Marriage and Biology[1]

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Since only women can give birth, only female infidelity can put householders at risk of raising alien genetic material. This means that husbands have more to lose from their partners' infidelity and therefore have a stronger interest in deterrence than their wives do. If men earn most of the household's market income, they are more able to withhold consumption opportunities from a spouse than if the roles were reversed. This paper develops a simple model to capture these incentives. It is consistent with several widely-observed phenomena and also produces novel testable implications.
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> Iago: 'If you are so fond over her iniquity, give her patent to offend,
> for if it touch not you it comes near nobody.'
> Othello: 'I will chop her into messes! Cuckold me?'
> -William Shakespeare, *Othello*

I - Introduction

This paper presents a new way of looking at households' economic behaviour from the perspective of biology. It is a fact of biology that only women bear children and that consequently only a man can unwittingly raise offspring that is genetically alien to him. If preferences for raising offspring with shared DNA have at least some genetic component, then evolution favours men who wish to raise their own offspring, because men who do not care will not have as many (own) children. This fact has been a starting point for many treatments of unselfish behaviour by fathers towards their offspring coupled with selfishness in relation to other children[2]. The present article develops it into a model of household formation, yielding new predictions consistent with a wide array of empirical findings.

Assuming that there is a preference for raising one's own offspring, it follows immediately from the aforementioned biological fact (that only women bear children) that men have more to lose from being cheated on by their wives, than have their wives in the reverse situation (although wives surely dislike being two-timed, biology implies that they do not dislike it *as much* as do men). Cuckolded men forego the opportunity to spend resources on raising their own offspring when they raise the children of some other man, which is detrimental to the survival of their genes. The classic law-and-economics insight that the severity of the punishment should rise in the severity of the crime (Becker, 1968) implies that men have a stronger incentive than do women to deter infidelity.

Households that allow husbands to deter female infidelity are ones in which the man contributes most of the market income. Unfaithful wives are then "punished" by husbands' withholding consumption opportunities from them. Such punishments are efficient if they bring about the desired outcome at less cost than alternative means. Since physically abusing the wife may induce her to leave the marriage and at least imperils her fertility, and since hunting down the fellow with whom she had the affair could be dangerous, withholding consumption opportunities is a good candidate for efficient punishment. Husbands' out-earning their wives is therefore a mechanism to eliminate the latter's incentives to commit adultery.

This paper constructs a model of household formation around these biological incentives. The model also predicts, *inter alia*, that the income gap will decrease in relative terms as families' incomes

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[2] There are several treatments of population-wide outcomes of genetically encouraged behaviour which deal extensively with altruism within the family due to the genetic links of the members, including classic treatments such as *Sociobiology* by Edward O. Wilson, or popular ones like Richard Dawkins' *The Selfish Gene*. Economists have also discussed evolutionary-biological bases for why fathers should care about their own children (e.g. Becker, 1976 and 1981; Posner, 1992), or why firms maximize profits in the market (Alchian, 1950).

increase. This is essentially because husbands must be in a position to "punish" unfaithful wives in order to avoid spending scarce resources on raising children that are not theirs. The relative income gap decreases in total market income because a stream of income which *proportionately* improves upon the prospects of an unmarried or punished woman by only a little bit is nevertheless a big *absolute* increase when incomes are high. The only non-biological explanation for why husbands should be particularly wary of contributing less than precisely fifty per cent of their households' market income in the literature is due to Bertrand *et al.* (2015), and is based upon male identity demanding that a husband makes more market income than does his wife[3].

The model also generates a number of other implications. For instance, higher male (permanent) income inequality implies that wives face a greater risk when committing adultery, since, in case their affair results in their husband's divorcing them, new matches are less likely to be with men of a standing similar to the one of the most recent husband. Being associated with greater risk, adultery committed by women should therefore decrease the more male (permanent) income inequality there is. Consequently, husbands in high-inequality societies must somewhat paradoxically out-earn their wives by a smaller magnitude than must husbands in low-inequality societies, *ceteris paribus*. For the same reason, the present model predicts a higher frequency of female home-makers in countries with lower rather than higher (permanent) income inequality.

Relative income contributions within households are important for several reasons. Apart from the quality of marriages, they also impact labour-force participation and the gender "wage gap". If biology compels males to out-earn females in functioning marriages, gender differences will naturally arise, though the present biological incentives predict them to decrease in proportion to one another as total household incomes rise.

These biological incentives may complement other theories of household formation, mainly in the form of a constraint. For instance, the maximization of a joint product could take place under the constraint that the husband must out-earn the wife. The main contributions of the present article are thus twofold: (1) the finding that men will out-earn their wives purely due to the biological fact that only women bear children and the biological hypothesis that men have a taste for raising their own offspring; and (2) the conditions under which men may have to out-earn their wives by even more, including implications for marriages from institutions and contraceptives, as well as from the aforementioned issues of wealth and inequality.

The remainder of this paper is structured as follows: Section II provides an overview of some of the related literature. Section III outlines the model that captures the biological incentives outlined in this section, and the main results of husbands out-earning wives with the proportional difference decreasing in total household market income. Section III highlights some of the important predictions concerning male-female income differences and implications from inequality, as well as a number of additional predictions and discussion, contrasting the present article with other work in family and labour economics. Section V summarizes and concludes. Throughout, the discussion will deal with 'husbands' and 'wives' but it should be obvious that unmarried heterosexual couples in deep relationships are equally part of the analysis.

II - Background
Incentives from biology have been incorporated in other treatments' explanations of various aspects of household behaviour. For example, the high incomes of prostitutes have been adduced to the importance of commitment to husbands. Prostitutes require large compensating differentials for their work since they cannot land a husband by offering sexual exclusivity (Edlund and Korn, 2002). On the same theme, Rai and Sengupta (2013) analyse pre-marital confinement of girls and young

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[3] There are of course many rationales for why men earn more than women (e.g. discrimination, childbearing, or socially-conditioned preference differences), but they do not imply that market income differences should be legion also *within* households. Within-household specialization similarly fails to account for the significance of the fifty per cent mark in relative contributions to household market income by husbands.

women such as seclusion, foot binding, and other practices to induce or enforce docility as signalling devices of future fidelity.

Saint-Paul (2015) provides a model in which men pay for the legitimacy of their progeny by transferring consumption possibilities to their wives, which leads to hypergamy (women marrying men of higher socioeconomic standing than themselves) since high-income men have low marginal utility of consumption, whereas the opposite is true of low-income women. Since women who marry average men forego mating opportunities with high-quality males, the result is that men marry down and women marry up. As a result, the highest-quality women have trouble finding husbands.

There is rather strong evidence for hypergamy. Historical practices such as bride prices and the absence of groom prices underscore the tendency of husbands' (or their families') out-earning wives (Edlund, 2013, pp. 654-656 provides a good discussion). Studies on courtship spending tend to be similarly biologically motivated and focused on male expenditures (Bergstrom and Bagnoli, 1993; Bronsert *et al.*, 2017). In modern times, marriage rates rise more strongly with income for men than for women (CPS data reported in Saint-Paul, 2015), and the aforementioned study by Bertrand *et al.* (2015) shows striking distributions in which the frequency of marriage drops sharply just after the point at which men earn fifty per cent or more of household income.

As these papers indicate, sexual and marital mores which stress the fidelity of wives and the economic superiority of the husband are ubiquitous. This pervasiveness suggests that social norms are less simple a foundation than is biology for understanding manifold, disparate practices of arguably rather similar effects (i.e. inducing female fidelity in one form or another). Since the technical aspects of procreation are the same everywhere, sexual and marital mores of similar effects are apt to be the consequences of biological forces, and the premiss follows that the male disadvantage in ascertaining paternity implies higher costs for males of female adultery.

What are the incentives for women to commit adultery? From the biological point of view, a wife may be interested in cuckolding her husband because doing so diversifies the genetic material with which she mixes hers and thereby enhances the viability of her progeny. In addition, there is the "sexy son"-hypothesis (Fisher, 1930), which says that infidelity with a ladies' man (i.e. a man possessing characteristics prized by many women) that results in a son is apt to make him, like his father, an unusually successful procreator, which in the long run spreads the wife's genes farther. Of course, many factors that might not be biological will likewise incentivize female (as well as male) infidelity, such as romance, the dullness of one's husband, or the excitement of a paramour.

There are theoretical exceptions to the view that men respond negatively to cuckoldry. For instance, Liedtke and Fromhage (2012) develop a model in which (half-)siblings care for one another, so that if the male householder is the father of but some fraction of his wife's children, his caring for all of them is still optimal because the (half-)siblings all help one another. The husband's offspring will benefit from fitter half-siblings, so the family survives.

However, virtually all thorough empirical studies indicate that non-paternity is rare, with estimates ranging from less than one per cent of children in a German study using bone-marrow transplantation samples (Wolf *et al.*, 2012), to between one or two per cent per generation in a multi-century Flemish study based on a combination of genealogical and surname data (Larmuseau *et al.*, 2013). Studies with a greater focus on groups of lower socio-economic standing tend to produce somewhat higher estimates, occasionally in the area of ten per cent or more (an example is Cerda-Flores *et al.*, 1999, though they do not explain their sample selection in any great detail).

Longitudinal studies on cuckoldry fail to show large changes over time even though they span periods over which modern contraceptive aides became increasingly available That the incidence of non-paternity is almost uniformly very low but does rise on occasion is an indication that husbands by nature choose rather good ways of deterring adultery by their wives, adapting to different technologies and institutions as necessary. Plausibly the vagaries of income trajectories under the circumstances when this deterrence fails make it more difficult to maintain relative dominance in household market income. Additionally, other men may be more likely to be of better quality when a wife is married to a very low-status one.

The focus on deterrence of infidelity in the present approach differs from those taken by the related biologically-motivated literature and produces an array of empirical implications. For instance, since the fifty-per-cent mark in husbands' contributions to household income is an outcome of special significance in the present paper, there is no reason to expect the highest-earning women to remain unmarried (as in Saint-Paul, 2015) because they only have to earn less than do the highest-earning men. Indeed, the proportion of never-married women aged 35-39, as reported in Saint-Paul (2015), is fairly flat across incomes; 15,7 per cent of women earning less than $5,000 18.1 per cent of women earning more than $100,000. The corresponding figures for men are 44.4 and 9.6 per cent, respectively. These patterns are consistent with most women marrying, and with men finding it increasingly difficult to sustain a marriage the lower their incomes fall.

A number of papers have uncovered phenomena which are consistent with the present biological model. For instance, Stuart *et al.* (2011) find that winning an Academy Award ("Oscar") is significantly associated with a greater risk of divorce for best actress, but not for best actor. Looking at narrow political races, Folke and Rickne (2016) document that job promotions in the political sector have similarly detrimental effects on marriages when the wife is promoted, but no effect when it is the husband. Among the women in the top one per cent of the Swedish income distribution, approximately 40 per cent have a partner in the same percentile and three quarters have a partner in the top decile. The corresponding numbers for the men in the Swedish top income percentile are below ten per cent and below 25 per cent (Boschini *et al.*, 2017).

By how much husbands wish to out-earn their wives is also affected by institutional and technological factors, variations in which allow adultery to be committed by wives with different probabilities of impunity. If it is likely that a marital transgression will be discovered, men do not have to out-earn their wives by as much as when this is less likely. For instance, DNA tests for paternity increase the probability that an unfaithful wife be found out and consequently allow husbands' incomes to be lower than otherwise.

Other predictions by the present paper are also consistent with a number of broad and widely-noted empirical tendencies. If husbands out-earn their wives and most people marry, a gender 'pay gap' will spontaneously arise which, *ceteris paribus*, is greater in poorer societies and smaller in wealthier ones. Other explanations for the 'pay gap', such as lower female flexibility regarding work hours or different negotiating tactics for jobs, could be thought of as consequences of intra-household pressures on men to earn most market income (see Goldin, 2014, for an overview of potential explanations for the 'pay gap'). Also consistent with the present paper are the oft-observed male marriage premium and female marriage penalty[4]

That males contribute most of the market income within households has recently been suggested to be due to perceptions of male and female identity, *inter alia* because if the wife's earnings potential is larger than that of her husband she is nevertheless more likely to be a homemaker or earn less than her husband if she does work (Bertrand *et al.*, 2015). This finding is hard to reconcile with explanations based on human capital or specialization; comparative advantages predict that in those cases where the woman's earnings capacity exceeds that of her husband, she should account for most of her household's market income and her husband should do more non-market work (Becker, 1973, p. 828). By contrast, the biological incentives suggested by this paper predict no such thing, since the husband must out-earn the wife for the marriage to work.

A focus on biological incentives can also turn apparently Pareto-suboptimal outcomes into efficient ones. For instance, Udry's (1996) finding that male-controlled plots of land in Burkina Faso

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[4]These names refer to the common findings that married men out-earn single men whereas single women out-earn married women. The male marriage premium is usually estimated to be around or above ten per cent (e.g. Bardasi and Taylor, 2008; Ginther and Zavodny, 2001), and have been attributed to one or several of ability bias (only productive men get married), signalling (marriage is certifies goodness), or human capital (marriage makes men more productive, maybe due to household specialization). The female marriage penalty is often estimated at around ten per cent in studies relying on the National Longitudinal Survey of Youth (e.g. Light, 2004). In contrast to the male premium, the lower wages of married women is more difficult to attribute to (in)ability bias. Specialization within the household (or employer perceptions that this will be the case, i.e. signalling) has usually been thought to be behind the reduction in female wages upon marriage.

are cultivated more intensively than are female-controlled ones within the same family (so that their marginal returns are not the same) makes sense from the constitutional-choice perspective, since in the possibility of hidden action the husband must have resources sufficient to punish infidelity.

III – The Model

The following simple model shows the basic mechanisms giving rise to the husband's contributing more than half of household market income. In terms of structure, it may be thought of as a principal-agent problem in which husbands are the principals who wish to rear offspring that share their genetic material. Wives are the agents who may work for them (produce a child with their husband), or shirk (produce a child with someone else). A husband uses part of his income to supplement that of his wife, but only so long as she remains faithful to him. Through divorce or simply through retraction, it is the prospective loss of this supplement that deters female adultery. In this sense, the model's mechanism is reminiscent of the efficiency-wage model by Shapiro and Stiglitz (1984).

The punishment comes with a varying degree of permanence, captured by a parameter ρ, which is below one when an adulteress is "branded" or – in case of divorce – has poor marriage-market prospects. The degree of punishment permanence may go above one for wives whose marriages are simply bad matchings (which encourages adultery and eases its consequences). A related but distinct variable, m, captures a punishment rescindment rate, though it may equally be thought of as a remarriage rate. For example, with ρ substantially less than one m close to one, women punished by divorce would get remarried fairly easily, but only to men of substantially lower calibre than their former husbands.

Note that there is no need to assume that an unfaithful wife be automatically *divorced*, although associated institutional features (to be discussed later) such as divorce settlements may surely affect how punishment is carried out. The important thing for the husband fearing cuckoldry is to withhold consumption possibilities and this happens without a divorce when the husband simply pools less of his own market income with that of his wife's. Such withholding can take place by directing consumption away from the wife, and only ultimately by divorcing her. The wife can certainly do her best to direct resources away from her husband, too. When her market income is less than that of her husband, the wife will instead direct the production of household services away from her husband's preferences. This is not modelled, but it is quite evident that whenever the wife can divert significant value from the husband in this way, the gap in market income must increase in response.

Although wives surely dislike their husbands' cheating on them, they cannot deter this behaviour as easily as can their husbands since biological differences imply that their ability to do so would threaten the viability of the household. Essentially, the biological perspective implies that women dislike spousal unfaithfulness less intensely than to men. It is an unfortunate fact for women that their husbands can commit adultery with impunity (from the perspective of household finances). When at least some people are unmarried sometimes, one extramarital affair need not imply another extramarital affair, which ensures that these household rules to deter adultery do indeed aggregate (*cf.* Masters, 2008, where this does not happen as easily because *both* husband and wife are committed).

The following establishes the essential building blocks of the simple model. Let V_P denote the net present value for a married but unfaithful woman who has been punished by her husband (again, not necessarily by divorce), and consequently, until the punishment is rescinded or until she is remarried, has to rely on only her own income. In other words, V_P is the value function of a punished woman. The woman's own income is denoted by $(1-h)\,w_{HH}$, where w_{HH} is total household market income, and h is the husband's contribution to it (more on V_P below). V_M^U, s, and r denote the value function of the married but unfaithful wife, the share of total household market income consumed by the wife, and the interest rate, respectively.

The probability of being found out when unfaithful is treated as exogenous and is denoted by p. The practice of keeping wives in harems with eunuchs to supervise them is testament to the fact that

it is possible for a husband to influence p, yet such influence is hardly boundless since even in harems a wife may have some way of bribing a eunuch to let her cuckold her husband (as well as by taking different precautions outwith harems). The possibility of institutional features to impact p is discussed in greater detail below in Section III.

Looking ahead a short period of time $[0, \Delta t]$, the unfaithful wife's stream of payoffs is written

$$V_M^U = sw_{HH}\Delta t + e^{-r\Delta t}[p\Delta t V_P + (1 - p\Delta t)V_M^U].$$

That is, at every instant, she receives a share s of the intensity of her household's pooled market income at each moment in time and, with appropriate discounting, continues to do so unless found out, in which case she gets V_P. Since $e^{-r\Delta t} \approx (1 - r\Delta t)$ for small exponents, the above expression turns into

$$V_M^U = sw_{HH}\Delta t + (1 - r\Delta t)[p\Delta t V_P + (1 - p\Delta t)V_M^U].$$

Isolating V_M^U on one side yields

$$(p\Delta t + r\Delta t - \Delta t^2 rp)V_M^U = sw_{HH}\Delta t + (1 - r\Delta t)p\Delta t V_P.$$

The above expression can be rearranged into

$$V_M^U = \frac{sw_{HH}\Delta t}{p\Delta t + r\Delta t - \Delta t^2 rp} + \frac{p\Delta t V_P}{p\Delta t + r\Delta t - \Delta t^2 rp} - \frac{\Delta t^2 rp V_P}{p\Delta t + r\Delta t - \Delta t^2 rp}.$$

Eliminate duplicate Δt's from numerators and denominators:

$$V_M^U = \frac{sw_{HH}}{p + r - \Delta trp} + \frac{pV_P}{p + r - \Delta trp} - \frac{\Delta trp V_P}{p + r - \Delta trp}.$$

As $\Delta t \to 0$, this expression approaches $V_M^U = \frac{sw_{HH}}{p+r} + \frac{pV_P}{p+r}$, which, with all the terms multiplied by $(p + r)$ and pV_M^U alone on the right-hand side, yields equation (1):

(1) $$rV_M^U = sw_{HH} + p(V_P - V_M^U).$$

Turning now to the faithful wife, who like an unfaithful wife gets a share s of the household's total market income w_{HH} and loses the opportunity cost c of foregone extramarital mating opportunities (in lieu of this opportunity cost, one could posit a benefit to having an affair in equation (1), which comes to the same thing). This happens at all times t and goes on into the indefinite future. The interest rate is again r.

$$V_M^F = (sw_{HH} - c)t + e^{-r\Delta t}V_M^F.$$

We look ahead a short period of time $[0, \Delta t]$. Since $e^{-r\Delta t} \approx (1 - r\Delta t)$, the above expression is

$$V_M^F = (sw_{HH} - c)t + (1 - r\Delta t)V_M^F,$$

which may be rewritten as

$$r\Delta t V_M^F = (sw_{HH} - c)\Delta t.$$

Divide both sides by Δt to obtain equation (2)

(2) $$rV_M^F = sw_{HH} - c$$

Solving (1) and (2) for V_M^U and V_M^F yields

$$(3) \qquad V_M^U = \frac{sw_{HH} + pV_P}{p + r},$$

and

$$(4) \qquad V_M^F = \frac{sw_{HH} - c}{r}.$$

Women are faithful when $V_M^F \geq V_M^U$, i.e. when $\frac{sw_{HH} - c}{r} \geq \frac{sw_{HH} + pV_P}{p + r}$, or equivalently the condition that

$$(5) \qquad sw_{HH} \geq rV_P + \frac{(r + p)c}{p}.$$

This expression says that the share of household market income that goes to the wife must not fall below her stream of benefits if punished, plus a fidelity bonus that increases in the opportunity cost of fidelity and in the discount rate, and falls in the probability that a wife's unfaithfulness is discovered.

Punished women receive $rV_P = (1 - h)w_{HH} + m(\rho V_M - V_P)$[5], where h is the husband's contribution to household income, V_M is the married woman's expected utility, and m, as mentioned above, is the per unit of time degree to which her transgression is "forgiven". Equally, m may be thought of as the punishment rescindment rate or the remarriage rate, if divorced. The term ρ (as also discussed above) captures a permanent part of the punishment (for $\rho < 1$), as divorcées have at times been commonly held in disrepute. The reverse case, $\rho > 1$, may be interpreted as the present match being a bad, one, which encourages adultery.

Stable marriages are clearly characterized by fidelity, so that $V_M = V_M^F$. Using this condition, one may insert equation (4) into the expression for rV_P to obtain

$$(6) \qquad rV_P = \frac{w_{HH}(r - rh + m\rho s) - m\rho c}{r + m}.$$

Equation (6) says that a punished woman is unambiguously better off the higher is her household's income, and more so the lower is her husband's share of household income, but she would be better off regardless of h. This is partly because whatever her husband's share, a larger household income means that her share represents more absolute income. In addition, the possibility of punishment rescindment (for high household incomes relative to c) offers additional security[6]. The greater the part of her punishment is permanent (i.e. the lower is ρ), the worse off she is provided that her share of household income is greater than the opportunity cost of fidelity.

There is an alternative interpretation of the parameter ρ. Rather than capturing the permanence of a punishment, it may equally be thought of as saying something about the likelihood that a divorced woman will find a similar-calibre husband for her next try at matrimony. This interpretation carries some predictions regarding the role of male (permanent) income inequality because if the chances of finding a similar man go down then so does rV_P, implying fewer instances of adultery in societies with more (permanent) income inequality among men, *ceteris paribus*. Because female adultery is associated with greater downside risk, such higher-inequality societies also have less pressure on males to out-earn their wives.

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[5] This comes from $V_p = mV_M + (1 - m)V_p = mV_M - mV_p + V_p = m(V_M - V_p) + V_p$, where $V_p = (1 - h)V_M$.

[6] Differentiating (6) with respect to m yields $\frac{(0.5w_{HH} - c)(r + m) - w_{HH}(r - rh + 0.5m) - m \times c}{(r + m)^2}$, which is positive for $h \geq \frac{1}{2} + \frac{cr + 2cm}{w_{HH}r}$, i.e. when the husband earns at least half of the household's income and the household's income is sufficiently greater than c.

Substituting (6) into (5) and rearranging yields the fidelity condition on the husband's share of household income

$$(7) \qquad h^* \geq \frac{c}{w_{HH}} \left(\frac{p+r+m}{p} + \frac{m-m\rho}{r} \right) + 1 - s\left(1 + \frac{m-m\rho}{r} \right).$$

Since deterrence means that the wife's contribution to household income cannot exceed her consumption of it, a lower s requires a higher h. To see the effect of greater opprobrium for unfaithful women (i.e. when ρ declines), differentiate (7) with respect to ρ; husbands must contribute more to household income if the wife's consumed share of household income exceeds her opportunity cost of fidelity, but the husband may contribute less if $sw_{HH} < c$. That is, a more severe permanent punishment makes a high opportunity cost of fidelity more bearable (it is not worth the risk) and h may fall, but if c is negligible to begin with, rV_P in equation (6) is greater, meaning that punished women are better off and husbands must compensate by a higher h. Under the interpretation of ρ as the probability of finding a new, similar-stature husband for a divorced woman, this confirms the above result on male (permanent) income inequality. These derivations lead to the following proposition.

PROPOSITION: The husband's contribution to his household's total market income must exceed fifty percent to incentivize his wife to remain loyal to him and not have an extramarital affair, but may fall arbitrarily close to this mark as total household market income rises, assuming that husband and wife divide total household market income equally between them, so that the wife gets one half in monogamous marriages. Also assuming that there is neither permanent punishment nor any terrible matches so that $\rho = 1$, the following proof follows immediately.

PROOF: With the assumptions mentioned in the proposition that $s = 0.5$ and $\rho = 1$, equation (7) becomes

$$(8) \qquad h^* \geq \frac{1}{2} + \frac{c}{w_{HH}} \times \frac{m+r+p}{p}.$$

It is evident from equation (8) that a division of household market income other than fifty-fifty would establish other thresholds, but in monogamous marriages fifty-fifty (or something very close to it) would seem like the natural division. ∎

IV – Implications
This section distils and discusses some of the main implications of the foregoing model, and how they fit with extant knowledge of gender roles. In turn, implications for inequality, labour-force participation, specialization, institutions, technology, and widespread perceptions and preferences with regard to gender roles are discussed in what follows.

Looking at equation (8), it is evident that the more impatient the wife is (i.e. the higher is r), the higher h must be. Furthermore, it is easy to see that the effect on the critical share of the husband's contribution h^* of an increase in the probability that an adulteress is found out, p, is to make it go down, which is in line with the classic findings in law and economics that one need not be able to punish so severely if a crime is easily detected (Becker, 1968). An increase in the social acceptability (or punishment rescindment rate, or remarriage rate) of marital infidelity, m, puts upward pressure on h^*, in line with intuition: for whatever punishment there is, if it is felt for a shorter time it must be felt more greatly in order to deter wrongdoing.

The effect of an increase in total household income is to drive h^* asymptotically down towards one half. This captures some of the long-run developments that have occurred in many advanced countries, where the point at which the husband's income just exceeds fifty per cent has become increasingly common among married couples (Bertrand *et al.*, 2015, p. 579). The outcome illustrates

how a slight excess over fifty per cent will represent absolutely larger consumption possibilities usable for punishment the higher is household income. This point also draws more mass as household incomes rise because a relatively small but absolutely large difference induces "punished" women to seek remarriage or rescindment (m is positive).

Indeed, a striking finding in family economics in recent years is that of the sharp decline in the distribution of husbands' contributions to their households' income just after the point at which they earn fifty per cent. The discoverers, Bertrand *et al.* (2015), attribute this finding to male identities being inconsistent with contributing less than one half. The present model also finds a special significance of this point in relative contributions to household income, and thereby offers an alternative explanation to that of identity.

Although an established and important part of economic science, identity-based theories of household behaviour face the hurdle of explaining why perceptions of identity remain so stable over time even amidst great financial incentives for them to change. As Bertrand *et al.* (2015) note, wives fail to specialize in market work even when their predicted earnings capacity exceeds that of their husbands. Biological incentives and identity economics are not mutually exclusive explanations, so biology helps to account for the money left on the table while providing other implications.

In equation (7), a higher ρ raises the husband's required contribution h when the share of household market income consumed by the wife is greater than her benefit of an extramarital affair (as will be the case when husbands successfully deter adultery by their wives):

$$\frac{\partial h}{\partial \rho} = -\frac{cm}{w_{HH}r} + \frac{sm}{r} = -c + sw_{HH},$$

which is greater than zero when $sw_{HH} \geq c$. In other words, if finding a husband of a similar income to one's most recent one becomes likelier (i.e. ρ goes up), the husband must contribute a greater share of the household's total market income. Since such new husbands are harder to find the more unequal a society is, one would expect such societies to be characterized by (1) more equal relative contributions to total household market income by husband and wife, and by (2) less adulterous behaviour on the part of wives.

Such tendencies hold if all else is held equal. Under this interpretation of ρ, it would also seem natural to think that a divorced woman's finding a husband of similar standing to her previous one should be still more difficult at the top, where the number of men with higher incomes than the previous husband is necessarily lower than at the bottom of the income distribution (given the usual income distribution in which the median income is far below the mean). Additional implications follow.

Income Trajectories and Labour-force Participation: Since (nearly) equal contributions to household market income are more likely for higher total household income, wives' wages are expected to be suppressed more at the bottom than at the top of the income distribution. It follows that increasing married female labour-force participation occurs first among relative high-income earners, and last among low-income earners, while wives' incomes follow a similar trajectory of being closest to those of their husbands at the top and taking longer to achieve near-parity the worse-off are husbands at the bottom.

Such pressures, in turn, encourage assortative matching, because women who can earn a relatively high market income have incentives to seek out similarly capable men, whose relatively high position in the income distribution makes them least likely to object to having a high-earning wife[7]. At the very bottom where pressures to make money may be overwhelming, increases in

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[7] Note that assortative matching relates to individual *ranks* in gender-specific income distributions. While models of assortative matching traditionally place no importance on the relative incomes of husband and wife, introducing fear of cuckoldry tips the balance to favour men as the primary income earners, with women approaching the fifty per cent mark as incomes rise higher.

female labour-force participation are apt to come at the price of familial disharmony as men substitute other means to deter infidelity for a high income, and of increasing rates of non-paternity (as in the evidence discussed in Section II).

For groups of low socioeconomic standing, women are also presumably paired with men of below-average quality, which means that opportunities for extramarital affairs are likelier than otherwise to be with men of higher quality than their husband, when societies are sufficiently heterogeneous that higher-quality males are around. This raises c in the present model and strains relationships. This would also be consistent with Bertrand *et al.* (2015)'s finding that the discontinuity at the husbands' side of the fifty per cent mark of household income contributions is greater for poorly-educated couples than for highly-educated couples (online appendix, p. 25).

Specialization: Biological incentives share with human capital considerations the implication that husbands will specialize in market work while wives specialize in household work, giving rise not only to the male marriage premium, but also to the female marriage penalty (Becker, 1991, pp. 37-48). In contrast to human capital theory, biological incentives suggest that same-sex households have less pressure than others to specialize in household and market work since any progeny cannot be related to both householders. Studies on same-sex households have produced mixed results on specialization, but generally find that there is less of it among same-sex cohabitants of both homo- and heterosexual inclinations (see Zavodny, 2008, for a thorough overview and study, which also finds no cohabitation premium for same-sex individuals irrespective of sexual preference).

Another addition to explanations based upon human capital is that infertile women and their husbands should have similar labour-market outcomes as fertile married couples. Although the husband in such couples knows that his wife cannot give birth to another man's child, he should nevertheless desire to contribute the majority of total household income because attraction and pair-bonding have a biological basis and it is unlikely that we should have evolved preferences over household contributions which depend upon such inconspicuous details of the mate's characteristics.

Institutions: Theories based purely on human capital and specialization have difficulties explaining why wives earning most of a household's market income may do more household work than do their husbands. The finding that this is what happens is (like many others) due to Bertrand *et al*, (2015), although it has not been replicated by German data (Wieber and Holst, 2015). Bertrand and her co-authors argue that women compensate for having incomes that conflict with the male identity of being the main contributor to the household. However, wives' accounting for most market *and* non-market work might also be seen as a seclusion mechanism which guards husbands from the threat of cuckoldry by limiting the wife's opportunities for extramarital affairs. This institutional characteristic would have the effect of raising p.

This mechanism is akin to how, at various times and in different places, many wives have been secluded in the more literal sense of being put in harems, as well as through mechanisms such as foot binding and other practices mentioned in the introduction. Raising p by limiting the wife's time essentially does the same job as do more tangible acts of legislation or social norms in reinforcing the censure of female adultery. Seclusion mechanisms presumably reduce the woman's earnings capacity, thereby enabling low-earning men to marry a woman (and higher-earning men to marry several women) knowing that a husband's withholding of consumption opportunities from his wife (wives) will be an effective deterrent of infidelity.

In line with commentary on unintended effects of welfare programmes (e.g. Murray, 1984), increased payments and greater availability of social assistance would put greater strain on low-income marriages, since outside options improve for wives of low-income men. Examining the impact of the Welfare Reform Act in the US of the 1990's, in which a more stringent assistance system was implemented, Bitler *et al.* (2004) estimate that divorce rates did indeed fall upon Welfare Reform. Lemieux and Milligan (2008) find more suggestive evidence of the same phenomenon in a regression-discontinuity study of welfare reform in Quebec.

Improved outside options can also come from prenuptial agreements, joint-access bank accounts, and the vagaries of divorce settlements, since they make it more difficult for the husband to divert consumption possibilities from the wife. These issues immunize wives (in higher-income households) from the threat of punishment by their husbands, thereby rendering pointless any relative earnings advantage for men, and removing disincentives for wives to be unfaithful. Wives therefore have an incentive to limit their access to joint bank accounts or the amount of money in them, or not to ask for prenuptial agreements (which are indeed quite rare). It may be harder to pre-commit to an unfavourable divorce settlement, though perceptions among the general public are oftentimes such that the husband should be awarded most of the estate (Hersch and Shinall, 2017).

A different institutional feature, joint or separate taxation of married couples' incomes, is of obvious relevance to the present model. Under graduated income-tax regimes in which higher rates are imposed on higher incomes, the lower-earning spouse faces a disincentive to work when incomes are taxed jointly (i.e. when the household is the tax unit rather than its individuals separately).

When husbands out-earn their wives, it follows that their propensity to do so increases under joint taxation and a graduated income tax. Consequently, jurisdictions with individual taxation should, *ceteris paribus*, see greater pressure on husbands to earn more because they encourage wives to enter the labour market. This pressure may manifest itself in one of three ways: it may encourage husbands to supply more labour to maintain their lead in relative contributions to household income; it may result in greater marital disharmony; or it may reduce the apparent elasticity of female labour supply as they temper their earnings in an effort to help their husbands maintain their advantage.

Technology: That husbands have always been loath to lose exclusive sexual access to their wives is a traditional belief in family economics. In discussing adultery and its effects on marital stability, Becker (1991, p. 48) notes that "men are reluctant to rear children fathered by others". Similar reasoning is found in Posner's (1992) discussion on why polyandry (one woman's marrying more than one man) is so rare. Advances in contraception and paternity testing allow husbands to rule out non-paternity, which may seem to eliminate the harm done by an unfaithful wife[8]. However, because the preferences for female fidelity are rooted in biology, it would take a great many generations for recent technological advances to have any effect on genetic selection of preferences that do not mind female adultery to become a substantial fraction of the male population. Hence, these advances affect p (and thereby h) rather than preferences.

Contraceptives may reduce the probability that adulterous wives are discovered by eliminating physical evidence of extramarital affairs (less risk of conception). To this extent, contraceptives put upward pressure on husbands' wages relative to those of their wives since the low probability of detection requires a sterner punishment. However, since contraceptives reduce the risk of extramarital affairs, they may be engaged in with greater frequency, which implies a higher probability of discovery and downward pressure on husbands' wages. DNA-based paternity tests, on the other hand, unambiguously increase p[9].

Perceptions and Preferences: Lastly, the present model is also consistent with the empirics of male and female expectations of, and preferences for, characteristics in males and females. Hersch and Shinall (2017) devise a survey with a hypothetical divorce case and varying occupational backgrounds of a husband and a stay-at-home wife, whose previous career either matched that of her husband or earned her a lower income. Whether male or female, the respondents invariably award the husband

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[8] This is not strictly true; paternity tests can yield erroneous results. Michael (1974) estimates the incidence of conception when a couple has regular intercourse using a variety of contraceptive techniques. For even a 99-per-cent effective contraceptive, the probability of conception still exceeds ten per cent in a five-year interval (p. 133).

[9] Paternity tests are not uncommon in the US; there were around 280,000 DNA-based paternity tests performed in the early 2000's (Bishai *et al*., 2006) out of nearly four million births in 2014 (of which approximately 40 per cent were to unmarried women) reported by the CDC: https://www.cdc.gov/nchs/fastats/births.htm. The number of tests relative to the number of births overstates the incidence of doubtful cases, however, since one child may have several possible candidate fathers.

the majority of the household's assets. Though the authors do not state it, these results are consistent with a common expectation among respondents that the husband be household's primary earner, so that he consequently may receive the majority of the household's assets upon divorce.

In a study on speed dating, Fisman *et al.* (2006) present findings on desirable mate characteristics. From the present model, one would expect males to wish to marry women whose (permanent) market incomes are lower than are their own, and women to have the reverse preference, and in their discussion of prior literature, they report that this is essentially what psychologists have long tended to find (pp. 675-676). For instance, a partner's earning potential is valued more by women than by men.

The paper by Fisman and coathors is noteworthy because the authors are able to record several personality traits of their subjects through the speed-dating setup. Thus, they find that variables such as ambition, intelligence, and socioeconomic background are all valued more by women than they are by men. Ambition and intelligence are in fact *dis*valued by a man when a woman exhibits more of them than he does, which is precisely what is to be expected if the optimal marital rules require males to contribute more than half of household income.

V – Conclusion

This paper introduces a mechanism based upon biology that leads husbands to wish to out-earn their wives in order to reduce the latter's incentives to commit adultery. Adultery by wives harms husbands more than adultery by husbands harms wives, since only husbands may come to spend scarce resources on raising genetically alien material. Thus, the mechanism introduced by the present paper essentially rests on preferences which evolutionary biology suggests should be widespread.

The present approach in which husbands out-earn wives to deter infidelity seems to be consistent with many disparate empirical findings in labour economics, such as the male marriage premium and female marriage penalty, the gender "pay gap", the widespread tendency of husbands to earn more than fifty per cent of their households' market income, differences between the sexes in mate selection, and a reduced pressure for household specialization among same-sex cohabitants.

In addition, new implication from the present model include that of male (permanent) income inequality being correlated with a reduced pressure on husbands to out-earn their wives, some dynamics of female labour-force participation, as well as pressures on relative market incomes within households from technological and institutional developments. For traditional marriages more generally, the implication from the present model is that husbands will continue to tend to earn at least fifty per cent of household income, and that marriages which do not obey this rule are more susceptible to discord.

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