Wealth Accumulation in the US: Do Inheritances and Bequests Play a Significant Role?*

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1. Introduction

Two of the most basic frameworks which economists use for analyzing national saving and private wealth accumulation are the life–cycle model (e.g., Modigliani [1986]) and the so–called altruistic or dynastic model (e.g., Barro [1974] and Becker [1974]). In the first, households care about their own lives. Since concave utility functions lead them to desire a relatively level time path of consumption, they save during high income years, as in middle age, in order to be able to maintain their standard of living through dissaving in periods of lower income, as during retirement. In the second model, households care about their descendants as well as themselves, and thus they build and exhaust estates and inheritances to smooth their dynasties' consumption paths over many generations. The difference between the two models is of more than pedagogical interest since they can produce strongly contrasting policy implications. In particular, a generous (and unfunded) social security system and/or a large national debt tend to displace private wealth accumulation in a life–cycle framework, raising interest rates and reducing an economy's physical capital stock (or increasing its reliance on financial inflows from abroad). In the simplest dynastic model, on the other hand, these effects are totally absent (e.g., Barro [1974]). The purpose of this paper is to formulate a model nesting both life–cycle saving and intentional bequests, and then to attempt to evaluate, with a calibration, the importance of each motive for saving, and the implications for policy analysis.

In this paper's model, each household has a finite life span, a life cycle of earnings, and access to actuarially fair annuities and life insurance. Two key points are that in addition to its own lifetime consumption, every household cares about the consumption possibilities of its descendants, and that there is heterogeneity among households in the form of an exogenous distribution of earning abilities within every birth cohort. A household with a high earning ability may choose to build an estate to share its good luck with its descendants; a household with an average, or below average, earning ability may decide not to leave a bequest at all, reasoning that its descendants will, even without an inheritance, have consumption possibilities comparing favorably with its own. In the end, although all households accumulate life–cycle savings to finance their retirement, only high earners (or households with large inheritances) tend to save additional amounts to make transfers to their adult children.

Just as the two basic saving frameworks have quite different predictions about the effects of policy, a variety of results are possible from the hybrid model; hence, to identify which outcomes one might expect to predominate in practice, this paper attempts to calibrate parameter values. The analysis focuses on long–run equilibria. The model generates unique steady–state equilibrium distributions of private net worth and intergenerational transfers. The two most difficult parameters to calibrate are the weight each household places on the lifetime utility of its grown children relative to itself, and the degree of flexibility, in terms of intertemporal substitution and willingness to bear risk, inherent in household utility functions. This paper sets the intergenerational weight so that steady–state aggregative private net worth in the model matches U.S. data for 1995, and it sets the curvature of household utility functions so that the model's stationary equilibrium distribution of intergenerational transfers yields Federal estate tax revenues matching data for the same year.

Section 6 quantitatively compares the steady–state distribution of private net worth from the calibrated model with the *1995 Survey of Consumer Finances.* It is well known that the U.S. distribution of wealth is very concentrated (e.g., Wolff [1996a]) and that a pure life–cycle model is unlikely to be able to account for this feature of the data (e.g., Huggett [1996]). This paper shows that intentional intergenerational transfers provide a plausible explanation for the skewness of the empirical distribution.

Perhaps the model's most surprising outcome pertains to public policy: under the "best" calibration, the model suggests that paying down the national debt or funding the social security system would tend to affect the economy in the way the pure life–cycle model predicts, rather than the manner the simplest dynastic model suggests. This result is not preordained: the model determines the extent and the implications of bequest activity endogenously, and this paper's analysis shows that policy results characteristic of the pure life–cycle and purely dynastic frameworks are both possible for the hybrid model.

This paper's organization is as follows. Section 2 provides a brief intuitive discussion of our model's potential policy implications. Section 3 presents the equations of the model. Section 4 discusses several special features of it, including our specification of the estate tax. Section 5 calibrates parameters. Section 6 presents results: it compares the simulated distribution of private net worth with data, it derives long–run policy implications consistent with the calibrated parameter values, and it estimates the relative importance for total private wealth accumulation of life–cycle and bequest–motivated saving. Section 7 concludes.

2. Policy

This section presents an intuitive discussion of possible outcomes for public policy. This paper does not attempt to explain or follow business cycle phenomena; rather, it exclusively focuses on long–run, or steady–state, equilibria. Although individual dynasties face uncertainty about the earning–ability realizations of their descendants, there is no aggregative uncertainty or randomness; thus, in a steady state, the rate of interest and the wage per "effective" labor unit are constant — simplifying the analysis a great deal. This paper assumes a closed economy.

Figures 1–3 illustrate the derivation of long–run equilibria for life–cycle, dynastic, and hybrid models.[1] Other than private saving and consumption, this paper works with a highly aggregated framework. Let K_t be the economy's steady–state stock of physical capital and L_t the labor supply. Assume the latter is inelastic. Omit, for this section, technological change. Suppose there is a Cobb–Douglas aggregate production function, so that GDP is $K^\alpha \cdot L^{1-\alpha}$, with $\alpha \in (0,1)$. Then with competitive behavior in the production sector, the ratio of factor shares is constant. Specifically, if W is the steady–state wage and r the steady–state interest rate, $r \cdot K_t/[W \cdot L_t] = \alpha/(1-\alpha)$. Moving r to the right–hand side of the equation, one has a hyperbolic relation between $K_t/[W \cdot L_t]$ and r. That is the "demand for capital" curve in each figure.

Begin with a purely life–cycle model. Suppose each household starts life with two adults and two minor children. As the adults reach middle age, the children mature and

[1] Tobin [1967] employs a similar diagram.

leave to form their own households — and their parents cease accepting responsibility for their support. When the adults reach old age, they retire. At each r one can sum the net worth, in wage units, desired by households of every age. Aggregating over different age groups, Figure 1's "supply curve" plots total household net worth, in wage units, for different long–run interest rates. In the very simple case of logarithmic preferences, two–period lives, and inelastic labor supply of one unit in youth and 0 in old age, the curve will be vertical. In general, the supply curve may be rising or falling because increases in the interest rate lead to complex income and substitution effects; however, in contrast to the dynastic model below, there is no reason to expect it to be horizontal.

The long–run supply and demand for capital are equal where the curves intersect. This is the general framework of Diamond [1965], Auerbach and Kotlikoff [1987], Kotlikoff [1998], and others. Figure 1's steady–state equilibrium interest rate is r_0.

Introduce a national debt D. Private wealth accumulation must be sufficient to finance the debt as well as the physical capital stock; hence, the steady–state equilibrium interest rate changes to r_1 in Figure 1. If $r_1 > r_0$, the steady–state capital intensivity of the illustrative economy is lower with a positive national debt. Auerbach and Kotlikoff [1987], for example, obtain long–run comparative static results of this nature.

Figure 2 switches to a dynastic model. Begin with the simplest setup, in which all dynasties are identical and lack life cycles. Provided market conditions actually lead households to desire to make bequests, the "supply of financing curve" for our diagram then has an unambiguous shape: it must be horizontal. Note that if c_t is a dynasty's time–t consumption, r is the steady–state interest rate, ξ is the dynasty's intergenerational subject discount factor, and $u(c_t)$ is its current flow of utility, every dynasty's first–order conditions for utility maximization imply

$$u'(c_t) = (1 + r) \cdot \xi \cdot u'(c_{t+1}).$$

In a steady state, $c_{t+1} = c_t$; hence, the steady–state interest rate depends only on preference parameters — i.e.,

$$(1 + r) \cdot \xi = 1 \ .$$

Thinking in terms of private budget constraints, as dynasties smooth their consumption across time periods, for an aggregative steady state the equilibrium interest rate must be such that each dynasty desires at each date to consume its labor earnings plus the interest on its assets. Then the principal of each dynasty's wealth remains intact, allowing equal consumption in the future. The principal in question, however, can be of any magnitude, implying a perfectly flat long–run supply curve in Figure 2.

Consider a national debt D. In Figure 2, without a debt the steady–state equilibrium interest rate is r_0. With a debt, although the supply of financing must exceed the physical capital stock, the horizontal supply curve can accommodate any degree of difference without a change in r. Thus, the long–run equilibrium capital intensivity of production remains the same regardless of the magnitude of D — a manifestation of Barro's [1974] well–known "Ricardian neutrality" result.

This paper's model has both life–cycle saving and intentional intergenerational transfers (bequests and/or *inter vivos* gifts). Although households have finite life spans and life cycles of earnings — and thus save in anticipation of retirement, dissave during retirement, etc. — they also care about their grown children and other descendants. If all households were identical, all would choose the same bequest amount. Then Figure 2's supply curve would reemerge. In fact, U.S. data do not show universal intergenerational transfers (e.g., Altonji *et al.*[1997], Laitner and Ohlsson [2001]). Nor can a model with identical agents contribute much to explaining the U.S. distribution of wealth. The present paper, in contrast, assumes that households differ with respect to earning ability. There is an exogenous distribution of abilities, which reemerges in every birth cohort. Each household receives a one–time–only realization from this distribution when it begins work. A household with a very lucky realization will be a candidate to share its good fortune with its descendants — in order to smooth dynastic consumption — through gifts and/or bequests. A household with a low earning ability, in contrast, will expect its descendants to have high consumption relative to its own even without a transfer, and will likely choose to leave nothing. The model determines a Markov transition function relating the transfer a household receives from its parents to, conditional on its earning ability, the transfer it desires to leave. The transition function has a unique stationary distribution. The stationary distribution determines the long–run cross–sectional distribution of wealth among living households. The mean net worth accumulations for all surviving households determines the model's supply of financing for each prospective steady–state interest rate.

Figure 3 illustrates the hybrid model's "supply curve." Suppose curve ab comes from life–cycle saving alone. If all households have the mean earning ability, and all choose to leave positive intergenerational transfers, the curve would be cd (as in Figure 2). With the hybrid model and heterogeneous earning abilities, the actual curve will resemble EF (see Section 3). For a given interest rate, estate building will tend to make private wealth higher than life–cycle saving alone, positioning EF to the right of ab. Precautionary saving will make wealth accumulation higher than for the certainty dynastic model as well; thus, cd will bound EF from above. In fact, EF will asymptotically approach cd.[2] The latter implies that EF must be quite flat at its right–hand end.

In terms of policy results, we need to know whether the supply and demand curves of the hybrid model intersect at a point like F, where supply is very interest elastic, or at a point like E, where the elasticity more closely resembles a typical life–cycle model. At F, policy implications will be like those of Figure 2; at E, they will be like those of Figure 1. Either category of outcome is possible; which case one should expect in practice depends on which parameter values are best in other respects.

3. Theoretical Model

This paper's theoretical model has three distinctive elements. First, households are "altruistic" in the sense of caring about the utility of their grown–up descendants. Second, within each birth cohort there is an exogenous distribution of earning abilities. Third, households cannot have negative net worth at any point in their lives (perhaps because bankruptcy laws stop financial institutions from making loans without collateral); similarly,

[2] Section 3 presents detailed arguments. Intuitively, at very high wealth levels, dynasties can self–insure against generational changes in their earnings, leading to results resembling Figure 2's model.

intergenerational transfers must be nonnegative (so that parents cannot extract old age support from reluctant children through negative gifts and bequests). These elements lead to a distribution of intergenerational transfers and, ultimately, a distribution of wealth. In general, a high–earning–ability parent with a low–earning–ability child will tend to want to make an *inter vivos* gift and/or bequest, but a low–earning–ability parent with a high–earning–ability child will not. As stated, this paper focuses exclusively on steady–state equilibria, and, although individual family lines face earnings uncertainty, the latter averages out so that there are no aggregative stochastic fluctuations.

The basic framework is similar to Laitner [1992], although in contrast to the latter this paper incorporates estate taxes, assumes earning abilities are heritable within family lines, and, in particular, allows limited altruism in the sense that a parent caring about his grown children may, in his calculations, weight their lifetime utility less heavily than his own.[3] In contrast to Laitner [2001a], the present paper employs *1995 Survey of Consumer Finances* data in its analysis, provides a very detailed model of estate taxes, and assumes all households have the same preference ordering — rather than some family lines being altruistic, and some not. Laitner [2001b] omits earnings differences within dynasties. Although the analysis is then much simpler, polar–case policy results resembling Figure 2 are virtually inevitable — rather than being dependent upon calibration outcomes.

Other comparisons to the existing literature are as follows. In contrast to Becker and Tomes [1979], Loury [1981], and others, this paper omits special consideration of human capital. In contrast to Davies [1981], Friedman and Warshawsky [1990], Abel [1985], Gokhale *et al.* [2001], and others, the present paper assumes that households purchase actuarially fair annuities to offset fully mortality risk; consequently, all bequests in this paper's model are intentional. In contrast to Blinder [1974], Altig and Carlstrom [1999], Altig *et al.* [2001], and others, in this paper parents calculate their desired bequest thinking about their descendants' consumption possibilities — rather than caring about the magnitude of their transfer alone. In contrast to Bernheim and Bagwell [1988], this paper assumes perfectly assortative mating — adopting the interpretation of Laitner [1991], who shows that a model of one–parent households, each having one child, can mimic the outcomes of a framework in which each set of parents has two children and mating is endogenous. In contrast to Auerbach and Kotlikoff [1987], Kotlikoff [1998], and others, the present paper assumes that households supply labor inelastically. Similarly, each surviving household retires at the same age.

<u>Framework</u>. Time is discrete. The population is stationary. Think of each household as having a single parent and single offspring (see the reference to assortative mating above). The parent is age 22 when a household begins. The parent is 26 when his child is born. When the parent is 48, the child is 22. At that point, the child leaves home to form his own household. The parent works from age 22 through 63 and then retires. No one lives beyond age 90. There is no child mortality. In fact, for simplicity there is no parent mortality until after age 48. The fraction of adults remaining alive at age s is q_s.

Labor hours are inelastic. Each adult has an earning ability z, constant throughout

[3] This paper's altruism is one–sided: to concentrate on the upper tail of the wealth distribution, we do not consider children's support of their elderly parents. More generally, see, for instance, Laitner [1997].

his life, and evident from the moment he starts work. Letting e_s be the product of experiential human capital and labor hours, and letting g be one plus the annual rate of labor–augmenting technological progress, an adult of age s and ability z who was born at time t supplies $e_s \cdot z \cdot g^{t+s}$ "effective" labor units at age s. The age–profile of e_s is exogenously given. This paper focuses on steady–state equilibria in which the wage per effective labor unit, W, the interest rate, r, the income tax rate, τ, and the social security tax rate, τ^{ss}, are constant. Markets supply actuarially fair life insurance and annuities. One plus the net–of–tax interest factor on annuities for an adult of age s is

$$R_s = \frac{1 + r \cdot (1 - \tau)}{q_{s+1}/q_s} \ . \tag{1}$$

Our model of z comes from Solon [1992]: if in dynasty j, z'_j is the lifetime earning ability of the son of a father with ability z_j, then

$$\ln(z'_j) = \zeta \cdot \ln(z_j) + \mu + \eta_j \ , \tag{2}$$

where $\zeta \in (-1, 1)$ and μ are parameters, and η_j is random sample from an exogenously given distribution.

Utility is isoelastic. If an adult has consumption c at age s, his household derives utility flow

$$u(c, s) = \frac{c^\gamma}{\gamma}, \quad \gamma < 1 \ ,$$

where $u(c, s) = \ln(c)$ in place of the case with $\gamma = 0$. If his minor child has consumption c^k, an adult household derives, at age s, an additional utility flow

$$u^k(c, s) = \begin{cases} \omega^{1-\gamma} \cdot \frac{c^\gamma}{\gamma}, & \text{if } 26 \le s < 48, \\ 0, & \text{if } s \ge 48. \end{cases}$$

Consider a parent aged 48. Let t be the year he was born. Let his utility from remaining lifetime consumption be $U^{old}(a_{48}, z, t)$, where his earning ability is z, and his assets for remaining lifetime consumption are a_{48}. Then

$$U^{old}(a_{48}, z, t) = \max_{c_s} \sum_{s=48}^{90} q_s \cdot \beta^{s-48} \cdot u(c_s, s), \tag{3}$$

$$\text{subject to:} \quad a_{s+1} = R_{s-1} \cdot a_s + e_s \cdot z \cdot g^{t+s} \cdot W \cdot (1 - \tau - \tau_{ss}) + ssb(s, z, t) \cdot (1 - \frac{\tau}{2}) - c_s,$$

$$a_{91} \ge 0,$$

where $u(.)$ and q_s and R_s are as above, $\beta \ge 0$ is the lifetime subjective discount factor, a_s stands for the net worth the parent carried to age s, and $ssb(s, z, t)$ specifies social security benefits at age s.

The utility over ages 22–47 for a parent born in year t is $U^{young}(a_{22}, a_{48}, z, t)$ if he carries assets a_{22} into age 22, carries assets a_{48} out of age 47, and has earning ability z. Thus,

$$U^{young}(a_{22}, a_{48}, z, t) = \max_{c_s} \sum_{s=22}^{47} q_s \cdot \beta^{s-22} \cdot [u(c_s, s) + u^k(c_s^k, s)], \tag{4}$$

$$\text{subject to:} \quad a_{s+1} = R_{s-1} \cdot a_s + e_s \cdot z \cdot g^{t+s} \cdot W \cdot (1 - \tau - \tau_{ss}) - c_s - c_s^k,$$

$$a_s \geq 0 \quad \text{all} \quad s = 22, ..., 48.$$

As stated, the model assumes bankruptcy laws prevent households from borrowing without collateral, giving us the last inequality constraint in (4). For the sake of computational expedience, on the other hand, this paper assumes that such constraints do not bind for older households, making them superfluous in (3).

To incorporate altruism, let $V^{young}(a_{22}, z, t)$ be the total utility of a 22–year old altruistic household carrying initial assets a to age 22, having earning ability z, and having birth date t — where "total utility" combines utility from lifetime consumption with empathetic utility from the consumption of one's descendants. Let $V^{old}(a_{48}, z, z', t)$ be the total utility of a 48–year old altruistic household which has learned that its grown child has earning ability z'. Then letting $E[.]$ be the expected value operator, and letting $\xi > 0$ be the intergenerational subjective discount factor, we have a pair of Bellman equations

$$V^{young}(a_{22}, z, t) = \max_{a_{48} \geq 0} \{U^{young}(a_{22}, a_{48}, z, t) + \beta^{26} \cdot E_{z'|z} [V^{old}(a_{48}, z, z', t)]\},$$

$$V^{old}(a_{48}, z, z', t) = \max_{b_{48} \geq 0} \{U^{old}(a_{48} - b_{48}, z, t) + \xi \cdot V^{young}(T(b_{48}, t, z'), z', t + 26)\},$$

where b_{48} is the parent's intergenerational transfer, and $T(b_{48}, t, z')$ is the net–of–transfer–tax inheritance of the child (see Section 4). As stated, we require $b_{48} \geq 0$. Thus, parents cannot compel reverse transfers from their children. To preserve homotheticity, we require that estate tax brackets, deductions, and credits grow with factor g over time — and that the same is true for social security benefits (see below).

Then with isoelastic utility, one can deduce

$$U^{young}(a_{22}, a_{48}, z, t) = g^{\gamma \cdot t} \cdot U^{young}(a_{22}/g^t, a_{48}/g^t, z, 0),$$

$$U^{old}(a_{48}, z, t) = g^{\gamma \cdot t} \cdot U^{old}(a_{48}/g^t, z, 0),$$

$$V^{young}(a_{22}, z, t) = g^{\gamma \cdot t} \cdot V^{young}(a_{22}/g^t, z, 0),$$

$$V^{old}(a_{48}, z, z', t) = g^{\gamma \cdot t} \cdot V^{old}(a_{48}/g^t, z, z', 0).$$

Substituting a for a_{22}/g^t, a' for a_{48}/g^t, and b for b_{48}/g^t, the Bellman equations become

$$V^{young}(a, z, 0) = \max_{a' \geq 0} \{U^{young}(a, a', z, 0) + \beta^{26} \cdot E_{z'|z}[V^{old}(a', z, z', 0)]\}, \tag{5}$$

$$V^{old}(a, z, z', 0) = \max_{b \geq 0} \{U^{old}(a - b, z, 0) + \xi \cdot g^{\gamma \cdot 26} \cdot V^{young}(T(b/g^{26}, 0, z'), z', 0)\}. \tag{6}$$

Suppose maximization yields $\phi(a_{22}, s, t, z)$ as the net worth of a family of age $s = 22, 23, ..., 47$, ability z, birth date t, and initial net worth a_{22}; $\psi(a_{22}, t, z, z')$ as its gross of tax intergenerational transfer when its child has earning ability z'; and, $\Phi(a_{22}, s, t, z, z')$ as its net worth at age $s = 48, ..., 90$. Then homotheticity implies

$$\phi(a_{22}, s, t, z) = g^t \cdot \phi(a_{22}/g^t, s, 0, z)\,, \tag{7}$$

$$\psi(a_{22}, t, z, z') = g^t \cdot \psi(a_{22}/g^t, 0, z, z')\,, \tag{8}$$

$$\Phi(a_{22}, s, t, z, z') = g^t \cdot \Phi(a_{22}/g^t, s, 0, z, z')\,. \tag{9}$$

All families have the same ω, β, and ξ.

There is an aggregate production function

$$Q_t = [K_t]^\alpha \cdot [E_t]^{1-\alpha}, \quad \alpha \in (0, 1), \tag{10}$$

where Q_t is GDP, K_t is the aggregate stock of physical capital, and E_t is the effective labor force. The model omits government capital, though K_t includes houses and consumer durables. K_t depreciates at rate $\delta \in (0, 1)$. Normalizing the size of the time–0 birth cohort to 1 (so that every birth cohort has size 1), and employing the law of large numbers,

$$E_t = \sum_{s=22}^{63} g^t \cdot q_s \cdot e_s. \tag{11}$$

The price of output is always 1. Perfect competition implies

$$W_t = (1 - \alpha) \cdot \frac{Q_t}{E_t} \quad \text{and} \quad r_t = \alpha \cdot \frac{Q_t}{K_t} - \delta. \tag{12}$$

Government issues D_t one–period bonds with price 1 at time t. Assume

$$D_t/Q_t = \text{constant}. \tag{13}$$

Let SSB_t be aggregate social security benefits. The social security system is unfunded, with

$$SSB_t = \tau^{ss} \cdot W_t \cdot E_t. \tag{14}$$

If G_t is government spending on goods and services, assume

$$G_t/Q_t = \text{constant}. \tag{15}$$

Leaving out the social security system, in which benefits and taxes contemporaneously balance, the government budget constraint is

$$G_t+r_t\cdot D_t = \tau\cdot[W_t\cdot E_t+r_t\cdot K_t+r_t\cdot D_t]+D_{t+1}-D_t+\int_0^{\infty}\int_0^{\infty}[b-T(b,t,z')]\cdot F^t(db,dz')\,, \tag{16}$$

where $F^t(b,z')$ is the joint distribution function for parental transfers b to households of age 22 at time t and earning ability z' — so that the last term is estate–tax revenues (recall the normalization on cohort populations). This paper assumes public–good consumption does not affect marginal rates of substitution for private consumption.

Households finance all of the physical capital stock and government debt. Let $H(z'\,|\,z)$ be the distribution function for child earning ability z' conditional on parent ability z (recall the Solon model). Then when NW_t is the aggregate net worth held which the household sector carries from time t to $t+1$, the economy's supply and demand for financing balance, using the law of large numbers, if and only if

$$\frac{K_{t+1}+D_{t+1}}{E_t} = \frac{NW_t}{E_t} \equiv \frac{\sum_{s=22}^{47} q_s\cdot\int_0^{\infty}\int_0^{\infty}\ \phi(T(b,t-s,z),s,t-s,z)]\cdot F^{t-s}(db,dz)}{E_t}$$
$$+\frac{\sum_{s=48}^{90} q_s\cdot\int_0^{\infty}\int_0^{\infty}\int_0^{\infty}\ \Phi(T(b,t-s),s,t-s,z,z')\cdot H(dz'\,|\,z)\cdot F^{t-s}(db,dz)}{E_t}\ . \tag{17}$$

In "equilibrium" all households maximize their utility and (1)–(17) hold. A "steady–state equilibrium" (SSE) is an equilibrium in which r_t and W_t are constant all t; in which Q, K, and E grow geometrically with factor g; and, in which the time–t distribution of pairs $(b/g^t,z)$ is stationary. The last implies

$$F^t(b,z) = F^0(b/g^t,z) \equiv F(b/g^t,z) \quad \text{all} \quad b,z,t\,. \tag{18}$$

This paper focuses exclusively on steady–state equilibria.

Existence and Computation of Equilibrium. We can amend Propositions 1–3 of Laitner [1992] in a straightforward manner to establish the existence of a steady–state equilibrium.

The propositions imply that we can compute a steady–state equilibrium as follows. Perfectly competitive behavior on the part of firms together with our aggregate production function yield

$$\frac{(r+\delta)\cdot K_t}{W\cdot E_t} = \frac{\alpha}{1-\alpha}\ ,$$

where K_t/E_t is stationary in a steady state. Household wealth finances the physical capital stock and the government debt. Combining the two uses of credit,

$$\frac{K_{t+1}+D_{t+1}}{W\cdot E_t}=g\cdot[\frac{\alpha}{1-\alpha}\cdot\frac{1}{r+\delta}+\frac{D_t}{W\cdot E_t}]=g\cdot[\frac{\alpha}{1-\alpha}\cdot\frac{1}{r+\delta}+\frac{1}{1-\alpha}\cdot\frac{D_t}{Q_t}]\,. \tag{19}$$

Line (13) makes D_t/Q_t a parameter; thus, (19) yields the "demand" for financing curve in Figure 3.

Define $\bar{r}$ from

$$(1+\bar{r})^{26}\cdot(1-\tau^{beq})\cdot\xi\cdot\beta^{26}\cdot g^{(\gamma-1)\cdot 26}=1, \tag{20}$$

where τ^{beq} is the maximal marginal tax rate on bequests. Fix any r with $r\cdot(1-\tau)<\bar{r}$, and fix $W=1$. We can solve our Bellman equations using successive approximations: set $V^{old,1}(.)=0$; substitute this for $V^{old}(.)$ on the right–hand side of (5), and solve for $V^{young,1}(.)$; substitute the latter on the right–hand side of (6), and solve for $V^{old,2}(.)$; etc. This yields convergence at a geometric rate: as $j\to\infty$,

$$V^{young,j}(.)\to V^{young}(.) \quad \text{and} \quad V^{old,j}(.)\to V^{old}(.)\,.$$

This paper's grid size for numerical calculations is 250 for net worth and 25 for earnings. The grids are evenly spaced in logarithms — except for even division in natural numbers for the lowest wealth values.

Turning to the distribution of inheritances and wealth, for a dynastic parent household born at t, policy function (8) yields

$$a'_{22}/g^{t+26}=T(\psi(a_{22}/g^t,0,z,z')/g^{26},0,z')\,, \tag{21}$$

where a'_{22} is initial net worth in the dynasty's next generation. Line (2) implies

$$z'=[z]^{\zeta}\cdot e^{\mu}\cdot e^{\eta}, \tag{22}$$

where η is taken to have a known distribution. Together (21)–(22) determine a Markov process from points $(a_{22}/g^t,z)$ to Borel sets of points $(a'_{22}/g^{t+26},z')$ one generation later. We assume the distribution of η has bounded support. Then as in Laitner [1992], there are bounded intervals $\mathcal{A}$ and $\mathcal{Z}$ with $\mathcal{A}\times\mathcal{Z}$ an invariant set for the Markov process, and there is a unique stationary distribution for the process in this set. In terms of distribution functions $F^t:\mathcal{A}\times\mathcal{Z}\to[0,1]$ — recall (18), the Markov process induces a mapping, say, J with

$$F^{t+26}=J(F^t)\,, \tag{23}$$

and iterating (23) from any starting distribution on $\mathcal{A}\times\mathcal{Z}$ yields convergence to the unique stationary distribution. Again, our numerical grid in practice is 250×25. The stationary distribution and lifetime behavior yield expected net worth per household normalized by average current earnings. Using the law of large numbers, we treat the latter ratio, $NW_t/(W\cdot E_t)$, as nonstochastic.[4] This generates the supply curve of Figure 3.

[4] Note that assuming $W=1$ above is not restrictive: with homothetic preferences, a different W raises the numerator and denominator of the steady–state ratio $NW_t/(W\cdot E_t)$ in the same proportion.

Laitner's [1992] propositions show $NW_t/(W \cdot E_t)$ varies continuously with r and has a horizontal asymptote at $r = \bar{r}/(1-\tau)$, as shown in the figure; thus, we must have an intersection of the demand and the supply curves. An intersection determines an equilibrium for the model. There are no steady states above the asymptote, because household net worth is infinite for $r \geq \bar{r}/(1-\tau)$.

4. Timing and Taxes

Dynamic programming determines a given dynasty's desired transfer, say, $b_{48} = \psi(a_{22}, t, z, z')$, as in (8). If the heir faces binding liquidity constraints (see (4)), the transfer must be made promptly — delays or impediments will invalidate our Bellman equations. If liquidity constraints do not bind, or if a fraction of b_{48} suffices to lift them, the timing of remaining transfers is, in mathematical terms, indeterminate: in terms of behavior, a parent is then indifferent between completing his transfer at age 48, leaving a fraction of his transfer for his estate at death, making a sequence of gifts over many years, etc. This section considers the timing of transfers in more detail, and presents the resolution of the indeterminacy which our computations employ. Then it turns to the related issue of the specification of estate taxes.

Timing. In practice, conflicting forces influence the age at which a parent makes his intergenerational transfer. On the one hand, taxes encourage early transfers — Section 5 notes that tax rates on *inter vivos* gifts are slightly lower than those on estates. Further, since tax rates are progressive, an early–in–life transfer faces lower taxes than a late–in–life sum with the same present value. On the other hand, a wealthy donor may feel that he can earn a higher rate of return on financial investments than his heirs (e.g., Poterba [1998]); a parent may value wealth for its own sake (e.g., Kurz [1968]) or as a means of securing his children's attentions (e.g., Bernheim *et al.* [1985]); or, a parent may want to delay in transferring his estate to protect himself against possible strategic behavior on the part of his children (e.g., a parent making a prompt transfer might find that his child consumes the sum quickly and then asks for more help — see Laitner [1997]). Although presumably many wealthy decedents make *inter vivos* transfers, data show that taxable estates empirically are an order of magnitude larger than taxable gifts (e.g., Pechman [1987,tab. 8.2] and Poterba [1998,tab.4]).

In light of the evidence, this paper's model presumes that parents strongly prefer to make their intergenerational transfers at death. Specifically, our computations assume that parents who want to make intergenerational transfers to their children do so through *inter vivos* gifts when liquidity constraints bind on the children, but that once a parent has transferred enough to lift his child's constraints, the parent saves his remaining transfers for his bequest. We make the following additional assumption for the sake of computational simplicity: if a parent remains alive at age 74 (when his child is 48), he makes his "bequest" (i.e., his final transfer) then.[5]

Taxes. We must specify Federal gift and estate taxes in a way consistent with the timing

[5] The reason for the age limit of 74 for transfers is that after that time the grandchild's earning ability is revealed. While the additional information would affect the parent's planning in theory, in practice it seems unlikely that surviving 75 year olds alter their consumption appreciably on the basis of their grandchildren's success in the labor market.

above.[6]

There are many opportunities for avoiding taxes that are only available to living donors. In 1995, a husband and wife, for instance, could each annually transfer a \$10,000 gift to each child, and to the spouse of each child, without incurring a tax liability. Policing lifetime gifts is extremely difficult; thus, parents presumably can shelter their grown children, provide facilities and resources for joint vacations, etc., without, in practice, reporting to the IRS. Transfer pricing provides other options. Suppose, for instance, that a father's labor has annual marginal revenue product of \$10 million and his son \$1 million. Then the father might agree to work for \$8 million per year with an implicit understanding that his son, employed at the same firm, would earn \$3 million.

With such a perspective, this paper assumes zero tax liability on *inter vivos* gifts. For a net–of–tax transfer x, our analysis of timing determines the present value of *inter vivos* gifts, say, x_1, and the actuarial present value of bequests at death, x_2. (By definition, $x_1 + x_2 = x$.) For a current–value bequest X_2, we can determine the current gross bequest, say, Y_2, consistent with Section 5's "effective" 1995 U.S. tax system. At parent age 48, let the present actuarial value of desired gross bequests Y_2 for all possible ages of death be y_2. Then for gross transfer $x_1 + y_2$ at parent age 48, the tax liability is $y_2 - x_2$. In particular, for a parent age 48 at time 0, last section's tax function is

$$T(x_1 + y_2, 0, z') = y_2 - x_2. \tag{24}$$

Since our calculations for y_2 depend on the way x is split between gifts and bequests, which, in turn, depends on z', the latter must be an argument of tax function $T(.)$. Note also that our treatment assumes parents deduce their estate–tax liability realizing that they will apportion their net transfer in accordance with our timing assumption, and that the latter itself, under our treatment, is insensitive to the nominal tax rate. In other words, this paper resorts to a "model" of the very complex Federal tax on gifts and estates.

In our computations, we assume a tax function, say, $T^0(.)$, stored as a 250×25 matrix over Section 3's grid for $\mathcal{A} \times \mathcal{Z}$; we solve the Bellman equation for $V^{young}(.)$ and $V^{old}(.)$ conditional on $T^0(.)$; deducing the division of possible net transfers between gifts and estates on the basis of these value functions, we construct a new tax function, say, $T^1(.)$; we solve the Bellman equations for $V^{young}(.)$ and $V^{old}(.)$ conditional on $T^1(.)$; repeat our steps to derive $T^2(.)$; etc. Provided we have convergence to a fixed point $T(b, 0, z')$, i.e.,

$$T^j(b, 0, z') \rightarrow T(b, 0, z') \quad \text{all} \quad (b, z'), \tag{25}$$

$T(.)$ is a usable tax function. (In the computations below, convergence is never a problem.)

5. Calibration

Calibrating the hybrid model requires that we (i) characterize the distribution of earning abilities, (ii) characterize the Federal estate tax, and (iii) set values for parameters α, δ, ω, τ^{ss}, g, τ, β, ξ, and γ. This section first discusses total private net worth in the U.S. economy. Then it turns to (i)–(iii). This paper uses 1995 data throughout.

[6] This paper ignores state gift, estate, and inheritance taxes beyond the level of the allowable Federal credit for state taxes.

Total Private Net Worth. Our basic aggregative private net worth figure comes from the *1995 Survey of Consumer Finances.*[7] The survey provides a detailed set of asset and debt measurements for 4299 households, including a random "area probability" sample of 2781 and a so–called "list" sample of 1518. The "list sample," which comes from a tax file of wealthy households, makes this survey uniquely comprehensive and interesting. According to the survey, 1995 aggregate household net worth was $21.1 tril.

Two defects of the survey are that it omits most private pension wealth and that it omits consumer durables other than automobiles, boats, and luxury items such as jewelry, furs, and antiques. Park [2001] shows the value of private pensions was $5.5 tril., of which the survey includes only $1.4 tril. Herman [2000, tab.13] implies the aggregate value of remaining categories of consumer durables was $1.2 tril. Adding 21.1 + (5.5-1.4) + 1.2, we have $26.4 tril.[8]

We make two additional adjustments. First, pension, as well as IRA and Keogh, accounts have a future income tax liability on their principal. The calibrations below assume a proportional income tax rate of 23%, implying an aggregative tax liability on these accounts of $1.6 tril. Second, many financial assets have an implicit tax liability for accrued, but not realized, capital gains. Poterba and Weisbenner [2000, table 4] allow us to compute a percentage of net worth in other real estate, business, other business, and directly held stock for households in six net–worth categories (i.e., 0–250K, 250–500K, 500–1000K, 1–5M, 5–10M, 10M+), and then to estimate the share of unrealized capital gains per cell. (We omit capital gains on own residence, since most of these are tax exempt.) We use a capital gains tax rate of 20%.[9] The aggregate implicit tax liability is $1.1 tril. In the end, our total private net worth figure for 1995 is $23.7 tril.

The Distribution of Earnings. The 1995 SCF collects data on household earnings for 1994. The survey measures wages and salaries, survey variable X5702, and business income, variable X5704. Since our theoretical model assumes a constant returns to scale aggregate production function with capital's share $\alpha = .2985$, we define a "household's earnings" as $X5702 + (1 - \alpha) \cdot X5704$. Table 1, column 1, summarizes the distribution of this constructed variable. This subsection processes it further and uses it to develop a parametric description of the distribution of earnings.

Table 1, column 2, adjusts for marital status. Our model assumes all adults are married. Of course, that is not true in the data. Thus, for conformity with the model, we double the SCF earnings of singles, and halve their weight — in effect marrying singles to spouses with identical earning ability.

Our theoretical model assumes that each working–age household inelastically supplies labor and earns at time t

$$W_t \cdot e_s \cdot z_j,$$

[7] See http://www.federalreserve.gov/pubs/oss/oss2/95/scf95home.html.

[8] For comparison, the U.S. Flow of Funds show 1995 net worth for the household sector and non–profit institutions combined of $27.4 tril.

[9] Unrealized capital gains in estates receive special tax treatment in practice, an issue to which we return below.

where W_t is the wage; e_s is age–s human capital from experience; and, z_j is household j's life–long earning ability. However, we assume that the SCF data include an independent, family specific, yearly shock ϵ_{jt}, so that earnings in the survey measure

$$W_t \cdot e_s \cdot z_j \cdot \epsilon_{jt} \ . \tag{26}$$

(Our theoretical analysis ignores the last shock — implicitly assuming that households can effectively self–insure against such short–run fluctuations.) Using the data, we calculate mean earnings for 5–year age groups (i.e., 20–24, 25–29, etc.); impute the mean earnings to the median age for the group; and, from the means, linearly interpolate $W_t \cdot e_s$ all ages s. Dividing each household's earnings by the interpolated value, $W_t \cdot e_s$, yields our observations of $z_j \cdot \epsilon_{jt}$. Our theoretical model requires an earnings distribution with a compact support; hence, we truncate observations with $z_j \cdot \epsilon_{jt}$ below .2 or above 20,000. For consistency with the model, we also drop observations having $s < 22$ or $s > 63$. Table 1, column 3, summarizes the normalized, age–restricted observations.

Estimates from panel data suggest roughly equal variances for $\ln(z_j)$ and $\ln(\epsilon_{jt})$ (see, for example, King and Dicks–Mireaux [1982]). As the variance of $\ln(z_j \cdot \epsilon_{jt})$ for column 2's data is .5155, this paper assumes

$$\ln(\epsilon_{jt}) \sim \text{normal}(0, \sigma_\epsilon^2) \quad \text{with} \quad \sigma_\epsilon^2 = .2577. \tag{27}$$

For intergenerational earning ability equation (2), this paper adopts Solon's [1992] estimate $\zeta = .45$. To allow thick tails for the earnings distribution, we assume a t distribution for η, the latter being a normal$(0, \sigma_\eta^2)$ random variable divided by an independent χ^2 variable with n degrees of freedom. For $n \to \infty$, η is lognormal. Otherwise, its density is

$$f_\eta(\eta; \sigma_\eta, n) = \frac{\Gamma(\frac{n+1}{2})}{\sigma_\eta \cdot \Gamma(\frac{n}{2}) \cdot \sqrt{\pi \cdot n}} \cdot [\frac{1}{(1 + (\frac{\eta}{\sigma_\eta})^2/n)}]^{(n+1)/2}. \tag{28}$$

The analysis proceeds as follows. Fix an n. Truncate the support of η to

$$[(1-\zeta) \cdot (\ln(.2) - \mu), \ (1-\zeta) \cdot (\ln(20000) - \mu)].$$

We numerically approximate the stationary density function for z using (2) and (28): choose (μ, σ_η) so that the mean of the approximating density is 1 and the variance of $\ln(z)$ is one–half the variance of the log of the observations from Table 1, column 3; then derive summary statistics for the product of z and the independent lognormal ϵ specified in (27). Table 1, column 4, presents outcomes for $n = 100$ — for which z is virtually lognormal. Table 1, column 5, presents results for $n = 4.8624$, this paper's choice of n. The latter minimizes the χ^2 test statistic derived from the frequencies implicit in column 3 and the new summary.[10] For this n, the calculations above imply $\mu = -.1050$ and $\sigma_\eta = .3701$. Table 1, column 5, provides a much closer match with the data than column 4.

[10] For a minimum chi squared estimator, the chi square statistic is 7.18, with 9 degrees of freedom. The p–value is .38. Note, however, that strictly speaking the test statistic requires a random sample, rather than a nonrandom and weighted sample.

Federal Gift and Estate Taxes. Federal gift and estate tax revenues play a major role in the calibrations below.

Table 2, column 1, lists 1995 Federal estate tax rates.[11] The Federal gift tax uses the same schedule — although one applies the gift tax to net–of–tax amounts. In 1995, each taxpayer had a lifetime credit of $192,800 for combined gift and estate taxes; there were unlimited marital and charitable deductions; and, each year a taxpayer could exclude any number of gifts of $10,000 or less to separate individuals. Two important points are that (i) despite the high rates in Table 3, 1995 aggregate gift and estate tax collections were only $17.8 billion (a figure which sums $14.8 billion of federal revenues — see the *Economic Report of the President* [1999] — with $3.0 billion credited for state death duties — see Eller [1997]), and (ii) gift tax collections are typically an order of magnitude lower than revenues from estate taxes. Because of the second point, our model does not include a gift tax — as explained in Section 4. Here we attempt to derive for our numerical analysis a specification of the Federal estate tax that is consistent with low collections. We assume that since the Federal tax falls on large estates, tax avoidance is nontrivial. In particular, we assume that because of avoidance, the rates of Table 2, column 1, fall on only a fraction θ^f of each nominally taxable dollar of estate.

The upper section of Table 3 presents 1995 tax data from Eller [1997] on large estates (gross estate less debts), marital deductions, and charitable deductions. Consider single households in the SCF. If NW_j is SCF net worth for household j, if φ_j is the household's SCF sample weight, and if p_j is the probability of death this year for the household head's age and sex from a standard mortality table, one can construct analogues of the variables of columns 1, 2, 4, and 6 at the top of Table 3 from $p_j \cdot \varphi_j$ times, respectively,

$$1, \quad NW_j \cdot [\theta^c + \theta^f \cdot (1 - \theta^c)], \quad 0, \quad NW_j \cdot \theta^c, \tag{29}$$

where θ^c is the fraction of the estate going to charity and θ^f is, as stated, the fraction of taxable wealth actually reported on a decedent's estate tax form. We assume

$$\theta^c = \begin{cases} \theta^{c,low}, & \text{for } NW_j < 10,000,000, \\ \theta^{c,high}, & \text{otherwise,} \end{cases}$$

Continuing with the SCF data, we treat "partners" as two singles, each having half a household's net worth. Married couples are more complicated. If θ^m is the fraction of the first decedent's estate transferred (tax free) to the surviving spouse, and if $\bar{p}_j$ is the mortality rate for the head's spouse, the four figures corresponding to (29) are $(p_j + \bar{p}_j + p_j \cdot \bar{p}_j) \cdot \varphi_j$ times

$$1, \quad \frac{NW_j}{2} \cdot [\theta^m + \theta^c + \theta^f \cdot (1 - \theta^m - \theta^c)], \quad \frac{NW_t}{2} \cdot \theta^m, \quad \frac{NW_t}{2} \cdot \theta^c \tag{30}$$

for a first decedent's estate. To cover the chance that both spouses die the same year, one must add $p_j \cdot \bar{p}_j \cdot \varphi_j$ times

[11] In practice, there was a bracket above $10 million with a marginal rate .60, and a higher bracket returning to marginal rate .55 — these arising from the phase–out of lower infra–marginal rates. This paper ignores the .60 bracket.

$$1, \quad \frac{NW_j}{2} \cdot (1+\theta^m) \cdot [\theta^c + \theta^f \cdot (1-\theta^c)], \quad 0, \quad \frac{NW_j}{2} \cdot (1+\theta^m) \cdot \theta^c \,. \tag{31}$$

to pick up the second spouse's estate. Using all of the households in the 1995 SCF, we choose our θ's to minimize the sum of squared deviations between columns 1, 2, 4, and 6, for rows 1–6, of the upper and lower segments of Table 3. The minimizing values are $\theta^{c,low} = .04$, $\theta^{c,high} = .22$, $\theta^m = .40$, and $\theta^f = .58$.

The estimated value of θ^f implies that "estate planning" reduces a taxable estate about 42%. This seems credible in light of the many strategies available for avoiding estate taxes (e.g., Schmalbeck [2000]). Applying Table 2's tax rates to the implied flow of taxable estates from the SCF, aggregate annual revenues are \$18.7 billion. In contrast, imposing $\theta^f = 1$, and repeating the steps above, implied 1995 Federal estate tax collections are \$42.9 billion — a figure in line, for instance, with Wolff's [1996b] calculations from the 1992 SCF — but contrary to empirical evidence.

Charitable foundations deserve special attention. Wealthy households consume, in part, through charitable gifts, and a parent can transfer power over donations to his children by creating a private foundation (which his descendants presumably can control). Contributions to such foundations are tax free. Eller's [1997] data (from 1992) show that donations to private foundations constitute 28.8% of charitable contributions in estates. Though our model's estates do not include general charitable contributions or transfers to spouses, they do include donations to private foundations.

This paper computes "effective" estate tax rates as follows. For an empirical transfer of x which parents direct to their children, the reported taxable estate is $x \cdot (1 - .288 \cdot \theta^c) \cdot \theta^f$. The tax rates of Table 2, column 1, and the uniform credit generate a tax assessment on the latter sum. For the median amount in each of Table 2's brackets, we compute the marginal tax rate taking avoidance into account. Table 2, column 2, presents the rates. Table 2, column 3, presents the (rounded) rates our simulations actually employ. The minimum gross estate for any tax due is \$1,038,000; the minimum in the simulations is \$1,000,000.

Finally, an empirical estate escapes income taxation on capital gains unrealized during the decedent's life: an executor raises all assets to market value before calculating the estate tax liability, but all capital gains are exempt from income taxation. We compute the capital gains tax liability using Poterba and Weisbenner [2000], as above, and a proportional rate of .20. Table 2, column 4, presents marginal estate tax rates corrected both as in column 2 and for the saving in capital gain taxes. Column 5 presents the rounded rates which the simulations use.

In the end, households in our simulations use the "perceived marginal tax rates" of Table 2, column 5, to guide their behavior. Each simulation simultaneously computes government estate–tax revenues using the "effective marginal tax rate" of Table 2, column 3. Our calibrations compare the government revenues with the \$18.7 billion/year derived above from column 3 and the 1995 SCF.[12]

[12] Our figure for aggregate 1995 U.S. wealth imputed private pensions and consumer durables. Since pensions are often annuitized, and consumer durables often have little resale value, we ignore both in our estate–tax computations here.

Ratios and parameters. National Income and Product Account 1995 corporate wages and salaries as a fraction of total corporate factor payments yield our estimate $\alpha = .2985$.

Subtracting the privately held national debt from our SCF measure of total private net worth yields our measure of K_t. With Q_t the 1995 GDP, we have $K_t/Q_t = 2.7573$. We assume a gross–of–tax interest rate of 5%/yr.[13] For consistency with our α and K_t/Q_t, we then need $\delta = .0583$.

There is no population growth in our simulations. We simply set our technological progress factor g to 1.01.

We set a proportional tax τ^{ss} on earnings up to the 1995 social security limit ($61,200) so that taxes exactly cover 1995 retirement benefits ($287.0 bil.). Within each birth cohort, social security benefits are progressive: for each cohort, we allocate benefits across our earning groups according to the benefit formula and maximum in *U.S. Social Security Administration* [1998]. Over time, both the tax limit and the brackets for the benefit formula rise with factor g.

Using 1995 Federal, state, and local expenditures on goods and services, $G_t/(w \cdot E_t) = .2643$. Taking the 1995 ratio of Federal debt to $1 - \alpha$ times GDP, $D_t/(w \cdot E_t) = .6347$. The empirical ratio $(K_t + D_t)/(W \cdot E_t)$ is 4.6109 for 1995.

We assume no child mortality and no adult mortality until age 48. Table 4 presents our figures for q_s, which reflect average 1995 mortality rates for U.S. men and women. The implied average life span is 77 years. Table 4, column 2, presents our age profile for experiential human capital, taken from 1995 SCF household earnings (as described above).[14] The figures correspond to $W \cdot e_s$ in the model.

Mariger [1986] estimates that children consume 30% as much as adults; Attanasio and Browning [1995,p.1122] suggest 58 percent; Gokhale *et al.* [2001] assume 40 percent. Recent estimates based on the U.S. Consumer Expenditure Survey in Laitner [2003] suggest a lower figure, and, based on the latter, we set $\omega = .1750$.

Lifetime first–order conditions for adult consumption at different ages imply

$$q_s \cdot [c_s]^{\gamma-1} \geq q_{s+1}\beta \cdot R_s \cdot [c_{s+1}]^{\gamma-1} \iff [\beta \cdot (1 + r \cdot (1-\tau))]^{1/(1-\gamma)} \cdot c_s \leq c_{s+1},$$

with equality when the nonnegativity constraint on household net worth does not bind. Laitner [2003] estimates from Consumer Expenditure Survey data an average growth rate with age in each household's consumption of about 2%/yr (see also Laitner [2001b]). Accordingly, we set

$$[\beta \cdot (1 + r \cdot (1-\tau))]^{1/(1-\gamma)} = 1.02\,. \tag{32}$$

Table 5 summarizes our calibrations of α, δ, ω, τ^{ss}, and g.

We are left with τ, β, γ, and ξ. We adjust these until for a given simulation (i) the government budget constraint holds, (ii) consumption growth condition (32) holds for

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[13] Auerbach and Kotlikoff's [1987] interest rate is .067, and Cooley and Prescott's [1995] is .072.

[14] In order to convert take home pay to total compensation, we multiply SCF wages and salaries by 17.49/12.58 — see *Statistical Abstract of the United States* [1997, table 676].

unconstrained ages, (iii) aggregate estate tax collections (roughly) equal \$18.7 bil. from our analysis above, and (iv) the empirical capital stock plus government debt to earnings ratio matches the right–hand side of (17). (Note that since the empirical ratio capital and debt to earnings and our aggregate production function alone determine the interest rate, in all calibrations $r = .05$.) It is easy to compute τ from (16) given our assumptions and requirement that estate–tax revenues equal their empirical counterpart. Given τ, it is also simple to compute β from (32).

For a selection of values of γ, we then iterate on ξ until the right–hand sides of (17) and (19) agree (recall note 4). We expect a higher ξ to lead to higher intergenerational transfers and bequest–motivated saving; thus, a higher ξ should shift the supply curve of Figure 3 to the right. The role of the isoelastic exponent γ is more subtle. When γ is low, agents are rigid in their tastes — they manifest a low intertemporal elasticity of substitution, and a high degree of relative risk aversion. When γ is near 1, they are flexible. In terms of simulations, when γ is low, intergenerational transfers will tend to be high, as households build dynastic wealth to insure their descendants against bad earnings realizations. Thus, a lower γ will imply a supply curve further to the right in Figure 3. This, in turn, implies that parameter combinations successful at matching the empirical aggregate net worth and interest rate will have a monotone relationship: with a low γ, a relatively low ξ will generate sufficient wealth to match the data; when γ is high, ξ will have to be high as well.

Different (γ, ξ) combinations will lead to different equilibrium distributions of intergenerational transfers. Consider a calibration with a low γ and low ξ. The low ξ means many households will choose not to make intergenerational transfers; however, the low γ makes households uncomfortable with risk and intergenerational differences, which will impel very high earners to leave substantial estates despite ξ. In the end, estate building will tend to be very concentrated (implying the same for the distribution of wealth). For parameter combinations with high γ and high ξ, estate–motivated saving will tend to be more widespread and less concentrated. Since the Federal estate tax is progressive, a more concentrated distribution of estates implies higher estate–tax revenues; thus, estate–tax revenues will tend to be higher with low (γ, ξ) combinations.

Table 6 presents simulations for different values of γ. As stated, in each column τ adjusts for the government budget constraint, β for (32), and ξ to equate the right–hand sides of (17) and (19). The pattern we anticipated holds: a low γ requires a low ξ, and the combination yields high estate–tax revenues. The best match with empirical estate–tax revenues is $\gamma = 0.0$.

The value of β in Table 6, column 4, is consistent with existing work (e.g., Cooley and Prescott [1995]). The estimate $\xi = .41$ implies parents value the utility of their grown children about half as much as their own. Using a somewhat different model, Nishiyama (2000, table 8–9) derives estimates .51 and .58 for an analogous parameter. The value $\gamma = 0.0$ is at the upper end of the range of conventional estimates: simulations often employ $\gamma = -4$ to 0 (e.g., Davies [1982] and Auerbach and Kotlikoff [1987]).[15]

[15] Gokhale *et al.* [2001] uses $\gamma = -\infty$. See also Hall [1988]. On the other hand, Browning *et al.*'s [1999] survey finds several estimates greater than 0.

6. Results

Questions of particular interest are: (a) What fraction of steady–state private net worth in the model is due to life–cycle saving? (b) How well does the simulated distribution of wealth from the model match U.S. data? (c) Does the "best" calibration imply an equilibrium in Figure 3 resembling E or F?

Share of Life–Cycle Wealth Accumulation. A well–known paper by Kotlikoff and Summers [1981] argues that life–cycle saving might account for as little as 20% of total U.S. private net worth. Modigliani [1988] suggests a figure of 80%. Altig *et al.* [2001], for instance, suggest that bequests account for about 30% of private net worth.

One can simulate our model with $r = .05$ and $\xi = 0$, the latter eliminating intergenerational transfers within dynasties. Steady–state private net worth as a fraction of empirical net worth then provides a measure of the relative importance of life–cycle saving. The last row of Table 6 presents outcomes.

In all of the simulations, life–cycle saving alone explains 84% of private net worth. A larger consumption weight for children or steeper lifetime earnings profiles from faster technological change would tend to diminish the role of life–cycle saving. A comparison of columns in Table 6 suggests that if the role of life–cycle accumulation were smaller, we would need a higher γ to avoid overshooting empirical estate–tax revenues.

Distribution of Net Worth. Table 7 presents summary statistics on the U.S. distribution of net worth from the *1995 Survey of Consumer Finances.* Column 1 presents unadjusted private net worth data. As many commentators have noted, the distribution's upper tail is highly concentrated: the top 1% of wealth holders have 35% of the household sector's net worth. Table 7's remaining columns process the survey data with steps corresponding to those Section 5 applies to aggregate net worth. Column 2 incorporates missing private pension net worth, now at the level of individual households.[16] Since pension wealth is more equally distributed than, say, financial net worth, column 2 displays less concentration than column 1. The share of the top 1%, for example, falls from 34.9% to about 29.4%. Column 3 imputes consumer durables omitted from the survey. The imputations are based on Wolff [1987,p.254].[17] As one might expect, concentration declines further, with the share of the top 1% falling to 28.2%. Column 4 corrects private pension and IRA amounts for income tax liability. As in Section 5, we assume a proportional income tax with rate .23. Similarly, we use Poterba and Weisbenner's estimates of unrealized capital gains by wealth level — recall Section 5 — to impute each household's implicit capital gains tax liability. The two tax adjustments roughly cancel one another. Table 7, column 5, limits the sample

[16] We use the survey's numerous questions about pension provisions of current and previous jobs — see Park [2001]. Our aggregate amount of pension net worth corresponds reasonably closely with U.S. Flow of Funds totals — see Park [2001].

[17] Wolff's regression equation is based on a 1969 survey. The independent variables are income, income squared, age, marital status, dummy for female head, and dummy for urban resident. We drop the last, and we use earnings in place of income. (In fact, letting earn* be the vertex of the implied parabola, we use $\min\{earn, earn^*\}$ as our income argument.) We make a proportional adjustment so that the aggregate equals our $1.2 tril. total for omitted durables in Section 5.

to households aged 22–73, as our model assumes that households begin with 22 year old adults and that parents complete all intergenerational transfers before age 74.

To see the degree of agreement between our best simulation and the SCF data, compare column 3 of Table 6 with column 5 of Table 7. The Gini coefficient for the data is .73; for the simulation it is .71. The share of wealth held by the top 1% in the data is 27.7 percent; for the simulation, it is 21.5 percent. The shares of the top 5% and 10% in the data are 47.5 and 60.0 percent, respectively; in the simulation, they are 37.5 and 51.3 percent. For the earnings distribution, Table 1, column 3, the Gini is .40, and the shares of the top 1, 5, and 10% are 9.2, 21.3, and 31.0 percent, respectively. Holding the interest rate at our 5%/year level, we can impose $\xi = 0$ and simulate the stationary distribution of private net worth from life–cycle saving alone. Column 5 of Table 6 presents the outcome. The shares of the top 1, 5, and 10% are 13.3, 30.8, and 46.3 percent, respectively, and the Gini is .69. Thus, as in Huggett [1996], life–cycle saving alone fails to explain the upper tail of the U.S. wealth distribution. The hybrid model, while far from perfect, can do much better.

Our model's ability to make substantial progress in matching the high empirical concentration of the U.S. distribution of net worth distinguishes it from earlier attempts such as Blinder [1974] and Laitner [2001a]. Blinder has a much different setup, with intentional, but nonaltruistic, bequests — i.e., "joy of giving" bequests. Davies [1982] and Laitner [2001a] both allow preference differences among households (the latter being correlated with earning abilities in Davies). Our model's performance in this respect is not better than Gokhale *et al.* [2001]. Indeed, the approaches represent possible alternatives: Gokhale *et al.*'s bequests are unintentional (there being no private annuities — despite highly risk averse agents); ours, in contrast, are intentional and "altruistic."[18]

Policy. Section 2's discussion shows that the interest elasticity of the supply of financing at the steady–state equilibrium point can be crucially important for public policy. The bottom of Table 6 numerically solves for elasticities for each value of γ.

The demand elasticities are all small and identical; all come from (19). The supply elasticities, on the other hand, vary by an order of magnitude. Nevertheless, none of the demand elasticities in the table exceed 3.66. For $\gamma = -2$, the supply elasticity is .30; for $\gamma = 0$, our "best" simulation in terms of estate–tax revenue, it is 1.41; for $\gamma = .5$, it is 3.66. The last column in Table 6 shows the elasticity for life–cycle saving alone would be 1.13.

In terms of Figure 3, it then seems fair to say that our best calibration implies an outcome resembling point E rather than F. This leads to the prediction that changes in social security policy and national debt will tend to affect the U.S. economy's steady–state interest rate and capital intensivity significantly — as in life–cycle simulations such as Auerbach and Kotlikoff [1987], Kotlikoff [1998], and Altig *et al.* [2001].

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[18] Empirical work often has difficulty definitively ruling out one model of bequest behavior relative to others — e.g., Altonji *et al.* [1997], Laitner and Ohlsson [2001], Laitner and Juster [1996]. In general, note that this paper's model is consistent with estate–tax avoidance effort on the part of rich households; Gokhale *et al.* is not. See Laitner [2002] for other comparisons and contrasts.

7. Conclusion

This paper studies a model which combines life–cycle and dynastic motives for saving. It calibrates a steady–state equilibrium version of the model using U.S. data on total national wealth and aggregative estate tax revenues. The calibrated model is reasonably consistent with the high degree of inequality in the actual U.S. distribution of private net worth — much more so than a pure life–cycle saving model.

The most surprising result of this paper's calibration is that the model favors parameter values that yield a moderate overall interest elasticity for the steady–state supply of net worth for the economy. The implication is that paying down the national debt or funding part, or all, of the social security system would tend to have noticeable long–run effects on interest rates and the economy's capital intensivity. The results suggest that policy analyses based on conventional overlapping generations frameworks may tend to be more useful and realistic than those stemming from simple representative agent models.

Table 1. The Distribution of Earnings

	SCF Data			Theoretical Model	
Statistic	Un–adjusted	Adjusted Singles	Normalized, Ages 22–63, Restricted Amounts	DF=100	DF=4.86
Gini	.49	.46	.40	.46	.48
Share Top .5%	9.2%	9.0%	6.5%	3.1%	6.6%
Lower Bound	$375,000	$475,000	$6.68	$5.73	$6.38
Share Top 1%	12.5%	12.1%	9.2%	4.8%	8.9%
Lower Bound	$267,000	$300,000	$4.57	$4.79	$5.00
Share Top 2%	17.4%	16.6%	13.1%	9.0%	12.7%
Lower Bound	$200,000	$219,000	$3.34	$3.93	$3.93
Share Top 3%	21.2	20.1%	16.1%	12.1%	15.8%
Lower Bound	$160,000	$186,000	$2.87	$3.47	$3.40
Share Top 4%	24.3%	23.1%	18.8%	14.9%	18.5%
Lower Bound	$134,000	$156,000	$2.57	$3.15	$2.82
Share Top 5%	27.0%	25.7%	21.3%	17.6%	21.0%
Lower Bound	$117,000	$140,000	$2.30	$2.91	$2.82
Share Top 10%	37.3%	35.6%	31.0%	28.4%	31.4%
Lower Bound	$84,000	$99,000	$1.72	$2.24	$2.14
Share Top 20%	52.6%	50.3%	45.8%	44.7%	46.8%
Lower Bound	$62,000	$74,000	$1.31	$1.63	$1.55
Share Top 50%	82.0%	80.0%	76.5%	75.8%	76.5%
Lower Bound	$33,000	$43,000	$.80	$.90	$.86
Share Top 90%	99.3%	99.2%	97.9%	97.4%	97.4%
Lower Bound	$8,000	$10,000	$.26	$.37	$.37
Mean	$47,000	$57,000	$1.000	$1.000	$1.000
Observations (incl. all imputations)	17,125	17,125	14,695	NA	NA
Households	3425	3425	2939	NA	NA

Source: col. 1: 1995 SCF. See text.
col. 2: Previous, double singles' earnings and halve weight.
col. 3: Previous, normalize mean, ages 22–63, and amounts .2–20,000.
col. 4: Model, degrees freedom 100.
col. 5: Model, degrees freedom 4.86.

Table 2. Estate Tax Rates 1995 (Percent)

Tax Bracket ($ thousands)	Nominal Marginal Tax Rate	Effective Marginal Tax Rate		Perceived Marginal Tax Rate After Correction For Capital Gains	
		Empirical	Assumed For Simulations	Empirical	Assumed For Simulations
0 – 10	18	0	0	-1.5	-1.5
10 – 20	20	0	0	-1.5	-1.5
20 – 40	22	0	0	-1.5	-1.5
40 – 60	24	0	0	-1.5	-1.5
60 – 80	26	0	0	-1.5	-1.5
80 – 100	28	0	0	-1.5	-1.5
100 – 150	30	0	0	-1.5	-1.5
150 – 250	32	0	0	-1.5	-1.5
250 – 500	34	0	0	-8	-1.5
500 – 750	37	0	0	-6	-1.5
750 – 1000	39	0	0	-6	-1.5
1000 – 1250	41	21	21	16	17
1250 – 1500	43	23	23	17	17
1500 – 2000	45	24	24	18	17
2000 – 2500	49	24	24	19	17
2500 – 3000	53	26	26	20	17
3000 – 10000	55	32	30	10	17
10000 – 15000	55	32	30	18	17
15000 – 20000	55	30	30	17	17
20000 – 30000	55	30	30	17	17

Source: see text.

Table 3. Gross Estates, Marital and Charitable Deductions

Bracket	Gross Estate		Marital Deductions		Charitable Deductions	
(thousand $)	number (000)	amount (bil $)	number (000)	amount (bil $)	number (000)	amount (bil $)
1995 U.S. Federal Estate Tax Data						
0 – 600	37.3	26.5	14.9	5.4	5.8	1.0
600 – 1000	24.6	34.3	12.2	10.5	5.0	1.8
1000 – 2500	5.3	17.1	2.8	6.3	1.4	.9
2500 – 5000	1.7	10.9	.9	4.2	.5	1.0
5000 – 10000	.6	7.4	.3	3.2	.2	.7
10000 – 20000	.3	14.7	.2	6.1	.1	3.4
Simulations Using Estimated θ's						
0 – 600	22.5	17.2	13.9	5.6	22.5	1.0
600 – 1000	16.6	24.8	12.4	9.5	16.6	1.3
1000 – 2500	6.0	19.8	3.4	6.3	6.0	1.1
2500 – 5000	3.2	21.2	2.0	7.1	3.2	1.2
5000 – 10000	1.1	15.2	.6	4.0	1.1	.9
10000 – 20000	.3	12.4	.3	4.7	.3	3.4

Source: see text.

Table 4 Survival Rates and Experiential Human Capital					
Age	q_s	e_s	Age	q_s	e_s
22	1.0000	33370	57	0.9533	94132
23	1.0000	37972	58	0.9451	90828
24	1.0000	42572	59	0.9362	86285
25	1.0000	47174	60	0.9264	81741
26	1.0000	51775	61	0.9158	77199
27	1.0000	56377	62	0.9042	72656
28	1.0000	59376	63	0.8918	68114
29	1.0000	60771	64	0.8785	
30	1.0000	62169	65	0.8643	
31	1.0000	63565	66	0.8493	
32	1.0000	64962	67	0.8333	
33	1.0000	66992	68	0.8163	
34	1.0000	69656	69	0.7982	
35	1.0000	72319	70	0.7789	
36	1.0000	74982	71	0.7585	
37	1.0000	77646	72	0.7370	
38	1.0000	79870	73	0.7143	
39	1.0000	81657	74	0.6904	
40	1.0000	83445	75	0.6654	
41	1.0000	85231	76	0.6393	
42	1.0000	87018	77	0.6120	
43	1.0000	90217	78	0.5835	
44	1.0000	94828	79	0.5539	
45	1.0000	99441	80	0.5233	
46	1.0000	104053	81	0.4918	
47	1.0000	108665	82	0.4526	
48	1.0000	110216	83	0.4049	
49	1.0000	108706	84	0.3483	
50	0.9957	107196	85	0.2838	
51	0.9909	105688	86	0.2142	
52	0.9858	104178	87	0.1446	
53	0.9803	102390	88	0.0824	
54	0.9743	100326	89	0.0354	
55	0.9678	98261	90	0.0087	
56	0.9608	96196	91	0.0000	

Sources: Column 1 from average death rates 1994, *Statistical Abstract of the United States* [1997,p.89]
Column 2 from 1995 SCF — see text.

Table 5. Parameter Values and Empirical Ratios

Name	Value
Parameter	
α	.2985
δ	.0583
g	1.0100
τ^{ss}	.0652
μ_η	-.1050
σ_η	.3701
n	4.8624
ζ	.4500
ω	.1750
Ratio	
$G_t/(W \cdot E_t)$	.2643
$(K_t + D_t)/(W \cdot E_t)$	4.6109
$[\beta \cdot (1 + r \cdot (1 - \tau))]^{\frac{1}{1-\gamma}}$	1.0200

Source: see text.

Table 6. Simulated Distribution of Wealth

Statistic	Dynastic Model with $\gamma =$ -2.0	-1.0	0.0	0.5	Pure Life–Cycle Portion of Model $\gamma = 0.0$
Gini	.71	.71	.71	.70	.69
Share Top 1%	22.4%	22.2%	21.5%	19.9%	13.3%
Lower Bound	$1,534,000	$1,534,000	$1,540,000	$1,579,000	$1,389,000
Share Top 2%	27.6%	27.4%	26.8%	25.4%	19.1%
Lower Bound	$1,237,000	$1,245,000	$1,263,000	$1,312,000	$1,090,000
Share Top 3%	31.7%	31.5%	31.0%	29.8%	23.3%
Lower Bound	$911,000	$911,000	$915,000	$951,000	$840,000
Share Top 4%	35.0%	34.9%	34.4%	33.2%	27.1%
Lower Bound	$857,000	$849,000	$854,000	$859,000	$807,000
Share Top 5%	38.2%	38.0%	37.5%	36.4%	30.8%
Lower Bound	$815,000	$814,000	$818,000	$820,000	$773,000
Share Top 10%	51.8%	51.7%	51.3%	50.4%	46.3%
Lower Bound	$600,000	$603,000	$614,000	$629,000	$518,000
Share Top 20%	69.9%	69.8%	69.5%	68.8%	67.2%
Lower Bound	$417,000	$418,000	$421,000	$423,000	$396,000
Share Top 50%	97.6%	97.6%	97.5%	97.4%	97.6%
Lower Bound	$90,000	$91,000	$94,000	$95,000	$71,000
Share Top 90%	100.0%	100.0%	100.0%	100.0%	100.0%
Lower Bound	$0	$0	$0	$0	$0
Mean	$263,000	$263,000	$263,000	$262,000	$215,000
Estate Tax Revenue	$21.6 bil.	$21.0 bil.	$19.0 bil.	$14.5 bil.	NA
Parameters					
β	1.02	1.00	.98	.97	NA
ξ	.06	.15	.41	.67	NA
τ	.23	.23	.23	.23	NA
Supply and Demand Elasticities for Figure 3 (absolute values)					
Supply	.30	.57	1.41	3.66	1.13
Demand	.40	.40	.40	.40	.40
Share of Private Net Worth from Life–Cycle Saving					
Fraction	.84	.84	.84	.84	NA

Source: See text.

Table 7. Unadjusted and Adjusted 1995 SCF Distribution of Wealth					
	Variant				
Statistic	1	2	3	4	5
Share Top 1%	34.9%	29.4%	28.2%	28.1%	27.7%
Lower Bound	$2,456,500	$2,545,838	$2,566,387	$2,335,019	$2,335,847
Share Top 2%	43.1%	36.9%	35.4%	35.3%	35.1%
Lower Bound	$1,317,200	$1,509,913	$1,523,435	$1,354,714	$1,378,650
Share Top 3%	48.5%	42.1%	40.4%	40.2%	40.1%
Lower Bound	$997,029	$1,186,598	$1,200,041	$1,049,550	$1,056,242
Share Top 4%	52.6%	46.3%	44.4%	44.1%	44.1%
Lower Bound	$786,585	$958,947	$972,148	$854,263	$854,265
Share Top 5%	56.1%	49.8%	47.8%	47.4%	47.5%
Lower Bound	$679,789	$833,960	$848,717	$745,184	$751,694
Share Top 10%	67.9%	62.9%	60.6%	59.7%	60.0%
Lower Bound	$381,022	$534,293	$547,208	$485,742	$490,099
Share Top 20%	80.6%	78.2%	75.7%	74.7%	75.1%
Lower Bound	$197,109	$284,940	$297,142	$263,500	$260,888
Share Top 50%	96.4%	95.9%	94.0%	93.6%	93.7%
Lower Bound	$57,400	$74,469	$86,702	$81,466	$78,715
Share Top 90%	100.3%	100.2%	99.8%	99.8%	99.8%
Lower Bound	$60	$500	$11,398	$11,153	$11,047
Gini	.79	.76	.73	.73	.73
Mean	$212,820	$255,500	$267,620	$240,158	$238,063
Observations (incl. all imputations)	21,495	21,495	21,495	21,495	19,111
Households	4,299	4,299	4,299	4,299	3,822

Source: col 1: 1995 SCF (see text)
col 2: Previous, including all private pensions
col 3: Previous, including all consumer durables
col 4: Previous, less income taxes on private pensions and IRAs, less capital gains taxes
col 5: Previous, ages 22–73.

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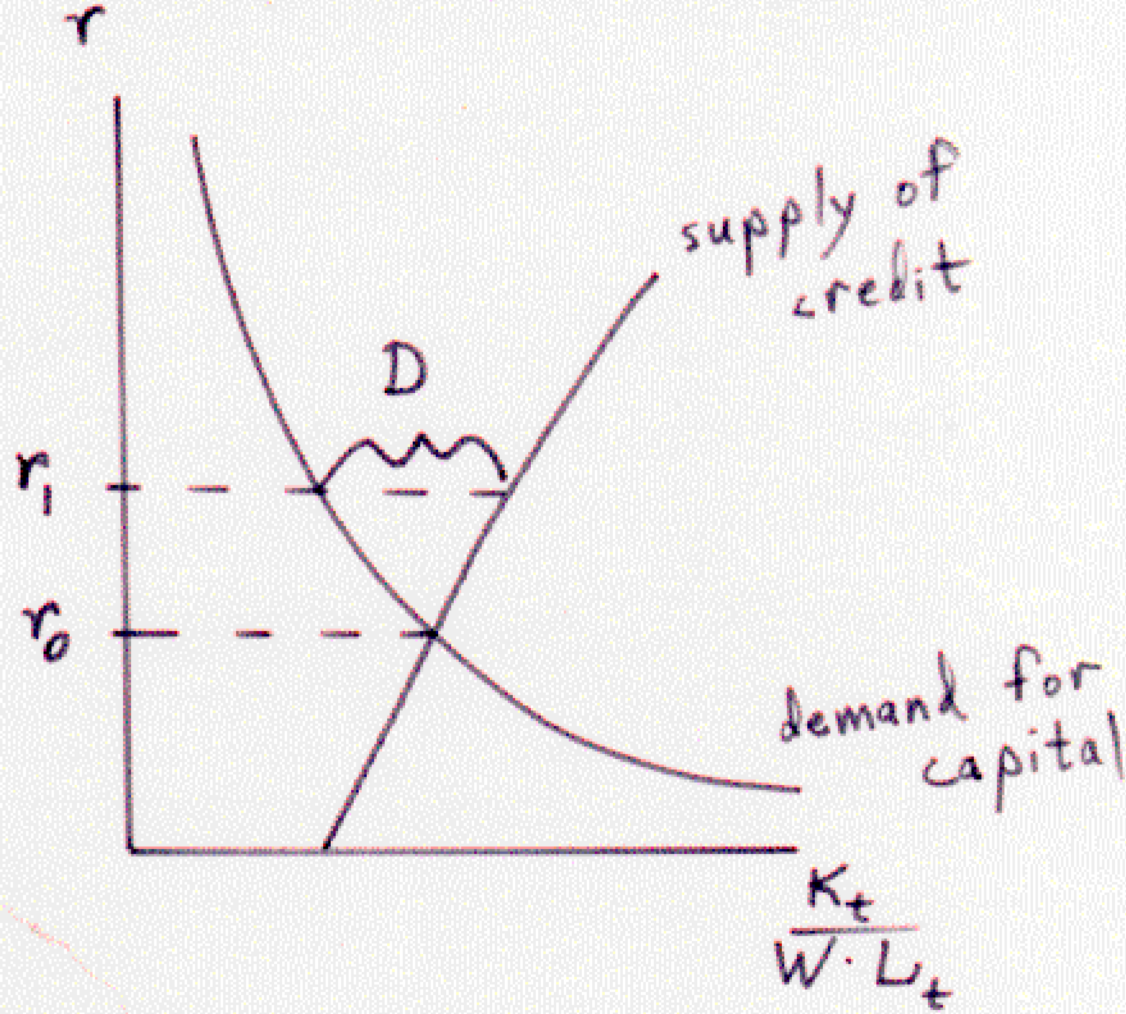

Figure 1: The demand for capital and supply of credit in a life–cycle model

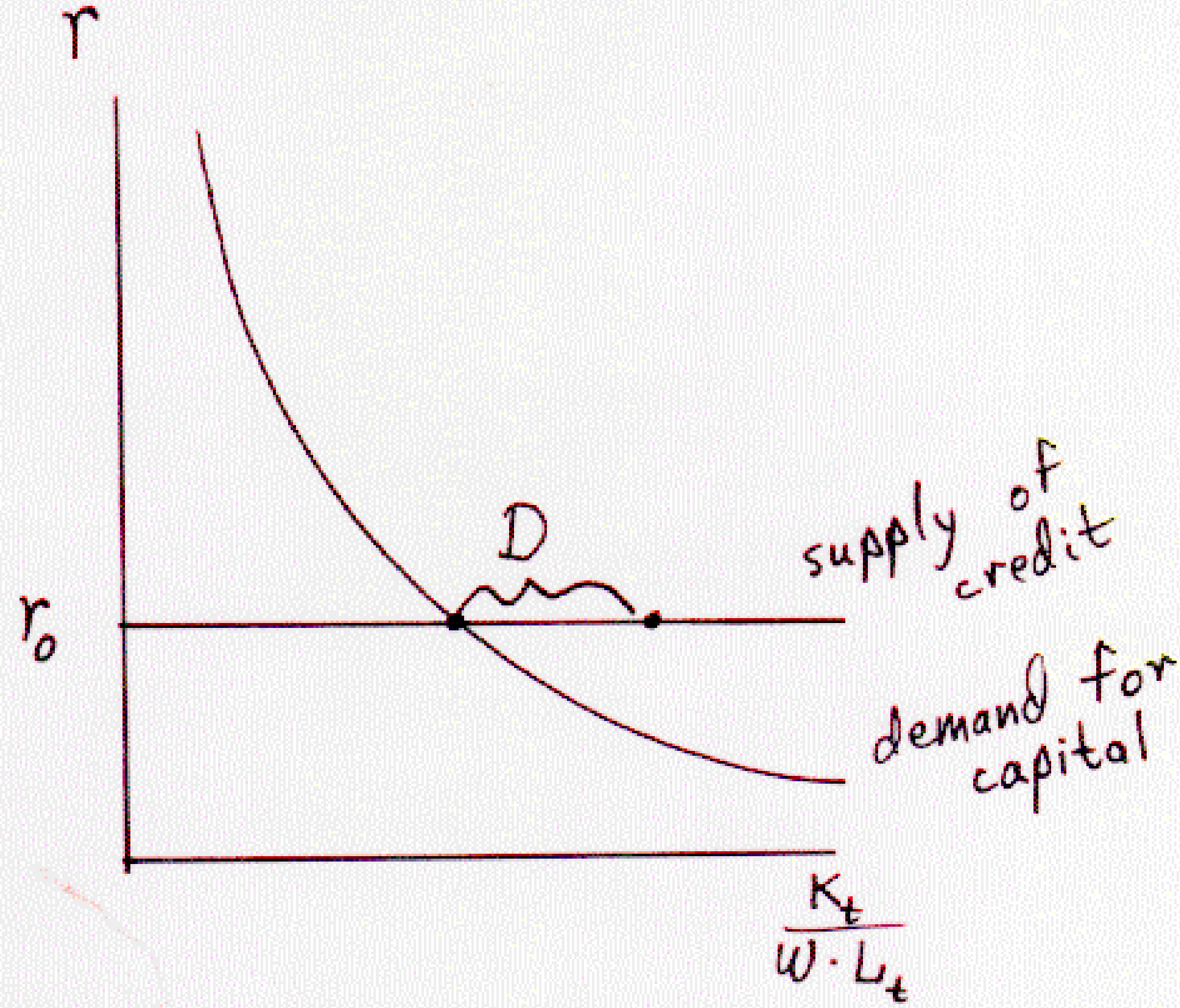

Figure 2: The demand for capital and supply of financing with identical, dynastic family lines

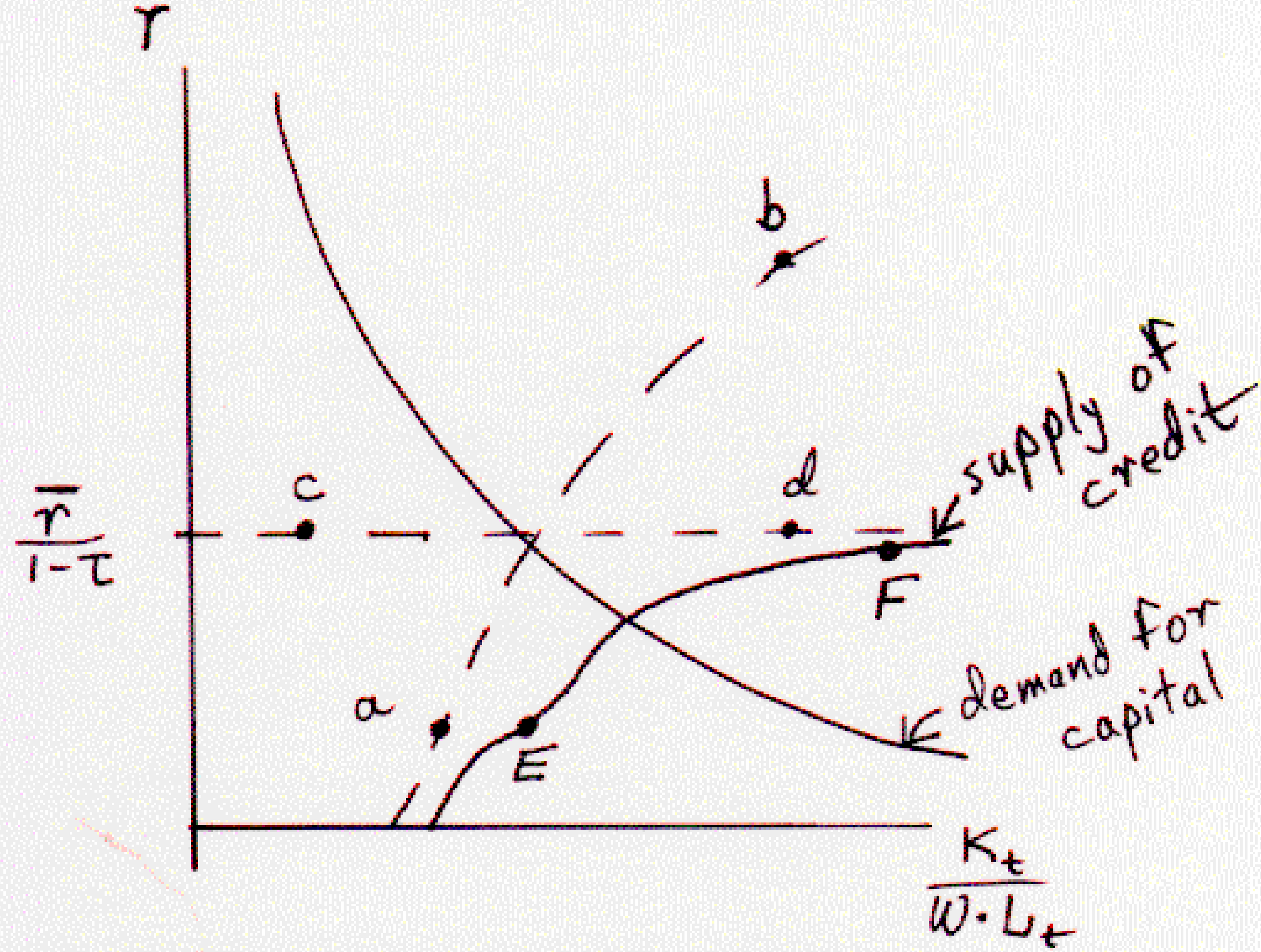

Figure 3: The demand for capital and supply of financing with this paper's hybrid model