On the Consequences of Eliminating Capital Tax Differentials

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Abstract

In the United States structure and equipment capital are effectively taxed at different rates. Recently, President Obama joined the group of policy makers and economists who propose to eliminate these differentials. This paper analyzes the consequences of this reform using an incomplete markets model with equipment-skill complementarity. The reform improves productive efficiency by eliminating distortions in capital accumulation. It also increases the degree of equality by reducing the skill premium. The reform increases average welfare by approximately 0.1%. The gains are about 0.2% if we take into account the temporary bonus depreciation rules when calculating status quo capital tax rates.


Keywords: Uniform capital tax reform, equipment capital, structure capital, equipment-skill complementarity.

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1 Introduction

In the current U.S. tax code different types of capital are taxed at different rates effectively. Recently, President Obama’s administration has proposed to eliminate these differentials in a budget neutral way.\footnote{See the 2011 U.S. President’s State of the Union Address at http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address. For more details, see the President’s Framework for Business Tax Reform (2012).} This reform, which we refer to as the uniform capital tax reform throughout the paper, intends to eliminate the inefficiencies in capital accumulation arising from differential taxation. If implemented, this reform would affect capital accumulation decisions, and, therefore, returns to capital as well as wages. This way the reform would affect the majority of the U.S. population. Therefore, it is important to understand the implications of the reform in advance.

This paper analyzes the aggregate and distributional consequences of the uniform capital tax reform using an incomplete markets model with two types of capital and equipment-skill complementarity. We find that this reform creates quantitatively significant productive efficiency gains by reallocating capital from low to high return capital. In addition, by decreasing the skill premium, eliminating capital tax differentials redistributes from the rich to the poor. We show that this redistributive effect of the reform, which has been overlooked in the policy debates, can be quantitatively significant. Importantly, the reform does not suffer from the usual efficiency vs. equality trade-off: it improves both.

Specifically, we build an infinite horizon model with heterogeneous agents with the following features. First, agents are either skilled or unskilled, and the skill type is permanent. Second, both skilled and unskilled agents are subject to idiosyncratic labor productivity shocks. Third, there are two types of capital, structure capital and equipment capital, and the production function features a higher degree of complementarity between equipment capital and skilled labor than between equipment capital and unskilled labor, as documented empirically for the U.S. economy by Krusell, Ohanian, Ríos-Rull,
and Violante (2000).\(^2\) Finally, the government uses linear taxes on capital income and consumption, and a non-linear labor income tax schedule to finance government consumption and repay debt. We solve for the stationary competitive equilibrium of this model and calibrate the model parameters to the U.S. economy. The main objective of the paper is to use the calibrated model to evaluate the long-run effects of a uniform capital tax reform, which equalizes the tax rates on the two types of capital while keeping the rest of the fiscal policies intact. Keeping the rest of the fiscal policy tools intact is important, because the actual reform proposal is concerned with changing capital taxes only.

Gravelle (2011) estimates that the U.S. effective corporate tax rate on equipment capital is 26% and that on structure capital is 32%.\(^3\) Combining the 15% flat capital income tax rate that consumers face with the differential capital tax rates at the corporate level, the overall effective tax rate on equipment capital is 37.1% while the overall effective tax rate on structure capital is 42.2%. We find that in our model a budget neutral tax reform that eliminates capital tax differentials equates the tax rates on both types of capital at 39.66%.

This uniform tax reform has two effects on the economy. First, it improves productive efficiency by reallocating a given capital stock more efficiently between the two types of capital. Intuitively, by taxing structure capital at a higher rate than equipment capital, the current tax code distorts firms’ capital decisions in favor of using more equipment capital. As a result, the marginal return to equipment capital is lower than the marginal return to structure capital under the current tax system. By eliminating the tax differentials, the proposed reform eliminates this distortion through capital reallocation from

\(^2\)Flug and Hercowitz (2000) provide evidence for equipment-skill complementarity for a large set of countries.

the capital type with lower returns, equipment capital, to the capital type with higher returns, structure capital. This way capital reallocation brings the economy closer to its production possibilities frontier. Second, under equipment-skill complementarity, a lower level of equipment capital in the new steady state decreases the skill premium, indirectly redistributing from the skilled to the unskilled. This implies a more egalitarian distribution of resources between skilled and unskilled agents. We conclude that the proposed reform does not involve the usual equality vs. efficiency trade-off: eliminating capital tax differentials not only increases efficiency, but also improves equality.

Next, we measure the steady-state welfare consequences of the uniform capital tax reform. We first consider a Utilitarian social welfare function that puts equal weights on all agents. Using this measure, we find that the overall steady-state welfare gains of the reform are 0.09% in terms of lifetime consumption. We also compute the welfare gains for skilled and unskilled agents separately. We find that on average the unskilled agents’ welfare increases by 0.15% whereas the skilled agents’ welfare decreases by less than 0.01%. We interpret these findings as follows. By increasing productive efficiency, the reform increases average welfare for both types of agents. Through indirect redistribution, the reform increases welfare of unskilled agents and decreases welfare of skilled agents. It turns out that, in the benchmark calibration, the efficiency gains and redistribution losses almost fully offset each other for the skilled agents, resulting in a small welfare loss. For the unskilled agents, the redistributive gains plus the efficiency gains sum up to a significant welfare gain.

Some authors have argued that investment in equipment capital might create positive externalities on economic growth. If that is the case, efficiency could call for taxing equipment at a lower rate than structures. Thus, a reform that increases equipment capital taxes and decreases structure capital taxes could be detrimental to efficiency. However, Gravelle (2001) points out that it is hard to support the existence of such positive externalities on empirical grounds. Specifically, Auerbach, Hassett, and Oliner (1994) finds no empirical evidence of equipment investment having positive externalities in the context of a Solow growth model with multiple types of capital. On a similar note, Wolff (2002) finds no empirical evidence that computer investment is linked to TFP growth. The current paper abstracts from externalities.

The government could also accompany the capital tax reform by a modification of the
The status quo capital tax rates that we use in our benchmark analysis are based on permanent U.S. tax law. Since 2001 there have been temporary bonus depreciation rules that have applied to equipment capital and have implied larger differences in the tax rates between the two types of capital. We find that the welfare implications of the uniform capital tax reform are much larger if we take these temporary bonus depreciation rules into account when we calculate the status quo structure and equipment capital tax rates. In this case, the overall steady-state welfare gains of the reform are 0.19%. The skilled agents’ welfare decreases by 0.02% while the unskilled agents’ welfare increases by 0.31%.

In this paper, we compare welfare across steady states. In an environment similar to ours, Domeij and Heathcote (2004) shows that a government that ignores short-run welfare finds it optimal to choose very low capital tax rates in order to encourage long-run capital accumulation, and that such a reform can have dire welfare consequences in the short-run. Steady state welfare comparisons do not suffer as much from this critique in the context of the uniform capital tax reform analyzed in this paper. This is because average capital taxes are almost unaffected by the tax reform, and there is only a small, 0.4%, increase in the aggregate capital stock from the initial to the new steady state. To check the validity of this argument, we analyze another tax reform, in which the uniform capital tax is set so that the aggregate capital stock remains unchanged across steady states. This requires uniform capital taxes to be slightly higher than in the benchmark reform. We find that the welfare gains of this reform are over two thirds of the benchmark welfare gains, validating our argument.

We also conduct a number of robustness checks and find that the main quantitative conclusions are robust to alternative preference specifications. As expected, the reform is more redistributive when we assume a higher degree of equipment-skill complementarity. Assuming that the United States is an labor tax code in order to distribute the efficiency gains across agents in a different way. In particular, the government could distribute a larger share of the efficiency gains to the skilled agents to ensure that they are not worse off. An example of such a reform is provided in Section 4.3.
open economy that faces a fixed world interest rate does not change the main results substantially. We also find that the implications of the reform in general depend on the degree of labor tax progressivity and the nature of labor productivity processes, which underlines the importance of modeling these components. Nonetheless, the main quantitative conclusions are robust to small deviations in the degree of labor tax progressivity and the degree of idiosyncratic labor productivity risk around their benchmark values.

**Related Literature.** This paper is related to a set of papers that evaluate the consequences of eliminating capital tax differentials. The closest to this paper is Auerbach (1989), who computes the welfare gains associated with eliminating the capital tax differentials that existed prior to the U.S. Tax Reform Act of 1986. Because he is not interested in the distributional consequences of his reform, Auerbach uses a model without heterogeneity. Modeling heterogeneity is crucial for our paper, however, because our main message is that a uniform capital tax reform improves not only efficiency, but also equality. Auerbach (1983) and Gravelle (1994) both compute the deadweight loss of misallocation of capital that is created by differential taxation of capital and find losses that are in the range of 0.10 to 0.15 % of U.S. GNP assuming Cobb-Douglas production technologies. Recently, Gravelle (2011) evaluates the implications of reforming the tax depreciation rules present in the U.S. tax code for the effective tax rates on different types of capital and for the corporate tax revenues. Unlike our paper, she is not interested in the economy-wide implications and the welfare consequences of her reform.

There is a related literature that analyzes optimal capital tax policy in environments with multiple types of capital. The productive efficiency result of Diamond and Mirrles (1971) implies that, in an environment with multiple capital types, all capital should be taxed at the same rate. Auerbach (1979) shows that in an overlapping generations environment it might be optimal to tax capital differentially if the government is exogenously restricted to a narrower set of fiscal instruments than in Diamond and Mirrles (1971). Similarly, Feldstein (1990) proves the optimality of differential capital taxation in a static model in which the government is restricted to set the tax rate on one type
of capital equal to zero. Conesa and Dominguez (2013) considers an economy with tangible and intangible capital where capital is taxed twice: first, through a corporate income tax, and second, at the consumer level, through a dividend tax. They find that the optimal long-run policy features zero corporate taxes and positive dividend taxes.

Our earlier work, Slavík and Yazici (2014), studies optimal capital and labor taxation in an environment with equipment-skill complementarity, and finds that the optimal tax system features a differential between taxes on equipments and structures. The aim of the current paper is different: instead of analyzing a hypothetical optimal tax system, the current paper quantitatively evaluates the consequences of a reform recently proposed by the Obama administration. Moreover, the optimal tax problem considered in Slavík and Yazici (2014) includes choosing labor income taxes while the reform considered in the current paper keeps labor income taxes intact. This is important because the actual reform proposal does not include changing the status quo labor income taxes. The difference between the questions of interest in the two papers requires using different tools of analysis as well. Slavík and Yazici (2014), following the New Dynamic Public Finance literature, uses dynamic mechanism design techniques while the current paper uses an incomplete markets model with labor productivity risk to conduct a thorough quantitative analysis.

In terms of methodology, this paper is related to a growing literature, which analyzes the quantitative effects of tax reforms using incomplete markets models with heterogeneous agents, such as Imrohoroglu (1998), Ventura (1999), Conesa and Krueger (2006), Conesa, Kitao, and Krueger (2009), and Heathcote, Storesletten, and Violante (2012). Our paper is most closely related to Domeij and Heathcote (2004) in the sense that both papers provide positive analyses of capital tax reforms. While Domeij and Heathcote (2004) focuses on the consequences of capital tax cuts, we analyze an environment with multiple capital and focus on a policy reform which (by equalizing capital tax rates) changes the mix between equipment and structure capital taxation, but leaves the overall level of capital taxation virtually unaffected. Under-
standing the consequences of the uniform capital tax reform is relevant given the current policy debates fueled by the proposal of the Obama administration. Methodologically, we contribute to this literature by analyzing tax reforms in a quantitative model with equipment-skill complementarity.\textsuperscript{6} Modeling equipment-skill complementarity creates a novel mechanism through which changes in technology (accumulation of different types of capital in our model) affect the wage distribution. This feature of the model is important as it allows us to take into account the effect of our tax reform on the wage distribution.

The rest of the paper is organized as follows. In Section 2, we lay out the model. Section 3 discusses calibration. Section 4 provides our main quantitative findings, and Section 5 concludes.

2 Model

We consider an infinite horizon growth model with two types of capital (structures and equipments), two types of labor (skilled and unskilled), consumers, a firm, and a government.

Endowments and Preferences. There is a continuum of measure one of agents who live for infinitely many periods. In each period, they are endowed with one unit of time. Ex-ante, they differ in their skill levels: they are born either skilled or unskilled, $i \in \{u, s\}$. Skilled agents can only work in the skilled labor sector and unskilled agents only in the unskilled labor sector. The skill types are permanent. The total mass of the skilled agents is denoted by $\pi_s$, the total mass of the unskilled agents is denoted by $\pi_u$. In the quantitative analysis, skill types correspond to educational attainment at the time of entering the labor market. Agents who have college education or above are classified as skilled agents and the rest of the agents are classified

\textsuperscript{6}There is a recent paper by Angelopoulos, Asimakopoulos, and Malleya (2015), which analyzes optimal labor tax smoothing in a Ramsey model with capital-skill complementarity. Unlike our paper, Angelopoulos, Asimakopoulos, and Malleya (2015) works with a representative household model with a single type of capital. He and Liu (2008) analyzes the effects of eliminating capital income taxes in a similar representative household environment with equipment-skill complementarity.
as unskilled agents.

In addition to heterogeneity between skill groups, we model heterogeneity within each skill group by assuming that agents face idiosyncratic labor productivity shocks over time. The productivity shock, denoted by $z$, follows a type-specific Markov chain with states $Z_i = \{z_{i,1}, ..., z_{i,I}\}$ and transitions $\Pi_i(z'|z)$. An agent of skill type $i$ and productivity level $z$ who works $l$ units of time produces $l \cdot z$ units of effective $i$ type of labor. As a result, her wage per unit of time is $w_i \cdot z$, where $w_i$ is the wage per effective unit of labor in sector $i$. As we show in Section 4.6, the modeling of productivity shocks is important for the implications of the uniform capital tax reform.

Preferences over sequences of consumption and labor, $(c_{i,t}, l_{i,t})_{t=0}^{\infty}$, are defined using a separable utility function

$$E_i\left(\sum_{t=0}^{\infty} \beta_t^i (c_{i,t}) - v(l_{i,t})\right),$$

where $\beta_t^i$ is the time discount factor which is allowed to be different across skill types.\(^7\) For each skill type, unconditional expectation, $E_i$, is taken with respect to the stochastic processes governing the idiosyncratic labor shock. There are no aggregate shocks.

**Technology.** There is a constant returns to scale production function: $Y = F(K_s, K_e, L_s, L_u)$, where $K_s$ and $K_e$ refer to aggregate structure capital and equipment capital and $L_s$ and $L_u$ refer to aggregate effective skilled and unskilled labor, respectively. We also define a function $\tilde{F}$ that gives the total wealth of the economy: $\tilde{F} = F + (1 - \delta_s)K_s + (1 - \delta_e)K_e$, where $\delta_s$ and $\delta_e$ are the depreciation rates of structure and equipment capital, respectively.

\(^7\)Attanasio, Banks, Meghir, and Weber (1999) provide empirical evidence for differences in discount factors across education groups. In our quantitative analysis, we calibrate the discount factors so as to match the observed difference in wealth between skilled and unskilled agents. The calibration implies that the skilled discount factor is slightly larger than the unskilled discount factor which is in line with the empirical evidence provided by Attanasio, Banks, Meghir, and Weber (1999). We also perform a version of our benchmark quantitative exercise in which we assume that the discount factors are equal for the two types of agents. As we report in Section 4.5, the main quantitative results are robust to this modification.
The key feature of the technology is equipment-skill complementarity, which means that the degree of complementarity between equipment capital and skilled labor is higher than that between equipment capital and unskilled labor. This implies that an increase in the stock of equipment capital decreases the ratio of the marginal product of unskilled labor to the marginal product of skilled labor. In a world with competitive factor markets, this implies that the skill premium, defined as the ratio of skilled to unskilled wages, is increasing in equipment capital. Structure capital, on the other hand, is assumed to be neutral in terms of its complementarity with skilled and unskilled labor. These assumptions on technology are in line with the empirical evidence provided by Krusell, Ohanian, Ríos-Rull, and Violante (2000). Letting $\frac{\partial F}{\partial m}$ be the partial derivative of function $F$ with respect to variable $m$, we formalize these assumptions as follows.

**Assumption 1.** $\frac{\partial F}{\partial L_s}$ is independent of $K_s$.

**Assumption 2.** $\frac{\partial F}{\partial L_u}$ is strictly increasing in $K_e$.

There is a representative firm which, in each period, hires the two types of labor and rents the two types of capital to maximize profits. In any period $t$, its maximization problem reads:

$$\max_{K_{s,t}, K_{e,t}, L_{s,t}, L_{u,t}} F(K_{s,t}, K_{e,t}, L_{s,t}, L_{u,t}) - r_{s,t} K_{s,t} - r_{e,t} K_{e,t} - w_{s,t} L_{s,t} - w_{u,t} L_{u,t},$$

where $r_{s,t}$ and $r_{e,t}$ are the rental rates of structure and equipment capital, and $w_{u,t}$ and $w_{s,t}$ are the wages rates paid to unskilled and skilled effective labor in period $t$.

**Asset Market Structure.** There is a single risk free asset which has a one period maturity. Consumers can save using this asset but are not allowed to borrow. Every period total savings by consumers must be equal to total borrowing of the government plus the total capital stock in the economy.

**Government.** The government uses linear consumption taxes every period $\{\tau_{c,t}\}_{t=0}^\infty$ and linear taxes on capital income net of depreciation. The tax rates on the two types of capital are allowed to be different. Let $\{\tau_{s,t}\}_{t=0}^\infty$ and
\{\tau_{e,t}\}_{t=0}^\infty \) be the sequences of tax rates on structure and equipment capital. It is irrelevant for our analysis whether capital income is taxed at the consumer or at the corporate level. We assume without loss of generality that all capital income taxes are paid at the consumer level. The government taxes labor income using a sequence of possibly non-linear functions \( \{T_t(y)\}_{t=0}^\infty \), where \( y \) is labor income and \( T_t(y) \) are the taxes paid by the consumer. This function allows us to model the progressivity of the U.S. labor income tax code, which is important for the implications of the uniform capital tax reform as we show in Section 4.6. The government uses taxes to finance a stream of expenditure \( \{G_t\}_{t=0}^\infty \) and repay government debt \( \{D_t\}_{t=0}^\infty \).

In our quantitative analysis we focus on the comparison of stationary equilibria. For that reason, instead of giving a general definition of competitive equilibrium, here we only define stationary recursive competitive equilibria. The formal definition of non-stationary competitive equilibrium is relegated to Appendix A. In order to define a stationary equilibrium, we assume that policies (government expenditure, debt and taxes) do not change over time.

Before we define a stationary equilibrium formally, notice that, in the absence of aggregate productivity shocks, the returns to saving in the form of the two capital types are certain. The return to government bond is also known in advance. Therefore, in equilibrium all three assets must pay the same after-tax return, i.e., \( R = 1 + (r_s - \delta_s)(1 - \tau_s) = 1 + (r_e - \delta_e)(1 - \tau_e) \), where \( R \) refers to the stationary return on the bond holdings. As a result, we do not need to distinguish between saving through different types of assets in the consumer’s problem. We denote consumers’ asset holdings by \( a \).

**Stationary Recursive Competitive Equilibrium (SRCE).** SRCE is two value functions \( V_u, V_s \), policy functions \( c_u, c_s, l_u, l_s, a'_u, a'_s \), the firm’s decision rules \( K_s, K_e, L_s, L_u \), government policies \( \tau_c, \tau_s, \tau_e, T(\cdot) \), \( D, G \), two distributions over productivity-asset types \( \lambda_u(z, a), \lambda_s(z, a) \) and prices \( w_u, w_s, r_s, r_e, R \) such that

1. The value functions and the policy functions solve the consumer problem
given prices and government policies, i.e., for all $i \in \{u, s\}$:

$$V_i(z, a) = \max_{(c_i, l_i, a'_i) \geq 0} u(c_i) - v(l_i) + \beta_i \sum_{z'} \Pi_i(z'|z) V_i(z', a'_i) \quad \text{s.t.}$$

$$(1 + \tau_c) c_i + a'_i \leq w_i z_l - T(w_i z_l) + Ra,$$

where $R = 1 + (r_e - \delta_e)(1 - \tau_e) = 1 + (r_e - \delta_e)(1 - \tau_e)$ is the after-tax asset return.

2. The firm solves:

$$\max_{K_s, K_e, L_s, L_u} F(K_s, K_e, L_s, L_u) - r_s K_s - r_e K_e - w_s L_s - w_u L_u.$$  

3. The distribution $\lambda_i$ is stationary for each type, i.e. $\forall i : \lambda'_i(z, a) = \lambda_i(z, a)$. This means:

$$\lambda_i(\bar{z}, \bar{a}) = \int_{z} \int_{a} a \cdot \lambda_i(z, a) \cdot da \cdot d\Pi_i(\bar{z}|z).$$

4. Markets clear:

$$\sum_i \pi_i \int_{z} \int_{a} a \cdot d\lambda_i(z, a) = K_s + K_e + D,$$

$$\pi_s \int_{z} \int_{a} z l_s(z, a) \cdot d\lambda_s(z, a) = L_s,$$

$$\pi_u \int_{z} \int_{a} z l_u(z, a) \cdot d\lambda_u(z, a) = L_u,$$

$$C + G + K_s + K_e = \tilde{F}(K_s, K_e, L_s, L_u),$$

where $C = \sum_{i=u,s} \pi_i \int_{z} \int_{a} c_i(z, a) \cdot d\lambda_i(z, a)$ denotes aggregate consumption.

5. Government budget constraint is satisfied.

$$RD + G = D + \tau_c C + \tau_e (r_e - \delta_e)K_e + \tau_s (r_s - \delta_s)K_s + T_{agg}.$$
where \( T_{agg} = \sum_{i=u,s} \pi_i \int_z \int_a \mathcal{T}(w_i z l_i(z,a)) \cdot d\lambda_i(z,a) \) denotes aggregate labor tax revenue.

We explain how we solve for the SRCE in Appendix B.

### 3 Calibration

To calibrate model parameters, we assume that the SRCE defined in the previous section - computed under the current U.S. tax system - coincides with the current U.S. economy. We first fix a number of parameters to values from the data or from the literature. These parameters are summarized in Table 1. We then calibrate the remaining parameters so that the SRCE matches the U.S. data along selected dimensions. Our calibration procedure is summarized in Table 2.

One period in our model corresponds to one year. We assume that the period utility function takes the form

\[
    u(c) - v(l) = \frac{c^{1-\sigma}}{1-\sigma} - \phi \frac{l^{1+\gamma}}{1+\gamma}.
\]

In the benchmark case, we use \( \sigma = 2 \) and \( \gamma = 1 \). These are within the range of values that have been considered in the literature. We calibrate \( \phi \) to match the average labor supply.

We further assume that the production function takes the same form as in Krusell, Ohanian, Ríos-Rull, and Violante (2000):

\[
    Y = F(K_s, K_e, L_s, L_u) = K_s^\alpha \left( \nu \left[ \omega K_e^\rho + (1-\omega) L_s^\theta \right]^{\frac{\gamma}{\theta}} + (1-\nu) L_u^\eta \right)^{\frac{1-\alpha}{\eta}}. 
\]  

Krusell, Ohanian, Ríos-Rull, and Violante (2000) estimate \( \alpha, \rho, \eta, \) and we use their estimates, but they do not estimate \( \omega \) and \( \rho \). We calibrate these parameters to U.S. data, as we explain in detail below.

As for government policies, we assume that the government consumption-to-output ratio equals 16%, which is close to the average ratio in the United States during the period 1980 – 2012, as reported in the National Income and...
### Table 1: Benchmark Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Source</th>
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</thead>
<tbody>
<tr>
<td>Preferences</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative risk aversion parameter</td>
<td>( \sigma )</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Inverse Frisch elasticity</td>
<td>( \gamma )</td>
<td>1</td>
<td></td>
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<tr>
<td>Technology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structure capital depreciation rate</td>
<td>( \delta_s )</td>
<td>0.056</td>
<td>GHK</td>
</tr>
<tr>
<td>Equipment capital depreciation rate</td>
<td>( \delta_e )</td>
<td>0.124</td>
<td>GHK</td>
</tr>
<tr>
<td>Share of structure capital in output</td>
<td>( \alpha )</td>
<td>0.117</td>
<td>KORV</td>
</tr>
<tr>
<td>Measure of elasticity of substitution between equipment capital ( K_e ) and unskilled labor ( L_u )</td>
<td>( \eta )</td>
<td>0.401</td>
<td>KORV</td>
</tr>
<tr>
<td>Measure of elasticity of substitution between equipment capital ( K_e ) and skilled labor ( L_s )</td>
<td>( \rho )</td>
<td>-0.495</td>
<td>KORV</td>
</tr>
<tr>
<td>Relative supply of skilled workers</td>
<td>( \pi_s/\pi_u )</td>
<td>0.778</td>
<td>U.S. Census</td>
</tr>
<tr>
<td>Productivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity persistence of skilled workers</td>
<td>( \rho_s )</td>
<td>0.9408</td>
<td>KL</td>
</tr>
<tr>
<td>Productivity volatility of skilled workers</td>
<td>( \text{var}(\varepsilon_s) )</td>
<td>0.1000</td>
<td>KL</td>
</tr>
<tr>
<td>Productivity persistence of unskilled workers</td>
<td>( \rho_u )</td>
<td>0.8713</td>
<td>KL</td>
</tr>
<tr>
<td>Productivity volatility of unskilled workers</td>
<td>( \text{var}(\varepsilon_u) )</td>
<td>0.1920</td>
<td>KL</td>
</tr>
<tr>
<td>Government polices</td>
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<tr>
<td>Labor tax progressivity</td>
<td>( \tau_l )</td>
<td>0.18</td>
<td>HSV</td>
</tr>
<tr>
<td>Overall tax on structure capital income</td>
<td>( \tau_s )</td>
<td>0.422</td>
<td>Gravelle (2011)</td>
</tr>
<tr>
<td>Overall tax on equipment capital income</td>
<td>( \tau_e )</td>
<td>0.371</td>
<td>Gravelle (2011)</td>
</tr>
<tr>
<td>Consumption tax</td>
<td>( \tau_c )</td>
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<td>KL</td>
</tr>
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<td>Government consumption</td>
<td>( G/Y )</td>
<td>0.16</td>
<td>NIPA</td>
</tr>
<tr>
<td>Government debt</td>
<td>( D/Y )</td>
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<td>St. Louis FED</td>
</tr>
</tbody>
</table>

This table reports the benchmark parameters that we take directly from the literature or the data. The acronyms GHK, KORV, HSV, and KL stand for Greenwood, Hercowitz, and Krusell (1997), Krusell, Ohanian, Rios-Rull, and Violante (2000), Heathcote, Storesletten, and Violante (2012), and Krueger and Ludwig (2013), respectively. NIPA stands for the National Income and Product Accounts.
Product Accounts (NIPA) data. To approximate the progressive U.S. labor tax code, we follow Heathcote, Storesletten, and Violante (2012) and assume that tax liability given labor income $y$ is defined as:

$$T(y) = \bar{y} \left[ \frac{y}{\bar{y}} - \lambda \left( \frac{y}{\bar{y}} \right)^{1-\tau_l} \right],$$

where $\bar{y}$ is the mean labor income in the economy, $1 - \lambda$ is the average tax rate of a mean income individual, and $\tau_l$ controls the progressivity of the tax code. Using 2005 Current Population Survey (CPS) data, Heathcote, Storesletten, and Violante (2012) estimate $\tau_l = 0.18$. We use their estimate and calibrate $\lambda$ to clear the government budget, following their procedure.

Gravelle (2011) documents that the effective tax rates on structure capital and equipment capital differ at the firm level. Specifically, the effective corporate tax rate on structure capital is 32% and the effective corporate tax rate on equipment capital is 26%. We assume that the capital income tax rate at the consumer level is 15%, which approximates the U.S. tax code. This implies an overall tax on structure capital of $\tau_s = 1 - 0.85 \cdot (1 - 0.32) = 42.2\%$ and an overall tax on equipment capital of $\tau_e = 1 - 0.85 \cdot (1 - 0.26) = 37.1\%$. These numbers are in line with a 40% tax on overall capital reported by Domeij and Heathcote (2004). We follow Mendoza, Razin, and Tesar (1994) and assume that the consumption tax $\tau_c = 5.0\%$. Finally, we assume a government debt of 60% of GDP, as in the U.S. between 1990 and the Great recession.

We set the ratio of skilled to unskilled agents to be consistent with the 2011 US Census data. We cannot identify the mean levels of the idiosyncratic labor productivity shock $z$ for the two types of agents separately from the remaining parameters of the production function and therefore set $E[z] = 1$ for both skilled and unskilled. This assumption implies that $w_i$ corresponds to the average wage rate of agents of skill type $i$. Thus, skill premium in the model economy is given by $w_s/w_u$. We assume that the processes for $z$ differ across the two types of agents. Specifically, we assume that for all $i \in \{u, s\}$:

$$\log z_{t+1} = \rho_i \log z_t + \varepsilon_{i,t}.$$  

Following Krueger and Ludwig (2013), we set $\rho_s = 0.9408, var(\varepsilon_s) = 0.0100, \rho_u = 0.8713, var(\varepsilon_u) = 0.0192$. We approximate
This table reports our benchmark calibration procedure. The production function parameters $\nu$ and $\omega$ control the income share of equipment capital, skilled and unskilled labor in output. The tax function parameter $\lambda$ controls the labor income tax rate of the mean income agent. Relative skilled wealth refers to the ratio of the average skilled asset holdings to the average unskilled asset holdings. The acronym HPV stands for Heathcote, Perri, and Violante (2010). NIPA stands for the National Income and Product Accounts, and FAT stands for the Fixed Asset Tables.

these processes by finite number Markov chains using the Rouwenhorst method described in Kopecky and Suen (2010).

There are still six parameter values left to be determined: these are the two production function parameters, $\omega$ and $\nu$, which govern the income shares of equipment capital, skilled labor and unskilled labor, the labor disutility parameter $\phi$, the discount factors $\beta_s$ and $\beta_u$, and the parameter governing the overall level of taxes in the tax function, $\lambda$. We calibrate $\omega$ and $\nu$ so that (i) the labor share equals 2/3 (approximately the average labor share in 1980 – 2010 as reported in the NIPA data) and (ii) the skill premium $w_s/w_u$ equals 1.8 (as reported by Heathcote, Perri, and Violante (2010) for the 2000s). We choose $\phi$ so that the aggregate labor supply in steady state equals 1/3 (as is commonly assumed in the macro literature). We calibrate $\beta_s$ and $\beta_u$ so that (i) the capital-to-output ratio equals 2.9 (approximately the average of 1980 – 2011 as reported in the NIPA and Fixed Asset Tables data), and (ii) the asset holdings of an average skilled agent are 2.68 times those of an average unskilled agent (as in the 2010 U.S. Census). Finally, following Heathcote, Storesletten, and Violante (2012), we choose $\lambda$ to clear the government budget constraint in equilibrium. Table 2 summarizes our calibration procedure.

### Table 2: Benchmark Calibration Procedure

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Target</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production function parameter</td>
<td>$\omega$</td>
<td>0.4800</td>
<td>Labor share</td>
<td>2/3</td>
<td>NIPA</td>
</tr>
<tr>
<td>Production function parameter</td>
<td>$\nu$</td>
<td>0.6551</td>
<td>Skill premium</td>
<td>$\frac{w_s}{w_u}$</td>
<td>1.8</td>
</tr>
<tr>
<td>Disutility of labor</td>
<td>$\phi$</td>
<td>123.7</td>
<td>Labor supply</td>
<td>1/3</td>
<td></td>
</tr>
<tr>
<td>Skilled discount factor</td>
<td>$\beta_s$</td>
<td>0.9825</td>
<td>Capital-output ratio</td>
<td>2.9</td>
<td>NIPA, FAT</td>
</tr>
<tr>
<td>Unskilled discount factor</td>
<td>$\beta_u$</td>
<td>0.9807</td>
<td>Rel. skilled wealth</td>
<td>2.68</td>
<td>U.S. Census</td>
</tr>
<tr>
<td>Tax function parameter</td>
<td>$\lambda$</td>
<td>0.8423</td>
<td>Gvt. budget balance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4 Consequences of the Reform

In this section, we use the model calibrated in Section 3 to analyze the aggregate and distributional consequences of a budget neutral capital tax reform that equates the tax rates on structure and equipment capital. We are interested in measuring the effects of reforming the capital tax system keeping other government policies, including the labor tax code, intact.\(^8\) The government also needs to finance the pre-reform level of expenditure and debt in the new steady state. Keeping the rest of the fiscal policy tools intact is important, because the actual reform proposal is concerned with changing capital taxes only.

We first analyze the effects of the budget neutral uniform capital tax reform on prices and macroeconomic quantities. Second, we show that the reform improves both productive efficiency and equality. Third, we compute the welfare implications of the reform.

A brief summary of our results is as follows. We find that the reform equates capital taxes at 39.66%. This means that the tax rate on equipment capital increases by about 3 percentage points whereas the tax rate on structure capital decreases by approximately the same amount. The change in the average capital tax is negligible. As a result of the tax changes, the amount of equipment capital decreases and the amount of structure capital increases. Interestingly, the average return to capital stays almost the same even though the total capital stock increases and the supply of both types of labor decline in the new steady state. This is due to the fact that the reform improves the productive efficiency of the economy by reallocating capital from low return capital to high return capital. In addition, we find that the reform gives rise to a more egalitarian distribution of consumption and hours worked between skilled and unskilled agents. The average steady-state welfare increases by 0.09%. This is a substantial welfare gain given that the reform involves a relatively modest change to the capital tax system. We find that the overall

\(^8\)Observe, however, that even though the labor tax code remains intact, labor income tax revenue might still change since the reform affects prices and people’s labor supply in equilibrium.
welfare gains of the uniform capital tax reform are 0.19% if we take the temporary bonus depreciation rules, which are currently in place, into account when we calculate the status quo capital tax rates.

Our results are robust to alternative preference specifications. Interpreting the United States as an open economy which faces a fixed interest rate does not change the main results substantially either. As expected, the reform is more redistributive for a higher degree of equipment-skill complementarity. We also show that our results in general depend on the degree of labor tax progressivity and individual labor productivity risk. Nonetheless, for small changes in labor tax progressivity, and individual labor productivity risk around their benchmark values, the results are quite robust.

4.1 Macroeconomic Variables

Taxes and Prices. The first two rows of Table 3 display the current capital taxes as well as the uniform tax rate implied by the tax reform. We find that the uniform tax rate that applies to both types of capital and satisfies government’s budget given the status quo labor income taxes, debt, and spending policies is 39.66%. Importantly, as we report in the third row of the table, the average tax on capital is almost unchanged. This implies that the reform we analyze changes the mix between equipment and structure capital taxes, but leaves overall capital taxation virtually unaffected.\(^9\)

The three rows in the middle of Table 3 report the pre-tax returns to capital net of depreciation before and after the reform. The fourth and the fifth rows show that after the reform the return to structure capital declines while the return to equipment capital stays the same.\(^9\)

\(^9\)The tax numbers reported in the table are cumulative in the sense that they accumulate the capital income taxes that are paid at the firm level and at the consumer level. Alternatively, we can deduct the 15% flat capital income tax that consumers face to get the effective corporate capital income tax rates. In that case, while the pre-reform corporate effective tax rate on equipment is 26% and that on structures is 32%, the post-reform uniform effective corporate tax rate is 29.01%. This number could be interpreted as the statutory corporate tax rate if the equality of the effective tax rates on equipment and structure capital was achieved by setting the depreciation allowances for the two types of capital equal to their actual economic depreciation rates.
Table 3: Taxes and Prices Before and After the Reform

<table>
<thead>
<tr>
<th>Variable</th>
<th>Status Quo</th>
<th>Reform</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau_s$</td>
<td>42.20%</td>
<td>39.66%</td>
<td>-6.0%</td>
</tr>
<tr>
<td>$\tau_e$</td>
<td>37.10%</td>
<td>39.66%</td>
<td>6.9%</td>
</tr>
<tr>
<td>avg. $\tau$</td>
<td>39.62%</td>
<td>39.66%</td>
<td>0.1%</td>
</tr>
<tr>
<td>$r_s - \delta_s$</td>
<td>2.56%</td>
<td>2.45%</td>
<td>-4.1%</td>
</tr>
<tr>
<td>$r_e - \delta_e$</td>
<td>2.35%</td>
<td>2.45%</td>
<td>4.3%</td>
</tr>
<tr>
<td>avg. $r - \delta$</td>
<td>2.46%</td>
<td>2.45%</td>
<td>0.0%</td>
</tr>
<tr>
<td>$w_s/w_u$</td>
<td>1.8</td>
<td>1.7964</td>
<td>-0.20%</td>
</tr>
<tr>
<td>$w_s$</td>
<td>0.5495</td>
<td>0.5491</td>
<td>-0.09%</td>
</tr>
<tr>
<td>$w_u$</td>
<td>0.3053</td>
<td>0.3056</td>
<td>0.11%</td>
</tr>
</tbody>
</table>

This table reports the effects of the uniform capital tax reform on steady-state taxes and prices. $\tau_s$ denotes the tax on structure capital, $\tau_e$ denotes the tax on equipment capital, avg. $\tau$ denotes the average tax on capital. $r_s - \delta_s$ denotes the pre-tax return on structure capital net of depreciation $\delta_s$, $r_e - \delta_e$ denotes the pre-tax return on equipment capital net of depreciation $\delta_e$, and avg. $r - \delta$ denotes the average return on capital net of depreciation. $w_s$ denotes the average wage of the skilled agents, $w_u$ denotes the average wage of the unskilled agents, and $w_s/w_u$ denotes ratio of skilled to unskilled wages, i.e. the skill premium.

Turn to equipment capital increases until they are equalized. This is because the reform gives rise to an increase in the level of structure capital and a decrease in the level of equipment capital, as reported in Table 4. The sixth row of Table 3 displays the average returns to aggregate capital where the average is computed by weighing the return to each type of capital by its amount. We see, maybe somewhat surprisingly, that the average return to capital does not change much even though the aggregate capital stock increases and the level of both types of labor inputs decline (see Table 4 below). With diminishing returns to capital and capital-labor complementarity, one would expect the observed changes in aggregate capital stock and labor supply to decrease the average return to capital further. However, because of the uniform capital tax reform, there is capital reallocation from the capital with lower returns, equipment capital, towards the capital with higher returns, structure capital. This

\[10\] The non-arbitrage condition implies that after-tax returns to the two types of capital must be equal. After the reform, the capital tax is uniform and, thus, the pre-tax returns to the two types of capital are equal as well.
reallocation prevents the average return to capital from decreasing further. The fact that the average return to capital remains virtually unchanged suggests that the reform improves productive efficiency. We quantify and discuss the improvement in productive efficiency in detail in Section 4.2.

Finally, the last three rows of Table 3 report the effects of the reform on wages. First, the skill premium, $w_s/w_u$, decreases. This is a direct implication of the decline in the stock of equipment capital and the assumptions on technology. We also find that the average wage of the skilled agents, $w_s$, decreases whereas the average wage of the unskilled agents, $w_u$, increases. This is because the reform increases the amount of structure capital in the new steady state. This implies that wages of both types of agents increase by the same proportion since, by Assumption 1, the complementarity between structure capital and the two types of labor is the same. The reform also decreases the level of equipment capital which depresses the wages of both types of agents. However, because of equipment-skill complementarity formalized in Assumption 2, the impact on skilled wages is larger. Quantitatively, we find that the cumulative effect is negative for skilled wages and positive for unskilled wages.

Allocations. Table 4 displays the effects of the tax reform on aggregate allocations. The left panel shows how factors of production and total output are affected. The right panel shows how net after-tax capital income and consumption for the two groups of agents change.

The lower tax rate on structure capital gives rise to an increase in its level in the new steady state. In contrast, the higher tax rate on equipment capital results in a lower level of equipment capital. Overall, we find that the reform increases the steady state level of total capital stock by 0.40%. The increase in the total capital stock is due to the fact that the reform increases the average productivity of a given amount of capital by eliminating the distortion in capital allocation.

We find that skilled labor supply decreases by 0.01% and unskilled labor supply decreases by 0.05%. The reason for the labor supply changes is as follows. As reported in Table 3, wages decrease for the skilled agents. A decline in wages pushes labor supply up due to an income effect and down due
Table 4: Changes in Allocations due to the Reform

<table>
<thead>
<tr>
<th>Variable</th>
<th>Change</th>
<th>Variable</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K_s$</td>
<td>1.34%</td>
<td>$C_s$</td>
<td>-0.02%</td>
</tr>
<tr>
<td>$K_e$</td>
<td>-0.53%</td>
<td>$C_u$</td>
<td>0.07%</td>
</tr>
<tr>
<td>$K$</td>
<td>0.40%</td>
<td>$C$</td>
<td>0.02%</td>
</tr>
<tr>
<td>$L_s$</td>
<td>-0.01%</td>
<td>$(R - 1) \cdot A_s$</td>
<td>0.50%</td>
</tr>
<tr>
<td>$L_u$</td>
<td>-0.05%</td>
<td>$(R - 1) \cdot A_u$</td>
<td>0.42%</td>
</tr>
<tr>
<td>$L$</td>
<td>-0.04%</td>
<td>$Y$</td>
<td>0.02%</td>
</tr>
</tbody>
</table>

This table reports the effects of the uniform capital tax reform on allocations. “Change” refers to the percentage change between the pre-reform and post-reform steady state. $K_s$ denotes equipment capital, $K_e$ denotes structure capital, $K$ denotes aggregate capital, $L_s$ denotes the average supply of skilled labor, $L_u$ denotes the average supply of unskilled labor, and $Y$ denotes output. $C_s$ denotes the average skilled consumption, $C_u$ denotes the average unskilled consumption, and $C$ denotes average (aggregate) consumption. $(R - 1) \cdot A_s$ denotes the average after-tax return to skilled agents’ asset holdings, and $(R - 1) \cdot A_u$ denotes the average after-tax return to unskilled agents’ asset holdings.

to a substitution effect. When $\sigma > 1$, as in our benchmark parameterization, the income effect dominates, which implies that skilled labor supply should increase with wage.\(^{11}\) In addition, skilled labor supply is pushed down because of an income effect related to the increase in the skilled agents’ average net after-tax capital income $(R - 1) \cdot A_s$ (see the right panel of the Table 4). It turns out that these effects almost offset each other and the skilled labor supply decreases only slightly. In contrast, as reported in Table 3, unskilled wages increase, and this pushes unskilled labor supply down since $\sigma > 1$. In addition, average unskilled capital income $(R - 1) \cdot A_u$ increases which decreases their labor supply. In the end, unskilled labor supply decreases more than skilled labor supply. Overall, we find that changes in the levels of factors of production lead to an increase in output.

The first two rows of the right panel of Table 4 report the average consumption levels of the skilled agents, $C_s$, and the unskilled agents, $C_u$. We

\(^{11}\)This comparative statics result holds exactly in a static model without wealth. The presence of positive wealth weakens the income effect.
find that consumption of the skilled agents decreases. The reason is that the negative effect of the decrease in the skilled agents’ wages on their consumption dominates the positive effect of the increase in their capital income. Unskilled consumption, on the other hand, increases, because both wages and capital income of the unskilled agents increase.

4.2 Productive Efficiency and Equality

In this section, we discuss the efficiency and equality consequences of the uniform capital tax reform. We find that the reform improves productive efficiency and increases the degree of equality between skilled and unskilled agents.

**Productive Efficiency.** Productive efficiency measures how efficient the economy is in turning inputs into output. The productive efficiency result of Diamond and Mirrlees (1971) suggests that the differential tax treatment of the two types of capital might create inefficiencies by distorting capital accumulation decisions. Indeed, before the reform, the pre-tax return to structure capital is higher than the pre-tax return to equipment capital. Intuitively, then, a reform towards uniform capital taxation should create capital reallocation from the capital with lower returns, equipment capital, towards the capital with higher returns, structure capital. This reallocation, then, would increase the average return to capital, bringing the economy closer to its production possibility frontier. To see to what extent this argument applies to the reform in our model, we need to compare the before and after reform average returns to capital.

However, the tax reform does not only affect the way aggregate capital is allocated across the two capital types but it also changes the level of aggregate capital and the supply of both types of labor. In fact, in our benchmark analysis, the total capital stock increases and the supply of both types of labor decrease, putting a downward pressure on the average return to capital. Thus, in order to isolate the capital reallocation gains of the reform, we decompose the total change in the average return to capital as follows.
We first define an auxiliary interim allocation in which the aggregate capital and the labor supplies of both skilled and unskilled agents are kept constant at the pre-reform steady-state levels. In this interim allocation, capital is allocated across the two capital types in a way that equates their marginal returns, which is what happens when taxes on the two types of capital are equalized. The change in the average return to capital from the pre-reform steady state to the interim allocation measures the gains of allocating aggregate capital across the two types more efficiently. We call these gains reallocation gains. We call the change in the average return to capital from the interim allocation to the post-reform steady state the residual change. This component captures the change in average return to capital which is due to the changes in the level of aggregate capital and the changes in the labor supplies. This decomposition of the change in the average capital return is summarized in Table 5.

We find that the residual change is $-1.38\%$, implying a cumulative effect of $-0.04\%$.

**Equality.** Next, we discuss the consequences of the reform for the degree of equality between the skilled and the unskilled agents. Before the reform unskilled agents work more than skilled agents. As reported in Table 4, after the reform, both labor supplies decline but unskilled labor supply declines more, implying a more equal distribution of hours worked across agents. Sec-

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The tax reform affects the allocation of labor as well. Our measure of reallocation gains, however, measures the gains coming from a better allocation of capital alone and deliberately ignores the gains arising from a better allocation of labor by not optimizing over labor in the interim allocation. In this sense, our measure provides a lower bound for total reallocation gains.
ond, skilled consumption declines and unskilled consumption increases, which makes the consumption distribution more equal. This is especially interesting given the fact that the labor tax code is kept intact. There is more equality after the uniform capital tax reform because the reform redistributes indirectly from the skilled to the unskilled agents by decreasing the skill premium. By increasing the tax rate on equipment capital, the reform decreases the level of equipment capital. Under the assumption of equipment-skill complementarity, the decline in equipment capital then decreases the skill premium as shown in the last row of Table 3.

Eliminating capital tax differentials improves productive efficiency in our model. Because of the nature of the pre-reform capital tax differentials in the U.S. tax code (structure capital tax rate being higher than equipment capital tax rate), the uniform capital tax reform that we consider also increases equality. As a result, this reform does not suffer from the efficiency vs. equality tradeoff, which is usually present in tax reforms. In the next section, we evaluate how the efficiency and equality improvements of the reform manifest themselves in terms of welfare.

4.3 Welfare Gains

In this section, we analyze the steady state welfare gains of switching from the current capital tax system to a system with a uniform 39.66% capital tax rate. Our measure of welfare gains and losses is standard. The welfare gains of allocation $x$ relative to allocation $y$ are defined as a fraction by which the consumption in allocation $y$ would have to be increased in each date and state in order to make its welfare equal to the welfare of allocation $x$.

First, we want to evaluate the effect of the reform on aggregate welfare. To do so, we consider a Utilitarian social welfare function which puts an equal weight on every agent. The welfare gains of the uniform capital tax reform under this welfare criterion are 0.09% in consumption equivalent units. Then, we evaluate the welfare consequences of the reform for skilled and unskilled agents.

\footnote{We find that the reform decreases inequality also when measured by the Gini coefficient. The pre-tax total income Gini decreases by 0.32%, while the wealth Gini decreases by 0.03%.}
separately. We find that the average skilled welfare declines by 0.01% whereas the average unskilled welfare increases by 0.15%. We interpret these findings as follows. The reform, by abolishing tax differentials, increases productive efficiency, which increases welfare for both types of agents. However, the reform also depresses equipment capital accumulation, and hence, decreases the skill premium, which implies indirect redistribution from the skilled agents to the unskilled agents. It turns out that, under our benchmark parameterization, the efficiency gains and redistribution losses incurring to the skilled agents almost fully offset each other, resulting in a small welfare loss. For the unskilled agents, the redistributive gains plus the efficiency gains sum up to a significant welfare gain of 0.15%.

A Reform where Both Types Gain. We also analyze a uniform capital tax reform, in which the government distributes a larger share of the efficiency gains to the skilled agents to ensure that the average skilled welfare is unchanged. In this reform, the uniform tax rate on capital is slightly below the benchmark reform level. This implies a smaller decrease in the skill premium and, hence, less indirect redistribution from the skilled to the unskilled. To make up for the capital tax revenue loss, the government decreases \( \lambda \), which increases the overall level of labor taxes, but does not change labor tax progressivity. In particular, the parameter \( \tau_l \), which controls labor tax progressivity, is kept constant. As a result of this reform, unskilled welfare goes up by 0.15% while skilled welfare does not change by construction (more precisely, the unskilled gain 0.147% in this reform while they gain 0.150% in the benchmark reform). More generally, by choosing a lower level of the uniform capital tax rate and the appropriate \( \lambda \), the government can distribute a positive share of the overall welfare gains of the reform to the skilled agents.\(^{14}\)

\(^{14}\)For instance, there is a reform that distributes all the gains of uniform capital taxation to the skilled agents subject to keeping unskilled welfare unchanged. In this reform, skilled welfare increases by 0.48%. The welfare gains of this reform should be taken with caution though. The reason is that, unlike the benchmark reform, in which average taxes on capital remain almost unchanged, this alternative reform decreases the average taxes on capital significantly, to 36.61%, and increases labor tax collection substantially. As a result, steady-state level of total capital stock increases much more than it does in the benchmark reform, namely by 1.7%, which makes steady-state welfare comparison less desirable.
A Reform with Fixed Aggregate Capital Stock. Our benchmark reform increases the total capital stock by 0.4% from the initial to the new steady state. Comparing welfare across steady states with different capital levels can be problematic since raising capital from one steady state to the next might be costly over the transition. Therefore, to abstract from the steady-state welfare gains coming from the increase in aggregate capital, we consider an alternative reform, in which we choose the uniform capital tax rate so that the aggregate capital stock is constant across steady states. We find that aggregate welfare increases by 0.06%, which implies that two thirds of the welfare gains in the benchmark reform are coming from a more efficient allocation of the pre-reform amount of aggregate capital between equipment and structure capital.

4.4 Accounting for Bonus Depreciation

The status quo structure and equipment capital tax rates of Gravelle (2011) that we use in our benchmark analysis are based on the permanent U.S. tax laws. However, since 2001, there have been temporary provisions that have made it possible to deduct an extra fraction of the value of capital in the first year of the capital’s tax life (bonus depreciations). Table 6 summarizes the evolution of these provisions.

These provisions have only applied to assets with tax life less than 20 years, and, therefore, have included equipments, but have excluded most structures. As a result, these provisions have created an extra tax advantage for equipments. Gravelle (2003) calculates that with the 50% bonus depreciation, which has been in place for most of the last decade, the effective taxes on equipments and structures are 14% and 29%. In this section, we analyze the consequences of the uniform capital tax reform under this scenario. We recalibrate the model under these tax rates to match the same set of moments in the data.

\footnote{The uniform capital tax rate that keeps the aggregate capital at the pre-reform steady-state level is 40.55%, which is higher than the one in the benchmark reform, 39.66%. This creates extra revenues for the government, and thus, to keep the government budget balanced, we decrease the total labor tax revenue by increasing \( \lambda \).}
Table 6: Bonus Depreciation in the U.S. Tax Code

<table>
<thead>
<tr>
<th>Start date</th>
<th>End date</th>
<th>Bonus depreciation</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/11/2001</td>
<td>5/5/2003</td>
<td>30%</td>
</tr>
<tr>
<td>1/1/2008</td>
<td>9/8/2010</td>
<td>50%</td>
</tr>
<tr>
<td>9/9/2010</td>
<td>12/31/2011</td>
<td>100%</td>
</tr>
<tr>
<td>1/1/2012</td>
<td>12/31/2014</td>
<td>50%</td>
</tr>
</tbody>
</table>

This table shows the evolution of the temporary bonus depreciation provisions in the U.S. tax code for the last 15 years.

and conduct the same budget neutral capital tax reform exercise.

The results of the reform under the 50% bonus depreciation law are compared with the benchmark reform in Table 7. After adding the 15% capital income tax paid at the consumer level, the overall tax on equipment and structure capital are 27.75% and 39.65%, respectively in the status quo economy. The uniform capital tax reform equates the taxes on the two types of capital at 34.00%. The efficiency gains - as measured by capital reallocation gains - are 2.89%, more than twice the gains in the benchmark case. This is no surprise since the differentials, and hence, the distortion of the status quo tax code, is much larger in this case. The skill premium declines by 0.42%, which is twice as much as in the benchmark case. Finally, we find that while overall welfare increases by 0.19% in consumption equivalence units, the skilled lose by 0.02% and unskilled gain by 0.31%. Thus, the welfare consequences of the reform are also amplified if we use the alternative effective tax rates calculated by Gravelle (2003) for the case of a 50% bonus depreciation. In that sense, our benchmark results should be taken as a conservative estimate of the welfare gains associated with the uniform capital tax reform.
Table 7: Reform Consequences under a 50% Bonus Depreciation

<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>50% Bonus Depreciation</th>
</tr>
</thead>
<tbody>
<tr>
<td>status quo $\tau_s$</td>
<td>42.20%</td>
<td>39.65%</td>
</tr>
<tr>
<td>status quo $\tau_e$</td>
<td>37.10%</td>
<td>27.75%</td>
</tr>
<tr>
<td>post-reform uniform tax</td>
<td>39.66%</td>
<td>34.00%</td>
</tr>
<tr>
<td>reallocation gains</td>
<td>1.35%</td>
<td>2.89%</td>
</tr>
<tr>
<td>$w_s/w_u$</td>
<td>-0.20%</td>
<td>-0.42%</td>
</tr>
<tr>
<td>welfare gains</td>
<td>0.09%</td>
<td>0.19%</td>
</tr>
<tr>
<td>skilled gains</td>
<td>-0.01%</td>
<td>-0.02%</td>
</tr>
<tr>
<td>unskilled gains</td>
<td>0.15%</td>
<td>0.31%</td>
</tr>
</tbody>
</table>

This table reports the implications of the uniform capital tax reform for two different capital tax regimes. The column “Benchmark” refers to the benchmark exercise in which the status quo capital taxes are calculated using the permanent U.S. law. The column “50% Bonus Depreciation” refers to an exercise in which the status quo structure and equipment capital tax rates are calculated assuming the temporary 50% bonus depreciation rule. Regarding the rows of the table, “uniform tax” refers to the uniform tax on equipment and structure capital that leaves steady state government budget balanced, “reallocation gains” refers to the change in net output associated with a more efficient allocation of capital, “$w_s/w_u$” denotes the ratio of skilled to unskilled wages. “Welfare gains” denote the aggregate steady state welfare gains of the reform, while “skilled gains” (“unskilled gains”) refers to the skilled (unskilled) agents’ steady state welfare gains.

### 4.5 Sensitivity Analysis

In this section, we analyze the sensitivity of our quantitative results to the parameters that control preferences, technology, progressivity of the labor tax code, and labor productivity risk. Specifically, we perform the following exercise. We change the parameter of interest and keep all other parameters that we do not calibrate fixed. We recalibrate the model under this new parameterization. Then, we conduct the uniform capital tax reform, and evaluate the changes in macroeconomic aggregates and welfare in the new steady state. In addition, we also analyze an open economy version of the model.
Table 8: Sensitivity to Preference Parameters

<table>
<thead>
<tr>
<th>$\sigma$</th>
<th>Benchmark 1</th>
<th>Benchmark 2</th>
<th>Benchmark 4</th>
<th>Benchmark 2</th>
<th>Benchmark 2</th>
<th>Benchmark 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma$</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>uniform tax</td>
<td>39.62%</td>
<td>39.66%</td>
<td>39.68%</td>
<td>39.67%</td>
<td>39.66%</td>
<td>39.64%</td>
</tr>
<tr>
<td>reallocation gains</td>
<td>1.38%</td>
<td>1.35%</td>
<td>1.32%</td>
<td>1.34%</td>
<td>1.35%</td>
<td>1.36%</td>
</tr>
<tr>
<td>$w_s/w_u$</td>
<td>-0.15%</td>
<td>-0.20%</td>
<td>-0.27%</td>
<td>-0.21%</td>
<td>-0.20%</td>
<td>-0.18%</td>
</tr>
<tr>
<td>welfare gains</td>
<td>0.04%</td>
<td>0.09%</td>
<td>0.12%</td>
<td>0.09%</td>
<td>0.09%</td>
<td>0.09%</td>
</tr>
<tr>
<td>skilled gains</td>
<td>0.01%</td>
<td>-0.01%</td>
<td>-0.07%</td>
<td>-0.02%</td>
<td>-0.01%</td>
<td>-0.001%</td>
</tr>
<tr>
<td>unskilled gains</td>
<td>0.06%</td>
<td>0.15%</td>
<td>0.21%</td>
<td>0.16%</td>
<td>0.15%</td>
<td>0.14%</td>
</tr>
</tbody>
</table>

This table reports the sensitivity of our main quantitative results to preference parameters. Each column reports the results for a particular combination of $\sigma$ (the curvature of utility from consumption) and $\gamma$ (the curvature of disutility of labor). We always change a particular parameter and leave the rest of the parameters that are not calibrated unaffected. Regarding the rows of the table, “uniform tax” refers to the uniform tax on equipment and structure capital that leaves steady state government budget balanced, “reallocate losses” refers to the change in net output associated with a more efficient allocation of capital, “$w_s/w_u$” denotes the ratio of skilled to unskilled wages. “Welfare gains” denote the aggregate steady state welfare gains of the reform, while “skilled gains” (“unskilled gains”) refers to the skilled (unskilled) agents’ steady state welfare gains.

We find that the reform decreases the steady state level of equipment capital and increases the steady state level of structure capital in all the sensitivity exercises we conduct. Similarly, it is always the case that consumption and hours worked become more equally distributed between skilled and unskilled agents. In what follows, we do not report these results, but instead focus on the efficiency and equality consequences of the reform.

Sensitivity to Preference Parameters. Table 8 summarizes our sensitivity results with respect to changes in preference parameters. First, the uniform capital tax rate is very close to the benchmark value in all the exercises. Second, the productive efficiency gains from capital reallocation are
quantitatively very similar to those in the benchmark case as shown in the row called “reallocation gains.” Third, the skill premium decreases by roughly 0.2% in all the exercises, which implies a more equal distribution of consumption and labor across agents. We conclude that our finding that the uniform capital tax reform improves both efficiency and equality is robust to preference parameters. Aggregate steady state welfare gains are around 0.1%, they increase with $\sigma$, but do not change much with $\gamma$. Typically, skilled agents lose and unskilled agents gain from the reform. An interesting case is the one with $\sigma = \gamma = 1$, in which both types of agents gain. The reason is that in this parameterization, the decline in skilled consumption is very modest and is more than offset by the decrease in skilled labor supply. This case shows that the uniform capital tax reform increases both types’ average welfare for a set of reasonable parameter values, even without being accompanied by a modification of the labor tax code.

Additional Sensitivity. We report additional sensitivity in two separate tables. Table 9 reports sensitivity with respect to production function parameters, the discount factor, and the openness of the economy. Table 10 reports sensitivity with respect to labor income tax progressivity and labor productivity risk.

The first row of Table 9 shows that, in all these exercises, the uniform capital tax rate is very close to the benchmark value. In addition, the second and third rows of Table 9 show that the reform improves both efficiency and equality as in the benchmark case. Next, we discuss each robustness exercise reported in Table 9 in more detail.

Elasticities of Substitution. The column denoted by “$\eta = 0.79$” reports the consequences of the reform in an economy with higher elasticity of substitution between equipment capital and unskilled labor. Specifically, we set $\eta = 0.79$ instead of the benchmark value of $\eta = 0.401$. For this elasticity

---

\[ \eta = \frac{1}{(1 - \eta)} \]  

\[ \rho = \frac{1}{(1 - \rho)} \]  

This value has been used, for example, in He and Liu (2008), who use the same production function as ours, and comes from an empirical study by Duffy, Papageorgiou, and
value, we observe that skilled welfare decreases more and unskilled welfare increases more relative to the benchmark parameterization. This is intuitive: higher $\eta$ means a lower degree of complementarity between equipment capital and unskilled labor. In that case, a decline in equipment capital decreases unskilled wages less and, therefore, depresses the skill premium more relative to the benchmark case, as reported in the third row of Table 9. This means that there is a higher degree of indirect redistribution from the skilled to the unskilled. The average welfare gain is higher relative to the benchmark case because of the concavity of the utility function. As for the productive efficiency gains, they are significantly lower than those in the benchmark reform. This is also intuitive. A higher value of $\eta$ makes equipment capital more substitutable with unskilled labor. When an input is more substitutable by other inputs to production, the distortions in its accumulation are less costly in terms of productive efficiency. Therefore, a uniform capital tax reform that eliminates such distortions implies lower efficiency gains.

The column denoted by “$\rho = -1$” reports the consequences of the reform in an economy with a lower elasticity of substitution between equipment capital and skilled labor (in the benchmark $\rho = -0.495$). The productive efficiency gains of eliminating the distortions in capital accumulation are significantly larger because now it is harder to substitute equipment capital by skilled labor. The results regarding equality are similar to those in the previous exercise, which is intuitive: lower $\rho$ means a higher degree of complementarity between equipment capital and skilled labor, which, in relative terms, is similar to a lower degree of complementarity between equipments and unskilled labor. To conclude, in a world with a higher degree of equipment-skill complementarity, a greater portion of the gains of the uniform capital tax reform accrues to the unskilled people, thereby increasing the egalitarian nature of the reform.

**Uniform Discount Factors.** Next, we calibrate a version of our model in which all agents have the same discount factor. This calibration drops the relative wealth of the skilled and unskilled agents as one of the calibration targets. The results of the uniform tax reform are reported in Table 9 in the

Table 9: Sensitivity to Technology, Patience, and Openness

<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>$\eta = 0.79$</th>
<th>$\rho = -1$</th>
<th>Uniform $\beta$</th>
<th>Open Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>uniform tax</td>
<td>39.66%</td>
<td>39.67%</td>
<td>39.65%</td>
<td>39.29%</td>
<td>39.59%</td>
</tr>
<tr>
<td>reallocation gains</td>
<td>1.35%</td>
<td>1.26%</td>
<td>1.79%</td>
<td>1.36%</td>
<td>1.35%</td>
</tr>
<tr>
<td>$w_s/w_u$</td>
<td>-0.20%</td>
<td>-0.28%</td>
<td>-0.24%</td>
<td>-0.17%</td>
<td>-0.20%</td>
</tr>
<tr>
<td>welfare gains</td>
<td>0.09%</td>
<td>0.10%</td>
<td>0.10%</td>
<td>0.10%</td>
<td>0.06%</td>
</tr>
<tr>
<td>skilled gains</td>
<td>-0.01%</td>
<td>-0.05%</td>
<td>-0.02%</td>
<td>-0.02%</td>
<td>-0.05%</td>
</tr>
<tr>
<td>unskilled gains</td>
<td>0.15%</td>
<td>0.19%</td>
<td>0.18%</td>
<td>0.17%</td>
<td>0.14%</td>
</tr>
</tbody>
</table>

This table reports additional sensitivity results. Each column reports the results for a particular parameter specification. We always change a particular parameter and leave the rest of the parameters that are not calibrated unaffected. “$\eta = 0.79$” refers to an exercise in which we increase the elasticity of substitution between equipment capital and unskilled labor by increasing $\eta$ from its benchmark value of 0.401 to 0.79. The column “$\rho = -1$” refers to an exercise in which we decrease the elasticity of substitution between equipment capital and skilled labor by increasing $\rho$ from its benchmark value of $-0.495$ to $-1$. The column “Uniform $\beta$” refers to an exercise in which all agents are assumed to have the same discount factor. The column “Open Economy” refers to an exercise in which the after-tax interest is kept fixed. Regarding the rows of the table, “uniform tax” refers to the uniform tax on equipment and structure capital that leaves steady state government budget balanced, “reallocation gains” refers to the the change in net output associated with a better allocation of capital, “$w_s/w_u$” denotes the ratio of skilled to unskilled wages. “Welfare gains” denote the aggregate steady state welfare gains of the reform, while “skilled gains” (“unskilled gains”) refers to the skilled (unskilled) agents’ steady state welfare gains.

column entitled “Uniform $\beta$”. We find that our main quantitative results do not depend on the assumption of heterogenous discount factors.\footnote{18}

**Open Economy.** The United States is not literally a closed economy, but following the literature, we consider that scenario a useful benchmark. In this section, we consider the polar opposite case and analyze the consequences of the uniform capital tax reform assuming that the United States is a small open economy that faces a fixed world interest rate. This exercise illustrates to what extent the implications of the uniform capital tax reform depend on the

\footnote{18With a uniform discount factor, however, the calibrated model does not match the observed wealth distribution across skilled and unskilled agents. In the model with uniform discount factors the average wealth of a skilled agent is 1.66 times the average wealth of the unskilled agent, while in the data (and in the benchmark model, in which the relative wealth is one of the calibration targets) it is 2.68.}
degree of openness. In particular, we calibrate the after-tax interest rate so that in the steady state, the net foreign asset position is -20% of GDP, which is approximately the number for the U.S. economy as reported by the Bureau of Economic Analysis.

The results of the uniform capital tax reform for this environment are reported in the last column of Table 9. We find that the reallocation gains and the skill premium changes are very similar to the closed economy benchmark. For both agents, the welfare gains are smaller in the open economy exercise. The reason is the following. Recall that equating capital taxes increases the return to capital due to the reallocation from less to more productive capital. In our benchmark closed economy, this encourages asset accumulation of domestic agents towards the new steady-state, which increases their steady-state welfare. In an open economy, higher return to capital implies an immediate capital inflow from abroad until the (after-tax) return to capital is equal to its pre-reform level. As a result, the asset holdings of the domestic agents stay largely unchanged across the steady states. This implies that the change in aggregate capital stock across steady states does not contribute to the welfare gains of domestic agents. Therefore, not surprisingly, the overall welfare gains in the open economy exercise are almost the same as the welfare gains in a closed economy in which we abstract from the effect of capital accumulation on aggregate welfare by keeping aggregate capital fixed. We discuss the details of this exercise in Section 4.3.

**Labor Tax Progressivity.** We take the estimate of the progressivity of the labor income tax code $\tau_l$ from Heathcote, Storesletten, and Violante (2012) which uses 2005 CPS data to estimate this parameter. It is likely that estimations using different data sets might give different estimates.\textsuperscript{19} To ensure that our results are not sensitive to this parameter value, we conduct our analysis for $\tau_l = 0.15$ and $\tau_l = 0.21$ as well. The results are reported in the second and third columns of Table 10. We find that our results are robust to small changes in the progressivity parameter.

\textsuperscript{19}See for instance Bakis, Kaymak, and Poschke (2014) which uses CPS data for the period 1979-2009 and finds $\tau_l = 0.17$. 

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<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>$\tau_l = 0.15$</th>
<th>$\tau_l = 0.21$</th>
<th>Higher risk</th>
<th>Lower risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>uniform tax</td>
<td>39.66%</td>
<td>39.65%</td>
<td>39.67%</td>
<td>39.66%</td>
<td>39.66%</td>
</tr>
<tr>
<td>reallocation gains</td>
<td>1.35%</td>
<td>1.35%</td>
<td>1.35%</td>
<td>1.35%</td>
<td>1.35%</td>
</tr>
<tr>
<td>$w_s/w_u$</td>
<td>-0.20%</td>
<td>-0.20%</td>
<td>-0.20%</td>
<td>-0.20%</td>
<td>-0.20%</td>
</tr>
<tr>
<td>welfare gains</td>
<td>0.09%</td>
<td>0.09%</td>
<td>0.09%</td>
<td>0.09%</td>
<td>0.09%</td>
</tr>
<tr>
<td>skilled gains</td>
<td>-0.01%</td>
<td>-0.01%</td>
<td>-0.01%</td>
<td>-0.01%</td>
<td>-0.01%</td>
</tr>
<tr>
<td>unskilled gains</td>
<td>0.15%</td>
<td>0.15%</td>
<td>0.15%</td>
<td>0.15%</td>
<td>0.15%</td>
</tr>
</tbody>
</table>

This table reports the results of the reform for different levels of labor tax progressivity and labor productivity risk. The column “Benchmark” refers to the benchmark quantitative analysis. The columns “$\tau_l = 0.15$” and “$\tau_l = 0.21$” refer to exercises in which we change the labor progressivity parameter $\tau_l$ from its benchmark value of 0.18. The columns “Higher risk” and “Lower risk” refer to exercises in which we increase and decrease the variance of the idiosyncratic shocks by 25%, respectively. In both exercises, we keep the skill persistence parameters unchanged. Regarding the rows of the table, “uniform tax” refers to the uniform tax on equipment and structure capital that leaves steady state government budget balanced, “reallocation gains” refers to the change in net output associated with a better allocation of capital, “$w_s/w_u$” denotes the ratio of skilled to unskilled wages. “Welfare gains” denote the aggregate steady state welfare gains of the reform, while “skilled gains” (“unskilled gains”) refers to the skilled (unskilled) agents’ steady state welfare gains.

**Productivity Risk.** In our benchmark exercise, we parameterize the labor productivity processes for skilled and unskilled agents following Krueger and Ludwig (2013). In this section, we analyze whether the consequences of the uniform capital tax reform are sensitive to the amount of idiosyncratic labor productivity risk present in the economy. We do so by conducting the uniform capital tax reform first in an economy in which the variance of the idiosyncratic shock is 25% higher for both skilled and unskilled agents. The fourth column of Table 10, called “Higher risk,” summarizes the effects of the reform under this parameterization. We also conduct our reform for an economy in which the variance of idiosyncratic shock is 25% lower for both groups. The results
of this exercise are reported in the column called “Lower risk” in Table 10. We find that the consequences of the reform are quantitatively not different from the benchmark case for both higher and lower risk economies. Thus, we conclude that our results are not sensitive to changes in labor productivity risk around the benchmark level of risk.

4.6 Importance of Modeling Labor Tax Progressivity and Labor Productivity Risk

In the previous section, we show that our quantitative results are robust to changes in the labor income tax progressivity and labor productivity risk parameters. This robustness result does not imply, however, that modeling progressivity of the labor income tax code and labor productivity risk are unimportant for the analysis at hand. In this section, we underline the importance of modeling progressivity and labor productivity risk by providing examples in which deviations from the benchmark modeling of progressivity and risk significantly alter the quantitative predictions of our analysis regarding the capital tax reform. Thus, we conclude that modeling labor tax progressivity and labor productivity risk are both crucial when it comes to evaluating the consequences of the uniform capital tax reform.

Progressivity of the Labor Tax Code. The reform proposed by Obama administration is a partial reform of the tax code in the sense that all government policies other than capital taxes remain unchanged. It is natural to suspect that the nature of the status-quo labor tax code affects the implications of the reform. To verify that this is indeed the case, we evaluate the consequences of the reform for an economy in which the labor income taxes are deliberately chosen to be significantly more progressive than the actual U.S. code by setting $\tau_l = 0.54$.\footnote{To get an idea about how different the degree of progressivity in the two labor tax systems are, observe that in the benchmark labor tax system, an individual with half the mean labor income pays 4.6% and a person with twice the mean income pays 25.6% average labor income tax while in the more progressive system these numbers are -22.5% and 42.1%, respectively.} We recalibrate the model economy under this
Table 11: Importance of Labor Tax Progressivity and Labor Productivity Risk

<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>$\tau_l = 0.54$</th>
<th>Alternative risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>uniform tax</td>
<td>39.66%</td>
<td>39.76%</td>
<td>39.71%</td>
</tr>
<tr>
<td>reallocation gains</td>
<td>1.35%</td>
<td>1.36%</td>
<td>1.36%</td>
</tr>
<tr>
<td>$w_s/w_u$</td>
<td>-0.20%</td>
<td>-0.19%</td>
<td>-0.24%</td>
</tr>
<tr>
<td>welfare gains</td>
<td>0.09%</td>
<td>0.14%</td>
<td>0.06%</td>
</tr>
<tr>
<td>skilled gains</td>
<td>-0.01%</td>
<td>0.05%</td>
<td>-0.07%</td>
</tr>
<tr>
<td>unskilled gains</td>
<td>0.15%</td>
<td>0.19%</td>
<td>0.15%</td>
</tr>
</tbody>
</table>

This table reports the results of the reform for different levels of labor tax progressivity and labor productivity risk. The column “Benchmark” refers to the benchmark quantitative analysis. The columns “$\tau_l = 0.54$” refers to an exercise in which we change the labor progressivity parameter $\tau_l$ from its benchmark value of 0.18. The column “Alternative risk” refers to exercises in which both types of agents have the labor productivity process provided by Castaneda, Díaz-Giménez, and Ríos-Rull (2003). Regarding the rows of the table, “uniform tax” refers to the uniform tax on equipment and structure capital that leaves steady state government budget balanced, “reallocation gains” refers to the change in net output associated with a better allocation of capital, “$w_s/w_u$” denotes the ratio of skilled to unskilled wages. “Welfare gains” denote the aggregate steady state welfare gains of the reform, while “skilled gains” (“unskilled gains”) refers to the skilled (unskilled) agents’ steady state welfare gains.

We see that even though the reallocation gains and the change in skill premium are similar to the benchmark case, the welfare effects of the reform are both quantitatively and qualitatively different. In the economy with the highly progressive system, Utilitarian welfare gains are about 50% higher. Moreover, there is a qualitative difference: both skilled and unskilled agents gain as a result of the reform, while the skilled lose in the benchmark. This column shows that, as expected, modeling progressivity matters for the implications of the uniform capital tax reform.

**Productivity Risk.** The nature of labor productivity risk affects the amount of precautionary savings and hence aggregate capital accumulation. Therefore, it is natural to expect that the implications of the uniform capital tax reform, in general, depend on labor productivity risk. The last column of Table 11 called “Alternative risk” provides an example which shows that
this is indeed the case. In this example, we replace the benchmark labor productivity processes with the one provided by Castaneda, Díaz-Giménez, and Ríos-Rull (2003) for both skilled and unskilled agents, calibrate the model to the same set of moments, and then analyze the consequences of the reform. The welfare gains of the reform are less than 2/3 of the benchmark welfare gains, in particular because the skilled welfare loss is more than seven times larger relative to the benchmark. This is because the skilled premium declines more than in the benchmark. This exercise confirms that the degree of labor productivity risk matters for the consequences of the reform.

It is important to understand that the exercises we conduct in this section are not sensitivity exercises. In this section we show that, in general, modeling labor tax progressivity and labor productivity risk matters for the implications of the uniform capital tax reform. To do so, we take the alternative parameters to be quite different from the benchmark values.

5 Conclusion

In the current U.S. tax code different types of capital are taxed at different rates effectively. Recently, President Obama’s administration has proposed a reform to eliminate these differentials. If implemented, this reform would affect firms’ capital accumulation decisions, and, therefore, returns to capital as well as wages. This way the reform would affect the majority of the U.S. population. Therefore, we believe that it is important to understand the implications of the reform in advance, which is the aim of the current paper.

We find that the reform leads to improvements in productive efficiency. We also find that by decreasing the skill premium, the reform increases the degree of equality in the economy. This implies that the reform does not suffer from the usual efficiency vs. equality trade-off. As result of the reform, skilled

\textsuperscript{21}Castaneda, Díaz-Giménez, and Ríos-Rull (2003) chooses the productivity process to match certain moments of the wealth distribution in the U.S. Our exercise is supposed to be illustrative, and therefore, we do not adjust the productivity process to our model. Notice that there is still a skill premium in our model since the marginal products of skilled and unskilled labor are different.
agents’ steady-state welfare slightly decreases, while unskilled agents’ welfare increases, resulting in aggregate welfare gains of approximately 0.1%. The overall welfare gains of the uniform capital tax reform are about 0.2% if we take into account the temporary bonus depreciation rules when we calculate the status quo capital tax rates.
References


Appendix

A Definition of Competitive Equilibrium

First, denote the partial history of productivity shocks up to period $t$ by $z^t \equiv (z_0, ..., z_t)$. Also, denote the unconditional probability of $z^t$ for agent of skill type $i$ by $P_{i,t}(z^t)$. For each agent type, this unconditional probability is achieved by applying the transition probability matrix $\Pi^i(z'|z)$ recursively. We denote by $Z^t_i$ the set in which $z^t$ lies for an agent of type $i$.

Equilibrium. A competitive equilibrium consists of a policy $(\tau_{c,t}, T_t(\cdot), \tau_{s,t}, \tau_{e,t}, D_t, G_t)_{t=0}^\infty$, an allocation $((c_{i,t}(z^t), l_{i,t}(z^t), a_{i,t+1}(z^t)))_{z^t \in Z^t_i}^\infty, K_{s,t}, K_{e,t}, L_{s,t}, L_{u,t})_{t=0}^\infty$, and a price system $(r_{s,t}, r_{e,t}, w_{s,t}, w_{u,t}, R_t)_{t=0}^\infty$ such that:

1. Given the policy and the price system, the allocation $((c_{i,t}(z^t), l_{i,t}(z^t), a_{i,t+1}(z^t)))_{z^t \in Z^t_i}^\infty$ solves each consumer $i$’s problem, i.e.,

$$\max_{\{c_{i,t}(z^t), l_{i,t}(z^t), a_{i,t+1}(z^t)\}_z^t} \sum_{t=0}^\infty \sum_{z^t \in Z^t_i} P_{i,t}(z^t) \beta^t_i u(c_{i,t}(z^t)) - v(l_{i,t}(z^t)) \quad \text{s.t.}$$

$$\forall t \geq 0, z^t,$$

$$(1 + \tau_{c,t})c_{i,t}(z^t) + a_{i,t+1}(z^t) \leq l_{i,t}(z^t) w_{i,t} z_t - T_t(l_{i,t}(z^t) w_{i,t} z_t) + R_t a_{i,t}(z^{t-1}),$$

$$\forall t \geq 0, z^t, \quad c_{i,t}(z^t) \geq 0, a_{i,t+1}(z^t) \geq 0, l_{i,t}(z^t) \geq 0,$$

given $a^0_i > 0$,

where $R_t = [1 + (1 - \tau_{s,t})(r_{s,t} - \delta_s)] = [1 + (1 - \tau_{e,t})(r_{e,t} - \delta_e)]$ is the after-tax return to savings via holding bonds, structure capital, or equipment capital.

2. In each period $t \geq 0$, taking factor prices as given, $(K_{s,t}, K_{e,t}, L_{s,t}, L_{u,t})$ solves the following firm’s problem:

$$\max_{K_{s,t}, K_{e,t}, L_{s,t}, L_{u,t}} F(K_{s,t}, K_{e,t}, L_{s,t}, L_{u,t}) - r_{s,t} K_{s,t} - r_{e,t} K_{e,t} - w_{s,t} L_{s,t} - w_{u,t} L_{u,t}.$$

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3. Markets for assets, labor, and goods clear: for all $t \geq 0$,

$$K_{s,t} + K_{e,t} + D_t = \sum_{i=u,s} \pi_i \sum_{z^{t-1} \in Z^{t-1}_i} P_{i,t-1}(z^{t-1}) a_{i,t}(z^{t-1}),$$

where $z^{-1}$ is the null history,

$$L_{i,t} = \pi_i \sum_{z^t \in Z^t_i} P_{i,t}(z^t) l_{i,t}(z^t) z_t$$

for $i = u, s$,

$$G_t + \sum_{i=u,s} \pi_i \sum_{z^t \in Z^t_i} P_{i,t}(z^t) c_{i,t}(z^t) + K_{s,t+1} + K_{e,t+1} = \tilde{F}(K_{s,t}, K_{e,t}, L_{s,t}, L_{u,t}).$$

4. The government’s budget constraint is satisfied every period: for all $t \geq 0$,

$$G_t + R_t D_t = D_{t+1} + \sum_{j=s,e} \tau_{j,t} (r_{j,t} - \delta) K_{j,t} + \sum_{i=u,s} \pi_i \sum_{z^t \in Z^t_i} P_{i,t}(z^t) \left( T_{l,t}(z^t) w_{i,t} z_t + \tau_{c,t} c_{i,t}(z^t) \right).$$

B Numerical Method

In this section, we outline our solution method.

General Solution Method for the Calibration Exercise. Traditionally, one would solve for a SRCE for a fixed set of parameters, including those that will be calibrated (i.e., $\omega, \nu, \phi_s, \beta_s, \beta_u$). This is done in the following way.

1. Start with an initial guess on prices $w_s, w_u, R$, government expenditure $G$ and transfers $T$.

2. **Inner loop**: Solve for the policy functions given these parameters. The details of this computation are explained below.

3. Find the stationary distributions $\lambda_s, \lambda_u$ implied by the policy functions.

4. Compute aggregate capital and labor supplies along with output. Given these, compute prices $w_s, w_u, R$ implied by demand, government expen-
diture $G$ as a fraction of output. Compute the implied transfers $T$ that clear government budget.

5. Check if these prices and government policies coincide with the initial guesses. If not, update the guesses on prices, transfers and government expenditure and iterate.

One would normally solve this problem for each set of parameters during the calibration procedure, in which we are calibrating $\omega, \nu, \phi, \beta_s, \beta_u$ to hit a selected set of targets. We found it useful to include the calibration procedure directly into the loop above. Our procedure that combines solving for the SRCE with the calibration procedure is as follows.

1. Start with an initial guess on $w_s, w_u, R, G, T, \omega, \nu, \phi, \beta_s, \beta_u$.

2. Repeat steps 2. - 4. from above.

3. Check if the prices and government policies coincide with the initial guesses. Check if the aggregate labor supply, the skill premium, the labor share, the capital-to-output ratio and the relative asset holdings match the targets (see Table 2). If not, update the guesses on $w_s, w_u, R, G, T, \omega, \nu, \phi, \beta_s, \beta_u$ and iterate.

**Solving the Inner Loop.** Next, we briefly outline our version of the endogenous grid method (EGM) for the incomplete markets model with endogenous labor, i.e. how we solve the ‘inner loop’ above. The policy function iteration version of the standard EGM with fixed labor and income shocks captured by shocks to $y_t$ can be summarized as follows (we find it useful to use time indices, although this method can be used for stationary problems as well):

1. With an initial guess on $a_{t+2}$ and a fixed $a_{t+1}$, we use the Euler equation
to recover $a_t$

\begin{align*}
u'(c_t) &= \beta R_{t+1} E_t [u'(c_{t+1})] \\
u'(R_t a_t + y_t - a_{t+1}) &= \beta R_{t+1} E_t [u'(R_{t+1} a_{t+1} + y_{t+1} - a_{t+2})] \\
a_t &= \frac{1}{R_t} \{u'^{-1}(\beta R_{t+1} E_t [u'(R_{t+1} a_{t+1} + y_{t+1} - a_{t+2})]) - y_t + a_{t+1}\} \tag{2}
\end{align*}

2. Once we have $a_t(a_{t+1}, y_t)$ we ‘invert’ it to get $a_{t+1}(a_t, y_t)$. We also recover $c_t(a_t, y_t)$. Then we go backward starting in the last period in a finite horizon problem. We iterate until $a_{t+1} = a_{t+2}$ in an $\infty$ problem.

Our Method with Endogeneous Labor. In our model the complication is that income is endogeneous, because the labor choice is endogeneous, so that labor income of type $i \in \{s, u\}$ agent in period $t$ is: $y_{i,t} = w_{i,t} z_t \cdot l_{i,t}$ with $l_{i,t}$ endogenous. To take care of endogenous labor (and consumption taxes, which were not included in the discussion above), we need to take into account the intratemporal optimality condition (dropping the index $i$ for type for simplicity):

$$
\lambda(1 - \tau_l)(w_l z_l l_t)^{-\tau_l} w_l z_l u'(c_t) = -(1 + \tau_c) u'(l_t)
$$

Therefore the system we need to solve is:

$$
\begin{align*}
u'(c_t) &= \beta R_{t+1} E_t [u'(c_{t+1})] \\
\lambda(1 - \tau_l)(w_l z_l l_t)^{-\tau_l} w_l z_l u'(c_t) &= -(1 + \tau_c) u'(l_t) \\
(1 + \tau_c) c_t + a_{t+1} &= \lambda(w_l z_l l_t)^{1-\tau_l} + R_t a_t
\end{align*}
$$

The intratemporal optimality condition is non-linear and thus costly to solve numerically. We therefore solve the non-linear intratemporal optimality condition only occasionally, similarly to the method proposed by Barillas and Fernandez-Villaverde (2007). In our model, we assume that government debt is a given fraction of output. Transfers are included in the labor tax function. We also need to take into account that the tax function takes mean income $\bar{y}$
as an argument. Our method can thus be summarized as follows:

1. **Loop in labor policies:** Fix an initial guess on policy \( l_t(a_t, z_t) \) and labor disutility parameter \( \phi \).

2. **Loop in prices and calibrating the parameters:** Fix \( w_s, w_u, R, B, \omega, \nu, \beta_s, \beta_u, \lambda, \bar{y} \).
   
   (a) We use \( y_t = \lambda(w_t z_t l_t)^{1-\tau_l} \) and solve for policies \( c_t \) and \( a_{t+1} \) as if \( y_t \) was exogenous using equation (2). Observe that to use equation (2), we need to express the labor policy as \( l_t(a_{t+1}, z_t) \) rather than \( l_t(a_t, z_t) \). We use \( l_t(a_t, z_t) \) and \( a_t(a_{t+1}, z_t) \) to get \( l_t(a_{t+1}, z_t) \). This approach is in fact very similar to the original endogenous grid idea.

   (b) We find the stationary distributions \( \lambda_s, \lambda_u \) implied by the policy functions.

   (c) We then compute aggregate capital and labor supplies along with output. Observe that while labor policies are constant in this loop, labor supply will depend on the stationary asset distributions. Given these, we compute prices \( w_s, w_u, R \) implied by demand, mean labor income \( \bar{y} \), government debt \( B \) and government expenditure \( G \) as a given fraction of output.

   (d) We then check if the prices coincide with the initial guesses. We check if the new \( \bar{y} \) and \( B \) coincide with the guesses and whether the government budget balances (given that \( G \) is a given fraction of output). We check if the aggregate labor supply, the skill premium, the labor share, the capital-to-output ratio and the relative asset holdings match the targets (see Table 2). If not, we update the guesses on \( w_s, w_u, R, B, \omega, \nu, \beta_s, \beta_u, \lambda, \bar{y} \) and iterate.

3. Given the policy \( c_t \) we find the labor policy \( \hat{l}_t \) that satisfies the intratemporal first order condition (3). We set \( \phi \) so that aggregate labor hits the target.

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4. We then use \( \alpha l_t + (1 - \alpha)\hat{\beta}_t \) (with \( \alpha \in (0, 1) \)) as a new guess for the labor policy and iterate until convergence. While we have no theorem that guarantees convergence, we find that the procedure performs well in our model.

**Solution Method for the Reform Exercise.** We use the same method as just outlined with one difference. In Step 2., we keep \( B, \omega, \nu, \beta_s, \beta_u, \lambda, \bar{y} \) fixed and search for equilibrium \( w_s, w_u, R, \) as well as for \( \tau_s = \tau_e \) that clear government budget.