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COLLATERAL, ASYMMETRIC INFORMATION AND PARETO-IMPROVING LABOR TAXATION

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Summary

Why do poor people stay poor? This paper examines that question in a simple, highly stylized setting that illustrates how the decisions of poor persons over occupational choice are distorted when their ability to succeed in higher education is private information, not known to a lender.

Our model is one of occupational choice. There are two occupations--low skill and professional. Individuals must undertake a program of higher education to be able to enter a profession, but successful completion of the program is uncertain. Each individual has the ability to obtain private information about his probability of successfully completing the program. Given his private information, he will make his occupational choice. A perfectly competitive capital market exists through which individuals can borrow to finance professional education. These loans are risky to a bank since individuals will default if they are unsuccessful in entering the profession. A borrower's downside risk--the cost of the program that he will bear if he is unsuccessful--is smaller the more that he borrows, and this will affect his occupational choice. Knowing his incentives though not his private information, a lender will infer that the smaller a borrower's own stake in the investment (the more he borrows from the bank), the lower his probability of loan repayment. The bank will therefore charge an individual who borrows more a higher interest rate. The interest rate can be so high that human capital formation is beyond the reach of the poorest individuals.

Within this model, the paper establishes two results. First, a wage tax whose revenues are returned to taxpayers by lump sum grants in an amount equal to the expected tax payment can substitute for the lack of collateral on the part of some individuals. It thereby yields a Pareto improvement. Second, a wage tax whose revenues are distributed lump sum to the poor can raise

productivity and, through that effect, social welfare. Numerical simulations illustrate that the resulting gains can be significant.

The assumption that an individual's success probability in higher education is private information is extreme. Clearly one of the many functions of mandatory, publicly provided education for children is a screening one where those most likely to succeed in professional occupations are publicly identified. But to the extent that abilities are not perfectly observable, the model considered in this paper calls into question the standard views that wage taxation must generate excess burden, and that there must be a trade-off between equality and efficiency.

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Abstract. This paper considers a model in which *laissez-faire* does not attain an efficient sorting of individuals across occupations because of private information in the capital market. The paper establishes two results. First, a labor tax whose revenues are returned to taxpayers by lump sum grants in an amount equal to the expected tax payment can substitute for the lack of collateral on the part of some individuals. It thereby yields a Pareto improvement. Second, a labor tax whose revenues are distributed lump sum to the poor can raise productivity and, through that effect, social welfare.

Collateral, Asymmetric Information, and Pareto-Improving Labor Taxation

I. Introduction

Recent literature has drawn attention to the importance of agency costs in capital markets and has shown that these costs are reduced when individuals have more wealth (and hence more collateral). This paper shows that a tax policy that lowers the price of labor in each state of the world below the market price, and returns the revenues by lump sum grants in an amount equal to the expected tax payment, can substitute for the lack of collateral on the part of some individuals. As a result, a labor tax can yield a Pareto improvement.

This tax policy can be thought of as a redistribution of income across states of nature. The redistribution creates a riskless source of income (the lump sum grant) which a borrower can use as collateral against debt. The Pareto improvement that is obtained is a striking result since in the model presented in this paper individuals are risk neutral.[1]

The model that we use to illustrate the gains in welfare is an adaptation of the two-state model developed by de Meza and Webb [1987] and Bernanke and Gertler [1990]. Our model is one of occupational choice. There are two occupations--low skill and professional. Individuals must undertake a program of education to be able to enter a profession, but successful completion of the program and entry into the profession is uncertain. Each individual has the ability to obtain private information about his probability

[1]The view of the tax system as a redistribution across states of nature goes back at least to Domar and Musgrave [1944]. The implications of this view for Pareto optimal taxation when individuals are risk averse and risk markets are missing have been studied by Diamond, Helms, and Mirrlees [1980], Varian [1980], Eaton and Rosen [1980a and 1980b], Dixit [1989], and Hoff [1991]. The motivation behind the use of tax policy in those papers was *to smooth utility across states*. The motivation in this paper is completely different; it is *to reduce agency costs*. A critical factor in both this paper and the earlier papers is the incompleteness of markets.

of successfully entering the profession. This asymmetry of information precludes a complete forward labor market and distorts the capital market. A tax on labor introduces a small distortion in the labor-leisure choice, but the grant that it finances reduces a big distortion in the capital market. Numerical simulations illustrate the resulting gains. For an individual with zero capital endowment, the tax/transfer policy can recover more than 75 percent of the loss in his expected utility created by agency costs.

A second implication of the analysis is that there need not be a trade-off between equity and efficiency even when equalizing transfers are financed by distortionary taxes. It is a general result for economies with private information that lump sum transfers have effects on technical efficiency, as emphasized in Hoff [1992]. In the model presented in this paper, poverty undermines productivity. Lump sum grants to the poor financed out of a uniform labor tax on all individuals will raise average net labor productivity and thereby increase social welfare.

II. The Model

There are two endowment goods, labor and capital. Capital can be invested in an asset that yields a riskless gross return, r, or in a program of professional education. The cost per person of the educational program is 1, and the payoff if the individual successfully completes the program is an increase in his labor productivity from w to αw, where $\alpha > 1$. If he fails the program, the gross return to capital invested in education is zero, and his labor earnings are also zero.[2]

A natural way to interpret the model is that an individual's labor productivity is w in a low-skill occupation, while it is αw in a profession ($\alpha > 1$). After undertaking but failing the professional educational program, an individual remains unqualified for the profession but will have become

[2]The assumption of zero labor income in the case of failure in the educational program greatly reduces the notational complexity of the model, without changing its qualitative results. Our qualitative results require only that an individual who fails in the program defaults on his loan.

unsuited for the low-skill occupation.

For each individual, the probability of success in the professional education program is p. p is distributed according to the cumulative distribution function H(p). An individual can learn his probability of success at a utility cost e by preparing for professional education. The effort cost e might be interpreted as the utility foregone by applying oneself in primary and secondary school. Without preparing for profession education, an individual can never succeed in it. Thus, every individual undertaking professional education knows his probability of success beforehand.

Individuals are risk neutral with expected utility

$$U = Ey(\ell) - v(\ell) - e \tag{1}$$

where Ey is expected wealth and $v(\ell)$ is the disutility of labor, with $v(0) = 0$, and v' and $v'' > 0$.

III. The First-best Allocation

This section considers the benchmark case of the first-best allocation when there is no private information. Solving the problem recursively, we can write the utility payoff from success in the education program as

$$R = \max_{\ell} \alpha w \ell - v(\ell)$$

The social opportunity cost of undertaking professional education is the foregone surplus from working in the unskilled occupation,

$$S = \max_{\ell} w\ell - v(\ell)$$

plus the capital cost r.

Given the optimal level of labor supply conditional on an individual's entry into each occupation, the remaining social welfare problem is one of occupational choice. This entails two decisions: (a) the fraction (m) of the population that will prepare for the educational program, and (b) the reservation success probability (p^*) such that only if an individual's success

probability exceeds p^* does he undertake the program after completing the initial preparation. In this way the population is sorted initially into three groups, and the net social product of each group is represented in fig. 1:

--- A fraction 1-m does not prepare for professional education. The net social product of an individual in this group is S, the first terminal node in fig. 1.

--- A fraction $mH(p^*)$ prepares for professional education but does not undertake it because preparation reveals that each individual's probability of success is below p^*. The net social product of an individual in this group is S-e, the second terminal node in fig. 1.

--- A fraction $m[1-H(p^*)]$ undertakes professional education after the initial preparation. If an individual is successful, his net social product is R-r-e; if he fails, it is -r-e.

In the figure, a solid circle indicates a decision node, where the social planner makes a decision with respect to a given individual. An open circle indicates a chance node, where the next event is determined by a random mechanism according to probabilities shown on the branches that follow the chance node.

For future use, let h(p) denote the density function of p, and let h^* and H^* denote the functions evaluated at p^*. Given p^*, the average success rate in the education program is

$$p(p^*) = E(p|p \leq p^*)$$

Conditional on having invested e and learned p, the social surplus from professional education is

$$\Delta(p) \equiv pR - [r + S] \tag{2}$$

From fig. 1 it can be checked that the social surplus to the prior stage of

preparing for professional education is positive if and only if $[1-H^*]\Delta(\hat{p}) \geq e$.

Assuming a utilitarian social welfare function, maximum social welfare is attained with the values of p^* and m that solve[3]

$$(3) \qquad \max_{p^*,m} \quad [1-m]S + mH^*S + m[1-H^*]\hat{p}R + r[\bar{W} - m[1-H^*]] - me$$

$$\text{subject to} \quad 0 \leq m \leq 1$$

Because the marginal utility of consumption is assumed in (1) to be constant, only average wealth, $\bar{W}$, rather than the whole vector of endowments enters the maximand. This specification of the social welfare function is convenient because it abstracts from any direct welfare effect arising from changes in the distribution of wealth. In this model, the distribution of wealth will induce a change in social welfare only through its effect on agency costs that arise from private information.

The socially optimal value of p^*, indicated by a subscript 0, is implicitly defined by[4]

$$(4) \qquad p^*_0 R = r + S$$

The socially optimal value of m is

$$(5) \qquad [1 - H^*_0]\Delta(p^*_0) \gtreqless e \quad \Longleftrightarrow \quad \begin{array}{l} m = 1 \\ m \text{ indeterminate} \\ m = 0 \end{array}$$

We will assume throughout the paper that the expected social surplus from preparation for the educational program, given the optimal threshold p^*_0,

[3]It is assumed that resources are sufficient to provide all individuals with an education; that is, per capita physical wealth, $\bar{W}$, is at least one.

[4]In deriving the first-order condition for p^* from (3), we've used the fact that $dp/dp^* = h^*[\hat{p} - p^*]/[1-H^*]$. The second-order condition with respect to p^* is satisfied since $R \geq 0$.

exceeds its utility cost, or

$$(6) \qquad [1 - H^*]\Delta(\hat{p}_0) \geq e$$

At the social optimum every individual prepares for professional education in order to learn his probability of success in undertaking such training.

IV. The Competitive Equilibrium When There Is Private Information

This section explores how the occupational sorting of individuals, determined by p^* and m, differs from the socially optimal allocation in a decentralized economy with private information. The information structure is that:

> *(A1) It is private information to the individual (a) whether he has learned his probability of success in the educational program, and (b) what the value of that probability is after he learns it.*

In the decentralized allocation, an individual for whom endowment wealth W is less than 1 will require external finance to undertake the educational program. Borrowing is channelled through a financial market where perfect competition and the pooling of risk drive expected profits of lenders down to zero. Since a borrower is unable to repay any of the loan if he does not succeed in the educational program, and since the probability of success is private information, to break even the lender will require a gross finance charge per dollar lent of

$$(7) \qquad i(p^*_b) = r/\hat{p}(p^*_b),$$

where p^*_b is the borrower's choice of reservation probability that is consistent with his incentives.

Each borrower's finance charge is a function of his own p^*_b. In turn, p^*_b is the solution to the individual's utility-maximizing choice of whether or not to undertake the educational program:

$$(8) \qquad \max_{p^*} \; [1-H^*]\hat{p}[R - i[1 - W]] + H^*[rW + S]$$

yielding the first-order condition

$$p^*_b[R - i[1-W]] = rW + S \tag{9}$$

At the borrower's reservation probability of success, p^*_b, his expected private benefit from professional education (the LHS term) is equal to his opportunity cost (the RHS term). It will prove useful to rearrange (9) by using (7) to yield

$$p^*_bR = r\{W + [1-W]p^*_b/\hat{p}(p^*_b)\} + S \tag{10}$$

Propositions 1 and 2 review the main results of Bernanke and Gertler [1990] in the context of this extended model.

Proposition 1. *The decentralized economy reproduces a first-best allocation if $W \geq 1$.*

Proof. If an individual evaluates his success probability and finances his own education, his choice of p^* maximizes $[1-H^*][\hat{p}R - r] + H^*S + rW$, which yields the first-order condition, $p^*R = r + S$, so that (from (4)) $p^* = p^*_b$. It follows from (6) that he will choose to evaluate his probability of success. It follows from the next proposition that borrowing reduces the expected surplus from education; hence, he will finance his own education.■

Proposition 2. *If an individual needs to borrow to finance education, then his choice of p^* and his expected surplus from preparation for professional education are increasing functions of his wealth. Formally, $dp^*_b/dW > 0$ and $d\{[1-H^*_b]\Delta(p^*_b)\}/dW > 0$.*

Proof. By construction, $p^*/\hat{p}(p^*) < 1$ and $W < 1$. Hence the term in braces on the RHS of (10) is strictly less than one, which implies that

$$(11) \qquad p^*_b R < r + S$$
$$= p^*_0 R \quad \text{(using (4))}$$

or $p^*_b < p^*_0$. Differentiating (10) yields $dp^*_b/dW > 0$, as was to be shown.

A borrower's expected surplus from preparation for education is $[1-H^*_b]\Delta(\hat{p}_b)$. To see this, note that conditional on $p > p^*$, the private expected gain less the private opportunity cost of professional education is

$$(12) \qquad \hat{p}_b[R - i[1-W]] - [rW + S] = \hat{p}_b R - [r + S] \qquad \text{(using (7))}$$
$$= \Delta(\hat{p}_b) < \Delta(\hat{p}_0) \qquad \text{(using (2) and (11))}$$

We can use the functional notation $\Delta(\hat{p}_b)$ to simplify the first-order condition with respect to p^*_b. Substituting $\Delta(\hat{p}_b)$ into (8) yields

$$\max_{p^*} \hat{p}_b(R - i[1-W]) - H^*\Delta_b$$

so that the first-order condition for an interior p^*_b is

$$(13) \qquad (R - i[1-W])d\hat{p}/dp^* = h^*\Delta(\hat{p}_b) + H^*d\Delta(\hat{p}_b)/dp^*$$

The rate of change of the expected surplus with respect to wealth is

$$d([1-H^*]\Delta(\hat{p}_b))/dW = (-h^*\Delta + [1-H^*]d\Delta/dp^*)dp^*_b/dW$$
$$= (d\Delta/dp^* - d\hat{p}/dp^*[R - i[1-W]])dp^*_b/dW \qquad \text{(using (13))}$$
$$= i[1-W][d\hat{p}/dp^*]dp^*_b/dW \qquad \text{(by differentiating (12))}$$

which, by inspection, is strictly positive, as was to be shown. See fig. 2A■.

An individual who must borrow will not wish to prepare for the educational program if the sunk cost e exceeds the expected surplus, or $e > [1-H^*]\Delta(\hat{p}_b)$. Suppose that this inequality holds for some wealth endowment. Since the expected surplus is strictly increasing in wealth and is greater than e for $W \geq 1$, then by continuity there exists some positive level of endowment, denoted $\underline{W}$, such that the expected surplus less the preparation

cost is zero.[5] Individuals for whom $W \leq \underline{W}$ will not undertake the initial stage of preparation and hence are closed out of the profession. Such individuals fall in the region of zero-investment in human capital, illustrated in fig. 2B.

No individual is rationed out of the market in the sense of Stiglitz and Weiss [1981]: there is no demand for funds that goes unsatisfied.[6] But demand by the poorest stratum of the economy falls to zero because for that group, the costs of borrowing to acquire human capital are prohibitive. Poorer persons face higher interest rates not because they are on average less able, but because reliance on the financial market for a larger part of the cost of the investment induces entry into the financial market of less able persons. "Bad risks drive out good risks."

V. Pareto-Improving Labor Taxation

Because the opportunity cost of capital is assumed invariant at r, the cost of asymmetric information is borne solely by the borrowers, and none by the lenders. A borrower may be viewed as an issuer of a bond, collateralized by his earnings. The lender perceives the quality of the bond differently according to the initial wealth of the issuer. Low wealth brings in low quality bonds with a lower probability of repayment, and which therefore command a lower price (a higher interest rate) in the market.

An individual could increase his initial wealth if he could sell his labor in state-contingent markets. But it is straightforward to show that such state-contingent labor markets are precluded by the information structure of this model. Recall from (A1) above that whether an individual knows his

[5]The condition $W > \underline{W}$ also guarantees that the second-order condition for p^*_b is satisfied.

[6]Rationing (as modelled in Stiglitz and Weiss [1981]) cannot occur because p^*_b (which determines the quality of the loan) is a *rising* function of the interest rate charged, as can be checked by differentiating the expression defining p^*_b in (9). Hence, a lender's profits are strictly monotonic in the interest rate charged both through the direct effect on his revenues, holding default rates fixed, and through the effect on the riskiness of his portfolio.

probability of success in professional education is private information. An individual can gain from forward labor sales only if he needs funds to pursue an education. Therefore, an individual would wish to learn his success probability before going to the forward market, and then to sell labor forward only if he found his success probability exceeded his reservation rate, p^*--that is, *only if he had already made his occupational choice in favor of the professional occupation*. Knowing this, a buyer on the forward state-contingent market would not buy labor in the unskilled occupation at any price, and would pay no more than $\hat{p}/r$ per dollar of future labor earnings in the professional occupation. Thus an incentive-compatible market for state-contingent labor would be redundant--it would allow individuals precisely the same intertemporal reallocations as the credit market does.[7] Only if one could compel individuals who do not seek an education to engage in forward labor sales could a complete set of state-contingent labor markets exist.

We will now show that a partial substitute for the missing market in state-contingent labor is a labor tax whose revenues are returned in lump-sum fashion. Consider a labor tax at rate t and a lump sum grant G equal to the expected value of tax payments made by the individual, where the expectation is taken without knowledge of the individual's success probability. The lump sum grant permits the individual to finance a part of his education through a bond, issued in amount G/r, that is collateralized by his future transfer payment, G. Since G is riskless, the bond can be issued at the riskless rate of return.

[7]The information problem that restricts the scope of the state-contingent labor market also restricts the feasible financial contracts. In a two-state model where the borrower knows his type but the lender does not, the pure debt contract is the optimal financial contract (a formal proof is in Bernanke and Gertler [1990, Appendix]. The intuition behind their result is straightforward. Agency costs arise because borrowers are not cautious enough in making investments. A lender could induce borrowers to be more cautious if he could write a contract under which the potential borrower would receive a *positive* payment in the case that he did not actually undertake professional education. But since individuals can learn their success probability before contracting with the lender, such a contract would also attract the least able individuals--those who knew they would not wish to make any investment.

The after-tax utility payoffs to labor in the two occupations are

$$S_t \equiv \underset{\ell_s}{\text{Max}}\ [1-t]w\ell_s - v(\ell_s)$$

$$R_t \equiv \underset{\ell_r}{\text{Max}}\ [1-t]\alpha w\ell_r - v(\ell_r)$$

An individual's expected utility conditional on pursuing professional education is now

$$\hat{p}(R_t - i[1-W-G/r]) - r[G/r] - G$$

so that his unconditional expected utility (for $\underline{W} < W < 1$) is

$$(14) \qquad U = \underset{p^*}{\text{Max}}\ H^*[S_t + rW + G] + [1-H^*]\hat{p}(R_t - i[1-W-G/r]) - e$$

As in (9) above, p* is implicitly defined[8] from the first-order condition by

$$(15) \qquad p^*(R_t - i[1-W-G/r]) = rW + S_t + G$$

The LHS is the expected benefit of professional education at the reservation probability of success; the RHS is the opportunity cost of education.

Comparing (15) with (9) it is apparent that the tax/transfer policy changes p* through two channels. First, the tax funds a grant that allows the individual to increase his stake in the investment in professional education by G/r in current dollars. In this way the tax/transfer scheme provides a substitute for collateral. With more wealth at risk, the individual is more selective in his choice of whether or not to proceed with professional education. Differentiating (15) with respect to W and G yields this ***collateral effect***:

$$(16) \qquad \partial p^*/\partial G = [1/r]\ \partial p^*/\partial W > 0$$

and the sign condition follows from proposition 2.

Second, the labor tax affects the *income premium* in the profession,

[8]For ease of notation, henceforth the subscript b on p^*_b will be omitted.

denoted D. We have $dR_t/dt = -\alpha w \ell_r$ and $dS_t/dt = -w\ell_s$. The tax reduces the *income premium* and thereby further reduces the incentive to gamble on education if

$$(17) \qquad D \equiv p^*\alpha w \ell_r - w\ell_s > 0$$

D is ambiguous in sign in the general case, but is strictly positive if the disutility of labor is

$$(18) \qquad v(\ell) = \ell^{\eta}$$

with $\eta > 1$. This is the case of constant labor supply elasticity.[1] Differentiating (15) with respect to t yields what we might call the ***relative price effect*** of the tax policy to distinguish it from its *collateral effect*:

$$(19) \qquad \partial p^*/\partial t = D \Big/ \left\{ R_t + i[1-W-G/r][d\ln\hat{p}/d\ln p^* - 1] \right\}$$

where the denominator is strictly positive (noting (15)).

The ability of the tax/transfer scheme to mitigate the selection problem in the capital market is illustrated numerically in fig. 3. In the simulation, the parameter η in (18) is set equal to 3, corresponding to a (compensated and uncompensated) labor supply elasticity of 0.5. Wage rates w in the unskilled profession are 4.5 and wage rates in the skilled profession are α times greater than wages in the unskilled profession, where $\alpha = 3.4$. The cost of education is one unit, and the gross riskless interest rate r over the period the educational loan is outstanding is 7. Success probabilities p for each individual are distributed according to the bell-shaped density function $h(p)=6(p-p^2)$. The shaded areas in the figure illustrate the magnitude of the "lemons" problem, i.e., the deviation of p^* from p^*_0, for wealth endowments in the interval [0,1]. The sum of the two shaded areas

[1] The labor supply elasticity given (18) is $1/[\eta-1]$. Utility maximization implies $\ell_r = \alpha^{1/(\eta-1)}\ell_s$, so that $R_t = \alpha^{\eta/(\eta-1)}S_t$. Noting (15), $p^*R_t > S_t$. Using the preceding expression for R_t, $p^*\alpha^{\eta/(\eta-1)}S_t > S_t$, or $p^*\alpha^{\eta/(\eta-1)} > 1$. Multiplying both sides of this inequality by $w\ell_s$ and substituting in the expression for ℓ_r, we have $p^*\alpha w\ell_r > w\ell_s$, as was to be shown.

illustrates the distortion in p^* from first-best under *laissez-faire*, and the black shaded area illustrates that part of the distortion that is eliminated by the Pareto-optimal tax/transfer policy. For example, at endowment wealth of one-half unit, the *laissez-faire* equilibrium yields $p^* = .409$, equilibrium under a Pareto-optimal tax/transfer policy yields $p^* = .434$, and the first-best threshold is $p^*_0 = .463$, independent of endowment wealth.

Of course, the tax/transfer policy has to be judged by its effect on welfare. The welfare effects of the tax/transfer policy are the sum of three terms[10]: the direct effect of the tax, the direct effect of the transfer, and the indirect effect of the tax/transfer policy via its influence on p^*:

$$(20) \qquad dU = \frac{\partial U}{\partial dt} dt + \frac{\partial U}{\partial G} dG + \frac{\partial U}{\partial i}\frac{di}{dp^*}\left[\frac{\partial p^*}{\partial G} dG + \frac{\partial p^*}{\partial t} dt\right]$$

To solve for di/dp^*, recall the lenders' zero-profit condition, $i = r/\hat{p}$, so[11]

$$(21) \qquad [\partial U/\partial i][di/dp^*] = -h^*\Delta(p^*) > 0$$

Recalling (2), $\Delta(p) = pR_t - S_t - r$ and the sign condition in (21) follows from (11). $\Delta(p^*)$ is the *negative* social payoff to education for the marginal investor that is incurred because borrowers who do not succeed at professional education do not expect to absorb its full cost; instead they shift part of it to the borrowers who are successful.

Letting N denote an individual's expected pre-tax labor earnings,

$$(22) \qquad N \equiv H^* w\ell_s + [1-H^*]\hat{p}\alpha w\ell_r,$$

we can rewrite dU in (20), using (16) and (21), as

$$(23) \qquad dU = -Ndt + dG - h^*\Delta(p^*)\left\{[\partial p^*/\partial W]dG/r + [\partial p^*/\partial t]dt\right\}$$

[10]The terms $\partial U/\partial p^*$, $\partial U/\partial \ell_s$, and $\partial U/\partial \ell_r$ are zero (and hence are suppressed) because the individual is optimizing with respect to those variables.

[11]The derivation uses the value of p^*R_t from (15).

The tax/transfer policy will be Pareto improving if $dU > 0$ when the net government cost of the policy is zero. The government budget associated with each person is, in expectation, $B = tN - G$. Diversification across taxpayers ensures that a transfer, G, that is feasible in expected terms will also be feasible in realizations *ex post*. Consider a balanced budget change increasing G and t such that $dB = 0$:

$$(24) \qquad dB = Ndt - dG + t\left\{ [\partial N/\partial t]dt + [\partial N/\partial p^*]\left\{ [\partial p^*/\partial t]dt + [\partial p^*/\partial G]dG \right\} \right\} = 0$$

The first difference on the RHS, $Ndt - dG$, is the revenue effect of the policy at the initial tax base, while the terms inside the large brackets are the changes in the initial tax base, N, resulting from the tax/transfer policy. $\partial N/\partial t$ is the usual marginal deadweight loss of a labor tax, weighted by the share of the population in each occupation. It arises because individuals reduce their working hours in order to avoid the tax. It is always negative and proportional to the labor supply elasticity. $\partial N/\partial p^*$ $(= -h^*D)$ is the change in the tax base arising from changes in occupational choice, and is generally ambiguous in sign. $\partial p^*/\partial t$ is the effect of the tax on occupational choice, and it is also ambiguous in sign (noting (19)). Finally, the term $\partial p^*/\partial G$ is the effect of the transfer on occupational choice; it is positive in sign (noting (16)).

To check whether the tax/transfer policy is Pareto-improving, it remains only to substitute the balanced budget condition (24) into the welfare expression (23):

$$(25) \qquad dU\Big|_{dB=0} = -h^*\Delta(p^*)\left\{ [\partial p^*/\partial W]dG/r + [\partial p^*/\partial t]dt \right\}$$
$$+ t\left\{ [\partial N/\partial t]dt + [\partial N/\partial p^*]\left\{ [\partial p^*/\partial W]dG/r + [\partial p^*/\partial t]dt \right\} \right\}$$

The RHS consists of two terms. The first term is the change in agency costs resulting from the change in p^*. The transfer, dG, unambiguously reduces agency costs (noting (16)), and that effect will be strengthened by the

relative price effect of the tax policy if labor supply has constant elasticity (recalling footnote 9). The first term will thus be larger (a) the greater the density of persons who would withdraw from the market if their collateral were increased, as measured by h^*, (b) the greater the distortion from the first-best, p^*, as measured by the negative social surplus $\Delta(p^*)$, (c) the greater the change in p^* through the *collateral effect*, and (d) the greater the change in p^* through the *relative price effect*.

The second term in (25) is the effect of the tax/transfer policy on the tax base. Starting from a zero tax rate, the government initially is collecting no money from labor taxes and so the change in labor earnings N does not affect the budget. The second term vanishes. Hence,

$$dU/dt(G)\Big|_{\substack{dB = 0 \\ t = 0}} > 0$$

which proves

Proposition 3. *If $\underline{W} < W < 1$ and if the* income premium *D to professional education, defined in (17), is positive, then there exists a Pareto-improving tax/transfer policy consisting of a positive labor tax whose revenues are returned to the taxpayer by a lump sum grant in an amount equal to the expected tax payment.*

The proof of this proposition is based on an infinitesimal tax rate. But for the proposition to have practical relevance, it must be true for finite values of t. The simulation presented below provides a way of evaluating the proposition with representative parameters. Fig. 4 is based on the same parameter values described for fig. 3 and assumes, in addition, a value of e that is sufficiently low that each individual chooses to learn his success probability, i.e., chooses to "prepare" for a professional occupation. The figure shows the Pareto optimal wage tax rate as a function of the taxpayer's wealth. The optimum occurs where the marginal deadweight loss in the labor market from increasing the tax rate is just

offset by the marginal utility gain from reductions in agency costs. For taxpayers with low wealth, marginal increases in collateral in the form of the future grant can lead to large reductions in agency costs. For these taxpayers, a relatively high tax rate on labor (11.8 percent for those with zero wealth) is Pareto optimal. The optimal tax rate is a declining function of wealth. For those with wealth greater than one unit, no agency costs are incurred and the optimal tax rate is, of course, zero.

Fig. 5 expresses the Pareto improvement from the optimal labor tax rate as a percentage of the difference between utility obtained under a first-best allocation and the *laissez-faire* utility. The effectiveness of the tax/transfer policy is decreasing with an individual's endowment wealth, but is still important even as endowment wealth approaches one. For those with no capital endowment, the tax/transfer policy recovers more than 75 percent of the loss in utility created by agency costs. At wealth levels of .95, two-thirds of the loss in utility due to agency costs is recovered.

VI. The Equity-Efficiency Trade-off Revisited

The previous section examined the Pareto optimal tax/transfer scheme. The scheme entailed no *ex ante* redistribution of wealth. This section considers the optimal amount of redistribution in society given the utilitarian social welfare function which is maximized by (3). The answer given here is different from the usual answer to this problem, where the benefits of redistribution depend on the society's preference for equality. Here there is no preference for equality -- the social marginal utility of consumption is a constant -- but redistribution increases social welfare by reducing the misallocation of labor across occupations which arises because of private information.

Over-Investment in Education

We consider first the case where parameters are such that all individuals wish to prepare for professional education in the *laissez-faire* equilibrium (i.e., in fig. 1, $\underline{W} < 0$). Over-investment in education occurs in

the *laissez-faire* equilibrium because individuals who finance professional education through borrowing will pursue it even when their success probabilities are lower than the socially optimal reservation probability.

Parameter values for these simulations are the same as in the earlier simulation. We now additionally need to specify a distribution of wealth and, for simplicity, we assume there are only two wealth levels: zero wealth and two units of wealth. We consider differential proportional wage taxes on the zero-wealth and high-wealth individuals, with transfer payments made only to the poor.[12] Given the assumed constant labor supply elasticity, the wage tax reduces the *income premium* (Γ in (17)) and thereby discourages entry into the profession: there is a *relative price effect* for both rich and poor in addition to the *collateral effect* for the poor. Since both effects are strictly welfare-increasing for the poor, tax rates on the poor will exceed those on the rich.

Fig. 6 shows the socially optimal tax rate schedule for a range of populations at the two wealth levels. The horizontal axis measures the ratio of those with wealth of 2 units relative to those without wealth. If no high-wealth individuals exist, the socially optimal tax rate on the poor is 11.8 percent, identical to the earlier example illustrated in fig. 4. As the number of high-wealth individuals increases, the taxes they pay make it desirable to reduce the tax rates on those without wealth. While tax rates fall, the size of the per capita grant to the poor increases. Because the larger grant to the poor induces them to choose a reservation success probability closer to the social optimum and because the lower tax rates (but broader coverage) reduce the excess burden in the labor market, the *ex ante* redistributive tax/transfer policy can bring social welfare close to the first-best solution.

Fig. 7 shows the percentage reduction in agency costs that is achievable under this *ex ante* redistributional tax/transfer policy. This measure is the

[12]By "poor" (or "rich") we are referring to individuals with zero (or high) initial wealth endowments.

same as that used in fig. 5. Fig. 7 shows that if there are as many as 50 individuals with wealth of two units for every individual with zero wealth, over 93 percent of the deviation in social welfare created by agency costs can be recaptured.

Under-Investment in Education

Finally, we wish to consider the case where individuals with the lowest wealth do not prepare for professional education in the *laissez-faire* equilibrium. As shown in fig. 2, this occurs when the utility cost of preparation, e, is at least as great as the expected surplus from education in the presence of agency costs. In this case, the *ex ante* non-redistributive tax/transfer scheme will not, for all parameter values, be able to induce preparation and thereby yield a Pareto improvement. To see this, consider an individual who is just indifferent between preparing or not preparing for professional education. The wage tax, for some parameter values, will reduce the after-tax *income premium* in the profession by more than the grant that it finances reduces agency costs; the net effect of the *ex ante* non-redistributive tax/transfer scheme is thus only to impose a distortion on labor supply, without affecting occupational choice. But an *ex ante* redistributive tax/transfer scheme has a greater potential for increasing welfare.

We use the same parameter values as in the previous simulations. Additionally, we specify a value for e such that $\underline{W} \geq 0$, i.e., individuals with zero wealth do not prepare for education in the *laissez-faire* equilibrium. We consider a tax/transfer scheme in which a single wage tax rate applies to high- and zero-wealth individuals alike, and tax revenues finance a lump sum grant paid to each zero-wealth individual.

The extent to which agency costs can be overcome in this case again depends on the distribution of the population over these two wealth levels. For the same reason that the *ex ante* non-redistributive tax/transfer scheme can fail when $\underline{W} > 0$, the redistributive tax/transfer scheme cannot, for all parameter values, induce preparation by those with zero wealth endowment. But

as the ratio of high-wealth to low-wealth individuals in the population increases, the impact of the redistributive policy through the *collateral effect* becomes large, and so does the effect on welfare. If, for example, the ratio of rich to poor is 10:1, and if the paramter e is set so that $\underline{W} = 0$, i.e., individuals without wealth are indifferent to preparing for education in the *laissez-faire* equilibrium, then the optimal uniform wage tax, at 2.4 percent, recovers 78 percent of the loss in social welfare created by agency costs. If the parameter e is set at the level at which an individual with 0.1 units of wealth would be indifferent to preparation in the *laissez-faire* equilibrium, then the optimal uniform wage tax, at 1.3 percent, recovers more than half of the loss in social welfare created by agency costs.

This brings us to a final point. It relates to instruments not so far discussed in this paper but used extensively in practice -- credit taxes and credit subsidies. de Meza and Webb [1987] have shown that if the only choice that individuals make is with respect to the threshold rate p^*, then a first-best allocation can be achieved by *taxing* credit. But it is straightforward to see that a tax on credit is also an indirect tax on professional education; for individuals near the margin of indifference between preparing and not preparing for professional education, that tax would push them over the threshold and shut them out of the profession entirely. Credit subsidies on the other hand, can move individuals over the threshold so that they prepare for professional education, but they do so at the cost of aggravating the selection problem (the distortion from p^*_0). What is striking about the labor tax/transfer policy considered in this paper is that it can address *both* margins simultaneously. With a sufficiently small percentage of poor in the entire population, a uniform labor tax that finances lump sum transfers to the poor can bring the economy very close to first-best.

VII. Conclusion

Individuals make choices over both labor supply and occupation. We considered a model in which *laissez-faire* attains an efficient allocation of

time between labor and leisure conditional on occupational choice, but does not attain an efficient sorting of individuals across occupations because of asymmetric information. A labor tax will have a *negative* excess burden. Although it introduces a distortion in the labor-leisure choice, the transfers that it finances reduce a bigger distortion over occupational choice.

Within a simple model of investment in human capital, we also establish conditions under which human capital formation is beyond the reach of the poorest individuals. It is denied not because poorer persons are on average less able, but because when education needs to be financed by debt, less able persons are induced to enter the financial market. These bad risks can be so important that they shut down the market for lending to the poorest groups, as Bernanke and Gertler [1990] have emphasized in a different context.

Our assumption that an individual's likelihood of success in an education program is private information is extreme. Clearly one of the many functions of mandatory, publicly provided primary and secondary education is a screening one where those most likely to succeed in professional occupations are publicly identified. But to the extent that abilities are not perfectly observable, the mechanisms considered in this model call into question the standard views that income taxation must generate excess burden and that there must be a trade-off between equity and efficiency.

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Figure 1

The Net Social Product of Labor

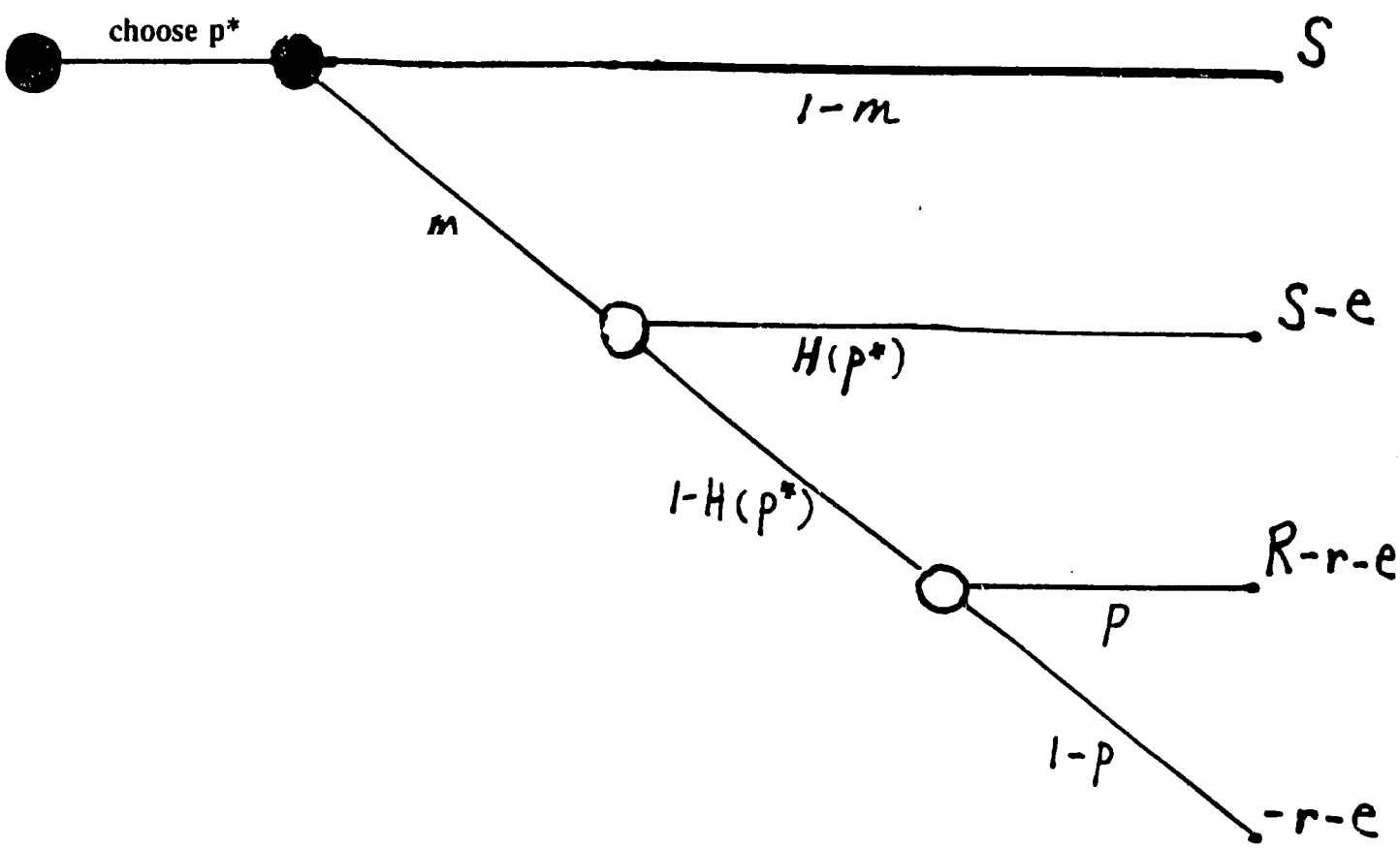


Figure 2

(A) The expected surplus from professional education as a function of wealth.

(B) Regions of zero-investment and over-investment in education as a function of wealth.

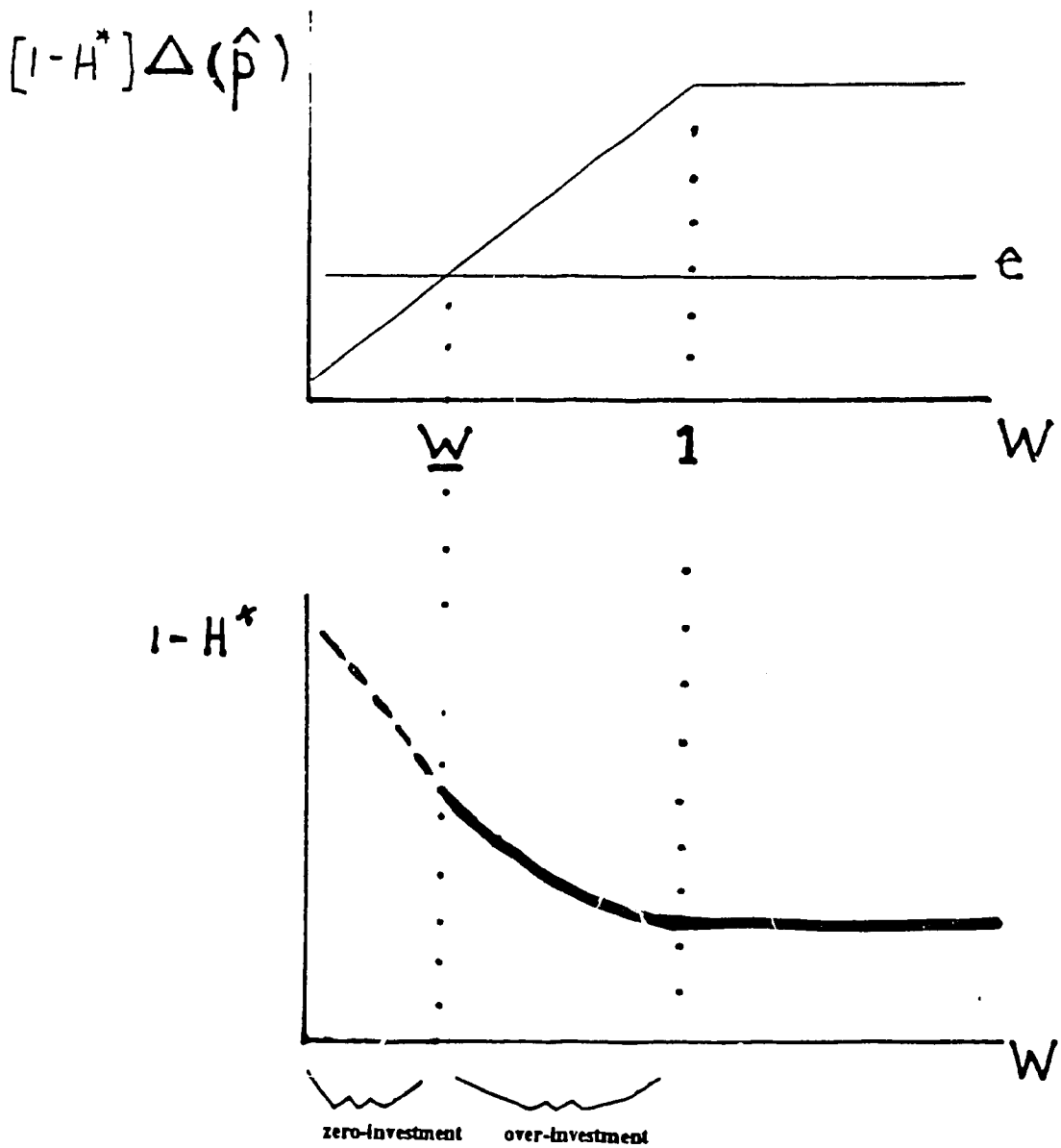


Figure 3

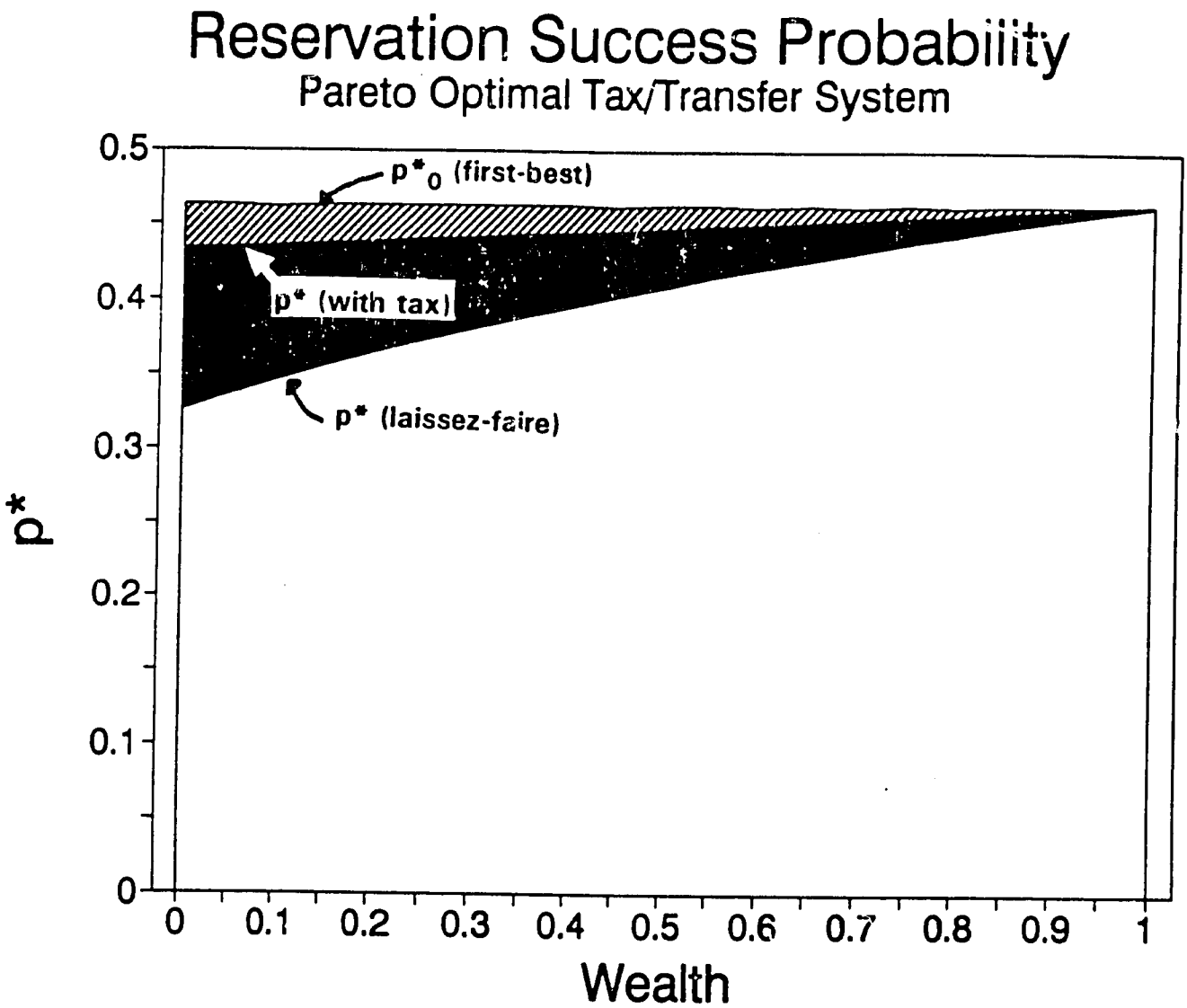

Reservation Success Probability
Pareto Optimal Tax/Transfer System
p*0 (first-best)
p* (with tax)
p* (laissez-faire)
p*
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Wealth

Figure 4

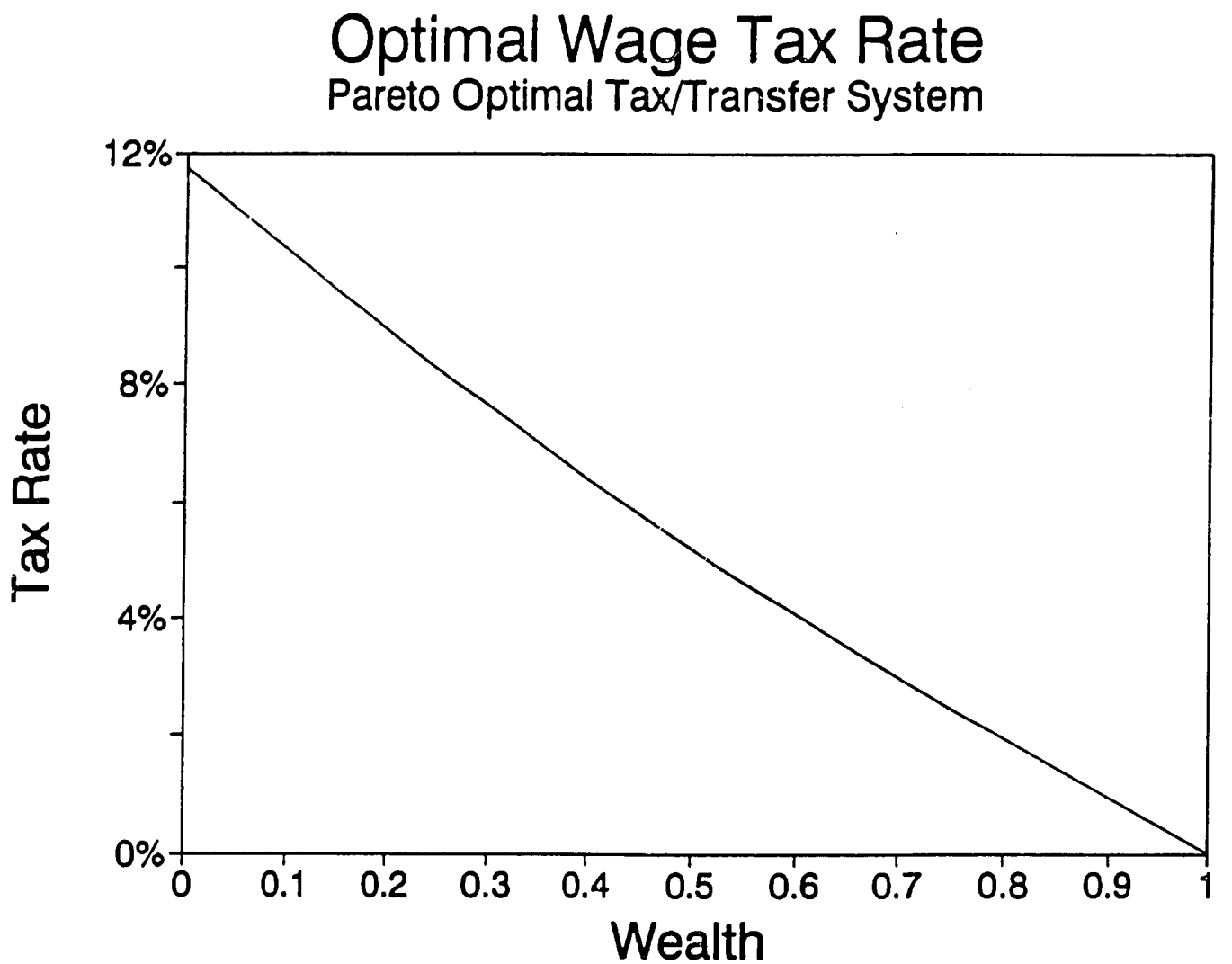

Optimal Wage Tax Rate
Pareto Optimal Tax/Transfer System
12%
8%
4%
0%
Tax Rate
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Wealth

Figure 5

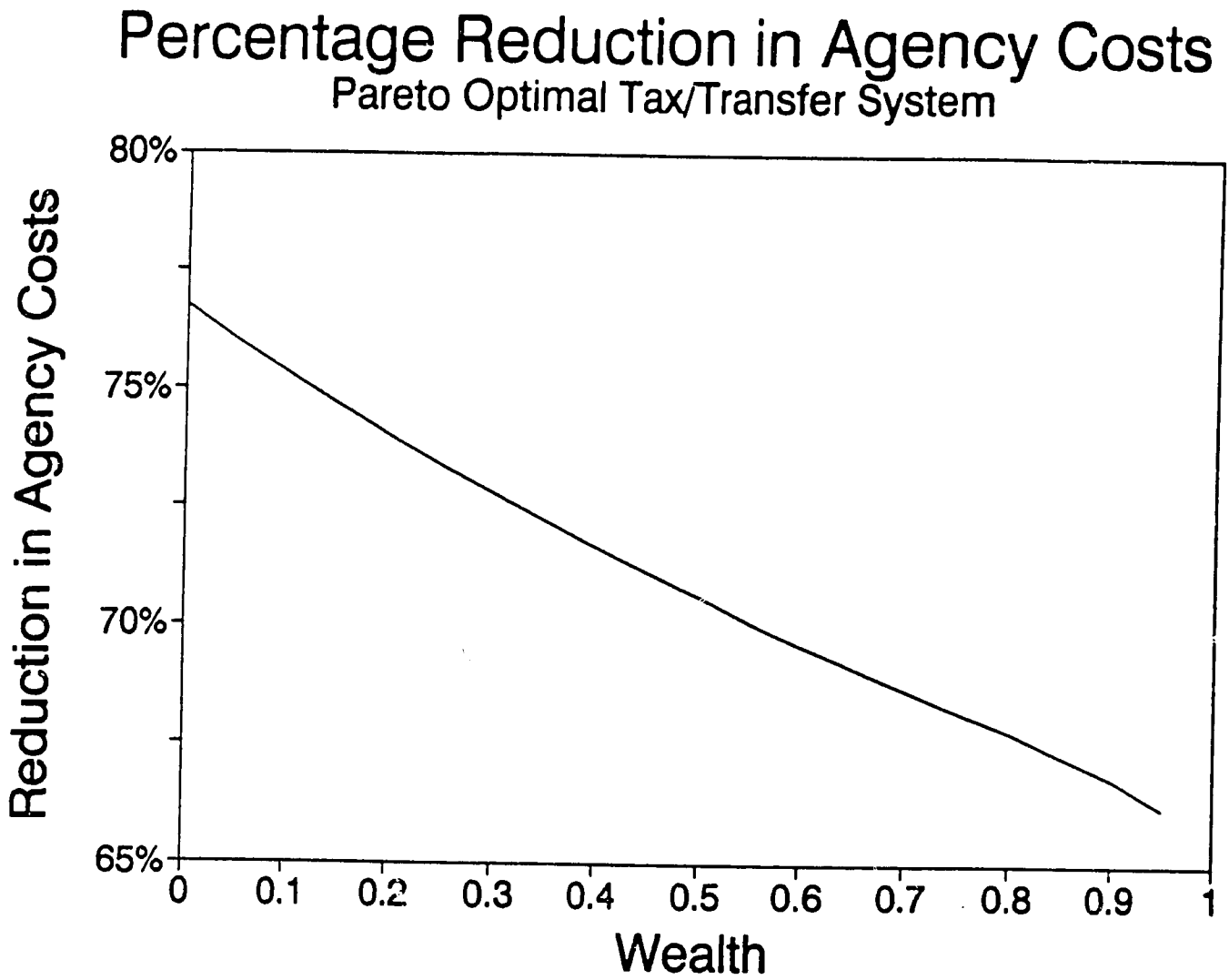

Percentage Reduction in Agency Costs
Pareto Optimal Tax/Transfer System
Reduction in Agency Costs
80%
75%
70%
65%
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Wealth

Figure 6

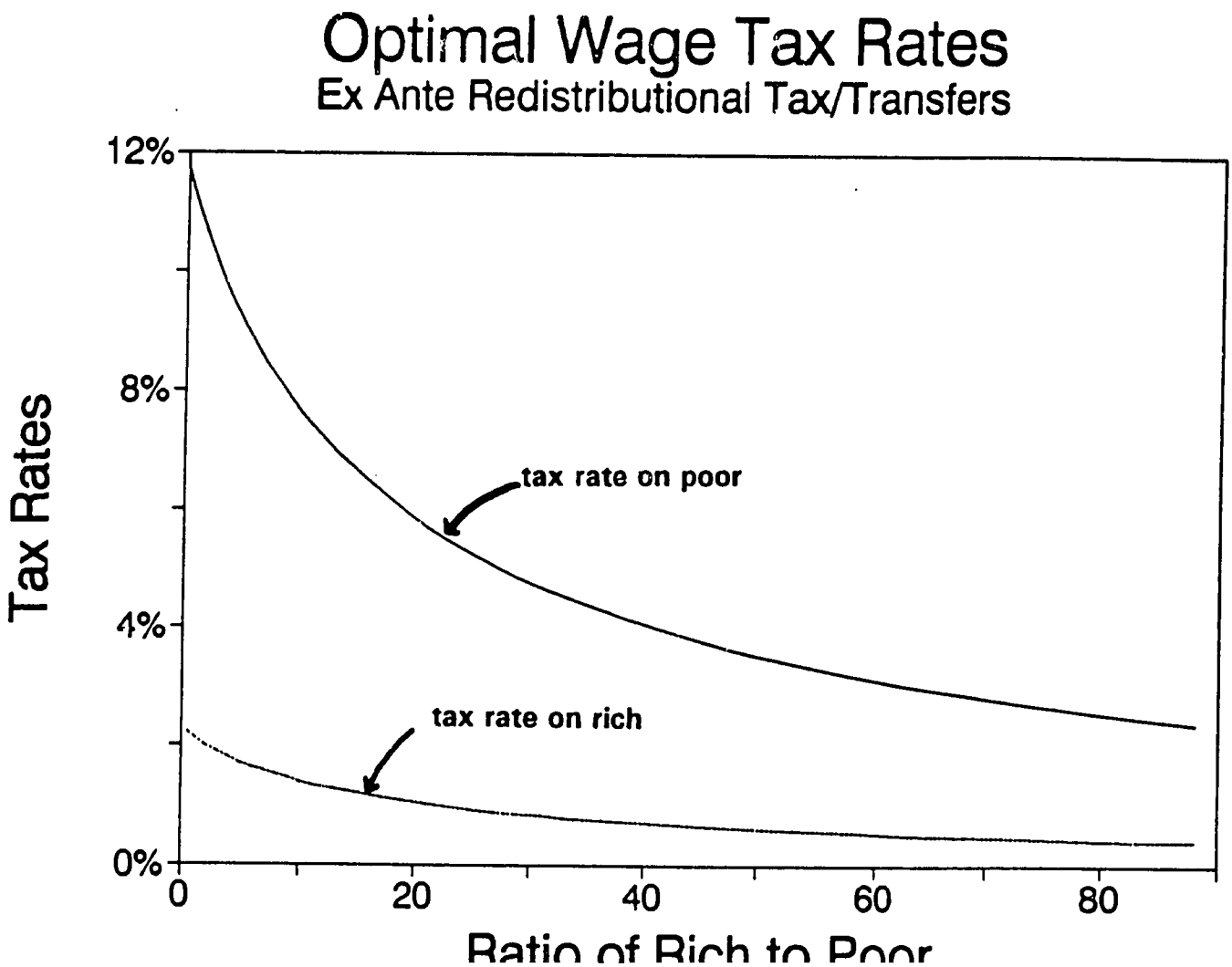
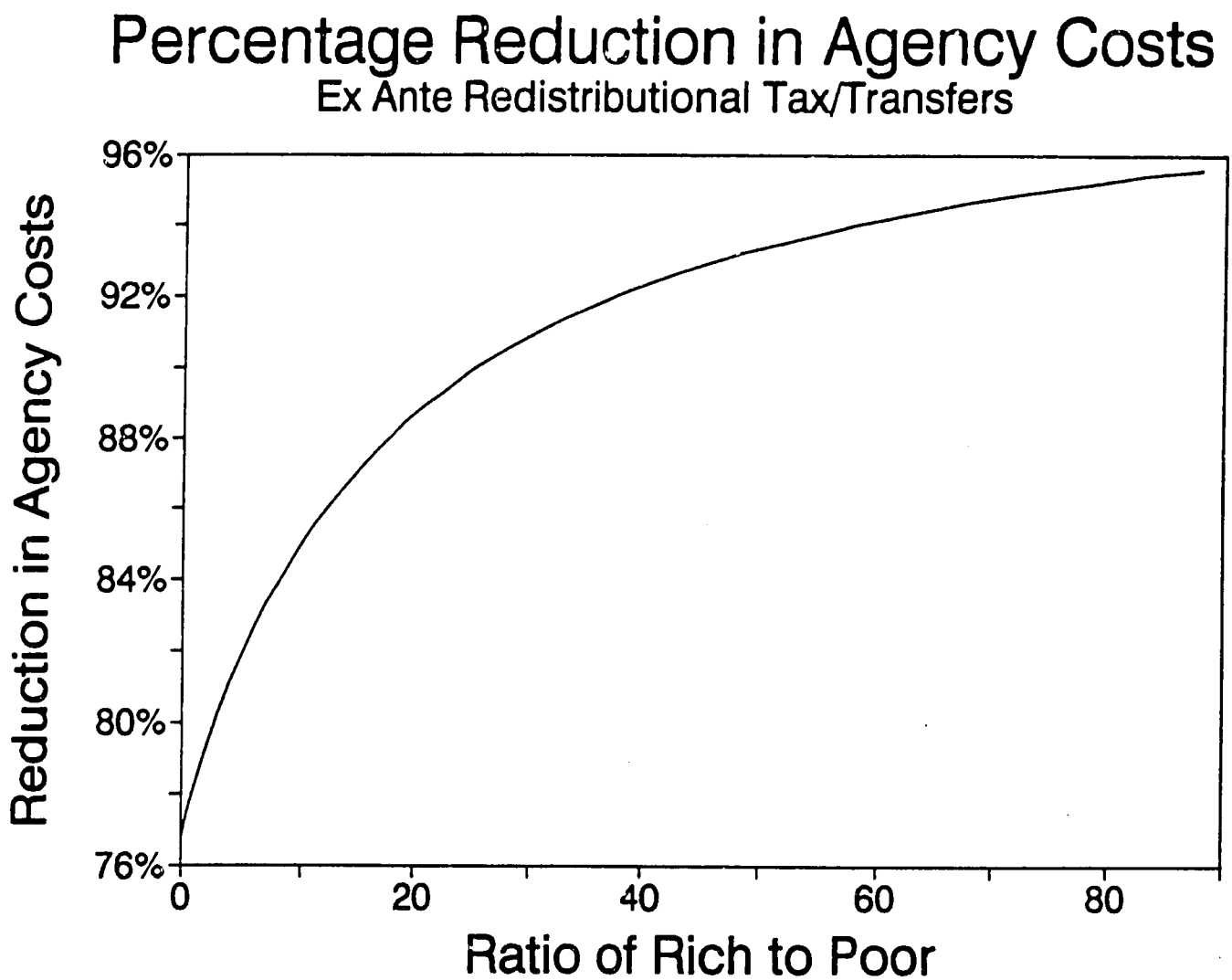

Optimal Wage Tax Rates
Ex Ante Redistributional Tax/Transfers
12%
8%
4%
0%
Tax Rates
tax rate on poor
tax rate on rich
0
20
40
60
80
Ratio of Rich to Poor

Figure 7


Percentage Reduction in Agency Costs
Ex Ante Redistributional Tax/Transfers
Reduction in Agency Costs
96%
92%
88%
84%
80%
76%
0
20
40
60
80
Ratio of Rich to Poor