

Implications of Some Alternatives to Capital Income Taxation

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A general prescription of economic theory is that taxes on capital income are bad. That is, a robust feature of a large variety of models is that a positive tax on capital income cannot be part of a long-run optimum. This result suggests that it may be useful to search for alternatives to taxes on capital income. Several recent proposals advocate a move to fundamentally switch the tax base toward labor income or consumption and away from capital income. The main point of this article is to demonstrate that, as a quantitative matter, uninsurable idiosyncratic risk is important to consider when contemplating alternatives to capital income taxes. Additionally, we show that tax reforms may be viewed rather differently by households that differ in wealth and/or current labor productivity.

We are motivated to quantitatively evaluate the risk-sharing implications of taxes by the findings of two recent theoretical investigations. These are, respectively, Easley, Kiefer, and Posen (1993) and Aiyagari (1995). The work of Easley, Kiefer, and Posen (1993) develops a stylized two-period model where households face uninsurable idiosyncratic risks. Their findings suggest that, in general, when households face uninsurable risk in the returns to their human or physical capital, it is useful to tax the income from these factors and then rebate the proceeds via a lump-sum rebate. However, the framework employed in this study does not provide implications for the long-run steady state. Conversely, Aiyagari (1995) constructs an infinite-horizon economy in which households derive value from public expenditures and face

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uninsurable idiosyncratic endowment risks and borrowing constraints. In this case, the optimal long-run capital income tax rate is positive. Specifically, Aiyagari (1995) shows that the optimal capital stock implies an interest rate that equals the rate of time preference. However, labor income risks generate precautionary savings that force the rate of return on capital below this rate. Therefore, to ensure a steady state with an optimal capital stock, a social planner will need to discourage private-sector capital accumulation. A strictly positive long-run capital income tax rate is, therefore, sufficient to ensure optimality.¹

The approach we take is to study several stylized tax reforms in a setting that allows the differential risk-sharing properties of alternative taxes to play a role in determining their desirability. We, therefore, choose to evaluate a model that combines features of Easley, Kiefer, and Possen (1993) with those of Aiyagari (1995), and is rich enough to map to observed tax policy. In terms of the experiments we perform, we study the tradeoffs involved with using either (i) labor income or (ii) consumption taxes to replace capital income taxes. Our work complements preceding work on tax reform by focusing attention solely on the differences that arise specifically from the exclusive use of either labor income taxes or consumption taxes. To our knowledge, the divergence in allocations emerging from the use of either labor or consumption taxes has not been investigated.² We study a model that confronts households with risks of empirically plausible magnitudes, and allows them to self-insure via wealth accumulation. Our work is most closely related to three infinite-horizon models of tax reform studied respectively by Imrohoroglu (1998), Floden and Linde (2001), and Domeij and Heathcote (2004). The environment that we study is a standard infinite-horizon, incomplete-markets model in the style of Aiyagari (1994), modified to accommodate fiscal policy. The remainder of the article is organized as follows. Section 1 describes the main model and discusses the computation of equilibrium. Section 2 explains the results and Section 3 discusses robustness and concludes the article.

1. MODEL

The key features of this model are that households face uninsurable and purely idiosyncratic risk, and have only a risk-free asset that they may accumulate. For tractability, we will focus throughout the article on stationary equilibria

¹ Another strand of work by Erosa and Gervais (2002) and Garriga (2000) illustrates settings in which the long-run capital income tax remains strictly positive because households face trading frictions that arise from living in a deterministic overlapping-generations economy.

² Imrohoroglu (1998) mentions this difference in a life-cycle model but does not discuss the source for the divergence.

of this model in which prices and the distribution of households over wealth and income levels are time-invariant.

Households

The economy has a continuum of infinitely lived ex ante identical households indexed by their location i on the interval $[0, 1]$. The size of the population is normalized to unity, there is no aggregate uncertainty, and time is discrete. Preferences are additively separable across consumption in different periods, letting β denote the time discount rate. Therefore, household $i \in [0, 1]$ wishes to solve

$$\max_{\{c_t^i\} \in \Pi(a_0, z_0)} E_o \sum_{t=0}^{\infty} \beta^t u(c_t^i), \quad (1)$$

where $\{c_t^i\}$ is a sequence of consumption, and $\Pi(a_0, z_0)$ is the set of feasible sequences given initial wealth a_0 and productivity z_0 . To present a flow budget constraint for the household, we proceed as follows.

Households face constant proportional taxes on labor income (τ^l), on capital income (τ^k), and on consumption (τ^c).³ Households enter each period with asset holdings a^i and face pre-tax returns on capital and labor of r and w , respectively. Each household is endowed with one unit of time, which it supplies inelastically, that is, $t^i = 1$, and receives a lump-sum transfer b . It then receives an idiosyncratic (i.e., cross-sectionally independent) productivity shock z^i , which leaves it with income wq^i , where $q^i \equiv e^{z^i}$. Given the taxes on capital and labor income, the household comes into the period with gross-of-interest asset holdings $(1+r(1-\tau^k)a^i)$ and after-tax labor income $(1-\tau^l)wq^i$. The household's resources, denoted y^i , in a given period are then

$$y^i = b + (1 - \tau^l)wq^i + [1 + r(1 - \tau^k)]a^i. \quad (2)$$

If we denote private current-period consumption and end-of-period wealth by c^i and $a^{i'}$, respectively, the household's budget constraint is

$$(1 + \tau^c)c^i \leq y^i - a^{i'}. \quad (3)$$

The productivity shock evolves over time according to an AR(1) process

$$z^{i'} = \rho z^i + \varepsilon^i, \quad (4)$$

³A tax on consumption can be implemented simply via a retail sales tax, as we do here, or via an income tax with a full deduction for any savings. See, for example, Kotlikoff (1993).

where ρ determines the persistence of the shock and ε_t^i is an i.i.d. normally distributed random variable with mean zero and variance σ_ε^2 .

Stationary Recursive Household Problem

Given constant tax rates, constant government transfers, and constant prices, the household's problem is recursive in two state variables, a and z . Suppressing the household index i , we express the stationary recursive formulation of the household's problem as follows:

$$v(a, z) = \max u(c) + E[v(a', z')|z], \quad (5)$$

subject to (2), (3), and the no-borrowing constraint:

$$a' \geq 0 \quad (6)$$

Given parameters (τ, b, w, r) , the solution to this problem yields a decision rule for savings as a function of current assets a and current productivity z :

$$a' = g(a, z|\tau, b, w, r). \quad (7)$$

To reduce clutter, in what follows we denote optimal asset accumulation by the rule $g(a, z)$ and optimal consumption by the rule $c(a, z)$. As households receive idiosyncratic shocks to their productivity each period, they will accumulate and decumulate assets to smooth consumption. In turn, households will vary in wealth over time. The heterogeneity of households at a given time- t can be described by a distribution $\lambda_t(a, z)$ describing the fraction (measure) of households with current wealth and productivity (a, z) . In general, the fraction of households with characteristics (a, z) may change over time. More specifically, let $P(a, z, a', z')$ denote the transition function governing the evolution of distributions of households over the state space (a, z) . $P(a, z, a', z')$ should be interpreted as the probability that a household that is in state (a, z) today will move to state (a', z') tomorrow. It is a function of the household decision rule $g(\cdot)$, and the Markov process for income z .

We will focus, however, on stationary equilibria, whereby $\lambda_t(a, z) = \lambda(a, z), \forall t$. Therefore, we locate a distribution $\lambda(a, z)$ that is invariant under the transition function $P(\cdot)$, which requires that the following hold:

$$\lambda(a', z') = \int P(a, z, a', z')d\lambda. \quad (8)$$

We denote the stationary marginal distributions of household characteristics a and z by λ_a and λ_z , respectively. Given this, aggregate consumption $C \equiv \int_{A \times Z} c(a, z)d\lambda$, aggregate savings $A \equiv \int g(a, z)d\lambda$, and aggregate labor supply $L \equiv \int q(z)d\lambda_z$ all will be constant.

Firms

There is a continuum of firms that take constant factor prices as given and employ constant-returns production in physical capital K and labor L . Given total factor productivity Λ , aggregate output Y then is given by a production function:

$$Y = F(\Lambda, K, L). \quad (9)$$

Physical capital depreciates at constant rate δ per period.

Government

There is a government that consumes an aggregate amount C^G and transfers an aggregate amount $B \equiv \int bd\lambda$ in each period. To finance these flows, the government may collect revenues from taxes on labor income, capital income, and consumption. Therefore, given $\lambda(a, z)$, tax revenue in each period denoted $T(\tau, B)$ is

$$T(\tau, B) = \int_{AxZ} [\tau^l w q(z) + \tau^k r g(a, z) + \tau^c c(a, z)] d\lambda. \quad (10)$$

The government's outlays in each period are given by

$$G = B + C^G, \quad (11)$$

where C^G is government consumption. The preceding collectively imply that the economy-wide law of motion for the capital stock is given by

$$K' = (1 - \delta)K + F(\Lambda, K, L) - C - C^G. \quad (12)$$

In equilibrium, $T(\tau, B) = G$. In our model, we abstract from government debt for two reasons. First, we wish to maintain a simpler environment and second, the ratio of public debt has fluctuated substantially over the past several decades, making a single, long-run number more difficult to interpret.

Equilibrium

Given constant tax rates $\tau = [\tau^l \ \tau^k \ \tau^c]$, factor productivity Λ , government consumption C^G , and per capita transfers b , a stationary recursive competitive general equilibrium for this economy is a collection of (i) a constant capital stock K ; (ii) a constant labor supply L ; (iii) constant prices (w , r); (iv) decision rules for the household $g(a, z)$ and $c(a, z)$; (v) a measure of households $\lambda(a, z)$ over the state space; (vi) a transition function $P(a, z, a', z')$ governing the law of motion for $\lambda(a, z)$; and (vii) aggregate

savings $A(\tau, B, r, w) \equiv \int g(a, z)d\lambda$, such that the following conditions are satisfied:

1. The decision rules solve the household's problem described in (1).
2. The government's budget constraint holds

$$G(\tau, B|r, w) = T(\tau, B). \quad (13)$$

3. Given prices, factor allocations are competitive:

$$\begin{aligned} F_k(\Lambda, K, L) - \delta &= r, \text{ and} \\ F_l(\Lambda, K, L) &= w. \end{aligned} \quad (14)$$

4. The aggregate supply of savings satisfies the firm's demand for capital

$$A(\tau, B, r, w) = K. \quad (15)$$

5. The distribution of households over states is stationary across time:

$$\lambda(a', z') = \int P(a, z, a', z')d\lambda. \quad (16)$$

Discussion of Stationary Equilibrium

Our focus on stationary equilibria warrants some discussion. In particular, even if government behavior were time-invariant, there may be equilibria in which prices faced by households vary over time in fairly complicated ways. Unfortunately, computing such equilibria is very difficult when households face uninsurable income shocks each period. The problems arise because even under constant prices, it is not possible that household-level outcomes remain constant through time. In turn, the distribution of households over wealth and productivity may vary through time. The moments of that distribution will, of course, vary as well. In such a setting, households would have to forecast an entire sequence of cross-sectional distributions of wealth and productivity over the infinite future in order to forecast the prices needed to optimally choose their own individual level of consumption and savings. Given the difficulties previously discussed, we restrict attention to equilibria where prices and allocations remain stationary over time. Under this simplification, households maximize their utility under a conjecture that they will face an infinite sequence of constant prices and taxes, and markets clear. In our case, the prices, taxes, and transfers are as follows: $w, r, \tau = [\tau^l \ \tau^k \ \tau^c]$, and b , respectively.

In turn, the solution to the household optimization problem generates a time-invariant rule that governs optimal consumption and savings as a function of current resources and productivity. In such a stationary setting, it is more

reasonable (and indeed, often to be expected) that a household's movements through time will be described by a single, unique, distribution.⁴ Intuitively, household decisions determine how the endogenous state variable of wealth evolves from one period to the next. However, because future productivity shocks are drawn at random, so is future wealth. In our model, wealth moves through time in a way that its probability distribution one period from now depends only on current wealth and current productivity. This type of movement occurs because productivity shocks are purely first-order autoregressive, and the household wishes only to choose wealth one-period ahead. In sum, wealth and productivity together follow a first-order Markov process. Under fairly general circumstances, the long-run behavior of such processes is time-stationary. Namely, across any two arbitrarily chosen (but sufficiently long) *windows of time*, the fraction of time that a household spends at any given combination of wealth and productivity will be equal. More useful for us, however, is that the preceding then generally implies that, across any two dates, the fractions of any (sufficiently large) *collection of households* with a given level of wealth and productivity will also be equal. That is, the cross-sectional distribution of households over wealth and productivity will be time-invariant.⁵ If this stationary distribution also clears markets, households are justified in taking the conjectured infinite sequence of constant prices as given.⁶

Measuring the Effects of Policy

The welfare criterion used here is the expectation of discounted utility taken with respect to the invariant distribution of shocks and asset holdings, as is standard in the literature.⁷ It is denoted by Φ and is given by

$$\Phi = \int v(a, z) d\lambda, \quad (17)$$

where $v(\cdot)$ is the value function as defined in (5), and λ is the equilibrium joint distribution of households as described in (16). Let Φ^{bench} denote the value under the benchmark and Φ^{policy} denote the value under an alternative policy.

Given Φ , we can compare welfare across policy regimes by computing the proportional increase/decrease to benchmark consumption that would make

⁴ For example, Huggett (1993) provides a proof of this for the case where households face two levels of shocks, have unbounded utility (as we do here), and face a borrowing constraint.

⁵ More generally, the relevant "state-vector" will have a constant cross-sectional distribution.

⁶ Households only take *equilibrium* prices as given. If prices did not clear markets, households or firms could not rationally take them as given when optimizing. Consequently, households or firms would have no guarantee of being able to buy (sell) the quantities they wished.

⁷ See, for example, Aiyagari and McGrattan (1998).

households indifferent between being assigned an initial state from the benchmark stationary distribution and being assigned a state according to the stationary distribution that prevails under the proposed policy change. Under our assumed CRRA preferences, this is given as:

$$\Psi = \left(\frac{\Phi^{bench}}{\Phi^{policy}} \right)^{\frac{1}{1-\mu}} - 1. \quad (18)$$

$\Psi > 0$ implies that the policy is welfare improving, while $\Psi < 0$ implies the reverse.⁸

Parameterization

In the benchmark economy, the goal of the calibration is to locate the discount rate, β^* , that allows the capital market to clear at observed factor prices, transfer levels, and tax rates. We then will use β^* when computing outcomes in the policy experiments. The model period is one year. We follow the work of both Domeij and Heathcote (2000) and Floden and Linde (2001) in parameterizing the benchmark economy. We observe directly some of the parameters associated with benchmark policy. These consist of the three tax rates measured by Domeij and Heathcote (2000) as $\tau^l = 0.269$, $\tau^k = 0.397$, and $\tau^c = 0.054$, respectively.⁹ Lump-sum transfers as a percentage of output are set following Floden and Linde (2001), at $\frac{B}{Y} = 0.082$. We specify production by a Cobb-Douglas function whereby $F(\Lambda, K, L) = \Lambda K^\alpha L^{1-\alpha}$. The interest rate, $r^* = 0.04$, and capital-output ratio of 3.32 follow Prescott (1986). Lastly, we set factor productivity Λ to normalize benchmark equilibrium wages w^* to unity.

We assume that a is bounded below by zero in every period, which precludes borrowing. This follows the work of Floden and Linde (2001), Domeij and Heathcote (2000), Domeij and Floden (2006), and Ventura (1999). We restrict the households' asset holdings to the interval $A=[0, \bar{A}]$. However, we set \bar{A} high enough that it never binds.

The utility function is CRRA and is given by $u(c) = \frac{c^{1-\mu}}{1-\mu}$. We set $\mu = 2.0$, as is standard. The values governing the income process are subject to more debate, however. We, therefore, study economies under two different levels of earnings risk that collectively span a range of estimates documented by Aiyagari (1994). In particular, we study a "high-risk" economy, in which $\sigma_\varepsilon = 0.2$, and also a "low-risk" economy, in which $\sigma_\varepsilon = 0.1$. With respect to the persistence of shocks, a reasonable view of the literature suggests that

⁸To convert model outcomes into dollar equivalents, note that average labor income in the model is normalized to unity, and average labor income in 2006 U.S. data is approximately \$50,000.

⁹We use tax rates as measured for 1990–1996 in Domeij and Heathcote (2000), Table 2.

ρ lies between 0.88 and 0.96. We therefore choose $\rho = 0.92$. The household discounts at a rate β that, for each level of earnings risk, will be calibrated to match aggregate capital accumulation under observed factor prices, depreciation, and tax policy.

To parameterize α , δ , and Λ , we will use direct observations on (i) the output-capital ratio, (ii) the interest rate r , and (iii) the share of national income paid to labor $\frac{wL}{Y}$. First, given prices w and r , the profit-maximizing levels of capital and labor that a firm wishes to rent solve the following problem:

$$\max \Lambda K^\alpha L^{1-\alpha} - wL - (\delta + r)K. \quad (19)$$

For labor, this has the first-order necessary condition:

$$(1 - \alpha)\Lambda K^\alpha L^{-\alpha} = w.$$

Multiplying both sides by L and rearranging allow us to write:

$$(1 - \alpha) = \frac{wL}{Y}.$$

Thus, α can be inferred from the observed share of national income going to labor. Turning next to depreciation, optimal capital has the first-order necessary condition:

$$\alpha \Lambda K^{\alpha-1} L^{1-\alpha} = r + \delta, \quad (20)$$

which, after multiplying by K and rearranging, allows us to use the measured output-capital ratio $\frac{Y}{K}$ to recover δ as a function of observables:

$$\delta = \alpha \frac{Y}{K} - r.$$

Lastly, to set total factor productivity such that equilibrium wages are normalized to unity, we use the first-order condition for labor demand. First, note that we must locate a value of Λ such that

$$w = (1 - \alpha)\Lambda K^\alpha L^{-\alpha} = 1. \quad (21)$$

However, since capital must satisfy (20), optimal capital (fixing $L = 1$) is given by

$$K = \left(\frac{r + \delta}{\alpha \Lambda} \right)^{\frac{1}{\alpha-1}}. \quad (22)$$

Substituting into (21), we have

Table 1 Parameters

Parameter	Value {high, low}	Source
τ_{bench}^l	0.269	Domeij and Heathcote (2000)
τ_{bench}^k	0.397	Domeij and Heathcote (2000)
τ_{bench}^c	0.054	Domeij and Heathcote (2000)
r_{bench}^*	0.04	Prescott (1986)
$\frac{b}{Y}$	0.082	Floden and Linde (2001)
β	{0.9587, 0.9673}	Calibrated to clear capital mkt. at r_{bench}^*
μ	2.0	Standard in literature
α	0.36	Kydland and Prescott (1982)
δ	0.0685	Calibrated to match $\frac{K}{Y} = 3.32$, given α , r_{bench}^*
Λ	0.865	Calibrated to match $w = 1$
ρ	0.92	Floden and Linde (2001)
σ_ε	{0.2, 0.1}	Similar to Aiyagari (1994)

$$(1 - \alpha)\Lambda \left(\frac{r + \delta}{\alpha\Lambda} \right)^{\frac{\alpha}{\alpha-1}} = 1,$$

which then implies that

$$\Lambda = \left(\frac{1}{1 - \alpha} \right)^{1-\alpha} \left(\frac{r + \delta}{\alpha} \right)^\alpha.$$

Table 1 summarizes our parameter choices.

Computation

We solve the recursive formulation of the household's problem by applying standard discrete-state-space value-function iteration (see, for example, Ljungqvist and Sargent [2000] 39–41). In order to do this, we first assume that the productivity shocks can take 25 values. We follow Tauchen (1986) to obtain a discrete approximation of the continuous-valued process defined in (4). For assets, we use a grid of 500 unevenly spaced points for wealth, with more points located where the value function exhibits more curvature. In the benchmark economy, we know that prices and transfers must match the data. Therefore, treating prices and transfers as fixed, we guess a value for β , solve the household's problem, and obtain aggregate savings. We then iterate on the discount factor β until we clear the capital market. Labor supply is

inelastic, so the labor market clears by construction.¹⁰ Once we have located a discount factor that clears the capital market, we obtain aggregate tax revenue $T(\tau, B)$.¹¹ We then set government consumption, C^G , as the residual that allows the government budget constraint to be satisfied.¹²

For the policy experiments, note first that our definition of revenue neutrality means that the revenue needed by the government is exactly the level needed in the benchmark, as we hold both transfers and government consumption fixed at their benchmark *levels*. Given this condition, we compute equilibria by iterating on both tax rates and the interest rate. Specifically, we first guess an interest rate that, under the aggregate labor supply of unity, also yields the wage rate. We then guess a tax rate and impose the precise level of transfers obtained from the benchmark. Given these parameters, we can solve the household's problem, from which we obtain aggregate savings. We then check whether savings clears the capital market, and if not, we update the interest rate. Once we have found an allocation that clears the capital market, we check whether the government's budget constraint is satisfied. That is, we check whether the market-clearing allocation found allows the government to raise the same level of revenue as in the benchmark. If not, we adjust the specific tax rate that is under study in a given policy experiment. We then return to the iteration on the interest rate in order to clear the capital market. We continue this process until we have located both an interest rate and a tax rate whereby capital market-clearing and the government budget constraint are both simultaneously satisfied.

2. RESULTS

The experiments conducted in this article compare allocations obtained in the benchmark economy with those obtained under four alternative tax regimes. These are regimes that raise revenue by (i) using only consumption taxes, (ii) using only labor income taxes, (iii) eliminating labor income taxes, and (iv) eliminating consumption taxes. The results are then presented in two sections. First, we study aggregate outcomes alone. Second, we study how households in different circumstances behave and also how their welfare changes across taxation regimes. We then discuss the robustness of our findings.

¹⁰ Nakajima (2006) contains a useful description of the iterative scheme used here.

¹¹ We simply multiply aggregate consumption C , capital K , and individual labor income wL in that allocation by their respective tax rates.

¹² Our use of the taxes estimated by Domeij and Heathcote (2004) and transfers estimated by Floden and Linde (2001) implies that our measure of government consumption as a percentage of output will not necessarily coincide with that obtained in the latter. However, in our benchmark, we find very similar results, 20.3 percent vs. 21.7 percent in Floden and Linde (2001).

Table 2 Aggregates

High-Risk	τ_l	τ_k	τ_c	r^*	w^*	Y	C	K^{INC}	$\frac{K^{INC}}{Y}$	K^{CM}	$\frac{K^{INC}}{K^{CM}} - 1$	Ψ
Benchmark	0.269	0.397	0.054	0.040	1.001	1.566	1.067	5.203	3.32	3.493	48.97%	\$0
τ^c only	0.000	0.000	0.400	0.022	1.101	1.734	1.122	6.903	3.98	4.974	38.77%	\$1,010
τ^l only	0.360	0.000	0.000	0.026	1.084	1.696	1.130	6.489	3.83	4.974	30.45%	\$1,026
τ^c & τ^k	0.000	0.397	0.347	0.035	1.027	1.604	1.069	5.557	3.47	3.493	11.71%	\$305
τ^l & τ^k	0.320	0.397	0.000	0.041	0.997	1.558	1.067	5.126	3.29	3.493	46.77%	-\$45
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Low-Risk												
Benchmark	0.269	0.397	0.054	0.040	1.002	1.565	1.020	5.193	3.32	4.190	23.92%	\$0
τ^c only	0.000	0.000	0.390	0.025	1.087	1.697	1.061	6.499	3.83	5.697	14.06%	\$3,136
τ^l only	0.370	0.000	0.000	0.025	1.086	1.698	1.068	6.506	3.83	5.697	14.19%	\$1,927
τ^c & τ^k	0.000	0.397	0.330	0.040	1.001	1.565	1.013	5.187	3.32	4.190	23.79%	\$663
τ^l & τ^k	0.320	0.397	0.000	0.040	1.002	1.564	1.023	5.185	3.32	4.190	23.74%	-\$21

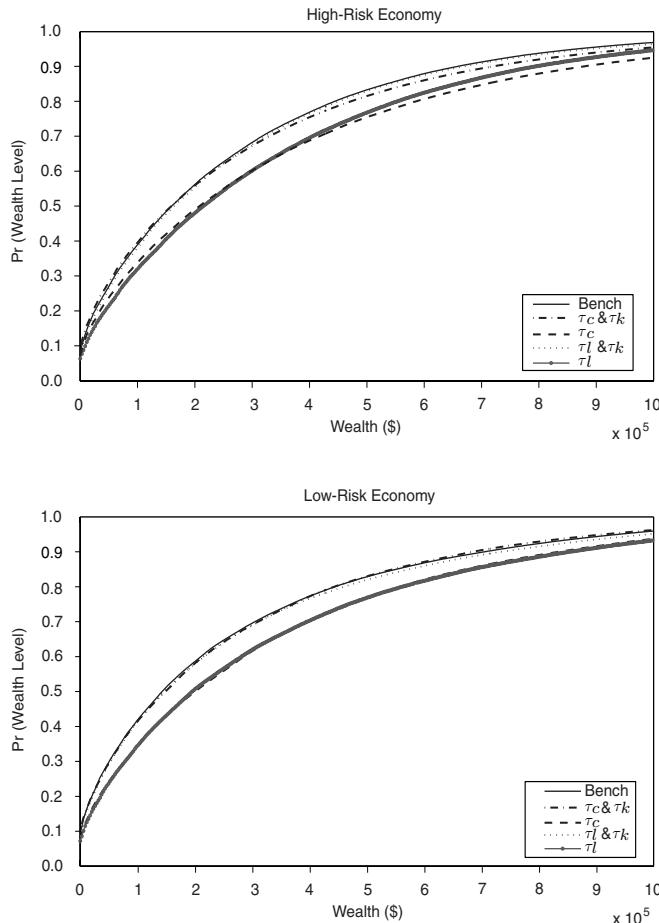
Tax Policy and Long-Run Aggregates

Our findings for aggregate outcomes can be summarized as follows. First, capital income taxes are unambiguously important for allocations. Second, a regime of pure consumption taxation leads to the highest steady-state savings rates among the alternatives we consider. Third, we find that the increased steady-state savings rates are, in turn, generally associated with substantially larger capital stocks than the alternatives. Fourth, the implications of taxation regime depend, in some cases strongly, on the level of income risk faced by households. Table 2 presents aggregate summary data from both the high- and low-risk economies.

We first turn to a discussion of distortions to capital accumulation resulting from differing tax regimes. Table 2 displays the over-accumulation of capital that results from differing tax regimes under incomplete markets as compared to the complete-markets case, denoted by K^{INC} and K^{CM} , respectively. It is important to note, however, that K^{CM} is calculated using the effective interest rate implied by β and τ^k . That is, the over-accumulation, $\frac{K^{INC}}{K^{CM}} - 1$, expressed in the tables takes the tax regime as given, and thus, is a symptom of incomplete markets and the inability of households to completely insure themselves against risk. From this calculation, we observe that regimes with no capital taxation result in less over-accumulation of capital, especially in the low-risk economy. This implies that households are able to insure themselves more fully through precautionary savings under policies that do not tax returns to capital. Additionally, income risk matters for the way in which households respond to pure consumption taxes. This can be seen by noting that in the low-risk economy, households over-accumulate capital by the smallest percentage under the pure consumption tax policy, while in the high-risk economy, households over-accumulate by a large percentage under the same regime. This further elucidates the role taxes play in an household's ability to insure itself against future risk.

Ignoring distributional issues, we now address the issue of whether pure consumption taxation regimes yield large benefits in terms of increased aggregate output and consumption. The answer here is unambiguously "yes." In the long run, under both high- and low-income risk, pure consumption taxation is associated with capital deepening, as measured by the capital-output ratio on the order of 20 to 25 percent. This fact can also be seen in Figure 1, which shows the cumulative distribution of wealth under the various tax regimes. Average long-run consumption is also higher across income-risk categories and is made possible by the fact that the increased capital stock does not require disproportionately greater resources to maintain.

However, it does not appear to be necessary to move to a strictly consumption-based tax system to realize much of the gains from eliminating capital income taxes. In Table 2, we see that a regime of pure labor income taxes has much the same effect when measured in terms of impact

Figure 1 Cumulative Distribution of Capital

on the capital stock, consumption, and output. That is, the intertemporal distortion arising from capital taxation seems most significant. Given the intuition provided at the outset for the differential risk-sharing properties arising from the two main alternatives to capital income taxes, the question now is, in terms of aggregates, how large are these differences? The short answer here is “not much.” In other words, pure labor income taxes and pure consumption taxes yield broadly similar outcomes.

However, before concluding that consumption taxes are a “free lunch,” there is one meaningful difference. The size of the increase in capital stock arising from a move to pure consumption taxes is much larger when income risk is higher. This is a key point that suggests that not all the increase in capital

accumulation arising from a move to consumption taxes should be interpreted as emerging from the removal of an intertemporal distortion to savings.

We now turn to the differences created by using consumption taxes instead of labor income taxes. The key finding is that capital over-accumulation grows substantially from the use of consumption taxes in the high-risk economy, from approximately 30 to 38 percent, while it remains essentially constant, at 14 percent, in the low-risk economy. This finding is a clear indicator that consumption taxes indeed have undesirable risk-sharing consequences, which households attempt to buffer themselves against.

Perhaps even more persuasive evidence for the increased risk to households created by consumption taxation is the fact that we calibrated the high- and low-risk economies separately. In particular, we see from Table 1 that the calibrated discount factor in the high- and low-risk economies are $\beta = 0.9673$ and $\beta = 0.9557$, respectively. This difference is greater than a full percentage point. To put the implications of the preceding into perspective, we check what this means for the complete-markets capital level, K^{CM} , which is calculated to match the interest rate implied by β and τ^k . In percentage terms, the ideal capital stock in the high-risk economy is around 15 percent smaller than under the low-risk economy.¹³ Yet, despite this, the steady-state capital stock under pure consumption taxes grows by 40 percent under high-income risk, and by just 14 percent under low-income risk. Moreover, in Table 2, we see that in absolute terms, the capital stock is substantially larger under pure consumption taxes when income risk is high.

Studying the implications of consumption taxes for steady-state welfare further clarifies the sense in which the “size” of the economy, as measured by output, is a misleading measure of welfare gains. In particular, we see first that welfare gains from a move to consumption taxes under low-income risk are substantial, at approximately \$3,000 annually, or 7 percent of median income. Further, this gain dwarfs the gains obtained from moving, in the low-risk economy from the benchmark, to a pure labor income tax regime, which is only about two-thirds as large (\$1,927). The elimination of capital taxation results in consumption increases in both economies. However, even though the growth is larger in the high-risk economy, the welfare gains are smaller.

Intuitively, the risk created by consumption taxation demands a buffer stock of savings of a size that depends crucially on the income risk that households face. The response of the size of the buffer stock can be seen in terms of savings rates. Specifically notice that both the regime of pure consumption taxes and the regime of pure labor income taxes generate almost identical savings in the low-risk economy, but lead to a 2 percentage point (6 percent)

¹³ That is, $(5.69-4.97)/4.97 \approx 0.15$.

Table 3 Volatilities

High-Risk	σ_{cons}	$\frac{\sigma_{cons}}{\mu_{cons}}$	Savings Rate
Benchmark	.376	.352	.391
τ^c only	.403	.359	.353
τ^l only	.398	.352	.334
τ^c & τ^k	.386	.361	.333
τ^l & τ^k	.375	.351	.315
<hr/>			
Low-Risk			
Benchmark	.251	.246	.348
τ^c only	.241	.227	.375
τ^l only	.281	.263	.371
τ^c & τ^k	.227	.224	.353
τ^l & τ^k	.258	.252	.346

increase in the high-risk economy relative to its nearest alternative, which is the pure labor income tax.

In Table 3, we display both the standard deviation of consumption as well as the coefficient of variation of consumption, which is the ratio of the standard deviation to the mean. The coefficient of variation highlights the consumption risk associated with a given policy.¹⁴ These data show again that increased aggregate output is not necessarily attributable to fewer distortions but instead may be due to more risk exposure for households. In the high-risk economy, increases in output and the capital stock are always accompanied by increases in the standard deviation and coefficient of variation of consumption, indicating that under each policy, the household is subject to increased risk. By contrast, in the low-risk economy, a move to a pure consumption tax yields lower variation in consumption, both in absolute and relative terms. This serves to further illustrate that the effects of tax policies depend in important ways on the underlying income risk that households face.

Our results make clear that when choosing between the polar extremes of pure labor taxes and pure consumption taxes, income risk must be taken into account. Is the same warning applicable to more intermediate tax reforms as well? To answer this, we study the effects arising from holding capital income taxes fixed at their benchmark level and moving to alternative regimes, which raise the remainder of revenues via only one of the two remaining taxes. That is, we consider two alternatives: (1) $\tau^k = 0.397$ and $\tau^l = 0$ and

¹⁴ Specifically, for a mean-preserving proportional risk, multiplying the coefficient of variation of consumption by one-half of the coefficient of relative risk aversion yields the percentage of mean consumption that a household would be willing to pay to avoid a unit increase in standard deviation. See, for example, Laffont (1998, 22).

(2) $\tau^k = 0.397$ and $\tau^c = 0$. In each of these cases, the remaining tax is set to meet the government's expenditure requirements.

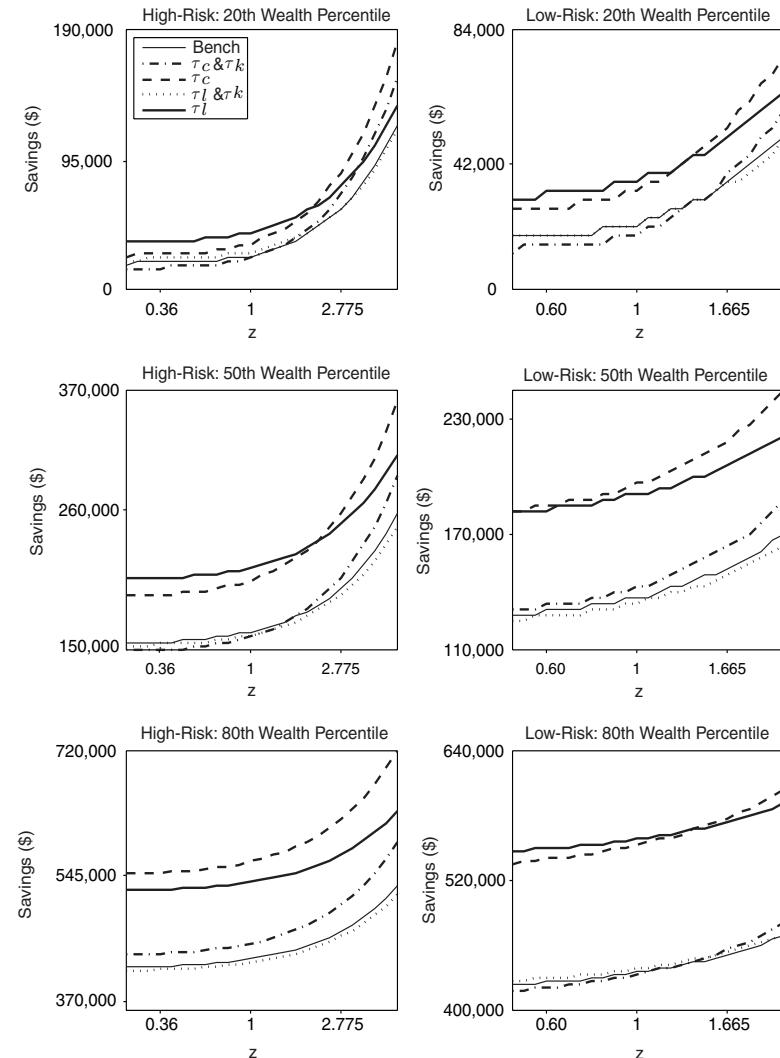
Three findings are worth emphasizing. First, steady-state welfare under regimes in which labor income taxes are eliminated are preferable to those in which consumption taxes are eliminated. This is true under both specifications of income risk. Once again, however, the gains from preserving consumption taxes are much larger (roughly double) when income risk is low. Second, under high-income risk, not only are the gains to eliminating labor income taxes smaller, but also the gains themselves are, in large part, an artifact of the increased buffer stock that households build up. This is seen in the substantially larger capital stock associated with the "no-labor-tax" regime relative to the "no-consumption-tax" regime.

Lastly, notice that though allocations under the no-consumption-tax regime are in some ways similar to the other allocations, the reliance in this case on a combination involving a subset of the available tax instruments does worse in welfare terms than the alternatives. That is, welfare-maximizing policies are those that either (1) use one instrument alone, such as in the cases with pure labor or consumption taxes, or (2) use all three instruments, such as in the benchmark. We now turn to the effect of tax policies on the household-level savings decisions that ultimately generate the aggregates discussed previously.

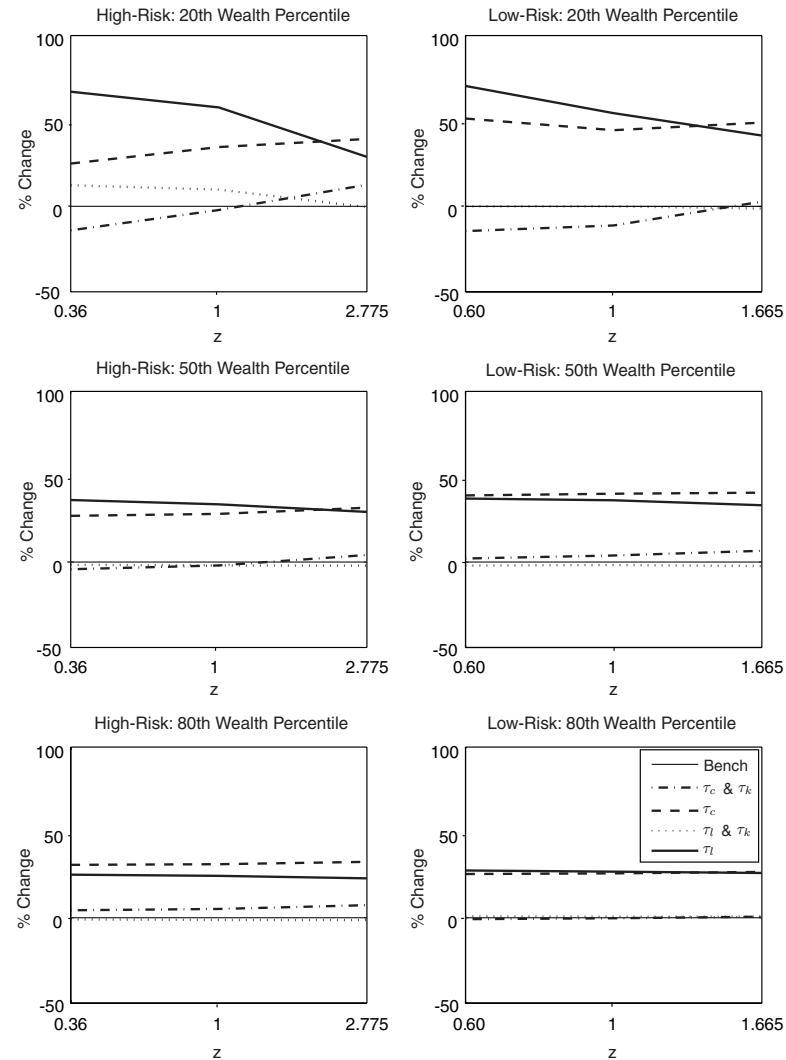
Household-Level Outcomes

Tax Policy and Changes in Savings

Having focused earlier on the response of economy-wide aggregates, we now study a variety of subsets of households in order to understand the origins of the aggregate responses. We first discuss household savings behavior and then turn to welfare. In Figures 2 and 3, we study the effects of changes in policy on the amount of wealth accumulated in both the high- and low-risk economies across income shocks. Notice, first, that the two regimes in which capital income taxes are eliminated, both generate the largest increases in savings, which is consistent with the substantial growth of the capital stock seen in the aggregate. Conversely, as long as capital income taxes are used at all, savings rates do not deviate substantially from the benchmark. Notice, though, that deviations from the benchmark at low levels of skill and wealth are greatest for the case in which revenues are raised through labor taxes only. However, it is still true that, on average, the level of savings is highest under a consumption-tax-only regime. For those with low wealth, as seen for the 20th percentile of wealth, the response of savings rates to tax policy also is more sensitive to current labor productivity (see Figure 3). Intuitively, for low-wealth households, labor income is important in determining the current budget, especially as these households cannot borrow.

Figure 2 Savings Decision Rules Given Income Shock

We also see that the current productivity shock received by the household has very little effect on the response to policy changes for wealthy households (in other words, those that are above the median of the wealth distribution). The preceding is true regardless of current labor productivity. Additionally, even for low-wealth households, the response to a change from the benchmark to either of the two alternative policies with positive capital tax rates is relatively unaffected by current productivity. For poorer households, however, savings

Figure 3 Deviations in Level of Savings from the Benchmark

does respond to the elimination of capital taxation. Specifically, in both the high- and low-risk economies, savings rates under pure labor income taxes are relatively higher for low-productivity households than for high-productivity households.

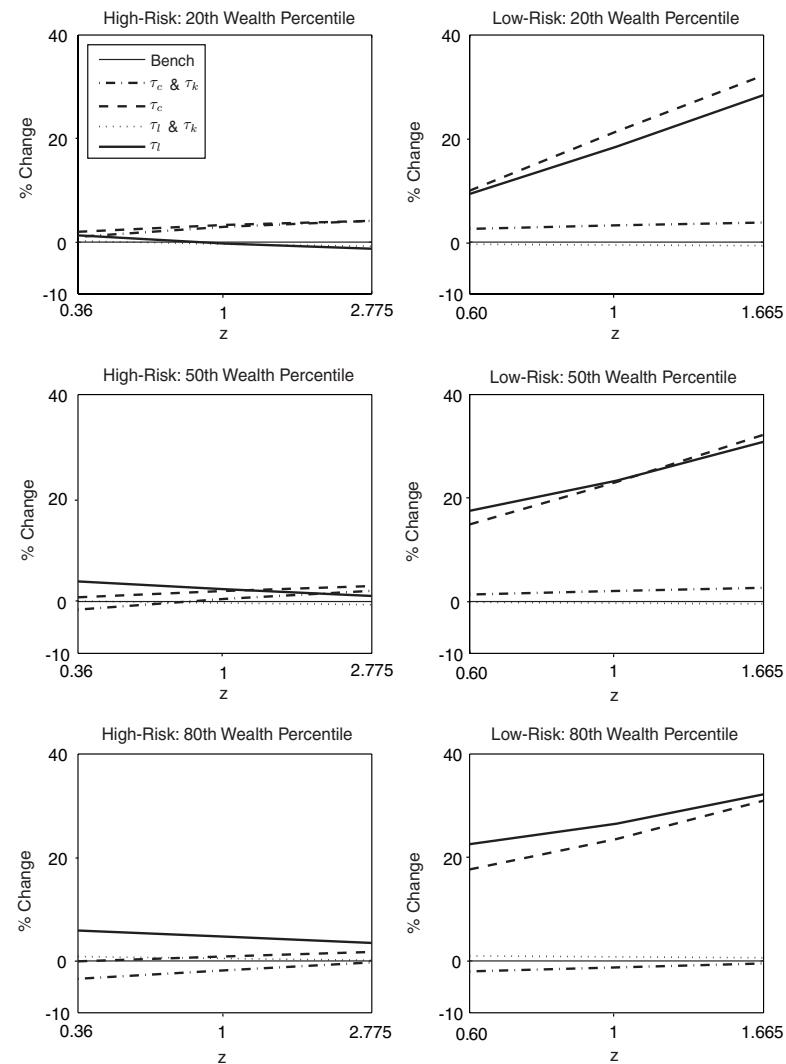
Consider next a switch from the benchmark to either of the two policies under which consumption taxes are zero, that is, τ^l only and (τ^l, τ^k) . In these cases, the changes generated by making the policy switch are very small

relative to the changes generated by a switch from the benchmark to the other alternative taxation regimes. The intuition for this finding is that under policies featuring proportional labor income taxes, higher current productivity implies that a larger amount of the household's income is extracted to pay taxes. If consumption is being smoothed, savings behavior will have to respond. Conversely, under policies that eliminate labor taxes altogether, those with high productivity are proportionally richer than counterparts who face labor taxes and, thus, are able to save and consume more. We also note the largest deviations in savings from the benchmark arise for low-wealth households. The intuition supporting this result is that low-wealth households are comparatively more affected by any increase or decrease in taxes because of their inability to smooth consumption through the use of previously accumulated wealth.

Household Welfare

Turning now to the welfare consequences of the alternative tax policies, we partition the population by wealth and current productivity. We study the welfare gains or losses emerging from policy changes by computing the quantity in (18) for households with each particular combination of current wealth and productivity. The central implication of our welfare analysis is simple: the welfare gains from a move to capital income taxes depend very strongly on the level of income risk faced by households. In particular, we saw previously that steady-state welfare gains from removing capital income taxes are much larger under low-income risk than under high-income risk. Figure 4 shows that this difference arises from the fact that essentially all households benefit more from such a policy under low-income risk than under high-income risk. In this sense, the distributional effects are somewhat simple to document. Specifically, the order of magnitude of the welfare gains we find is approximately 10 to 30 percent for various households under low-income risk, but only around 2 to 5 percent under high-income risk. This is particularly striking given that capital stocks in the high-income risk economies are larger than those in the low-income risk economies.

The insurance-related effects of pure consumption taxes can also be seen because under both income processes, high-productivity households gain most from the switch to pure consumption taxes. By contrast, the welfare effects of labor income taxes turn out to depend on both productivity and wealth. In particular, under low-income risk, the elimination of capital taxes seems more important than the way in which the resulting revenue shortfall is financed. That is, households are essentially indifferent between a move to pure labor income taxes and a regime of pure consumption taxes. In sharp contrast, high-income risk leads households to prefer high labor income taxes when they have low productivity, and to prefer high consumption taxes when they have high labor productivity. This is precisely a result of smoothing behavior: the

Figure 4 Deviations in Consumption Equivalent from Benchmark

income-poor consume more than their income, and income-rich, the reverse. The high levels of income risk faced by households then lead them to prefer to smooth their tax liability across states of the world.

When ordering households by their wealth holdings, we again see a divergence between those who gain and those who lose from a pure consumption tax. In the low-risk setting, the gains from moving to consumption (or labor) taxation generate the largest gains for the wealthy. By contrast, under

high-income risk, the gains accruing to wealthier households shrink systematically. Conversely, high-wealth households in the high-risk economy gain more than their lower-wealth counterparts because of the switch to a pure labor tax.

3. ROBUSTNESS AND CONCLUDING REMARKS

In this article, we studied the differential implications arising from two commonly proposed alternatives to capital income taxes. Our findings suggest that consumption and labor income taxes have quite different effects and will be viewed disparately by households that differ in both wealth and current labor productivity. In terms of robustness, we focused exclusively on the role played by uninsurable income risk, as the latter is a source of some contention in the literature. However, our results may well depend on several additional assumptions. Notably, our analysis is restricted to an infinite-horizon setting. A central issue that arises, therefore, is the ability of most (in other words, all but the least fortunate) households to build up a substantial “buffer-stock” of wealth, in the long run. This accumulation then renders the risk-sharing problem faced by households easier to confront. In this sense, the infinite-horizon setting, while convenient, may underestimate the hardship caused by uninsurable risks. In particular, the polar opposite of the dynamic model is the pure life-cycle model in which households care only about their own welfare, and not at all about the welfare of their children. Under this view, the young will enter life with no financial wealth, and will, therefore, be very vulnerable to both income shocks and tax systems that force them to pay large amounts when young. In such a setting, high consumption taxes may be substantially more painful than in our present model.

A model with overlapping generations would also allow us to highlight the intergenerational conflicts created by tax policy, something that our present model cannot address. One specific issue that would then be possible to address is that, at any given point in time, a switch to consumption taxation away from income taxation would hurt those who had saved a great deal. In a life-cycle model, this group would be, in general, relatively older. After all, older households, especially if retired, earn little labor income, but consume substantial amounts. Conversely, young households that have not saved much will not oppose consumption taxes in the same way—especially if they are currently consuming amounts less than their income (i.e., are saving for retirement).

In addition to using dynasties, we simplified our analysis by employing an inelastic labor supply function. This is, of course, not necessarily innocuous. If taken literally, such a specification would call for a 100 percent labor tax that was then rebated to households in a lump-sum payment. Immediately, risk sharing would be perfect. Common sense strongly suggests that labor effort,

even if inelastic over some ranges, would likely fall dramatically as tax rates approached 100 percent. Thus, future work should remove this abstraction in order to more accurately assess the costs of high tax rates.

More subtle, however, is the possibility that with elastic labor supply, households have an additional means of smoothing the effects of productivity shocks. That is, by working more when highly productive and less when not, a household can more easily accumulate wealth and enjoy leisure. Recent work of Marcket, Obiols Homs, and Weil (forthcoming) and Pijoan-Mas (2006) argues that variable labor effort can be an important smoothing device. In fact, Marcket, Obiols Homs, and Weil (forthcoming) even demonstrate that the additional benefit of being able to alter labor effort can lead to a capital stock that is *lower* than the complete-markets analog. In turn, the impetus for positive steady-state capital income taxes may simply disappear.

Lastly, throughout our model, we prohibited borrowing. The expansion of credit seen in recent years (see, for example, Edelberg 2003 and Furlotti 2003) may now allow even low-wealth households to borrow rather than use taxable labor income to deal with hardship. In turn, the tradeoffs associated with a switch to consumption taxes will be altered. In ongoing work, we extend the environment to allow for life-cycle wealth, nontrivial borrowing, and elastic labor supply. Such an extension will, we hope, provide a more definitive view of the consequences of alternatives to capital income taxation.

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