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Differential Fecundity, Markets and Gender Roles

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Abstract

Women are fecund for a shorter period of their lives than men. This paper investigates how differential fecundity interacts with marriage, labor and financial markets to affect gender roles. The main findings of the paper are: (i) Differential fecundity does not have any market invariant gender effect. (ii) Gender roles depend on competition for mates in the marriage market and the way in which ex-post differences in earnings affect that competition. (iii) Gender differences in the labor market can occur without corresponding differences in labor market opportunities, productivities in child rearing, or social norms. (iv) With uncertainty in human capital accumulation and no insurance against this uncertainty, the model generates behavior which is consistent with observed gender roles.

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1 Introduction

Women are fecund for a shorter period of their lives than men. This paper investigates how differential fecundity interacts with marriage, labor and financial markets to affect gender roles.[1] It builds on Becker's landmark insights on marriage markets, human capital accumulation, the time cost of child rearing and the tradeoff between the quantity and quality of children.[2] I also borrow heavily from the thriving research program in economics of the family.[3]

My main findings are: (i) Differential fecundity does not have any market invariant gender effect. (ii) Gender roles depend on competition for mates in the marriage market and the way in which ex-post differences in earnings affect that competition. (iii) Gender differences in the labor market can occur without corresponding differences in labor market opportunities, productivities in child rearing, or social norms. (iv) With uncertainty in human capital accumulation and no insurance against this uncertainty, the model is consistent with the following observed gender roles:[4]

1. Divorced women are less likely to remarry than divorced men (Chamie and Nsuly (1981)).

2. There are proportionately less never ever married women than men (Haines (1996)).

3. The average age of first marriage is lower for women than men (Bergstrom and Bagnoli (1993)).

4. The age of first marriage for men is positively correlated with their wage.[5]

[1] Bergstrom (1994) used it to explain the prevalence of polygyny rather than polyandry.

[2] His contributions are summarized in Becker (1993, 1991).

[3] Bergstrom (1995) and Weiss (1993).

[4] The references provide international evidence.

[5] Using US data, Bergstrom and Schoeni (1992), Vella and Collins (1990) found a positive correlation. Keeley (1975) found a negative correlation. Bergstrom and Schoeni argued that Keeley's results are due to model misspecification. Using Taiwanese data, Zhang (1995) found a positive correlation for one subsample, a negative correlation for another subsample and a positive correlation for the pooled sample.

5. Married men spend more time in the labor force than married women. They spend less time on child rearing than their spouses (Blau and Ferber (1986): Chapter 10, Blau and Kahn (1995)).

6. Married men have higher wages more than married women (Blau and Kahn).

This paper explains the above differences as follows. Consider a constant population society where individuals live for three periods, one as a child, one as a young adult and one as an old adult. Every young adult has to decide whether to marry or remain single. Abstracting from other benefits of marriage, the only reason to marry is to have children. Young and old men are fecund whereas only young women are fecund.

An adult may have at most one spouse at a time (monogamy). An adult may marry when young, divorce and remarry another person when old. Since the only role of marriage is to procreate, young single men and women, old single and divorced men may marry. Old single and divorced women will not marry or remarry respectively (Point (1)).

Eligible men must offer the same reservation utility to prospective spouses (young women) if they wish to marry. I assume women prefer to marry rather than remain single which means that all young women will marry.

In a stationary equilibrium with a equal number of young men and women, some young men must remain single when some divorced men remarry. Some of these single young men will remain unmarried when they are old. If all single young men marry when old, then divorced men cannot remarry since there will not be enough eligible women. Thus when some divorced men remarry, some men will always be single. Since all young women marry, there are proportionately less never ever married women than men (Point (2)). While some men will always remain single, some single young men will marry when they become old. Thus the average age of first marriage is lower for women than men (Point (3)).

All young adults have the same labor market opportunities. Time at work produces current income and increases the expected future wage of the individual. Due to uncertainty in human capital accumulation, only some old adults will be successful in obtaining a higher wage. Single old men who marry have higher wages than young married men and single old men who do not marry. They use this higher wage to compensate their spouses for marrying older men (Point (4)). Vella and Collins anticipated this result.[6]

When a young couple marry, they each have to decide how much time to spend in the labor market and how much time to spend with their children. The mother can use her future labor earnings to only buy private consumption when old. The father can use his future labor earnings to buy future private consumption and to compete for a new wife (and have another child) if his current marriage fails. Thus the young father has a potential additional use for future labor income which is not available to the mother. The cost of working, time spent with their child, is the same for both parents. With an additional benefit but the same cost, the father will choose to spend more time at work than the mother (Point (5)). His current labor earnings will also be higher (Point (6)).

Economists have observed and explained points (5) and (6) by noting that mothers spend more time at child rearing and accumulate less human capital than fathers.[7] My contribution is only to provide a new rationale for this difference in time use.

The positive correlation between the level of future labor earnings and the incidence of remarriage is critical in generating current differences in time use between husbands and wives.[8] In this model, the correlation is due to the lack of insurance against human capital uncertainty. Without human capital uncertainty, there is no remarriage and no difference in time use between young husbands and wives. If there is fair insurance against human capital uncertainty, the gender difference in time use is ambiguous. There is a counterfactual negative correlation between the level of future labor earnings and the incidence of remarriage. These alternative predictions show the importance of market structures in determining gender roles.

A caveat is in order. Although qualitatively consistent, the quantitative significance of the considerations here for explaining observed gender roles remains to be established. There are other factors which affect observed gender roles.[9] I do not discuss these other factors, not because they are

[6]They also used differential fecundity to argue why men are more willing than women to delay marriage and accumulate human capital which can be used to compensate women for marrying older men.

[7]Mincer and Polachek (1974). Also see Browning (1992).

[8]Becker et al. (1977), Wolf and MacDonald (1979) provide evidence of this correlation in US data.

[9]The literature on gender roles is huge. Economic discussions include Becker (1991), Bergstrom and Bagnoli, Blau and Ferber, Cain (1986), Goldin (1990), Lundberg and Startz

quantitatively unimportant, but because my focus elsewhere.

The basic model is discussed in Sections (2) and (3). Two other market structures are discussed in Sections (4) and (5). The conclusion is in Section (6).

2 The Basic Model

In this model, every adult can potentially consume two goods: (i) children services, which are public goods for the parents, and (ii) a private consumption good. As emphasized by Bergstrom (1995) and Weiss (1994), it is convenient to use transferable utilities to model the preferences of parents when there are public and private goods within a household. So in the basic model, I assume that parents have constant marginal utility of private consumption. I will also assume that there are no financial markets. After presenting the basic model, I will discuss a model with general utility functions and complete financial markets. It turns out that the absence of fair insurance against human capital uncertainty is descriptively more accurate than a model with complete markets.

The discount rate is assumed to be zero throughout this paper.

There are equal numbers of men and women born in every period. Each individual lives for three periods, one as a child and two as adults. While parents can invest in children, child quality is purely a consumption good. Every young man is alike and every young woman is alike. In the first period of their adult lives, each adult has a wage of l. The adult who works τ hours will earn $l\tau$. Let the wage of an adult in the second period be h ($> l$) if the adult is successful in his or her human capital accumulation and l otherwise. The probability of successful human capital accumulation is equal to $p\tau$ where τ is the individual's hours of work in the first period and $0 < p < 1$. Let $\underline{p\tau} = 1 - p\tau$.

Young men, young women and old men can have children if they can find fertile spouses. Old women cannot have children. Every marriage produces two identical twins in the first period of marriage. I abuse language and will talk about the child from a marriage since both children are identical.[10] If a young woman marries an old man, the marriage ends after one period because the old man dies afterwards. If a young man marries a young woman, the

(1983). Losh-Hesselbart (1987) and Wright (1994) survey research by non-economists.

[10] Two children per new marriage are needed to keep the population constant over time.

marriage may survive into the second period because a married couple derive more services from their child than a divorced couple. Let the exogenous probability of divorce be π. A divorced man may remarry and have another child. A divorced woman will not remarry because she cannot have another child and there is no other gain from marriage.

All young women will marry. They can marry young men, old divorced men or old single men. Since there are more marriageable men than young women, a necessary condition for the marriage market to clear is that young women derive the same expected discounted utility from each type of mate. Let the expected discounted utility that a young woman receives from a marriage be Z.

It is convenient to begin the analysis with the behavior of single old men.

2.1 Single Old Men

Actions in the first and second period of an adult's life are denoted by 1 and 2 superscripts respectively. Children follow the ages of their fathers because mothers are always young. Partial derivatives are denoted with subscripts.

The price of the consumption good is 1. A single old single man has a wage w equal to h or l. If he does not marry, he will spend all his time, normalized to 1, working and obtain a consumption of w. I assume he obtains a utility equal to his consumption w.

If he marries, let him consume e^2 and produce a child of quality q^2. Let his utility in the second period be $u(q^2, e^2) = q^2 e^2$. $q^2 \geq 1$ since I have implicitly assumed that the quality of the child is one for a man without a child. Child quality is determined in the first period of marriage and no further investment in the child is necessary.

Let the father spends t^2 time at work and $\underline{t^2} = 1 - t^2$ time with the child. Let the mother spends n^1 time at work and $\underline{n^1} = 1 - n^1$ time with the child. Let the amount of child's consumption be k^2. Child quality, $q^2 = q(k^2, x(\underline{t^2}, \underline{n^1}))$. q is increasing and linearly homogenous in k and x. x is increasing, symmetric and linearly homogenous in $\underline{t}$ and $\underline{n}$. $x_{\underline{tt}} < 0$ and $x_{\underline{nn}} < 0$. Father's and mother's time can be either substitutes or complements in producing child quality. The symmetry restriction on x rules out comparative advantage by a mother in child rearing. Furthermore, q is linearly homogenous in k, $\underline{t}$ and $\underline{n}$.

Let the mother's consumption in the first period be c^1. Her first period utility is $u(q^2, c^1) = q^2 c^1$. Let her consumption in the second period be c^2.

Her utility in the second period is then $\delta q^2 c^2$ where $\delta \leq 1$ reflects the fact that she is a single mother. Since there is no need to further invest in the child, c^2 is equal to her second period wage, w^f. w^f is equal to h with probability pn^1 or l with probability $\underline{pn^1}$. Her expected utility in the second period is $E(\delta q^2 w^f | n^1)$ where E is the expectation operator. Her expected discounted utility from marriage to an old single man is therefore $q^2 c^1 + E(\delta q^2 w^f | n^1)$. This expected discounted utility must be at least as large as Z for her to be willing to marry him.

I assume husbands and wives can enforce first period marriage agreements.[11] So an old man with wage w who marries for the first time will choose t^2, n^1, k^2, c^1, e^2 to solve:[12]

$$u^j(Z, w) = \max_{\{t^2, n^1, k^2, c^1, e^2\}} q^2 e^2 \tag{1}$$

subject to:

$$\begin{aligned} Z &\leq q^2 c^1 + E(\delta q^2 w^f | n^1) && (2) \\ e^2 + c^1 + k^2 &\leq wt^2 + n^1 l && (3) \end{aligned}$$

At the optimum, equation (2) should hold with equality because if there is an inequality, the man can reduce his wife's consumption and increase his own without violating equation (2). Likewise, equation (3) should also hold with equality at the optimum. Let equations (2) and (3) hold with equality. Solve equation (2) for c^1 and substitute it into equation (3). Then, solve equation (3) for e^2 and substitute it into the objective function (1) to get:

$$u^j(Z, w) = \max_{\{t^2, n^1, k^2\}} [q^2(wt^2 + n^1 l + \delta E(w^f | n^1) - k^2) - Z] \tag{4}$$

The benefit of the transferable utility assumption can be seen in equation (4) where the reservation utility of a wife, Z, is additively separable in the husband's objective function. The optimal choices of t^2, n^1, k^2 are independent of Z.

[11] The case for efficient intrahousehold allocations is made by Chiappori and his collaborators (e.g. Alderman et al. (1995), Chiappori (1992), Browning, et. al. (1994)).

[12] For analytic convenience, I study the men's decision problems subject to giving women their reservation utilities rather than vice versa. As the within household actions are efficient, my choice has no substantive consequence.

Let a^j denote the optimal quantity of a chosen by the husband and $R^j = (wt^j + n^j l + \delta E(w^f|n^j) - k^j)/q^j$. The first order conditions with respect to t^2, n^1, k^2 are:

$$\begin{aligned} R^j q_x^j x_{\underline{t}}^j &= w \quad (5) \\ R^j q_x^j x_{\underline{n}}^j &= l + \delta p(h-l) \quad (6) \\ R^j q_k^j &= 1 \end{aligned}$$

Combine equations (5) and (6) to get:

$$\frac{x_{\underline{t}}^j}{x_{\underline{n}}^j} = \frac{w}{l + \delta p(h-l)} \tag{7}$$

Since x is linearly homogenous and symmetric in $\underline{t}$ and $\underline{n}$, equation (7) implies:

Proposition 1 *An old husband whose wage is h (l) will spend less (more) time with his child than his young wife. Conversely, he will work more (less) than his young wife.*

Compared with her husband, the wife has an additional benefit from working which is that she improve her expected future earnings. Thus if her current wage is the same as that of her husband, she should work more than him. On the other hand, if her husband's wage is h, the difference in their current wage, $h - l$, exceeds the marginal increase in her expected future wages, $\delta p(h - l)$. So he should work more than her.

Using the envelope theorem,

$$\begin{aligned} u_Z^j &= -1 \quad (8) \\ u_w^j &= q^j t^j \quad (9) \end{aligned}$$

A old single man with wage w who has to decide whether to marry or not will solve:

$$u^o(Z, w) = \max[w, u^j(Z, w)] \tag{10}$$

In order to get the result that a wealthier single old man is willing to give up more consumption to marry, let:

Axiom 1 $u^j_w = q^j t^j > 1$

Axiom [1] and equation (10) imply that whenever a single old man with wage w chooses to marry, all single old men with higher wages will also choose to marry. Axiom [1] says that the complimentarity between child services and own consumption is sufficiently large so that the income effect dominates the substitution effect (the cost of time with the child increases) with an increase in the wage.

2.2 Single Young Men

Young men who do not marry will spend all their time at work ($t^s = 1$), consume l and obtain a utility of l in period 1. A single young man will obtain a second period wage of h with probability $p(1)$ and a second period wage of l with probability $\underline{p(1)}$. His second period utility as a single old man, $u^o(Z, w)$, will depend on his wage. The expected discounted utility of being a single young man is then:

$$U^s(Z) = l + E(u^o(Z, w)|t^s)$$

Let Z^h and Z^l be such that $h = u^j(Z^h, h)$ and $l = u^j(Z^l, l)$. Then:

$$\begin{aligned} U^s_Z &= -1 \ , && Z < Z^l \\ U^s_Z &= -p \ , && Z^l \le Z \le Z^h \\ U^s_Z &= 0 \ , && Z^h < Z \end{aligned} \tag{11}$$

When Z is low ($< Z^l$), both rich and poor single old men will marry. When Z is in the intermediate range, only rich single old men will marry. Old single men will not marry when $Z > Z^h$. A plot of $U^s(Z)$ is shown in Figure 1.

2.3 Divorced Men

A marriage between a young man and a young woman may break up after the first period with probability π. Every divorced man has a child from his marriage in the first period. Let the quality of the child be q^1. This quality cannot be changed in the second period. Let the divorced man have wage w.

If he does not remarry, he will work full-time and achieve a utility of $\beta q^1 w$. $\beta \leq 1$ reflects the cost of divorce.

If he remarries, let him consume c^2 and produce another child of quality q^2. Let his utility from remarriage be $\beta q^1 u(q^2, c^2)$.

As specified above, the utility function of a divorced man is the same as the utility function of a single old man multiplied by βq^1.

Assume that young women do not discriminate against divorced men. That is, young women are willing to marry divorced men as long as they provide the same level of discounted expected utility, that is Z, as other potential husbands. In this case, a remarried man chooses t^2, n^1, k^2, c^1, e^2 to solve:

$$u^r(Z, w) = \max_{t^2, n^1, k^2, c^1, e^2} [\beta q^1 q^2 e^2] \tag{12}$$

subject to equations (2) and (3). Except for the constant factor, βq^1, in the objective function (12), the remarried man solves the same problem as the single old man who marries for the first time. Let a^r denote the optimal quantity of a that the remarried man chooses. Then $a^r = a^j$ for $a = t^2, n^1, k^2, c^1, e^2$. Thus young women who marry divorced men have the same outcomes as those who marry single old men.

The utility of a divorced man with wage w is:

$$u^d(Z, w) = \max[\beta q^1 w, \beta q^1 u^j(Z, w)] = \beta q^1 u^o(Z, w) \tag{13}$$

The Z cutoffs for remarriage by rich and poor divorced men are the same as those for the single old men, that is , Z^h and Z^l.

2.4 Divorced Women

Divorced women do not remarry because they cannot have any more children and there is no other gain to marriage. Thus a divorced woman with wage w^f will work full-time and consume w^f. Let the quality of her child from the first period be q^1. Her utility in the second period is $\beta q^1 w^f$.

2.5 Old Married Men and Women

Men and women who marry when young will remain married in the second period with probability $\underline{\pi} = 1 - \pi$. Without loss of generality, I assume that there is no risk sharing within marriage in the second period.[13] Thus an old husband with wage w and an old wife with a wage of w^f will consume w and w^f respectively. Let their child from the first period have quality q^1. The old husband will achieve a utility of $u(q^1, w) = q^1 w$ and the old wife will achieve a utility of $u(q^1, w^f) = q^1 w^f$. There is no discounting of the child's quality because the marriage stays intact. The gain from marrying young is that parents can enjoy their child in both periods. The cost of marrying young is that human capital accumulation by the parents are adversely affected.

2.6 Married Young men

Consider the marriage between a young man and a young woman. Let the husband spend time t^1 time at work and $\underline{t^1}$=$1 - t^1$ time with their child. Let the wife spend time n^1 at work and $\underline{n^1} = 1 - n^1$ with their child. Let the father's, mother's and child consumption in the first period be e^1, c^1 and k^1 respectively. Then the child's quality is $q^1 = q(k^1, x^1(\underline{t^1}, \underline{n^1}))$. The first period utility of the wife is $q^1 c^1$. Her expected discounted utility from marriage is:

$$q^1 c^1 + (\underline{\pi} + \pi\beta) q^1 E(w^f | n^1)$$

The young man's utility in the first period is $q^1 e^1$. His expected discounted utility from marriage is:

$$q^1 e^1 + (\underline{\pi} E(w|t^1) + \pi\beta E(u^o(Z, w)|t^1)) q^1$$

In order to attract a wife, the young man must offer his wife a reservation utility of Z. So he will choose t^1, n^1, k^1, c^1, e^1 to solve:

$$U^m(Z) = \max_{\{t^1, n^1, k^1, c^1, e^1\}} q^1 e^1 + (\underline{\pi} E(w|t^1) + \pi\beta E(u^o(Z, w)|t^1)) q^1 \tag{14}$$

subject to:

$$\begin{aligned} Z &\leq q^1 c^1 + (\underline{\pi} + \pi\beta) q^1 E(w^f | n^1) && (15) \\ c^1 + e^1 + k^1 &\leq l(t^1 + n^1) && (16) \end{aligned}$$

[13]The only risk is labor income. Since the marginal utility of consumption across states for both spouses are the same, risk sharing is redundent.

Following the earlier discussion, both constraints must bind in equilibrium. Then substitute e^1 and c^1 from the now binding constraints into the objective function (14) to get:

$$U^m(Z) = \max_{\{t^1,n^1,k^1\}} q^1(l(t^1+n^1)+(\underline{\pi}+\pi\beta)E(w^f|n^1)-k^1+\underline{\pi}E(w|t^1)+\pi\beta E(u^o(Z,w)|t^1))-Z \tag{17}$$

Let j^m denote the choice of quantity j which solves the above maximization problem. Let $R^m = l(t^m+n^m)+(\underline{\pi}+\pi\beta)E(w^f|n^m)-k^m$. Then the first order conditions with respect to t^1, n^1 and k^1 satisfy:

$$\begin{aligned} R^m q_x^m x_{\underline{t^1}}^m &= q^m(l+p(\underline{\pi}(h-l)+\pi\beta(u^j(Z,h)-u^j(Z,l)))) && (18) \\ R^m q_x^m x_{\underline{n^1}}^m &= q^m(l+p(\underline{\pi}+\pi\beta)(h-l)) && (19) \\ R^m q_k^m &= q^m && (20) \end{aligned}$$

Divide equations (18) by (19) to get:

$$\frac{x_{\underline{t^1}}^m}{x_{\underline{n^1}}^m} = \frac{l+p(\underline{\pi}(h-l)+\pi\beta(u^j(Z,h)-u^j(Z,l)))}{l+p(\underline{\pi}+\pi\beta)(h-l)} \tag{21}$$

By Axiom (1), $u^j(Z,h)-u^j(Z,l) \geq h-l$. Consequently $t^m \geq n^m$ in order to satisfy equation (21). This result is summarized in:

Proposition 2 *Young married men work more than their wives.*

The above proposition is driven by the fact that young married men may remarry if their first marriages fail. Remarriages are more likely if their second period wages are higher. Their second period wages depend on the amount of work they do in the first period. The option value of remarriage, which is not available to women, causes young men to work more than their wives.

Looking only at labor market opportunities and time use in this model, an analyst may conclude that women have a comparative advantage in child rearing. But by construction, women do not have a comparative advantage in child rearing. Rather, it is what men and women can do with the same labor market opportunities that creates the difference in time use.

Two corollaries immediately follows proposition (2):

Corollary 3 *Young married men earn more than their wives.*

Corollary 4 *Married men have higher wage growth than their wives.*

Divorced men do not necessary earn more than divorced women because although the men have a higher expected wage, divorced men who remarry work less than divorced women with the same wage.

Since I assumed old married men and women work the same hours, the following corollary is also immediate:

Corollary 5 *There is convergence in hours of work between husbands and wives over their marriage.*

By the envelope theorem:

$$\begin{aligned} U_Z^m &= -(1+\pi\beta)\ , && Z < Z^l \\ U_Z^m &= -(1+\pi\beta p t^m)\ , && Z^l \le Z \le Z^h \\ U_Z^m &= -1\ , && Z^h < Z \end{aligned} \tag{22}$$

When Z, the reservation utility of a young wife, is equal to zero, $U^m(0) > U^s(0)$ because the young husband can duplicate the young single man's behavior and additionally have his wife's time to spend on the child.

Figure 1 shows a feasible $U^m(Z)$ function.

3 Marriage Market Clearing

Depending on parameter values, there are three types of feasible marriage market equilibria.[14] Only one type of equilibrium involves divorce and remarriage. I will focus on this equilibrium because it is the only equilibrium which is consistent with all the observed gender roles discussed in the introduction of this paper.

Although I focus on one equilibrium, the different types of equilibria in this model are useful because of the diversity of observed marriage experiences across cultures.

[14] I ignore the case where nobody marries.

3.1 Marriage with Divorce and Remarriage

Let Z^* be such that $U^m(Z^*) = U^s(Z^*)$. Z^* exists and is unique. The equilibrium with marriage, divorce and remarriage is characterized by the fact that $Z^l \leq Z^* \leq Z^h$. Such an equilibrium is depicted in Figure 1. In this case, I will argue that Z^* is the market clearing reservation utility for young wives.

Let $Z = Z^*$. At Z^*, young men are indifferent between marrying or remaining single. Let the number of young men and women in each period be normalized to 1. Let m^* be the market clearing number of young men who marry. Then the number of rich single old men is $(1 - m^*)p$. The number of old divorced men who remarry is $m^* \pi p t^m(Z^*)$. Equate, in each period, the total number of men in search of young wives with the number of young females to get:

$$m^* + (1 - m^*)p + m^* \pi p t^m(Z^*) = 1 \tag{23}$$

Rearrange equation (23) to get:

$$m^* = \frac{1 - p}{1 - p + \pi p t^m(Z^*)} \tag{24}$$

Since m^* is a positive fraction, it is feasible. By construction, it satisfies market clearing.

The propositions below hold for this equilibrium. Since $Z^l \leq Z^* \leq Z^h$,

Proposition 6 *Divorced men who remarry have a higher wage than those who do not.*

Proposition 7 *Single old men who marry have a higher wage than those who do not.*

Corollary 8 *Single old men who marry have a higher wage than young men who marry.*

Corollary 9 *Poor single old men never marry.*

The above corollary shows that some men, single men who are unlucky in the labor market, will never marry.

The only old men who marry or remarry have high wages. By proposition (1), they work and earn more than their wives. Together with proposition (2), this market equilibrium implies:

Proposition 10 *Husbands work and earn more than their wives.*

Since $p > pt^m(Z^*)$, the model also predicts that:

Proposition 11 *The incidence of marriage for single old men is higher than the incidence of remarriage for divorced old men.*

Since no divorced woman remarries,

Proposition 12 *Divorced women are less likely to remarry than divorced men.*

As all women marry, the model predicts that:

Proposition 13 *There are proportionately more never ever married men than women.*

Only young women marry whereas some young men and some single old men will marry for the first time. Thus:

Proposition 14 *The average age of first marriage is lower for women than men.*

3.2 Old Husbands and Young Wives

Let $Z^* < Z^l$. In this case, Z^* cannot be market clearing. If $Z = Z^*$, all divorced men and old single men will want to marry. All old single men and young married men must add up to 1 in each period. Thus the addition of divorced men into the market for young wives will exceed the supply of young wives and contradicts market clearing.

Consider Z^{**} such that $Z^* < Z^{**} \leq Z^l$. Then Z^{**} is a market clearing reservation utility for young wives. Let $Z = Z^{**}$. In this case, all young men will remain single and all old single men will marry young women. The market clears. Note Z^{**} is not unique.

There is no divorce or remarriage in this equilibrium. The proportion of never ever married men is equal to the proportion of never ever married women which is equal to zero. These predictions are not relevant in most contemporary industrialized societies. I will not examine this equilibrium further.

3.3 Divorce without Remarriage

This equilibrium is characterized by the fact that $Z^* \geq Z^h$. When $Z > Z^h$, no old single or divorced man will want to marry. If $Z < Z^*$, all young men will prefer to marry than remain single. Let Z^{***} be such that $Z^h \leq Z^{***} \leq Z^*$. I claim that Z^{***}, which is not unique, is a market clearing reservation utility for young wives. When $Z = Z^{***}$, only young men marry young women which is market clearing. The age of first marriage is the same for both men and women. No divorced man remarries. I will not discuss this equilibrium further.

4 No Uncertainty

The basic model assumes that the accumulation of human capital is stochastic and that there is no insurance against human capital uncertainty. In this section, I reexamine the model where human capital accumulation is non-stochastic. The reexamination shows that without human capital uncertainty, there is no difference in time use between young husbands and wives.

Instead of the stochastic human capital accumulation technology discussed in the previous section, let a worker's second period non-random wage be $w(\tau) = l + p\tau(h - l)$ where τ is his or her time spent at work in the first period. All other aspects of the model remain as before.

There are two feasible market equilibria with young married men. In the first, all young men marry. In this case, there are no young women for divorced men to remarry. Divorced men face the same opportunities as divorced women. Given the symmetry in the rest of the model, young men will not choose different hours of work from their wives. Due to the transferable utility assumption, symmetric behavior occurs even though husbands and wives may have different expected lifetime utilities.

In the second type of equilibrium, some young men will marry whereas others will remain single. Since all young married men are identical, they will choose the same hours of work, t'. Their second period wage will be $w(t') < w(1)$. Their second period wage is less than those that of single old men who will have a wage of $w(1)$. By assumption [1], single old men will willingly outbid divorced men for wives. Due to the equal number of men and women in each cohort, young married men and single old men who marry will match up with all the young women. There are no young women left for divorced men to marry. Thus in this case as well, divorced men face the same effective opportunities as divorced women. So young married men will choose the same hours of work as their wives. In this equilibrium, there are gender roles. For example, some young men marry and other young men remain single whereas all young women marry.

This section has shown that, without human capital uncertainty, all young married men will work the same hours as their wives which is counterfactual. Whether this finding is robust to other sources of heterogeneity across individuals remains to be investigated.

This section has shown that gender roles depend on the interaction between differential fecundity and the structure of the labor market. The next section will show that the structure of financial markets are important as well.

5 Complete Markets

Consider a model with human capital uncertainty, complete markets, fair lotteries and full contracting between husbands and wives.[15] Unlike the model without uncertainty, there are ex-post differences across individuals here due to human capital uncertainty. In order to keep the paper within a reasonable length, I assume an equilibrium with remarriage exists and show that a divorced man who obtains a wage of h will work more and is less likely to remarry than if he obtains l. I will also show that wives may work more or less than their young husbands.

With full insurance, there is no income effect affecting the demand for commodities between different states. The time cost of children increases as the wage increases. Thus the substitution effect reduces the demand for child quality as the wage increases.[16] Put another way, with full insurance, it is optimal for the divorced man to work more in the high wage state and consume less child services in order to buy more child services in the low wage state where child services are cheaper.

The ambiguity in differences in hours of work is due to the fact that a

[15] Lotteries are useful in environments with indivisibilities (e.g. Bergstrom (1986), O'Flaherty and Siow (1991), Rogerson (1988), Prescott and Townsend (1984)).

[16] This argument and some subsequent proofs mimic those in the implicit contracts literature (Rosen (1985)).

young husband do not see as much of a gain from the high wage state as in the basic model without insurance. The low wage state is valued relatively higher under full insurance because child services are cheaper in that state.

Hayashi et al. (1996) and the references therein provide evidence against full risk sharing between and across households. The counterfactual correlation between labor earnings and remarriage, and the ambiguous prediction of the gender difference in hours of work, also suggest that the complete markets model is descriptively less accurate than the basic model.

The next subsection of the paper provides the proof of the two claims made above. Without loss of continuity, readers may skip to the conclusion.

5.1 Proof of Claims

The transferable utility model does not work well with these many markets because the individual wants to transfer all consumption to the state with the highest marginal utility of consumption. Specialization in consumption is not an issue in the basic model because there is no financial market there. I will use a more general specification of preferences here.

Let $u(q^1, e^1)$ be the within period utility of a young married man with a child of quality q^1 and own consumption level e^1. q^1 is as defined earlier. $u(.)$ is increasing and concave in both arguments. Let $\mu(q^2, e^2, q^1, i)$ be his within period utility when old when he has a second period child of quality q^2 ($q^2 = 1$ if he does not have a second period child), consumes e^2, has a child of quality q^1 from the first period, and enjoys marital status $i = \{m, d\}$. $\mu(.)$ is increasing and concave in the first three arguments. The analog of Axiom [1] is:

Axiom 2 $\mu_{q^2 e^2} > 0$

Axiom [2] says that child quality and private consumption are complements.

Similarly, let $v(q^1, c^1)$ and $\nu(q^1, c^{iw^f}, i)$ be the first and second period utilities respectively of a young married woman with a child of quality q^1, first period consumption c^1, marital status i in the second period ($i = m, d, s$)[17], and c^{iw^f} is her second period consumption in marital state i and wage state w^f

[17] s is single. A woman enters state s in the second period if she marries an old man. A woman who marries a young man can only enter states m or d.

$= \{h, l\}$. $v(.)$ and $\nu(.)$ are increasing and concave in their first two arguments. $\Gamma^{iw^f}(n^1)$ is the probability of her being in state iw^f. E.g. $\Gamma^{mh}(n^1) = \underline{\pi} p n^1$.

With complete markets, it is convenient to assume that he sold his wage income from full-time work in second period to the market in the first period.

I begin the analysis by considering the second period decision problem of a man who was married in the first period. Let $U(q^1, y^{iw}, i, w)$ be his value function in state iw. i refers to his marital status. w refers to his wage. q^1 is the quality of his first period child. y^{iw} is his income transfer into the state and therefore his wealth in the state. Let $\Gamma^{iw}(t^1)$ be the probability of being in state iw. E.g., $\Gamma^{mh}(t^1) = \underline{\pi} p t^1$.

If he remains married, his second period value function in state mw is:

$$U(q^1, y^{mw}, m, w) = \mu(1, y^{mw}, q^1, m) \tag{25}$$

If he is divorced and in state dw, he can enter a lottery and obtain:

Problem P1

$$\begin{aligned} U(q^1, y^{dw}, d, w) &= \max_{\{\theta^w, y^\mu\}} \theta^w \mu(1, y^\mu, q^1, d) + \underline{\theta^w} r(q^1, y^r, w) \\ \text{s.t. (i) } 0 &\leq \theta^w \leq 1 \\ \text{(ii) } 0 &\leq y^\mu \leq y^{dw} \\ \text{(iii) } y^r &= \begin{cases} 0, \ \theta^w = 1 \\ \frac{y^{dw} - \theta y^\mu}{\underline{\theta^w}}, \ 0 < \theta < 1 \\ y^{dw}, \ \theta^w = 0 \end{cases} \end{aligned} \tag{26}$$

With probability θ^w, he receives an income transfer of y^μ, does not remarry and obtains a utility of $\mu(1, y^\mu, q^1, d)$. With probability $\underline{\theta^w} = 1 - \theta^w$, he receives an income transfer of y^r, remarries and obtains a utility of $r(q^1, y^r, w)$ which will be defined momentarily. The lottery allows him to obtain a higher expected utility than if he can only choose between remarriage or not. He can still choose either extreme by setting θ^w to 1 or 0. y^r is defined such that the lottery is fair.

$r(q^1, y^r, w)$ is defined as:

Problem P2

$$r(q^1, y^r, w) = \max_{\{q^2, e^2, c^1, c^{iw^f}, t^2, n^1\}} \mu(q^2, e^2, q^1, d) \tag{27}$$

subject to his new wife getting her reservation utility:

$$V(q^2, c^1, c^{swf}) = v(q^2, c^1) + \sum_{swf} \Gamma^{swf}(n^1)\nu(q^2, c^{swf}, s) \geq Z \tag{28}$$

and his second period budget constraint:

$$k^2 + e^2 + c^1 + w\underline{t^2} + l\underline{n^1} + \sum_{swf} \Gamma^{swf}(n^1)c^{swf} \leq y^r + l + \sum_{swf} \Gamma^{swf}(n^1)w^f \tag{29}$$

The first period decision problem of a young husband is now stated. He will solve:

Problem P3

$$\max_{\{k^1, e^1, c^1, y^{iw}, c^{iwf}, t^1, n^1\}} u(q^1, e^1) + \sum_{iw} \Gamma^{iw}(t^1)U(q^1, y^{iw}, i, w) \tag{30}$$

subject to his wife getting her reservation utility:

$$v(q^1, c^1) + \sum_{iwf} \Gamma^{iwf}(n^1)\nu(q^1, c^{iwf}, i) \geq Z \tag{31}$$

and his first period budget constraint:

$$k^1 + e^1 + c^1 + l(\underline{t^1} + \underline{n^1}) + \sum_{iw} \Gamma^{iw}(t^1)(y^{iw} - w) + \sum_{iwf} \Gamma^{iwf}(n^1)(c^{iwf} - w^f) - 2l \leq 0 \tag{32}$$

Together, the budget constraints (29) and (32) embody complete markets and contracting. The young husband is able to choose income transfers to himself, his wife, and if necessary, a new wife, between all states at probabilistically fair prices.

I assume that Z is sufficiently high such a wife's and their child's expected discounted consumption exceed her expected discounted earnings. In other words, marriage or remarriage is costly for the husband.

Consider problem P3. Let λ and α be the multipliers associated with constraints (31) and (32) respectively. Let $\widehat{a}$ denote the optimal choice of a. The first order conditions with respect to y^{iw} is:[18]

$$\widehat{U^{iw}_{y^{iw}}} = \alpha \ \forall \ iw \tag{33}$$

[18] I will discuss the rest of the first order conditions later.

Now consider the behavior of a divorced man. Let him be in state dw. His behavior in this state is linked to his behavior in other states only through his income transfer, $\widehat{y^{dw}}$. Given the income transfer, his behavior is describe by the solution to problem P1. The optimal income transfer satisfies equation (33).

For the moment, assume that it is optimal for the divorced man to remarry with positive probability. Let $\gamma = (1/\alpha)$. Following Browning et al. (1985), it is convenient define the divorced man's profit function under remarriage:

Problem P4

$$\max_{\{k^2,e^2,c^1,c^{swf},\underline{t^2},\underline{n^1}\}} \gamma\mu(q^2,e^2,q^1,d)-[k^2+e^2+c^1+w\underline{t^2}+l\underline{n^1}+\sum_{swf}\Gamma^{swf}(n^1)(c^{swf}-w^f)]$$

subject to $V(q^2,c^1,c^{swf}) \geq Z$

The effect of the income transfer on his behavior is incorporated into the term γ which denotes his price of utility. Let σ denote the multiplier associated with his new wife's reservation utility constraint. Then the profit function may be rewritten in Lagrangian form:

Problem P5

$$\max_{\{k^2,e^2,c^1,c^{swf},\underline{t^2},\underline{n^1}\}} \gamma\mu(q^2,e^2)+\sigma V(q^2,c^1,c^{swf})-[k^2+e^2+c^1+w\underline{t^2}+l\underline{n^1}+\sum_{swf}\Gamma^{swf}(n^1)(c^{swf}-w^f)] \tag{34}$$

I have suppressed q^1 and d in his utility function and will do so from hereon when there is no confusion.

Conditional on remarrying, the lemma below shows that the man buys less child quality if his wage is in the higher state.

Lemma 15 $\widehat{q^2_w} \leq 0$

Proof: Consider Problem P5. Due to risk aversion and full insurance, the optimal choice of c^{swf} is to set it to a constant, $\widehat{c^s}$. Then $\sum_{swf}\Gamma^{swf}(n^1)\widehat{c^{swf}}$ is independent of n^1. So the cost of using k^2, $\underline{t^2}$ and $\underline{n^1}$ to produce q^2 is $k^2+w\underline{t^2}+(l+ph+(1-p)l)\underline{n^1}$. Since q^2 is linearly homogenous in the inputs, the cost function for q^2 may be expressed as $\Gamma(1,w,l+ph+(1-p)l)q^2$. $\Gamma(.)$ is the shadow price of q^2. $\Gamma_w \geq 0$. Problem P5 may be re-expressed as:

Problem P6

$$\max_{\{e^2,c^1,c^s,q^2\}} \gamma\mu(q^2,e^2)+\sigma V(q^2,c^1,c^s)-e^2-c^1-\Gamma q^2-\phi c^s \tag{35}$$

The above is a standard profit maximization problem. Since $\Gamma_w \geq 0$, standard revealed preference arguments show $\widehat{q^2_w} \leq 0$.■

Lemma 16 *Let the divorced man choose to remarry with positive probability.* $\widehat{\mu_w} \leq 0$.

Proof: Consider Problem P6. The optimal choice of e^2 will satisfy:

$$\widehat{\mu_{e^2}} = 1/\gamma = \alpha \tag{36}$$

Holding α constant, when the wage changes:

$$\widehat{e^2_w} = -(\widehat{\mu_{e^2 q^2}}/\widehat{\mu_{e^2 e^2}})\widehat{q^2_w} \tag{37}$$

His utility in state dw is $\mu(\widehat{q^2},\widehat{e^2})$. As the wage changes, $\widehat{\mu_w} = [\widehat{\mu_{q^2}} - \widehat{\mu_{e^2}}\widehat{\mu_{e^2 q^2}}/\widehat{\mu_{e^2 e^2}}]\widehat{q^2_w}$. By Axiom [2] and lemma (15), $\widehat{\mu_w} \leq 0$.■

Lemma 17 $r_{y^r}(y,w) \geq \mu_{e^2}(1,y)$

Proof: Consider problem P2. By the envelope theorem, $r_{y^r}(y,w) = \mu_{e^2}(\widehat{q^2(y)},\widehat{e^2(y)})$. Since remarriage is costly, $\widehat{e^2(y)} \leq y$. Together with $\widehat{q^2(y)} \geq 1$ and Axiom [2], the lemma follows.■

Costly remarriage also implies:

Lemma 18 *There exists* $\underline{y} > 0$ *such that if* $y \leq \underline{y}$, $r(y,w) \leq \mu(1,y)$.

Lemmas (17) and (18) imply that $r(y,w)$ crosses $\mu(1,y)$ from below as y increases as shown in figure 2.

Let $\underline{y(w)}$ and $\overline{y(w)}$ be such that:

$$\begin{aligned} S(w) &= r_{y^r}(\overline{y(w)},w) = \mu_{e^2}(1,\underline{y(w)}) &(38)\\ r_{y^r}(\overline{y(w)},w) &= \frac{r(\overline{y(w)},w)-\mu(1,\underline{y(w)})}{\overline{y(w)}-\underline{y(w)}} &(39)\end{aligned}$$

$\underline{y(w)}$ and $\overline{y(w)}$, and thus $S(w)$, are uniquely defined by equations (38) and (39). See figure 2.

Lemma 19 $S_w = r_w(\overline{y(w)}, w)/(\overline{y(w)} - \underline{y(w)}) \leq 0$

Proof: The first equality in the lemma is obtained by differentiating equation (39) and applying equation (38) to the result. The inequality follows from applying the envelope theorem to problem P2 with respect to w.■

Conditional on divorce, q^1 and y^{dw}, apply the Kuhn Tucker theorem to Problem P1 to get:

Proposition 20

$$\widehat{\theta^w} = \begin{cases} 1 & \widehat{y^\mu} = y^{dw} & y^{dw} < \underline{y(w)} & \mu_{e^2}(1, y^{dw}) > S(w) \\ \frac{\overline{y(w)} - y^{dw}}{\overline{y(w)} - \underline{y(w)}} & \widehat{y^\mu} = \underline{y(w)} & \underline{y(w)} \leq y^{dw} \leq \overline{y(w)} & \mu_{e^2}(1, \underline{y(w)}) = r_{y^r}(\overline{y(w)}, w) = S(w) \\ 0 & \widehat{y^\mu} = 0 & \overline{y(w)} < y^{dw} & r_{y^r}(y^{dw}, w) < S(w) \end{cases} \tag{40}$$

The above proposition takes y^{dw} as given. The next proposition shows the behavior of the divorced man when y^{dw} is optimally chosen. Combine proposition (20) and equation (33) to characterize the behavior of the divorced man when his wage is w:

Proposition 21

$$\begin{array}{cc} \widehat{\theta^w} = 1 & \mu_{e^2}(1, \widehat{y^{dw}}) = \alpha > S(w) \\ 0 < \widehat{\theta^w} < 1 & \mu_{e^2}(1, \widehat{y^{dw}}) \leq \alpha = S(w) \leq r_{y^r}(\widehat{y^{dw}}, w) \\ \widehat{\theta^w} = 0 & r_{y^r}(\widehat{y^{dw}}, w) = \alpha < S(w) \end{array}$$

Combine lemma (19) and proposition (21) to get:

Proposition 22 *If a divorced man who has a high wage remarries with positive probability, he will always remarry if he has a low wage. If a divorced man who has a low wage does not always remarry, he will not remarry if he has a high wage.*

I will now discuss whether a young husband work more or less than his wife. Consider the rest of the first order conditions for problem P3. Let $\widehat{R} = \widehat{u_q} + \sum_{iw} \widehat{\Gamma^{iw}} \widehat{U_q^{iw}} + \lambda(\widehat{v_q} + \sum_{iw} \widehat{\Gamma^{iwf}} \widehat{\nu_q^{iwf}})$. The first order conditions with respect to $k^1, e^1, c^1, c^{iwf}, t^1$ and n^1 are:

$$\begin{aligned}
\widehat{R}\widehat{q_k} &= \alpha && (41)\\
\widehat{u_{e^1}} &= \alpha && (42)\\
\lambda\widehat{v_{c^1}} &= \alpha && (43)\\
\lambda\widehat{\nu^{iw^f}_{c^{iw^f}}} &= \alpha\ \forall\ iw^f && (44)\\
\widehat{R}\widehat{q_x}\widehat{x_{\underline{t}^1}} + \alpha\sum_{iw}\widehat{\Gamma^{iw}_{t^1}}\widehat{y^{iw}} &= \alpha l + \sum_{iw}\widehat{\Gamma^{iw}_{t^1}}\left[\widehat{U^{iw}} + \alpha w\right] && (45)\\
\widehat{R}\widehat{q_x}\widehat{x_{n^1}} + \alpha\sum_{iw^f}\widehat{\Gamma^{iw^f}_{n^1}}\widehat{c^{iw^f}} &= \alpha l + \sum_{iw^f}\widehat{\Gamma^{iw^f}_{n^1}}\left[\lambda\widehat{v^{iw^f}} + \alpha w^f\right] && (46)
\end{aligned}$$

Equations (25) and (33) imply that an old married man will have a constant level of utility, that is $U(\widehat{q^1}, \widehat{y^{mh}}, m, h) = U(\widehat{q^1}, \widehat{y^{ml}}, m, l)$ and consequently $\widehat{y^{mh}} - \widehat{y^{ml}} = 0$. Equation (44) implies that (i), an old married woman will have a constant level of utility, that is $\nu(\widehat{q^1}, \widehat{c^{mh}}, m) = \nu(\widehat{q^1}, \widehat{c^{ml}}, m)$ and $\widehat{c^{mh}} = \widehat{c^{ml}}$. (ii) An old divorced woman will also have a constant level of utility, that is $\nu(\widehat{q^1}, \widehat{c^{dh}}, d) = \nu(\widehat{q^1}, \widehat{c^{dl}}, d)$ and $\widehat{c^{dh}} = \widehat{c^{dl}}$. Then divide equations (45) by (46) and simplify to get:

$$\frac{\widehat{x_{\underline{t}^1}}}{\widehat{x_{\underline{n}^1}}} = 1 - (\widehat{y^{dh}} - \widehat{y^{dl}})\frac{p\pi(\alpha - \frac{(\widehat{U^{dh}} - \widehat{U^{dl}})}{(\widehat{y^{dh}} - \widehat{y^{dl}})})}{\alpha(l + p(h-l))} \qquad (47)$$

Proposition 23 *(i) If the divorced man always remarry, a wife will work more than her young husband. (ii) If* $0 < \widehat{\theta^h} < 1$ *or* $0 < \widehat{\theta^l} < 1$*, a wife will work as much as her young husband. (iii) If the high wage divorced man never remarry and the low wage divorced man always remarry, a wife will work less than her young husband.*

Proof: Referring to equation (47),

(i) $\widehat{y^{dh}} - \widehat{y^{dl}} > 0$ and $\widehat{U^{dh}} - \widehat{U^{dl}} < 0$. So $\frac{\widehat{x_{\underline{t}^1}}}{\widehat{x_{\underline{n}^1}}} < 1$.

(ii) $\alpha = \frac{(\widehat{U^{dh}} - \widehat{U^{dl}})}{(\widehat{y^{dh}} - \widehat{y^{dl}})}$. So $\frac{\widehat{x_{\underline{t}^1}}}{\widehat{x_{\underline{n}^1}}} = 1$.

(iii) $\widehat{y^{dh}} - \widehat{y^{dl}} < 0$ and $\alpha > \frac{(\widehat{U^{dh}} - \widehat{U^{dl}})}{(\widehat{y^{dh}} - \widehat{y^{dl}})}$. So $\frac{\widehat{x_{\underline{t}^1}}}{\widehat{x_{\underline{n}^1}}} > 1$.■

6 Conclusion

This paper investigated how differential fecundity interacts with market structures to affect gender roles. There is a lot of further work to be done.

In this paper, ex-post differences in earnings across individuals affected gender roles. Whether other forms of heterogeneity across individuals exacerbate or mitigate gender differences remains to be investigated.

The paper abstracts from endogenous marital dissolutions and issues of child custody.[19] For example, what are the implications of awarding primary child custody to the parent who spent the most time with the child in the event of a divorce?

I assumed that parental investments do not influence the opportunities of their children. It is important to relax this assumption.

With continued advances in pre- and post-natal care, and a declining demand for children, twenty five year old divorced men should not be concerned about the fecundity of their female counterparts. But fifty year old divorced men may be concerned about the fecundity of their counterparts. How will the marriage market for twenty five year olds be affected if fifty year old divorced men show a preference for younger second wives?

Finally, the quantitative significance of the concerns discussed here for explaining observed gender roles remains to be established.

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Figure 1: $U^m(Z)$ and $U^s(Z)$

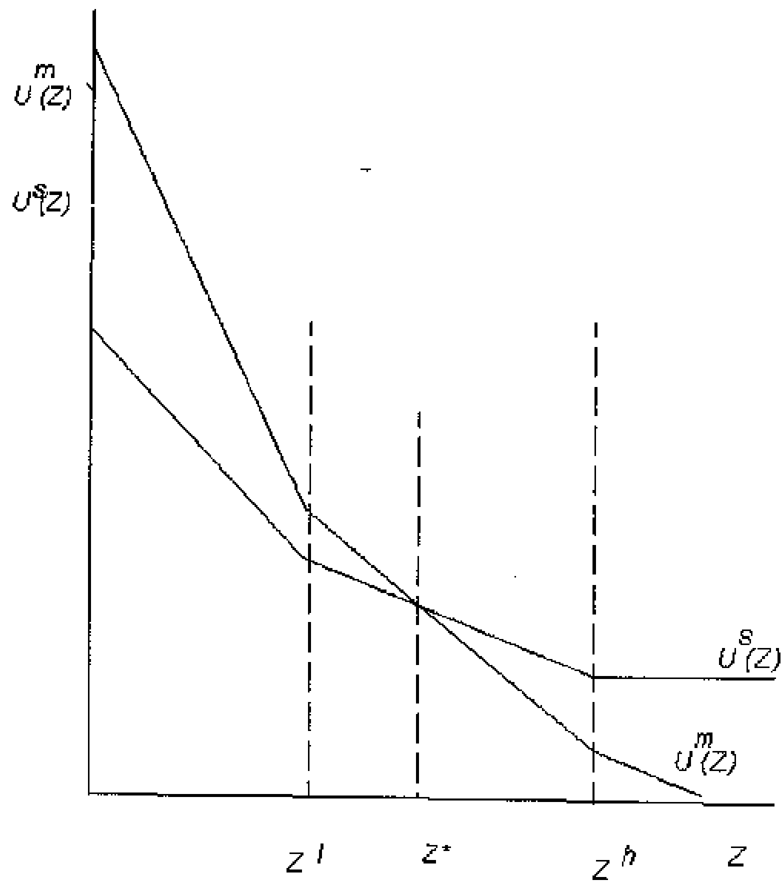

Figure 2: $\mu(1,y)$, $r(y,w)$ and $S(w)$