SOCIAL SECURITY, DEMOGRAPHIC TRENDS, AND ECONOMIC GROWTH: THEORY AND EVIDENCE FROM THE INTERNATIONAL EXPERIENCE

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ABSTRACT

We study the impact of pay-as-you-go (PAYG) social security tax rates on demographic and economic trends through an endogenous-growth model where human capital is the engine of growth, family choices affect its formation in children, and family formation itself is a choice variable. We show that family formation and subsequent decisions by married and single households concerning children and savings are subject to adverse effects by the PAYG system. We model the underlying inter-temporal and intergenerational links using an OLG framework, but our basic results are shown to hold under a dynastic framework as well. We implement the model using simulation analysis, as well as panel data from 57 countries over 32 years (1960-1992). We find that PAYG tax measures account for a sizeable part of the downward trends in family formation and fertility worldwide and also lower private savings and the rate of economic growth, especially in OECD countries.

Introduction

Social security has become a subject of intense policy concern in recent years because of growing evidence of its financial vulnerability. In this paper, we focus on a related but no less important issue: the possible impact of social security on demographic trends and economic growth. Data from 57 countries used in our study show, for example, that the average annual marriage net of divorce rate per 1000 population age 15 and over fell from 9.72 in 1960 to 6.40 in 1990, and the average total fertility rate fell from 3.82 in 1965 to 2.07 in 1989. These dramatic changes reflect secular trends common to all countries. We present a theoretical model and empirical evidence indicating, however, that the defined-benefits, pay-as-you-go (PAYG), social security systems operating in most countries have independently contributed to these trends.

To start from the end: we examine a panel of 57 countries over the period 1960-1992. Controlling for the stage of economic development, survival probabilities of different age groups, government's share of the economy, and country-specific idiosyncratic factors, we find that the "pension" portion of social security benefits in GDP, which approximates the system's equilibrium tax rate (PEN), has adverse effects on: a. the rate of marriage net of divorce – decreasing marriage and increasing divorce; b. the total fertility rate; c. the private savings rate; and d. some schooling attainment measures and per-capita GDP growth. These effects are especially large for family formation and fertility, and in OECD countries; they are not duplicated when PEN is replaced by a benefits measure that includes other welfare programs; and they are generally not observed in countries where social security is a provident fund, rather than a defined-benefits system.

Is there a systematic way to rationalize all of these findings? The insights we offer, which also guide our empirical work, are based on a model of endogenous growth where human capital is the engine of growth, family choices affect its formation in children, and family formation itself is a choice variable. Theoretically, we focus on the way the scale of the PAYG system, as indicated by the level of tax rates and defined benefits, impacts all of these choices. In this context, our paper generalizes the analysis of social security's effects on fertility in Becker and Barro (1988), which does not allow for human capital formation and endogenous growth, and in Ehrlich and Lui [EL] (1998), which does not model family formation as a separate choice variable and uses a narrower concept of altruism. The emphasis on family formation enables us to derive new insights concerning trends in the average fertility rate across countries, which are a product of family formation and the desired fertility rate within families, and to explore the role of family formation in savings, human capital investment, and economic growth. Also, unlike Becker, Murphy and Tamura [BMT] (1990), and EL (1998), our formulation allows for interior solutions for all family choices (fertility, human capital investments, and savings) all along the development path, from stagnant equilibrium, through a takeoff period triggered by some parameter shocks, to self-sustaining growth equilibrium. We are thus able to investigate the role of social security tax rates in countries that are at different stages of development. While our model takes social security taxes and benefits to be exogenous policy variables, empirically we allow for their possible endogeneity as well.

Our main insight is that exogenous increases in the PAYG social security tax rate can adversely affect family formation and at least one of the family's subsequent choices: fertility, savings, and investment in human capital. We also derive conditions under which **all** may be adversely affected. Our basic results hold independently of the economy's stage of transition to a growth regime, which itself is endogenous to our model. They also hold regardless of the existence of private alternatives to old-age insurance, and regardless of whether we rely on overlapping-generations or dynastic formulations of our model.

The basic source of these effects is an externality inherent in the PAYG system. The old-age benefits are "defined": they are fixed at the individual level, largely independently of one's own contributions, and certainly independently of one's children's contributions, or whether one has any children. Therefore, individuals have little incentive to take such contributions into account in making fertility, investment, or savings decisions, and the incentive to form a family is affected by the implicit subsidy defined benefits provide to single (childless) households.

I. The Model

We assume a closed economy with competitive product and labor markets and workers of homogeneous capacity. Workers differ, however, in some idiosyncratic attributes that affect their matching prospects, which is why in equilibrium not all form families. We also limit search for a potential partner to a single period at the start of adulthood, by the end of which each person winds up either "married" or "single" (we do not model divorce separately). "Search", consisting of efforts to find and bond with a match, increases the **probability** of marriage, p, which we assume for analytical simplicity to be a **prerequisite** for having children. We assume that family formation decisions and all subsequent lifetime choices are based on rational expectations.

The engine of growth in this economy is human capital, and its accumulation is based on a production technology linking parents' human capital and investment in children's education with the human capital formed in the latter (as in BMT, 1990 and EL, 1991, 1998):

(1) $H_{t+1} = A(\overline{H} + H_t)h_t^{\mu}$

In equation (1), $\overline{H}$ denotes raw labor, h_t ($\in [0,1]$) is the fraction of the production capacity parents invest in the human capital of each child, H_{t+1}, and A captures technological or environmental factors influencing effective intergenerational transmission of knowledge, such as family stability. For computational convenience, but without loss of generality, we henceforth set $\mu = 1$.

In our benchmark model, we adopt an overlapping-generations (OLG) framework, since this facilitates the integration of the family formation decision into the decision framework. We recognize three overlapping generations: children, young parents, and old parents. Young children depend on their parents for nurture and investments in education. Parents are motivated by altruism toward their children, but are also partly dependent on them for old-age support, or informal care and companionship, which can be satisfied through self-insurance, or an informal "family security" setup, entailing optimal transfers from adult children.

We allow for this complementary motive for parental investments in children partly because available data show that old-age support for parents is alive not just in developing countries, but also in developed ones.[1] Furthermore, it guarantees the existence of **interior solutions** for all of the model's endogenous variables under both stagnant and growth equilibria, which is an attractive feature of the model since our empirical results are consistent with interior solutions for all family choices in developing as well as developed countries. Treating old-age support as an endogenous variable also enables us to determine the direction of change in its relative importance as the economy becomes more developed. To simplify the family's self-insurance system, we assume, first, that all siblings, whether single or married, form an extended-family insurance pool whereby all intergenerational transfers are actuarially fair and free of default risks.[2] This assumption is relaxed, however, in section I.4. We also consider a version of our basic framework under a dynastic family setting in section I.5, where family resources are pooled and the direction of intergenerational transfers can in principle be determined as an endogenous solution.

In our benchmark model, the relevant objective function for the representative young adult is given by the lifetime expected utility function:

(2) $W(t) = U(C_0(t)) + p_t V_m^*(t) + (1-p_t) V_s^*(t)$,

where p_t denotes the probability of a successful marriage, and $V_m^*(t)$ and $V_s^*(t)$ denote the maximized expected lifetime utilities if the person winds up married or single, respectively. The first term in equation (2) denotes the utility of consumption during the single search-for-a-mate period when the young adult is already in full possession of the earning capacity ($\overline{H}+H_t$) generated by the parents. Search concludes in that period. Hence

(3) $C_0(t) = (\overline{H}+H_t)(1-\lambda(p_t))$,

where $\lambda(p)$ is the fraction of production capacity spent on search. The probability of a successful marriage, $p = p(\lambda)$, is a continuously increasing and concave function of λ, with $p(1) \leq 1$. Its inverse function is thus $\lambda(p)$ with $\lambda'(p) > 0$, $\lambda''(p) > 0$, and $\lambda(0)=0$.[3] The utility operator in each period is $U(C) = [1/(1-\sigma)][C^{1-\sigma}-1]$, with $0<\sigma<1$.

1. Optimization analysis

Optimization involves a two-step procedure. In the first, one maximizes the expected lifetime utilities, $V_m^*(t)$ and $V_s^*(t)$, conditional on being either a successfully married parent, or single and childless. In the second, the marriage decision is resolved.

A. *If married*, the young adult thus maximizes the expected utility from marriage:

(4) $V_m^*(t) = \max\ [1/(1-\sigma)][C_{m1}(t)^{1-\sigma}-1]+\delta\pi_2[1/(1-\sigma)]\{[C_{m2}(t+1)^{1-\sigma}-1]+[C_{m3}(t+1)^{1-\sigma}-1]\}$, where

(5) $C_{m1}(t) = (\overline{H}+H_t)(1-vn_t-h_tn_t-s_{mt}-\theta)-\pi_2w_tH_t$,

(6) $C_{m2}(t+1) = \pi_1n_tw_{t+1}H_{t+1} + D(\overline{H}+H_t)^{1-\kappa}[(\overline{H}+H_t)s_{mt}]^{\kappa} + S_{t+1}$, and

(7) $C_{m3}(t+1)=B(\pi_1n_t)^{\beta}(\overline{H}+H_{t+1})^{\alpha}$, with $\beta > \alpha = 1$.

In equation (5), $C_{m1}(t)$ and n_t represent a young parent’s consumption and the number of children per parent (treated as a continuous variable), while v denotes the cost of raising a child, h_t the uniform educational investment in each, and s_{mt} the savings rate, all fractions of production capacity, ($\overline{H}+H_t$). The competitive wage per unit of ($\overline{H}+H_t$) is normalized as 1. The policy variable θ is the PAYG system's tax rate on earning capacity, and w_t is the rate at which each child transfers material benefits or services to the old parent per unit of the child's human capital the parent helped generate.[4] The variables π_1 and π_2 denote probabilities of survival from childhood to adulthood and from adulthood to old age, while δ is a discount factor. In this extended-family context (unlike that of section I.4 below), the expected number of surviving children, $\pi_1 n_t$, and transfer to a surviving parent, $\pi_2 w_t$, can be treated as certain magnitudes.

In equation (6), the consumption of a parent at old age, $C_{m2}(t+1)$, combines informal care or other transfers from surviving adult children, income from savings, and social security benefits, S_{t+1}, given in equation (11) below. Income from savings is derived via a home-production process, $F=D(\overline{H}+H_t)^{1-\kappa}[(\overline{H}+H_t)s_{mt}]^{\kappa}$, $0<\kappa<1$, in which surviving old persons convert accumulated assets that fully depreciate within one generation to old-age consumption. This simplifying assumption enables us to avoid modeling a distinct capital market, while capturing the idea that the equilibrium return from capital in a closed economy is subject to diminishing returns.

In equation (7), $C_{m3}(t+1)=B(\pi_1 n_t)^{\beta}(\overline{H}+H_{t+1})^{\alpha}$, with $\alpha = 1$, defines the "altruism function" in the context of our overlapping-generation framework, whereby parents derive utility vicariously from the number and potential income of surviving offspring. This specification is closely related to that of altruism in dynastic models, and, as we will see, the two specifications yield essentially the same results. To ensure interior solutions in both fertility and educational investment, it is necessary that **$\beta>\alpha=1$**, otherwise quality would dominate quantity of children in a growth-equilibrium steady state: quantity always has a higher marginal cost if investment in education is applied uniformly to all children. To ensure the concavity of equation (4), we must further restrict $\beta<[1/(1-\sigma)]$ and $\alpha\leq1$, as growth equilibrium is not sustainable if $\alpha > 1$.

B. *If single*, the young adult would maximize a "selfish" expected utility function:[5]

(8) $V_s^*(t) = \max\ [1/(1-\sigma)][C_{s1}(t)^{1-\sigma}-1] + \delta\pi_2[1/(1-\sigma)][C_{s2}(t+1)^{1-\sigma}-1-1]$, where

(9) $C_{s1}(t) = (\overline{H} + H_t)(1-s_{st} - \theta) - \pi_2 w_t H_t$, and

(10) $C_{s2}(t+1) = D(\overline{H} + H_t)^{1-\kappa}[(\overline{H} + H_t)s_{st}]^{\kappa} + S_{t+1.}$

The single person's old-age consumption thus depends strictly on income from savings and social security benefits. These benefits are determined by a balanced-budget constraint applying to the PAYG system. We assume that all adults, regardless of marital status, pay the same taxes and enjoy the same defined benefits. Since only children born to married agents contribute to social security, the balanced-budget defined-benefits per recipient are given by:

(11) $S_{t+1} = p_t(\pi_1/\pi_2)n_t\theta(\overline{H} + H_{t+1})$.

2. Family formation decision, subsequent choices, and equilibrium outcomes

Pursuant to the economic approach to marriage (see Becker 1993), being married "pays" relative to staying single, i.e., $V_m^*(t) > V_s^*(t)$, because of the emotional and material rewards from children – marriage's unique product. Given the solutions for $V_m^*(t)$ and $V_s^*(t)$, the optimal probability of marriage, p_t, is determined by maximizing equation (2) with respect to p_t:

(12) $\Delta(t) \equiv [V_m^*(t) - V_s^*(t)] - \phi(p_t)\ (\overline{H} + H_t)^{1-\sigma} = 0.$ [6]

The marginal benefit of p_t is the utility differential from being married rather than single, and $\phi(p_t) \equiv [1-\lambda(p_t)]^{-\sigma}\lambda'(p_t)$ is its marginal cost per unit of production capacity. Optimal p_t is positive and unique, as $\phi(0)=0$ and $\phi(p)$ is rising with p. Since the numerous young adults in the economy have identical search costs and matching odds, the marriage market clears probabilistically: the value of p, which equates equation (2) across all young adults ex-ante, is also equal to the ex-post equilibrium fraction of married adults. Optimal p also depends, however, on the equilibrium values of all subsequent choices by married and single households, as summarized below.

For married agents, the values of n_t, $h_{t,}$ and s_{mt} that maximize (4) are found from

$$(13)\quad [C_{m2}(t+1)/C_{m1}(t)]^{\sigma} \geq \delta A\pi_1\pi_2 w_{t+1}[1+\beta N_t^{*}(\overline{H}+H_{t+1})/H_{t+1}]/[1+(v/h_t)] \equiv \delta R_{mn},$$

$$(14)\quad [C_{m2}(t+1)/C_{m1}(t)]^{\sigma} \geq \delta A\pi_1\pi_2 w_{t+1}(1+\alpha N_t^{*}) \equiv \delta R_{mh},$$

$$(15)\quad [C_{m2}(t+1)/C_{m1}(t)]^{\sigma} \geq \delta\pi_2 D\kappa/s_{mt}^{1-\kappa} \equiv \delta R_{ms},$$

and the optimal value of the parental support rate, w_{t+1},is determined so as to satisfy

$$(16)\ dW(t+1)/dw_{t+1} = [\partial W(t+1)/\partial H_{t+1}]\,[\partial H_{t+1}/\partial w_{t+1}] + \partial W(t+1)/\partial w_{t+1} = 0.$$

In equations (13)-(15), the LHS terms denote the marginal rate of substitution in consumption between adulthood and old age, R_{mi}, i = n, h, s, denote the expected rates of return on investments in the quantity and quality of children and on savings, and $N_t^{*} \equiv C_{m2}^{\sigma}C_{m3}^{1-\sigma}/[\pi_1 w_{t+1} n_t(\overline{H}+H_{t+1})]$ is the ratio of psychic relative to material rewards. As is immediately seen, the rates of return to children's quantity (n) and quality (h) are comprised of two parts: an old-age insurance benefit, and a purely altruistic reward. Also, the combined rewards do not rule out savings as a source of future consumption, given that it is initially productive, i.e., that $R_{ms}(s_m=0) > R_{mn} = R_{mh}$. Moreover, equations (13)-(15) are consistent with the existence of interior solutions for n_t, h_t, and s_{mt} independently of the level of human capital formation, i.e., under both stagnant and growth equilibria. Equation (16), in turn, sets the optimal compensation rate for parents for their educational investments in children as one that maximizes equation (2) for each child. Since the full analysis underlying this choice is similar to that in EL (1998), we include an outline of it in Appendix A.1.

As a special case of our benchmark model, we also allow for the possibility that the family-based old-age insurance system becomes non-operational (w=0). In this "pure altruism" case, equation (15) remains intact while (13) and (14) become:

$$(13')\quad [C_{m2}/C_{m1}]^{\sigma} \geq \delta A\pi_2\pi_1^{\beta}B\beta[(\overline{H}+H_{t+1})^{\alpha}/H_{t+1})]/[1+(v/h_t)]\ n_t^{\beta-1}[C_{m2}/C_{m3}]^{\sigma} \equiv \delta R_{mn},$$

$$(14')\quad [C_{m2}/C_{m1}]^{\sigma} \geq \delta A\pi_2\pi_1^{\beta}B\alpha n_t^{\beta-1}[C_{m2}/C_{m3}]^{\sigma} \equiv \delta R_{mh}.$$

These conditions can be shown to imply, however, that while optimal fertility is positive in both steady states, in a stable stagnant equilibrium where $H_t=H_{t+1}$, investment in human capital is nil $h_t=h^*=0$ (a "Malthusian trap"), while in a stable, self-perpetuating growth equilibrium it becomes $h_t=h^*=\alpha\nu/(\beta-\alpha)$, with $\alpha=1$. These results are identical, except for notation, to the results obtained in BMT's (1990) dynastic model (see Appendix A.6). The comparison between these results and our benchmark case (equations 13-16, with w*>0) indicates that allowing for optimal intergenerational transfers within the family rules out a "Malthusian trap", as it tilts parental choices toward promoting children's quality, and away from specializing in quantity of children.

For single agents, the only choice variable is the optimal savings rate. From (8) we have:

(17) $[C_{s2}(t+1)/C_{s1}(t)]^{\sigma} \geq \delta\pi_2 D\kappa/s_{st}^{1-\kappa} \equiv \delta R_{ss}$.

To derive full equilibrium outcomes for all endogenous variables, we now incorporate the balanced budget constraint for social security benefits, S_{t+1}, of equation (11), into the first-order optimality conditions for the representative agent, as given in equations (12)-(17). These equations form a set of non-linear, second-order simultaneous difference equations. Since no closed-form solutions exist, the equilibrium values of p, n, s, h, and w must be derived through simulations, although some key comparative dynamic implications can also be derived analytically (see Appendix). In our benchmark model with an optimal positive parental reward rate determined endogenously, two stable steady states are shown to exist: Low enough values of A, (1/v), π_1, or $(1/\theta)$ below threshold levels could lead separately or jointly to a stagnant-equilibrium steady state whereby $H_{t+1} = H_t$. **Discrete** upward jumps in one or all of these parameters, in contrast, can cause a take-off from stagnant equilibrium into a regime of self-sustaining growth characterized by a period of **demographic transition** (see section I.3.E below) in which the steady-state values of both n and p ultimately fall as the economy moves from stagnant to growth equilibria. Notably, however, our simulations indicate that an upward jump in θ can lower the values of all of our endogenous variables, regardless of the dynamic regime – stagnant or growth equilibrium – or the stage of transition into the perpetual growth steady state.

In the pure altruism case (w=0), since optimal human capital investment, h*, is nil in a stagnant equilibrium, or equals $\alpha\nu/(\beta-\alpha)$ in any growth regime, h* would be independent of θ. Discreet jumps of sufficient magnitude in A, (1/v), π_1, and $(1/\theta)$ can still produce a takeoff to growth in this case, featuring a similar "demographic transition".

Tables I.A presents simulated solutions of the model's endogenous variables (p, n, h, s_m, s_s, and the optimal compensation rate w) in a steady state of persistent growth, in both our general benchmark case (a) and the special, "pure altruism" case (b), when the model's basic parameters support such equilibrium, along with corresponding comparative dynamic implications of discrete, once-and-for-all changes in the tax rate θ. Table **I.B** presents similar simulations when the model's parameters support a stagnant-equilibrium steady state.[7]

3. Comparative dynamic implications of the model

The following propositions, except when otherwise noted, apply under both stagnant and growth steady states. We are interested in the comparative dynamic implication of exogenous changes in θ under both stagnant and growth equilibrium steady states since the international panel data we study empirically include countries at different levels of development.

A. *The savings rates of married and single household*: In our general benchmark model (case a), the optimal rate of savings for old-age consumption is necessarily lower for young parents than for single adults, or $s_{st} > s_{mt}$. Proof: see Appendix A.2.

The rationale is simple. At zero human capital investment in children (h=0), and regardless of optimal n, the rate of return to parents from investment in h, R_{mh} in equation (14), which is invariable to h, must exceed the rate of return on savings they would obtain if they chose to save the same amount as singles, R_{ss} in equation (17), otherwise it would not pay to invest. Parents must thus have lower optimal savings and higher consumption at old age, relative to singles ($C_{m2}>C_{s2}$). While this proof does not apply in the pure altruism case (b) where parents do not obtain old-age material benefits, our simulations in Table I indicate that $s_{st} > s_{mt}$ in this case as well.[8]

B. *The impact of social security on family formation:* Our simulations in Table I indicate that a rise in the social security tax rate (θ) depresses the gains from family formation, (V_m-V_s), and thus its equilibrium level of (p). This holds as long as the consumption flows of married and single adults compare as follows: $C_{m1}<C_{s1}$ and $C_{m2} >C_{s2}$. Proof: See Appendix A.3.

Higher parenting costs typically imply that $C_{m1}<C_{s1}$. An increase in θ thus lowers the utility of young parents relative to single young adults. Given that the net effect of a higher θ is to raise the equilibrium social security benefits per recipient S_{t+1} (see equation 11), this benefits single old adults more than married ones since in our benchmark model, $C_{m2} > C_{s2}$ by proposition A. Indeed, the defined-benefits system generally provides a subsidy to single recipients because they share in the larger social security pie produced by offspring of married ones without having to bear the latter's parenting costs. Both effects lower the welfare gain from family formation.[9]

Note, however, that in PAYG systems, pension rights earned by a working spouse also benefit in various degrees spouses engaged in home production, which our homogeneous-worker model abstracts from. Thus, θ may also provide some subsidy to marriage. Its net impact on family formation therefore depends in practice on the relative strength of these opposing effects.

C. *The impact of social security on savings, fertility, and investment in education*: An increase in the value of the social security tax rate, θ, that raises the defined benefits per recipient in equilibrium, cannot increase **all** of the three family-choice variables, s_m, n, and h: **at least one** of these must decline, and possibly all three. In single households, this proposition implies that a higher θ **necessarily** lowers the savings rate, s_s. Proof: see Appendix A.4.

A rise in the tax rate, θ, lowers first-period consumption while raising the equilibrium defined benefits per recipient S_{t+1} if the elasticity of the marriage probability with respect to θ is less than 1. (This is a sufficient condition; the simulations in Table I invariably support this assumption.) The increased tax thus raises the marginal rate of substitution in consumption (MRS) relative to the rates of return from children's quantity and quality, and savings (equations 13-15). Consequently, at least one of these variables must be downsized in equilibrium, and this applies **unambiguously** to savings (the only choice variable) in the case of singles.[10]

What determines whether all family-choice variables adjust in the same, or varying, directions in equilibrium? While an increase in θ lowers the rate of return from investing in both children's quantity and quality, relative to the MRS for parents (a common "scale effect"), it also reduces the weight of emotional, relative to material benefits (N) in parents' total return from children, and this effect, by itself, lowers the rate of return of fertility relative to human capital investment, as $\beta > \alpha = 1$ in equation (7), which could raise optimal investment in children (a "substitution effect"). The net effect depends on whether the scale effect dominates the substitution effect. Only under a stagnant equilibrium, where $H_t=H_{t+1}$, our simulations indicate that a higher θ reduces n and raises h. Even in this case, however, the equilibrium level of H and corresponding income fall. In a growth equilibrium steady state, a higher θ is seen to reduce both n and h. Moreover, the decline in family formation p may have an independent adverse effect on investment in children: to the extent that p is also an index of family stability, this would affect the efficiency of investment in children's education if we assume that $A=A(p)$ in equation (1), with $A'(p)>0$ (see fn. 6).

By proposition C, a higher θ is expected to lower the savings rate of singles. But how is parental savings, s_{mt}, affected? By combining (14a) and (15a), the latter can be expressed as

$$s_{mt} = \left[\frac{Dk}{A\pi_1 w_{t+1}} \frac{(\beta-\alpha)A(\overline{H}+H_t)h_t + \beta\overline{H} - \alpha\nu A(\overline{H}+H_t)}{(\beta-\alpha)A(\overline{H}+H_t)h_t + \beta\overline{H}} \right]^{1/(1-k)},$$

which makes s_{mt} and h_t "complements", or $(ds_{mt}/dh_t)>0$, with respect to an exogenous shift in θ. For this reason, n, h, and s_m (and certainly s_s) may all fall, as is shown in Table I.

Proposition C applies in the "pure altruism" case (b) as well. As previously indicated, if altruism is the only motivating force for parents, investment in human capital reaches a corner solution, h=0, in a stagnant equilibrium, while in a growth-equilibrium steady state it becomes a constant, $h=\alpha\nu/(\beta-\alpha)$, which is unresponsive to θ (see appendix A.6). An increase in θ still raises the MRS in consumption relative to the emotional rates of return on n and s_m for parental units, however, so that at least one of these variables would be adversely affected, and possibly both, as shown for the benchmark case above. The constancy of h is a peculiar aspect of the certainty-equivalent specification of the altruism function (7). Indeed, it is modified in section I.4 below.

D. *The impact of changes in survival probabilities*. The analysis of sections B and C can be used to predict the role of other observable parameters, such as the survival probabilities from childhood to adulthood (π_1) and from adulthood to old age (π_2). An increase in either probability raises both the material and emotional benefits to parents from own and children's survival, and thus the equilibrium value of family formation, p. Because they increase the overall expected rewards to parents from children, the higher π_1 and π_2 also **lower** the optimal resource-transfer rate from children to parents, w. A higher π_1 raises also the rates of return on investments in children (both n and h) relative to the parents' MRS, but it lowers the rate of return on savings (s_m and s_s). While the ultimate adjustment in the equilibrium value of s_m is thus likely to be downward, the equilibrium values of n or h, or both, must increase. An exogenous increase in π_2, in contrast, increases the rate of return on savings, because of the higher likelihood of longevity. The equilibrium value of s_m is thus expected to increase, while those of n, or h, or both must increase as well. Our extensive simulations bear out all of these expectations.

E. *Comparative dynamics over the demographic transition*: A one-time upward shock in the technology of producing human capital, A, a decreases in the cost of raising a child, v, or an increase in the child's survival probability, π_1 can produce a takeoff from a stagnant to a growth equilibrium and a "demographic transition" phase linking the two, over which family formation (p) and fertility (n), and thus, more dramatically, the product of the two, **pn** – an index of the "total fertility rate" – trend downward, and the marginal growth in human capital (Ah) trends upward following the initial takeoff stage, in which both p_t and n_t temporarily rise, essentially because of a pure "wealth effect". This is seen in simulations charting the transition path of these variables (which we skip to save space), and from comparisons of steady-state values of these variables in Table I. The sharp decline in total fertility rates in many developed countries is thus explained as an outcome of the declines in both family formation and the average fertility per parent. It is also noteworthy that the optimal material transfers from children to old parents as a fraction of the adult child's return from human capital, w*, is substantially higher in the stagnant equilibrium, relative to the growth equilibrium, steady state essentially because of persistent growth in human capital in a growth equilibrium – thus in developed, relative to developing countries. Also, in all our simulations of the benchmark model (case a), a higher tax rate, θ, consistently exerts adverse effects on all of the model's endogenous variables at all stages of economic development, but especially at the growth equilibrium steady stage, where the absolute elasticities of our endogenous variables with respect to θ consistently exceed those in the stagnant equilibrium.

4. Generalizing the benchmark model to account for an uncertain survival of children

So far we assumed that expected old-age support and companionship were certain in an extended family context. In a "core-family", both are subject to risks of children's non-survival, or related exogenous defaults. In part A of Table II, we simulate a simple extension in which the benefits to parents are subject to two 'states of the world': either no children survive, or at least one survives and assumes the obligations of all siblings towards their parents (see Appendix A.5). For simplicity, w is treated as a constant. Here an increase in π_1 always **lowers** optimal fertility, n, essentially because it reduces the uncertainty of children's survival, and thus the need to bear more children to insure that some survive. Also, investment in human capital is no longer independent of θ even in the pure altruism case (b). Indeed, a higher θ is now seen to lower the growth- equilibrium values of n, h, s, and p in both cases. Proposition C thus applies even when there is uncertainty regarding private provision of old-age support (cf. Imrohoroglu et al. 2003), essentially because it arises from the incentive effects on family choices generated by the defined-benefits, PAYG system.

5. The Model in a Dynastic setting

Do the basic propositions derived through our OLG framework hold also under a dynastic framework? Existing formulations recognize only a single period of life for each generation. To allow for the intergenerational transfers mandated by a PAYG system, we need to recognize two relevant periods in the life cycle of each generation. We also abstract from the family formation choice (assuming p=1), since it cannot be naturally integrated in a dynastic setting, and focus on the growth-equilibrium steady state. The value function can then be stated in its usual recursive form:

(4a) $V_t(H_t) = \max\, [1/(1-\sigma)][C_1(t)^{1-\sigma}-1] + \delta\pi_2[1/(1-\sigma)][C_2(t+1)^{1-\sigma}-1] + \delta\pi_2(\pi_1 n_t)^{\beta(1-\sigma)}Vt_{+1}(H_{t+1})$,

where $C_1(t) = (1-vn_t - h_t n_t - s_t - \theta - \pi_2 w)H_t$, $C_2(t+1) = \pi_1 n_t w H_{t+1} + DH_t^{1-\kappa}(H_t s_t)^{\kappa} + S_{t+1,}$

$H_{t+1} = AH_t h_t$, and $S_{t+1} = (\pi_1/\pi_2)n_t\theta H_{t+1}$.

The main difference between the specification of the value function (4a) and the objective function in our benchmark model (4) is that altruism is here defined to incorporate the offspring's utility, rather than full income, into the dynasty head's utility, and thus the utilities of all future generations as well. In a growth steady state, the value function associated with each generation, $V_t(H_t)$, depends on the single state variable, H_t, since the "raw" human capital endowment $\overline{H}$ vanishes in importance relative to H_t as the latter grows without bound. We also take the compensation rate w to be exogenously given, although we can also allow for an extension that makes w endogenous within this dynastic setting. Formally, a key difference between equation (4a) and our benchmark model is that B in equations (4) and (7) is not a constant parameter, but a function of all the basic parameters of the benchmark model.

The optimality conditions for interior values of the control variables s_t, n_t, and h_t are now:

$0 = -C_1(t)^{-\sigma}H_t + \delta\pi_2 DH_t\kappa s_t^{\kappa-1}\ C_2(t+1)^{-\sigma}$,

$0 = -C_1(t)^{-\sigma}(v+h_t)H_t + \delta\pi_1\pi_2 wH_{t+1}C_2(t+1)^{-\sigma} + \delta\pi_2(\pi_1 n_t)^{\beta(1-\sigma)}\beta(1-\sigma)V_{t+1}(H_{t+1})/n_t$,

$0 = -C_1(t)^{-\sigma}(n_t/A) + \delta\pi_1\pi_2\, n_t wC_2(t+1)^{-\sigma} + \delta\pi_2(\pi_1 n_t)^{\beta(1-\sigma)}V_{t+1}'(H_{t+1})$,

where, by the envelope theorem, the derivative of V_{t+1} with respect to the state variable H_{t+1} is:

$V_{t+1}'(H_{t+1}) = C_1(t+1)^{-\sigma}\,(1-vn_{t+1}-s_{t+1}-\theta-\pi_2 w)+\delta\pi_2\, Ds_{t+1}^{\kappa}\, C_2(t+2)^{-\sigma}$,

and from the functional form of equation (4a) we know that that $V_{t+1}'(H_{t+1})=(1-\sigma)V_{t+1}/H_{t+1}$.

It is easy to show that the optimal steady state values of h and s have an explicit relation: $h = [v/(\beta-1)][D\kappa s^{\kappa-1}/(D\kappa s^{\kappa-1} - \pi_1 wA)]$, which implies that they move in the same direction as a result of a shock in θ, as is the case in our benchmark model. Also, a rise in the steady-state social security tax rate, θ, has **adverse effects** on all family-based choices, as indicated by the simulations of part B of Table II, essentially because the individual dynasty head takes defined social security benefits to be unaffected by family choices.

Moreover, these effects hold if we assume that the dynasty head also controls the pooled incomes of the overlapping generations of earners within the family. In this case, where the dynasty head determines the optimal values of s_t, n_t, and h_t along with the consumption allocation decisions across the co-existing generations, the direction and magnitude of optimal intergenerational transfers are implicitly determined endogenously (see Appendix A.7). This underscores the fact that the impact of θ cannot be neutralized by "Ricardian Equivalence" adjustments, even in the presence of bequest. Note also that in this dynastic framework, a rise in θ unambiguously lowers the dynasty head's **welfare,** $V_t(H_t)$.[11]

II. Empirical Implementation

We test these propositions against international panel data by estimating a **reduced-form** specification of our model: The dependent variables measure the model's endogenous variables, and the regressors measure the model's basic parameters, including the social security tax rate, θ. Although we emphasize a reduced form directly related to the model's basic parameters, we also include additional regressors accounting for some conventional determinants of family formation, fertility, or saving, which we do not model explicitly, in order to test the robustness of our results. Also, although θ is an exogenous variable in our model, we allow for its possible endogeneity in our regressions analysis. For variable construction, sources, and sample data, see Appendix A.8.[12]

1. The Sample and Variable Construction

Our social security data are taken from *The Cost of Social Security*, published by the International Labour Office (ILO). The data are available in 57 countries over 33 years, 1960-1992, but in some countries not for all years. We measure our theoretical social security tax rate, θ, by the "pension" portion of social security benefits relative to GDP (PEN). Under a balanced budget, expected benefits per recipient equal $\pi_2 S_{t+1} = p_t \pi_1 n_t \theta_{t+1}(\overline{H} + H_{t+1})$ (see equation 11), and expected earnings per worker equals $Q_{t+1} = p_t\pi_1 n_t(\overline{H}+H_{t+1})$. It follows that $\pi_2 S_{t+1}/Q_{t+1}=PEN=\theta_{t+1}$. In a stable PAYG setup, PEN is thus a consistent measure of the concurrent θ. In short-run situations, it is possible that PEN will be subject to dynamic adjustments towards its balanced-budget value. In section IV.4 we allow such possibility as a sensitivity test of our findings.

We use the population's annual marriage net of divorce rate (NETMARRY) as a proxy for our family formation variable (p),[13] and the population's total fertility rate (TFR) as a proxy for our fertility variable. The World Bank's reported national savings rate (NSAV), and Summers and Heston's (1992) investment rate (I) are used to impute alternative private savings rate measures, using national income account identities. These are explained in section III.3.

To approximate our theoretical steady state level of per-capita investment in human capital, **h**, or, equivalently, the rate of human capital formation and productivity growth **Ah** (see equation 1) we use as a measure the long-term per-capita GDP growth rate, since by our model per-capita income growth converges on (1+g)=Ah in a steady state. To corroborate our results, we also attempt to construct a direct measure of per-capita investment in human capital based on three variants of schooling data: the average schooling years in the population (SCHYR), the average enrollment rate in secondary schools (SEC), and a quality measure of human capital: students' performance scores in international knowledge tests (SCORE) (see section IV).

Our basic explanatory variables include PEN, measures of the survival probabilities to adulthood and old age (Pi1 and Pi2), per capita GDP, and the GDP share of government spending (G). We also include additional regressors recognized as relevant in previous studies based on panel data. For example, we include several variables concerning the economic status of women because our model does not distinguish between males and females, but mothers' employment opportunities may have special relevance for family decisions. The data sources we use for all our variables are presented in Appendix A.8.

We control for the economy's development stage partly by including initial income levels in our key regressions and we also test the sensitivity of our results to separation of our full sample to OECD and Non-OECD countries, as well as to Provident-funds and Non-provident-funds countries.

2. Model Specification

Our basic regression specification is a linear model with country-specific fixed-effects:

(18) $L\,\bar{y}_{t,t+4} = \alpha_0 + \alpha_1 LPEN_t + \alpha_2 LPi1_t + \alpha_3 LPi2_t + \alpha_4 LG_t + u_t,$

where $\bar{y}_{t,t+4}$ measures the average value of each of our four endogenous variables, including per-capita income growth ($GDPN_{t+4}/GDPN_t$), over a 5-year lead period, from t to t+4; L denotes natural logs; and α_0 is a vector of country-specific dummy variables. The remaining regressors (X) are measures of the model's basic parameters in period t.

The basic idea is to treat the mean realized values of the model's endogenous variables over a 5-year-lead period as samples of their equilibrium values along the long-term development path, and to test the effects of initial changes in our measure of θ, PEN, on these 5-year-lead values (see Barro and Lee, 2003). Although in this specification, PEN_t is technically a predetermined variable, we also present regressions treating it as an endogenous variable, using a 2SLS procedure described later in this section. We rely on two sample specifications to estimate equation (18): In variant (18.a) the sample we use includes "rolling" 5-year periods, where $\bar{y}_{t,t+4}$ and the X_t are computed over overlapping beginning periods (t, t+1, etc). In variant (18.b) $\bar{y}_{t,t+4}$ and X_t are computed for non-overlapping 5-year periods. Clearly, the sample size associated with (18.b) becomes much smaller. Although a 5- year lead period is common in the literature, we also examined 3 and 7 lead-year specifications. The regression results were qualitatively similar to those reported in tables 1-4.

In all regressions based on equation (18), we add as regressors the share of government spending in GDP, G_t, to isolate and differentiate the effect of PEN from that of general government spending and taxes. In the regressions for p, n, and s, we also introduce per capita GDP, $GDPN_t$, treated as an endogenous variable in (18), to account for the economy's stage of transition to a steady state of growth.[14] The family-formation regressions include also the deviation of the female population share from 50 percent in absolute value (DSEX). Other variables added as regressors in variants of equation (18) are female labor force participation rate (FLFP) and the ratio of female relative to male schooling (FSCH). In the savings regression we also introduce money supply (M2) and inflation rate (INFLA) as possibly relevant regressors (see section II.3). The country-dummies in equation (18) control for missing country-specific **institutional** factors, including inter-country differences in variable measurement,[15] or the initial values of physical capital. This fixed-effects specification captures **within-country** variations in our regressors, X, but we also try specifications captures **between-country**, or both **within- and between- country,** variations in X.

In addition to (18), we employ an alternative specification below to compute the **long-term** growth of per-capita income or schooling attainments, (1+g) = Ah, which we use as proxies for our theoretical long-term growth of human capital formation and per-capita income. In a steady state:

(19) $GDPN_t = (GDPN_0) \exp[g(X_t)t] \exp(u_t)$, and by the logic of equation (18)

(20) $g(X_t) = \beta_1 + \beta_2 LPEN_t + \beta_3 LPi1_t + \beta_4 LPi2_t + \beta_5 LG_t$.

Taking the log of (19), the growth rate equation (20) can then be estimated from:

(21) $LGDPN_t = \beta_0 + \beta_1 t + \beta_2 t \cdot LPEN_t + \beta_3 t \cdot LPi1_t + \beta_4 t \cdot LPi2_t + \beta_5 t \cdot LG_t + u_t$,

where β_0 is a vector of country-specific dummy variables. The growth rate g over the entire sample period is thus estimated by the sum of the coefficients the time-trend variable (t) and the interaction terms associated with it. The **interaction terms** (tX), in turn, capture both between- and within-country variations in the explanatory variables (X), and may thus improve our ability to estimate the long-term effects of these variables, including PEN, on the growth rate. In another version of equation (21) - (21a) - we add the interaction terms of t and our country dummies ($t\beta_0$) to allow for heterogeneous growth rates across countries, making (21a) analogous to (18).

To account for the possible endogeneity of PEN, we employ a 2SLS estimation procedure. Huasman's tests reject the exogeneity of PEN_t in regressions explaining marriage, net marriage, and fertility, marginally so in the case of income growth. Indeed, in countries with exceptionally high values of these variables, the PAYG system can more easily **sustain high** "defined benefits" that are set by politicians. Also, equilibrium $GDPN_t$ is obviously an endogenous variable in our system, and we treat it as such. Instrumental variables used consistently in our first-stage regressions to derive predicted values of PEN and GDPN (in addition to the exogenous variables included in (18)) are: the number of years elapsing since the social security programs have been legislated (MATURE), its squared value (MATURESQ), the population share of age groups 0-14 (AGE) and 65 and over (POP65), the population share of females (SEX), the economy's inflation rate (INFLA) as well as one-period lagged PEN and GDPN. These instruments are intended to account for the impact of qualifying elderly workers (see Boadway and Wildasin, 1989, and Mulligan and Sala-i-Martin's 1999 political-economy models of "demand" for PAYG social security) and past or prospective build-ups of surpluses in social security budgets, captured partly by the system's maturity or the share of school-age children and retirees, on the political willingness to raise social security taxes and benefits. Basmann's test indicates that these variables can indeed serve as instrumental variables in the first-stage regressions, and they are also found to have inconsistent and insignificant effects if added as regressors in the structural model. INFLA is used as an added instrument for GDPN to capture the long-term impact of monetary policy on the macro economy.

As part of our sensitivity analysis, we introduce PEN in both linear and logarithmic forms. A Box-Cox analysis of optimal transformation generally favors using a linear transformation of PEN in equation (18), but a logarithmic one in both equations (18) and (21) in the case of the growth regressions. It also favors a log transformation for all other variables in both equations (18) and (21). Although we report only the results from the selected transformations, those based on the alternative transformations of PEN yield similar elasticity estimates.

III. Empirical Findings

1. Family Formation Regressions

In **Table 1**, the dependent variables are the annual rates of marriage, divorce, and net marriage in the population age 15 and over, averaged over a 5-year lead period. The basic regression specification is (18) and all variables are entered in logs except PEN. Models (columns) 1 and 2 present OLS estimates of (18.a), augmented by DSEX, with and without country dummies ("fixed effects"). In model 3 the specification includes female labor force participation rate (FLFP) and female-male ratio of schooling years (FSCH). In models 4 and 5, we estimate models 1 and 3 via 2SLS, treating PEN and LGDPN as endogenous (the instrumental variables are listed in the legend). In models 6 and 7, we re-estimate models 1 and 3, based on non-overlapping periods.

A complete analysis of the determinants of PEN is beyond the scope of this paper, but our **first-stage** regressions indicate that political support for a PAYG social security system is greater in countries with aging populations, more qualifying male workers, and more mature systems. That our OLS estimates of the PEN effects are lower than the 2SLS estimates in all of the regressions, except those concerning divorce and NSAV, is also consistent with the endogeneity argument since these are likely to be subject to reverse causality. In countries with exceptionally high rates of marriage, fertility, and productivity growth (but not divorce or savings), social security contributions would be higher, encouraging legislators to raise defined benefits for retirees. The first-stage LGDPN regression shows that higher inflation rates affect LGDPN adversely.

Table 1 indicates that the effects of PEN are statistically significant and consistent with our predictions: while a higher PEN **reduces** marriage, it **raises** significantly divorce. (This is despite the fact that in some countries a non-working spouse has an incentive to stay married over a minimal period of years to be entitled to collect pension benefits vested with the working spouse – see section I.3b.) Despite its limitations as a measure of family formation (see footnote 13), PEN has a statistically significant effect in **all** NETMARRY regressions, and distinct from the generally negative impacts of the government's tax or spending rate, G, or the average income level, GDPN.

Proposition D and our simulations also indicate that an increase in π_1 or π_2 will increase optimal family formation, as it would raise the marginal benefits from marriage. Both effects are confirmed in Table 1, albeit at a marginally significant level in the 2SLS regressions.[16] Table 1 shows that the more imbalanced is the female-male ratio in the population, the lower is the marriage rate. Consistent with Becker's theory of marriage, lower female labor force participation and higher (thus more similar) female, relative to male, schooling are also found to raise net family formation.

2. Fertility Regressions

In **Table 2**, the dependent variable, TFR, stands for the average number of children born to all females aged 15-49, averaged over a 5-year lead period. Theoretically, TFR represents, therefore, the product of the fertility rate per parent, n, and the share of parental households in the population, p. Since the latter is approximated by NETMARRY, however, TFR can be expected to be a monotonically increasing, but not necessarily proportional, function of n and NETMARRY.[17]

Models 1-7 are analogous to those of NETMARRY with the exception that in models 3, 5, and 7 we add LNETMARRY as a regressor (treated as endogenous in model 5), along with

LFLFGP and LFSCH, and model 1A shows the effect of including NETMARRY in model 1. The first-stage regressions include the instrumental variables used in our family formation regressions (the variable SEX also serves as an instrument in this and subsequent structural regression).

In all of Table 2's models, PEN has a negative and significant effect on TFR. By including the net marriage rate as an additional regressor in models 1A, 3, 5 and 7, we attempt to isolate the **partial** effect of PEN on fertility within families (n) conditional on our proxy for p, which is what we analyzed theoretically. In model 1A the partial effect of PEN on TFR in elasticity terms is -.051, while that of NETMARRY is .2314. The unconditional elasticity of TFR with respect to PEN in model 1A can thus be imputed as -0.051+ 0.2314*(-0.379) = -0.138, where -0.379 is the estimated elasticity of NETMARRY with respect to PEN in Table 1. This estimate is very close to the estimated elasticity in model 1, -0.113. A very similar finding applies to our corresponding 2SLS estimates. Tables 1 and 2 are thus seen to exhibit remarkably consistent results.

Consistent with our analysis in section I.4, Pi1 significantly lowers fertility, while Pi2 generally raises it. Although current GDPN has a negative and statistically significant effect on fertility, reflecting our predicted general time pattern of TFR over the demographic transition, the estimated effects of PEN on fertility remain statistically significant and distinct from the effect of G as well. The negative coefficient associated with female labor force participation accounts for the impact of higher labor market opportunities on the shadow price of the quantity of children, given their relative educational attainments, but it is interesting to note that, controlling for FLFP, higher relative educational attainments of females increase desired fertility, even when NETMARRY is accounted for. Conceivably, the more similar are the educational attainments of married couples, the greater is their demand for public goods within marriage, including children.

3. Savings Regressions

Our theoretical savings variable is the individual savings rate, s. As empirical counterparts we use two alternative measures. The first is the fraction of national savings in GDP (NSAV) reported by the World Bank. The national-income-accounts identity links this measure with the private savings rate (a proxy for s) as follows: PSAV = NSAV+DEFICIT, where DEFICIT is the fraction of the government deficit in GDP. We utilize this identity to run the "savings" regression in an unrestricted form by entering DEFICIT as an additional regressor. Alternatively we use the share of investment in GDP (I), as a savings measure, based on another national-income-accounts identity, S = I + DEFICIT + NX. In this regression set, we thus include both DEFICIT and the fraction of net exports in GDP (NX) as additional regressors.

Models 1-7 and 1A in Table 3 are analogous to those in Table 2, except that the additional regressors in models 3 and 7 include, apart from FLFP and FSCH, money supply (M2) and the inflation rate (INFLA), since these variables may exert independent effects on the yields in capital markets, from which our model abstracts for simplicity.

Note that PSAV is imputed as the proportion of savings to aggregate income. It thus approximates the **weighted average** of the savings rates by married and single adults, or [ps_m + $(1-p)s_s$] where s_m and s_s are the savings rates for married and single agents respectively, weighted by their respective population shares. Theoretically, the effect of PEN on PSAV therefore incorporates both compositional and behavioral effects. An increase in PEN may reduce both s_m and s_s by proposition C of section I.3. It also reduces the marriage probability, however, which is expected to raise the average savings rate by proposition A. The effect of PEN on PSAV may thus be ambiguous if it also reflects the reduction in the net marriage rate, p. To account for this ambiguity, we present the regressions for NSAV with and without NETMARRY as a regressor.

The results of Table 3 show that PEN exerts an adverse effect on the private savings rate, consistent with our simulations in Table I. The magnitudes of the PEN effects vary somewhat across the NSAV, or I regression sets, but all fall within overlapping ranges. Although based on different regression specifications, these findings are also consistent with Feldstein (1997), using US time series data, and Samwick (2000) using cross-section data from 94 countries averaged over 1991-94.

Inconsistent with proposition A, however, the effect of NETMARRY on the average savings rate is positive in all regressions. A basic reason may be that actual savings include not just savings for own old-age needs, which is the only objective of savings we model theoretically, but also a component designed to finance children's higher educational costs, which would therefore rise with NETMARRY.

The same argument may also explain why the effect of young-age survival probability, Pi1, is not generally consistent with our theoretical prediction that a higher Pi1 should decrease the savings rate in married households (but have no effect on singles). Since married families save partly to finance children's education, a higher Pi1 would increase this tendency. A higher Pi2, in contrast, is shown in Table 3 to increase the savings rate, which is what our model predicts. None of the added variables entering model 3 of the alternative savings regressions is found to have a consistent and significant effect, or to alter the estimated effects of PEN. We report these results essentially as sensitivity tests.

4. Per Capita GDP Growth Regressions

In **Table 4** we report our "growth" regression results. In part A, we implement equation (18), where the dependent variable in log terms is the per-capita GDP growth rate over a 5-year lead period. In part B, we implement equation (21), where the dependent variable is LGDPN, the long-term growth rate is estimated as the coefficient of the time trend, T, and the impact of our regressors is estimated via interaction terms of the time trend with the regressors. This specification enables us to study the impact of our basic model parameters on productivity growth directly, rather than through their impact on human capital formation.[18]

The regression models in part A are analogous to those in the earlier tables (with model 5 omitted to save space). The regressions in part B feature similar iterations of equation (21). Note that in model 1 of both parts A and B, the interaction terms of the time trend and the country dummies allow for just within-country variability in all regressors and, thus for **heterogeneous** growth rates. In the other regression in part B, the interaction terms capture both within- and between- country variations. Models 4 and 5 produce 2SLS estimates, and since we find LGDPN to be serially correlated, we use the Greene (2000) method to account for both the endogeneity of LPEN and LNETMARRY and the serially correlated errors. In model 8, we also include lagged LGDPN as a regressor, to account for a potential unit-root problem associated with LGDPN, although our tests did not produce conclusive evidence of such a problem.

The introduction of LNETMARRY as an added regressor in models 3 and 4 of both parts A and B has a special significance. Although our theoretical analysis abstracted from ascribing to family formation any direct effect on human capital formation, such an effect can be established through a straightforward extension of our model, since our theoretical "probability of marriage" is also a proxy for the average duration of **stable** marriages; the latter enhances the opportunity of married households to invest in children. In Model 4, we estimate the importance of family formation (p) by introducing NETMARRY as an additional endogenous regressor.

Consistent with our main prediction, LPEN exhibits a significant **adverse** effect on the long-term income growth rate in all regressions. The results of models 3 and 4 also suggest that the total effect of PEN on the growth rate can indeed be divided into the net direct effect of PEN on investment in human capital by families, as well as its indirect effect on family formation. We estimate that the direct effect of PEN on the rate of economic growth constitutes roughly 80 % of its total effect, and the remainder 20% is attributed to its impact on family formation.[19]

The survival probability Pi2 generally exhibits a positive effect on the GDPN growth rate when these effects are also statistically significant, while Pi1 has a generally negative coefficient. The reason may partly be that Pi1, computed as the survival probability from age 0 to age 24, does not account effectively for the age at which young adults enter the labor force and contribute to production. In contrast, in constructing Pi2, we were able to correct for the age at which old-age "dependency" begins according to the social security law (see Table A.8 in our appendix).

Government spending as a share of GDP, G, generally shows an adverse effect on growth, consistent with the findings in Ehrlich and Lui (1999). The estimated effect of PEN cannot be ascribed, therefore, to higher government spending or a higher general tax rate. In Table 4, female labor force participation is generally found to enhance the growth rate, while female relative schooling is found to have the opposite effect, although these effects are not consistent.

IV. Corroborations and Additional Sensitivity Tests

1. Human Capital Regressions. In section III, we used measures of long-term per-capita income growth to test our model's implication about the steady-state human capital and productivity growth rate, Ah. In part (1) of Table A, we attempt to construct more direct measures of the human capital formation based on schooling attainments proxies, using the basic regression specifications of Table 4. In Table A, we report only the estimated regression coefficients for our focus variable, PEN.

In the first three columns implementing equation (18.a), the dependent variables are the growth rates over a 5-year lead period of three schooling measures: average schooling years in the population (SCHYR), secondary school enrollment rates (SEC), and our international test scores measure (SCORE). The first two are essentially quantity rather than quality measures of schooling, and they do not fully reflect parental inputs into children's education. The serious limitations of "schooling" measures as proxies for human capital formation notwithstanding, these measures appear to better approximate the **stock** of human capital per worker, rather than investment flows, even in the case of SEC, which may indeed be partly a stock measure because it is the average enrollment rates of 6 cohorts. In the following three columns implementing equation (21), the effect of PEN on the long-term growth rate is estimated via the interaction term T*LPEN, as in Table 4.[20]

Consistent with our main prediction, LPEN or T*LPEN exhibit a pronounced and significant **adverse** effect on the long-term growth rates of our human capital proxies. Taken together with the results of Table 4, the "human capital formation" regressions of Table A lend support not just to our results concerning the adverse "growth effects" of social security taxes, but also to our underlying theoretical analysis, whereby human capital serves as the engine of growth.

2. PAYG v. Provident-Fund Systems. An important corroborative test of our model is the comparative effect of PEN in countries where social security operates as **defined-contributions "provident fund"**, rather than a PAYG, defined-benefits system. In provident fund countries, PEN represents essentially a compulsory retirement-savings rate rather than a tax. It may alter voluntary private savings only to the extent that the former exceeds the latter. But even in this case, there will be little change in private savings if individuals can borrow against their provident-fund savings. Some provident funds even permit using individual balances to finance health, education, and housing needs, which allows the rate of savings to adjust to its privately desired level. We thus expect PEN to exert little impact on family choices in provident-fund, relative to PAYG, countries.

Our sample includes just three countries where social security operates as a government-managed provident fund (Fiji, Malaysia and Singapore). Applying the "Chow test" to test the equality of the regression coefficients in this subset relative to our non-provident-fund subset in all regressions we reject the hypothesis of equal PEN coefficients.[21] Moreover, PEN is found to have statistically **insignificant** effects on all our endogenous variables when we run separate regressions for the provident-funds countries. And when these countries are excluded from the total sample, PEN's impact becomes slightly larger than in tables 1-4. In contrast, we find virtually no changes in the estimated regression coefficients when we exclude from the total sample countries that had 0 PEN (i.e., no social security systems) over our sample period (Hong Kong, Korea, and Venezuela).

3. OECD v. Non-OECD Countries. Our theoretical model anticipates similar qualitative effects for the social security tax rate θ and other basic parameters at all phases of economic development, but not necessarily the same quantitative effects. Indeed, our theoretical simulations in Table I indicate that the estimated elasticities of p, n, and s with respect to θ are higher in the growth-equilibrium steady state relative to the stagnant equilibrium. To control for large gaps in the level of development, we have separated our sample to OECD and non-OECD countries. Consistent with our simulations, the elasticities of each of the endogenous variables with respect to PEN are found to be significantly higher in the OECD, relative to the non-OECD sets. This can also be the outcome of poorer data in the non-OECD subset, and its smaller sample size (about 30% of that of the full set in the various regressions). Note that for countries at an initial transition to a growth regime, the growth of per-capita GDP, (1+g), is not an efficient measure of the growth-equilibrium value of Ah. This may explain why the PEN effect on growth less pronounced in the non-OECD set.

4. Other Sensitivity Tests. Our social security tax measure, PEN, was constructed as the ratio of "pension" benefits to GDP. **Total** benefits, as reported by the ILO, also include typically welfare payments for unemployed, employment injury payments, and maternity benefits, which are **not** expected to exert the same negative intergenerational externality we predict for the theoretical

PAYG tax rate, θ (see fn. 10). Maternity benefits may actually increase the incentive to bear children. To test this implication, we have replaced PEN by NETBEN, defined as the ratio to GDP of total social security benefits minus pension benefits. The estimated effects of NETBEN are found to be weaker and less pronounced than those in tables 1-4 in general (not reported to save space).

Tables 1-4 regressions are based on within-country variations in all variables over time either exclusively (as in the fixed-effects regressions) or jointly with cross-country variations. We have also run regressions based exclusively on cross-country variations, which eliminate any influence of common time trends. Our basic results remain robust (see Table A). We have also calculated the Huber/White robust estimates of the regression coefficients' standard errors in Tables 1-4, on the assumption that the error terms are heteroscedastic across countries. The robust estimates are shown to be very similar to the non-robust estimates.

In Tables 1-4 we have treated PEN_t (or $LPEN_t$) as a "balanced-budget" measure of our theoretical tax variable, θ_t. To test the sensitivity of our results to possible deviations of the observed PEN_t (in linear or log form) from its balanced-budget value, we have re-estimated model 1's version of equation (18) in each table by inserting both PEN_t and PEN_{t-1} as regressors. This specification (equation 18.1a) is interpretable as representing a dynamic partial adjustment process whereby the change in PEN between any two consecutive periods adjusts to the gap between the equilibrium value of PEN, $PEN^{*}= \theta_t$, and the one-period lagged value of PEN as follows:

(22) $PEN_t - PEN_{t-1} = \varpi(\theta_t - PEN_{t-1})$, which implies that $\theta_t = PEN^{*} = \eta PEN_t + (1-\eta) PEN_{t-1}$, with $\eta=(1/\varpi)>0$. The estimated coefficients of PEN_t and PEN_{t-1} in this specification would then reflect the products of the adjustment coefficient η or $(1-\eta)$ and the behavioral effect of θ_t, α_1. Note that under a consistent form of PEN (linear or log) in equations (18.1a) and (22), the coefficients η and α_1 cannot be identified separately if we use either a linear OLS, or a non-linear maximum

likelihood, estimation method. However, the regression coefficients of PEN_t and PEN_{t-1} add up by equation (22) to the behavioral effect of θ_t we seek to estimate (α_1). In all cases, their estimated **sum** in equation (18.1a) is found to be negative and significant statistically. Moreover, its magnitude is very close to, and indistinguishable statistically from, the estimated effect of PEN in tables 1-4. These results indicate the robustness of our estimated PEN effects in tables 1-4.[22]

V. Projections and Policy Implications

The estimated coefficients of PEN in Tables 1-4 are not just significant statistically, but quantitatively as well. **Table B** illustrates their projected impact in all countries with PAYG, defined-benefits systems, using two scenarios: a. a reduction in the mean level of PEN over 1960-1991 to its level in 1960; and b. a 25% reduction in PEN. The projections are illustrated for the "world" set, based on the non-provident-fund sample regressions, and for the U.S., based on our OECD-set regressions in table A, using the conservative OLS regression results of model 1.

For the U.S., for example, we project that had the average PEN remained constant at its 1960 level of .0459, instead of the average level of .0666 over the sample period, the rate of marriage net of divorce would have increased by 12.6%, and the total fertility rate would have increased by 6.5% over the sample period.[23] Also, the average savings rate would have risen by 2.7%, and the mean annual growth rate of per-capita GDP would have increased from 1.86% to 2.23%, implying that its 1991 would have been higher by 11.8 percent. Comparable projections apply to the "world" set if its average PEN remained at its 1960 level of .0322 instead of .056 over the sample period.

Our projections support Feldstein's estimate that social security depresses private savings. Using U.S. data, Feldstein (1997) concluded that elimination of social security taxes in the U.S. would raise the private savings level by 60%. Based on the regression models for savings and income-growth using the OECD data in Table A (but with PEN entered as a linear regressor in both models) we project that if PEN were reduced to 0 from its mean level of 0.0666 over 1960-1991, the private U.S. savings level would have risen by 45.7% in 1991.

The projections in Table B also indicate the potential impact of a partial shift from the current PAYG system to personal retirement accounts (PRA), based on defined contributions. Our projected effects of a 25 percent tax reduction, for example, may apply to such a shift, assuming that the mandated savings rate would not exceed the optimal savings rate desired by individuals, or that individuals could efficiently borrow against their PRA balances.

Despite the limitations of our data, taken together our empirical results are highly consistent with detailed propositions of our theoretical analysis and the theoretical simulations of section I, derived under both the OLG and dynastic versions of our model. The empirical results are also remarkably consistent across the regressions of tables 1-4. They suggest that the adverse effects of the PAYG system especially on family formation and fertility, but on economic growth as well, have also augmented the system's financial vulnerability. Although our theoretical analysis in this paper focuses on the complex incentive effects generated by the PAYG system, leaving aside the question why such system has been adopted in the first place, our model and econometric investigation suggest that reforming social security in the direction of a defined-contributions system may generate a boost not just for families and the economy, but for social security itself.

Quite apart from these policy implications, our study indicates the importance of the family for economic growth, which is the underlying theme of this work. Needless to say, our work is not exhaustive. For example, we have not fleshed out the implications of our analytical framework on trends in labor force participation and life expectancy, or on generational welfare gains and losses from the PAYG system. We leave the study of these issues for future work.

Appendix

A.1 Optimal investments in children and savings in equations (13)-(15) are conditional on the compensation parents expect to receive for their educational investments in each child, w_{t+1}, assuming that the implicit family contracts are fully honored (see fns. 1 and 2). We follow the approach in EL (1991) in analyzing the choice of w_{t+1} as a principal-agent problem, given that parents and (unborn) children cannot negotiate a Pareto optimal bargaining solution for n and h. Accordingly, parents (acting as agents) select values of w_{t+1} that maximize equation (2) for children. The resulting Stackelberg-equilibrium solution is inferred from:

(16) $dW(t+1)/dw_{t+1} = [\partial W(t+1)/\partial H_{t+1}]\,[\partial H_{t+1}/\partial w_{t+1}] + \partial W(t+1)/\partial w_{t+1} = 0$

$= \{[1-\lambda(p_{t+1})]^{1-\sigma} + p_{t+1}d_{m1}(t+1)^{-\sigma}c_{m1}(t+1) + (1-p_{t+1})d_{s1}(t+1)^{-\sigma}c_{s1}(t+1)\}A(\partial h_t/\partial w_{t+1})$

$\quad - \pi_2[p_{t+1}d_{m1}(t+1)^{-\sigma} + (1-p_{t+1})d_{s1}(t+1)^{-\sigma}]Ah_t,$

where $d_{m1}(t+1)\equiv(1-vn_{t+1}-h_{t+1}n_{t+1}-s_{m(t+1)}-\theta-\pi_2w_{t+1}\tau_{t+1})$, $\tau_{t+1}\equiv[H_{t+1}/(\overline{H}+H_{t+1})]$, $c_{m1}(t+1)\equiv(1-vn_{t+1}-h_{t+1}n_{t+1}-s_{m(t+1)}-\theta-\pi_2w_{t+1})$, $d_{s1}(t+1)\equiv(1-s_{s(t+1)}-\theta-\pi_2w_{t+1}\tau_{t+1})$, and $c_{m1}(t+1)\equiv(1-s_{s(t+1)}-\theta-\pi_2w_{t+1})$. In a growth equilibrium steady state, $d_{m1}(t+1) = c_{m1}(t+1)$, and $d_{s1}(t+1) = c_{s1}(t+1)$. The optimal compensation rate, w^*, equates the marginal cost and benefit to grown-up children from rewarding their parents for the earning capacity they helped create, subject to the "reaction function" {h, w} governing the parents' investment decision ($\partial h_t/\partial w_{t+1}$).

A.2 Suppose $s_{mt} \geq s_{st}$. Then $C_{m1} < C_{s1}$ if parents also invest in children. From (15) and (17) we know that $R_{ss} \geq R_{ms}$ in this case, and thus $(C_{s2}/C_{s1}) \geq (C_{m2}/C_{m1})$ as well, which also implies that $C_{m2} \leq C_{s2}$. But if parents save more than single adults, they also benefit directly from children at old age, and thus $C_{m2} > C_{s2}$, which is a contradiction.

A.3 To facilitate an analytical proof we take the compensation rate w to be a given constant. Totally differentiating $\Delta(t)$ in equation (12) with respect to θ and dividing it by $(\overline{H}+H_t)^{1-\sigma}$, we obtain the following growth-equilibrium steady state:

$\Delta_\theta \equiv \Delta_\theta(t)/(\overline{H}+H_t)^{1-\sigma} = -(c_{m1}^{-\sigma} - c_{s1}^{-\sigma}) + p\delta\pi_1 n(c_{m2}^{-\sigma} - c_{s2}^{-\sigma})\,Ah\,[1 - E_{n\theta} - E_{h\theta}]$,

where $c_{m1} = 1- vn- hn- s_m- \pi_2w- \theta$, $c_{m2} = [\pi_1nw+ p(\pi_1/\pi_2)]Ah + Ds_m^{\kappa}$, $c_{s1} = 1- s_s- \pi_2w- \theta$, $c_{s2} = p(\pi_1/\pi_2)n\theta Ah + Ds_s^{\kappa}$, $E_{n\theta} = -d\ln(n)/d\ln(\theta)$, and $E_{h\theta} = -d\ln(h)/d\ln(\theta)$. Since $c_{m2} > c_{s2}$ by the logic of proposition A and $\Delta_p \equiv \Delta_p(t)/(\overline{H}+H_t)^{1-\sigma}$ is negative by the second order optimality condition, $dp/d\theta = -\Delta_\theta/\Delta_p < 0$ provided that $c_{s1} \geq c_{m1}$ (which is always the case if spending on raising children is sufficiently large) and the sum of the elasticities of h and of n with respect to θ is less than one. Our simulation analysis indicates that the sum of these elasticities is indeed less than unity for a wide range of variations in the model's underlying parameters.

A.4 If the absolute elasticity of family formation with respect to the social security tax rate is lower than one, the increase in the tax rate will raise the social security benefits per adult, and hence the consumption ratio, (C_2/C_1), for both a married adult and a single adult. EL (1998) proves that this increase in the consumption ratio lowers at least one of the three choice variables determined by equations (13)-(15) for a married young parent. For a single adult, the increase in the consumption ratio will lower the saving rate according to equation (17).

A.5 The specification of this case follows EL (1998). For married agent, the prospect of old-age consumption is $\{D(\overline{H}+H_t)^{1-\kappa}[(\overline{H}+H_t)s_{mt}]^{\kappa} + S_{t+1}\}$ with probability $(1-\pi_1)^n$, and $\{[\pi_1 n_t w_{t+1} H_{t+1}]/[1-(1-\pi_1)^n] + D(\overline{H}+H_t)^{1-\kappa}[(\overline{H}+H_t)s_{mt}]^{\kappa} + S_{t+1}\}$ with probability $1-(1-\pi_1)^n$, respectively. The altruism function when at least one child survives is $B\{(\pi_1 n_t)/[1-(1-\pi_1)^n]\}^{\beta} H_{t+1}^{\alpha}\}$. Part B of Table II illustrates the comparative dynamics results associated with a change in θ.

A.6 We can prove that a stable stagnant steady state with all interior solutions for endogenous variables doesn't exist when w=0. From the condition $R_{mn}=R_{mh}$, we have

(A.6.1) $h_t = \{\alpha v - \beta\overline{H}/[A(\overline{H}+H_t)]\}/(\beta-\alpha)$.

Suppose that we have constant h* and n* in the stagnant steady state so that $H_t = H^*$ and $h^* = \{\alpha v - \beta\overline{H}/[A(\overline{H}+H^*)]\}/(\beta-\alpha)$. Suppose now $H_t < H^*$. In this case equation (A.6.1) implies that h_t will be smaller than h*. From our FOC's, $R_{mn}/R_{mh} = [\beta/(v+h_t)] \div [\alpha A(\overline{H}+H_t)/(\overline{H}+H_{t+1})]$. When h_t gets smaller than h*, the numerator $[\beta/(v+h_t)]$ gets bigger and therefore the denominator should become bigger, too. That is, $(\overline{H}+H_t)/(\overline{H}+H_{t+1}) > (\overline{H}+H^*)/(\overline{H}+H^*)=1$ and therefore $H_t > H_{t+1}$. This indicates that H_t falls away from H*. The stagnant steady state solution is thus not stable - the only stable stagnant steady state is a "Malthusian trap" where h=0. In this Malthusian steady state, n>0, and the parameter restriction $\beta > \alpha v A$ should hold to have $R_{mn} > R_{mh}$ at h=0.

A.7 If the dynasty head in period t also controls the pooled incomes of the overlapping generations of earners in period t+1, the consumption allocation decisions are first determined to maximize the corresponding joint utilities as seen by the dynasty head:

$[1/(1-\sigma)][C_2(t+1)^{1-\sigma}-1] + (\pi_1 n_t)^{\beta(1-\sigma)} [1/(1-\sigma)][C_1(t+1)^{1-\sigma}-1]$, subject to the budget constraint:

$\pi_2 C_2(t+1) + \pi_1 n_t C_1(t+1) = \pi_2 S_{t+1} + \pi_2 D H_t s_t^{\kappa} + \pi_1 n_t(1-vn_{t+1}-h_{t+1}n_{t+1}-s_{t+1}-\theta)H_{t+1}$. The first-order optimality conditions provide the optimal consumption allocation rule as follows:

$[C_1(t+1)/C_2(t+1)]^{\sigma} = (\pi_1 n_t)^{\beta(1-\sigma)-1}\, \pi_2$.

Plugging this optimal solution for each period beyond period t into the expected utility of the dynasty head in period t, the relevant value function in period t becomes:

$$V_t(H_t) = \max\, [1/(1-\sigma)][C_1(t)^{1-\sigma}-1]$$

$$+\, \delta\pi_2\{[1/(1-\sigma)][C_2(t+1)^{1-\sigma}-1] + (\pi_1 n_t)^{\beta(1-\sigma)} [1/(1-\sigma)][C_1(t+1)^{1-\sigma}-1]\} + ...,$$

$$= \max\, [1/(1-\sigma)][C_1(t)^{1-\sigma}-1] + \delta\pi_2\, \Omega_a(n_t)V_{t+1}(H_{t+1}),$$

where $\Omega(n_t) \equiv [(\pi_1 n_t)^{[1-\beta(1-\sigma)](1-\sigma)/\sigma}\ \pi_2^{(\sigma-1)/\sigma} + (\pi_1 n_t)^{\beta(1-\sigma)}]$. The optimality conditions for interior values of the control variables s_t, n_t, and h_t, used in our simulations in part B of Table II are:

$$0 = -C_1(t)^{-\sigma}\, \pi_1 n_{t-1}\, H_t/\Phi(n_{t-1}) + \delta\pi_2^{2}\, \Omega(n_t)\, C_1(t+1)^{-\sigma}\, DH_t\kappa s_t^{\kappa-1}/\Phi(n_t),$$

$$0 = -C_1(t)^{-\sigma}\, \pi_1 n_{t-1}(v+h_t)H_t/\Phi(n_{t-1}) + \delta\pi_2[\partial\Omega(n_t)/\partial n_t]V_{t+1}(H_{t+1}),$$

$$0 = -C_1(t)^{-\sigma}\, \pi_1 n_{t-1}\, n_t/[A\, \Phi(n_{t-1})] + \delta\pi_2\, \Omega(n_t)\, V_{t+1}'(H_{t+1}),$$

where, by the envelope theorem, $V_{t+1}'(H_{t+1}) = C_1(t+1)^{-\sigma}\pi_1 n_t(1-vn_{t+1}-s_{t+1}-\theta)/\Phi(n_t)$,

$\Phi(n_t) \equiv [(\pi_1 n_t)^{[1-\beta(1-\sigma)]/\sigma}\ \pi_2^{(\sigma-1)/\sigma} + (\pi_1 n_t)]$, and $V_{t+1}'(H_{t+1})=(1-\sigma)V_{t+1}/H_{t+1}$,. The direction of intergenerational transfers can be determined, in principle, by comparing the consumption flows for each of the overlapping generations relative to their assigned share of the family income.

A.8 Variables used, sources, and mean values over the sample period 1960-1992.

Variable	Description	Mean [Std. Dev.]
PEN ("Pension")	Old-age, survivor, and disability-insurance portion of social security benefits as a share of GDP (ILO)	0.056 [.040]
NETMARRY	Current marriage net of divorce rate (UN)	8.35 [2.82]
MARRY	Marriage rate: the annual number of marriages per 1000 population age 15 and over (UN)	10.06 [2.53]
DIVORCE	Divorce rate: the annual number of divorces per 1000 population age 15 and over (UN)	1.69 [1.19]
TFR	Total fertility rate: number of children born to an average woman over her reproductive years (UN)	2.81 [1.28]
NSAV	National saving rate as share of GDP (WB)	23.15 [7.81]
I	GDP shares of capital investment (Summers-Heston)	23.71 [7.47]
DEFICIT	Share of the government deficit in GDP (IMF)	2.94 [4.25]
NX	current account surplus (IMF)	-5.54 [117.0]
SCHYR	Average schooling years in the population 25 years and over (Barro-Lee)	6.22 [2.46]
SEC	Students enrolled in secondary schools as a share of official secondary school-age children (UNESCO)	0.60 [0.23]
SCORE	Students' performance scores in international knowledge tests[1] (ETS)	268.5 [51.6]
GDPN	Real per-capita income (Summers-Heston)	6753 [3911]
G	GDP shares of government spending (Summers-Heston)	14.69 [5.98]
Pi1	Survival probability of the population from ages zero to twenty four (UN)	0.95 [0.04]
Pi2	Survival probability from the official qualifying age for pension benefits through the following fifteen years[2] (UN)	0.64 [0.12]
DSEX	Deviation of females' population share from 50 percent in absolute value (WB)	0.93 [1.50]
FLFP	Female labor force participation rate (WB)	38.34 [12.9]
FSCH	Ratio of average schooling years for females to that for males (Barro-Lee)	0.85 [0.16]
M2	Aggregate money supply (WB)	0.69 [11.71]
MATURE	Number of years elapsing from the year when the pension benefits program started (SSA)	39.34 [24.1]
POP65	Population share of the age group 65 and up (UN)	0.09 [3.97]
AGE	Population share of the age group 0-14 (UN)	0.29 [0.09]
SEX	Population share of the female (UN)	0.51 [0.02]
INFLA	Annual inflation rate (Summers-Heston)	5.03 [3.01]
PUBED	Share of public education expenditures in GDP (UNESCO)	4.60 [1.57]

1. The Educational Testing Service (ETS) of the International Association for the Evaluation of Educational Achievement (IEA) has conducted cross-country evaluations of educational achievement in science over the past four decades. These tests reveal the **relative** achievements of students in different countries in a given year, but they are not comparable over time, since they are not adjusted for changes in the tests' degree of difficulty. To make such adjustments, we calibrate the international test scores using data about the achievements of US students in standardized science tests from 1970 on, as reported by the National Assessment of Educational Progress (NAEP) of the U.S. Department of Education. Specifically, the ETS scores in a given year are multiplied by the ratio of the U.S. NAEP score to the U.S. **relative** international test score in the same year, to account for a common cohort effect in all countries. The U.S. can serve as an anchor because it has participated in all the international tests.

2. Typically, the official qualifying age for pension benefits is 55 or 60 in developing countries, and 60 or 65 in developed countries.

3. Data sources:

(ILO) International Labor Office, *The Cost of Social Security*, and *Year Book of Labour Statistics*, Geneva, various issues.

(UN) United Nations, *Demographic Yearbook*, various issues.

(WB) World Bank, *World Development Indicators*, 1998.

(IMF) International Monetary Fund, *International Financial Statistics*, various issues

(UNESCO) United Nations Educational, Scientific and Cultural Organization, *Statistical Yearbook*, various issues.

(ETS) Educational Testing Service, *A World of Differences*, 1989.

(SSA) Social Security Administration, *Social Security Programs Throughout the World*, 1995, 97, 99.

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ENDNOTES

[1] Recently, the 1999 "MetLife Juggling Act Study", conducted by the National Center for Women and Aging at Brandeis University, shows that 25 percent of all U.S. households provide care for an elderly person and that care-giving costs individuals upwards of $659,000 over their lifetimes in lost wages, social security benefits, and pension contributions.

[2] EL (1998) states sufficient conditions for young adults to comply with any implicit intergenerational contracts they have with their old parents. A key one is that they can expect their own children to treat them the same way they treat their old parents. Compliance with implicit contracts may also hold for childless single adults with no children because of parental mentoring or siblings' sanctions. Furthermore, since in this benchmark formulation all siblings are members of the extended family's insurance pool, the compliance conditions spelled out in EL (1991) would apply to single adults as well if they are at least minor partners in the investment decisions reached within the families of their married siblings.

[3] Institutional, legal, and religious constraints also determine the cost of "search" for a durable marriage. Empirically, we account for these via fixed- (or random-) effects regression models.

[4] The efficient compensation rate w is specified as a fraction of the offspring's return on human capital, rather than earnings, since this way both children and parents always share the costs and benefits of human capital investment. Making w a fraction of earning capacity would deny net benefits to children if H_{t+1} were low. While for simplicity we here take all intergenerational transfers to be monetary costs and ignore leisure, our basic propositions would not be affected if all transfers involved time costs (see EL 1998 appendix C).

[5] Note that since $C_{S3}(t+1)$ is zero for singles, the utility from it becomes $-[1/(1-\sigma)]$.

[6] The equilibrium value of p is also an index of family stability, and as such it may serve as an efficiency parameter affecting the transmission of knowledge from parents to kids, or $A= A(p)$ with $A'(p)>0$ in equation (1). Since our basic results hold independently of this effect, we eschew a formal specification of A(p) in (12).

[7] Interior equilibrium solutions in our benchmark case (a) are ensured by the parameter set: $B>0$, $1=\alpha<\beta<[1/(1-\sigma)]$, and $w>0$. Under the pure altruism case (b), β needs to be further restricted: In a growth equilibrium, where $Ah>1$, $\beta<\alpha+\alpha vA$, whereas under the stagnant equilibrium, $\beta>\alpha vA$.

[8] In the pure altruism case (b), if $s_{mt}<s_{st}$, in which case $R_{ms} \geq R_{ss}$ and $(C_{m2}/C_{m1}) \geq (C_{s2}/C_{s1})$, it is still possible that both $C_{1m} < C_{1s}$ and $C_{m2} < C_{s2}$, since old parents do not derive any material benefits from children. Note that our formulation treats savings strictly as a means of financing old-age consumption. It thus ignores savings aimed at financing children's higher education, which our model recognizes as part of the cost of educating children.

[9] In the pure altruism case, however, it is theoretically possible that a higher θ will raise p if altruistic parents' old-age consumption were lower than that of singles' ($C_{2m}<C_{2s}$). Our simulations in Table I indicate, however, that a higher θ lowers p in both cases (a) and (b).

[10] This "intergenerational tax effect" does not extend necessarily to payroll taxes that are temporal transfer payments: these do not necessarily alter the inter-temporal rate of substitution in consumption relative to the rates of return from children or savings. Note also that the survival probabilities π_1 and π_2 are assumed to be exogenous. If life expectancy were to increase as a result of a higher θ, this could work to partially raise the incentive to save.

[11] Social security unambiguously lowers the dynasty-head's utility in this case, since it cannot improve on the optimal intergenerational transfers as determined within the extended family. In the OLG model (with or without old age insurance), in contrast, social security can, in principle, increase the **parent's** utility, V_m*, unless parents and children are able to take full advantage of the full mutual benefits from parental investments in children's education through a Pareto optimal bargaining solution (see Appendix A.1).

[12] Ehrlich and Zhong (1998) report a preliminary empirical analysis of some of the issues examined in this section using similar data. Although the results are generally consistent, we differ in the econometric specification we use to implement our theoretical model, the time period we cover, and the extensive corroborating evidence we develop.

[13] The theoretically relevant measure of p is the share of parental households among all households, for which no accurate data exist. A proxy for it would be the share of legally married households in the population. However, this variable, if available, is typically reported in population censuses conducted every 5 or 10 years. Changes in the "flow" variable, NETMARRY, can still capture the change in the "stock" variable, p_t in a steady state, albeit imperfectly, because marriage and divorce occur at different points over the life-cycle.

[14] Current GDPN includes both transitory and cyclical deviations from its equilibrium value along the dynamic growth path. If deviations of the dependent variables from their equilibrium values were a function of current GDPN, this would also justify its inclusion as an additional regressor. We have also experimented with regression methods controlling for cyclical changes in GDPN over the sample periods, but these did not affect our results.

[15] For example, the marriage or divorce rate statistics depend on the way cohabitation is counted.

[16] It is arguable that population longevity is also an endogenous variable affecting, as well as being affected by, PEN. However, Hausman's tests reject the endogeneity of Pi1 and Pi2 in all the regressions reported in Tables 1-4. We therefore treat Pi1 and Pi2 consistently as exogenous regressors.

[17] NETMARRY is not necessarily proportional to p (see footnotes 13 and 15). Since households with children include single parents, NETMARRY may be an even noisier proxy of p.

[18] While in this set of regressions, Box-Cox tests imply that LPEN, thus T*LPEN should be entered in logarithmic, rather than natural terms, a linear transformation of PEN yielded similar results. In some countries, the reported "pension" benefits are zero over the entire sample period or over some parts of it (Columbia, El Salvador, Guatemala, Hong Kong, Honduras, Jordan, Korea, Thailand, Tunisia, Venezuela). In the log transformations of PEN here and in Table A, we replace 0 by 0.00001, a value substantially below the smallest value of PEN in our full sample.

[19] The total elasticity of GROWTH with respect to PEN in model 3 is -0.0035+ 0.026*(-0.379) = -0.0045, where -0.379 is the elasticity of NETMARRY with respect to PEN as estimated in Table 1. The direct effect of PEN (-0.0035) is about 80 percent of the total effect (-0.0045).

[20] It is interesting to note that when we treat our human capital measures as flow (h), rather than stock (H) variables, the effect of PEN on our education measures becomes positive and significant, contrary to the results of Table A.

[21] For our four endogenous variables, we used our original set of regressors plus their interaction terms with a dummy variable distinguishing the provident-fund countries. F-tests were performed on the OLS regression results.

[22] We have also tried an alternative specification of the adjustment process whereby $\theta_t = \eta_1 PEN_t + \eta_2 PEN_{t-1} + (1-\eta_1-\eta_2)PEN_{t-2}$, which again produced similar estimates of the effect of PEN* relative to the estimated effects of PEN in tables 1-4. Running this specification or equation (18.1a) via 2SLS resulted in the same inferences.

[23] The projected change in LnTFR in the US is computed as –2.9549*(0.0459-0.0666) = .0493, where –2.9549 is the PEN coefficient in model 1 of Table A for the OECD set. We calculate the projected level of TFR as 2.17*exp(.0493) = 2.31, where 2.17 is the sample mean of TFR in the U.S. The projections for all other variables are similarly calculated. These projections are higher if we rely on the 2SLS estimates in Table A, especially for TFR. The projections are also higher for the OECD countries: Using the regression results of model 1 in Table A for the OECD sample, we project that if average PEN remained at its 1960 level of .044 instead of .076 over the sample period, the rates of marriage net of divorce, TFR, and average savings would have increased by 20.3%, 9.9%, and 4.1% from their mean levels over the sample period (1.00, 2.80, 23.35), respectively. We similarly project that the per capita GDP level in 1991 would have been 11.8 percent higher than its actual mean level of 6067.5.

Table I. Comparative Dynamics in the Benchmark OLG Model: Impact of the Social Security Tax Rate (θ)

A. Growth equilibrium steady state									
Case	**p**	**n**	**p·n**	**h**	**s_m**	**s_s**	**Avg. sav**	**w†**	**$(V_m–V_s)$††**
(a) w (endo) >0, α = 1									
θ = 0.056	0.643190	1.092135	0.702450	0.376444	0.001356	0.085123	0.031245	0.320456	1.456393
θ = 0.066	0.640890	1.074735	0.688787	0.374208	0.001278	0.075832	0.028051	0.325627	1.432159
[Elasticity#]	[0.0200]	[0.0892]	[0.1089]	[0.0333]	[0.3221]	[0.6112]	[0.5725]		
(b) w = 0, α = 1									
θ = 0.056	0.567741	1.434055	0.814172	0.166667	0.107337	0.149702	0.125649	0	0.831431
θ = 0.066	0.567647	1.429873	0.811663	0.166667	0.099733	0.140903	0.117533	0	0.830830
B. Stagnant equilibrium steady state†††									
Case	**p**	**n**	**p·n**	**H**	**s_m**	**s_s**	**Avg. sav**	**w†**	**$(V_m–V_s)$††**
(a) w (endo) >0, α = 1									
θ = 0.056	0.574515	2.834728	1.628594	0.039804	0.053251	0.142800	0.091353	1.760216	0.875463
θ = 0.066	0.574361	2.826032	1.623163	0.037157	0.050646	0.134222	0.086219	1.791749	0.874441
[Elasticity#]	[0.0015]	[0.0171]	[0.0186]	[NA]	[0.273948]	[0.336392]	[0.3147]		
(b) w = 0, α = 1									
θ = 0.056	0.576174	3.344934	1.927264	0	0.098632	0.142185	0.117091	0	0.886557
θ = 0.066	0.576117	3.337587	1.922841	0	0.090456	0.132532	0.108291	0	0.886171

Note: Parameter values used: $\sigma = 0.7$, $\delta = 0.8$, $\pi_1 = 0.95$, $\pi_2 = 0.64$, v =0.01, A=12, B = 0.1, $\beta = 1.06$, k = 0.65, D = 1, $\overline{H} = 1$. The steady-state growth equilibria are independent of $\overline{H}$. The marriage search function is specified as $\lambda(p) = Lp^{\varepsilon}$, with, L = 1.5, $\varepsilon = 5$. Average savings rate is $\mathbf{p \cdot s_m} + (1-\mathbf{p})\mathbf{s_s}$.

† The expected compensation to an old parent by each child, $\pi_2 w$, is 64% of w when $\pi_2 = 0.64$

†† The values for V_m and V_s are normalized by dividing equations (4) and (8) by ($\overline{H} + H_t$) and adding the constant term $(1/1\text{-}\sigma)$ to the utility operator U. The welfare gain from marriage is indicated by $(V_m - V_s)$.

††† In case of the stagnant equilibria, we set A=1 and v =0.08.

Elasticity of each endogenous variable with respect to θ.

Table II. Comparative Dynamic Effects of the Social Security Tax (θ) Under Alternative Specifications

A. The Benchmark OLG model with uncertain survival of children at the growth equilibrium steady states

Case	p	n	p·n	h	s_m	s_s	Avg. sav	w	$(V_m–V_s)$
(a)† w (exog) >0, α = 1									
θ = 0.056	0.642464	1.981068	1.272765	0.205422	0.001370	0.085763	0.031544	0.32	1.448703
θ = 0.066	0.639655	1.968356	1.259069	0.202662	0.001337	0.076866	0.028554	0.32	1.419305
(b) w = 0, α = 1									
θ = 0.056	0.567230	2.087021	1.183821	0.114375	0.106369	0.149793	0.125162	0	0.828185
θ = 0.066	0.567130	2.084672	1.182280	0.114162	0.098806	0.141009	0.117074	0	0.827555

B. Dynastic models at the growth equilibrium steady state††

Case	n	h	s	V
(i) w = 0				
θ = 0.056	4.887197	0.166667	0.000899	17.538444
θ = 0.066	4.812613	0.166667	0.000731	16.863222
(ii) w (exog) = 0.01				
θ = 0.056	4.855884	0.168128	0.000596	18.692959
θ = 0.066	4.780682	0.168050	0.000510	17.834851
(iii)††† Income pooling				
θ = 0.056	3.446405	0.072965	0.811207	0.681008
θ = 0.066	3.449634	0.072962	0.801123	0.676022

Notes: Parameter values used in the simulations reported in this table are the same as in Table 1.

† We set w=0.32 in this case.

†† In this dynastic model, we assume that all agents are "married" and w is exogenous. We set A = 8 in this case.

††† Here the dynasty head makes all allocation decisions after pooling the incomes of the overlapping generations. We set A = 25, v=0.001, k=0.95, and D=5.

Table 1. Family Formation Regressions: Net Marriage, Marriage and Divorce

	LNETMARRY							LMARRY				LDIVORCE			
	Model 1 OLS	Model 2 OLS w/o FE	Model 3 OLS	Model 4 2SLS	Model 5 2SLS	Model 6 OLS Non-overlap	Model 7 OLS Non-overlap	Model 1 OLS	Model 3 OLS	Model 4 2SLS	Model 6 OLS Non-overlap	Model 1 OLS	Model 3 OLS	Model 4 2SLS	Model 6 OLS Non-overlap
PEN	-6.7686	-4.4034	-6.5193	-7.9613	-7.7693	-8.0439	-8.5330	-4.5399	-4.5002	-5.3671	-5.9332	5.5392	4.0250	3.7994	3.5647
	-17.46	-13.62	-15.84	-17.38	-16.29	-8.11	-7.27	-17.72	-15.91	-16.25	-8.13	9.03	7.09	5.39	2.40
	[-0.379]	[-0.247]	[-0.365]	[-0.446]	[-0.435]	[-0.451]	[-0.478]	[-0.254]	[-0.252]	[-0.301]	[-0.332]	[0.310]	[0.225]	[0.213]	[0.200]
LPi1	2.6131	0.8878	3.4845	3.1164	3.7154	1.0702	2.1687	0.7660	0.8010	0.9623	0.6746	3.0551	-0.3529	-0.6109	2.4271
	5.02	1.58	6.07	5.52	6.44	1.01	1.56	3.00	2.98	3.35	1.24	3.71	-0.45	-0.72	1.38
LPi2	0.2533	0.0025	0.2280	0.2426	0.2013	0.3523	0.2980	0.1812	0.1696	0.1525	0.2537	-0.0685	0.0361	0.0454	0.0136
	5.39	0.05	4.64	5.06	4.14	2.74	2.00	5.78	5.04	4.50	2.86	-0.92	0.53	0.63	0.07
LG	-0.1233	-0.1772	-0.1038	-0.1668	-0.1850	-0.0089	-0.0510	0.0231	-0.0003	-0.0361	-0.0245	0.7309	0.4589	0.4709	0.3425
	-2.40	-6.40	-1.75	-2.99	-2.93	-0.07	-0.33	0.66	-0.01	-0.81	-0.26	9.00	5.60	5.04	1.78
LGDPN	-0.3671	-0.2356	-0.4011	-0.3739	-0.3906	-0.1899	-0.2858	-0.0342	-0.0598	-0.0453	-0.0249	0.7095	0.6735	0.7150	0.4952
	-9.63	-9.27	-9.05	-8.56	-7.96	-2.24	-2.54	-1.61	-2.41	-1.62	-0.46	11.76	11.02	9.86	3.49
LDSEX	-0.0246	-0.0250	-0.0062	-0.0210	-0.0063	-0.0186	0.0082	-0.0098	-0.0073	-0.0076	0.0092	-0.0042	-0.0537	-0.0532	-0.0740
	-3.13	-3.01	-0.72	-2.67	-0.75	-0.95	0.29	-1.83	-1.21	-1.28	0.53	-0.33	-4.53	-4.26	-2.05
LFLFP			-0.2703		-0.2642		-0.0595		-0.0663	-0.0588	0.1010		1.1587	1.2042	1.1795
			-4.79		-4.51		-0.42		-1.71	-1.45	1.18		14.88	13.91	6.66
LFSCH			0.3730		0.3233		0.1505		0.4004	0.3080	0.3720		0.3003	0.4063	0.2076
			2.55		2.20		0.45		5.63	4.15	2.72		1.49	1.87	0.49
Adj. R^2	0.6383	0.4667	0.6778			0.6591	0.6739	0.4649	0.4939		0.5491	0.6291	0.7604		0.7877
N	751	751	638	663	573	168	144	871	754	676	172	751	638	573	144

Notes: All regressions employ a fixed-effects regression model (except model 2), but the results for country-dummies are suppressed. Rows show the estimated β and β/S_β for each variable. The square-bracketed numbers for PEN convert the estimated coefficients into **elasticity** terms. In all regressions the dependent variables are averaged over a 5-year lead period. The "2SLS" model accounts for the endogeneity of both PEN and LGDPN. Instrumental variables include, in addition to exogenous structural regressors, LAGE, MATURE, MATURESQ, LPOP65, LINFLA, and lagged PEN and LGDPN. Model 6 and 7 repeat the specification of model 1 and 3 using non-overlapping 5-year periods.

Table 2. Total Fertility Rate Regressions

Dependent Variable: LTFR

	Model 1 OLS	Model 2 OLS w/o FE	Model 1A OLS	Model 3 OLS	Model 4 2SLS	Model 5 2SLS	Model 6 OLS Non-overlap	Model 7 OLS Non-overlap
PEN	-2.0145	-4.5059	-0.9088	-0.9822	-7.5810	-5.3479	-2.1421	0.1730
	-7.23	-17.89	-2.92	-3.21	-11.08	-5.03	-2.93	0.18
	[-0.113]	[-0.252]	[-0.051]	[-0.055]	[-0.425]	[-0.300]	[-0.120]	[0.010]
LPi1	-2.5384	-4.2479	-1.7980	-1.6433	-2.3499	-1.1136	-1.8617	-1.7652
	-7.14	-8.96	-4.38	-4.12	-6.53	-2.62	-2.41	-1.91
LPi2	0.1113	0.1646	0.0440	0.0588	0.0941	0.0791	0.0503	-0.0928
	3.47	4.45	1.39	1.91	2.50	2.03	0.58	-0.96
LG	-0.2010	0.1543	-0.1822	-0.1233	-0.0433	-0.0719	-0.2053	-0.1621
	-5.00	7.14	-4.83	-2.97	-0.94	-1.43	-2.31	-1.52
LGDPN	-0.4218	-0.1266	-0.3111	-0.2981	-0.1945	-0.1880	-0.4346	-0.2855
	-16.70	-6.43	-10.35	-9.23	-4.80	-3.76	-7.08	-3.21
LNETMARRY			0.2314	0.1681		0.0896		0.2195
			10.68	7.79		1.91		3.32
LFLFP				-0.2883		-0.2116		-0.3425
				-7.46		-4.54		-3.65
LFSCH				0.5092		0.5198		0.3648
				5.59		4.65		1.75
Adj. R-sq.	0.7321	0.7203	0.7458	0.7908			0.7250	0.7729
N	642	642	563	520	535	417	155	122

Notes: See notes to Table 1. Model 2 presents the OLS regression result without fixed effects. In all regressions the dependent variable is averaged over a 5-years lead period. Model 4 accounts for the endogeneity of both PEN and LGDPN. Instrumental variables include, in addition to exogenous structural regressors, LAGE, LSEX, MATURE, MATURESQ, LPOP65, LINFLA and lagged LPEN and LGDPN. Model 5 accounts for the endogeneity of PEN, LGDPN, and LNETMARRY, with lagged LNETMARRY as an additional IV. Models 6 and 7 repeat the specifications of models 1 and 3 based on non-overlapping 5-year periods.

Table 3. Savings Regressions: World Bank and Summers-Heston data

Dep. variable	LNSAV							LI						
	Model 1	Model 2	Model 1A	Model 3	Model 4	Model 6	Model 7	Model 1	Model 2	Model 1A	Model 3	Model 4	Model 6	Model 7
	OLS	OLS	OLS	OLS	2SLS	OLS	OLS	OLS	OLS	OLS	OLS	2SLS	OLS	OLS
		w/o FE				Non-overlap	Non-overlap		w/o FE				Non-overlap	Non-overlap
PEN	-1.6584	-1.2355	-0.4757	-1.1662	-1.6456	-1.9531	-1.1183	-2.4082	0.5368	-0.7761	-0.6340	-2.5568	-3.1577	-0.8616
	-5.56	-4.55	-1.36	-3.63	-4.33	-2.59	-1.14	-8.74	1.59	-2.28	-1.98	-7.62	-4.56	-0.89
	[-0.093]	[-0.069]	[-0.027]	[-0.065]	[-0.092]	[-0.109]	[-0.063]	[-0.135]	[0.030]	[-0.044]	[-0.036]	[-0.143]	[-0.177]	[-0.048]
LPi1	0.9939	1.8744	2.7507	2.9070	0.9193	0.7206	0.7439	-0.9699	3.1532	-1.5195	-0.6882	-0.8093	-0.9256	-1.8057
	3.04	4.87	5.32	5.66	2.46	1.08	0.62	-3.32	6.68	-3.30	-1.48	-2.56	-1.54	-1.59
LPi2	0.1079	0.1264	0.0452	0.0589	0.0918	0.2217	0.0713	0.1619	0.1919	0.0895	0.0619	0.1554	0.2799	0.1551
	2.79	3.28	1.10	1.51	2.10	2.04	0.57	4.53	4.01	2.29	1.62	4.11	2.74	1.28
LG	-0.1474	-0.3152	-0.1289	-0.1391	-0.1755	-0.1738	-0.1386	-0.0030	-0.0494	0.0288	0.0209	-0.0976	0.0198	-0.0274
	-3.26	-12.06	-2.85	-2.83	-3.38	-1.78	-0.89	-0.07	-1.59	0.67	0.44	-2.18	0.22	-0.18
DEFICIT	-0.0263	-0.0219	-0.0283	-0.0268	-0.0253	-0.0231	-0.0201	-0.0058	-0.0026	-0.0030	-0.0097	-0.0034	-0.0099	-0.0125
	-13.00	-10.31	-12.73	-11.47	-11.55	-4.79	-3.28	-2.81	-0.99	-1.29	-3.84	-1.59	-2.06	-1.97
NX								-0.0172	-0.0104	-0.0171	-0.0181	-0.0147	-0.0251	-0.0224
								-9.88	-3.57	-8.22	-8.83	-8.27	-5.92	-4.12
LGDPN	0.1723	0.0363	-0.0546	-0.0785	0.1701	0.2092	-0.0607	0.1544	0.0868	0.1058	0.1952	0.1200	0.2646	0.3253
	6.32	1.66	-1.57	-1.91	5.17	3.25	-0.56	6.07	3.22	3.31	4.83	4.11	4.46	2.99
LNETMARRY			0.0857	0.1332			0.0931			0.1705	0.1879			0.1445
			3.28	4.93			1.09			6.98	7.24			1.82
LFLFP				0.1726			0.1311				0.0371			-0.0524
				3.90			1.09				0.85			-0.43
LFSCH				-0.1451			-0.4687				-0.1056			-0.3391
				-1.15			-1.56				-0.83			-1.09
LM2				0.0100			0.0082				-0.0235			-0.0235
				1.38			0.45				-3.32			-1.33
LINFLA				0.0378			0.0321				-0.0003			-0.0037
				4.67			1.65				-0.03			-0.19
Adj. R-sq.	0.2824	0.3900	0.3709	0.4502		0.2877	0.4244	0.2684	0.2159	0.3452	0.4301		0.3790	0.5095
N	800	800	632	514	667	178	112	784	784	631	508	666	173	110

Notes: See notes for Table 1. NSAV is the national savings rate as reported by the World Bank data. I is the investment ratio to GDP as reported in the Summers and Heston data. Model 4 for both LNSAV and LI accounts for the endogeneity of PEN and LGDPN. Instrumental variables include, in addition to exogenous structural regressors, LSEX, LAGE, MATURE, MATURESQ, LPOP65, LINFLA, and lagged PEN and LGDPN. Model 6 and 7 repeat the specifications of models 1 and 3 based on non-overlapping 5-year periods.

Table 4. Per Capita GDP Growth Regressions

A. 5-YEAR-LEAD GROWTH RATES (GROWTH)

Dep. variable	Model 1 OLS	Model 2 OLS w/o FE	Model 3 OLS	Model 4 2SLS	Model 6 OLS Non-overlap	Model 7 OLS Non-overlap
Constant	-0.0278†	0.0443	-0.0070†	-0.0691†	0.0102†	-0.0877
		6.96				
LPEN	-0.0075	-0.0017	-0.0035	-0.0075	-0.0078	-0.0086
	-5.39	-3.88	-2.00	-3.67	-2.13	-1.75
LPi1	-0.1662	0.0134	-0.0393	-0.1578	-0.0837	-0.1733
	-3.75	0.45	-0.56	-2.46	-0.96	-1.21
LPi2	0.0380	0.0210	0.0219	0.0390	0.0482	0.0632
	7.15	5.42	3.11	5.69	3.88	3.49
LG	0.0153	-0.0043	0.0254	0.0286	0.0032	0.0124
	2.91	-2.06	3.31	3.90	0.29	0.69
LNETMARRY			0.0026	0.0036		0.0007
			0.69	0.83		0.08
LFLFP			0.0079			0.0232
			1.00			1.48
LFSCH			-0.0384			0.0753
			-4.18			2.14
Adj. R-sq.	0.1699	0.0624	0.1670		0.1949	0.2446
N	928	928	644	648	206	143

B. SAMPLE-PERIOD GROWTH RATE (LGDPN)

	Model 1 OLS Hetero growth	Model 2 OLS	Model 3 OLS	Model 4 2SLS w/ AR(1)	Model 5 2SLS w/ AR(1)	Model 8 OLS
T	-0.0003††	0.0552	0.0266	0.0592	0.0439	0.0035
		18.80	2.92	11.64	4.58	3.01
T*LPEN	-0.0021	-0.0020	-0.0010	-0.0027	-0.0020	-0.0003
	-7.09	-11.26	-3.79	-2.18	-1.71	-5.00
T*Lpi1	-0.1138	0.0613	0.0284	0.0180	0.0193	0.0097
	-8.82	3.51	1.04	1.23	1.30	1.54
T*Lpi2	-0.0013	0.0036	0.0041	-0.0009	-0.0010	0.0002
	-1.36	2.63	2.34	-1.20	-1.31	0.52
T*LG	-0.0116	-0.0111	-0.0108	-0.0204	-0.0200	-0.0012
	-9.11	-11.08	-7.18	-15.10	-14.56	-3.20
T*LNETMARRY			0.0052	0.0055	0.0071	
			4.44	3.07	3.79	
T*LFLFP			0.0048		0.0037	
			2.59		1.91	
T*LFSCH			-0.0378		-0.0008	
			-10.29		-0.74	
$LGDPN_{-1}$						0.9232
						95.82
Adj. R-sq.	0.9411	0.7870	0.8262			0.9767
N	1333	1333	752	819	793	1210

Notes: See notes to Table 1. The regressions in Part A implement regression specification (18.b), with the dependent variable measured as the average growth rate of GDPN over a 5-year lead period (GROWTH). The results for country dummies are suppressed. Here estimated coefficients represent elasticity terms. Models 1 and 2 are regressions with and without fixed-effects. Model 4 accounts for the endogeneity of LPEN and LNETMARRY. Instrumental variables include, in addition to exogenous structural regressors, LSEX, LAGE, MATURE, MATURESQ, LPOP65, LINFLA, and lagged LPEN and LNETMARRY. Models 6 and 7 repeat the specifications of model 1 and 3 based on non-overlapping 5-year periods. In Part B we implement the "growth" regression specification of equation (21). In model 1, we enter both country-dummies and their interaction terms with T as additional regressors. Models 4 and 5 report 2SLS regression estimates accounting for both the endogeneity of LPEN and LNETMARRY and serially correlated errors using Greene's method. We use here the same set of instrumental variables used in model 4 of Part A. † = Coefficient representing the mean value of constant terms of all country dummies. †† = Coefficient representing the mean value of the interaction terms of T and all country dummies.

Table A. Additional Sensitivity Tests

(1) Human capital formation regressions

	SCHYRGTH	SECGTH	SCOREGTH		LSCHYR	LSEC	LSCORE
LPEN	-0.0014	-0.0020	0.0026	T*LPEN	-0.0007	-0.0024	-0.0020
	-3.79	-4.00	1.19		-4.40	-11.30	-4.84

(2) Provident funds

	LNETMARRY		LMARRY		LDIVORCE	LTFR		LNSAV	LI	GROWTH	
	Model 1	Model 4	Model 1	Model 4	Model 1	Model 1	Model 4	Model 1	Model 1	Model 1	Model 4
[Provident Funds]											
PEN	-0.0826	-1.3803	-4.3476	-4.1581	-0.2276	0.7515	1.5838	-1.6926	0.8148	-0.0043	-0.0048
	-0.12	-0.97	-5.79	-6.18	-0.25	1.27	1.21	-2.22	1.13	-0.57	-0.55
[Non Provident Funds]											
PEN	-7.0481	-8.3784	-4.3791	-5.2602	5.8500	-2.3912	-8.3800	-0.8952	-1.9553	-0.0075	-0.0081
	-17.84	-17.83	-16.91	-17.05	9.30	-8.17	-12.28	-3.01	-6.86	-5.15	4.45

(3) OECD countries

	LNETMARRY		LMARRY		LDIVORCE	LTFR		LNSAV	LI	GROWTH	
	Model 1	Model 4	Model 1	Model 4	Model 1	Model 1	Model 4	Model 1	Model 1	Model 1	Model 4
[OECD]											
PEN	-5.7664	-7.4780	-3.1179	-3.8227	5.5751	-2.9549	-8.9272	-1.2611	-1.0299	-0.0099	-0.0091
	-12.72	-13.83	-11.54	-11.75	7.94	-8.82	-10.31	-5.00	-4.85	-4.51	-3.70
[Non OECD]											
PEN	-2.3173	-2.3968	-3.2162	-3.8137	0.2293	-0.0938	-8.7398	-0.3102	-0.0975	-0.0042	-0.0046
	-4.18	-3.50	-6.29	-5.82	0.17	-0.16	-2.93	-0.33	-0.12	-1.83	-1.38

(4) Between-country estimated effects

	LNETMARRY	LTFR	LNSAV	GROWTH
PEN	-4.4936	-5.6484	-1.5311	-0.0030
	-2.95	-4.65	-1.36	-3.31

Note: Part (1) shows estimates based on model 1 (OLS) regressions. Because of space constraints, we cannot show the 2SLS results in this part, but these are similar to the reported OLS results in regressions where the Hausman test justifies 2SLS estimation. In parts (2) and (3), we report estimates based on both model 1 (OLS) and model 4 (2SLS) regressions wherever the Hausman tests indicate that PEN should be treated as endogenous. Part (4) shows estimates based on model 1 (the OLS regressions) of Tables 1-4. As in Tables 1-4, in parts (2)-(4) of this table, PEN is entered in log form to estimate all the GROWTH regressions.

Table B. Impact of Hypothetical Tax Reductions: Projections for the World and US Economies

	(1) Actual mean 1961-91	(2) Projected mean Going back to the 1960 tax rate†	(3) Reducing the sample mean tax rate by 25%†
WORLD		From .056 to .0322	From .056 to .042
Net Marriage Rate	8.35	9.93	9.27
Total Fertility Rate	2.81	2.97	2.91
Private Saving Rate	25.94	26.50	26.27
Per Capita GDP Growth Rate	2.84 %	3.26 %	3.06%
Per Capita GDP††	$10,452	$11,842	$11,154
U.S.		From .0666 to .0459	From .0666 to .0499
Net Marriage Rate	8.11	9.13	8.92
Total Fertility Rate	2.17	2.31	2.28
Private Saving Rate	21.08	21.64	21.53
Per Capita GDP Growth Rate	1.86 %	2.23 %	2.14 %
Per Capita GDP††	$17,594	$19,678	$19,191

Note: Projections for the "world" are based on regression estimated for the non-provident-fund sample in model 1 (OLS) of the relevant endogenous variables in Table A. Projections for the U.S. are based on the regressions estimated for the OECD sample of model 1 (OLS) in Table A, which does not include any provident-fund countries.

† Average tax rate, as approximated by PEN = Pension benefits/GDP.

†† This row shows the actual and predicted per capita GDP in 1991, rather than their mean values over 1961-91.