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Rotten parents

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Abstract

We study the implications of the trade-off between child quality and child quantity for the efficiency of the rate of population growth. We show that if quantity and quality are inversely related then, even in the case of full altruism within the family, *population growth is inefficiently high*, if the family does not have, or does not choose to use, compensating instruments (for example, bequests or savings are at a corner). In non-altruistic models this trade-off certainly generates a *population problem*. We therefore prove that *the repugnant conclusion is not only repugnant, it may be inefficient*. Moreover, we cannot expect intra-family contracting to resolve the inefficiency since it involves contracts which are not credible.

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1. Introduction

The 'population problem' has been at the center of economic analysis since at least the time that Malthus wrote. Models, following Becker (1960), have tended to lead the theoretical literature towards a presumption that the rate of population

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growth is Pareto efficient, and hence, that there was no population problem. There seem to be three reasons for this. Firstly, the dynastic model of an altruistically linked family (as in Barro and Becker (1988)) generates a rate of population growth which is efficient under standard assumptions.

The second reason is that economists working outside the Becker framework have been unable to construct a convincing rationale for the existence of a population problem on the basis of a specification of an intertemporal social welfare function (see for example the discussion in Razin and Sadka (1995) Chapter 5). While the equilibrium rate of population growth might not be the one which maximizes a social welfare for a particular set of intergenerational welfare weights, it is Pareto optimal. This is so since, even though the given equilibrium rate of population growth may imply very low child quality and therefore welfare (the so-called 'repugnant conclusion' of Parfit (1984)), it is the rate which maximizes the utility of the parents. Thus, for example, lower fertility, while it might improve the welfare of the children, would reduce the utility of parents.

Thirdly, while many examples of externalities and market failures stemming from population growth have been suggested, economists do not seem to be convinced of their importance (see e.g. Kelley (1988)).[1] To the extent that they are, they argue that the externalities are usually caused by other factors interacting with population growth (such as badly defined property rights on natural resources and inefficiently provided public goods) and it is not actually population growth that is to blame. As a result of this one rarely hears an economist claiming that there is a population problem. Lee and Miller (1991), in perhaps the most careful empirical treatment of these issues, argue that there is no convincing evidence one way or the other; though Dasgupta (1995) is one prominent counterexample, it is not clear exactly what he thinks is *the* key issue which generates such a problem.[2]

In this paper we argue that there is one externality which may generate a

[1]One argument is that if parents plan to have another child they treat the future wage rate as given, but that if all parents increase their families then the effect on labor supply will cause the wage rate will fall. As Willis (1987) showed however, this effect is a pecuniary externality which does not imply inefficiency when markets are complete. An alternative argument, studied by Nerlove et al. (1987), is that population growth may have adverse effects by crowding public goods and infrastructure, the counter argument being that a larger population reduces the average cost of provision. Alternatively, one could imagine situations where individual preferences were defined directly over the level of population (people may dislike crowded cities and enjoy open spaces). Yet again such an externality might go either way (some people clearly do like to be surrounded by other people). Simon (1977) has also argued that population growth may have positive externalities by stimulating innovation (more Einsteins in a big population) (see also Kremer, 1993); and many recent endogenous growth models feature 'scale effects' where the growth rate of the economy is an increasing function of the level of population. On the other hand, Romer (1987) argues that there may be negative external effects from population growth. Another possible source of externalities is environmental degradation, as in the model of Nerlove (1991).

[2]The discussion in Coleman (1993) implicitly assumes there are large negative externalities stemming from population growth.

population problem: the inverse relationship between child quality and child quantity. Many empirical studies have documented this relationship,[3] which induces a negative externality from parental fertility choice on infra-marginal children. Such an externality occurs naturally if the family has limited resources (mother's time) or assets (family land). As parents add children to the family, the quality and welfare of infra-marginal children is reduced. We show that this effect operates even if parents are fully altruistic,[4] and in situations where potentially compensating instruments (such as educational expenditures or bequests) are unavailable or at a corner, it unambiguously implies that fertility is inefficiently high. This externality gives children an incentive to contract with their parents to have smaller families. We argue, however, that the family cannot be expected to solve the potential inefficiency through such contracts because the necessary transfers from children to parents are not credible.

In an intertemporal framework where capital markets are imperfect, we consider a situation in which parents cannot borrow against future income. We then show that, even if bequests are positive, the quality–quantity trade-off generates an inefficiently high level of fertility if savings are at a corner. In other words, it is necessary for both bequests and savings to be interior for parents to correctly internalize the externality they impose on their children.[5]

We also study this externality in the context of a non-altruistic model, specifically the old-age security model. We show that in this model the level of fertility is inefficiently high. In such models, even if parents have compensating instruments, they will not internalize the externality. This result is important since the old-age security model is perhaps the salient model of population growth in the literature on economic development. We therefore show that in many salient cases *where quantity and quality are inversely related, the repugnant conclusion may not only be repugnant, it can be Pareto inefficient.*

The paper proceeds as follows. In Section 2 we begin with the simplest possible model which illustrates the nature of our results. This model is the standard

[3] See, for example, Rosenzweig and Wolpin (1980); King (1987); Hanushek (1992); Mulligan (1997a) and the survey by Haveman and Wolfe (1995).

[4] By this we mean the model of Becker (1991) where parents care about the number and utility of their children.

[5] Intuitively, although altruistic parents realize that having higher quantity reduces the quality of 'infra-marginal' children they only value this deterioration at the same rate that the children do if their marginal utilities of consumption are equated, and this is only guaranteed by bequests and savings being interior. Our results relate to those of Weil (1986) who showed that in the dynastic set-up Ricardian equivalence only holds in the case where bequests are interior, and Becker and Murphy (1988); Nerlove et al. (1988) and Razin and Sadka (1995) who investigate other cases where a non-negativity constraint on bequests can generate inefficiencies. The latter papers show that human capital investment is inefficient in this case and while this effect is present in our paper it is not the focus of the analysis. The non-negativity constraint on bequests is the reason why the 'Rotten Kid Theorem' of Becker (1974), which implies that family members take actions to maximize the joint family income, does not hold in our model (see Bergstrom, 1989).

altruistic model of household resource allocation and fertility, where parents care both about the number of children they have and their children's utility. In Section 3 we develop the altruistic model further by considering two periods for parental consumption and introducing savings. In Section 4, we show that the results are even stronger in the old-age security model of fertility. In that section we show that, even if parents have other instruments to attempt to offset the externality stemming from quantity, fertility will still be inefficiently high. Section 5 concludes with a brief discussion of the policy implications of our results.

2. Altruism and the welfare economics of the quantity–quality trade-off

2.1. Fundamentals

In this section we build the simplest model which illustrates the results of this paper. We assume that parents are endowed with a joint utility function defined over own consumption, denoted c_p, the number of children that they have, n, and the utility of their children (all of whom have identical preferences and are treated identically by parents). As is conventional, we shall assume that n is a continuous variable, though we shall present an intuitive explanation for our results in the case where fertility is integer. Parental utility is denoted, $W(c_p,n,V(c_c))$, where $V(c_c)$ is the utility function of a child which depends only on child consumption, c_c. We shall assume that W is separable (though nothing hinges on this) so that:

$$W(c_p,n,V(c_c)) \equiv U(c_p) + n\delta V(c_c) \tag{1}$$

where both $U:\Re_+ \to \Re, V:\Re_+ \to \Re$ are twice continuously differentiable, strictly increasing and strictly concave so that their partial derivatives are (in the standard notation), $U' > 0, V' > 0$ and $U'' < 0, V'' < 0$. Here $\delta > 0$ is a parameter measuring the extent to which parents are altruistic.

Parents have an exogenous income of m units of a numeraire consumption good whose price is unity, this income can be allocated between own consumption, per child bequests, denoted b, and child rearing. It costs σ units of income to raise a child. We assume that $b \geq 0$. Thus the budget constraint facing parents is, $c_p = m - n(\sigma + b)$. The quality of a child is a decreasing function of the number of children the family has, denoted $f(n)$.[6] We assume, $f:\Re_+ \to \Re_+$ is continuously differentiable and strictly decreasing with $f' < 0$. This formulation builds in the quantity–quality trade-off in the simplest possible way. The consumption of a child is therefore, $c_c = f(n) + b$. Thus the parents choose n and b to maximize:

[6] The interpretation of this quantity–quality trade-off is that the household possesses some resource, such as mother's time, or asset, such as land, which is fixed. In this case increasing the size of the family must reduce the per-capita amount of this which children get and directly reduce their quality.

$$U(m - n(\sigma + b)) + n\delta V(f(n) + b) \tag{2}$$

In general the first-order conditions for this problem, with respect to n and b, respectively, are:

$$U'(c_p)(\sigma + b) = \delta(V(c_c) + nV'(c_c)\ f'(n)) \tag{3}$$

$$U'(c_p) = \delta V'(c_c) \text{ and } b^* > 0 \text{ or } U'(c_p) > \delta V'(c_c) \text{ and } b^* = 0 \tag{4}$$

We begin by analyzing the case where bequests are at a corner, so that $U'(c_p) > \delta V'(c_c)$. Fertility is defined by Eq. (3) with $b^* = 0$. Is the n^* which satisfies (3), which we call the *laissez faire* level of fertility, efficient?[7] As parents choose to have more children, the average quality, and hence consumption of each child falls. Having an extra child exerts a negative externality of existing (infra-marginal) children. However, with the current model where parents are altruistic, it might seem as though parental fertility choice internalizes this externality (indeed the last term in (3) captures the dependence of n^* on this negative externality). We now show that in the case where $b^* = 0$ this is not so. Before doing so we need to discuss in more detail the concept of efficiency we use.

2.2. The concept of efficiency

To think about the welfare effects of fertility choices we need to be precise about the partial ordering we will use to rank different allocations. This is complicated here as different sets of people are alive under different scenarios. For example, imagine that one wishes to consider the effects on welfare of reducing the *laissez faire* level of fertility. Think in integer terms and imagine a family has n children. Reducing the family size to $n - 1$ may well increase the utility of the $n - 1$ children but what about the utility of the nth? We adopt the point of view advocated by Dasgupta (1993) and Broome (1993), that there is not a moral obligation to bring a 'potential person' into the world. In this case, from an ex ante point of view, and since we shall assume that all children are treated equally, what matters is the average welfare of individuals who are alive in different allocations. There is no trade-off between the utility levels of the living and bringing into the world the potentially living. With this in mind we make the following definition.

Definition 2.1. An allocation **x** is (strictly) Pareto preferred to an allocation **y** if in **x** the average utility of all living children and the utility of the parents is (strictly)

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[7] As is well known, in models of the type that we consider in this paper, where the budget constraint is non-linear, the constraint set may not be convex and we must be careful in analyzing the first-order conditions (see the discussion of these issues in Razin and Sadka, 1995). We shall assume throughout the paper that the relevant second-order condition is satisfied.

greater than the average utility of all living children and the utility of the parents in allocation **y**.

This definition leaves open the possibility that the number of children is different in the different allocations and it compares only the average utility of those alive. It also places no value on the existence of people as such except to the extent that this is reflected in people's preferences. The only thing that matters in comparing two allocations is the average welfare of parents and existing children. This welfare criterion is therefore a form of 'average utilitarianism'.

2.3. The inefficiency result

To show that the *laissez faire* level of fertility is Pareto inefficient under this definition we prove that there exists a contract where children make transfers to induce their parents to reduce the size of the family and hence have higher quality children, and which increases the utility of parents and leaves the average welfare of children unchanged. Since existing children are made worse off by having an increased family size, they would be prepared to pay their parents some amount to avoid this possibility. In the integer case, imagine that parents find it optimal to have $n+1$ children. To do this they have child n first. Now they plan to have one more child. With equal treatment all existing children will be hurt by this. We ask: do the existing children have an incentive to offer to pay the parents a transfer large enough for them to renounce another child? They do if bequests are at a corner.

Proposition 2.2. *If bequests are at a corner, then the laissez faire level of fertility in the altruistic model, n^*, is Pareto inefficient. Moreover, it is inefficiently high.*

Proof. We first construct a contract which entails a transfer dt from children to parents in exchange for a reduction in fertility, denoted dn. We construct this contract so that children's utility is unchanged.[8] This therefore satisfies the equation, $V'(c_c^*)[f'(n^*)\,dn - dt] = 0$ which implies that, $f'(n^*)\,dn = dt$. We can pick dn and dt such that this contract always exists. We now investigate the effect of a such contract on parental utility. Totally differentiating (2) (allowing for the contract) yields:

$$U'(c_p^*)(n^*dt - (\sigma - t)\,dn) + \delta V(c_c^*)\,dn + n^*\delta V'(c_c^*)(f'(n^*)\,dn - dt)$$

[8] The fact that the contract leaves the utility of a child unchanged is just a simple normalization that we use throughout the paper. It should be clear from the derivations below that by continuity there always exists another contract more favorable to children than the one we analyze where the utility of all existing children and parents is strictly higher.

By the envelope theorem, and evaluating at $t = 0$ this reduces to:

$$n^*[U'(c_p^*) - \delta V'(c_c^*)]\, dt > 0 \tag{5}$$

where the sign of (5) follows from the Kuhn–Tucker condition for $b^* = 0$. Therefore, when bequests are at a corner, the transfer scheme from the children to reduce family size increases parental welfare, and thus yields a Pareto improvement. Therefore n^* is inefficiently high. □

The proof of the result is intuitive. If children transfer income to parents this improves the welfare of parents if the gain in utility they get from the increased consumption more than compensates for the lower utility which results from having a smaller family. Since n is chosen optimally by parents the effect of a small reduction in n on parental utility is second-order, while the effect of the transfer is first-order. Other things equal the effect of the transfer is ambiguous since while it increases parental utility, it also decreases children's utility. However, the first effects dominates if parents do not equate their marginal utility of consumption to that of their children, which they do not unless they give positive bequests. Positive bequests only occur if altruism is sufficiently strong (or if δ is sufficiently large) or alternatively if the family is sufficiently rich (m is large).

What Proposition 2.2 shows is that, if children could commit themselves to a contract which would induce parents to reduce the family size then, if bequests were at a corner, this would implement a Pareto improvement. Could we expect the family to solve this potential source of inefficiency on its own? We now argue that it could not. This is because children do not have any resources from which they can compensate parents. They can only promise to do so when they are older and earning income. Moreover, this problem cannot be solved by capital markets. On the one hand, society does not legally enforce contracts signed by children and thus children cannot borrow to make the necessary transfers. On the other, parents would not borrow on behalf of children since the children cannot credibly promise to compensate them in the future.

To argue that we cannot expect intrafamily transfers, of the type designed above, to be made in equilibrium, we embed the above model of fertility choice and transfers into a two period game.[9] In the first period, parents choose fertility and bequests and children are born. In the second period, children get to earn income $f(n)$ as a function of their quality and parents are retired and can no longer have children. The key aspect of this structure is the realistic assumption that by the time children begin to earn a return on their quality, parents can no longer have children. The central question now is: can the system of transfers which were

[9] The analysis is so intuitive that we do not present a formal description of the extensive form of the game or the players' strategies.

constructed in the proof of Proposition 2.2 exist in a pure strategy subgame perfect equilibrium of the 'family game'?

Proposition 2.3. *The laissez faire level of fertility, n^*, is the unique pure strategy subgame perfect equilibrium level of fertility of the family game and, if the conditions of Proposition* 2.2 *hold, is Pareto inefficient.*

Proof. The proof of this result is an entirely straightforward backward induction argument. Start at the end of the game tree. In period 2, children have income $f(n)$ which they allocate to maximize utility. Since they care only about their own consumption they set $c_c = f(n)$ and $t = 0$. Thus they optimally make no transfers to their parents. In period 2 parents make no decisions, and in particular, it is too late to alter family size. Moving back into period 1, parents understand that children will behave optimally in period 2 and therefore choose n according to (3). The uniqueness of the equilibrium follows from the concavity of the parents optimization problem. □

There are two issues which arise in relation to Proposition 2.3. The first is that the problem that promises to make transfers are not credible could be resolved if children were assumed to be altruistic towards their parents (as in Kimball, 1987). This is possibly so, but is by no means necessarily true. We have already demonstrated that altruism is not sufficient to resolve the externality we have isolated. Moreover, even were this the case, it is not commonly understood that it is necessary to assume two-sided altruism to ensure efficiency of the rate of population growth.[10] Another possible resolution of this problem might be to consider repeated situations where overlapping generations of families play punishment strategies to make such contracts self-enforcing (as in the model of Ehrlich and Lieu, 1991). Clearly, ignoring issues of renegotiation, such mechanisms can potentially solve a commitment problem. If such mechanisms are considered significant then our contribution can be interpreted as pointing out that they may be necessary to ensure the efficiency of the population growth rate. A point not appreciated by the existing literature which often takes it as axiomatic that resource allocation within the family will be Pareto efficient.

3. Borrowing constraints and the quantity–quality trade-off

That bequests should be at a corner to generate the type of inefficiency we have identified above may appear very restrictive. In many instances, it is clear that

[10] In general, the existence of two-sided altruism will not be enough to ensure an efficient population size. What is needed is the existence of strictly positive transfers in equilibrium (see Baland and Robinson, 2000).

parents make positive gifts to their children, and should therefore be able to properly internalize the negative externality on their own children of their fertility decisions.[11] We now show that, even when bequest are positive, it is still possible that fertility is too high if parents face capital market imperfections.[12] To do this, we need to extend the basic model above to a two period model. To simplify the notation, we assume that there is no discounting. In period one, parents earn the exogenous income m, decide upon the number of children to have, n, and the amount they save for period 2, s. The budget constraint they face is thus: $c_p^1 = m - n\sigma - s$, where σ represents child rearing cost. Children have no utility in period 1.[13] In period 2, parents earn exogenous income m, and decide the amount to bequeath to their children, b. They consume the amount c_p^2, where $c_p^2 = m - nb + s$. Children's utility is defined as above and $c_c = f(n) + b$. We assume that parental utility, W, is separable, so that:

$$W \equiv U(c_p^1) + U(c_p^2) + n\delta V(c_c) \tag{6}$$

Parents choose n, b and s so as to maximize:

$$U(m - n\sigma - s) + U(m - nb + s) + n\delta V(f(n) + b) \tag{7}$$

As in Section 2, bequests are assumed to be non-negative, so that transfers, if any, are made from the parents to their children. Moreover, we assume that capital market are imperfect, in the sense that parents can save but cannot borrow. (We also consider in the next section a situation in which parents are not allowed to accumulate financial assets.) In other words, savings and bequests cannot be negative.

The three first-order conditions with respect to n, b and s are:

$$U'(c_p^1)\,\sigma + U'(c_p^2)\,b = \delta(V(c_c) + nV'(c_c)f'(n)) \tag{8}$$

$$U'(c_p^2) = \delta V'(c_c) \text{ and } b^* > 0 \text{ or } U'(c_p^2) > \delta V'(c_c) \text{ and } b^* = 0 \tag{9}$$

and

$$U'(c_p^1) = U'(c_p^2) \text{ and } s^* > 0 \text{ or } U'(c_p^1) > U'(c_p^2) \text{ and } s^* = 0 \tag{10}$$

Taking together these three conditions, one can see that, if b^* or s^* equal zero, the

[11] Note that our model requires that such inheritances or gifts are altruistically motivated. Laitner and Juster (1996) provide some evidence that, in most instances, inheritances received by children are accidental, unwanted transfers and not voluntary gifts by good willing parents (see also Mulligan, 1997b).

[12] A similar line of argumentation can be followed for the analysis of child labour (see Baland and Robinson, 2000).

[13] This is a simplifying assumption, and one can easily define children's utility for period 1. What really matters for the efficiency result is that the externality has effects in period 2, while fertility decisions are made in period 1. Savings decisions by the parents crucially link these two periods.

way parents evaluate the impact of the externality of an additional child on the welfare of the existing children, $V'(c_c)$, is always smaller than their marginal utility in period 1, $U'(c_p^1)$. They thus never take into account the full value of the effect of their decisions on their children. Hence, if the existing children could commit to transfer income to their parents in period 1, there is a possibility for mutually profitable intra-family trade, involving a lower number of children. Hence the following proposition,

Proposition 3.1. *If either bequests or savings are at a corner, then the laissez faire level of fertility,* n^*, *is Pareto inefficient. Moreover, it is inefficiently high.*

The proof of this result is omitted and closely follows the one used for Proposition 2.2. It must however be emphasized that, for the inefficiency result to hold, it is sufficient that either bequest or savings are at a corner. In other words, even if bequests are interior, fertility is too high if savings are at a corner.

4. The old-age security model

We now argue that the results which we have generated for the altruistic model extend naturally to other (non-altruistic) models of fertility. We do this in the context of a standard old-age security model (see Neher, 1971 and Nugent, 1985). Consider an old-age security model where parents live for two periods. Parents have separable utility defined over their consumption levels in these periods, but only have income in youth. To consume in old age they must have children. Assume children are born at the end of the first period and live only in the second. The utility function of parents is $U(c_p^1) + \beta U(c_p^2)$, where we assume that the function U is the same for consumption in both periods and is identical to the function U of the last section. Substituting the budget constraints:

$$U(m - (\sigma + h)\, n) + \beta U(nt(n)) \tag{11}$$

where $\beta \in (0,1)$ is a subjective discount factor. Here m is again income, σ child rearing cost and $nt(n)$ total transfers from children. Here we shall ignore bequests since, in a non-altruistic model where bequests do not enhance child quality and hence the amount of old age support they receive, parents always set $b^* = 0$.

We extend the model of quality creation of the last section to allow parents have another instrument, which we call 'human capital', to influence child quantity. One unit of income can create h units of human capital. We now assume that rather than just being a decreasing function of n, child quality is also an increasing function of the human capital investment by parents. This function is $f(n,h)$, where, $f:\Re^2_+ \to \Re_+$ is twice continuously differentiable, strictly decreasing in its first argument and strictly increasing in its second. We therefore have $f_n < 0, f_h > 0$ and

$f_{nn} > 0, f_{hh} < 0$. We also assume that $f(n,0) > 0$ and that $f_{hn} \leq 0$.[14] Children's utility is $V((1-\alpha)f(n,h))$ where the function V is identical to that of Section 2. For simplicity let, $t(n) = \alpha f(n,h)$ where $\alpha \in [0,1]$ is the sharing parameter which determines the proportion of children's income which they transfer to their parent.[15] Optimal fertility and human capital solve the first-order conditions:

$$U'(m-(\sigma+h)\,n)(\sigma+h) = \alpha\beta U'(n\alpha f(n,h))(f(n,h)+nf_n(n,h)) \tag{12}$$

$$U'(m-(\sigma+h)\,n) \geq \alpha\beta U'(n\alpha f(n,h))\; f_h(n,h) \tag{13}$$

When (13) is a strict inequality it implies that when f_h is sufficiently low, having a large low quality family, is the optimal way for parents to transfer resources into old age. One can easily use the arguments of Section 2 to show that in this case the n^* which solves (12) is inefficiently large. First note that by the envelope theorem the indirect utility of parents strictly increases when they accept a transfer for a reduction in n^*.[16] Now construct a contract so that children's utility is unchanged. With the transfer child utility is $V((1-\alpha)[f(n,h)-t])$, and the contract therefore satisfies, $f_n(n^*,0)\,dn = dt$. Such a contract then represents a Pareto improvement. We therefore have the following result.[17]

Proposition 4.1. *In the old-age security model when human capital investment is at a corner, then the laissez faire level of fertility, n^*, is Pareto inefficient. Moreover, it is inefficiently high.*

It is immediate from our previous arguments that such Pareto improving contracts will not be credible.

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[14]The sign on the cross-partial derivative is a sufficient (though not necessary) condition for f_h to decrease when both h and n both increase. A property we use in Proposition 4.2 below. It would be consistent with the natural assumption that $f(n,h)$ was homogeneous of degree zero, so that, by Euler's Theorem, $f_{hh}dh + f_{hn}dn = -f$.

[15]This specification of the security transfer is not important for the results. An alternative model might be that children get utility from giving gifts (as in Zhang and Nishimura, 1993), denoted g, to their parents so that their utility function would be, $V(f(n,h)-g)+W(g)$ where W is strictly increasing and concave. In this case parental utility would be, $U(m-(\sigma+h))+\beta U(ng(n,h))$, where the function $g(n,h)$ is implicitly defined by the first-order condition for the optimal choice of g by children. All the results of this section go through unchanged in this case.

[16]Note that in this non-altruistic model the bequest condition is irrelevant. The fact that this played a key role in the altruistic model was due to the fact that for the contract to be a Pareto improvement the rise in parental utility arising from increased consumption had to offset the fall in parental utility stemming from the effect of the transfer on child utility. Since parental utility is not directly a function of the utility of children in non-altruistic models this comparison is not relevant.

[17]A similar result can be obtained in the altruistic model if bequests are at a corner, when one generalizes the model developed in Section 2 to include human capital as a determinant of child quality.

When h is interior children contract for increased quality, and parents determine how this is produced. We now show that this too must involve parents lowering fertility. Intuitively, if parents must increase the value of f they can do this in several ways. While the case where they increase h and reduce n may seem the plausible one, in order to prove that fertility is too high relative to a more efficient allocation one must rule out the case where parents increase n but increase h sufficiently that the value of f increases. This case might seem somewhat pathological and indeed, as the argument below establishes, it is ruled out by the second-order condition. The other possible case is where both n and h fall, with n falling enough for f to rise (the case of n rising and h falling is of course inconsistent with an increase in f), this case is of course also consistent with fertility being too high in the laissez faire allocation.

In this section there is a conceptual issue which did not arise in the last section. Since parents anticipate that their children will offer them contracts when born, this will influence the ex ante incentives to have children.[18] We take this effect into account below in calculating the implications of intra-family contracting.

We now show that even when h is interior, fertility is inefficiently high. Intuitively, parents invest in human capital because they realize that it affects their old age income through the function f. However, since they are non-altruistic, they do not evaluate the effect of human capital investment at the socially efficient marginal rates. Children would therefore be willing to pay parents to invest more in human capital and this is what the proof of Proposition 4.2 establishes. For standard reasons, however, the offer of such payments (a contract) is not credible.

Proposition 4.2. *In the old-age security model even when parents have other instruments to influence child quality the laissez faire level of fertility*, n^*, *is inefficiently high.*

Proof. We construct the contract between children and parents in the same way as in the proof of Proposition 2.2. Such a contract is again designed to leave the utility of children unchanged and therefore satisfies:

$$(1-\alpha)\,V'((1-\alpha)[f(n^*,h^*)-t])(f_n dn + f_h dh - dt) = 0 \tag{14}$$

which implies that $f_n dn + f_h dh = dt$. Such a contract clearly exists. Now note that by the envelope theorem parental utility unambiguously rises. Thus such a contract is a Pareto improvement.

To see the effects of such a contract on fertility consider the first-order condition (13) and let c_p^{1*} denote the *laissez faire* level of first-period consumption for parents and $\hat{c}_p^1$ denote the post-contractual level. We focus on ruling out the case

[18]This issue did not arise in Section 2 because there the contracting was directly over family size.

where both h and n rise. We show that this is inconsistent with the second-order condition. In this case since f increases either h increases and n falls, or both fall, but in either case we will have established that fertility is inefficiently high. If both n and h increase then the contract implies that c_p^2 must rise, parental utility increases, and hence $U'(c_p^2)$ falls. Now consider the effects on $f_h(n,h)$. In the case where both h and n rise, the fact that $f_{hn} \leq 0$ implies that f_h falls, since, $d(f_h) = f_{hh}dh + f_{hn}dn < 0$. Hence the product $\alpha\beta U'(c_p^2)\, f_h$ falls. This implies that $U'(c_p^1)$ falls, or that, $U'(\hat{c}_p^1) < U'(c_p^{1}*)$, implying that $\hat{c}_p^1 > c_p^1*$, so $m - \hat{n}(\sigma + \hat{h}) > m - n*(\sigma + h*)$. This implies that $\hat{n}(\sigma + \hat{h}) < n*(\sigma + h*)$ which is clearly inconsistent with the hypothesis that $\hat{n} > n*$ and $\hat{h} > h*$. Thus we have a contradiction. Since the case where n goes up and h goes down cannot be feasible under the contract we must have $\hat{n} < n*$. Thus fertility is inefficiently high. $\square$

5. Conclusions and policy implications

In this paper we have developed a new argument about the 'population problem'. Thus far the literature has failed to converge either onto a convincing theoretical argument demonstrating inefficiency, or onto a consensus about the empirical importance of various types of externalities connected with population growth. Our contribution is to demonstrate that the inverse relationship between child quality and child quantity is a negative externality which may generate inefficiently high fertility. Somewhat surprisingly, this is unambiguously true even in the full altruism model when parents are sufficiently poor or insufficiently altruistic to leave positive bequests, or use other potentially offsetting instruments. Even when they do use such instruments we have demonstrated in Section 3 that the inability to borrow on the capital market provides another set of cases where fertility is inefficiently high. Possibly of more significance for economic development, we have shown that in the salient non-altruistic model of fertility choice, the old-age security model, fertility and thus the rate of population growth is unambiguously too high.[19] We believe that the generality of the results and their empirical content provide a significant new argument in the enduring debate about the population problem.

We have also argued that, under plausible assumptions about timing and capital markets, it is highly unlikely that families themselves will be able to solve the inefficiency isolated in this paper. This suggests that there may be a welfare enhancing role for government policy. Could this manifest itself as a population

[19] Though one must bear in mind that there are other assumptions embedded within the old-age security model, in particular incomplete financial markets, which cause deviations from the first-best allocation of resources. The significance of our result therefore also requires that these deviations are thought to describe important real world phenomena.

policy? While the model does generate a population problem, it is not clear that a population policy is appropriate. Note that in order to attain efficiency the government could subsidize human capital creation (which in essence it does through massive public support for education) or it could tax fertility (perhaps with a wage subsidy). Either policy would work and could be Pareto improving if paid for by a tax on children's earnings.[20]

However, it appears unlikely that a draconian limit of fertility would be Pareto improving. First note that it would never be Pareto improving unless the parents are compensated for having to have smaller families. Even if this were the case, one has to consider carefully the fact that we have developed the results of this paper by assuming that n is continuous. This is very convenient mathematically and can be thought of as an approximation to the case where n is integer. Nevertheless, in the integer case, the effect of higher fertility on quality has to be sufficiently severe for there to exist a transfer that leaves the children indifferent and strictly increases the utility of parents. If such a transfer does not exist then a population policy increases the welfare of children but reduces that of parents and the parents cannot be compensated.

One must also be cautious in suggesting that introducing a pay-as-you-go social security scheme would be welfare improving. While this precisely transfers money from children to parents it does not typically generate the correct marginal incentives for parents to alter the quantity–quality trade-off. Moreover, it may distort ex ante fertility decisions, an effect which works in the opposite direction.

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[20] It is easy to use the results of the paper to show that, for example, paying parents a wage subsidy funded by a tax on children can be Pareto improving.

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