Capital Taxes and Redistribution: The Role of Management Time and Tax Deductible Investment

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Abstract

Should capital income be taxed for redistributional purposes? Judd (1985) suggests that it should not. He finds that the optimal capital tax is zero at steady state from the point of view of any agent. This paper re-examines this question in an infinitely-lived worker-capitalist model, in which capitalists devote management time to build capital. Two forms of capital taxation are considered: one for which investment is not tax deductible (corporate tax) and a second one for which investment is fully and immediately tax deductible (dividend tax). Our main results are as follows. The optimal corporate tax is zero at steady state from the point of view of any agent. However, the optimal dividend tax is in general not zero at steady state and depends on preference parameters, life-time wealth and the point of view (Pareto weights) of the benevolent policymaker. For Pareto weights that lead to Pareto-improving reforms, we find that labor tax rates should be eliminated while dividend tax rates should be increased to around 36 per cent at steady state.

JEL Codes: E62, H23, H25.

Keywords: Optimal Policy; Capital Taxes; Redistribution; Investment Deductibility.

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1 Introduction

Should capital income be taxed for redistributional purposes? The seminal work of Judd (1985) suggests that it should not. He finds that the optimal redistributive tax on capital income is asymptotically zero from the point of view of any agent.[1] Given this result, most of the literature on optimal taxation has focused on the efficiency purposes of capital taxation in representative agent models rather than the redistributive side of capital taxation. In practice, however, capital taxes are far from zero. This is illustrated in Table 1 and Figure 1, where capital tax rates are also shown to vary substantially across countries and with the political turnover.

[Insert Table 1 and Figure 1 about here.]

Recently, in an important contribution to the literature of optimal taxation, Albanesi and Armenter (2012) identify a general optimality principle. Optimal policy should be such that permanent intertemporal distortions are eliminated in the long run. In terms of capital taxation, this general principle can be put into practice in two alternative ways: (i) capital taxes are set to zero, or (ii) investment is fully and immediately tax deductible so that constant capital taxes do not bring in permanent intertemporal distortions. A recent example of this distinction is in Conesa and Domínguez (2013). In a representative agent model with intangible assets and investment deductibility, we consider two forms of capital taxation: one for which investment is not tax deductible and a second one for which investment is fully and immediately tax deductible. For clarity of exposition, we refer to them as corporate taxes and dividend taxes respectively. In that paper, we found that, at steady state, while optimal corporate taxes are zero, the optimal tax rate on dividend income is positive, and equal to the optimal labor tax rate. We conjecture that these two different ways for capital taxation to attain the same efficiency principle must have different implications for redistribution.

This paper re-examines the optimal redistributive capital tax when investment is tax deductible. We consider an economic environment that merges those considered in Judd (1985) and Conesa

[1] In a representative agent model, Chamley (1986) also finds that steady state capital taxes should be set to zero. This result does not extend to OLG models, as shown in Erosa and Gervais (2002), Garriga (2017) and Conesa et al. (2009).

and Domínguez (2013): an infinitely-lived worker-capitalist model, in which workers provide raw labor to firms while capitalists can provide management time to build capital and/or raw labor. Management time is a form of intangible investment. It is sometimes called sweat equity, as it is made of hours invested by managers in their businesses to build equity. We again consider corporate taxes (for which investment is not tax deductive) and dividend taxes (for which investment is tax deductible). In comparison to Judd (1985), the only distinctive features of our environment are elastic labor supplies, management time and tax deductible investment.

Our main results are as follows. First, as in Judd (1985), the optimal redistributive corporate tax is zero at steady state from the point of view of any agent. Since investment is not tax deductible in corporate income, corporate taxes create permanent intertemporal distortions and are not optimal for efficiency neither for redistribution in the long run. Second, as Conesa and Domínguez (2013), the optimal dividend tax is not zero at steady state. As investment is fully and immediately tax deductible, a constant dividend tax does not imply any investment distortions and can be set at a positive level for both efficiency and redistribution. For efficiency purposes, Conesa and Domínguez (2013) find that dividend taxes should be set at the same level as labor taxes. For redistribution, however, this paper finds that the optimal dividend tax does not need to coincide with the labor tax rate. Moreover, the optimal steady-state dividend tax rate depends on the preference parameters, the life-time wealth of all agents and the point of view (Pareto weights) of the benevolent policymaker.

Our analytical results are illustrated with numerical examples. For our benchmark calibration, and for a policymaker with a very low Pareto weight on workers, the optimal long-run policy sets labor tax rates as high as 90 per cent and dividend tax rates as low as -67 per cent. As the policymaker becomes more pro-worker, optimal steady-state labor taxes decrease and dividend tax rates increase. For Pareto weights consistent with Pareto-improving reforms, we find that labor taxes are roughly eliminated while dividend taxes are increased to 36 per cent at steady state. For a policymaker that values workers and capitalists equally, the long-run optimal policy prescribes a 14 per cent subsidy to workers and a 69 per cent dividend tax to capitalists. For that and higher Pareto weights, the Kuhn-Tucker conditions on the raw labor supply by capitalists bind at steady state. For that range, as the Pareto weight on workers increases, long-run optimal taxes change only minimally with slight decreases in both labor and dividend tax rates.

Our paper is related to the public finance results on taxation with investment tax deductibility (such as Hall and Jorgenson (1971) and Auerbach (2002)). More recently, in a general equilibrium framework, Abel (2007) shows that full and immediate investment tax deductibility changes the distortionary properties of capital taxation.

Our work is also related to those of Rogers (1986) and Armenter (2007). Both study the relationship between credibility (of the optimal policy) and redistribution motives in the setup of Judd (1985). Armenter (2007) shows that the specific Pareto weights are important for the credibility of an optimal redistributive tax policy. More recently, Bassetto (2014) studies optimal redistributive taxes in an economy with real shocks and no capital. He finds that for extreme values of the Pareto weights, a government may impose large distortions in the economy in order to redistribute wealth.

The rest of the paper is organized as follows. Section 2 presents the environment economy. Section 3 sets the Ramsey problem and develops the main results. Section 4 concludes.

2 The Model Economy

This Section presents an infinite horizon model that merges the frameworks of Judd (1985) and Conesa and Domínguez (2013).

Time is discrete and indexed by $t = 0, 1, 2, ...$ Our environment considers a benevolent government and two types of infinitely-lived agents: capitalists and workers. Workers (agents of type 1) supply labor to firms but cannot save. Capitalists (agents of type 2) own firms and can save. In addition, capitalists dedicate management time to the firm in order to build new capital and, if they wish to, they may additionally supply raw labor. Population is normalized to one and is composed of a proportion κ of workers and a proportion $(1 - \kappa)$ of capitalists.

All workers are assumed to be identical within type. The preferences of each worker are

$$U_1 = \sum_{t=0}^{\infty} \beta^t u_1(c_{1,t}, n_{1,t}), \tag{1}$$

with the discount factor $\beta \in (0,1)$, and where the utility function u_1 is strictly increasing (decreasing) in consumption (labor), strictly concave (convex) in consumption (labor), twice continuously differentiable and, for notational convenience, separable between consumption $c_{1,t}$ and labor $n_{1,t}$. As workers cannot save or borrow,[2] their budget constraint is given by

$$c_{1,t} = (1 - \tau_t^n) w_t n_{1,t}, \tag{2}$$

in all periods t, where wages are w_t and labor income is taxed at the rate τ_t^n.

Given policies, prices and other agents' choices, workers choose $\{c_{1,t}, n_{1,t}\}_{t=0}^{\infty}$ to maximize (1) subject to (2). The resulting consumption-labor decision is

$$-u_{1n,t} = u_{1c,t} (1 - \tau_t^n) w_t. \tag{3}$$

Partial derivatives of the utility function are denoted with a subscript. Other derivatives follow a similar notation.

All capitalists are assumed to be identical within type. The preferences of each capitalist are

$$U_2 = \sum_{t=0}^{\infty} \beta^t u_2(c_{2,t}, n_{2,t} + e_{2,t}), \tag{4}$$

with $c_{2,t}$ consumption, $n_{2,t}$ labor, $e_{2,t}$ effort or management time, and where the utility function u_2 satisfies the same general properties as u_1, but may take a different specific form. Each capitalist owns a firm that produces a general good using the production function $f(k_t, n_t)$, where k_t is capital, n_t is the labor employed by the capitalist, and f is increasing, concave and satisfies the Inada conditions. We consider a symmetric equilibrium where all firms hire the same amount of labor, then $n_t = \left(\frac{\kappa}{1-\kappa}\right) n_{1,t} + n_{2,t}$. Capitalists can save by investing in their firms and by purchasing government bonds b_{t+1}. The budget constraint of a capitalist takes the form

[2] In the sensitivity analysis of our numerical exercise, we allow workers to save and borrow by buying and selling government bonds.

$$c_{2,t} + b_{t+1} = \left(1 - \tau_t^d\right) \Pi_t + (1 - \tau_t^n) w_t n_{2,t} + R_t^b b_t, \tag{5}$$

where capital income Π_t is

$$\Pi_t = \left(1 - \tau_t^k\right) \left[f\left(k_t, n_t\right) - w_t n_t\right] + \tau_t^k \delta k_t - x_t, \tag{6}$$

where τ_t^k is a corporate tax with investment x_t being not tax deductible, and τ_t^d is a dividend tax with investment being fully and immediately tax deductible, δ is the capital depreciation rate, and R_t^b is the return on government bonds in period t.

As mentioned, capitalists devote management time, $e_{2,t}$, and resources, x_t, to build new capital:

$$k_{t+1} = I\left(x_t, e_{2,t}\right) + \left(1 - \delta\right) k_t, \tag{7}$$

with I strictly increasing, concave, homogeneous of degree 1, continuously differentiable and satisfying Inada conditions. Equation (7) assumes that management time $e_{2,t}$ is necessary to transform resources x_t into new capital k_t. This form nests the standard neoclassical model whenever $I\left(x_t, e_{2,t}\right) = x_t$ is assumed for all $e_{2,t}$. Conesa and Domínguez (2013) consider two forms of capital, tangible and intangible capital, and different technologies for transformation of resources into each form of capital.

Given policies, prices and other agents' choices, a capitalist chooses $\{c_{2,t}, n_{2,t}, e_{2,t}, x_t, n_t, k_{t+1}, b_{t+1}\}_{t=0}^{\infty}$ to maximize (4) subject to (5)-(7), $n_{2,t} \geq 0$, and a no-Ponzi game condition on capital and bonds. Plugging capital income (6) into the budget constraint (5) and denoting ξ_t and φ_t as the multipliers on (5) and (7) respectively, the first order conditions for this problem are given by:

$$
\begin{aligned}
&[c_{2,t}] && u_{2c,t} = \xi_t, \\
&[n_{2,t}] && -u_{2n,t} \geq (1-\tau_t^n) w_t \xi_t,\ \ n_{2,t} \geq 0,\ \ n_{2,t}\left[-u_{2n,t} - (1-\tau_t^n) w_t \xi_t\right] = 0, \\
&[e_{2,t}] && -u_{2n,t} = I_{e2,t}\varphi_t, \\
&[x_t] && \varphi_t I_{x,t} = \left(1-\tau_t^d\right)\xi_t, \\
&[n_t] && f_{n,t} = w_t, \\
&[k_{t+1}] && \varphi_t = \beta \xi_{t+1}\left[1 + \left(1-\tau_{t+1}^k\right)(r_{t+1}-\delta)\right] + \beta\varphi_{t+1}, \\
&[b_{t+1}] && \xi_t = \beta \xi_{t+1} R_{t+1}^b,
\end{aligned}
$$

and the transversality conditions. Rearranging, the above optimality conditions can be summarized in the labor hiring decision $f_{n,t} = w_t$, a non-arbitrage condition on the return on bonds, and

$$
-u_{2n,t} \geq (1-\tau_t^n) w_t \xi_t,\ \ n_{2,t} \geq 0,\ \ n_{2,t}\left[-u_{2n,t} - (1-\tau_t^n) w_t \xi_t\right] = 0, \tag{8}
$$

$$
-\frac{u_{2n,t}}{I_{e2,t}} = \left(1-\tau_t^d\right)\frac{u_{2c,t}}{I_{x,t}}, \tag{9}
$$

$$
\left(1-\tau_t^d\right)\frac{u_{2c,t}}{I_{x,t}} = \beta\left(1-\tau_{t+1}^d\right)\left[I_{x,t+1}\left[\left(1-\tau_{t+1}^k\right)(f_{k,t+1}-\delta)+\delta\right] + (1-\delta)\right]\frac{u_{2c,t+1}}{I_{x,t+1}}. \tag{10}
$$

From the last two conditions, it is easy to see that corporate taxes distort investment while dividend taxes distort the time management decisions and the timing of investment.

The government collects taxes and issues bonds in order to finance an exogenous government consumption, $g_t > 0$, per period and paying debt obligations. Government consumption is unproductive, not valued by households and sufficiently large so that distortionary taxation is used in equilibrium. The preferences of the benevolent government are given by

$$
\gamma\kappa U_1 + (1-\gamma)(1-\kappa) U_2, \tag{11}
$$

with the Pareto weight $\gamma \in (0,1)$ on workers and $(1-\gamma)$ on capitalists. The government's sequential budget constraint is

$$(1-\kappa)\left[\tau_t^n w_t n_t + \tau_t^k (1-\tau_t^d)\left(f_{k,t}-\delta\right)k_t + \tau_t^d\left(f_{k,t}k_t - x_t\right) + b_{t+1}\right] = g_t + (1-\kappa)\, R_t^b b_t,$$

where capital tax rates are bounded according to $\tau_t^k \in [-1, 1]$ in all periods.

Finally, feasibility requires

$$\kappa c_{1,t} + (1-\kappa)\, c_{2,t} + (1-\kappa)\, x_t + g_t = (1-\kappa)\, f(k_t, n_t). \tag{12}$$

For a given government policy, the competitive equilibrium of this model economy is characterized by the budget constraint and the optimality condition for the workers, (2)-(3), the budget constraint and optimal conditions for the capitalists, (5)-(10), $f_{n,t} = w_t$, and the non-arbitrage condition on bonds, together with feasibility (12), market clearing and the transversality conditions.

3 The Optimal Redistributive Policy

This Section considers the optimal redistributive problem of the government at date 0. We assume that the initial after-tax interest rate on bonds R_0^b is given and that there is a commitment technology so that future governments have no incentive to deviate from the optimal policy plan prescribed by the government at 0.

In order to setup the government's problem, we follow the primal approach. The optimality conditions of the agents are substituted in their respective budget constraints to obtain the following implementability conditions

$$u_{1c,t} c_{1,t} + u_{1n,t} n_{1,t} = 0, \tag{13}$$

for the worker in each period, and

$$\sum_{t=0}^{\infty} \beta^t \left[u_{2c,t} c_{2t} + u_{2n,t}\left(n_{2,t} + e_{2,t}\right)\right] = W_0, \tag{14}$$

for the capitalist in its life-time, where

$$W_0 = -\frac{u_{2n,0}}{I_{n2,0}} \left[I_{x,0} \left[\left(1-\tau_0^k\right)(f_{k,0}-\delta)+\delta \right] + (1-\delta) \right] k_0 + u_{2c,0} R_0^b b_0.$$

In addition, as labor tax rates are the same across agents, the Kuhn-Tucker conditions on the labor choice of the capitalist require

$$-u_{2n,t} \geq -u_{1n,t}\frac{u_{2c,t}}{u_{1c,t}}, \quad n_{2,t} \geq 0, \quad n_{2,t}\left[-u_{2n,t}+u_{1n,t}\frac{u_{2c,t}}{u_{1c,t}}\right]=0. \tag{15}$$

Moreover, the upper and lower bounds on capital tax rates for each period $t \geq 1$ imply

$$1-\frac{1}{(f_{k,t}-\delta)}\left\{\frac{1}{I_{x,t}}\left[\frac{1}{\beta}\frac{u_{2n,t-1}}{I_{e2,t-1}}\frac{I_{e2,t}}{u_{2n,t}}-(1-\delta)\right]-\delta\right\} \in [-1,1]. \tag{16}$$

It is easy to verify that the set of feasible allocations that satisfy the implementability conditions (13), (14), (15), and (16) can be decentralized with the available tax rates.

The government's optimization problem is then defined as follows. Given $\{g_t\}_{t=0}^{\infty}$, the government at date 0 chooses the sequences $\{c_{1,t}, c_{2,t}, n_{1,t}, n_{2,t}, e_{2,t}, x_t, k_{t+1}\}_{t=0}^{\infty}$ to maximize (11) subject to the resource constraint (12), the technology of production of new capital (7), the implementability conditions of the workers (13) in each period, the life-time implementability conditions of the capitalists (14), the Kuhn-Tucker conditions (15), and the bounds on capital tax rates (16), given the initial conditions on capital, government bonds and after-tax interest rate on those bonds.

While the numerical computation incorporates conditions (15) and bounds (16), for the analytical analysis we assume that $n_{2,t}$ is optimally set to zero and that the upper and lower bounds on tax rates do not bind.[3] Then the Lagrangian for the government's problem is written as:

[3] Conesa and Domínguez (2013) already consider the case where the same agent provides the two forms of labor.

$$
\begin{aligned}
L &= \sum_{t=0}^{\infty} \beta^t \left[\gamma\kappa u_1(c_{1,t}, n_{1,t}) + (1-\gamma)(1-\kappa) u_2(c_{2,t}, e_{2,t})\right] \\
&+ \sum_{t=0}^{\infty} \beta^t \mu_t \left[(1-\kappa) f(k_t, n_t) - \kappa c_{1,t} - (1-\kappa) c_{2,t} - (1-\kappa) x_t - g_t\right] \\
&+ \sum_{t=0}^{\infty} \beta^t \phi_t (1-\kappa) \left[I(x_t, e_{2,t}) + (1-\delta) k_t - k_{t+1}\right] \\
&+ \sum_{t=0}^{\infty} \beta^t \lambda_{1,t} \kappa \left[u_{1c,t} c_{1,t} + u_{1n,t} n_{1,t}\right] + \lambda_2 (1-\kappa) \left[\sum_{t=0}^{\infty} \beta^t \left[u_{2c,t} c_{2,t} + u_{2n,t}(n_{2,t} + e_{2,t})\right]\right] \\
&- \lambda_2 (1-\kappa) \left[-\tfrac{u_{2n,0}}{I_{n2,0}} \left[I_{x,0} \left[\left(1-\tau_0^k\right)(f_{k,0} - \delta) + \delta\right] + (1-\delta)\right] k_0 + u_{2c,0} R_0^b b_0\right],
\end{aligned}
$$

where μ_t, ϕ_t, $\lambda_{1,t}$ and λ_2 denote the multipliers on (12), (7), (13), and (14). The resulting first-order conditions for all periods $t \geq 1$ can be found in the Appendix. At steady state, these optimality conditions can be summarized in

$$
\begin{aligned}
u_{1c,ss} \left\{\gamma + \lambda_{1,ss} \left[1 + \frac{u_{1cc,ss} c_{1,ss}}{u_{1c,ss}}\right]\right\} &= u_{2c,ss} \left\{(1-\gamma) + \lambda_2 \left[1 + \frac{u_{2cc,ss} c_{2,ss}}{u_{2c,ss}}\right]\right\}, \\
u_{1n,ss} \left\{\gamma + \lambda_{1,ss} \left[1 + \frac{u_{1nn,ss} n_{1,ss}}{u_{1n,ss}}\right]\right\} &= -f_{n,ss} u_{1c,ss} \left\{\gamma + \lambda_{1,ss} \left[1 + \frac{u_{1cc,ss} c_{1,ss}}{u_{1c,ss}}\right]\right\}, \\
u_{2n,ss} \left\{(1-\gamma) + \lambda_2 \left[1 + \frac{u_{2nn,ss} e_{2,ss}}{u_{2n,ss}}\right]\right\} &= -\frac{I_{e2,ss}}{I_{x,ss}} u_{2c,ss} \left\{(1-\gamma) + \lambda_2 \left[1 + \frac{u_{2cc,ss} c_{2,ss}}{u_{2c,ss}}\right]\right\}, \\
1 &= \beta \left[I_{x,ss} f_{k,ss} + 1 - \delta\right].
\end{aligned}
$$

Combining the last three with the competitive equilibrium conditions (3), (8) and (10), we obtain the following optimal steady state taxes:

$$
\tau_{ss}^n = \frac{\lambda_{1,ss} \left[\frac{u_{1nn,ss} n_{1,ss}}{u_{1n,ss}} - \frac{u_{1cc,ss} c_{1,ss}}{u_{1c,ss}}\right]}{\gamma + \lambda_{1,ss} \left[1 + \frac{u_{1nn,ss} n_{1,ss}}{u_{1n,ss}}\right]},
$$

$$
\tau_{ss}^d = \frac{\lambda_2 \left[\frac{u_{2nn,ss} e_{2,ss}}{u_{2n,ss}} - \frac{u_{2cc,ss} c_{2,ss}}{u_{2c,ss}}\right]}{(1-\gamma) + \lambda_2 \left[1 + \frac{u_{2nn,ss} e_{2,ss}}{u_{2n,ss}}\right]},
$$

$$
\tau_{ss}^k = 0.
$$

Then we find that the Ramsey tax plan is characterized by a zero corporate tax at steady state. As investment is not tax deductible, a non-zero corporate tax generates a permanent intertemporal distortion and it is optimal to eliminate such a distortion. This is satisfied independently of the Pareto weights and, therefore, holds true from the point of view of all agents. This is the result of Judd (1985) extended to the presence of management time.

The Ramsey tax plan does not prescribe a zero dividend tax at steady state. As investment is fully and immediately tax deductible, a constant dividend tax generates no intertemporal distortions but an intra-period distortion and may be set at a non-zero level. This is as in Conesa and Domínguez (2013). However, here, the optimal dividend tax rate does not coincide in general with the optimal labor tax rate. This results from the separation between the two types of labor. In a representative agent model, the agent that supplies labor to firms is the same as the one that invests time in their business. This does not need to be the case, however, in our two-type agent model. Moreover, the policymaker may not value each type equally. Consequently, optimal dividend and labor tax rates do not need to coincide at steady state.

To further characterize the optimal steady-state taxes, we consider utility functions of the form:

$$u_i(c_{i,t}, n_{i,t}) = \frac{{c_{i,t}}^{1-\sigma_i}}{1-\sigma_i} - \theta_i \frac{(n_{i,t}+e_{i,t})^{1+\chi_i}}{1+\chi_i}, \tag{17}$$

where σ_i and χ_i are the inverse of the intertemporal elasticity of consumption and labor respectively and θ_i the relative weight of leisure in the utility function.[4] For this form of utility functions (17), the optimal steady-state tax rates can be written as

$$\tau_{ss}^n = \frac{\lambda_{1,ss}(\sigma_1+\chi_1)}{\gamma+\lambda_{1,ss}(1+\chi_1)},$$

$$\tau_{ss}^d = \frac{\lambda_2(\sigma_2+\chi_2)}{(1-\gamma)+\lambda_2(1+\chi_2)},$$

$$\tau_{ss}^k = 0,$$

where $u_{1c,ss}\left[\gamma+\lambda_{1,ss}(1-\sigma_1)\right] = u_{2c,ss}\left[(1-\gamma)+\lambda_2(1-\sigma_2)\right].$

[4]Note that $e_{1,t}=0$ and $n_{1,t}>0$, while $e_{2,t}>0$ and $n_{2,t}=0$. For the numerical analysis, we allow for $n_{2,t}\geq 0$.

Therefore, while the Ramsey corporate tax rate is zero at steady state, the Ramsey dividend tax rate is not. Moreover, the Ramsey dividend tax does not need to coincide with the Ramsey labor tax at steady state. In fact, combining the above equations, optimal steady-state dividend taxes can be solved as a function of the optimal labor taxes as follows:

$$\left(1-\tau_{ss}^{d}\right)=\left(1-\tau_{ss}^{n}\right)\left[\frac{(1-\gamma)+\lambda_{2}\left(1-\sigma_{2}\right)}{\gamma+\lambda_{1,ss}\left(1-\sigma_{1}\right)}\right]\left[\frac{\gamma+\lambda_{1,ss}\left(1+\chi_{1}\right)}{(1-\gamma)+\lambda_{2}\left(1+\chi_{2}\right)}\right], \tag{18}$$

with

$$\frac{u_{1c,ss}}{u_{2c,ss}}=\frac{(1-\gamma)+\lambda_{2}\left(1-\sigma_{2}\right)}{\gamma+\lambda_{1,ss}\left(1-\sigma_{1}\right)},$$

which, for log utility functions for consumption and the same preference parameter values across agents, become

$$\left(1-\tau_{ss}^{d}\right)=\left(1-\tau_{ss}^{n}\right)\left(\frac{1-\gamma}{\gamma}\right)\left[\frac{\gamma+\lambda_{1,ss}\left(1+\chi\right)}{(1-\gamma)+\lambda_{2}\left(1+\chi\right)}\right], \tag{19}$$

with

$$\frac{c_{2,ss}}{c_{1,ss}}=\left(\frac{1-\gamma}{\gamma}\right).$$

Then, even when preference parameters of both agents are the same, optimal steady-state dividend and labor tax rates differ as long as $\frac{\lambda_2}{\lambda_{1,ss}}=\left(\frac{1-\gamma}{\gamma}\right)$ does not occur in equilibrium. Thus, only when the ratio of the distortionary cost of taxation among the agents $\frac{\lambda_2}{\lambda_{1,ss}}$ coincides with the ratio of their Pareto weights $\frac{1-\gamma}{\gamma}$, then long-run optimal dividend and labor tax rates are equal, i.e. $\tau_{ss}^{d}=\tau_{ss}^{n}$. For a given parameterization, there may be a Pareto weight γ for which $\frac{\lambda_2}{\lambda_{1,ss}}=\left(\frac{1-\gamma}{\gamma}\right)$ and then long-run dividend and labor taxes are identical. However, such precise value for the Pareto weight will depend on the specific parameters and initial conditions.

From the above findings, it is clear that optimal steady-state dividend and labor tax rates depend on the preference parameters of all agents (σ_1, σ_2, χ_1 and χ_2), the life-time wealth of all agents (which directly affects $\lambda_{1,ss}$ and λ_2) and the point of view of the policymaker (captured by the Pareto weights γ and $1-\gamma$). These features bring in inequality, in terms of preferences and wealth, and politics into the determinants of the "optimal" redistributive taxation.

For utility functions that are log in consumption and with the same parameters across agents, how would the long-run Ramsey allocation and taxes change if the policymaker becomes relatively more pro-worker, i.e. $\gamma\uparrow$? From the first-order condition on $c_{1,ss}-c_{2,ss}$, we have $\frac{c_{2,ss}}{c_{1,ss}}=\left(\frac{1-\gamma}{\gamma}\right)$. Thus, a more pro-worker government leads to lower relative consumption for the capitalists at steady state, i.e. $\frac{c_{2,ss}}{c_{1,ss}}\downarrow$. Combining the optimality conditions of effort and labor, we find

$$\left(\frac{e_{2,ss}}{n_{1,ss}}\right)^{\chi}=\left(\frac{\gamma+\lambda_{1,ss}\left(1+\chi\right)}{\left(1-\gamma\right)+\lambda_{2}\left(1+\chi\right)}\right)\frac{I_{e,ss}(x_{ss},e_{2,ss})/I_{x,ss}(x_{ss},e_{2,ss})}{f_{n}\left(k_{ss},n_{1,ss}\right)}.$$

From the above, and ceteris paribus, an increase in the Pareto weight γ leads to a higher relative hours worked by the capitalists, i.e. $\frac{e_{2,ss}}{n_{1,ss}}\uparrow$. If, in absolute terms, workers consume more and work less hours, how is that higher consumption achieved? The budget constraint of a worker is

$$c_{1,ss}=(1-\tau_{ss}^{n})f_{n}\left(k_{ss},n_{1,ss}\right)n_{1,ss}.$$

Then, a higher consumption requires that either labor tax rates go down and/or the capital stock goes up, that is $\tau_{ss}^{n}\downarrow$ and/or $k_{ss}\uparrow$. Looking at the optimal steady-state tax rates, and holding $\lambda_{1,ss}$ and λ_{2} constant, a more pro-worker policymaker increases dividend taxes and lowers labor taxes. However, the multipliers $\lambda_{1,ss}$ and λ_{2} cannot be held constant as they are endogenous and a government may want to lower λ_{2} in order to increase the capital stock at steady state. Therefore, as the overall effect is unclear and depends on the responses of different endogenous variables, the next Section resorts to a numerical analysis of the Ramsey allocation and taxes.

4 Quantitative Exercise

In this Section we provide a numerical assessment of the optimal redistributive capital and labor taxes presented in the previous Section.

We consider the following specific forms. For the utility functions, we assume (17), with $e_{1,t}=0$ and $n_{1,t}>0$, and $e_{2,t}>0$ and $n_{2,t}\geq 0$. Note that capitalists are allowed to supply raw labor, and therefore the Kuhn-Tucker conditions (15) are included in the Ramsey problem. We consider a standard Cobb-Douglas production function

$$f(k_t, n_t) = Ak_t^{\alpha} n_t^{1-\alpha}.$$

with $A > 0$, and $\alpha \in (0,1)$, and a general investment function

$$I(x_t, e_{2,t}) = B[\mu x_t^{\rho} + (1-\mu)\, e_{2,t}^{\rho}]^{\frac{1}{\rho}},$$

with $B > 0$, and $\mu \in (0,1)$. Note that $I(x_t, e_{2,t}) = Bx_t^{\mu} e_{2,t}^{1-\mu}$ for $\rho = 0$.

We consider the following parameter values. The population is composed of 90 per cent workers, i.e. $\kappa = 0.90$, and 10 per cent capitalists. We assume workers and capitalists do not differ in their utility functions. For both, we assume inverse intertemporal elasticities of consumption of $\sigma_1 = \sigma_2 = 1$, and labor of $\chi_1 = \chi_2 = 1.33$. The labor/effort disutility $\theta_1 = \theta_2$ is calibrated to deliver $n_1 = 0.33$ at the initial steady state. The discount factor β is set equal to 0.98 in accordance with an annual interest rate of 2 per cent.

For the final good production function, we assume a productivity parameter $A = 4$. We set a share of capital $\alpha = 0.40$ in order to get reasonable values for the consumption ratio $\frac{c_{2,ss}}{c_{1,ss}}$ and for $e_{2,ss}$.[5] The depreciation rate of capital δ is set to 6.7 per cent. For the intermediate good production function, we set $\rho = -0.50$ to have some complementarity between resources and effort in the production of capital. Then we calibrate B and μ to match an investment to capital ratio of $\frac{x_{ss}}{k_{ss}} = 0.037$ and a capital to output ratio of $\frac{k_{ss}}{f(k_{ss}, n_{ss})} = 1.65$. The first comes from Asker et al. (2015), who find that corporate firms invest around 3.7 per cent of their total assets. The second comes from the measurement of McGrattan and Prescott (2005), who estimate a tangible capital to output ratio of 1.65 in the corporate sector, which is equivalent to an aggregate capital to GDP ratio of 3. We later conduct sensitivity analysis to the above parameters.

For those parameter values, we assume that the economy starts off at an initial steady state with a government policy characterized by a government spending to output ratio equal to 19 per cent, a labor tax rate of 31.6 per cent, a dividend tax rate of 29.1 per cent and a corporate tax

[5] Aguiar and Bils (2015) find that the ratio of high-income to low-income consumption varies between 2.5 and 3.0. Our own calculations yield similar numbers for $\frac{c_{2,ss}}{c_{1,ss}}$, given our definition of capitalists and workers.

rate of 35 per cent.

Table 2 summarizes the parameter values and the initial steady state allocation and welfare for our benchmark calibration.

[Insert Table 2 about here.]

We assume then that our Ramsey tax reform takes place at that initial steady state. The results of this numerical exercise are reported below.

First, the theoretical findings of the previous Section are confirmed. We find that the optimal levels of the steady-state labor and dividend tax rates depend on the Pareto weights of the policymaker. Moreover, we also find how the Pareto weights affect the Ramsey allocation in the long-run. This is illustrated in the following table:

[Insert Table 3 about here.]

In Table 3, we find that, for all γ, capitalists consume more and work less than workers at the steady state Ramsey allocation. As the Pareto weight on workers γ increases, the relative consumption of the capitalists goes down and their relative hours worked increase. This effect is present although small for $\gamma \geq 0.485$. For $\gamma \in (0, 0.485)$, the ratio of the consumption of a representative capitalist over that of a representative worker is exactly equal to $\left(\frac{1-\gamma}{\gamma}\right)$ as predicted, while for $\gamma \in [0.485, 1)$, it is larger than $\left(\frac{1-\gamma}{\gamma}\right)$. For all Pareto weights on workers γ larger than 0.485, the Kuhn-Tucker conditions (15) on the raw labour supply of the capitalists bind at steady state. In particular, the Ramsey allocation satisfies

$$-u_{2n,ss} = -u_{1n,ss}\frac{u_{2c,ss}}{u_{1c,ss}}, \text{ and } n_{2,ss} = 0. \tag{20}$$

Then the capitalists' possibility of supplying raw labor as workers limits the extent of the redistribution towards workers. Given that capitalists consume more and work less than workers, it is clear that they enjoy a higher steady state utility than workers. In terms of overall welfare, Figure 2 depicts the ratio $\frac{U_2}{U_1}$ at the initial steady state and as implied by the Ramsey tax reform (taking into account the transition) for different values of the Pareto weight on workers γ.

[Insert Figure 2 about here.]

At the initial steady state, the welfare of a capitalist is 2.36 times that of a worker. This is equivalent to the capitalist enjoying a permanent consumption gain relative to workers of 160 per cent in each period. As the Pareto weight γ increases, our tax reform presents a decreasing $\frac{U_2}{U_1}$ ratio. This ratio reaches a minimum value of 1.17 as γ becomes close to one. For that, and in consumption equivalent terms, a capitalist would be consuming 16 per cent more than a worker permanently. Figure 2 also shows that, for Pareto weights $\gamma \in (0.26, 0.30)$, the Ramsey tax reform Pareto improves all workers and capitalists.

As the Pareto weight on workers γ increases, Table 3 also shows that the capital to output ratio at steady state increases. In our economy, the government's optimality condition for capital can be written as

$$1 = \beta \left[I_{x,ss} f_{k,ss} + 1 - \delta \right],$$

at steady state. The term $I_{x,ss}$ implies that the capital to output ratio depends not only on parameters but also on endogenous variables and can be then affected by the Pareto weight γ.

Table 3 shows that, in the long run, Ramsey corporate taxes are zero independent of the Pareto weights. Long-run Ramsey labor taxes are positive and can be large for $\gamma < 0.29$, while they are negative and provide a subsidy to workers for $\gamma \geq 0.29$. As the Pareto weight on workers γ increases, long-run Ramsey labor tax rates decrease. This effect is monotone throughout all γ, albeit smaller for $\gamma \geq 0.485$. Long-run Ramsey dividend taxes are negative for $\gamma \leq 0.11$, while they are positive and can be quite large for $\gamma > 0.11$. The changes in γ have however a non-monotone effect on long-run dividend tax rates. As the Pareto weight on workers increases, the long-run dividend tax rates first increase for $\gamma \in (0, 0.485)$, but then slightly decrease for $\gamma \in (0.485, 1)$.

For a policymaker with a very low Pareto weight on workers such as $\gamma = 0.01$, the optimal long-run policy sets labor tax rates as high as 90 per cent and dividend tax rates as low as -67 per cent. As the policymaker becomes more pro-worker, optimal steady-state labor taxes decrease and dividend taxes increase. For this calibration, optimal steady-state dividend and labor tax rates coincide in value at 14 per cent for a Pareto weight of $\gamma = 0.19$. For Pareto weights consistent with

Pareto-improving reforms $\gamma \in (0.26, 0.30)$, we find that labor taxes are roughly eliminated while dividend taxes are increased to 36 per cent at steady state.[6] For a policymaker that values workers and capitalists equally with $\gamma = 0.5$, the long-run optimal policy prescribes a 14 per cent subsidy to workers and a 69 per cent dividend tax to capitalists. For that and higher Pareto weights, the Kuhn-Tucker conditions (20) on the raw labor supply by capitalists bind at steady state. Using those conditions together with the first-order conditions on the labor supply of workers (3) and on the effort supply of capitalists (8), we obtain

$$\left(1 - \tau_{ss}^{d}\right) = \left(1 - \tau_{ss}^{n}\right) f_{n,ss} \frac{I_{x,ss}}{I_{e2,ss}}.$$

This shows that, once the Kuhn-Tucker conditions (20) bind, dividend and labor tax rates are tied together, limiting long-run redistribution. Consistent with that, for $\gamma \in (0.485, 1)$, we find that, as the Pareto weight on workers increases, long-run optimal taxes change only minimally with slight decreases in both labor and dividend tax rates.

Figure 3 shows the Ramsey tax rates during the transition. The Ramsey government chooses to use corporate taxes for redistribution during the transition but not at steady state. As the Pareto weight on workers γ increases, the number of periods for which corporate income is taxed at maximal rates increases. Except for very low γ, optimal dividend and labor tax rates converge from above to the steady state levels. The effect of the Pareto weight γ on the dividend and labor tax rates during the transition is in line with the one reported for the steady state. For $\gamma \geq 0.5$, Ramsey corporate, dividend and labor taxes do not differ much as γ changes.

[Insert Figure 3 about here.]

Tables 4.A, 4.B and 4.C illustrate the effect of differences in preference parameters between capitalists and workers on the steady-state Ramsey taxes and allocation. Changes in the intertemporal elasticity of consumption, in particular, considering $\sigma_1 = 2$ while $\sigma_1 = 1$, have a profound effect in both the Ramsey tax rates and the allocation. While increasing γ reduces the relative con-

[6] Table 3 includes a column that illustrates a Pareto-improving reform that yields a steady-state consumption ratio $\frac{c_{2,ss}}{c_{1,ss}}$ identical to the consumption ratio in the initial steady state.

sumption $\frac{c_{2,ss}}{c_{1,ss}}$ and increases the relative worked hours $\frac{e_{2,ss}}{e_{1,ss}}$, capitalists now consume and generally work substantially more than workers. Optimal labor (dividend) tax rates are substantially higher (lower). Identical steady-state levels of dividend and labor tax rates happen for $\gamma = 0.40$ approximately at 14 per cent. A Pareto-improving reform occurs now for $\gamma = 0.54$ and, interestingly, the policy prescription is similar to that of our benchmark with labor tax rates reduced to 2 per cent and dividend tax rates increased to 37 per cent. Table 4.B (4.C) considers a more (less) elastic labor supply by the capitalists. Changes in this parameter do not affect Ramsey taxes much, but do affect the Ramsey allocation. When the labor supply is more elastic (Table 4.B), capitalists do not always consume more than workers. For $\gamma \geq 0.60$, capitalists consume less but work also less than workers. When the labor supply is less elastic (Table 4.C), capitalists do not always work less than workers. For $\gamma \geq 0.20$, capitalists consume more but work also more than workers.

[Insert Tables 4.A, 4.B and 4.C about here.]

4.1 Sensitivity Analysis

In this Section, we conduct several numerical exercises to explore how sensitive our results are to our assumed parameter values and to the assumption that workers cannot save. Additionally, we also extend the model to incorporate intangible capital and evaluate its tax implications.

[Insert Tables 5.A to 5.G, 6, 7.A and 7.B, and Figure 4 about here.]

We first consider the possibility of workers having access to savings in terms of government bonds. Table 5.A. reports the steady-state Ramsey allocation and taxes. While, as before, capitalists consume more and work less than workers, the gap between them is slightly smaller. In terms of long-run policy, the ability to save by workers does not affect much the optimal level of corporate, dividend and labor income tax rates.

Through our sensitivity analysis, we find that while it is generally satisfied that the Pareto weight γ affects the long-run levels of dividend and labor taxes, the specific optimal levels depend on some parameter values. In particular, we find that the share of capital on income does affect substantially the optimal level of long-run dividend and labor tax rates. Table 5.B. shows that for a capital share of $\alpha = 0.30$, optimal long-run dividend (labor) tax rates are substantially lower (higher) than in our benchmark. Now labor tax rates are not subsidized even when γ approaches unity. Tables 5.C to 5.G and Table 6 show that changes in σ for all population, G, β, δ and ρ have a small effect on both long-run optimal taxes and allocation. Tables 7.A and 7.B summarize the long-run optimal taxes prescribed by a Pareto-improving reform and by a policymaker that values workers and capitalists equally for different parameter values. There we see that the optimal long-run policy is remarkably similar to the one found in our benchmark calibration. As shown in Figure 4, there are some small changes in the relative consumption gain by the capitalist. A lower capital share and a less elastic labor supply by the capitalists lead to higher relative consumption gains for the capitalists, while a more elastic labor supply by the capitalists, higher risk aversion coefficient and higher capital depreciation lead to lower relative consumption gains.

4.1.1 Intangible Capital Stock

In this Section, we extend the model to incorporate intangibles in the capital stock. More specifically, we consider that k_t now includes both tangible and intangible forms of capital, and that now capitalists also require intangible investment $x_{u,t}$ to produce new capital with the technology $I\left(x_{m,t}, x_{u,t}, e_{2,t}\right)$. Intangible investment reduces corporate profits

$$\Pi_t = \left(1-\tau_t^k\right)\left[f\left(k_t, \frac{\kappa}{(1-\kappa)}n_{1,t}+n_{2,t}\right) - w_t\left\{\frac{\kappa}{(1-\kappa)}n_{1,t}+n_{2,t}\right\} - x_{u,t}\right] + \tau_t^k\delta k_t - x_{m,t},$$

and affects feasibility

$$\kappa c_{1,t} + (1-\kappa)\, c_{2,t} + (1-\kappa)\left(x_{m,t}+x_{u,t}\right) + g_t = (1-\kappa)\, f(k_t, n_t).$$

Moreover, intangible investment makes corporate taxes distortionary as they affect the portfolio choice of investment by the capitalist. In the decentralized competitive equilibrium, this distortion is captured by the following optimality condition

$$\left(1-\tau_t^k\right) = \frac{I_{xu,t}}{I_{xm,t}}.$$

For this new model, we setup the Ramsey problem and solve it numerically. We assume the following investment function:

$$I\left(x_{m,t}, x_{u,t}, e_{2,t}\right) = B[\mu_x x_{m,t}^{\rho_x} + (1-\mu_x)\left(C\left[\mu_u x_{u,t}^{\rho_u} + (1-\mu_u)\, e_{2,t}^{\rho_u}\right]^{\frac{1}{\rho_u}}\right)^{\rho_x}]^{\frac{1}{\rho_x}},$$

and set $\rho_x = 0.001$ and $\rho_u = -0.5$. That is, the investment function is close to Cobb-Douglas between tangible resources $x_{m,t}$ and a composite of intangible resources and effort, and displays complementarity between intangible resources $x_{u,t}$ and managerial effort $e_{2,t}$. We calibrate C to target the hours worked by capitalists $e_{2,ss} = 0.33$. Other parameter values and targets are as in the benchmark except for the capital to output ratio, which is now equal to $\frac{k_{ss}}{f(k_{ss},n_{ss})} = 2.73$ and the depreciation rate $\delta = 0.08$ to take account of the intangible capital stock.[7]

[Insert Table 8 and Figure 5 about here.]

Table 8 and Figure 5 illustrate the numerical findings. The long-run Ramsey allocation is similar to our benchmark. The long-run Ramsey dividend and labor tax rates are higher than the benchmark. The main difference between these results and those with the benchmark model and calibration is that, with intangibles, corporate income is not taxed at maximal rates during the transition. Figure 5 shows that corporate income is optimally taxed very lightly and, for most Pareto weights, corporate income is subsidized in some periods during the transition.

5 Conclusions

In this paper we have examined capital taxes and redistribution in a model with management time and investment deductibility. With full and immediate expensing of investment, we find that the optimal redistributive features of capital taxes change dramatically. Optimal dividend taxes depend on preference parameters, life-time wealth and the point of view of the policymaker.

This is not only relevant for dividend taxes. The current US corporate tax reform includes an "immediate expensing" provision for all depreciable assets (except structures) for at least 5

[7] McGrattan and Prescott (2005) estimate an intangible capital stock of 1.083 of the corporate output and that intangibles depreciate at a higher rate than tangibles, at 10 per cent.

years. Ours results show the importance of this provision. Immediate expensing of investment eliminates the intertemporal distortions of constant capital taxes and connects capital taxes to time management choices. Then, at steady state, capital taxes do not need to be zero for efficiency purposes and their optimal level critically depends on the redistributive motives of the policymaker.

Our findings may help explain why capital taxes are different in different countries as well as why they change with government turnover.

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6 Appendix A: Optimality Conditions of Ramsey Problem

The first-order conditions for the Ramsey problem for all periods $t \geq 1$ are

$$
\begin{aligned}
&[c_{1,t}] && \gamma u_{1c,t} + \lambda_{1,t}\left[u_{1c,t} + u_{1cc,t}c_{1,t}\right] = \mu_t, \\
&[c_{2,t}] && (1-\gamma)\,u_{2c,t} + \lambda_2\left[u_{2c,t} + u_{2cc,t}c_{2,t}\right] = \mu_t, \\
&[n_{1,t}] && \gamma u_{1n,t} + \lambda_{1,t}\left[u_{1n,t} + u_{1nn,t}n_{1,t}\right] = -f_{n,t}\mu_t, \\
&[e_{2,t}] && (1-\gamma)\,u_{2n,t} + \lambda_2\left[u_{2n,t} + u_{2nn,t}e_{2,t}\right] = -I_{e2,t}\phi_t, \\
&[x_t] && I_{x,t}\phi_t = \mu_t, \\
&[k_{t+1}] && \phi_t = \beta\mu_{t+1}f_{k,t+1} + \beta\,(1-\delta)\,\phi_{t+1}.
\end{aligned}
$$

Rearranging, the above conditions can be summarized in

$$
\begin{aligned}
\gamma u_{1c,t} + \lambda_{1,t}\left[u_{1c,t} + u_{1cc,t}c_{1,t}\right] &= (1-\gamma)\,u_{2c,t} + \lambda_2\left[u_{2c,t} + u_{2cc,t}c_{2,t}\right], \\
\gamma u_{1n,t} + \lambda_{1,t}\left[u_{1n,t} + u_{1nn,t}n_{1,t}\right] &= -f_{n,t}\left\{\gamma u_{1c,t} + \lambda_{1,t}\left[u_{1c,t} + u_{1cc,t}c_{1,t}\right]\right\}, \\
\frac{1}{I_{e2,t}}\left\{(1-\gamma)\,u_{2n,t} + \lambda_2\left[u_{2n,t} + u_{2nn,t}e_{2,t}\right]\right\} &= -\frac{1}{I_{x,t}}\left\{(1-\gamma)\,u_{2c,t} + \lambda_2\left[u_{2c,t} + u_{2cc,t}c_{2,t}\right]\right\}, \\
\frac{I_{x,t+1}}{I_{x,t}}\left\{\frac{(1-\gamma)\,u_{2c,t} + \lambda_2\left[u_{2c,t} + u_{2cc,t}c_{2,t}\right]}{(1-\gamma)\,u_{2c,t+1} + \lambda_2\left[u_{2c,t+1} + u_{2cc,t+1}c_{2,t+1}\right]}\right\} &= \beta\left[I_{x,t+1}f_{k,t+1} + 1 - \delta\right].
\end{aligned}
$$

The solution to the above problem is the Ramsey allocation. The Ramsey tax plan that decentralizes that allocation can be obtained from the equilibrium conditions (3), (9) and (10).

7 Appendix B: Tables and Figures

Table 1: Capital Taxation Across Countries

	Corporate Tax	Dividend Tax	Overall Rate
Australia	30.0	46.5	46.5
France	36.4	44.0	64.4
Germany	30.2	26.4	48.6
Greece	26.0	10.0	33.4
Japan	37.0	10.0	43.3
Mexico	30.0	30.0	30.0
Poland	19.0	19.0	34.0
Spain	30.0	27.0	48.9
UK	23.0	37.5	46.5
US	39.1	30.3	57.6

Source: OECD (2013)

Figure 1: Top Marginal Tax Rates in the US, 1913-2015

Source: IRS

Table 2: Parameter Values and Initial Steady State Allocation and Welfare

	Benchmark Parameters					
Preference	β	$\sigma_1 = \sigma_2$	$\theta_1 = \theta_2$	$\chi_1 = \chi_2$		
	0.98	1.00	9.16	1.33		
Technology	A	α	δ	B	ρ	μ
	4.0	0.40	0.067	6.45	−0.50	0.50
Policy	τ^n	τ^k	τ^d	$\frac{g}{y}$		
	0.316	0.35	0.291	0.19		
	Initial Steady State Allocation					
Allocation	$\frac{c_2}{c_1}$	$\frac{e_2}{n_1}$	n_1	$\frac{c}{y}$	$\frac{x}{k}$	$\frac{k}{y}$
	2.61	1.00	0.33	0.75	0.037	1.65
	Initial Steady State Welfare					
Welfare	U_1	U_2	$\frac{U_2}{U_1}$			
	35.70	84.42	2.36			

Table 3: Ramsey Allocation and Taxes at Steady State

γ	0.01	0.10	0.20	0.277	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.99
$\frac{c_{2,ss}}{c_{1,ss}}$	99.00	9.00	4.00	2.61	2.33	1.50	1.06	1.05	1.05	1.05	1.04	1.04
$\frac{e_{2,ss}}{n_{1,ss}}$	0.79	0.82	0.92	0.94	0.95	0.95	0.95	0.96	0.96	0.97	0.97	0.97
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	1.50	1.54	1.63	1.65	1.66	1.66	1.66	1.67	1.67	1.68	1.68	1.68
τ^k_{ss}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^d_{ss}	−0.67	−0.02	0.17	0.36	0.41	0.58	0.69	0.69	0.69	0.69	0.68	0.68
τ^n_{ss}	0.90	0.37	0.12	0.01	−0.01	−0.09	−0.14	−0.14	−0.14	−0.14	−0.14	−0.14

Figure 2: The Ratio of $\frac{U_2}{U_1}$ for different γ

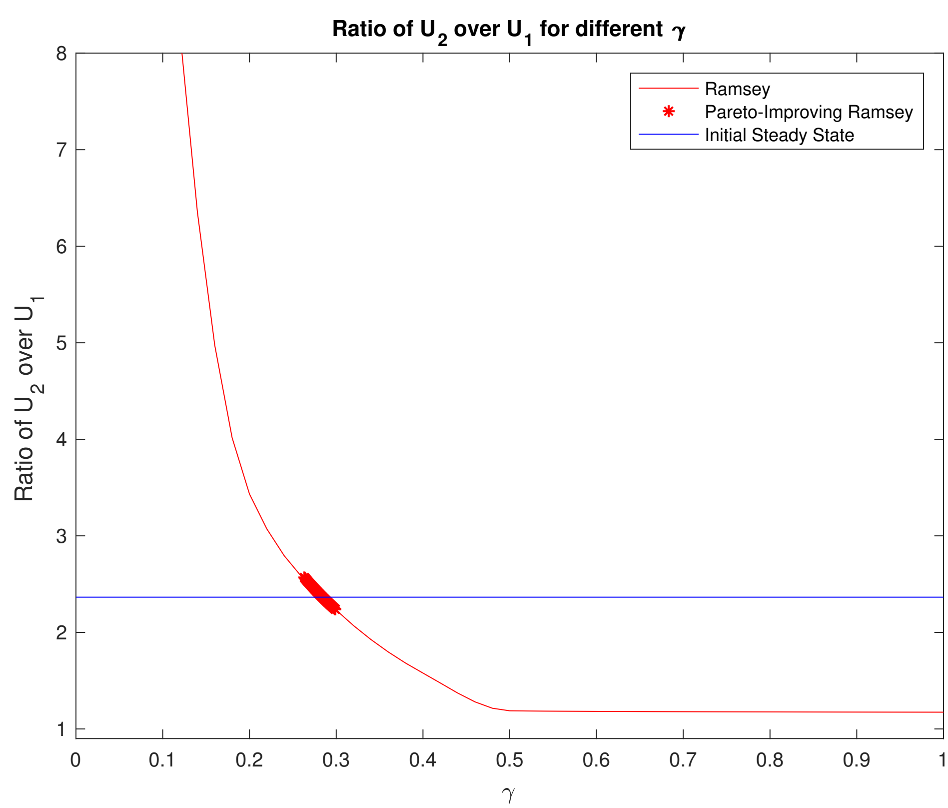

Figure 3: Ramsey Tax Rates during the Transition

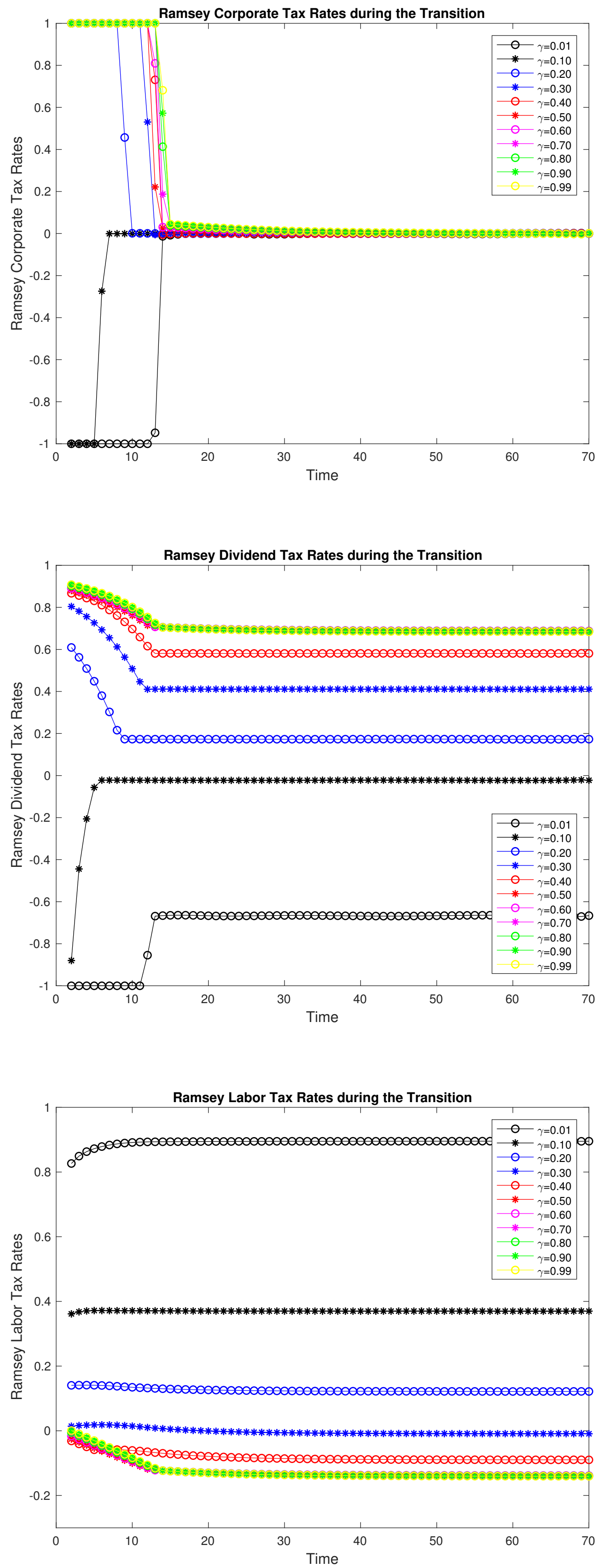

Table 4.A: Ramsey Allocation and Taxes at Steady State with $\sigma_1 = 2$ and $\sigma_2 = 1$

γ	0.01	0.10	0.20	0.30	0.40	0.50	0.543	0.60	0.70	0.80	0.90	0.99
$\frac{c_{2,ss}}{c_{1,ss}}$	161.00	19.22	9.79	6.32	4.35	3.05	2.61	2.11	1.79	1.77	1.76	1.75
$\frac{e_{2,ss}}{n_{1,ss}}$	0.49	0.93	1.11	1.29	1.41	1.49	152	1.54	1.57	1.59	1.60	1.61
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	0.92	1.31	1.43	1.56	1.63	1.68	1.70	1.71	1.73	1.74	1.74	1.75
τ_{ss}^k	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ_{ss}^d	−0.61	−0.26	−0.04	0.01	0.14	0.30	0.37	0.47	0.53	0.52	0.52	0.51
τ_{ss}^n	0.93	0.58	0.39	0.25	0.15	0.06	0.02	−0.02	−0.05	−0.05	−0.05	−0.05

Note: The calibration yields the parameters $\theta = 3.36$, $\mu = 0.45$, $B = 5.14$ and the initial allocation $\frac{c_2}{c_1} = 2.61$ and $\frac{e_2}{n_1} = 1.54$.

Table 4.B: Ramsey Allocation and Taxes at Steady State with $\chi_1 = \frac{1}{0.75}$ and $\chi_2 = \frac{1}{0.85}$

γ	0.01	0.10	0.20	0.277	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.99
$\frac{c_{2,ss}}{c_{1,ss}}$	99.00	9.00	4.00	2.61	2.33	1.50	0.99	0.98	0.98	0.97	0.97	0.97
$\frac{e_{2,ss}}{n_{1,ss}}$	0.72	0.76	0.86	0.87	0.88	0.89	0.89	0.89	0.90	0.90	0.90	0.90
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	1.50	1.54	1.64	1.66	1.66	1.67	1.67	1.68	1.68	1.68	1.68	1.69
τ_{ss}^k	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ_{ss}^d	−0.67	−0.02	0.17	0.36	0.41	0.58	0.71	0.71	0.71	0.70	0.70	0.70
τ_{ss}^n	0.90	0.37	0.12	0.01	−0.01	−0.09	−0.15	−0.15	−0.15	−0.15	−0.15	−0.15

Note: The calibration yields the parameters $\theta = 9.16$, $\mu = 0.51$, $B = 6.70$ and the initial allocation $\frac{c_2}{c_1} = 2.61$ and $\frac{e_2}{n_1} = 0.93$.

Table 4.C: Ramsey Allocation and Taxes at Steady State with $\chi_1 = \frac{1}{0.75}$ and $\chi_2 = \frac{1}{0.65}$

γ	0.01	0.10	0.20	0.277	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.99
$\frac{c_{2,ss}}{c_{1,ss}}$	99.00	9.00	4.00	2.61	2.33	1.50	1.15	1.14	1.14	1.13	1.13	1.13
$\frac{e_{2,ss}}{n_{1,ss}}$	0.96	0.90	1.00	1.02	1.03	1.03	1.03	1.04	1.04	1.05	1.05	1.05
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	1.50	1.54	1.63	1.65	1.65	1.66	1.66	1.66	1.67	1.67	1.67	1.67
τ_{ss}^k	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ_{ss}^d	−0.66	−0.02	0.17	0.36	0.41	0.58	0.67	0.66	0.66	0.66	0.66	0.66
τ_{ss}^n	0.90	0.37	0.12	0.02	−0.01	−0.09	−0.13	−0.13	−0.13	−0.13	−0.13	−0.13

Note: The calibration yields the parameters $\theta = 9.16$, $\mu = 0.49$, $B = 6.16$ and the initial allocation $\frac{c_2}{c_1} = 2.61$ and $\frac{e_2}{n_1} = 1.10$.

Table 5.A: Ramsey Allocation and Taxes at Steady State when Workers Save

γ	0.01	0.10	0.20	0.277	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.99
$\frac{c_{2,ss}}{c_{1,ss}}$	99.00	9.00	4.00	2.61	2.33	1.50	1.06	1.05	1.05	1.04	1.04	1.04
$\frac{e_{2,ss}}{n_{1,ss}}$	0.78	0.82	0.92	0.94	0.95	0.96	0.96	0.96	0.97	0.97	0.97	0.97
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	1.50	1.54	1.64	1.65	1.66	1.67	1.67	1.67	1.67	1.68	1.68	1.68
τ^k_{ss}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^d_{ss}	-0.67	-0.02	0.17	0.36	0.41	0.58	0.69	0.69	0.69	0.69	0.68	0.68
τ^n_{ss}	0.89	0.37	0.13	0.02	0.00	-0.08	-0.13	-0.14	-0.14	-0.14	-0.14	-0.14

Table 5.B: Ramsey Allocation and Taxes at Steady State with $\alpha = 0.30$

γ	0.01	0.10	0.20	0.30	0.363	0.40	0.50	0.60	0.70	0.80	0.90	0.99
$\frac{c_{2,ss}}{c_{1,ss}}$	99.00	9.00	4.00	2.33	1.75	1.50	1.08	1.06	1.06	1.05	1.05	1.04
$\frac{e_{2,ss}}{n_{1,ss}}$	0.76	0.76	0.85	0.92	0.93	0.94	0.94	0.95	0.96	0.96	0.97	0.97
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	1.54	1.52	1.61	1.69	1.70	1.71	1.71	1.72	1.73	1.74	1.74	1.74
τ^k_{ss}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^d_{ss}	-1.00	-0.25	0.00	0.19	0.33	0.41	0.55	0.54	0.54	0.54	0.54	0.53
τ^n_{ss}	0.91	0.46	0.25	0.14	0.09	0.07	0.03	0.03	0.03	0.03	0.03	0.03

Note: The calibration yields the parameters $\theta = 9.90$, $\mu = 0.54$, $B = 4.56$ and the initial allocation $\frac{c_2}{c_1} = 1.75$ and $\frac{e_2}{n_1} = 0.96$.

Table 5.C: Ramsey Allocation and Taxes at Steady State with $\sigma = 1.25$

γ	0.01	0.10	0.20	0.277	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.99
$\frac{c_{2,ss}}{c_{1,ss}}$	54.19	5.93	2.94	2.61	1.81	1.20	1.06	1.05	1.04	1.04	1.04	1.04
$\frac{e_{2,ss}}{n_{1,ss}}$	0.51	0.74	0.83	0.85	0.89	0.93	0.95	0.96	0.96	0.96	0.96	0.97
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	1.25	1.53	1.64	1.65	1.69	1.74	1.75	1.76	1.76	1.77	1.77	1.77
τ^k_{ss}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^d_{ss}	-0.52	0.02	0.32	0.37	0.51	0.66	0.69	0.69	0.69	0.69	0.68	0.68
τ^n_{ss}	0.82	0.24	0.05	0.02	-0.05	-0.12	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14

Note: The calibration yields the parameters $\theta = 7.13$, $\mu = 0.51$, $B = 6.78$ and the initial allocation $\frac{c_2}{c_1} = 2.61$ and $\frac{e_2}{n_1} = 0.91$.

Table 5.D: Ramsey Allocation and Taxes at Steady State with $G = 0.17$

γ	0.01	0.10	0.20	0.284	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.99
$\frac{c_{2,ss}}{c_{1,ss}}$	99.00	9.00	4.00	2.52	2.33	1.50	1.06	1.06	1.05	1.05	1.04	1.04
$\frac{e_{2,ss}}{n_{1,ss}}$	0.79	0.82	0.92	0.94	0.94	0.95	0.95	0.96	0.96	0.97	0.97	0.97
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	1.49	1.52	1.62	1.64	1.64	1.65	1.65	1.66	1.66	1.66	1.66	1.67
τ^k_{ss}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^d_{ss}	−0.72	−0.03	0.16	0.37	0.40	0.57	0.68	0.68	0.68	0.68	0.68	0.68
τ^n_{ss}	0.89	0.35	0.10	−0.02	−0.03	−0.12	−0.16	−0.17	−0.17	−0.17	−0.17	−0.17

Note: The calibration yields the parameters $\theta = 8.85$, $\mu = 0.50$, $B = 6.40$ and the initial allocation $\frac{c_2}{c_1} = 2.52$ and $\frac{e_2}{n_1} = 1.02$.

Table 5.E: Ramsey Allocation and Taxes at Steady State with $\delta = 0.08$

γ	0.01	0.10	0.20	0.277	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.99
$\frac{c_{2,ss}}{c_{1,ss}}$	99.00	9.00	4.00	2.71	2.33	1.50	1.05	1.05	1.04	1.04	1.04	1.03
$\frac{e_{2,ss}}{n_{1,ss}}$	0.82	0.84	0.94	0.95	0.96	0.96	0.96	0.97	0.97	0.97	0.97	0.98
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	1.51	1.53	1.62	1.64	1.64	1.65	1.65	1.65	1.65	1.66	1.66	1.66
τ^k_{ss}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^d_{ss}	−0.73	−0.03	0.19	0.37	0.43	0.60	0.70	0.70	0.70	0.70	0.70	0.70
τ^n_{ss}	0.90	0.37	0.12	0.02	−0.01	−0.09	−0.14	−0.14	−0.14	−0.14	−0.14	−0.14

Note: The calibration yields the parameters $\theta = 9.24$, $\mu = 0.48$, $B = 7.93$ and the initial allocation $\frac{c_2}{c_1} = 2.71$ and $\frac{e_2}{n_1} = 1.02$.

Table 5.F: Ramsey Allocation and Taxes at Steady State with $\beta = 0.97$

γ	0.01	0.10	0.20	0.277	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.99
$\frac{c_{2,ss}}{c_{1,ss}}$	99.00	9.00	4.00	2.61	2.33	1.50	1.10	1.08	1.07	1.07	1.06	1.06
$\frac{e_{2,ss}}{n_{1,ss}}$	0.71	0.77	0.88	0.91	0.92	0.93	0.93	0.94	0.95	0.95	0.95	0.96
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	1.48	1.55	1.66	1.69	1.69	1.71	1.71	1.72	1.72	1.73	1.73	1.73
τ^k_{ss}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^d_{ss}	−0.52	−0.02	0.14	0.32	0.36	0.54	0.65	0.64	0.64	0.64	0.64	0.64
τ^n_{ss}	0.90	0.37	0.12	0.01	−0.01	−0.09	−0.14	−0.14	−0.14	−0.14	−0.14	−0.14

Note: The calibration yields the parameters $\theta = 9.16$, $\mu = 0.55$, $B = 6.18$ and the initial allocation $\frac{c_2}{c_1} = 2.61$ and $\frac{e_2}{n_1} = 0.94$.

Table 5.G: Ramsey Allocation and Taxes at Steady State with $\rho = 0.001$

γ	0.01	0.10	0.20	0.277	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.99
$\frac{c_{2,ss}}{c_{1,ss}}$	99.00	9.00	4.00	2.61	2.33	1.50	1.07	1.06	1.05	1.05	1.04	1.04
$\frac{e_{2,ss}}{n_{1,ss}}$	0.78	0.82	0.92	0.94	0.94	0.95	0.95	0.96	0.96	0.97	0.97	0.97
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	1.54	1.57	1.66	1.68	1.68	1.69	1.69	1.70	1.70	1.71	1.71	1.71
τ^k_{ss}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^d_{ss}	-0.70	-0.03	0.16	0.35	0.40	0.57	0.68	0.68	0.68	0.68	0.68	0.68
τ^n_{ss}	0.90	0.38	0.13	0.02	0.00	-0.08	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13

Note: The calibration yields the parameters $\theta = 9.16$, $\mu = 0.27$, $B = 8.12$ and the initial allocation $\frac{c2}{c_1} = 2.61$ and $\frac{e2}{n_1} = 1.00$.

Table 6: Ramsey Allocation and Taxes at Steady State with $\gamma = 0.50$ for Different ρ

γ	0.25	0.001	-0.25	-0.50	-0.75	-1.00	-1.25	-1.50
$\frac{c_{2,ss}}{c_{1,ss}}$	1.07	1.07	1.07	1.06	1.06	1.06	1.06	1.06
$\frac{e_{2,ss}}{n_{1,ss}}$	0.95	0.95	0.95	0.95	0.96	0.96	0.96	0.96
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	1.72	1.69	1.68	1.66	1.66	1.65	1.64	1.64
τ^k_{ss}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^d_{ss}	0.68	0.68	0.69	0.69	0.69	0.69	0.69	0.70
τ^n_{ss}	-0.12	-0.13	-0.13	-0.14	-0.14	-0.14	-0.14	-0.14

Figure 4: Consumption Advantage by a Capitalist relative to a Worker in a Ramsey Reform

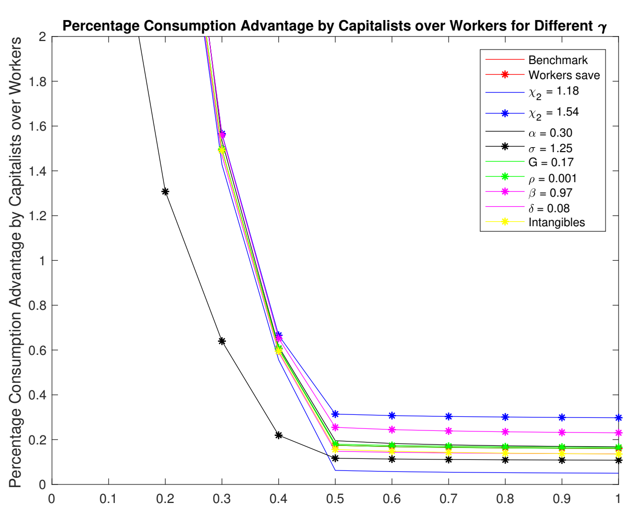

Table 7.A: Ramsey at Steady State and Relative Welfare Gain at a Pareto-Improving Reform

	$Bench$	$\sigma_1 = 2$	$\chi_2 = \frac{1}{0.85}$	$\chi_2 = \frac{1}{0.65}$	$Save$	$\alpha = 0.30$	$\sigma = 1.25$	$G = 0.17$	$\delta = 0.08$	$\beta = 0.97$	$\rho = 0.001$	$Intang$
γ	0.277	0.543	0.277	0.277	0.277	0.363	0.222	0.284	0.277	0.277	0.277	0.247
$\frac{c_{2,ss}}{c_{1,ss}}$	2.61	2.61	2.61	2.61	2.61	1.75	2.61	2.52	2.71	2.61	2.61	2.74
$\frac{e_{2,ss}}{n_{1,ss}}$	0.94	1.52	0.87	1.02	0.94	0.93	0.85	0.94	0.95	0.91	0.94	0.93
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	1.65	1.70	1.66	1.65	1.65	1.70	1.65	1.64	1.64	1.69	1.68	2.67
τ^k_{ss}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^d_{ss}	0.36	0.37	0.36	0.36	0.36	0.33	0.37	0.37	0.37	0.32	0.35	0.56
τ^n_{ss}	0.01	0.02	0.01	0.02	0.02	0.09	0.02	-0.02	0.02	0.01	0.02	0.10
$c2adv$	1.79	7.76	1.72	1.87	1.79	0.89	1.13	1.69	1.88	1.87	1.79	2.26

Table 7.B: Ramsey at Steady State and Relative Welfare Gain at Reform with $\gamma = 0.50$

	$Bench$	$\sigma_1 = 2$	$\chi_2 = \frac{1}{0.85}$	$\chi_2 = \frac{1}{0.65}$	$Save$	$\alpha = 0.30$	$\sigma = 1.25$	$G = 0.17$	$\delta = 0.08$	$\beta = 0.97$	$\rho = 0.001$	$Intang$
$\frac{c_{2,ss}}{c_{1,ss}}$	1.06	3.05	0.99	1.15	1.06	1.08	1.06	1.06	1.05	1.10	1.07	1.06
$\frac{e_{2,ss}}{n_{1,ss}}$	0.95	1.49	0.89	1.03	0.96	0.94	0.95	0.95	0.96	0.93	0.95	0.96
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	1.66	1.68	1.67	1.66	1.67	1.71	1.75	1.65	1.65	1.71	1.69	2.71
τ^k_{ss}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^d_{ss}	0.69	0.30	0.71	0.67	0.69	0.55	0.69	0.68	0.70	0.65	0.68	0.81
τ^n_{ss}	-0.14	0.06	-0.15	-0.13	-0.13	0.03	-0.14	-0.16	-0.14	-0.14	-0.13	-0.08
$c2adv$	0.17	9.10	0.06	0.31	0.17	0.20	0.12	0.17	0.15	0.25	0.18	0.16

Table 8: Ramsey Allocation and Taxes at Steady State with Intangible Capital

γ	0.01	0.10	0.20	0.247	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.99
$\frac{c_{2,ss}}{c_{1,ss}}$	99.00	9.00	4.00	2.74	2.33	1.50	1.06	1.05	1.04	1.04	1.04	1.04
$\frac{e_{2,ss}}{n_{1,ss}}$	0.82	0.84	0.92	0.93	0.94	0.95	0.96	0.96	0.97	0.97	0.97	0.97
$\frac{k_{ss}}{f(k_{ss},n_{ss})}$	2.51	2.54	2.66	2.67	2.69	2.70	2.71	2.72	2.72	2.73	2.73	2.73
τ^k_{ss}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^d_{ss}	−0.17	0.32	0.49	0.56	0.64	0.74	0.81	0.80	0.80	0.80	0.80	0.80
τ^n_{ss}	0.90	0.40	0.16	0.10	0.04	−0.04	−0.08	−0.08	−0.09	−0.09	−0.09	−0.09

Note: The calibration yields the parameters $\theta = 10.04$, $\mu_x = 0.19$, $B = 16.18$, $\mu_u = 0.25$, $C = 1.23$ and the initial allocation $\frac{c_2}{c_1} = 3.04$ and $\frac{e_2}{n_1} = 1.00$.

Figure 5: Ramsey Tax Rates with Intangible Capital during the Transition