# Estate Taxation and Human Capital with Information Externalities

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### Abstract

This paper investigates the effects of estate taxation when firms cannot directly observe worker skill levels. Imperfect labor market signaling gives rise to an information externality that causes workers to free-ride off of others' human capital acquisition. Inherited wealth exacerbates the information externality because risk-averse workers with larger inheritances exert less effort to acquire skills. By reducing these inheritances, an estate tax induces greater skill acquisition effort, resulting in a higher number of skilled workers, and in many cases, increased wages and output. In a parametrized model, I establish that the optimal estate tax rate is significantly above zero.

**Keywords:** Information externalities; signaling; free-rider problem; labor markets; bequests; inheritance taxes

**JEL Classification Numbers:** D62, D82, E21, E24, E60, H21

# 1 Introduction

Over a century ago, Andrew Carnegie observed that "the parent who leaves his son enormous wealth generally deadens the talents and energies of the son, and tempts him to lead a less useful and less worthy life than he otherwise would." More recently, Warren Buffett has echoed this sentiment by stating his intention not to leave a large fortune to his children. In this paper, I investigate the effect of inheritances on the effort people make to acquire labor market skills and the role estate taxation can play in mitigating any adverse consequences of inherited wealth.

To do so, I construct a theory of skill acquisition, imperfect labor market signaling, and inheritance heterogeneity. In a one period setting, I demonstrate theoretically that when firms cannot perfectly observe worker skills, an information externality arises that causes workers to free-ride off of others' human capital acquisition, resulting in too few skilled workers along with lower wages and output. With risk-averse workers, inheritances magnify the information externality because free-riding increases with inherited wealth. An estate tax can mitigate this externality by inducing higher effort, resulting in a more skilled workforce, higher wages, and higher output, *even when the government engages in wasteful spending with all the revenue.* The estate tax is progressive, with the resulting increase in wages leading to higher welfare for low inheritance households and lower welfare for households with the largest inheritances.

To understand the mechanism underlying these theoretical results, it is instructive to explore the nature of the information externality. In the model, only skilled workers are productive to firms, and firms only observe noisy signals of each worker's skill level. However, firms are also informed about

the overall proportion of skilled workers in the population. Firms form beliefs about the skill level of each worker based on the worker's signal and this proportion, resulting in signal-specific wages that are increasing in the share of skilled workers.

Workers' incentive to acquire skills comes from the fact that skilled workers are more likely to send positive signals to the labor market and thus to receive higher wages. The information externality arises because workers benefit from a higher overall proportion of skilled workers but do not internalize the effect of their own effort on that proportion. Instead, workers free-ride off of the skill acquisition of others. In the one period model, estate taxation reduces inherited wealth, thereby increasing workers' marginal utility of consumption and thus the gain to acquiring skills, partially reversing the effect of the information externality.

Next, I extend the one period model to an infinite horizon, dynastic OLG model with capital accumulation and incomplete markets. Youth exert effort to acquire lifelong labor market skills, after which point they become workers who enter a spot labor market each period and signal employers about their skill level. This dynamic setting introduces two additional effects of the estate tax. First, imperfect skill signaling acts as a form of uninsurable idiosyncratic risk to households when markets are incomplete, with estate taxation providing one means of social insurance against this risk. Second, estate taxation alters the incentive of altruistic households to acquire capital and leave bequests to their descendants.

In a parameterized version of the dynamic model, I show that, depending on the degree of altruism and on how revenues are used, the estate tax can increase the share of skilled workers and lead to higher wages and output. When youth receive only accidental bequests arising from mortality risk, the

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estate tax does not distort capital accumulation decisions. Therefore, even when the government wastefully spends all the revenue, the estate tax leads to additional skilled workers, higher wages, and higher output. Using the tax to finance lump sum transfers reverses the increase in skilled workers due to the convexity of youth effort choice in assets, but financing high-signal wage subsidies with the revenue leads to large increases in the number of skilled workers, wages, output, and welfare. When households exhibit perfect altruism toward their descendants, the estate tax reduces the incentive to accumulate wealth. Even so, financing high-signal wage subsidies with the estate tax causes an increase in skilled workers large enough to offset the reduced capital stock, resulting in higher output and welfare.

Lastly, I compute the estate tax rate that a benevolent social planner would choose to maximize ex-ante youth welfare. I show that the optimal estate tax is significantly above zero and depends on the degree of altruism and labor market signal accuracy. With only accidental bequests, the optimal estate tax ranges from 96% for high signal accuracy to 100% for low signal accuracy with accompanying welfare gains ranging from 1.78% to 12.05% of lifetime consumption. With perfect altruism, the optimal estate tax ranges from 25% for high signal accuracy to 98% for low signal accuracy with accompanying welfare gains ranging from 0.24% to 7.50% of lifetime consumption. When taking into account the transition path of the economy following implementation of the estate tax, population welfare gains in the model without altruistic bequests range from 3.86% to 8.04% of lifetime consumption, with over 98% of households in favor of the policy change. In the model with perfect altruism, welfare gains with the transition range from 0.51% to 6.17% of lifetime consumption, with between 77% and 99% of households benefiting.

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## 1.1 Related Literature

The information externality in this paper is similar to the one studied by Fang and Norman (2006), who investigate the effects of government-mandated discrimination in public sector hiring. They show that, under certain conditions, discrimination can be a net benefit for the discriminated group by partially alleviating the information externality. With a similar type of information externality, Popov and Bernhardt (2012) show that fraternity membership affects future labor market outcomes when firms cannot perfectly evaluate student productivities. Norman (2003) explicitly investigates the efficiency of statistical discrimination and shows that discrimination can reduce mismatch between workers and jobs. Lockwood (1991) studies a labor market model where firms imperfectly test workers prior to hiring them, giving rise to an information externality when some firms only hire workers who pass the test.

Several papers provide empirical evidence on the effect of inheritances on labor market decisions. Holtz-Eakin, Joulfaian and Rosen (1993) find that large inheritances have a sizable, negative effect on labor force participation. They find evidence of a smaller negative effect along the intensive margin, although Joulfaian and Wilhelm (1994) point out that the effect is larger when workers expect to receive additional inheritances.[1] Recently, Brown, Coile and Weisbenner (2010) show that the receipt of inheritance wealth is positively associated with earlier retirement. Bø, Halvorsen and Thoresen (2012) and Elinder, Erixson and Ohlsson (2012) find that labor income decreases following the receipt of inheritances.

This paper is also closely related to the literature on optimal taxation. Farhi and Werning (2010) analyze optimal estate taxation in an economy with

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[1]Expectation of a future inheritance or inter vivos transfer is more relevant for the mechanism in this paper, which arises from skill acquisition choices made earlier in life.

altruistic parents and heterogeneous productivity. Piketty and Saez (2013) develop a theory of optimal capital taxation with imperfect capital markets and heterogeneous random tastes for bequests. In the new dynamic public finance literature, Golosov, Kocherlakota and Tsyvinski (2003) establish the optimality of positive capital taxes to induce higher worker effort in economies with private information about worker skill levels. Lastly, several papers, including Bas and Bovenberg (2010), Kapicka and Neira (2013), Benabou (2002), Erosa and Koreshkova (2007), Bohacek and Kapicka (2008), and Krueger and Ludwig (2013) study optimal taxation with endogenous human capital.

## 2 The Static Model

### 2.1 Households

There is a continuum of households $i \in [0, 1]$, with agent $i$ receiving inheritance $a(i)$. The distribution of inheritances is given by the cdf $\Omega(a)$ with compact support $[0, \bar{a}]$ and continuous density function $f_\Omega(a)$. Households inelastically supply one unit of time to the labor market. However, only skilled workers are productive, with skilled workers supplying $x(i) = 1$ units of effective labor and unskilled workers supplying $x(i) = 0$ units of effective labor. Household preferences over consumption $c$ and effort $e$ spent acquiring skills are given by

$$U(c, e) = u(c) - v(e)$$

where $c \in \mathbb{R}_+$ and $e \in [0, 1]$. Consumption utility $u(c)$ is strictly increasing, continuously differentiable, and strictly concave. Effort disutility $v(e)$ is strictly increasing, twice continuously differentiable, and strictly convex.

Effort affects the probability of acquiring skills according to a Bernoulli distribution,

$$x(i) = \begin{cases} 1 & \text{with probability } e(i) \\ 0 & \text{with probability } 1 - e(i). \end{cases}$$

Workers' skill levels are private information. Upon entering the labor market, each worker sends an imprecise signal $s(i) \in \{l, h\}$ of its skill level to the labor market, with signal accuracy $p$ satisfying

$$p = \mathbb{P}(s(i) = h | x(i) = 1) = \mathbb{P}(s(i) = l | x(i) = 0) > \frac{1}{2}.$$

## 2.2 Firms

Firms use skilled labor $L$ to produce output $Y$ according to

$$Y = AL.$$

Unable to directly identify and hire only skilled workers, firms engage in Bertrand competition to hire low-signal and high-signal workers. Wages $w_s(\pi)$ equal the expected marginal product of each worker conditional on signal $s \in \{l, h\}$ and the commonly known fraction $\pi$ of skilled workers in the population.

## 2.3 Decision Problems

At the beginning of the period, workers make their effort choice, knowing their inheritance $a$, the proportional estate tax rate $\tau$, and the fraction $\pi$ of skilled workers in the population. After effort choices are made, workers discover whether they have acquired skills. Workers then enter the labor market, send

their signals to employers, and receive their wages after production occurs. The government uses the estate tax revenue for wasteful spending.

### 2.3.1 Household's Problem

A household with assets $a$ chooses effort $e$ to solve

$$V(a; \pi, \tau) = \max_{e \in [0,1]} [ep + (1 - e)(1 - p)]u(w_h(\pi) + a(1 - \tau))$$
$$+ [e(1 - p) + (1 - e)p]u(w_l(\pi) + a(1 - \tau)) - v(e) \tag{1}$$

Let $e(a; \pi, \tau)$ denote the household's effort policy function. Lemma 1 in the next section establishes the continuity of $e(a; \pi, \tau)$ in both $a$ and $\pi$.

### 2.3.2 Firm's Problem

Firms' beliefs about the skill level of a worker with signal $s(i)$ are given by

$$\mathbb{P}(x(i) = 1|s(i) = h) = \frac{\pi p}{\pi p + (1 - \pi)(1 - p)},$$
$$\mathbb{P}(x(i) = 1|s(i) = l) = \frac{\pi(1 - p)}{\pi(1 - p) + (1 - \pi)p}$$

From the law of large numbers, a firm hiring $L_h$ high-signal workers and $L_l$ low-signal workers receives effective labor $L$ equal to

$$L = \mathbb{P}(x(i) = 1|s(i) = h)L_h + \mathbb{P}(x(i) = 1|s(i) = l)L_l.$$

Therefore, firms choose $L_h$ and $L_l$ to solve

$$\max_{L_l, L_h} A \left[ \frac{\pi p}{\pi p + (1 - \pi)(1 - p)} L_h + \frac{\pi(1 - p)}{\pi(1 - p) + (1 - \pi)p} L_l \right] - w_h L_h - w_l L_l$$

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The necessary and sufficient conditions for profit maximization are

$$w_h(\pi) = \frac{\pi p}{\pi p + (1 - \pi)(1 - p)} A \tag{2}$$

$$w_l(\pi) = \frac{\pi(1 - p)}{\pi(1 - p) + (1 - \pi)p} A. \tag{3}$$

## 2.4 Equilibrium

Given beliefs $\pi$ about the population fraction of skilled workers, the actual fraction of workers that become skilled, and thus aggregate effective labor supply, is $L = \int e(a; \pi, \tau) d\Omega(a)$.

**Definition 1** *A Perfect Bayesian Nash Equilibrium is*

- *Household value and policy functions $V(a; \pi, \tau)$ and $e(a; \pi, \tau)$*

- *Wages $w_h(\pi)$ and $w_l(\pi)$*

- *Beliefs $\pi^*$ about the skilled fraction of the population*

*such that*

1. ***Household Optimization:*** *The household value and policy functions solve the household's problem, (1).*

2. ***Firm Optimization:*** *Wages satisfy (2) − (3).*

3. ***Consistency of Beliefs:*** $\pi^* = \int e(a; \pi^*, \tau) d\Omega(a)$.

# 3 Theoretical Results

This section proves the existence of a Perfect Bayesian Nash Equilibrium, analyzes its efficiency, and then looks at the welfare effects of estate taxes. Recall the following assumptions:

1. $u(c)$ is strictly increasing, continuously differentiable, and strictly concave; $v(e)$ is strictly increasing, twice continuously differentiable, and strictly convex.

2. $v(0) = 0$, $v'(0) = 0$ and $\lim_{e \to 1} v'(e) = +\infty$.

First, I establish some properties of household effort choice.

**Lemma 1** *Effort $e(a; \pi, \tau)$ is a continuous, single-valued function in $a$ and $\pi$.*

**Proof.** The worker's objective function is continuous and defined over a compact domain, $[0, 1]$. Therefore, the Extreme Value Theorem establishes that a solution exists.

Furthermore, the worker's objective function is strictly convex in $e$ because of the strict convexity of $v$. As a result, $e(a; \pi, \tau)$ is single-valued in $a$ and $\pi$.

Firms' beliefs $\mathbb{P}(x = 1 | s = h)$ and $\mathbb{P}(x = 1 | s = l)$ are continuous in $\pi$. Therefore, $w_h(\pi)$ and $w_l(\pi)$ are continuous in $\pi$. Because the choice set for $e$ does not vary with $a$ or $\pi$, and because the worker's objective function is continuous in $e$, $a$ and $\pi$, an application of Berge's Maximum Theorem establishes that $e(a; \pi, \tau)$ is upper hemi-continuous. Because $e(a; \pi, \tau)$ is single-valued, it is also continuous. ∎

**Lemma 2** *Effort $e(a; \pi, \tau)$ is interior and satisfies the first-order condition*

$$v'(e(a; \pi, \tau)) = (2p - 1)[u(w_h(\pi) + a(1 - \tau)) - u(w_l(\pi) + a(1 - \tau))]$$

**Proof.** The only constraint that $e$ must satisfy is linear, $0 \le e \le 1$, implying that the constraint qualification in the Kuhn-Tucker Theorem is satisfied, and

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thus,

$$(2p-1)[u(w_h(\pi)+a(1-\tau))-u(w_l(\pi)+a(1-\tau))]-v'(e(a;\pi,\tau))+\lambda_0-\lambda_1=0$$

where $\lambda_0$ is the Lagrange multiplier on the constraint $e \geq 0$ and $\lambda_1$ is the Lagrange multiplier on the constraint $1 - e \geq 0$.

By assumption 4, $\lim_{e \to 1} v'(e) = +\infty$, implying that $e < 1$ and hence $\lambda_1 = 0$.

The non-negativity constraint is also never binding, implying that $\lambda_0 = 0$. To see why, suppose that $\lambda_0 > 0$. Then $e = 0$ and $\lambda_0 = -(2p-1)[u(w_h(\pi)+a(1-\tau))-u(w_l(\pi)+a(1-\tau))]$ because $v'(0) = 0$. Because $w_h(\pi) \leq w_l(\pi)$ and $u(c)$ is an increasing function, $\lambda_0 \leq 0$, which is a contradiction. Therefore, $\lambda_0 = 0$ and, furthermore, $e = 0$ iff $w_h(\pi) = w_l(\pi)$. ∎

## 3.1 Existence

Now I establish sufficient conditions for the existence of a Perfect Bayesian Nash Equilibrium with a non-trivial fraction $\pi^* > 0$ of skilled workers.

**Theorem 1 (Existence of Perfect Bayesian Nash Equilibrium)** *Given* $\tau \in [0,1]$, *a non-trivial* ($\pi^* > 0$) *Perfect Bayesian Nash Equilibrium exists if*

$$\mathbb{E}_\Omega[u'(a(1-\tau))] > \frac{p(1-p)v''(0)}{(2p-1)^2 A}$$

**Proof.** Define $\phi(\pi,\tau) = \int e(a;\pi,\tau)d\Omega(a)$ and $g(\pi,\tau) = \phi(\pi,\tau) - \pi$. A non-trivial equilibrium is $\pi^* \in (0,1]$ such that $\phi(\pi^*) = \pi^*$, i.e. $g(\pi^*,\tau) = 0$.

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Note that $w_h(0) = w_l(0)$ and $w_h(1) = w_l(1)$. Therefore, workers do not exert any effort if $\pi = 0$ or $\pi = 1$, i.e. $e(a; 0, \tau) = e(a; 1, \tau) = 0 \ \forall a \in [0, \bar{a}]$ and $\tau \in [0, 1]$. Therefore, $\phi(0) = \phi(1) = 0$, implying that $g(0) = 0$ and $g(1) = -1 < 0$.

To show existence of $\pi^* > 0$, I first show that $\exists \pi \in (0, 1)$ such that $g(\pi, \tau) > 0$. Then, by the Intermediate Value Theorem, $\exists \pi^* \in (\pi, 1]$ such that $g(\pi^*, \tau) = 0$. To show the first claim, it suffices to show that $\phi(\pi, \tau)$ is differentiable in $\pi$ at the origin and $\phi_\pi(0, \tau) > 1$.

Define $f(e, \pi, \tau; a) = v'(e) - (2p-1)[u(w_h(\pi) + a(1-\tau)) - u(w_l(\pi) + a(1-\tau))]$. The first-order condition for $e(a; \pi, \tau)$ becomes $f(e, \pi, \tau; a) = 0 \ \forall a \in [0, \bar{a}]$.

Because $v \in C^2$ and $u \in C^1$, $f \in C^1$ with $f(0, 0, \tau; a) = 0$. Thus, given $a$ and $\tau$, the Implicit Function Theorem states that there exists an open neighborhood $\mathcal{N}_\varepsilon(0)$ about $\pi = 0$ for some $\varepsilon > 0$ such that $e(a; \pi, \tau) \in C^1 \ \forall \pi \in \mathcal{N}_\varepsilon(0) \bigcap [0, 1]$. Furthermore,

$$\left. \frac{\partial e}{\partial \pi} \right|_{\pi=0} = - \left. \frac{f_\pi}{f_e} \right|_{\pi=0} = \frac{1}{v''(\underbrace{e(a; 0, \tau)}_{0})}(2p-1)u'(a(1-\tau)) \left. \left( \frac{\partial w_h}{\partial \pi} - \frac{\partial w_l}{\partial \pi} \right) \right|_{\pi=0}.$$

Differentiating $w_h(\pi) - w_l(\pi) = \dfrac{\pi p}{\pi p + (1-\pi)(1-p)}A - \dfrac{\pi(1-p)}{\pi(1-p) + (1-\pi)p}A$ at $\pi = 0$ gives

$$\left. \left( \frac{\partial w_h}{\partial \pi} - \frac{\partial w_l}{\partial \pi} \right) \right|_{\pi=0} = \frac{(2p-1)A}{p(1-p)}.$$

Therefore, $\left. \dfrac{\partial e}{\partial \pi} \right|_{\pi=0} = \dfrac{(2p-1)^2 A u'(a(1-\tau))}{p(1-p)v''(0)}.$

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The above expression holds for all $a$, and because $e(a; \pi, \tau)$ is a bounded, continuous (and thus measurable) function, it follows that $\phi$ is differentiable at the origin and

$$\phi_\pi(0, \tau) = \frac{\partial}{\partial \pi}\bigg|_{\pi=0} \int e(a; \pi, \tau) d\Omega(a) = \int \frac{\partial e(a; \pi, \tau)}{\partial \pi}\bigg|_{\pi=0} d\Omega(a)$$
$$= \int \frac{(2p-1)^2 A u'(a(1-\tau))}{p(1-p)v''(0)} d\Omega(a) = \mathbb{E}_\Omega \left[\frac{(2p-1)^2 A u'(a(1-\tau))}{p(1-p)v''(0)}\right].$$

Therefore, a non-trivial Perfect Bayesian Nash Equilibrium exists if

$$\phi_\pi(0, \tau) > 1 \Leftrightarrow \mathbb{E}_\Omega[u'(a(1-\tau))] > \frac{p(1-p)v''(0)}{(2p-1)^2 A}.$$

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## 3.2  Efficiency and Welfare

The marginal benefit of increased effort to acquire skills is

$$I(\pi, a, \tau) = (2p-1)[u(w_h(\pi) + a(1-\tau)) - u(w_l(\pi) + a(1-\tau))]$$

and the marginal cost is $v'(e)$.

By increasing effort, workers are more likely to acquire skills, and therefore more likely to send a high signal to the labor market and receive a higher wage. Wages are higher for high-signal workers precisely because firms know that such workers have a greater probability of being skilled than low-signal workers. Note that $I(\pi, a, \tau)$ depends on the population fraction $\pi$ of skilled workers, with $I(\pi, a, \tau) = 0$ when $\pi = 0$ and also when $\pi = 1$. Therefore, for low $\pi$, an increase in $\pi$ increases the incentive to exert effort, making effort and $\pi$ complementary. However, for high $\pi$, further increases in $\pi$ decrease

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the incentive to exert effort.

In either case, $\pi$ is a public good because each worker's effort choice contributes to $\pi$ and all workers benefit from higher $\pi$. Workers, however, do not consider the impact of their effort on $\pi$, thereby underinvesting in effort. In short, the imprecise signaling of skills gives rise to an informational externality that causes workers to engage in informational free-riding. Theorem 2 formalizes this inefficiency result.

**Theorem 2 (Inefficiency of No-Tax Equilibrium)** *The Perfect Bayesian Nash Equilibrium with $\tau = 0$ is inefficient with too few skilled workers, $\pi^* < \pi^{opt}$.*

**Proof.** Recall that, given $\pi$, a worker with assets $a$ chooses effort $e(a; \pi, 0)$ such that

$$v'(e(a; \pi, 0)) = I(\pi, a, 0) = (2p - 1)[u(w_h(\pi) + a) - u(w_l(\pi) + a)]$$

Unlike workers, a utilitarian social planner problem internalizes the effect of each worker's effort choice on aggregate skilled labor $\pi$, solving

$$W = \max_{\pi, e(a)} \int \{[e(a)p + (1 - e(a))(1 - p)]u(w_h(\pi) + a)$$
$$+ [e(a)(1 - p) + (1 - e(a))p]u(w_l(\pi) + a) - v(e)\} \, d\Omega(a)$$
$$\text{subject to}$$
$$\pi = \int e(a) d\Omega(a)$$

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The social planner's choice $e(a)$ satisfies the first-order condition

$$v'(e(a)) = \underbrace{(2p-1)[u(w_h(\pi^{opt})+a) - u(w_l(\pi^{opt})+a)]}_{=I(\pi^{opt},a,0)=v'(e(a;\pi^{opt},0))} + f_\Omega(a)\left\{[e(a)p + (1-e(a))(1-p)]\right.$$

$$\left. \times u'(w_h(\pi^{opt})+a)\frac{\partial w_h}{\partial \pi} + [e(a)(1-p) + (1-e(a))p]u'(w_l(\pi^{opt})+a)\frac{\partial w_l}{\partial \pi}\right\}$$

where $\pi^{opt} = \int e(a)d\Omega(a)$.

The first term corresponds to the first-order condition of the worker's effort choice when $\pi = \pi^{opt}$. Therefore, $v'(e(a)) > v'(e(a;\pi^{opt},0))$ because the derivatives $u' > 0$, $\frac{\partial w_h}{\partial \pi} > 0$, and $\frac{\partial w_l}{\partial \pi} > 0$. From the strict convexity of the effort cost function, the condition $v'(e(a)) > v'(e(a;\pi^{opt},0))$ implies that $e(a) > e(a;\pi^{opt},0)$.

Therefore, $\pi^{opt} = \int e(a)d\Omega(a) > \int e(a;\pi^{opt},0)d\Omega(a)$, implying that $\phi(\pi^{opt},0) < \pi^{opt}$ and $g(\pi^{opt},0) < 0$, where $\phi$ and $g$ are as defined in the proof of equilibrium existence. Because $g(\pi,0) \geq 0 \; \forall \pi \in [0,\pi^*]$, it must be that $\pi^{opt} > \pi^*$. Therefore, the optimal skilled fraction of the population is greater than the equilibrium skilled fraction. ∎

## 3.3  Inheritance, Effort, and the Estate Tax

With risk-averse workers, the presence of inheritances exacerbates the effort distortion from the information externality. Higher inheritances reduce marginal utility and thus the incentive to exert effort, $I(\pi,a,\tau)$. Lemma 3 formally establishes that effort is decreasing in inherited assets.

**Lemma 3** *Effort $e(a;\pi,\tau)$ is decreasing in assets $a$ and increasing in the estate tax rate $\tau$.*

**Proof.** Recall that effort is determined implicitly by the condition $f(e, \pi, \tau; a) = 0$. Applying the Implicit Function Theorem and differentiating with respect to $a$ gives

$$\frac{\partial e}{\partial a} = -\frac{f_a}{f_e} = \underbrace{\frac{(2p-1)(1-\tau)}{v''(e(a; \pi, \tau))}}_{>0} \underbrace{[u'(w_h + a(1-\tau)) - u'(w_l + a(1-\tau))]}_{<0} < 0$$

The strict convexity of $v$ implies that the first term is strictly positive. The strict concavity of $u$ and the inequality $w_h > w_l$ imply that the second term is strictly negative. Therefore, effort is decreasing in assets. Also, effort is clearly increasing in the estate tax rate because

$$\frac{\partial e}{\partial \tau} = -\frac{a}{1-\tau}\frac{\partial e}{\partial a} > 0.$$

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By decreasing inheritances, an estate tax can mitigate the depressing effect of initial wealth on effort, thus leading to a higher proportion $\pi$ of skilled workers in the population. Because of the information externality, an increase in $\pi$ leads to higher wages for both high-signal and low-signal workers. Lemma 4 formalizes this result.

**Definition 2** *Let the (non-trivial) equilibrium skilled proportion of the population as a function of the tax rate be given implicitly by $\pi(\tau) = \phi(\pi(\tau), \tau)$, where $\phi(\pi, \tau) = \int e(a; \pi, \tau) d\Omega(a)$.*

**Lemma 4** *If $\phi_\pi(0, 0) > 1$ (which is equivalent to substituting $\tau = 0$ into the condition in theorem 1), then the equilibrium skilled proportion of the population increases in the estate tax rate, i.e. $\pi(\tau') > \pi(\tau)$ for all $\tau' > \tau$.*

**Proof.** The condition $\phi_\pi(0,0) > 1$ ensures that a non-trivial equilibrium exists for $\tau = 0$ and therefore for all $\tau > 0$, because of the concavity of $u$.

The partial derivative of $e(a; \pi, \tau)$ with respect to $\tau$ at $(a; \pi(\tau), \tau)$ is given by the Implicit Function Theorem,

$$\frac{\partial e}{\partial \tau} = -\frac{f_\tau}{f_e} = \frac{(2p-1)a}{v''(e(a; \pi(\tau), \tau))}[u'(w_l(\pi) + a(1-\tau)) - u'(w_h(\pi) + a(1-\tau))]$$

The strict convexity of $v$ implies that the denominator is strictly positive. Furthermore, the strict concavity of $u$ and the inequality $w_l(\pi(\tau)) < w_h(\pi(\tau))$ imply that the numerator is also strictly positive. Thus,

$$\frac{\partial e(a; \pi(\tau), \tau)}{\partial \tau} > 0 \ \forall a \in [0, \bar{a}], \text{ implying that } \phi_\tau(\pi, \tau)|_{\pi = \pi(\tau)} > 0 \text{ and } g_\tau(\pi, \tau)|_{\pi = \pi(\tau)} > 0.$$

Now consider two tax rates, $\tau' > \tau$. Equilibrium $\pi(\tau)$ satisfies $g(\pi(\tau), \tau) = 0$. From the above result, $g_\tau(\pi(\tau), \tau) > 0$, there must exist some $\pi > \pi(\tau)$ such that $g(\pi, \tau) > g(\pi(\tau), \tau) = 0$.

From the Intermediate Value Theorem, $\exists \pi(\tau') > \pi > \pi(\tau)$ such that $g(\pi(\tau'), \tau') = 0$. In other words, higher tax rates cause a higher equilibrium proportion of skilled workers, $\pi(\tau') > \pi(\tau)$.

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Theorem 3 demonstrates that an increase in the estate tax leads to welfare gains for low-asset households, *even when all the revenue is used for wasteful government spending.* By increasing the equilibrium fraction of skilled workers, the estate tax shrinks the information externality and causes wages to increase for all workers. For low-inheritance households, the benefit of higher wages more than compensates for the loss in initial wealth, making the estate tax a
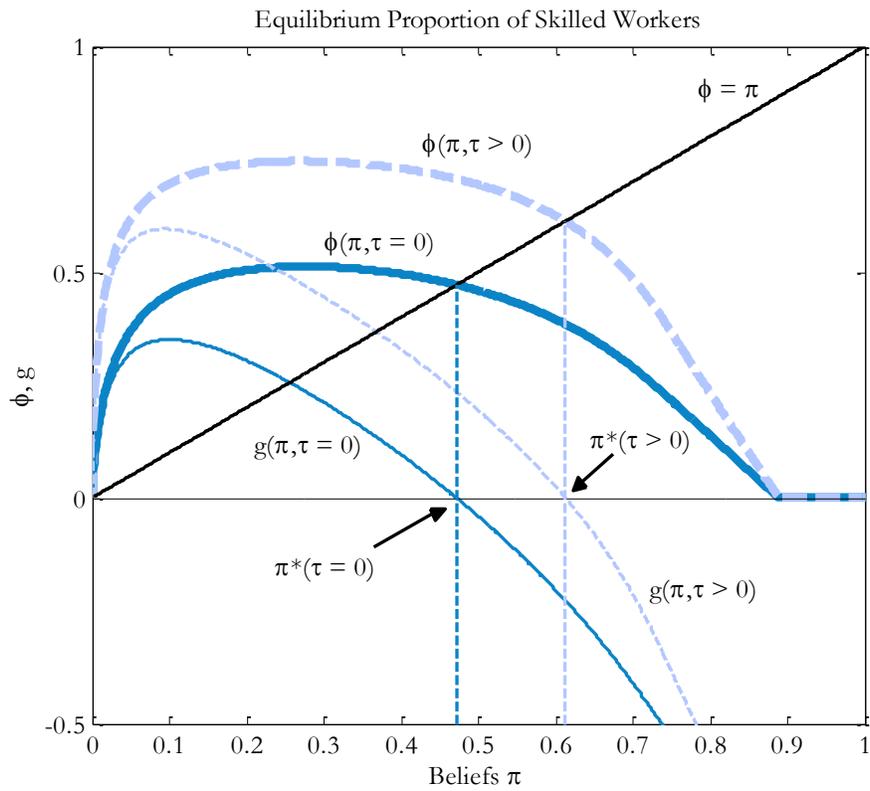
Figure 1: The equilibrium proportion of skilled workers for $\tau = 0$ and $\tau > 0$.

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progressive policy intervention.

**Definition 3** *Let $V(a; \pi(\tau), \tau)$ be the equilibrium welfare of a worker with inheritance $a$, given the estate tax rate $\tau$.*

**Theorem 3** *If $\phi_\pi(0,0) > 1$, then $\forall \tau \in [0,1)$ $\exists a(\tau) \in (0, \bar{a}]$ such that $\frac{dV(a; \pi(\tau), \tau)}{d\tau} > 0$ $\forall a < a(\tau)$. In words, there is a positive measure of workers with inheritance $a < a(\tau)$ for whom a small increase in the estate tax is welfare improving.*

**Proof.** From previous results that $e(a; \pi, \tau) \in C^1$ and $\pi(\tau) \in C^1$, $V(a; \pi(\tau), \tau)$ is continuously differentiable. Now consider a worker with no inheritance, namely, $a = 0$. Totally differentiating $V(0; \pi(\tau), \tau)$ gives

$$\frac{dV(0; \pi(\tau), \tau)}{d\tau} = \frac{\partial V(0; \pi(\tau), \tau)}{\partial \pi} \pi'(\tau) + \frac{\partial V(0; \pi(\tau), \tau)}{\partial \tau}.$$

For this worker with no inheritance,

$$V(0; \pi(\tau), \tau) = \max_{e \in [0,1]} [ep + (1-e)(1-p)]u(w_h(\pi(\tau))) + [e(1-p) + (1-e)p]u(w_l(\pi(\tau))) - v(e)$$

The envelope theorem and the fact that $\tau$ does not directly appear in the right-hand side of the above expression imply that

$$\frac{\partial V(0; \pi(\tau), \tau)}{\partial \tau} = 0$$
$$\frac{\partial V(0; \pi(\tau), \tau)}{\partial \pi} = [e(0; \pi(\tau), \tau)p + (1 - e(0; \pi(\tau), \tau))(1-p)]u'(w_h(\pi(\tau)))\frac{\partial w_h}{\partial \pi}$$
$$+ [e(0; \pi(\tau), \tau)(1-p) + (1 - e(0; \pi(\tau), \tau))p]u'(w_l(\pi(\tau)))\frac{\partial w_l}{\partial \pi}$$

Therefore, $\frac{dV(0; \pi(\tau), \tau)}{d\tau} > 0$ because $u' > 0$, $\frac{\partial w_h}{\partial \pi} > 0$, $\frac{\partial w_l}{\partial \pi} > 0$, and $\pi'(\tau) > 0$.

Now suppose that $\exists \hat{a} \in (0, \bar{a}]$ such that $\frac{dV(a; \pi(\tau), \tau)}{d\tau} \leq 0$ (otherwise the desired

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result trivially holds). By the Intermediate Value Theorem, $\exists a(\tau) \in (0, \widehat{a}]$ such that $\frac{dV(a(\tau);\pi(\tau),\tau)}{d\tau} = 0$, and by the continuity of $\frac{dV(a;\pi(\tau),\tau)}{d\tau}$, the result is $\frac{dV(a;\pi(\tau),\tau)}{d\tau} > 0 \ \forall a < a(\tau)$. ∎

This theorem does not establish whether a majority of households benefit from a higher estate tax, nor does it indicate what estate tax rate a utilitarian social planner would choose. Furthermore, by considering only a static environment, the one period model ignores possible effects that an estate tax has on capital accumulation and bequests. I investigate these issues in the remainder of the paper.

# 4 The Dynamic Model

This section extends the one period model to a dynamic setting. In the next section, I use a parametrized version of the model to analyze the effects of estate taxation and to solve for the optimal estate tax rate.

## 4.1 Households

Households face an infinite horizon and a constant mortality risk each period with survival probability $\varphi$. When a household with assets $a$ dies, it is replaced by a new household which inherits $a$ and pays a proportional estate tax $\tau$. New households—youth—make a one-time effort choice to acquire skills. Youth who acquire skills remain skilled until they die, and youth who do not acquire skills remain unskilled without any future opportunity to become skilled. Effort disutility is $v(e)$, period consumption utility is $u(c_t)$, and households have discount factor $\beta$.

Each period, skilled and unskilled workers enter a spot market for labor

and send a signal $s_t \in \{0, 1\}$ to employers, where $s_t = 0$ is a low signal and $s_t = 1$ is a high signal. The accuracy of the signal $p$ satisfies

$$p = \mathbb{P}(s_t = 1 | x = 1) = \mathbb{P}(s_t = 0 | x = 0) > \frac{1}{2}.$$

These imprecise, stochastic labor market signals affect the wage that a worker receives, thereby acting as a source of idiosyncratic risk. Financial markets are incomplete, with workers only able to self-insure by accumulating assets (capital). Households lend capital to firms and earn return $r_t$.

I consider two versions of the model. In the baseline version, there is no bequest motive, implying that youth only receive accidental bequests arising from mortality risk. In the second version, I assume that households are perfectly altruistic and actively accumulate savings to pass on to the next generation. Let $\psi \in \{0, 1\}$ denote the degree of altruism.

## 4.2  Firms

Firms operate a constant returns to scale technology using capital $K_t$ and skilled labor $L_t$,

$$Y_t = F(K_t, L_t).$$

As in the static model, firms cannot directly observe worker skill levels. Furthermore, firms cannot learn a worker's skill level over time because hiring is contracted in a spot market each period. Instead, firms engage in Bertrand competition for high-signal and low-signal workers each period, resulting in signal-specific wages $w_{s,t}$ that also depend on the percentage $\pi_t$ of skilled workers in the economy.

## 4.3 Government Policy

The government taxes inherited wealth at the proportional rate $\tau$. I consider four possible uses of the tax revenue: wasteful government spending, lump-sum rebates, wage subsidies for all youth, or wage subsidies only for youth receiving high signals. Let $T_{s,t}$ denote the transfer to youth with signal $s$.

## 4.4 Decision Problems

At the beginning of each period, youth exert effort $e$ to acquire skills. Afterward, all workers send signals to the labor market, production occurs, and workers receive their labor and capital income. Households then choose consumption $c$ and assets $a' \geq 0$.

A worker's individual state variables are skill level $x \in \{0, 1\}$ and cash at hand $y \in \mathbb{R}_+$. A youth's individual state is assets $a \in \mathbb{R}_+$. In what follows, I focus on the steady state economy.

### 4.4.1 Household's Problem

Workers have value function

$$V^x(y) = \max_{c \geq 0, a' \geq 0} u(c) + \beta \left\{ \varphi \left[ pV^x(y'_x) + (1-p)V^x(y'_{1-x}) \right] + (1-\varphi)\psi Y(a') \right\}$$

$$\text{subject to}$$

$$c + a' \leq y$$

$$y'_x = w_x + a'(1+r)$$

$$y'_{1-x} = w_{1-x} + a'(1+r)$$

$$(4)$$

Youth have value function

$$Y(a) = \max_{e \in [0,1]} \left[ \begin{array}{l} epV^1(y_1) + e(1-p)V^1(y_0) + (1-e)pV^0(y_0) \\ +(1-e)(1-p)V^0(y_1) - v(e) \end{array} \right]$$

where (5)

$$y_1 = w_1 + T_1 + a(1+r)(1-\tau)$$

$$y_0 = w_0 + T_0 + a(1+r)(1-\tau)$$

### 4.4.2 Firm's Problem

Firms choose $L_1$, $L_0$, and $K$ to solve

$$\max_{L_0, L_1} F \left( K, \underbrace{\frac{\pi p}{\pi p + (1-\pi)(1-p)} L_1 + \frac{\pi(1-p)}{\pi(1-p) + (1-\pi)p} L_0}_{\equiv L} \right) - w_1 L_1 - w_0 L_0 - (r+\delta)K$$

The necessary and sufficient conditions for profit maximization are

$$w_1 = \frac{\pi p}{\pi p + (1-\pi)(1-p)} F_L(K, L) \tag{6}$$

$$w_0 = \frac{\pi(1-p)}{\pi(1-p) + (1-\pi)p} F_L(K, L) \tag{7}$$

$$r = F_K(K, L) - \delta \tag{8}$$

## 4.5 Equilibrium

**Definition 4** *A Stationary Recursive Perfect Bayesian Nash Equilibrium is*

- *Household value and policy functions $V^x(y)$, $Y(a)$, $e(a)$, $c^x(y)$, and $a'^x(y)$*

- *Prices $w_1$, $w_0$, and $r$*

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- *Quantities $L_1$, $L_0$, and $K$*

- *Beliefs $\pi$ about the skilled fraction of the population*

- *Beginning-of-period measure $\mu_{youth}(a)$ of youth and end-of-period measure $\mu_{worker}(x, y)$ of workers*

*such that*

1. **Household Optimization:** *The household value and policy functions solve the household's problem, (4) – (5).*

2. **Firm Optimization:** *Prices satisfy (6) – (8).*

3. **Labor Markets Clear:** *$L_1 = \pi p + (1 - \pi)(1 - p)$ and $L_0 = \pi(1 - p) + (1 - \pi)p$, giving $L = \pi$.*

4. **Capital Market Clears:** *$K = \int a'^x(y)\mu_{worker}(dx, dy)$.*

5. **Goods Market Clears:** *$F(K, L) + (1 - \delta)K = \int c^x(y)\mu_{worker}(dx, dy) + \int a'^x(y)\mu_{worker}(dx, dy)$.*

6. **Consistency of Beliefs:** *$\pi = \int e(a)\tilde{\mu}_{youth}(da)$, where $\tilde{\mu}_{youth} = \frac{\mu_{youth}}{\int \mu_{youth}(da)}$.*

7. **Stationary Measures:** *The measures $\mu_{worker}$ and $\mu_{youth}$ are invariant with respect to the Markov process induced by stochastic skill acquisition, signaling, and all relevant policy functions.*

# 5   Dynamic Model Results

This section analyzes information externalities and estate taxation using a parametrized version of the dynamic model. After describing the parametrization, I demonstrate how the degree of labor market signal inaccuracy affects

equilibrium prices and allocations, both with and without altruistic bequests. From there, I analyze the effects of estate taxation under different assumptions about how the government uses the tax revenue. Lastly, I determine the optimal estate tax and its effect on the economy.

## 5.1 Parametrization

I focus on the baseline version of the model without altruistic bequests to parametrize the dynamic model. I set $p = 0.75$ a priori for the accuracy of the labor market signal but then check for robustness using less accurate ($p = 0.65$) and more accurate ($p = 0.85$) signals. The remainder of the parametrization is described below.

### 5.1.1 Households

I specify a constant relative risk aversion period utility function for consumption and quadratic disutility of effort,

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma} \text{ and } v(e) = \eta e^2,$$

with $\sigma = 2$ and $\eta = 0.2$. A risk aversion of 2 is common in the literature, and the choice $\eta = 0.2$ ensures that in all the computational experiments the skilled fraction of the population never gets too close to 0 or 1. I set the survival probability to $\varphi = 0.975$, giving households an average working lifespan of 40 years. The household discount factor is $\beta = 0.985$ to cause an effective discount rate without altruism of $\beta\varphi = 0.96$, resulting in a risk-free rate of approximately 4%.

### 5.1.2 Firms

I specify a Cobb Douglas production function

$$Y = AK^\alpha L^{1-\alpha}$$

with $\alpha = 0.36$, giving a 64% labor share. The depreciation rate of capital is $\delta = 0.1$, and I calibrate $A$ in the model to normalize baseline output to 1. When analyzing the model with a bequest motive, all parameters are kept the same except for $A$, which is recalibrated to normalize output.

## 5.2 No-Tax Equilibrium and Information Externalities

### 5.2.1 Equilibrium without Altruistic Bequests

Table 1 reports equilibrium prices and quantities for the baseline ($\psi = 0$) no-tax equilibrium for different values of signal accuracy $p$. A number of results stand out. First, the skilled fraction of workers $\pi$ increases with the accuracy of the labor market signal. As in the static model, the skilled worker share $\pi$ is a public signal that affects wage determination, and workers engage in informational free-riding by ignoring the contribution of their individual effort to $\pi$. As the labor market signal accuracy $p$ increases, the information externality diminishes and workers increase effort. In addition, equilibrium output and wages for high-signal and low-signal workers all increase with $p$.

However, the effect of signal accuracy on the capital-to-output ratio, and therefore on the marginal product of labor and the risk-free rate, is non-monotonic. On the one hand, higher wages resulting from greater signal accuracy give households more resources to allocate to capital accumulation. On the other hand, higher signal accuracy reduces idiosyncratic risk in the

Table 1: No-Tax Equilibria without Altruistic Bequests

|  | $p = 0.65$ | $p = 0.75$ | $p = 0.85$ |
|---|---|---|---|
| Skilled Worker % | 37.42% | 55.59% | 72.90% |
| Risk-Free Rate | 3.93% | 3.87% | 3.97% |
| Marg Prod of Labor | 1.149 | 1.151 | 1.147 |
| High-Signal Wage | 0.604 | 0.909 | 1.076 |
| Low-Signal Wage | 0.280 | 0.339 | 0.369 |
| Output | 0.672 | 1.000 | 1.306 |
| Capital-to-Output | 2.585 | 2.596 | 2.577 |

Comparison of equilibria without altruistic bequests
for different values of signal accuracy.

economy, causing households to engage in less precautionary saving. These two opposing forces result in an unambiguously larger capital stock when $p$ increases but in non-monotonic movements in the capital-to-output ratio and the marginal product of labor. Nevertheless, wages both for high-signal and low-signal workers increase substantially because the information wedges $1 - w_1/MPL$ and $1 - w_0/MPL$ shrink.

### 5.2.2 Equilibrium with Perfect Altruism

Table 2 reports equilibrium prices and quantities for the economy with perfect altruism ($\psi = 1$). Recall that all other parameters of the model are kept the same from the baseline model except for total factor productivity $A$, which is adjusted to re-normalize output to 1 when $p = 0.75$.

The equilibrium responds to changes in $p$ in much the same way as does the model without altruistic bequests, except here the capital-to-output ratio—and, therefore, the marginal product of labor and the risk-free rate— increase monotonically with the labor market signal accuracy. Setting $\psi = 1$ causes

Table 2: No-Tax Equilibria with Perfect Altruism

|  | $p = 0.65$ | $p = 0.75$ | $p = 0.85$ |
|---|---|---|---|
| Skilled Worker % | 40.66% | 59.38% | 75.98% |
| Risk-Free Rate | 1.35% | 1.09% | 0.97% |
| Marg Prod of Labor | 1.064 | 1.078 | 1.084 |
| High-Signal Wage | 0.596 | 0.878 | 1.027 |
| Low-Signal Wage | 0.287 | 0.353 | 0.388 |
| Output | 0.676 | 1.000 | 1.287 |
| Capital-to-Output | 3.171 | 3.248 | 3.282 |

Comparison of equilibria with perfect altruism for different values of signal accuracy.

workers to value the utility of their descendants, thereby giving workers another incentive to save. Thus, as high-signal and low-signal wages increase with $p$, workers allocate more resources to capital accumulation and estate building.

## 5.3 The Effects of Estate Taxation

To analyze the effects of estate taxation, I consider four possible uses of the tax revenue: wasteful government spending, lump-sum rebates to youth, wage subsidies to youth, and wage subsidies only to youth who receive a high signal upon entering the labor market. I report all results based on a signal accuracy of $p = 0.75$, both with and without altruistic bequests. In the next section, I compute optimal estate tax rates for different values of $p$ based on the best use of tax revenue.

### 5.3.1 Tax Revenues and the Government Budget Constraint

In all four cases, I restrict the government to run a balanced budget each period. In the stationary equilibrium, tax revenues are $REV = \tau \int a\mu_{youth}(da)$. With wasteful government spending, transfers to youth households are $T_1 = T_0 = 0$. With lump-sump transfers, youth households receive $T_1 = T_0 = REV/\int \mu_{youth}(da)$. If the government institutes wage subsidies for all youth, $T_1 = \gamma w_1$ and $T_0 = \gamma w_0$, where $\gamma$ is the subsidy rate. Lastly, $T_1 = \gamma_1 w_1$ and $T_0 = 0$ when the government subsidizes the wages only of high-signal youth. The subsidy rates $\gamma$ and $\gamma_1$ satisfy

$$REV = \gamma \left\{ w_1 \int [e(a)p + (1 - e(a))(1 - p)]\mu_{youth}(da) \right.$$
$$\left. + w_0 \int [e(a)(1 - p) + (1 - e(a))p]\mu_{youth}(da) \right\}$$
$$REV = \gamma_1 w_1 \int [e(a)p + (1 - e(a))(1 - p)]\mu_{youth}(da).$$

### 5.3.2 Estate Taxation without Altruistic Bequests

The effects of estate taxation depend significantly on how the revenues are used, as shown by table 3 in the case of a 50% estate tax without altruistic bequests. If the tax finances wasteful government spending, youth inherit less wealth and respond by increasing effort spent acquiring skills. In this case, the steady-state fraction of skilled workers increases from 55.59% to 58.37%. Though the tax causes a modest drop in the capital-to-output ratio because youth households begin life with lower wealth, the absence of a bequest motive means that the tax does not distort capital accumulation decisions. Furthermore, even as the marginal product of labor decreases because of the lower capital-to-output ratio, wages for all workers actually *increase with the*

*tax* because of a smaller information wedge. In addition, higher aggregate labor with the estate tax more than compensates for the decline in the capital stock, resulting in 3% *higher output* in steady state.

Table 3: Effects of a 50% Estate Tax with no Altruistic Bequests

|  | $\tau = 0$ | Tax Only | Rebate | Wage Subsidy | $w_1$ Subsidy |
|---|---|---|---|---|---|
| Skilled Worker % | 55.59% | 58.37% | 55.20% | 57.02% | 59.23% |
| Risk-Free Rate | 3.87% | 4.36% | 3.94% | 3.95% | 3.93% |
| Marg Prod of Labor | 1.151 | 1.129 | 1.148 | 1.147 | 1.148 |
| High-Signal Wage | 0.909 | 0.912 | 0.904 | 0.917 | 0.934 |
| Low-Signal Wage | 0.339 | 0.360 | 0.334 | 0.352 | 0.375 |
| Output | 1.000 | 1.030 | 0.990 | 1.022 | 1.063 |
| Capital-to-Output | 2.596 | 2.508 | 2.583 | 2.582 | 2.585 |

Comparison of pre-tax and post-tax equilibria for $p = 0.75$.

Tax-financed transfers to youth can either reinforce or counteract the wealth effect of estate taxation on skill acquisition effort. If the government refunds all tax revenues to young households through some type of transfer scheme, then youth do not experience a drop in aggregate wealth. However, as demonstrated in figure 2, the policy function for effort is strictly convex in inherited assets. Therefore, an estate tax with lump sum transfers actually reduces aggregate effort and the number of skilled workers by compressing the distribution of assets, leading to lower output and wages.

However, tax-financed wage subsidies increase the incentive to exert effort by magnifying the difference between low-signal and high-signal wages, especially when the subsidies only go to high-signal youth. As shown in table 3, the skilled worker share increases from 55.59% to 57.02% with uncontingent wage subsidies and to 59.23% with high-signal wage subsidies. Note that the effort-inducing effects of the estate tax alone account for 76% of the 3.64 per-
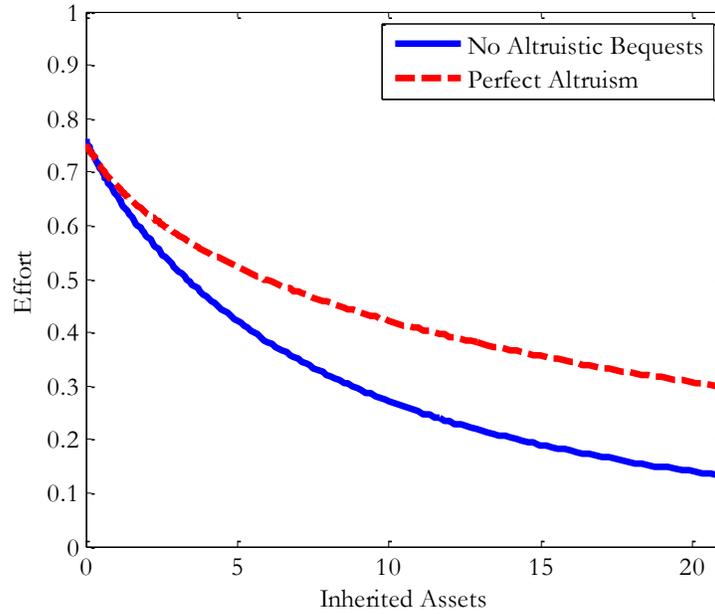
Figure 2: Skill acquisition effort as a function of inherited assets.

centage point increase, while the subsidy accounts for the remaining 24%. The tax and wage subsidies also cause 6% higher output, 2.75% higher wages for all high-signal workers, and 10.62% higher wages for all low-signal workers.

### 5.3.3 Estate Taxation with Perfect Altruism

Table 4 shows the effect of a 50% estate tax when households exhibit perfect altruism toward their descendants. In many respects, the results reflect those of the economy without altruistic bequests. When the tax finances wasteful government spending, both the skilled worker share and risk-free rate increase, from 59.38% to 61.98% and from 1.09% to 2.47%, respectively. However, the estate tax distorts the incentive to accumulate capital for perfectly altruistic households, causing the capital-to-output ratio to decrease by over 11%. As a result, high-signal wages and output decrease, and low-signal wages are es-

sentially unchanged. Lump sum transfers cause a further drop in output and wages by reversing the increase in the skilled worker share.

Table 4: Effects of a 50% Estate Tax with Perfect Altruism

|  | $\tau = 0$ | Tax Only | Rebate | Wage Subsidy | $w_1$ Subsidy |
|---|---|---|---|---|---|
| Skilled Worker % | 59.38% | 61.98% | 59.02% | 60.74% | 63.12% |
| Risk-Free Rate | 1.09% | 2.47% | 2.41% | 2.39% | 2.33% |
| Marg Prod of Labor | 1.078 | 1.009 | 1.011 | 1.012 | 1.015 |
| High-Signal Wage | 0.878 | 0.838 | 0.821 | 0.833 | 0.850 |
| Low-Signal Wage | 0.353 | 0.355 | 0.328 | 0.344 | 0.369 |
| Output | 1.000 | 0.977 | 0.933 | 0.961 | 1.001 |
| Capital-to-Output | 3.248 | 2.887 | 2.900 | 2.905 | 2.919 |

Comparison of pre-tax and post-tax equilibria for $p = 0.75$.

However, when the tax finances high-signal wage subsidies, the skilled worker share rises from 59.38% to 63.12%, and output *increases* by 0.1% because the increase in aggregate skilled labor offsets the drop in the capital-to-output ratio. The tax alone accounts for 70% of the 3.74 percentage point increase in the skilled worker share, while the subsidy accounts for the remaining 30%. Wage inequality drops because of a 3.19% decrease in high-signal wages and a 4.53% increase in low-signal wages.

## 5.4 Optimal Estate Taxation

Overall, the effects of an estate tax depend on the use of revenues and on the degree of altruism. With high-signal wage subsidies, the estate tax causes an increase in the skilled worker share, output, low-signal wages, and sometimes also high-signal wages. However, these benefits must be weighed against the cost of reduced initial youth wealth. In this section, I numerically solve the social planner's problem for the optimal (flat) estate tax rate, with tax rev-

enues financing high-signal youth wage subsidies. I assume that the social planner maximizes the ex-ante lifetime utility of youth households born into the stationary equilibrium implied by the chosen estate tax rate. The planner solves

$$\max_{\tau \in [0,1]} \int Y(a; \tau) \mu_{youth}(da; \tau).$$

By averaging ex-ante utility over all young households, this welfare function embeds the planner's concern for insuring households against idiosyncratic shocks. Therefore, the planner must trade off the insurance and labor market efficiency gains from estate taxation against its adverse effect on capital accumulation.

### 5.4.1  Optimal Estate Taxation without Altruistic Bequests

The optimal estate tax rate without altruistic bequests is 100% when $p = 0.65$ and $p = 0.75$, and the optimal rate is 96% when $p = 0.85$, as shown in table 5. These high optimal tax rates result in part because estate taxation does not distort households' capital accumulation decisions in the absence of altruistic bequests. Therefore, a higher estate tax translates to an increase in skilled workers, wages, and output. Furthermore, estate taxation coupled with wage subsidies act as a form of social insurance against the idiosyncratic risk generated by imperfect labor market signaling. As the labor market signal increases in accuracy, the information externality decreases, implying less idiosyncratic risk and smaller welfare gains from the estate tax. Nevertheless, the tax leads to sizable welfare gains for all three values of labor market signal accuracy.

Table 5: Optimal Estate Taxation without Altruistic Bequests

|  | $p = 0.65$ | $p = 0.75$ | $p = 0.85$ |
|---|---|---|---|
| *Tax Rate* | 100% | 100% | 96% |
| $\Delta$ *Welfare* | 12.05% | 4.89% | 1.78% |
|  |  |  |  |
| Skilled Worker % | 44.20% (37.42%) | 63.41% (55.59%) | 80.01% (72.90%) |
| Risk-Free Rate | 3.80% (3.93%) | 3.85% (3.87%) | 4.00% (3.97%) |
| High-Signal Wage | 0.687 (0.604) | 0.966 (0.909) | 1.097 (1.076) |
| Low-Signal Wage | 0.345 (0.280) | 0.422 (0.339) | 0.474 (0.369) |
| Output | 0.797 (0.672) | 1.142 (1.000) | 1.431 (1.306) |

Values for the no-tax equilibria are in parentheses.

### 5.4.2 Optimal Estate Taxation with Perfect Altruism

Optimal estate tax rates are lower in the economy with perfect altruism, reflecting the distorting effect estate taxes have on capital accumulation. As shown in table 6, the optimal tax rate is 98% when $p = 0.65$, 65% when $p = 0.75$, and 25% when $p = 0.85$. Implementing the optimal estate tax leads to sizeable welfare gains when $p = 0.65$ and $p = 0.75$ of 7.50% and 2.43%, respectively. However, welfare goes up by only a modest 0.24% when implementing the optimal estate tax for $p = 0.85$.

In all three cases, the optimal estate tax leads to an increase in skilled workers and a large spike in the risk-free rate. However, the impact of the estate tax on signal-specific wages and on output is not uniform. When the labor market signal is least accurate, the information externality is large enough to result in higher output and higher wages for all workers when the optimal estate tax is implemented, even with the decline in the capital stock. However, when $p = 0.75$ or $p = 0.85$, high-signal wages decrease after the estate tax is implemented while low-signal wages increase.

Table 6: Optimal Estate Taxation with Perfect Altruism

|                  | $p = 0.65$ | $p = 0.75$ | $p = 0.85$ |
|------------------|------------|------------|------------|
| *Tax Rate*       | 98%        | 65%        | 25%        |
| $\Delta$*Welfare* | 7.50%      | 2.43%      | 0.24%      |
|                  |            |            |            |
| Skilled Worker % | 47.54% (40.66%) | 64.30% (59.38%) | 77.70% (75.98%) |
| Risk-Free Rate   | 3.76% (1.35%) | 2.75% (1.09%) | 1.63% (0.97%) |
| High-Signal Wage | 0.599 (0.596) | 0.841 (0.878) | 0.999 (1.027) |
| Low-Signal Wage  | 0.313 (0.287) | 0.374 (0.353) | 0.400 (0.388) |
| Output           | 0.709 (0.676) | 1.001 (1.000) | 1.274 (1.287) |

Values for the no-tax equilibria are in parentheses.

### 5.4.3 Transition Paths and Welfare

As the previous results attest, implementing an estate tax with signal-contingent wage subsidies for youth can lead to large welfare gains. Furthermore, in addition to providing greater insurance of idiosyncratic risk, the estate tax in this economy can lead to significantly *higher* wages and output, contrary to conventional wisdom on the effects of wealth taxes. However, to gauge whether implementing such an estate tax scheme would benefit existing households, it is necessary to take into account the transition path of the economy from the no-tax equilibrium to the stationary equilibrium with the tax.

For youth, the transition reduces the welfare gains of the tax by front-loading the loss of wealth while delaying the increase in wages from the gradual climb in the skilled worker share. However, existing workers experience a windfall, as they receive gradually increasing wages without ever paying the estate tax themselves. The consumption equivalent welfare change for a young

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household with assets $a$ is given by

$$100 \left( \left[ \frac{Y(a; \tau)}{Y(a; 0)} \right]^{1/1-\sigma} - 1 \right)$$

and the consumption equivalent welfare change for an existing worker with cash at hand $y$ and skill level $x$ is given by

$$100 \left( \left[ \frac{V^x(y; \tau)}{V^x(y; 0)} \right]^{1/1-\sigma} - 1 \right).$$

To assess the aggregate welfare effect of implementing the optimal estate tax, I consider two different aggregation criteria. First, I consider a utilitarian social welfare function that averages individual household welfare gains using the stationary measures $\mu_{youth}$ and $\mu_{worker}$ from the no-tax equilibria. Second, I calculate the percentage of households who experience gains from implementing the tax.

Table 7 summarizes the welfare effects of implementing the optimal estate tax, taking into account the transition path. Without altruistic bequests, the average welfare gain ranges from 3.86% of lifetime consumption when $p = 0.85$ to 8.04% of lifetime consumption when $p = 0.65$. However, much of these gains accrue to existing workers, who experience gradually higher wages without paying the estate tax. By contrast, youth households at the time of initial implementation experience a smaller welfare gain of 3.46% when $p = 0.65$ and actually experience small welfare losses when $p = 0.75$ or $p = 0.85$. For youth, the delayed benefit of higher wages may not offset the initial loss in wealth, in part because they may die before wages rise substantially. Nevertheless, an overwhelming majority of households prefer to have the estate tax increased from 0% to its optimal level.

Table 7: Welfare Gains from Implementing the Optimal Estate Tax

|  | $p = 0.65$ | $p = 0.75$ | $p = 0.85$ |
|---|---|---|---|
| **No Altruistic Bequests** | | | |
| Average Welfare Gain | | | |
| *All Households* | 8.04% | 5.53% | 3.86% |
| *Youth* | 3.46% | -0.61% | -1.62% |
| Percent Who Favor | | | |
| *All Households* | 99.19% | 98.80% | 98.74% |
| *Youth* | 67.54% | 52.07% | 49.72% |
| **Perfect Altruism** | | | |
| Average Welfare Gain | | | |
| *All Households* | 6.17% | 2.17% | 0.51% |
| *Youth* | 4.86% | 1.51% | 0.31% |
| Percent Who Favor | | | |
| *All Households* | 98.93% | 95.32% | 77.49% |
| *Youth* | 83.37% | 69.62% | 60.93% |

The welfare gain measures the average increase in consumption equivalent utility immediately after implementation of the optimal estate tax, taking into account the gradual transition path of the economy.
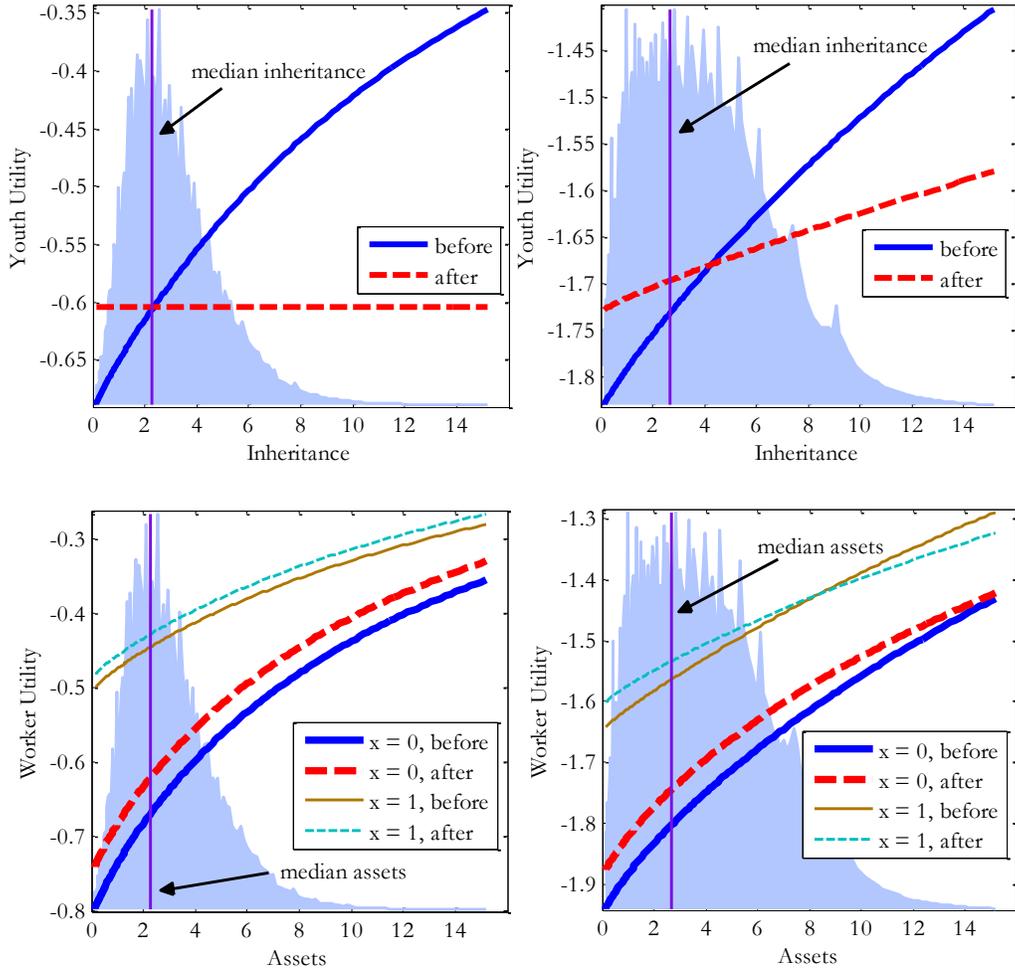
Figure 3: Youth utility $Y(a)$ and pre-signal worker utility $pV^x(w_x + a(1 + r)) + (1-p)V^x(w_{1-x} + a(1+r))$ immediately before and after implementation of the optimal estate tax when $p = 0.75$. The shaded areas represent the distributions of inheritance (for youth) and assets (for workers). The first column corresponds to the model without altruistic bequests and the second column corresponds to the model with perfect altruism.

With perfect altruism, aggregate welfare gains are somewhat smaller, although youth experience larger gains. These results largely reflect the fact that perfectly altruistic households value the utility of future generations, who in turn benefit from living under the new stationary equilibrium with the optimal estate tax. Therefore, even if some youth households do not experience the full benefits of the higher estate tax, their lifetime utility still improves because of the higher utility of their descendants. Similarly, existing workers take into account the utility cost of taxing their descendants in addition to the benefits of higher wages. As shown in figure 3, the policy is highly progressive. Low inheritance youth, along with low asset, low skilled workers are the primary beneficiaries, even as a large majority of the population experiences gains. Figure 4 plots the transition paths of the economy after implementation of the optimal estate tax when $p = 0.75$.
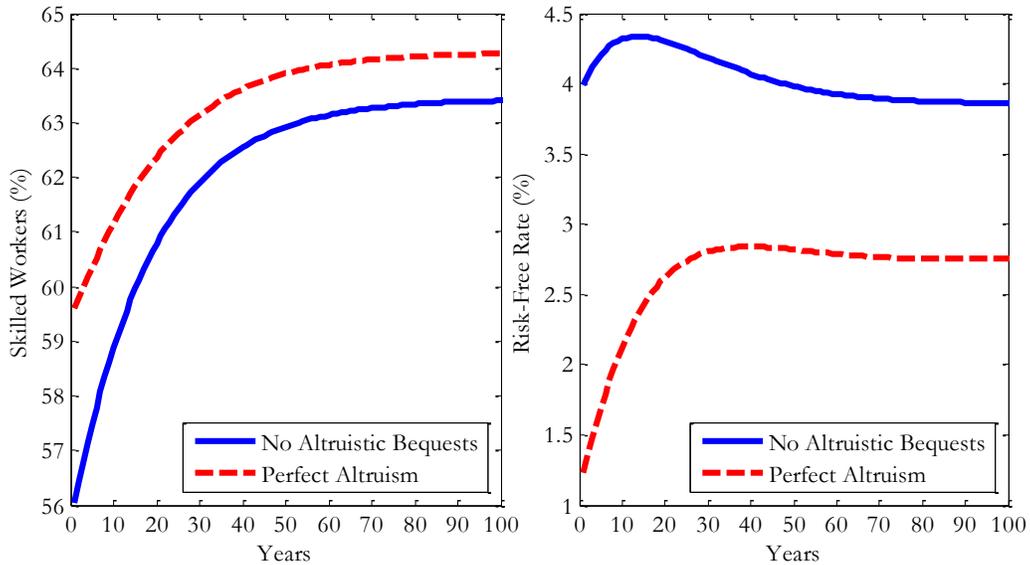


Figure 4: Transition paths of the economy when $p = 0.75$. The no-altruism estate tax rate is 100% and the perfect-altruism estate tax rate is 65%.

# 6  Conclusions

This paper investigates the effects of estate taxation when firms cannot directly observe worker skill levels. Imperfect labor market signaling gives rise to an information externality that causes workers to free-ride off of others' human capital acquisition. Inherited wealth exacerbates the information externality because risk-averse workers with larger inheritances exert less effort to acquire skills. By reducing these inheritances, an estate tax induces greater skill acquisition effort, resulting in a higher number of skilled workers. In many cases, the estate tax leads to increased wages and output, even when the government uses the revenue for wasteful spending. In a parametrized version of the model, I establish that the optimal estate tax rate is significantly different from zero and depends on the accuracy of skill signaling and on the degree of altruistic bequests.

These results provide avenues for additional research. Future work on optimal taxation and human capital policies should take into account how asset accumulation and information externalities interact to affect human capital decisions. Furthermore, information externalities create an additional channel through which unconditional money transfers can adversely affect skill acquisition, suggesting possible implications for optimal government welfare policies. Similar information externalities can also arise in other situations where agents benefit from and contribute to a group reputation. For example, grade inflation and financial aid may affect the degree to which college students shirk and free ride off of the reputation of their alma mater.

# References

Bas, J. and A. L. Bovenberg, "Human Capital and Optimal Positive Taxation of Capital Income," *International Tax and Public Finance* 17 (2010), 451–478.

Benabou, R., "Tax and Education Policy in a Heterogeneous-Agent Economy: What Levels of Redistribution Maximize Growth and Efficiency?," *Econometrica* 70 (2002), 481–517.

Bø, E. E., E. Halvorsen and T. O. Thoresen, "Inheritance as a Disincentive to Labor Effort," Working Paper, 2012.

Bohacek, R. and M. Kapicka, "Optimal Human Capital Policies," *Journal of Monetary Economics* 55 (2008), 1–16.

Brown, J., C. C. Coile and S. J. Weisbenner, "The Effect of Inheritance Receipt on Retirement," *The Review of Economics and Statistics* 92 (2010), 425–434.

Elinder, M., O. Erixson and H. Ohlsson, "Carnegie Visits Nobel: Do Inheritances Affect Labor and Capital Income?," *The B.E. Journal of Economic Analysis & Policy* 12 (2012), 1–37.

Erosa, A. and T. Koreshkova, "Progressive Taxation in a Dynastic Model of Human Capital," *Journal of Monetary Economics* 54 (2007), 667–685.

Fang, H. and P. Norman, "Government-Manded Discrimination Policies: Theory and Evidence," *International Economic Review* 47 (2006), 361–389.

Farhi, E. and I. Werning, "Progressive Estate Taxation," *The Quarterly Journal of Economics* 125 (2010), 635–673.

GOLOSOV, M., N. KOCHERLAKOTA AND A. TSYVINSKI, "Optimal Indirect and Capital Taxation," *Review of Economic Studies* 70 (2003), 569–587.

HOLTZ-EAKIN, D., D. JOULFAIAN AND H. ROSEN, "The Carnegie Conjecture: Some Empirical Evidence," *Quarterly Journal of Economics* 108 (1993), 413–435.

JOULFAIAN, D. AND M. O. WILHELM, "Inheritance and Labor Supply," *Journal of Human Resources* 29 (1994), 1205–1234.

KAPICKA, M. AND J. NEIRA, "Optimal Taxation in a Life-Cycle Economy with Endogenous Human Capital Formation," Working Paper, 2013.

KRUEGER, D. AND A. LUDWIG, "Optimal Progressive Taxation and Education Subsidies in a Model of Endogenous Human Capital Formation," *AER Papers and Proceedings* 103 (2013), 496–501.

LOCKWOOD, B., "Information Externalities in the Labour Market and the Duration of Unemployment," *Review of Economic Studies* 58 (1991), 733–753.

NORMAN, P., "Statistical Discrimination and Efficiency," *Review of Economic Studies* 70 (2003), 615–627.

PIKETTY, T. AND E. SAEZ, "A Theory of Optimal Capital Taxation," *Econometrica* 81 (2013), 1851–1886.

POPOV, S. V. AND D. BERNHARDT, "Fraternities and Labor Market Outcomes," *American Economic Journal: Microeconomics* 4 (2012).