposition holds. Meanwhile for the dishonest case, the allocation in state 1 and 3 is u_i^* so again a revealed preference argument can be made. The full proof is longer because of the possibility that the set of binding constraints may differ between α and α'. □

Let $v^T(u)$ be the maximum value of v possible for a given value of u when the truth-telling constraints are satisfied. Define $v^D(u)$ in an analogous manner.

Proposition 6. *Suppose* $f_1(u_2^T - \delta) > f_2(u_2^T)$ *then* $v^D(u) > v^T(u)$.

Proof. Suppose the truth-telling constraint on 2 is binding, so that $u_1^T = u_2^T - \delta$. Consider the dishonest allocation where in declared states i=1,3, $u_i^T = u_i^D$ so that in state $i = 2$, $u_2^D = u_2^T - \delta$. By assumption $v^T = f_1(u_1^T) + f_2(u_2^T) + f_3(u_3^T) < f_1(u_1^T) + f_1(u_2^T - \delta) + f_3(u_3^T)$. Thus, $v^T < v^D$. If the constraint, $u_2^T \geq u_1^T + \delta$ does not bind, then, $u_2^T > u_1^T + \delta$. As before $v^T = f_1(u_1^T) + f_2(u_2^T) + f_3(u_3^T) < f_1(u_1^T) + f_1(u_2^T - \delta) + f_3(u_3^T)$. Consider $u_1^D = (\frac{u_1^T + u_2^T - \delta}{2})$ while $u_3^D = u_3^T$. Since $f_i(.)$ is concave, $f_1(u_1^T) + f_1(u_2^T - \delta) + f_3(u_3^T) \leq 2f_1(\frac{u_1^T + u_2^T - \delta}{2}) + f_3(u_3^T)$ and again we have $v^D > v^T$. □

Write UPF_i to mean $UPF(i \mid i)$ and say that the UPF_i, $i = 2, 3$ has the single-crossing property when there exists u_i° such that $f_{i-1}(u_i^\circ - \delta) - f_i(u_i^\circ) = 0$ and for all feasible $u_i \neq u_i^\circ$, $(f_{i-1}(u_i - \delta) - f_i(u_i))\,(u_i^\circ - u_i) < 0$.

Proposition 7. *Suppose* UPF_2 *has the single-crossing property. Then there exists* u° *such that for all feasible* $u > u^\circ$, $v^D(u) - v^T(u) > 0$.

Proof. By the single crossing property $f_1(u_2 - \delta) > f_2(u_2)$ for all $u_2 > u_2^\circ$. Thus by Proposition 6, the result holds provided that there is a u° such that $u_2^T = u_2^\circ$. By the strict concavity of the f_i functions, for any u, the optimal value of u_i^T is unique. Then, since the constraint set is compact, invoking the Maximum Theorem (Berge (1963)), each of the u_i^T is continuous in u. And by Propositions 4 and 5 each of the u_i^T is increasing in u. By the definition of the f_i functions there is a value of u for which $u_2^T < u_2^\circ$. If there is no feasible u for which $u_2^T > u_2^\circ$ then the theorem holds but it may be empty of content. If there is a u such that $u_2^T > u_2^\circ$then by the continuity of $u_i^T$and the Mean Value Theorem, there is a u such that $f_1(u_2^T - \delta) - f_2(u_2^T) = 0$. $\square$

Single crossing is reasonable if say the utility obtainable from hiding is separable from utility obtainable within the household. Then representing state 2 as state 1 to the spouse offers the hider a fixed reward. Meanwhile if say the UPF is homothetic, the concave nature of the UPF also implies single crossing.

Proposition 8. *Suppose the UPF_2 has the single-crossing property, then $w^D - w^T$ is monotonically increasing in α.*

Proof. (see appendix) $\square$

Proposition 8 is conditional: it does not state that there is value of α for which the dishonest equilibrium is optimal. Still, the following will be true.

Corollary 9. *Suppose for some α, $w^D = w^T$. Then, for higher α the optimum is the dishonest equilibrium. Conversely, for lower α, the optimum is the truth-telling equilibrium.*

Proof. (see appendix) $\square$

Intuitively, the change in w for a small change in α is proportional to $(u - v)$. So we need to establish that if household utility is the same in the two equilibria, then $(u - v)$ is higher in the dishonest equilibrium. This is equivalent to showing that $u^D > u^T$ where u^D is utility in the dishonest equilibrium and u^T is utility in the truth-telling equilibrium.

It is worthwhile to consider some policy-oriented features of the model by considering how the nature of the optimal contract changes depends on α and δ. The motivating idea is that it might be possible to manipulate α for example by taxing husbands and allocating money to wives in a way that changes bargaining power.

Corollary 10. *Suppose UPF has the single crossing property and consider a rise in α to α' . (i) If it is the wife who has uncertain income and the nature of the optimum is unchanged then the rise in α increases the expected payoff to the wife. (ii) If the optimum at α is truthtelling and the optimum at α' is dishonest, and if it is the wife who has uncertain income then the expected payoff to the wife may fall. (iii) If it is the husband who has uncertain income and the nature of the optimum is unchanged then the rise in α decreases the* *expected payoff to the wife. (iv) If the optimum at α is truthtelling and the optimum at α' is dishonest, and if it is the husband who has uncertain income then the expected payoff to the wife may rise.*

Proof. Follows from Proposition 8. □

The fact that u and v are not necessarily monotonic in α raises some thorny questions about how the weights on individual utility are determined. It might for instance be in the best interest of one partner to hide power in order to manipulate the final value of u or v.

Proposition 11. *$w^D - w^T$ is monotonically increasing in δ.*

Proof. $w^T$is decreasing in δ, since any allocation that is feasible for δ is also feasible for $\delta' < \delta$. Meanwhile, the optimal values for $u_1^D$and u_3^D are unaffected by changes. And since $u_2^D = u_1^D + \delta\ w^D$ is increasing in δ. □

Proposition 11 shows that as δ increases (i.e. hiding becomes less costly), the dishonest equilibrium becomes relatively more attractive. If for low δ the truth-telling equilibrium is optimal, an increase in δ to the point where dishonesty is optimal, may raise the expected payoff of the person who is deceived. The intuition is simply that explained above: in the dishonest equilibrium, the deceived person does not have to give up some payoff in order to incentivize honesty. For increases in δ above the switching point produce no benefits to the deceived person: all the gains go to the deceiver. As with changes in α therefore, whether raising the cost of hiding is beneficial to the wife depends on who has the uncertain income and which of the equilibria is optimal. If it is the wife who has the risky income, but the dishonest equilibrium is optimal, then raising the cost of deception will lower her welfare provided the dishonest equilibrium is still optimal. However, if the cost of deception becomes sufficiently high (δ is sufficiently low), that the optimum is now truth-telling then her welfare can increase.

4.1. Diagrammatic Example.

When only one person has uncertain income, it is straightforward to present a diagrammatic example. The three utility possibility frontiers, A, B and C are as shown in Figure 1. Inside B and C respectively are two broken curves, which show the utility possibility frontiers if agent 1 hides the maximum possible from his or her spouse. Since hiding is not possible for the lowest income level, it has no broken curve.

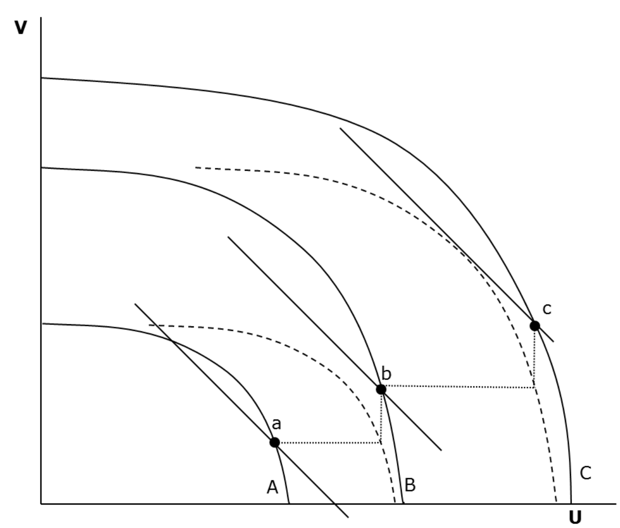

Figure 1: A Truth-telling equilibrium.

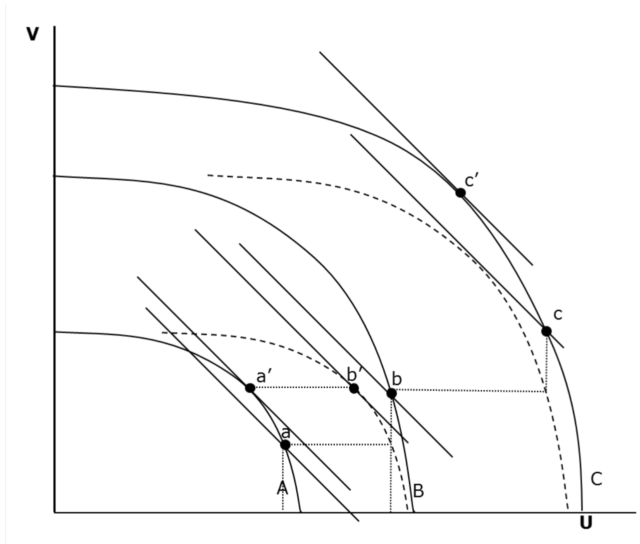

Figure 2: Equilibrium with Dishonesty

In Figure 1, the optimum truth-telling equilibrium is shown. At the optimum, the utility pairs represented by a, b and c are offered in return for signals that A, B and C are the frontiers, respectively. In this situation, the incentive compatibility constraint is binding for agent 1 at both b and c. In other words, the household contract offers agent 1 a utility for honestly declaring state 3 that leaves him or her indifferent between a declaration of state 3 and a declaration of state 2 (accompanied by hiding income). Similarly he or she is indifferent between honestly declaring state 2 when it occurs and dishonestly declaring state 1 and hiding income.

Figure 2 shows the same payoff structure but also shows a dishonest allocation which may ex ante dominate the honest equilibrium. In this case, the utility pairs are labelled by a', b' and c′. The pair represented by b′ is what results when the true state is 2 but the player declares that state 1 has occurred. Pairs a' and c′ meanwhile are the first best outcomes in state 1 and 3 respectively. In the case of state 3, the individual 1 must weakly prefer the allocation given by c′ and that obtainable from a declaration of state 2. But this can be enforced by stating that a payoff of zero is receivable when state 2 is declared.

Comparing the diagrams, it can be seen that the household is on a higher indifference line in state 3 in the dishonest equilibrium, whereas utility is lower in state 2. Agent 2 is better off in each state of the world in the dishonest disequilibrium, whereas agent 1 is always worse off. The net effect on ex ante household utility is ambiguous, although the diagram is suggests that ex ante welfare is higher under the dishonest equilibrium

4.2. Numerical Example.

The diagrams are suggestive but are not numerically exact. I now give a specific numerical example. For agent 2, income is constant at zero. There are 3 states for agent 1 producing income $y_j = y_0 + j - 1$. In state of the world j, UPF_i is defined by $y_j^2 = u_j^2 + v_j^2$. If agent 1 hides 1 unit of income s/he can obtain δ units of utility in addition to that assigned by the household allocation rule, with $0 \leq \delta$. In this situation, the first-best outcome produces utility levels, $\frac{u_j}{\alpha} = \frac{y_j}{\sqrt{\alpha^2+(1-\alpha)^2}} = \frac{v_j}{1-\alpha}$. Utility for the household is then $\sqrt{\alpha^2 + (1-\alpha)^2} 3\left(y_0 + 1\right)$.

For $\delta \leq \frac{\alpha}{\sqrt{\alpha^2+(1-\alpha)^2}}$, the truthful equilibrium is equal to the first best. For instance, when $\alpha = 0.5$, this requires $\delta \leq \frac{1}{\sqrt{2}}$. When $\delta > \frac{\alpha}{\sqrt{\alpha^2+(1-\alpha)^2}}$ in the truthful equilibrium the constraints imply that $u_j = u_1 + \delta(j-1)$ while u_1 solves,

$$\frac{3\alpha}{1-\alpha} = \sum_{j=1}^{3} \frac{(u_1 + (j-1)\delta)}{\sqrt[2]{y_j^2 - (u_1 + (j-1)\delta)^2}} \tag{9a}$$

This equation comes from using the constraints to eliminate all but u_1 from the maximization problem and then deriving the first order condition for it. Meanwhile, for the second agent, $v_j = \sqrt{\left(y_j^2 - u_j^2\right)}$. Average utility for the first player is $3\left(u_1 + \delta\right)$. Implicit differentiation of 9a shows that $(u_1 + \delta)$ is increasing in δ:

$$0 = \sum_{j=1}^{3} \left(\left(\frac{du_1}{d\delta} + 1 \right) + (j - y_0 - 1) \right) \left(\frac{1 + (u_1 + (j-1)\delta)}{\left(y_j^2 - (u_1 + (j-1)\delta)^2\right)^{0.5}} \right) \tag{10}$$

In other words as the cost of hiding income falls, the average utility of player 1 rises and the average utility of player 2 falls. Overall, average welfare falls as the equilibrium deviates further and further from the first best, in order to accommodate the incentive compatibility constraints.

Given the results of Proposition 1, states 1 and 3 are always reported honestly in any equilibrium. Thus any dishonest equilibrium must involve the misreporting of state 2. In any dishonest equilibrium, agent 1 reports state 3 truthfully, but otherwise sends a message that the state is 1. In this situation, the incentive compatibility constraints do not bind and $\frac{u_j}{\alpha} = \frac{y_0-1+j}{\sqrt{\alpha^2+(1-\alpha)^2}} = \frac{v_j}{1-\alpha}$. Meanwhile, when the state is 2, individual 1 obtains an additional payoff of δ.

When the dishonest equilibrium is the optimal outcome, the hider loses (comparing his or her situation to the honest equilibrium payoffs), while the non-hider gains. The result arises because in the dishonest equilibrium the non-hiding agent does not have to 'bribe' the potential hider to reveal his or her income.

The propositions are not sufficient to determine if hiding is part of the optimum. However, if $y_0 = 2$ and $\delta \geq 1/\sqrt{2}$ for example numerical solution of the problem reveal that hiding can be optimal. When $y_0 = 1$, the optimum is truthful. The difference occurs because of the gain to household welfare when in the best state of the world, the first best outcome is obtainable. This first best welfare rises from $2\sqrt{4.5}$ when, $y_0 = 1$, to $2\sqrt{8}$. A particular example is shown in Figure 3, below for $y_0 = 2$. This figure shows three curves for household utility as a function of α. The unconstrained curve shows utility if all income is revealed and truth-telling constraints are ignored. The truth-telling curve is the standard outcome when household utility is maximized subject to the truthtelling constraints. The 'Dishonest' curve depicts the case where agent 1 misrepresents state of the world 2. As can be seen for this value of δ, at higher levels of α (specifically when $\alpha\delta \geq 1$), household utility is maximized by not revealing state 2 truthfully, even if incentive compatibility were not an issue. For intermediate values of α, the dishonest equilibrium dominates the truth-telling equilibrium, while for the lowest values of α, truth-telling is optimal.[6]

5. Bilateral hiding.

As noted earlier, general results in the case of bilateral hiding are hard to come by. For that reason, I consider an example with 3×3 states, each of equal probability to illustrate the possibilities. As before, the household aims to maximize the weighted sum of utilities, $\sum_i \sum_j (\alpha u_{ij} + (1-\alpha) v_{ij})$. With

[6]With $\delta < 1$ it is possible to have values of $\alpha$for which the dishonest equilibrium is optimal.

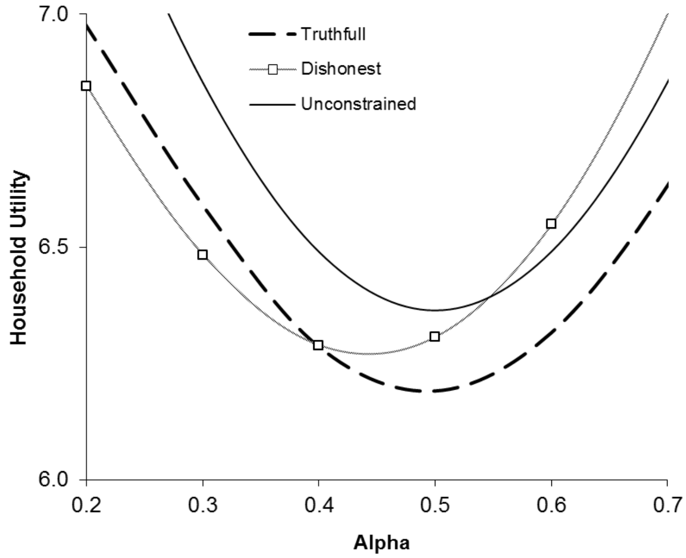

Figure 3: Household utility for $\delta = 1.3$

two players, in addition to a possible equilibrium where both players report all income truthfully, there are three possible equilibria involving dishonesty. One is where both players misrepresent one or more states of the world. A second is where the player with the higher weighting in household welfare (the *stronger* partner) is dishonest, but the other player tells the truth. In the final case it is the player with lower weighting (the *weaker* partner) who misrepresents some states, while the player with the higher weighting reveals states truthfully. I label these 3 cases, *Both, Strong* and *Weak*, respectively and produce examples in which each of the four possible outcomes is the optimum.

Out of 1 extra unit of hidden utility, partner 1 can achieve δ_i units of utility where I allow the possibility that δ may not be same for both partners. For the numerical example, the UPF is given by the formula:

$$(i + j + 2y_0 - 2)^p = u_{ij}^p + v_{ij}^p \tag{11}$$

where y_0 is the same for both partners and $p \geq 1$ is a measure of the curvature of the UPF. Higher values of p indicate greater concavity.

Proposition 12. *(i) As δ_1 increases the value of household welfare in the Truth and Weak equilibria does not rise; (ii) the value of household welfare* *in the Strong and Both equilibria does not fall. (iii) Conversely, as δ_2 rises, the value of household welfare in the Weak and Both equilibria does not fall; (iv) the value of household welfare in the Truth and Strong equilibria does not rise.*

Proof. Note that in all cases, the δ_is only enter the constraints - not the objective function. (i) As δ_1 increases, the feasible set of outcomes implementable by truth-telling shrinks in the Truth and Weak equilibria. Hence welfare cannot rise. (ii) Conversely the set of feasible outcomes implementable in Strong and Both grows. Parts (iii) and (iv) mirror parts (i) and (ii). □

As in the example of the previous section, for sufficiently low values of δ, the shape of the utility possibility frontier implies that in the unconstrained allocation each player has the following utility level:

$$u_{ij} = \frac{(i+j+2y_0-2)}{\left(1+\left(\frac{1-\alpha}{\alpha}\right)^{\frac{p}{p-1}}\right)^{\frac{1}{p}}} = \left(\frac{\alpha}{1-\alpha}\right)^{\frac{1}{p-1}} v_{ij}. \tag{12}$$

At the unconstrained allocation, household welfare is,

$$\left(\alpha^{\frac{p}{p-1}} + (1-\alpha)^{\frac{p}{p-1}}\right)^{\frac{p-1}{p}} \sum_i \sum_j (i+j+2y_0-2) \tag{13}$$

It follows that 1 extra unit of income made available to the household adds $\left(\alpha^{\frac{p}{p-1}} + (1-\alpha)^{\frac{p}{p-1}}\right)^{\frac{p-1}{p}}$ to household welfare. For sufficiently high values of δ, it is therefore optimal to consume resources privately. For $\alpha \geq \frac{1}{2}$, the critical value is,

$$\delta^c = \alpha^{-1}\left(\alpha^{\frac{p}{p-1}} + (1-\alpha)^{\frac{p}{p-1}}\right)^{\frac{p-1}{p}} \tag{14}$$

For $\delta > \delta^c$, household welfare is higher when person 1 hides their income. This function equals $2^{\frac{p-1}{p}}$ when $\alpha = 0.5$ and declines to 1 for $\alpha = 1$. For person 2, when $\alpha > 0.5$, the critical value of δ is,

$$\delta^{c2} = (1-\alpha)^{-1}\left(\alpha^{\frac{p}{p-1}} + (1-\alpha)^{\frac{p}{p-1}}\right)^{\frac{p-1}{p}} \tag{15}$$

For $\alpha > 0.5$, $\delta^{c2} > \delta^c$. Essentially when $\alpha > 0.5$, the second player has a lower weight in household welfare. Thus it is relatively more productive to put their income into the household pool rather than consuming it privately.

In the truth-telling equilibrium, each player must send a message without knowing the message of the other player. As a result the incentive constraints apply to average utilities, viz:

$$u_{i1} + u_{i2} + u_{i3} \geq u_{i-1\,1} + u_{i-1\,2} + u_{i-13} + 3\delta_1 \qquad i = j_0 + 1, ..., N \qquad (16a)$$

$$v_{1i} + v_{2i} + v_{3i} \geq v_{1\,i-1} + v_{2\,i-1} + v_{3\,i-1} + 3\delta_2 \qquad i = j_0 + 1, ..., N \qquad (16b)$$

As in the previous section, it is only the intermediate state that might be misrepresented. When $\alpha = 0.5$, and $p = 2$, it is possible to show that, for instance, $v_{ij} = u_{ji}$ which together with the production constraint implies that, $u_{ji} = \sqrt{(y_i + y_j)^2 - u_{ij}^2}$. By this means an algebraic solution is obtainable. In other cases, I find purely numerical solutions. Define a household as symmetric if $\alpha = 0.5$ and $\delta_1 = \delta_2$.

Proposition 13. *There exist (different) values of y_0, δ_i, p, α such that (i) all types of equilibria are optimal; (ii) the household is symmetric and the Both equilibrium is optimal; (iii) $\alpha > 0.5$, but the equilibrium is Weak; (iv) $\alpha > 0.5$, but the equilibrium is Strong; (v) dishonesty is not privately efficient, but the optimum is dishonest.*

Proof. The proof is by the examples below with the proof of part (i) provided by the totality of the subsequent examples. □

I prove part (ii) using Figure 4 which shows household welfare for various values of p, but where in all cases, $\alpha = 0.5$, $y_0 = 0$, and $\delta_i = 1.2$. In this diagram I omit the data for Strong since it is identical to the Weak equilibrium. It can be seen that for lower values of p, it is optimal for both agents to be dishonest. At higher levels of p (i.e. where the UPF is more concave), the Truthful equilibrium is the optimum.

In Figure 5 where alpha is varied between 0.5 and 0.99, the optimum varies between a dishonest equilibrium in which the Weak player misrepresents some income and a truth-telling equilibrium when values of α are closer to 0.5. This proves part (iii) of the proposition that the optimum may involve the Weaker partner hiding income. Note that this involves a case in which it is costlier for the Weak person to hide income.

I prove part (iv) using Figure 6 which shows household welfare for the four possible equilibria for different values of δ_2, but where in all cases, $\alpha = 0.6$, $y_0 = 0$, $p = 2$ and $\delta_1 = 1.2$. So partner 1 is the stronger. For partner 2, δ_2 varies from 0.8 to 1.3. Where the weak player is dishonest, household welfare

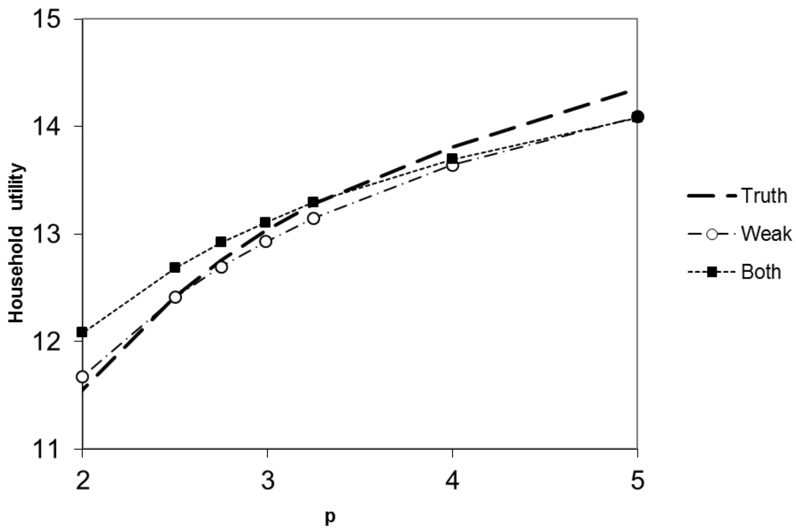

Figure 4: Household utility for $\delta_1 = 1.2$.

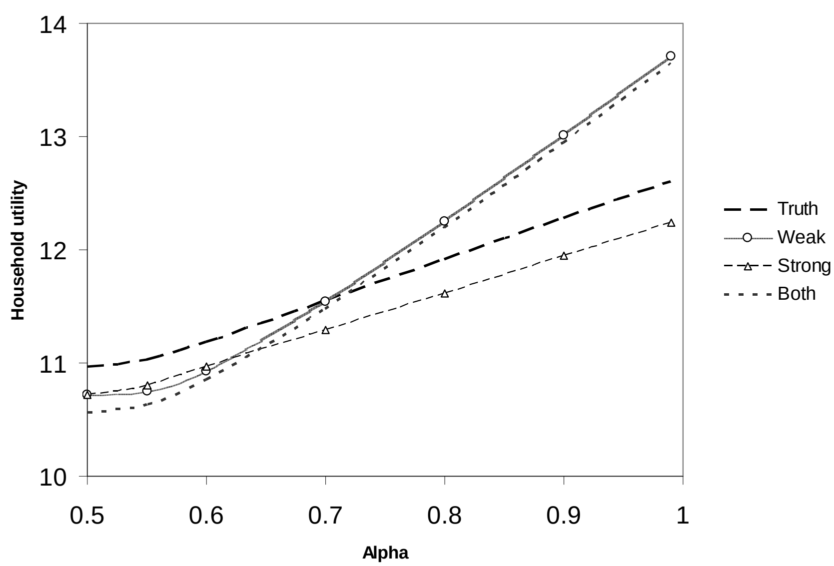

Figure 5: Household utility as alpha varies, for $\delta_1 = 1$, $\delta_2 = 0.9$,.0 $y_0 = 0$, $p = 1.5$.

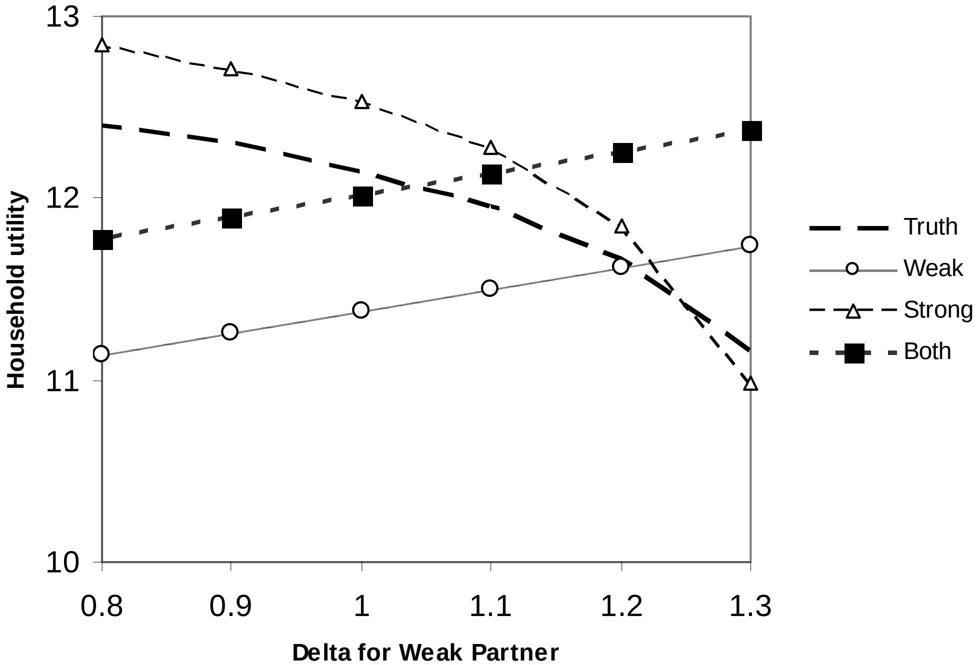

Figure 6: Household utility for $\delta_1 = 1.2$.

is increasing in δ_2 because the hidden resources provide more value to the weak player as δ_2 rises. Where this is the case, individual and household welfare is linear in δ_2. Where the equilibria requires the weak partner to tell the truth, δ_2 enters the constraints on allocations. As a result household welfare is decreasing in δ_2. As can be seen, the optimum varies with δ_2. For low values the optimum requires some misrepresentation by the stronger player and truth-telling in equilibrium by the weaker partner. For higher values, both players misrepresent the intermediate levels of income at the optimum, which is perhaps not surprising given that for higher values of δ_i we approach a situation where even the first best equilibrium involves 'hiding'. Nevertheless for the parameters used here it is still the case that the first best case solution does not involve misrepresentation: both players contribute all income to the household.

In Figure 7 which I use to prove part (v) alpha is again plotted on the x axis. In this example the gains from dishonesty are symmetric and dishonesty

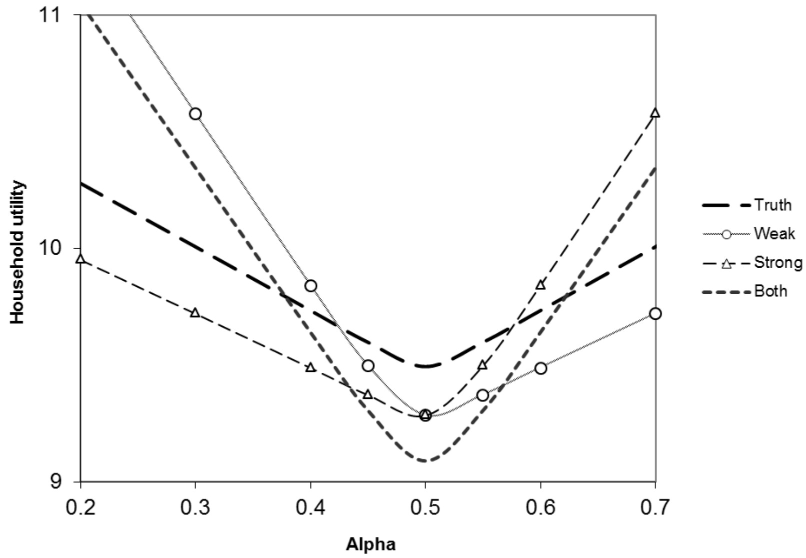

Figure 7: Household utility as alpha varies, for $\delta_i = 0.9$, $y_0 = 0$, $p = 1.1$.

is not privately optimal. I plot utility for values of alpha between 0.3 and 0.7, but the trends shown continue to the extreme values of 0 and 1. For simplicity, player 1 is always described as strong even though for $\alpha < 0.5$, more weight in the household welfare function is placed on the other player. Here for low values of alpha the optimum is one where player 1 is dishonest; around $\alpha = 0.5$, truth-telling is optimal and for higher values of α, the optimum involves misrepresentation by player 2.

Taken together these figures do not offer a simple picture of when each equilibrium is optimal, but they do illustrate the fact that each type is possible. We see examples of hiding by both strong and weak players and situations where it is efficient for both players to hide.

6. Conclusions.

Income and consumption hiding seems to be a regular part of intra-household decision-making in some societies. Spouses routinely keep some income and consumption from their partners, although the extent of this is limited and typically a cost of some kind must be incurred. It is straightforward to put forward a model in which agents wish to hide assets, given that the equilibrium notion does not take into account this possibility. However, it is not obviously clear why spouses would agree to rules that encourage dishonesty when hidden consumption is less efficient than openly made spending. In this paper I present a theory that can allow dishonesty in an equilibrium that is Pareto efficient ex ante. By means of an extended examples we can see that partners with higher costs of hiding are less likely to hide in equilibrium. Mutual hiding may indeed be optimal. In general there is no monotonic relationship between hiding and power, though when there is one-sided asymmetric information, misrepresenting income is positively linked to the weight in household utility.

The theory presented here is not complete in the sense that there may be other motives for hiding assets, some of which are apparent in the articles surveyed in section 2 and in the non-cooperative models of Malapit (2009) and Castilla and Walker (2013). A particularly obvious motive is that relationships can end, through divorce or death and partners may wish to (secretly) insure against the adverse effects that come with separation. Why secret? Openly saving money for divorce may send the wrong signals about the state of the relationship and hasten the actual end of the marriage.[7] A third but possibly less clear-cut set of reasons for individuals to hide money from their partners involves a demand for autonomy. Autonomy is the ability to decide matters for oneself. Many individuals have some preference for autonomy. As such it is not necessarily reflected in a demand for goods or services but in the demand for control, for a 'room of one's own'. Negotiated spending over money may not satisfy such a demand, whereas having a separate budget that is at least in part hidden from a partner may produce some satisfaction. Of course there may be many other motives for hiding. For example, behavioural economists also discuss notions of temptation: an inability or a reduced ability to commit to certain patterns of behaviour in the future. Spouses who publicly share a whole budget may be unable to refrain from constant bickering over its use. Hiding money may eliminate the temptation to interfere. So this paper has only dealt with one aspect of why spouses may wish to hide money or other assets from one another, but that does not preclude other motives from being important.

[7]In the model presented here, the hidden income can be thought of as saving for possible marital breakdown. What is not captured in the model is the possibility that the hidden asset, if discovered would increase the probability of separation.

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AppendixA. Household allocation decisions.

As an aside, we present a model of allocation that is consistent with the examples presented in sections 3 and 4. The utility for the partners are,

$$u = zx_1^{\beta} + \delta_1 r_1$$
$$v = zx_2^{\beta} + \delta_2 r_2$$

In the equations, x$_1$ and x_2 are expenditures on private goods purchased from the publicly observable household budget, while z is the household public good. The goods, r_1 and r_2 represent hidden (private) consumption expenditure. The partners must allocate resources between household goods and private consumption. If total income $2y_0 + i + j$ is reported then the welfare maximizing value of z is,

$$z = \frac{2y_0 + i + j}{1 + \beta}$$

It follows that the UPF for declared income is,

$$u_{ij}^{1/\beta} + v_{ij}^{1/\beta} = \beta \left(\frac{(2y_0 + i + j)}{1 + \beta} \right)^{\frac{\beta+1}{\beta}}$$

In other words, $1/\beta$ corresponds to p in the examples. Meanwhile, if player i hides 1 unit of income then she or he obtains an extra δ_i. in private consumption.

AppendixB. Omitted Proofs.

Proof. [Proposition 5] Part (i) Either $u_{i+1}^T = u_i^T + \delta$ in the Truthful solution or $u_i^T = u_i^*$. As a result, when the same truth-telling constraints are binding at both α' and α then by the same kind of revealed preference argument used in Proposition 4 the proposition holds. When different truth-telling constraints apply at α' and α then, since there are two truth-telling constraints in each case and each constraint may be binding or not, there are potentially 12 cases in which the pattern differs between α' and α. In the table below I set out the proof for each case. Binding and non-binding constraints are indicated by 0 and 1 respectively. For example 0,1 means that $u_3^T = u_2^T + \delta$ while $u_1^T = u_1^*$. I say that u_1 is free in such a case while u_3 is bound (the status of u_2 is not clear). Three basic observations are in order. First, if a truth-telling constraint is non-binding then the difference between the two relevant utilities must be at least δ. Second, if a truth-telling constraint is binding on u_1 then u_1 must lie below its unconstrained value. Third, if a truth-telling constraint is binding on u_3 then u_3 must lie above its unconstrained value.

α	α'	Proof
$0,0$	$1,0$	Suppose $u_1^{T'} < u_1^T$, then $u_2^{T'} < u_2^T$ and so $u_2^{T'} < u_2^* \leq u_2^{*'}$, but u_3 is free so can raise u_2 and with it, w. Thus $u_1^{T'} \geq u_1^T$. u_3 is always free, so $u_3^{T'} \geq u_3^T$. At α, u_2 is free. If it is free at α' then u_2 rises. If not then $u_2^{T'} \geq u_2^{*'}$. But $u_2^{*'} \geq u_2^*$, so u_2 also rises.
$0,0$	$0,1$	u_1 is free so rises. Suppose $u_3^{T'} > u_3^T$, then $u_2^{T'} > u_2^T$ as well. At α', $u_3^{T'} \geq u_3^{*'}$ but $u_3^{*'} \geq u_3^*$ so u_3 and u_2 are also higher.
$0,0$	$1,1$	If $u_1^{T'} \leq u_1^T$, then all u_i are lower, so $u_1^{T'} > u_1^T$. Suppose $u_3^{T'} < u_3^T$ then, w can be raised by increasing u_3 without breaking constraints. Suppose $u_2^{T'} < u_2^T$, then u_3 is also lower and in particular, $u_3^{T'} < u_3^* < u_3^{*'}$. But then w can be raised by increasing u_3.
$0,1$	$0,0$	Since u_1 is free, it rises. $u_2^T \leq u_2^*$. Thus, $u_2^T \leq u_2^* < u_2^{*'} = u_2^{T'}$. Suppose u_3 falls then u_2 is also lower. Hence u_3 rises.
$0,1$	1,0	Because of the pattern of binding constraints, $u_2^T \leq u_2^*$ and $u_2^{T'} \geq u_2^{*'}$ so u_2 rises. if u_3 falls, u_2 falls as well so u_3 rises. $(u_2 - u_1)$ falls, and u_2 rises so $u_1^T \leq u_1^{T'}$.
$0,1$	1,1	If $u_1^{T'} < u_1^T$, then u_2 and u_3 also fall. So $u_1^{T'} \geq u_1^T$. If u_2 is lower, then u_3 is also lower
1,0	0,0	Since u_3 is free, u_3 increases. At α, $u_1^T \leq u_1^*$, but at α' it is free so u_1 rises. If $u_2^{T'} < u_2^T$, then the lower constraint would be binding at α'. Hence u_2 also rises.
1,0	0,1	Since u_1^T is constrained, $u_1^T < u_1^*$. At α', u_1 is unconstrained so $u_1^{T'} \geq u_1^T$. Since $u_2^T - u_1^T = \delta$ and $u_2^{T'} - u_1^{T'} \geq \delta$ then $u_2^T \geq u_2^{T'}$.
1,0	1,1	If $u_1^{T'} < u_1^T$, then u_2 also falls, but then $u_3^{T'}$ is not bound. Thus u_1 and u_2 rise. If u_3 falls then $u_3^{T'} < u_3^{*'}$ so could increase w by increasing u_3.
1,1	0,0	$u_1^T \leq u_1^*$ so u_1 definitely rises. It follows that both u_2 and u_3 rise.
1,1	0,1	$u_1^T \leq u_1^*$ while $u_3 \geq u_3^{*'}$. $u_1^{T'} = u_1^{*'}$ so u_1 increases, but then u_2 must increase too. and since u_3 is bound to u_2 at both α and α' it increases as well.
1,1	1,0	$u_1^T \leq u_1^*$ while $u_3^T \geq u_3^*$. If u_3 falls then u_1 and u_2 also fall. So u_3 rises. If u_1 falls then so does u_2 while v_1 and v_2 rise. Suppose this is the case, then, $(\alpha' - \alpha)\left[(u_1^{T'} + u_2^{T'} - u_1^T - u_2^T) + \left(v_1^T + v_2^T - v_1^{T'} - v_2^{T'}\right)\right] < 0$. The solutions at α and α' satisfy the constraints at $\alpha'$and α, so: $\alpha'(u_1^{T'} + u_2^{T'} - u_1^T - u_2^T) \geq (1 - \alpha')\left(v_1^T + v_2^T - v_1^{T'} - v_2^{T'}\right)$ and $\alpha(u_1^T + u_2^T - u_1^{T'} - u_2^{T'}) \geq (1 - \alpha)\left(v_1^{T'} + v_2^{T'} - v_1^T - v_2^T\right)$. Adding inequalities yields the contradiction: $(\alpha' - \alpha)\left[(u_1^{T'} + u_2^{T'} - u_1^T - u_2^T) + \left(v_1^T + v_2^T - v_1^{T'} - v_2^{T'}\right)\right] \geq 0$.

Part (ii). In the case of the Dishonest solution, the incentive compatibility constraints are not binding for $i = 1$, 3. Thus the results come straight from $u_i^D = u_i^* \; i = 1, 3$ and a revealed preference argument that $u_i^{*'} > u_i^* \; i = 1, 3$. For $i = 2$, $u_2^D = u_1^D + \delta$, so u_2 also increases with α. $\square$

Proof. [Proposition 6] We need to establish that if household utility is the same in the two equilibria, then $(u-v)$ is higher in the dishonest equilibrium. This is equivalent to showing that $u^D > u^T$ where u^D is utility in the dishonest equilibrium and u^T is utility in the truth-telling equilibrium. In the case of the truth-telling equilibrium, the maximization problem is as follows (non-negative constraints on the variables are omitted for brevity):

$$\sum_j \left(\alpha u_j + (1-\alpha)\, v_j\right) \tag{B.1}$$

subject to,

$$u_3 - u_2 - \delta \geq 0 \tag{B.2}$$

$$u_2 - u_1 - \delta \geq 0 \tag{B.3}$$

$$f_3\left(u_3\right) - v_3 \geq 0 \tag{B.4}$$

$$f_2\left(u_2\right) - v_2 \geq 0 \tag{B.5}$$

$$f_1\left(u_1\right) - v_1 \geq 0 \tag{B.6}$$

In the case of the dishonest equilibrium, if we consider u_2 and v_2 as the actual allocations in state 2 (rather than messages sent), then in the maximization problem, B.1 remains the same, as do $(B.3)$, $(B.4)$ and $(B.6)$. However, $(B.2)$ and (B.5) must be replaced by,

$$u_3 - \delta \geq 0 \tag{B.7}$$

$$f_1\left(u_2 - \delta\right) - v_2 \geq 0 \tag{B.8}$$

$$v_2 - v_1 = 0 \tag{B.9}$$

By a revealed preference argument, the solution to maximization of (B.1) subject to the constraints (B.2)-(B.6) must not be feasible when the constraints are (B.3), (B.4), (B.6) and (B.7)-(B.9) and vice versa, unless (u^D, v^D) $=(u^T, v^T)$. For instance if (u^D, v^D) with $(u^D, v^D) \neq (u^T, v^T)$, satisfies the constraints of the truth-telling equilibrium, then so does a strictly convex combination of (u^D, v^D) and (u^T, v^T) . But then since $f(.)$ is strictly convex, we can find $(u^{T\prime}, v^{T\prime})$ where (u_i^T, v_i^T)=$(u_i^{T\prime}, v_i^{T\prime})$, $i = 1, 2$ and $(u_3^{T\prime}, v_3^{T\prime})$> (u_3^T, v_3^T) and that also satisfies all the constraints. Then (u^T, v^T) was not the optimum for truth-telling. A similar argument to applied to the case where the truth-tellling solution also satisfies dishonest equilibrium constraints. So, (u^D, v^D) either does not satisfy (B.2) or (B.5) or both. Conversely (u^T, v^T) does not satisfy at least one of (B.7)-(B.9). Since (B.2) is satisfied by u^T and $u_i^T \geq 0$, then (B.7) is also satisfied. Moreover if (B.9) is satisfied by u^T then applying (B.3) the constraint (B.8) would also be met. It follows that (B.8) is not satisfied. In other words, $f_1(u_2^T - \delta) < v_2^T$. $v_2^T \neq v_1^T$. $\square$