Optimal Fiscal Policy in the Presence of Declining Labor Share*

Orhan Erem Atesagaoglu† and Hakki Yazici‡

April 27, 2020

Numerous recent studies have documented that the labor's share in national income, which has been quite stable until the early 1980's, has been declining at a considerable rate since then. In this paper, we analyze the implications of this decline on the optimal capital and labor income taxation from the perspective of a government that needs to finance spending. Our main qualitative finding is that the optimal tax implications of the decline in the labor share depend on the mechanism responsible for it. In particular, if the labor share declines because of rising market power or other mechanisms that raise the share of profits in national income, then the decline in the labor share should optimally be accompanied with a rise in capital income taxes. If, on the other hand, the labor share declines because of a rise in capital share, then it has no bearing on optimal capital income taxation. In our baseline calibration, we find that the optimal tax rate on capital income rises about 5-10% from the early 1980's to 2020 depending on the increase in profit share.

JEL classification: E60, E61, E62
Keywords: Capital income tax; labor share; profit share

*We would like to thank Melanie Luhrmann and seminar participants at Bogazici University and University of Royal Holloway for their comments and suggestions.

† Istanbul Bilgi University. E-mail: erem.atesagaoglu@bilgi.edu.tr
‡ Sabanci University. E-mail: hakkiyazici@sabanciuniv.edu

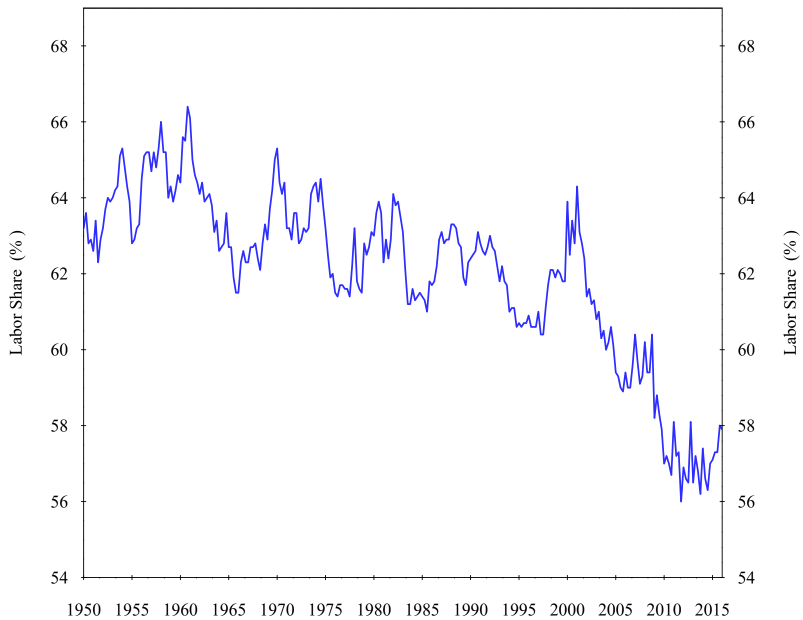
1 Introduction

Governments use income taxes and debt to finance their spending. A central question in macroeconomics is: How should governments allocate the tax burden between two main tax bases, capital and labor income, over time? An influential literature - dating back to the original contribution of Ramsey (1928) - provides a key insight regarding this question: it is optimal to set capital tax rate to zero. Chamley (1986) and Judd (1985) were the first ones to show that capital taxes should be zero in the long run in the neoclassical growth model. If one is willing to assume that preferences belong to a class that is standard in the macroeconomics literature, then the long-run result holds in the short run as well: except for a few initial periods, it is optimal to set taxes on capital income to zero and put all the burden of taxation on the labor income tax base.

In this paper, we analyze optimal capital and labor income taxation in an economy where the labor tax base is shrinking. This is a very relevant issue from the perspective of practical policymaking since there is a relatively broad consensus among economists that the labor's share in national income (labor share hereafter) has been declining in many developed economies.[1] Figure 1 below depicts labor share for the US economy for the post war era. It is stable until the early 1980's and has been falling at a considerable rate since then. This trend implies that a government that follows the suggestions of the Ramsey tax theory, by setting capital income taxes to zero or at least by keeping them low relative to labor income taxes, would experience a decline in overall tax revenues. Such a government would have to reform its tax system in order to make up for this decline. In an interview with Quartz in 2017, Bill Gates famously addressed this issue by stating that "Robots who take human jobs should pay taxes!" Since robots are part of the capital stock, his suggestion could be interpreted as raising the capital tax rate. In this paper, we investigate the optimal way of reforming the tax system in the presence of a decline in the labor share.

[1] See Elsby, Hobijn, and Sahin (2013), Karabarbounis and Neiman (2014), Autor, Dorn, Katz, Patterson, and Reenen (2017), Barkai (2019), De Loecker, Eeckhout, and Unger (2019), Acemoglu and Restrepo (2019), and Farhi and Werning (2013).

Figure 1 :U.S. Non-Farm Business Labor Share



To do so, we set up a representative agent neoclassical growth model in which there is a government that needs to finance an exogenous stream of expenditures using linear taxes on capital and labor income. We focus on a representative agent framework intentionally in order to avoid issues of inequality and redistribution. There is diverse opinion in the literature on the mechanisms that are responsible for the decline in labor share. Because we do not want to take a stance on which mechanisms are more important, our neoclassical growth model incorporates virtually all of them. Observe that the following equality holds in any economy in any given year:

$$Y = I_L + I_K + I_\Pi, \tag{1}$$

where Y is national income, I_L is the aggregate labor income received by workers, I_K is the aggregate capital income received by those who own the capital stock, and I_Π is the aggregate (pure) profit income received by those who own the firms. The profit income is defined as what a firm earns in excess of all production costs. The equality in (1) simply tells us that the national income is shared between labor income, capital income, and profit income. Therefore, if there is a decline in labor share, this must be happening due to a rise in capital share or a rise in profit share, or both. We categorize the theories of the decline in labor share proposed in the literature into two groups depending on whether they involve a rise in capital or profit share of income. Rise in automation, capital augmenting technical change, decline in capital prices and offshoring of labor-intensive production are all theories of rise in capital share whereas increasing product or labor market power are theories of increasing profit share.

Our main qualitative finding is that the nature of the optimal tax reform for an economy that experiences a decline in labor share depends on whether this decline is accompanied by a rise in capital or profit share. If labor share is declining because production is becoming more capital intensive, say due to a rise in automation or cheapening of capital, then it is optimal to increase labor income taxes to make up for the loss in tax revenue. If, on the other hand, the decline in labor share coincides with a rise in profit share, say due to declining competition in product markets, then it is optimal to increase the tax rate on capital income.

Intuitively, whenever there are pure profits in the economy, it is optimal for the government to tax them fully since taxing pure profits is non-distortionary. If taxing profit income at 100% is not an option for the government, an assumption maintained in the current paper, then it is optimal to tax factors that contribute to profit creation as this provides an indirect way of 'taxing' untaxed profits. Obviously, capital is one such factor as it contributes to production, and hence, profit generation. In fact, the optimal capital tax formula reveals that the optimal tax rate on capital is proportional to the after-tax profit share.

On the quantitative side, we calibrate our model to the decline in labor share observed in the US economy. Specifically, we calibrate the steady state of our model economy to 1980 U.S. economy in line with the empirical observations that the labor share was stable at two thirds until the early 1980's and profit share was close to zero. We then calibrate the evolution of the model economy to match the empirical evolution of income shares in the US between 1980 and now. We consider two alternative calibrations that follow two alternative findings from the literature as empirical targets. Barkai (2019) finds that the profit share in the U.S. economy increased by 14 percentage points over this period whereas De Loecker, Eeckhout, and Unger (2019) argues that the rise in profit share was 7 percentage points.

We first compute the optimal capital and labor income taxes if the government carried out the tax reform in 1980 foreseeing the upcoming trends in income shares (1980 reform hereafter). Under Barkai calibration, the optimal tax rate on capital income is initially very low around 0%, goes up to about 7% by 2020, and stabilizes at around 10% in the long run whereas the optimal tax on labor income is virtually flat at around 35%. The optimal capital taxes are around zero early on because the profit share was around zero in the 1980's, and the only reason to tax capital in the current model is to mimic a tax on profit income. After that the optimal capital tax rate follows closely the pattern of rising after-tax profit share. The pattern of optimal capital taxes is very similar under the De Loecker calibration but, as expected, the optimal capital taxes are lower, for instance, around 4%, in the long run. We also consider the optimal tax reform in 2020. We find that optimal capital tax rate starts from about 8% in 2020 and rises to 13% in the long run in the Barkai calibration while it increases from 4% in 2020 to 6% in the long run in De Loecker calibration. The optimal labor income taxes are also higher in the 2020 reform. The optimal tax rates are overall higher in this reform because government has to finance a higher initial debt at the time of reform, which is a result of 40 years of inefficient tax poilcy during 1980-2020.

It is important to stress that in this model the only reason for taxing capital is the need for financing government spending. In a more general model of taxation, there could be other reasons for taxing capital such as redistribution. In this regard, the optimal capital tax rates we compute here should be seen as informative about how strong our mechanism is for capital taxation and not as a prescription for actual capital tax rates.

Related Literature. An influential backdrop to our paper is Dasgupta and Stiglitz (1971) who show that, when there are pure profits in an economy and government is not allowed to tax profits at 100%, the productive efficiency result of Diamond and Mirrlees (1971) does not hold any more, and it is optimal to tax intermediate inputs that contribute to profit creation. Intuitively, taxing these inputs provide an indirect tax on profits. Jones, Manuelli, and Rossi (1997) show that this logic implies a positive tax on capital in the long run in the context of a neoclassical growth model. Like Dasgupta and Stiglitz (1971), the reason for positive profits in is decreasing returns to scale in production.

Our paper is also related to a set of papers that analyze optimal Ramsey taxation in the presence of market power in the product market. Specifically, Judd (2002) show that in, when there is monopolistic competition in the product market, the overall capital wedge is negative, asking for capital subsidies, in the long run. Guo and Lansing (1999) and Coto-Martnez, Garriga, and Snchez-Losada (2007) question the generality of Judd (2002)'s long-run capital subsidy result by considering restricted government policies and different economic environments.

Finally, there is a new burgeoning literature that makes a case for taxation of robots. Following the skill premium literature, Slavik and Yazici (2014) assume a machine-skill complementarity. This implies that machines raise the marginal product of the skilled relative to the unskilled, and this increases inequality. It is, thus, desirable to deter the accumulation of machines from the perspective of a redistributive government. Costinot and Werning (2018) argue for a similar rationale for taxing robots and trade in a static model with a more general production structure.[2] The key distinction of our paper from those is that in all these papers taxing robots is socially desirable because it is redistributive while we argue that taxing robots (capital in general) provides a more efficient way of financing government's budget.

[2]See also Thuemmel (2018) and Guerreiro, Rebelo, and Teles (2019) for similar arguments for taxation of robots.

2 Model

Consider a neoclassical growth model in which there is a representative consumer who lives infinitely many periods and takes prices and taxes as given. Every period this consumer decides on how much to work, consume, and save for the next period. There are also firms that produce and sell intermediate and final goods. Finally, there is a benevolent government that needs to finance an exogenously given stream of public spending.

Final Good Producers. Firms that produce the final good are perfectly competitive and operate constant returns to scale production functions. They operate a constant elasticity of substitution (CES) production function that combines a measure one of intermediate goods $y_{i,t}$. Taking prices of intermediate goods, $p_{i,t}$, as given, the problem of the representative final good firm is:

$$\max_{y_{i,t}} Y_t - \int_0^1 p_{i,t} y_{i,t} di$$

$$s.t.$$

$$Y_t = \left(\int_0^1 y_{i,t}^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}}.$$

The first-order optimality condition of this problem with respect to $y_{i,t}$ gives the demand as a function of price for each intermediate good:

$$y_{i,t} = Y_t p_{i,t}^{-\varepsilon}. \tag{2}$$

Intermediate Good Producers. Each intermediate good producer is a monopolistic competitor. Producer of intermediate good $y_{i,t}$ uses a CES technology to combine capital and labor to produce the intermediate good. This firm solves:

$$\pi_{i,t} = \max_{p_{i,t}, y_{i,t}, k_{i,t}, l_{i,t}} p_{i,t} y_{i,t} - r_t k_{i,t} - w_t l_{i,t} \tag{3}$$

$$s.t.$$

$$y_{i,t} = F_t(k_{i,t}, l_{i,t}) = \Big(\alpha_{k,t}(A_{k,t}k_{i,t})^{\rho} + \alpha_{l,t}(A_{l,t}l_{i,t})^{\rho}\Big)^{1/\rho}, \tag{4}$$

where r_t and w_t represent the real rental rate of capital and real wage rate, respectively.

The intermediate good firm's problem can be solved in two steps. In the first step, for a given marginal cost of producing the good, $m_{i,t}$, the firm chooses price to maximize profits:

$$\max_{p_{i,t}} p_{i,t} y_{i,t} - m_{i,t} y_{i,t} \quad s.t. \quad (2). \tag{5}$$

The solution to this problem implies a constant markup over marginal cost

$$p_{i,t} = m_{i,t} \frac{\varepsilon}{(\varepsilon - 1)}. \tag{6}$$

In the symmetric equilibrium of the model, all varieties have the same production function and all intermediate goods firms make identical choices of inputs and prices. This implies $y_{i,t} = Y_t$ and $p_{i,t} = 1$ for all $i \in [0, 1]$. We, therefore, have the optimal marginal cost of producing one more intermediate good equals for all firms $m_{i,t} = M_t = \frac{\varepsilon - 1}{\varepsilon}$. Gross markup, defined as the ratio of price divided by marginal cost, then equals $\mu = \frac{\varepsilon}{\varepsilon - 1}$.

In the second step, each firm chooses capital and labor to minimize the cost of producing intermediate good. The firms also make same input choices in the symmetric equilibrium, so we have $k_{i,t} = K_t$ and $l_{i,t} = L_t$. Marginal cost of producing one more unit using capital or labor at the optimum gives

$$\frac{r_t}{F_{K,t}} = \frac{w_t}{F_{L,t}} = \frac{\varepsilon - 1}{\varepsilon} = \frac{1}{\mu}. \tag{7}$$

Or more explicitly, rental rate and wage rate are given by

$$r_t = \frac{\varepsilon - 1}{\varepsilon}\Big(\alpha_{K,t}K_t^{\rho} + \alpha_{L,t}L_t^{\rho}\Big)^{1/\rho - 1}\alpha_{K,t}A_{K,t}^{\rho}K_t^{\rho-1} \tag{8}$$

$$w_t = \frac{\varepsilon - 1}{\varepsilon}\Big(\alpha_{K,t}K_t^{\rho} + \alpha_{L,t}L_t^{\rho}\Big)^{1/\rho - 1}\alpha_{L,t}A_{L,t}^{\rho}L_t^{\rho-1}.$$

Income Shares. We can use (5) to calculate

$$S_{\Pi,t} \equiv \frac{\Pi_t}{Y_t} = \frac{1}{\varepsilon}. \tag{9}$$

Next, we use rental rates given by (8) to compute the income shares of capital and labor:

$$S_{K,t} \equiv \frac{r_t K_t}{Y_t} = \frac{\varepsilon - 1}{\varepsilon}\frac{\alpha_{K,t}(A_{K,t}K_t)^{\rho}}{\alpha_{K,t}(A_{K,t}K_t)^{\rho} + \alpha_{L,t}(A_{L,t}L_t)^{\rho}} \tag{10}$$

$$S_{L,t} \equiv \frac{w_t K_t}{Y_t} = \frac{\varepsilon - 1}{\varepsilon}\frac{\alpha_{L,t}(A_{L,t}L_t)^{\rho}}{\alpha_{K,t}(A_{K,t}K_t)^{\rho} + \alpha_{L,t}(A_{L,t}L_t)^{\rho}}. \tag{11}$$

Representative consumer. There is a unit measure of identical consumers who live forever. Each consumer is born in period one with $k_1 > 0$ units of physical capital and b_1 units of government debt. Taking prices as given, consumers decide on their consumption, labor, and saving allocations every period. Furthermore, they decide on how to allocate their saving between buying physical capital and government bonds, and private claims. The period utility of an individual who consumes c units of consumption and supplies l units of labor equals $u(c, l)$, where utility function satisfies standard assumptions: $u_c, -u_{cc}, -u_l, -u_{ll} > 0$. People also discount future with a factor $\beta \in (0, 1)$. Taking prices $\{p_t, r_t, w_t\}_{t=1}^{\infty}$, taxes

$\{\tau_{k,t}, \tau_{l,t}, \tau_{\pi,t}\}_{t=1}^{\infty}$, and $k_1 > 0$ and b_1 as given, an individual chooses $\{c_t, k_{t+1}, l_t\}_{t=1}^{\infty}$ to solve:

$$\max_{c,k,l} \sum_{t=1}^{\infty} \beta^{t-1} u(c_t, l_t)$$

s.t.

$$\sum_{t=1}^{\infty} p_t \left(c_t + q_t k_{t+1}\right) \leq \sum_{t=1}^{\infty} p_t \left(w_t l_t (1 - \tau_{l,t}) + \bar{r}_t k_t + \pi_t (1 - \tau_{\pi,t})\right) + p_1 b_1,$$

where p_t is price of period t consumption good in terms of some numeraire and $\bar{r}_t = q_t + (r_t - q_t\delta)(1 - \tau_{k,t})$ is the after-tax gross rate of return to capital. It is straightforward to derive the following first-order optimality conditions of the consumer's problem:

$$\frac{\beta u_{c,t+1}}{u_{c,t}} = \frac{p_{t+1}}{p_t}, \tag{12}$$

$$p_t q_t = p_{t+1} \bar{r}_{t+1}, \tag{13}$$

$$\frac{u_{l,t}}{u_{c,t}} = -w_t (1 - \tau_{l,t}). \tag{14}$$

Government budget balance. Government uses capital, labor, and profit income taxes $\{\tau_{k,t}, \tau_{l,t}, \tau_{\pi,t}\}_{t=1}^{\infty}$ to finance an exogenous stream of spending $\{g_t\}_{t=1}^{\infty}$.

$$\sum_{t=1}^{\infty} p_t g_t + p_1 b_1 \leq \sum_{t=1}^{\infty} p_t \left(w_t l_t \tau_{l,t} + (r_t - q_t \delta) k_t \tau_{k,t} + \pi_t \tau_{\pi,t}\right). \tag{15}$$

Resource feasibility. Aggregate resource feasibility requires that for all $t \geq 1$

$$c_t + q_t k_{t+1} + g_t = F_t(k_t, l_t) + (1 - \delta) q_t k_t. \tag{16}$$

Market Equilibrium. *Given (k_1, b_1) and $\{g_t\}_{t=1}^{\infty}$, a tax-distorted market equilibrium is a policy $\{\tau_{k,t}, \tau_{l,t}, \tau_{\pi,t}\}_{t=1}^{\infty}$, an allocation $\{c_t, k_{t+1}, l_t\}_{t=1}^{\infty}$ and a price system $\{p_t, r_t, w_t\}_{t=1}^{\infty}$ such that:*

1. *Given policy and prices, allocation solves representative consumer's problem;*

2. *All firms maximize profits;*

3. *Markets for final and intermediate goods, capital, and labor clear;*

4. *Government's budget constraint is satisfied.*[3]

3 Optimal Tax System

Consider now the problem of a government who needs to finance a given stream of public spending. We assume that there is an institution or commitment technology through which the government can bind itself to a particular sequence of policies once and for all in period one. Once the policy is chosen, consumers and firms interact in capital, labor and goods markets according to the market equilibrium defined earlier. The government is sophisticated enough that it predicts that different government policies lead to different behavior of economic agents, which then leads to different market equilibria. There are possibly many policy sequences that can finance a given stream of government spending. Among those, the benevolent government chooses the one that maximizes representative consumer's welfare.

It is well-known that in optimal tax problems of this sort, the government would like to set the tax rate on capital income in the very first period as high as possible since this tax is effectively a lump-sum tax on first period capital income. To make the problem interesting, we make the assumption that the initial capital tax rate is set exogenously to $\bar{\tau}_{k,1}$. In this environment, it is optimal to tax profit income at 100% as taxing pure profits is non-distortionary. However, there may be a number of reasons in reality for why taxing pure profits at 100% may not be such a great idea. For this reason, we will set an upper bound for profit tax rates, $\{\bar{\tau}_{\pi,t}\}_{t=1}^{\infty}$. The government finds it optimal to set profit tax rate to this upper bound. The government also chooses $\tau = \{\tau_{k,t+1}, \tau_{l,t}\}_{t=1}^{\infty}$. Formally, given (k_1, b_1) and

[3] Notice that we do not need so specify resource feasibility as an equilibrium condition. This is because, under the preference assumptions we make, consumer's and government's budget constraints hold with equality, and these two imply resource feasibility.

$\{g_t\}_{t=1}^{\infty}$, the optimal tax policy, τ^*, solves the following optimal tax problem:

$$\max_{\tau} \sum_{t=1}^{\infty} \beta^{t-1} u(c_t, l_t)$$

subject to the fact that the tax system $\{\tau_{k,t}, \tau_{l,t}, \tau_{\pi,t}\}_{t=1}^{\infty}$, the allocation $\{c_t, k_{t+1}, l_t\}_{t=1}^{\infty}$ and the price system $\{p_t, r_t, w_t\}_{t=1}^{\infty}$ constitute a market equilibrium.

3.1 Primal Approach

The optimal tax problem defined above is a fairly hard problem to solve as the constraint set involves endogenous prices and consumer and firm maximization problems. Instead of attacking this problem directly, we are going to follow the primal approach which is a common way of attacking optimal tax problems in the literature. See Atkinson and Stiglitz (1976) among others. In this approach, we solve the optimal tax problem in three steps. First, we show that the optimal tax problem is equivalent to a planning problem where government chooses allocations directly subject to a number of conditions that summarize all restrictions on allocations that is implied by the tax-distorted market equilibrium. This problem is called the Ramsey problem in the literature. Second, we characterize the Ramsey allocation, namely, the allocation that solves the Ramsey problem, by a set of optimality conditions. Finally, we back out optimal tax rates by comparing optimality conditions that come out of the Ramsey problem and the tax-distorted competitive equilibrium. The following proposition establishes the first step of the primal approach. It shows that resource feasibility constraint together with the implementability constraint below characterizes tax-distorted market equilibrium completely.

$$\sum_{t=1}^{\infty} \beta^{t-1} \left(u_{c,t} c_t + u_{l,t} l_t\right) = \sum_{t=1}^{\infty} \beta^{t-1} u_{c,t} \pi_t (1 - \tau_{\pi,t}) + u_{c,1} (\bar{r}_1 k_1 + b_1). \tag{17}$$

Proposition 1. *If an allocation $\{c_t, k_{t+1}, l_t\}_{t=1}^{\infty}$ is part of a tax-distorted market equilibrium, then it satisfies resource feasibility (16) and implementability (17) constraints. Conversely,* *suppose an allocation $\{c_t, k_{t+1}, l_t\}_{t=1}^{\infty}$ satisfies (16) and (17). Then, we can construct prices and taxes such that this allocation together with constructed prices and taxes constitute an equilibrium allocation.*

Proof. Relegated to Appendix. $\square$

Ramsey problem. Government chooses allocation $(c, k, l) = \{c_t, k_{t+1}, l_t\}_{t=1}^{\infty}$ to solve the following problem:

$$\max_{c,k,l} \sum_{t=1}^{\infty} \beta^{t-1} u(c_t, l_t)$$

$$\text{s.t.}$$

$$c_t + q_t k_{t+1} \leq F_t(k_t, l_t) + (1-\delta) q_t k_t, \quad \text{for all } t,$$

$$\sum_{t=1}^{\infty} \beta^{t-1} \left(u_{c,t} c_t + u_{l,t} l_t\right) = \sum_{t=1}^{\infty} \underbrace{\beta^{t-1} u_{c,t}}_{price} \underbrace{(1-\tau_{\pi,t})\pi_t}_{volume} + u_{c,1}(\bar{r}_1 k_1 + b_1).$$

Notice that the first term on the right-hand-side of the implementability constraint is in blue. This term is the main difference of the implementability constraint in our problem relative to the standard Ramsey problems in the literature. This term shows up in the Ramsey problem because there are untaxed profits in equilibrium. In fact, it is equal to the net present value of untaxed profits in terms of period one consumption good. To see this notice that each period the physical amount of untaxed profits equals $(1-\tau_{\pi,t})\pi_t$ in terms of period t consumption good. To calculate the value of this in period one consumption then we multiply this by the price of consumption good in period t, that is by $p_t = \beta^{t-1} u_{c,t}$.

In the solution to this problem, the implementability constraint binds in the direction of left-hand-side should be greater than right-hand-side. In fact, an explicit derivation of this constraint from the government's budget constraint would reveal that the left-hand side corresponds to the revenue side of government's budget while the right-hand-side corresponds to its spending. As such, the net-present-value of untaxed profits appear as a cost in this problem. The brief intution for this is that since taxing pure profits is not distortionary, Ramsey government would like to tax them at 100%. When we only allow the government to tax profits at rate $\tau_{\pi,t}$, this is identical to a case where the government taxes profits at 100% but needs to give $(1-\tau_{\pi,t})$ back to consumers. This is why untaxed profit income appear as a cost in Ramsey government's problem.

Now, we derive first-order optimality conditions of the government to see how the existence of untaxed profits change a Ramsey planner's marginal cost-benefit analysis of changing capital, labor and consumption allocations. This is useful as it will help us understand the optimal tax formulas that come later on. Letting μ_t and λ be the Lagrangian multipliers on feasibility and implementability constraints and star allocation denote the Ramsey allocation, the first-order optimality conditions of this problem for $t \geq 2$ are: [4]

$$(k_t): \quad -\mu^*_{t-1}q_{t-1} + \mu^*_t\left(F^*_{k,t} + (1-\delta)q_t\right) - \lambda^*\beta^{t-1}u^*_{c,t}(1-\tau_{\pi,t})\frac{\partial \pi_t}{\partial k_t} = 0, \tag{18}$$

$$(l_t): \quad \beta^{t-1}u^*_{l,t} + \lambda^*\beta^{t-1}\left[u^*_{ll,t}l_t + u^*_{cl,t}c^*_t + u^*_{l,t} - u^*_{c,t}(1-\tau_{\pi,t})\frac{\partial \pi_t}{\partial l_t} - u^*_{cl,t}(1-\tau_{\pi,t})\pi^*_t\right] = \mu^*_t F^*_{l,t}, \tag{19}$$

$$(c_t): \quad \beta^{t-1}u^*_{c,t} + \lambda^*\beta^{t-1}\left[u^*_{cc,t}c^*_t + u^*_{lc,t}l^*_t + u^*_{c,t} - u^*_{cc,t}(1-\tau_{\pi,t})\pi^*_t\right] = \mu^*_t. \tag{20}$$

.

The first two terms in (18) represent the standard period $t-1$ physical cost of investing in period t capital and the period t physical return on capital. The blue term is new and related to the existence of untaxed profits. This term is negative which means that there is an additional cost of increasing capital from the perspective of the Ramsey planner. Intuitively, recall that untaxed profits enter as a cost to the planning problem. Increasing capital increases output and untaxed profits, and as such, increases this cost. For this reason,

[4] The first-order optimality conditions for consumption and labor need to be modified for $t=1$ to include terms related to $u_{c,1}(\bar{r}_1 k_1 + b_1)$. To be precise, these conditions are:

$$(c_1): \quad u_{c,1} + \lambda\left[u_{cc,1}c_1 + u_{lc,1}l_1 + u_{c,1} - u_{cc,1}(1-\tau_{\pi,1})\pi_1 - u_{cc,1}A_1\right] = \mu_1,$$

$$(l_1): \quad u_{l,1} + \lambda\left[u_{ll,1}l_1 + u_{cl,1}c_1 + u_{l,1} - u_{cl,1}(1-\tau_{\pi,1})\pi_1 - u_{c,1}(1-\tau_{\pi,1})\frac{\partial \pi_1}{\partial l_1} - u_{cl,1}A_1\right] = \mu_1 F_{l,1},$$

where $A_1 = \bar{r}_1 k_1 + b_1$ is the real value of initial assets. These conditions matter only for period one and period two taxes on labor and capital, respectively.

it is optimal to create a positive wedge in the capital accumulation decision of private agents, and this wedge is in proportion to capital's contribution to untaxed profit creation. The latter is given by

$$(1-\tau_{\pi,t})\frac{\partial \pi_t}{\partial k_t} = (1-\tau_{\pi,t})S_{\pi,t}F^*_{k,t}.$$

Because the rise in capital increases net-present-value of untaxed profit income by increasing the *volume* of profits, we call this the *volume wedge*. As we will see when we discuss optimal taxes in the next section, this wedge always calls for a positive tax on capital income.

A glance at (19) shows that there are potentially two new terms relative to standard Ramsey problems. The first term is analogous to the term in the first-order condition of capital. Increasing labor increases the *volume* of untaxed profits and thereby is costly. This implies that it is optimal to create a positive *volume wedge* for labor as well. This wedge is in proportion to labor's contribution to untaxed profit creation:

$$(1-\tau_{\pi,t})\frac{\partial \pi_t}{\partial l_t} = (1-\tau_{\pi,t})S_{\pi,t}F^*_{l,t}.$$

The volume wedge calls for a tax on labor income. The second blue term in (19) represents how increasing period t labor affects the value of period t untaxed profit income by changing its *price*, $\beta^{t-1}u_{c,t}$. Later on we assume separability between consumption and labor in the utility function. In that case, this term disappears.

Finally, the first-order condition with respect to consumption, (20), also containts a new term. This term represents how a change in period t consumption affects the net-present-value of untaxed profits in that period. Notice that a change in consumption affects value of profit by affecting the *price* of consumption good in that period and not the volume of profits. Since utility is concave, a rise in consumption implies a decline in price of consumption good in that period, which reduces the value of profits in that period. This implies that the Ramsey planner would like to encourage consumption in any period in proportion to its contribution to untaxed profit income. Since we do not allow for consumption subsidies (or taxes) directly, this *price wedge* on period t consumption will translate into a subsidy on period t capital income and a subsidy on period t labor income.

3.2 Optimal Taxes

In this section, we provide a decentralization of the Ramsey allocation in the market equilibrium and use this decentralization to compute optimal tax formulas.

Sales subsidies. We focus on a decentralization in which we enlarge the government's fiscal policy tools to include sales subsidies. These subsidies will be used to correct for underinvestment and underemployment that stem from monopoly distortions. This way the government does not have to use capital and labor income taxes to correct these distortions.[5] Letting $\tau_{s,t}$ be the sales subsidy faced by intermediate good firms, their problem becomes:

$$\pi_{i,t} = \max_{p_{i,t}, y_{i,t}, k_{i,t}, l_{i,t}} (1 + \tau_{s,t}) p_{i,t} y_{i,t} - r_t k_{i,t} - w_t l_{i,t}$$

$$s.t.$$

$$y_{i,t} = F_t(k_{i,t}, l_{i,t}) = \Big(\alpha_{k,t}(A_{k,t} k_{i,t})^\rho + \alpha_{l,t}(A_{l,t} l_{i,t})^\rho\Big)^{1/\rho}.$$

It is straightforward to show that setting $1 + \tau_{s,t} = \frac{\varepsilon_t}{\varepsilon_t - 1}$ corrects production distortions coming from monopolistic competition. In this case, interest and wage rates equal marginal products of capital and labor, respectively:

$$r_t = F_{k,t} \tag{21}$$

$$w_t = F_{l,t}. \tag{22}$$

[5] We have an extension where we do not allow the government to correct monopolistic distortions. There we show that our main results do not depend on whether we allow for such corrections.

Defining optimal capital and labor income taxes. When we combine the first-order optimality condition (14) of consumer with pricing condition (22), we see that in equilibrium:

$$F_{l,t}(1-\tau_{l,t})u_{c,t} = v_{l,t}. \tag{23}$$

Similarly, if we combine the first-order optimality conditions of consumer, (12) and (13), with pricing condition (21), we see that in equilibrium:

$$u_{c,t-1}q_{t-1} = \beta u_{c,t}\left[q_t + \left(F_{k,t} - \delta q_t\right)\left(1-\tau_{k,t}\right)\right]. \tag{24}$$

Using (23) and (24), we define the optimal tax on capital and labor income as optimal distortions that implement Ramsey allocation in equilibrium:

$$1-\tau^*_{l,t} = \frac{v^*_{l,t}}{u^*_{c,t}F^*_{l,t}}, \tag{25}$$

$$1-\tau^*_{k,t} = \frac{\frac{u^*_{c,t-1}q_{t-1}}{\beta u^*_{c,t}} - q_t}{\left(F^*_{k,t} - \delta q_t\right)}. \tag{26}$$

Characterizing optimal capital and labor income taxes. Now we provide a condition that characterizes optimal capital and labor income taxes. We assume utility is separable between consumption and labor, and that utility function regarding consumption satisfies constant elasticity of intertemporal substitution while disutility function regarding labor satisfies constant Frisch elasticity of substitution. It is important to stress that none of these assumptions are important for our results. They are mainly in place to simplify derivations.

Assumption 1. *Suppose, with some abuse of notation,*

$$u(c,l) = u(c) - v(l) = \frac{c^{1-\sigma}}{1-\sigma} - \frac{l^{1+\phi}}{1+\phi}.$$

Under this assumption, the general first-order optimality conditions for labor (19) and consumption (20) simplify to: for $t \geq 2$

$$(l_t): \quad \beta^{t-1} v^*_{l,t}[1+\lambda^*(1+\gamma)] + \lambda^* \beta^{t-1} u^*_{c,t}(1-\tau_{\pi,t}) \frac{\partial \pi_t}{\partial l_t} = \mu^*_t F^*_{l,t}, \tag{27}$$

$$(c_t): \quad \beta^{t-1} u^*_{c,t}[1+\lambda^*(1-\sigma)] - \lambda^* \beta^{t-1} u^*_{cc,t}(1-\tau_{\pi,t})\pi^*_t = \mu^*_t. \tag{28}$$

Proposition 2. *The optimal tax rate on capital and labor income in all $t \geq 2$ are given by*

$$\tau^*_{l,t} = 1 - (1 - V^*_t - P^*_t) \frac{1+\lambda(1-\sigma)}{1+\lambda(1+\phi)} \tag{29}$$

and

$$\tau^*_{k,t} = 1 - \frac{\frac{1-P^*_t}{1-P^*_{t-1}} \left[q_t + \left(F^*_{k,t} - \delta q_t\right)(1 - W^*_t)\right] - q_t}{F^*_{k,t} - \delta q_t}, \tag{30}$$

where

$$P^*_t = \frac{\lambda}{1+\lambda(1-\sigma)} \frac{u_{cc,t}}{u_{c,t}} (1-\tau_{\pi,t}) Y_t S_{\Pi,t} < 0, \tag{31}$$

$$W^*_t = V^*_t \frac{F_{K,t}}{F_{K,t} - \delta q_{t+1}} \frac{1}{1-P^*_t} > 0 \tag{32}$$

$$V^*_t = \frac{\lambda}{1+\lambda(1-\sigma)} (1-\tau_{\pi,t}) S_{\Pi,t} > 0. \tag{33}$$

Proof. To derive (29), combine (27) with (28), and plug the resulting expression into (25). To derive (30), combine (18) with (28), and plug the resulting expression into (26). □

Interpretting the optimal tax formulas. A glance at the optimal labor tax formula, (29), reveals that optimal labor tax is a combination of three wedges. The first one is the standard optimal Ramsey wedge, $\frac{1+\lambda(1-\sigma)}{1+\lambda(1+\phi)} < 1$, and calls for a tax on labor income. The other two, V^*_t and P^*_t appear because of the existence of untaxed profit income. They are both related to government's motive to tax pure profits away from consumers. $V_t^* > 0$ corresponds to the volume wedge on labor explained in the previous section and calls for a tax on labor income. Higher amount of period t labor means higher output in that period, which means higher after-tax profit income as long as $S_{\Pi,t} > 0$ and $\tau_{\pi,t} < 1$. Thus, taxing labor income provides an indirect way of taxing untaxed profit income away. $P_t^* < 0$ is the price wedge on labor, and calls for a subsidy on labor income in period t. Intuitively, a subsidy on labor income increases consumption in that period, decreasing the price of consumption good, and hence, decreasing the net-present-value of period t untaxed profit income.

The optimal capital tax formula, (30), reveals that the existence of pure profits create three wedges between Ramsey and equilibrium capital accumulation decisions. They are all related to government's motive to tax pure profits away from consumers. First, W_t^* corresponds to the *volume wedge* on capital discussed in the previous section, and calls for a tax on capital income. Intuitively, whenever there are profits in a period, they are increasing in the amount of capital. When the government is not allowed to fully tax away these profits, that is $1 - \tau_{\pi,t} > 0$, taxing capital provides an indirect way of taxing profits. Intuitively, taxing capital income decreases capital stock in period t, thereby directly decreasing period t production, and hence, profits. This calls for a tax on period t capital income.

The other two wedges, P_{t-1}^*, P_t^*, are price wedges. In general, when $S_{\pi,t} > 0$ and profit taxes less than 100%, $1 - \tau_{\pi,t} > 0$, it follows from u being strictly concave that $P_t^* < 0$. This means that the existence of untaxed pure profits in period t calls for a subsidy on period t capital income. Intuitively, a capital subsidy on period t capital income increases savings into period t, which increases amount of consumption in period t and decreases price of consumption in that period. Since period t profits accrue in period t prices, this effectively decreases period t profits, giving government an indirect way of taxing them. The exact same logic tells us that there is a price wedge going in the opposite direction, $P_{t-1}^* < 0$, that is calling for a tax on period t capital income. Intuitively, taxing capital income in period t, decreases saving from period $t-1$ into period t. As a result, period $t-1$ consumption increases, decreasing the net present value of period $t-1$ untaxed profits.

We expect that if in consecutive periods the share of after-tax profits is roughly equal, then the price effects would cancel out and the optimal tax rate on capital income would equal the volume wedge. The following corollary establishes that this intuition is exact at steady states where price terms cancel out exactly.

Corollary 1. *Suppose a steady state exists under the optimal tax system. The optimal tax rate on capital income at a steady state is given by $\tau_k^* = W^*$ and is strictly positive.*

A glance at the definitions of P_t^*, W_t^*, and V_t^* reveals that P_t^* is decreasing and W_t^* and V_t^* are increasing in profit income share, $S_{\pi,t}$ and decreasing in profit tax rate, $\tau_{\pi,t}$. In other words, both the volume and price wedges are stronger the larger is untaxed profit income share. The fact that W_t^* is increasing in profit share implies that in a world where profit's share in income is rising over time optimal capital income tax rate should also rise. As we will see in the quantitative section, this is indeed why optimal capital tax rate should have increased over time since the 1980's.

If in an economy either profit share is zero or the tax on profits is 100%, both volume and price wedges are zero, and we recover the standard optimal tax results. The following corollary summarizes this result.

Corollary 2. *If $S_{\pi,t} = 0$ or $\tau_{\pi,t} = 1$ in all t, then $\tau_{k,t}^* = 0$ and $\tau_{l,t}^* = 1 - \frac{1+\lambda(1-\sigma)}{1+\lambda(1+\phi)} > 0$ in all $t \geq 2$.*

4 Optimal Policy when Government cannot Correct Monopolistic Distortions

As indicated above, monopolistic distortions create underinvestment and underemployment due to monopolistic pricing in equilibrium. In a standard Ramsey problem, a benevolent government tries to correct these distortions with optimal fiscal policy. In reality, such distortions are considered as structural problems that should be be resolved with regulatory reforms. For that reason, fiscal policy in general is not considered as a tool that should be used to correct such market anomalies. In line with this view, in this section, we do not allow government to correct monopolistic corrections and we assume that government does not have access to such corrective polices. This requires a small revision in the resource constraint of the standard Ramsey problem, where the revised Ramsey problem is as follows:

Ramsey problem. For a given sequence of production functions $F_t(k_t, l_t)$, equipment prices q_t, markups ε_t and profits $\tilde{\pi}_t$, government chooses allocations to solve the problem of:

$$\max_{c,k,l} \sum_{t=1}^{\infty} \beta^{t-1} u(c_t, l_t)$$

s.t.

$$c_t + q_t k_{t+1} \leq \left(1 - \frac{1}{\varepsilon_t}\right) F_t(k_t, l_t) + \tilde{\pi}_t + (1-\delta) q_t k_t, \quad \text{for all } t,$$

$$\sum_{t=1}^{\infty} \beta^{t-1} \left(u_{c,t} c_t + u_{l,t} l_t\right) = \sum_{t=1}^{\infty} \beta^{t-1} u_{c,t} \pi_t (1 - \tau_{\pi,t}) + \bar{r}_1 k_1,$$

where $\pi_t = \frac{1}{\varepsilon_t} F_t(k_t, l_t)$ such that the following holds: $\tilde{\pi}_t = \frac{1}{\varepsilon_t} F_t(k_t, l_t)$.

In the revised resource constraint, aggregate output is written in two parts: (i) the part that goes to capital and labor income shares, and (ii) the part that constitutes profit share. According to this new setup, while government takes into consideration the fact that optimal policy can affect the former part, the latter part - the output that constitutes the profit share - does not get affected (directly) from fiscal policy from the perspective of government.

5 Quantitative Analysis

This section provides the discussion about the calibration of the model and simulation results.

5.1 Calibration: Initial Steady State

We choose parameters of the economy for the initial steady state (for the period before the decline in labor share has started: pre-1980) so that the model matches US economy along selected key moments for this time period. To complete this step, we need a code that solves for the steady state equilibrium of the economy, and an outer loop that executes calibration.

Preferences: The model is calibrated on an annual basis and the full set of parameters, targets and sources is summarized in Table 1. The discount factor β is set to 0.96 so that the model implied real interest rate is equal to 4.1% (Atkeson and Kehoe (2005)). The momentary utility function of the household takes the standard CRRA form of

Table 1. Parameter Values - Calibration to 1980

	Symbol	Value	Source/Target*
Preferences			
Discount Factor	β	0.96	Target Risk Free Rate=4.1%
CRRA Parameter	σ	1.50	-
Labor Supply Elasticity Parameter	ϕ	1.33	Chetty et al. (2011)
The Disutility of Hours Worked	ψ	17.0	Target Labor Supply=1/3
Production			
Elasticity of Substitution Parameter (between capital and labor)	ρ	0.20	KN (2014)
Capital Augmenting Technology Parameter	A_K	1.0	Normalization
Labor Augmenting Technology Parameter	A_L	1.0	Normalization
Depreciation Rate	δ	0.072	BEA
Capital-Share Parameter	α_K	0.295	BLS
Labor-Share Parameter	α_L	0.705	Target Labor Share=64% (BLS)
Elasticity of Substitution Parameter (between intermediate inputs)	ε	100	Target Pofit Share=1% (Barkai 2019)
Relative Price of Investment	q	1	Normalization
Government Policy			
Tax Rate on Labor Income	τ_l	29%	MGP (2010)
Tax Rate on Capital Income	τ_k	40%	MGP (2010)
Tax Rate on Profits	τ_π	40%	MGP (2010)
Government Expenditure	g/y	0.20	St. Louis FED
Government Debt	b/y	0.31	St. Louis FED

* The acronyms KN and MGP stand for Karabarbounis and Neiman (2014) and McGrattan and Prescott (2010), respectively. BLS and BEA stand for Bureau of Labor Statistics and Bureau of Economic Analysis, respectively.

$$u(c, l) = u(c) - v(l) = \frac{c^{1-\sigma}}{1-\sigma} - \psi \frac{l^{1+\phi}}{1+\phi}.$$

The coefficient of relative risk aversion σ is set to 1.50 as in line with the literature. The labor supply elasticity parameter ϕ is set to 1.33, which implies a Frisch elasticity of aggregate hours of 0.75 as in Chetty, Guren, Manoli, and Weber (2011). The parameter that captures the disutility of hours worker ψ is calibrated so that one third of available time is spent at work.

Production: The elasticity of substitution between capital and labor is captured by the parameter ρ and is set to 0.20 as in Karabarbounis and Neiman (2014). The capital-augmenting and labor-augmenting technology parameters - A_K and A_L - are normalized to one, without loss of generality. The capital depreciation rate δ is set to 0.072, which is equal to its pre-1980 level (over the period 1970-1980), calculated from BEA National Income and Product Accounts (NIPA) and BEA Fixed Asset Tables (FA). The labor share parameter α_L is internally calibrated to match the observed share of labor income for the U.S. nonfarm business sector over the period of 1947-1980, based on Bureau of Labor Statistics (BLS) data. Accordingly, the capital share parameter is α_K is set to $1 - \alpha_L$. The relative price of investment q is fixed and normalized to one, without loss of generality. This seems to be in line with the observed constancy in the relative price of investment over the period of 1947-1980, which also is documented by Karabarbounis and Neiman (2014) for the U.S. economy. The parameter that governs the elasticity of substitution between intermediate inputs ε is set to 100, implying a profit share of 1% which matches with the profit share findings of De Loecker, Eeckhout, and Unger (2019) for the period of 1980s and also in line with the findings of Barkai (2019).

Government Policy: The tax rates for the pre-1980 period are from McGrattan and Prescott (2010) and as follows. Accordingly, we set tax rates on capital income τ_k, labor income τ_l and profits τ_p equal to 40%, 29% and 40%, respectively. The level of government expenditure is calibrated to match a government expenditure to GDP ratio of 0.20, which is equal to its observed pre-1980 level calculated by using the St. Louis FED FRED data.

5.2 Calibration: The Evolution of the Economy

In this section, we discuss how the time-varying model inputs are calibrated. At this calibration stage, we assume that the tax rates changes exogenously over the period of interest, as in line with their observed value in the data. Recall that these tax rates are taken exogenous only at the calibration stage and will be endogenous when we start solving for the optimal Ramsey problem.

Accordingly, There are 7 time-varying inputs in the model - q, δ, β, τ_k, τ_p, ε and α_L - and displayed in Figure 2 and Figure 3. We fit a polynomial to match the change in price q over the period of interest, which captures the fact that (i) the decline starts in 1980s and (ii) the rate of decline slows down through the end, which implicitly implies that the declining trend in q is expected to vanish roughly around 2050s. Because we want to abstract from business cycle variations, the time-varying depreciation rate δ, the tax rate on capital income τ_k and the tax rate on profits τ_p are smoothed with piecewise linear series. The increase in β is taken from Farhi and Gourio (2018) which estimates that the discount rate increased roughly 0.01 between 1980s and 2000s. In line with their findings, we assume that β increases from 0.96 to 0.97 over the period of interest and the change takes place in a smooth linear pace.

The remaining two time-varying parameters that needs to be discussed are ε and α_L. In our model, the ε parameter generates the profit share in the economy and, therefore, play a crucial role. For the change in ε over the period of 1980-2019, we consider two alternative findings from the literature. Barkai (2019) finds that the profit share in the U.S. economy increased by 14 percentage points over the period of 1984-2014. On the other hand, De Loecker, Eeckhout, and Unger (2019) argues that the profit share in the U.S. economy has risen from close to 1% in 1980 to around 8% in 2016. In line with these studies, we consider two alternative calibrations where, (i) in "*Benchmark Calibration 1*", we assume that ε changes so that the profit share in simulated economy increases from 1% to 15% - as in line

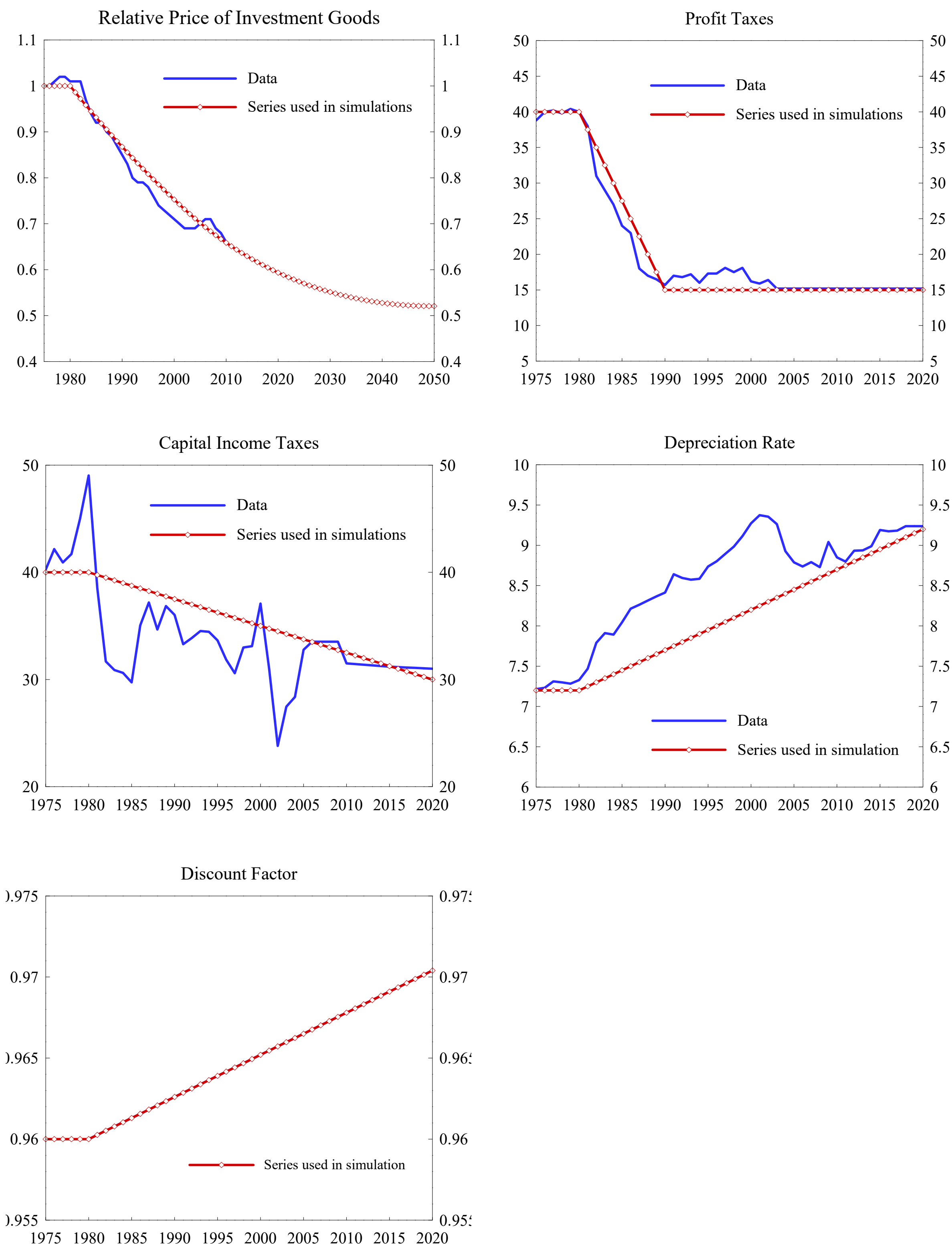


Figure 2: Changes in Factors (1980-2020) - Data vs. Series Used in Simulations

with Barkai (2019), and (ii) in "*Benchmark Calibration 2*", we assume that ε changes so that the profit share in simulated economy increases from 1% to 8% - as in line with De Loecker, Eeckhout, and Unger (2019). Figure 3 displays these two time-varying series used in simulations. Finally, the last time-varying input of our model - α_L - is calibrated to match the observed change in labor income share between 1980 and 2019. Recall that, in fact all time-varying inputs will have an affect on labor income share and, therefore, α_L is calibrated as the final time-varying input to match the observed decline in labor income share.

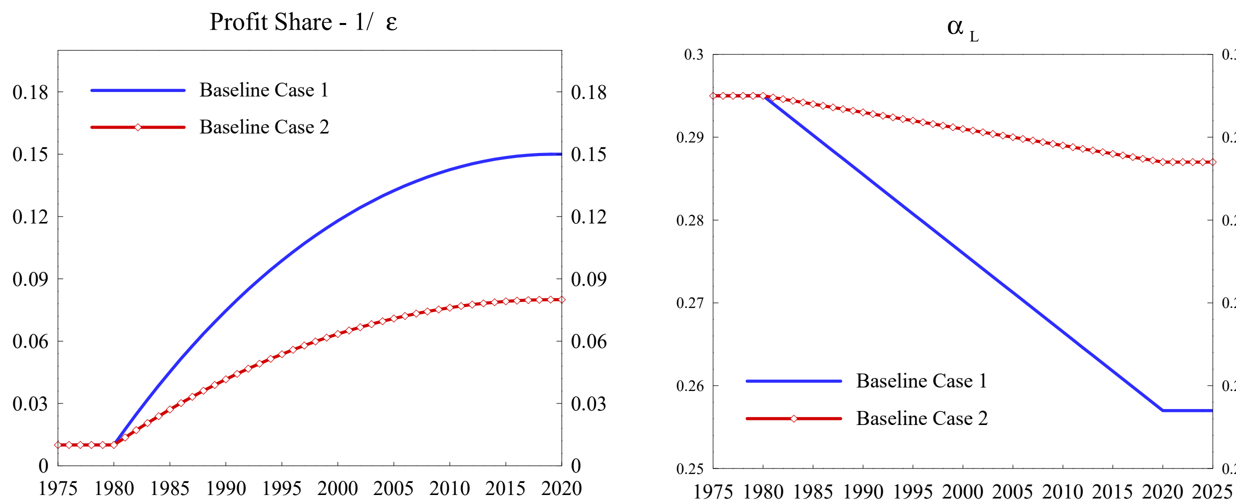


Figure 3: Changes in Profit Share and α_L - (1980-2020)
Series Used in Simulations

At this point, after the calibration of time-varying variables, we want to discuss how well does model fit to data. In particular, we want to focus on the model fit for the two alternative calibrations. The difference between these two alternative calibrations is ε and α_L parameters. Recall that, while α_L series are calibrated to match the observed change in labor income shares in both cases, the level changes in ε series are taken from the literature. Thus, we now want to discuss the validity of these two alternative ε series used in simulations.

We find that the choice of different ε series have significant affect on the simulated "*Average Product of Capital*" (APK). This turns out to be a crucial implication of our model that needs to be investigated. This is because, one of the stylized facts documented in the literature is that the difference between the Average Product of Capital (APK) and the return on government bonds ($\tilde{R}$) has increased significantly since the 1980s (see Caballero, Farhi, and Gourinchas (2017)) and, thus, we need to compare our simulated $APK - \tilde{R}$ series for both calibrations with the one observed in the data. To do that, we first want to derive the $APK - \tilde{R}$ expression from our model.

APK adds up after-tax rental income and profits, net of depreciation, relative to the capital stock:

$$APK_t = \frac{(r_t - \delta_t q_t)K_t(1-\tau_{k,t}) + Y_t \frac{1}{\varepsilon_t}(1-\tau_{\pi,t})}{q_{t-1}K_t}, \tag{34}$$

where $r_t = F_{K,t}\left(1 - \frac{1}{\varepsilon_t}\right)$. Consumer indifference between investment in capital and government bonds requires:

$$\tilde{R}_t = \frac{q_t}{q_{t-1}} + (1-\tau_{k,t})\frac{r_t - \delta_t q_t}{q_{t-1}}, \tag{35}$$

where $\tilde{R}_t$ is the gross return on government bond. Plugging (35) in (34), we get a condition between average return to capital APK and net real interest rate on government bond $\tilde{R}$, both of which are empirically measurable:

$$APK_t - \tilde{R}_t = \frac{q_{t-1} - q_t}{q_{t-1}} + \frac{Y_t \frac{1}{\varepsilon_t}(1-\tau_{\pi,t})}{q_{t-1}K_t}. \tag{36}$$

We can see from this equation that higher markups leads to an increase in $APK - \tilde{R}$. Moreover, $APK - \tilde{R}$ increases also when (i) the decline in equipment prices decelerates, and (ii) with any change that would increase Y/K. In our two alternative calibrations, we find that the dominant factor that affects $APK - \tilde{R}$ series turns out to be the change in markups. Figure 4A displays the simulated $APK - \tilde{R}$ series for our two alternative calibrations as well as the corresponding series in the data. In the data, while $APK - \tilde{R}$ was about 1.6% in

1980, it reached a level of almost 10.5% in 2016.[6] In our Benchmark Calibration 1, the simulated series shows that the $APK - \tilde{R}$ increases from 1.8% in 1980 to a level of 8.1% in 2016. While the level of increase is slightly underestimated, the simulated transition path seems to be tracking its data counterpart quite well. In our Benchmark Calibration 2, the simulated $APK - \tilde{R}$ increases from 1.8% in 1980 to a level of 4.1% in 2016. According to this alternative calibration, the level of increase in $APK - \tilde{R}$ is underestimated and the simulated transition path seems to be flatter compared to the data. Based on these findings, the ε series used in Benchmark Calibration 1 - which implies a 14 percentage points of increase in profit share - seems to be more in line with the empirical evidence on $APK - \tilde{R}$.

Figure 4A: APK- r (Data vs. Model)

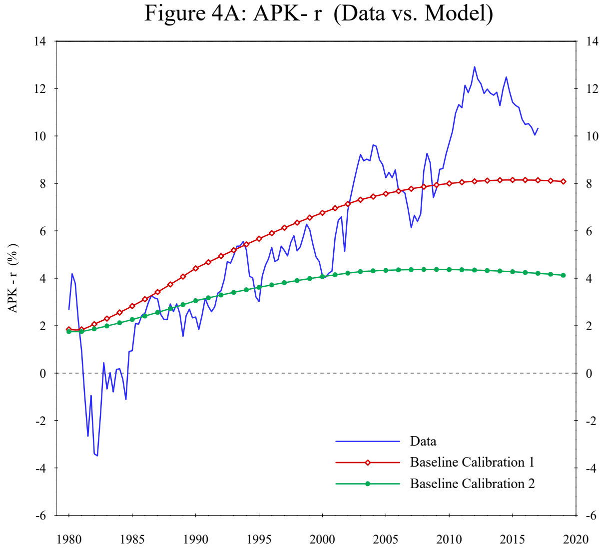
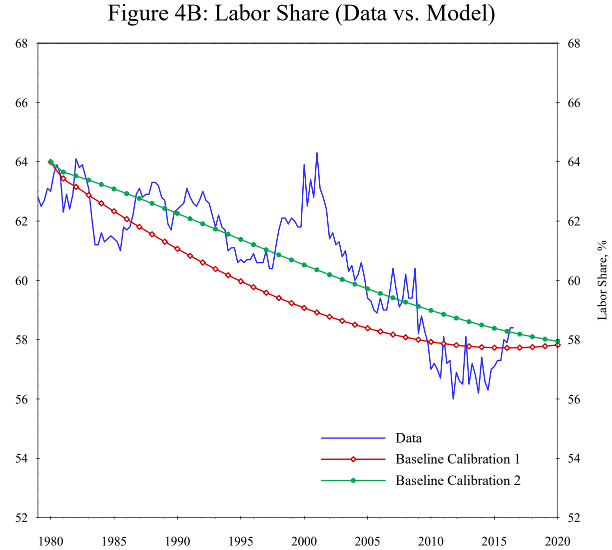


Figure 4B: Labor Share (Data vs. Model)



Finally, Figure 4B displays the evolution of labor income share for both calibrations. The simulated series seems to be tracking the observed decrease in U.S. nonfarm labor income share reasonably well over the period of interest.[7]

[6] The data on $APK - \tilde{R}$ series are from Caballero, Farhi, and Gourinchas (2017).

[7] Figure 3 shows that the α_L values used in our simulations decline with a constant rate by assumption. In order to track the observed decline labor income share better, one can assume that the α_L values used in our simulations can change in a non-linear fashion.

5.3 Quantitative Analysis: Optimal Fiscal Policy

When we solve for the optimal Ramsey taxes, we consider two alternative approach. (i) In our first approach, we assume that the planner solves for the optimal taxes starting now (the year 2020). This scenario seems to be the relevant approach for our analysis based on the assumption that - up till now - the government did not run a fiscal policy that is optimal in the sense we consider. This case, in short, will be referred to as "Ramsey-2020" problem. (ii) In our second approach, we assume that the planner solves for the optimal taxes starting 1980s. This scenario will show us the cost of postponing optimal taxation decisions in an economy where monopolistic distortions seems to be on an emerging trend. This case, in short, will be referred to as "Ramsey-1980" problem.

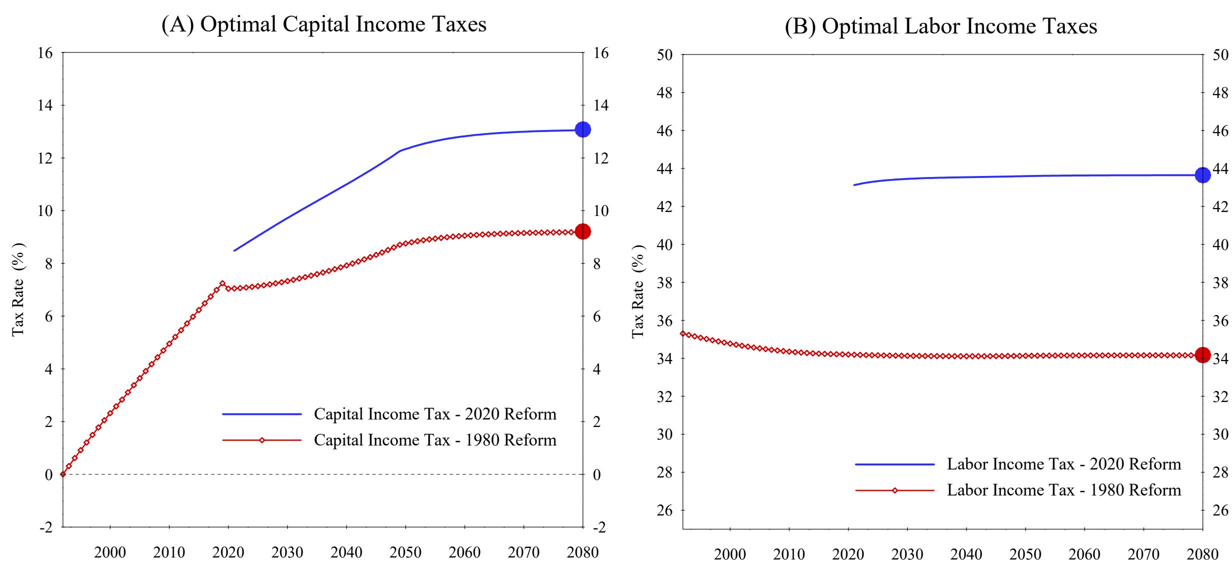


Figure 5: Optimal Ramsey Taxes : Benchmark Case 1

Figure 5A above illustrates the time-path of optimal capital taxes for Benchmark Case 1. When we solve for the optimal taxes starting in 2020, the optimal tax rate on capital starts roughly from a level of 8.5%, expected to increase by time and converge to its long-run steady state level of 13.1%. On the other hand, when we solve for the optimal taxes starting in 1980s, while the tax rate on capital is positive and increasing through time, it converges to a long-run steady state level of 9.2% which is smaller than the long-run capital tax level when optimal taxation starts in 2020. Moreover, for all calender years, optimal capital tax rates for the Ramsey-1980 problem turn out to be smaller than the ones implied by the Ramsey-2020 problem. Accordingly, postponing optimal fiscal policy decisions seems to be leading up to higher capital income taxes under the stylized aforementioned economic trends in action.

Figure 5B illustrates the time-path of optimal labor taxes for Benchmark Case 2. For the Ramsey-2020 problem, optimal labor income taxes takes a value of approximately 43% and stays roughly at this level through out the period of interest. On the other hand, for the Ramsey-1980 problem, optimal labor income start from a level of 35% and converge to a long-run steady state level of 34%. Once more, postponing optimal fiscal policy decisions seems to be leading up to higher labor income taxes under the economic trends considered in our study.

To understand the intuition behind the fact that postponing optimal fiscal policy decisions seems to be leading up to higher capital and labor income taxes, one needs to focus on the structure of the implementability condition. The simulations shows that the multiplier on implementability constraint takes a bigger value for the Ramsey-2020 problem, which is due to the fact that 3 "initial financing resources that are taken as given" on the right hand side of the constraint seems to be more binding. More in details, since initial levels of capital k_{2020}, profit π_{2020} and debt b_{2020} are all bigger than their 1980 levels, the right hand side of implementability constraint is more binding for the Ramsey-2020 problem. This leads up to a higher multiplier for the Ramsey-2020 problem, which indicates that the government needs to finance expenditures with higher tax rates. In particular, the tax formulas shows that a bigger multiplier leads to higher optimal taxes on capital and income both directly and indirectly (over the volume effect).

The optimal tax results for the Benchmark Case 2 are summarized in Figure 6A and 6B. Qualitatively, the results seems to be in line with ones for Benchmark Case 1, though slightly muted. For example, in Ramsey-2020 problem, optimal long run tax rates on capital and labor income are 5.7% and 37.5%, respectively, which are smaller than their counterparts in Benchmark 1 results, 13.1% and 43%, respectively. As one might expect, this is due to the fact that in Benchmark 2 the rise in profit share is smaller compared to Benchmark Case 1.

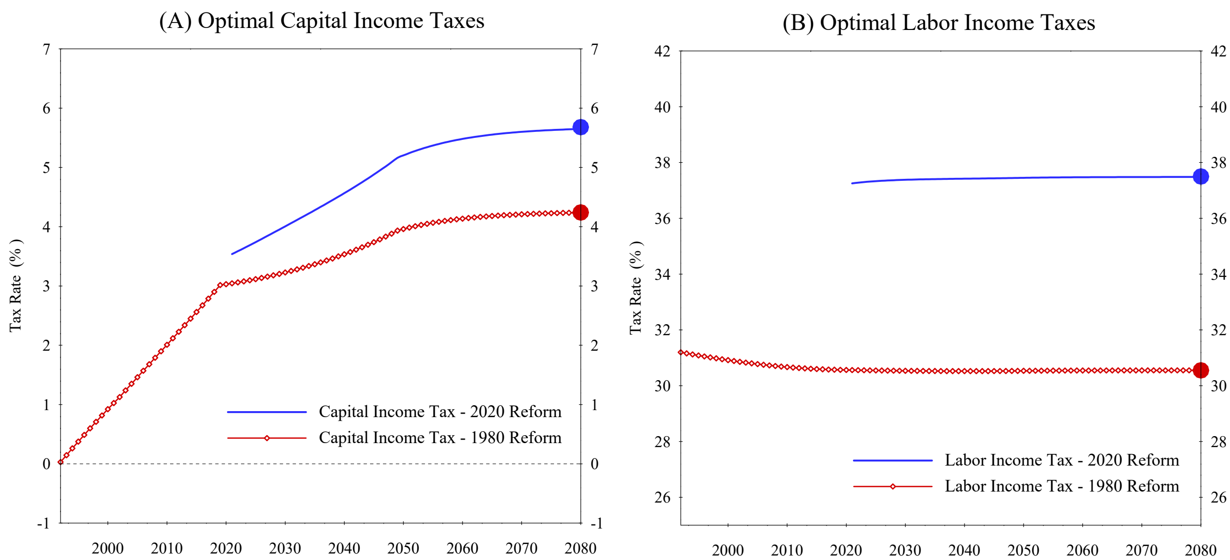


Figure 6: Optimal Ramsey Taxes: Benchmark Case 2

To sum up, both Ramsey problems seems to lead to a positive taxation of capital income at a significant level. However, recalling the fact that Benchmark 1 calibration leads to an $APK - r$ series that is more in line with the data, we argue that the results for Benchmark 1 Case should be taken into consideration with priority.

5.4 Quantitative Analysis: Optimal Fiscal Policy with No Correction for Monopolistic Distortions

Recall that monopolistic distortions create underinvestment and, in a standard Ramsey problem, a benevolent government tries to correct these distortions with fiscal policy. Since monopolistic distortions are usually considered as structural problems, we assume that government does not have access to such corrective polices. This requires a revision in the resource constraint of the Ramsey problem, which is summarized above in Section 4.

Based on this assumption, Figure 7 shows the optimal capital and labor income taxes for Benchmark Case 1. We observe that our previous findings are qualitatively robust under the presence of no correction for monopolistic distortions. Quantitatively, the results turn out to be slightly muted. When we solve for optimal taxes starting in 2020, (i) the optimal tax rate on capital starts roughly from a level of 5.6% and converge to its long-run level of 8.5%, and (ii) the optimal labor income tax is roughly stable at a level of 29%. For the Ramsey-1980 problem, (i) the tax rate on capital is positive and increasing through time, converging to a long-run level of 6.6%, and (ii) the tax rate on labor income is roughly stable around 24%.

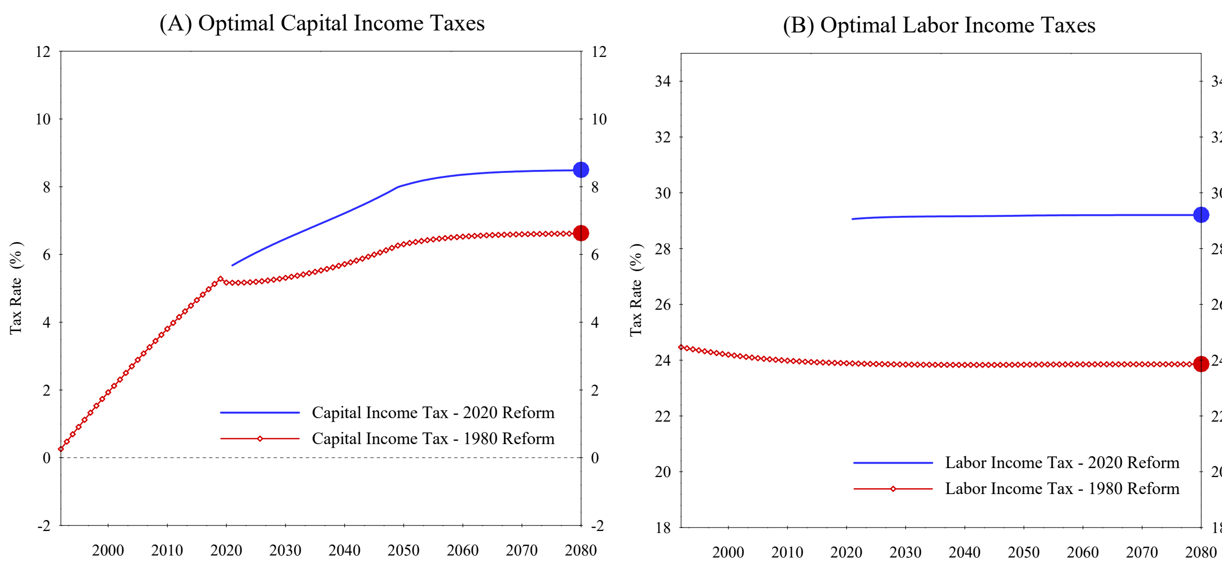


Figure 7: Optimal Ramsey Taxes - No Correction for Monopolistic Distortions
Benchmark Case 1

The optimal tax results for the Benchmark Case 2 under the assumption that government cannot correct monopolistic distortions are summarized in Figure 8A and 8B. Qualitatively, the results seems to be in line with our previous findings, though once more slightly muted. For example, in Ramsey-2020 problem, optimal long run tax rates on capital and labor income are 4.3% and 29.4%, respectively, which are slightly smaller than their counterparts in Benchmark Case 1. In Ramsey-1980 problem, optimal long run tax rates on capital and labor income turn out to be equal to 3.5% and 24.7%, respectively.

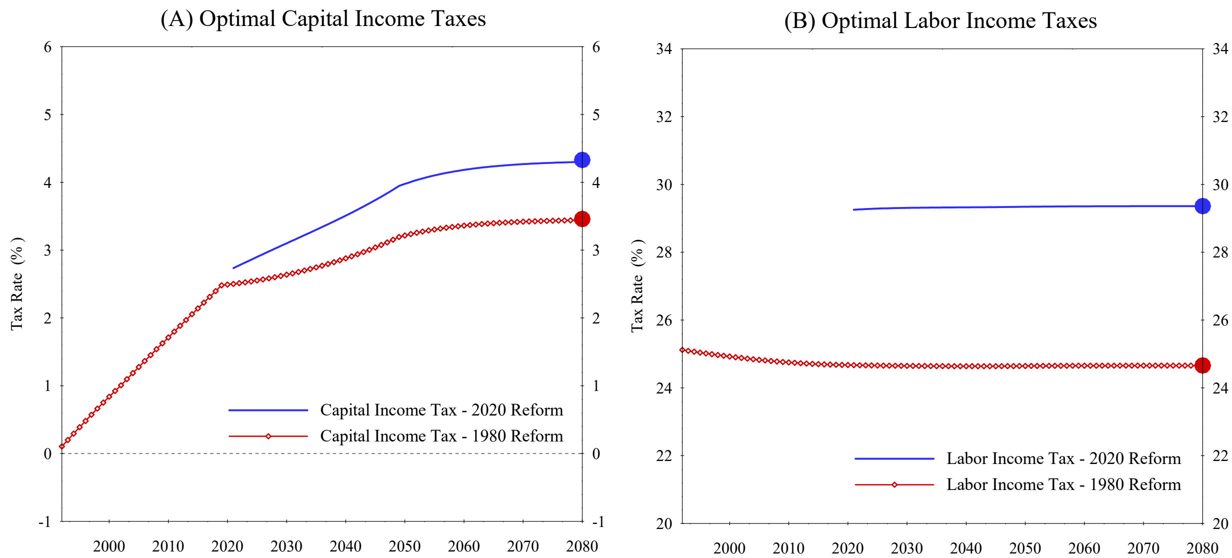


Figure 8: Optimal Ramsey Taxes - No Correction for Monopolistic Distortions

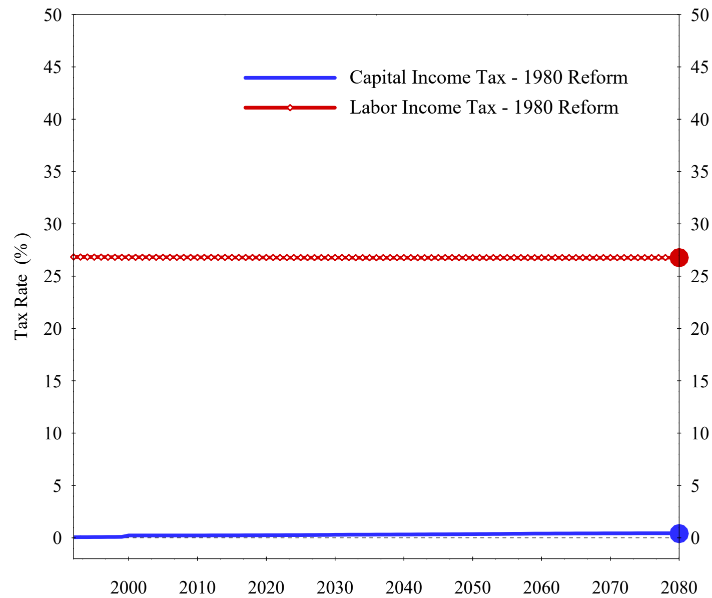
Benchmark Case 2

5.5 Counterfactual Analysis: Observed Decline in Labor Share = Rise in Capital Share

In this section, we investigate a counterfactual scenario in which we ask the following question: what if the observed decline in labor share comes from a rise in capital share (instead of a rise in profit share)? What are the optimal tax implications of this case? Figure 8 displays the time-varying path of optimal taxes for capital and labor under this counterfactual scenario. We find that optimal tax rate on capital income is roughly equal to 0, which is in line with the Chamley-Judd zero capital tax result.

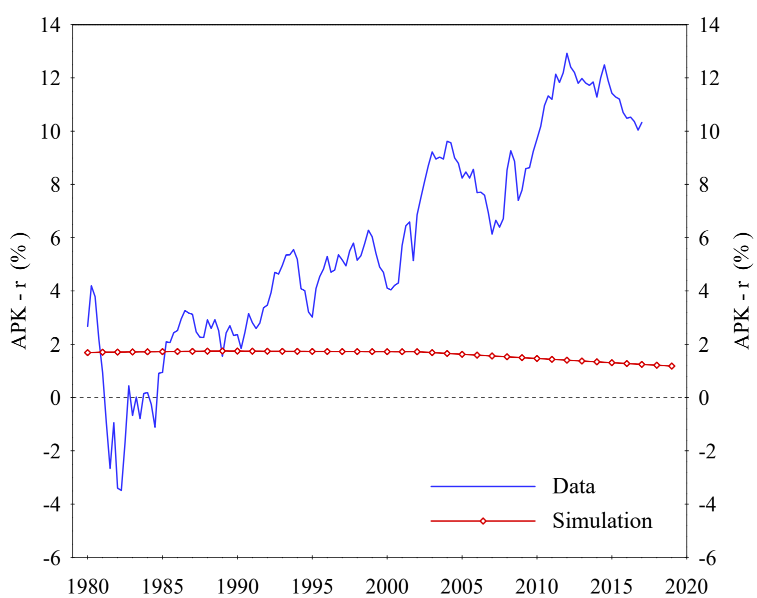
On the other hand, we find that the conjecture of the counterfactual scenario - "the observed decline in labor share possibly comes from a rise in capital share" - does not seem to be consistent with the observed change in $APK - \tilde{R}$ over the period of interest. Figure 10 displays the simulated $APK - \tilde{R}$ series under the counterfactual scenario as well as the corresponding series in the data. Between 1980s and today, while $APK - \tilde{R}$ increases roughly

Figure 9: Optimal Ramsey Taxes - No Change in Profit Share
(Decline in Labor Share = Rise in Capital Share)



from a level of 1.6% to 10.5% in the data, the simulated $APK - \tilde{R}$ declines from 1.8% in 1980 to a level of 1.2% in 2016. Accordingly, we argue that the conjecture of the counterfactual scenario is not consistent with the empirical evidence on returns.

Figure 10: APK- r (Data vs. "Model: No Increse in Profit Share")
(Decline in Labor Share = Rise in Capital Share)



6 Conclusion

Numerous recent studies have documented that the labor's share in national income, which has been quite stable until the early 1980's, has been declining at a considerable rate since then. In this paper, we analyze the implications of this decline on the optimal capital and labor income taxation from the perspective of a government that needs to finance spending. Our main qualitative finding is that the optimal tax implications of the decline in the labor share depend on the mechanism responsible for it. In particular, if the labor share declines because of rising market power or other mechanisms that raise the share of profits in national income, then the decline in the labor share should optimally be accompanied with a rise in capital income taxes. If, on the other hand, the labor share declines because of a rise in capital share, then it has no bearing on optimal capital income taxation. In our baseline calibration, we find that the optimal tax rate on capital income rises about 5-10% from the early 1980's to 2020 depending on the increase in profit share.

References

Acemoglu, D., and P. Restrepo (2019): "Automation and New Tasks: How Technology Displaces and Reinstates Labor," *Journal of Economic Perspectives*, 33(2), 3–30.

Atkeson, A., and P. J. Kehoe (2005): "Modeling and Measuring Organization Capital," *Journal of Political Economy*, 113(5), 1026–1053.

Atkinson, A. B., and J. E. Stiglitz (1976): "The Design of Tax Structure: Direct versus Indirect Taxation," *Journal of Public Economics*, 6(1–2), 55–75.

Autor, D., D. Dorn, L. F. Katz, C. Patterson, and J. V. Reenen (2017): "Concentrating on the Fall of the Labor Share," *American Economic Review*, 107(5), 180–185.

Barkai, S. (2019): "Declining Capital and Income Shares," *Journal of Finance, Forthcoming.*

Caballero, R. J., E. Farhi, and P.-O. Gourinchas (2017): "Rents, Technical Change, and Risk Premia Accounting for Secular Trends in Interest Rates, Returns on Capital, Earning Yields, and Factor Shares," *American Economic Review*, 107(5), 614–620.

Chamley, C. (1986): "Optimal Taxation of Capital Income in General Equilibrium with Infinite Lives," *Econometrica*, 54(3), 607–622.

Chetty, R., A. Guren, D. Manoli, and A. Weber (2011): "Are Micro and Macro Labor Supply Elasticities Consistent? A Review of Evidence on the Intensive and Extensive Margins," *American Economic Review*, 101(3), 471–475.

Costinot, A., and I. Werning (2018): "Robots, Trade, and Luddism: A Sufficient Statistic Approach to Optimal Technology Regulation," NBER Working Papers 25103, National Bureau of Economic Research, Inc.

Coto-Martnez, J., C. Garriga, and F. Snchez-Losada (2007): "Optimal Taxation with Imperfect Competition and Aggregate Returns to Specialization," *Journal of the European Economic Association*, 5(6), 1269–1299.

Dasgupta, P., and J. E. Stiglitz (1971): "Differential Taxation, Public Goods, and Economic Efficiency," *Review of Economic Studies*, 38(2), 151–174.

De Loecker, J., J. Eeckhout, and G. Unger (2019): "The Rise of Market Power and the Macroeconomic Implications," *Quarterly Journal of Economics, Forthcoming.*

Diamond, P. A., and J. A. Mirrlees (1971): "Optimal Taxation and Public Production I: Production Efficiency," *American Economic Review*, 61(1), 8–27.

Elsby, M., B. Hobijn, and A. Sahin (2013): "The Decline of the U.S. Labor Share," *Brookings Papers on Economic Activity*, 44(2 (Fall)), 1–63.

Farhi, E., and F. Gourio (2018): "Accounting for Macro-Finance Trends: Market Power, Intangibles, and Risk Premia," *Brookings Papers on Economic Activity*, 49(2 (Fall)), 147–250.

Farhi, E., and I. Werning (2013): "Insurance and Taxation over the Life Cycle," *Review of Economic Studies*, 80(2), 596–635.

Guerreiro, J., S. Rebelo, and P. Teles (2019): "What is the Optimal Immigration Policy? Migration, Jobs and Welfare," NBER Working Papers 26154, National Bureau of Economic Research, Inc.

Guo, J.-T., and K. J. Lansing (1999): "Optimal taxation of capital income with imperfectly competitive product markets," *Journal of Economic Dynamics and Control*, 23(7), 967–995.

Jones, L. E., R. E. Manuelli, and P. E. Rossi (1997): "On the Optimal Taxation of Capital Income," *Journal of Economic Theory*, 73(1), 93–117.

Judd, K. L. (1985): "Redistributive Taxation in a Simple Perfect Foresight Model," *Journal of Public Economics*, 28(1), 59–83.

——— (2002): "Capital-Income Taxation with Imperfect Competition," *American Economic Review*, 92(2), 417–421.

Karabarbounis, L., and B. Neiman (2014): "The Global Decline of the Labor Share," *The Quarterly Journal of Economics*, 129(1), 61–103.

McGrattan, E. R., and E. C. Prescott (2010): "Technology Capital and the US Current Account," *American Economic Review*, 100(4), 1493–1522.

Ramsey, F. P. (1928): "A Mathematical Theory of Savings," *The Economic Journal*, 38(152), 543–559.

Slavik, C., and H. Yazici (2014): "On the Consequences of Eliminating Capital Tax Differentials," Working paper.

Thuemmel, U. (2018): "Optimal Taxation of Robots," Discussion paper.