The macroeconomic effects of progressive versus proportional taxation in a life cycle model

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Preliminary

Abstract

This paper revisits the comparison between progressive and proportional taxes both in the steady state and during business cycles. Previous studies have shown that progressive taxation has two main advantages over a proportional system. It reduces income inequality and generates a lower output volatility (i.e. it is a better automatic stabilizer). These benefits come with a cost: a lower steady-state output level. In this paper, I show that modeling age heterogeneity among individuals has important implications for this comparison; the results become more favorable to progressive taxation. When age heterogeneity is taken into account, the cost of progressive taxation is lower while the benefits are significantly higher. I then use the model to investigate the mechanisms driving these results.

1 Introduction

A common criticism of progressive income taxation is that this system discourages labor supply, and investments in both physical and human capital (e.g. Erosa and Koreshkova, 2007; Heckman et al., 1998a; Aaberge et al., 1995). As a result, progressive taxes reduce GDP

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and growth. At the same time, a progressive tax system promotes a greater redistribution of income and is shown to have a positive effect on equality (e.g. Guvenen et al., 2014). This explains why economies often rely on progressive taxes as opposed to proportional (flat-rate) taxes to raise income and finance government purchases.

Erosa and Koreshkova (2007) develop an overlapping generations model where agents live for three periods (i.e. childhood, adulthood and old age) and altruistic parents make human capital investments for their children. Within this framework, they show that switching from a progressive system to a revenue-equivalent proportional tax increases steady-state GDP by 12.6% and earnings inequality (measured by the Gini coefficient) by 0.016 percentage points.

This paper revisits the costs and benefits of progressive taxes within a life cycle framework and shows that the cost of progressive taxation (i.e. lower output) is reduced when one models the full life cycle of a person. Progressive tax rates discourage labor supply of middle-age individuals, while they increase hours worked of young individuals and individuals who are close to retirement. As a result, introducing age differences among agents reduces the negative impact of progressive taxation on aggregate labor supply and output. At the same time, the benefit in terms of lower inequality is enhanced when age heterogeneity is introduced in the model. Switching to a proportional tax system would increase output by 2% only, while it would increase inequality (measured by the Gini coefficient) by 20% (or 3 percentage points). Thus, the trade-off between output and equity becomes more favorable to progressive taxation when age heterogeneity is taken into account.\footnote{The model developed in this paper is similar to that in Heckman et al. (1998a), who also investigate the impact of taxation on output and other macroeconomic variables. They show that changing from a progressive system to a proportional one would increase GDP by 1.5%. However, they abstract from labor supply decisions (and leisure). By including labor supply decisions in the model, I am able to explain why the impact on GDP decreases when age heterogeneity is introduced.}

Further, I also investigate the benefits of progressive taxation during business cycles. Mattesini and Rossi (2012) show that progressive taxation alters how individuals respond to both technology and demand shocks, and reduces output volatility. McKay and Reis (2016) quantify this effect. Changing from progressive taxation to proportional taxation would raise...
output volatility but the effect is negligible: volatility would increase by 0.23% only.²

I revisit this topic within a life cycle model with technology shocks, and show that the life cycle structure (absent in previous studies) is very important. I show that proportional and progressive taxes have similar effects on the average worker in the economy. However, they have very different effects on young agents and individuals close to retirement, who tend to earn less than the average worker. Progressive taxation helps low income individuals and greatly reduces the volatility of their labor supply and income. Therefore, introducing age heterogeneity in the model increases the stabilizing power of progressive taxation. In this framework, changing from a progressive tax system to a proportional one would increase output volatility by 6%.

Finally, I use the model to further investigate the mechanisms driving the results. Progressive taxation reduces output volatility through two channels: (i) with a progressive system the government taxes individuals less (more) heavily during recessions (expansions) and (ii) this is especially true among low income individuals, whose labor supply and income are highly volatile. First, tax rates are fixed, but individuals tend to fall in a lower tax bracket during recessions, while the opposite is true during expansions. Thus, progressive taxation is a better stabilizer because the tax rates paid by individuals adjust automatically to business conditions. On the contrary, the proportional tax rate remains constant. Second, progressive taxes specifically help more vulnerable individuals, whose labor supply and income are highly volatile. I show that the first effect is large, while the second effect tends to be small. In other words, progressive taxation stabilizes the economy mainly because the marginal tax rates adjust automatically to business conditions. The progressivity itself plays a minor role. Finally, I show that the stabilizing power of progressive taxation depends on several factors such as: the degree of heterogeneity in the model economy, the degree of progressivity of the

²Using a similar framework, also Engler and Strehl (2016) quantify the increase in output volatility caused by a proportional tax finding a significantly larger effect: switching to a proportional tax would increase output volatility by 12%. However, in their model, the proportional tax is not set to match the revenue that the government would collect under progressive taxation. Therefore, it is not clear if the results are driven by the degree of progressivity of the tax or by the fact that one system collects more money and therefore taxes individuals more heavily.
tax and the elasticity of labor supply.

The rest of the paper is organized as follows. The next section outlines the model, while Section 3 discusses the calibration procedure. The steady-state analysis is presented in Section 4, while Section 5 compares progressive and proportional taxes in the presence of technology shocks. Finally, Section 6 concludes by summarizing the main results.

2 The model

2.1 Households

The model consists of overlapping-generations with an uncertain lifespan who live at most for $A_{\text{max}} = 62$ years. Since the paper focuses on taxes and income, I restrict attention to life after mandatory education. Therefore, age one in the model is meant to match age 18 in reality. Setting $A_{\text{max}}$ equal to 62 implies that the model matches life expectancy in the US (i.e. 79 years).

For simplicity, population is kept constant and cohorts have identical size. I normalize total population to one and compute cohort size ($\theta_s$) as follows:

$$\theta_s = \frac{\phi_s - 1}{\theta_s - 1} \quad (s = 2, \ldots, A_{\text{max}})$$

and

$$\theta_1 = 1 - \sum_{s=2}^{A_{\text{max}}} \theta_s.$$ 

$\phi_j$ is the probability of surviving from age $j - 1$ to age $j$ and $\theta_1$ is set so that the sum of cohort shares is equal to one.

At the beginning of their life, agents maximize their expected discounted lifetime utility which depends on consumption $c$, leisure $l$, and the discount factor $\beta$:

$$E_t \sum_{s=1}^{A_{\text{max}}} \left( \prod_{j=0}^{s-1} \phi_j \right) \beta^{s-1} U(c_{t+s-1,s}, l_{t+s-1,s}),$$

where the subscript $t$ denotes the time period, while the subscript $s$ denotes age. $E$ represents the expectation operator. Given the presence of shocks to inputs' productivity, agents need to form expectations about the future state of the economy. The utility function is a common constant relative risk aversion utility function:
where $\epsilon$ represent agents’ preference for leisure versus other activities (i.e. working and learning), while $\eta$ measures the degree of relative risk aversion. When maximizing their utility, agents face the following constraints:

$$k_{t+1,s+1} = (1 + r_t - \delta)k_{t,s} + (1 - \tau(y_{t,s}))y_{t,s} - c_{t,s} + T_t$$ \hspace{2cm} \text{budget constraint (3)}

$$y_{t,s} = w_t h_{t,s} n_{t,s}$$ \hspace{2cm} \text{labor income (4)}

$$h_{t+1,s+1} = (1 - \delta_h) h_{t,s} + \Omega_s h_{t,s} x_{t,s}^{\gamma}$$ \hspace{2cm} \text{human capital accumulation (5)}

$$l_{t,s} + n_{t,s} + x_{t,s} = 1$$ \hspace{2cm} \text{time endowment constraint (6)}

$$l_{t,s}, n_{t,s}, x_{t,s}, c_{t,s}, h_{t,s} \geq 0$$ \hspace{2cm} \text{non negativity constraints (7)}

$$n_{t,s} = 0 \text{ for } s = A_{\text{ret}} : A_{\text{max}}$$ \hspace{2cm} \text{retirement constraint (8)}

where $k$ is physical capital, $r$ is the rental rate of physical capital, $\delta$ is the depreciation rate of physical capital and $y$ is labor income. Individuals pay taxes on labor income and receive lump-sum transfers $T_t$ from the government. The marginal tax rate is denoted by $\tau$.

Labor income is given by the product between hours worked $n$ and hourly pay $w_t h_{t,s} n_{t,s}$, which depends on a common component $w$ and individual-specific human capital $h_t$. Human capital is produced by allocating time to learning $x$ according to equation 5. Learning takes time away from leisure but increases human capital, which leads to a higher hourly pay and indirectly a higher consumption. In specific, equation 5 implies that future human capital ($h_{t+1,s+1}$) depends on the un-depreciated current human capital stock ($h_{t,s}(1 - \delta_h)$) and an investment component ($\Omega_s h_{t,s} x_{t,s}^{\gamma}$). The latter depends on time spent learning ($x$), quality of learning ($\gamma$) and individuals’ productivity in learning $\Omega$. I calibrate the productivity in learning following the methodology used in Hansen and Imrohoroglu (2009), which I discuss in detail in Section 3.

I assume that individuals start their life with zero physical capital, while they receive
a positive endowment of human capital. The latter is to reflect the human capital stock accumulated during mandatory education. Finally, equation 8 implies that agents must retire when reaching age $A_{ret}$.\(^3\)

### 2.2 Firms

The production sector consists of several identical firms that produce output $Y_t$ following a Cobb-Douglas production function:

$$Y_t = z_t K^{\alpha} N^{1-\alpha}$$  \hspace{1cm} (9)

$$\ln(z_t) = \rho \ln(z_{t-1}) + u_t$$  \hspace{1cm} (10)

$$u_t \sim N(0, \sigma^2)$$  \hspace{1cm} (11)

where $z$ denotes aggregate productivity, $K$ is the aggregate physical capital stock, $N$ is aggregate labor supply in efficiency units, $\alpha$ is the capital share of output. The markets for inputs and output are perfectly competitive. This, combined with constant returns to scale, implies that input prices are equal to their marginal products:

$$w_t = (1 - \alpha) z_t K_t^{\alpha} N_t^{1-\alpha}$$  \hspace{1cm} (12)

$$r_t = \alpha z_t K_t^{\alpha-1} N_t^{1-\alpha}.$$  \hspace{1cm} (13)

### 2.3 The government

The government collects taxes on labor income and redistributes the proceeds equally to everyone (i.e. both workers and retirees) through a lump-sum transfer. I select a lump-sum transfer because it is non distortionary. There no public goods in the model that need to be financed and the government does not hold debt. Therefore, the budget constraint for the government is given by:

\(^3\)Introducing endogenous mandatory retirement would complicate the model but would not change the results significantly, as shown in Alessandrini et al. (2015).
\[
\sum_{s=1}^{A_{ret}-1} \tau_{y_{t,s}} T_{t} \theta_{t} = \sum_{s=1}^{A_{max}} T_{t} \theta_{t}. \quad (14)
\]

Following Guvenen et al. (2014), the marginal tax rate \( \tau \) is modeled as a smooth function of normalized labor income:

\[
\tau(y_{t,s}) = \alpha_0 + \alpha_1 \frac{w_{t,h_{t,s}n_{t,s}}}{AE} + \alpha_2 \left( \frac{w_{t,h_{t,s}n_{t,s}}}{AE} \right)^\phi \quad (15)
\]

where \( \alpha_0, \alpha_1, \alpha_2 \) and \( \phi \) are parameters governing the shape of the marginal tax function, while \( AE \) denotes steady-state average earnings in the economy:

\[
AE = \sum_{s=1}^{A_{ret}-1} w_{t,h_{t,s}n_{t,s}} \theta_{t} \quad (16)
\]

\( AE \) is used to normalize labor income. This normalization is necessary because earnings in the model and in the data have different units. Guvenen et al. (2014) estimates equation 15 for several countries: Finland, Sweden, Denmark, Netherlands, Germany, France, UK and US. The tax systems in these countries are all progressive but the US and UK present a lower degree of progressivity. In this paper, I use the parameter values estimated by Guvenen et al. (2014) for the US economy. This will be my benchmark economy. Then, I will replace the marginal tax rate \( \tau \) with a proportional (flat-rate) tax and investigate the macroeconomic effects of this change. The proportional tax rate is set to collect the same tax revenue generated by a progressive tax. This is important in order to correctly compare progressive versus proportional taxation. Otherwise the results would be affected not only by the fact that the two tax regimes create different incentives, but also by the fact that one system is collecting more money than the other (and thus, one system is taxing individuals more heavily).
2.4 The equilibrium and solution method

The households’ problem can be represented in a recursive manner. Let \( V_t = V(k_{t,s}, h_{t,s}, K_t, L_t, z_t) \) be the maximized value of the objective function of an age-\( s \) individual. \( V_t \) is the solution of the following dynamic programming problem:

\[
V_t = \max_{c_{t,s}, n_{t,s}, x_{t,s}} U(c_{t,s}, l_{t,s}) + \beta \varphi_s E_t V_{t+1}
\]

subject to equations (3)-(8).

Given the initial physical and human capital stocks distributions, and the productivity sequence \( \Omega_s \), the equilibrium is a collection of policy rules \( \{c_{s,t}(k_{t,s}, h_{t,s}, K_t, L_t, z_t), n_{s,t}(k_{t,s}, h_{t,s}, K_t, L_t, z_t), x_{t,s}(k_{t,s}, h_{t,s}, K_t, L_t, z_t), h_{t+1,s+1}(k_{t,s}, h_{t,s}, K_t, L_t, z_t), k_{t+1,s+1}(k_{t,s}, h_{t,s}, K_t, L_t, z_t)\} \), input prices \( \{w_t, r_t\} \) and government policies \( \{\tau(y_{t,s}), T_t\} \) such that the households’ problem described by equations (1)-(8) is solved, equations (12)-(13) are satisfied, the government budget balances, the market-clearing condition is satisfied:

\[
z_t K_t^\alpha L_t^{1-\alpha} = C_t + K_{t+1} - (1 - \delta)K_t
\]

and individual decisions are consistent with aggregate outcomes:

\[
N_t = \sum_{s=1}^{A_{ret}-1} n_{t,s} h_{t,s} \theta_s
\]

\[
K_t = \sum_{s=1}^{A_{max}} k_{t,s} \theta_s
\]

\[
C_t = \sum_{s=1}^{A_{max}} c_{t,s} \theta_s
\]

The solution method is discussed in detail in Heer and Maussner (2009, ch. 10). In summary, I solve for the non-stochastic steady state \( (z = 1) \) using backward induction. I start by guessing aggregate capital \( (K) \), aggregate labor in efficiency units \( (N) \), the marginal tax rate function \( (\tau(y_s)) \) and lump-sum transfers. Given these guesses, I compute input prices and solve the household’s optimization problem. Starting from the last period and using the fact that \( k_{t+1,s+1} = 0 \) when \( s = A_{max} \), it is possible to recover all variables proceeding
backwards up until age 1. Then, I compute $N$ and $K$ using equations (18) and (19), the tax rate $\tau$ using equation (15) and the lump-sum transfer $T$ using equation (14). If these values do not match the initial guesses, I update the guesses and repeat all steps until convergence.

Once the steady state is solved, I introduce temporary shocks to $z$ following the RBC literature. I log-linearize the first-order conditions around the steady state and solve for the percentage deviation of each variable from its steady state value caused by a one-percent deviation of $z$ from its steady state.

3 Calibration

The model is targeted to the US economy. One model period corresponds to one year. The tax function parameters ($\alpha_0$, $\alpha_1$, $\alpha_2$ and $\phi$) are taken directly from Guvenen et al. (2014), while the remaining parameters are calibrated as follows.

Demographics

Survival probabilities are taken from the Life Tables estimated by Bell and Miller (2002). The maximum age is set to 62 to generate a life expectancy of 79 years, which corresponds to life expectancy in the data. The retirement age $A_{ret}$ is set to 48 (age 65 in reality) so that the model matches the ratio between the number of retirees and active population observed in the data.

Utility and production functions

The discount factor is set to 0.9625 so that the model generates a capital to output ratio equal to 3. The parameter $\epsilon$ is set to 1.88 in order to generate an average hours worked equal to 0.33 (i.e. 33% of time is spent working). The parameter $\eta$ determines risk aversion and is usually in the set (1-3). However, the literature has not agreed on one specific value. Values closer to one generate an output volatility in the model that is closer to that observed in the data.

\footnote{When $\eta = 1$ the utility function becomes a logarithmic function.}
data. Therefore, I initially set $\eta = 1.1$. In Section 5 I show how the results are affected when one uses larger values.

The capital share of output is set to 0.36 following Hansen and İmrohoroğlu (2009), while the depreciation rate of physical capital is set to 6% to generate a net rate of return to capital of 6%. The parameters $\rho$ and $\sigma$ determine the persistence and variance of the shock. These parameters are set to 0.814 and 0.0142, respectively. These represent the annual equivalents to the values estimated by Prescott (1986) using quarterly data.

*Human capital accumulation*

The parameter $\gamma$ determines how effective learning is in increasing a person’s human capital. This parameter captures factors such as student-teacher ratio, quality of training or education received, quality of educational resources, etc. I set this parameter so that the model generates an average time spent learning close to what is observed in the data. Using data from the American Time Use Survey (ATUS, 2003-2015), I find that, on average, Americans allocate 1.08% of their time to learning throughout their working life (age 18-65). Thus, I set $\gamma$ to match this statistic.

The depreciation rate of human capital, $\delta_h$, is set to 0.001. This is consistent with other studies using low depreciation rates. See for example Manuelli and Seshadri (2009); DeJong and Ingram (2001); Heckman et al. (1998b).

The calibration of $\Omega_s$ and the initial endowment of human capital follows Hansen (1993) and Hansen and İmrohoroğlu (2009). In specific, I use data on earnings from the Panel Study of Income Dynamics (1967-2015) and estimate human capital for age $s$ using: $HE_s/HE$, where $HE_s$ is hourly earnings at age $s$ and $HE$ is hourly earnings averaged across all ages. To obtain a smooth function, I estimate this ratio for 5 age groups (18-24, 25-34, 35-44, 45-54, 55-65) and then interpolate the values to obtain human capital at all ages. The initial endowment of human capital is set to match human capital at age 18 estimated using this procedure. Then, I estimate $\Omega_s$ using equation (5): $\Omega_s = \frac{h^*_{s+1} - (1-\delta_h)h^*_s}{\rho h^*_s x^*_s}$. $h^*_s$ is estimated as outlined above, while $x^*_s$ is estimated using data from ATUS. Once $\delta_h$ and $\gamma$ are set, and the
sequences \{h_s^*, x_s^*\} have been estimated, one can compute \(\Omega\) using the equation above.

## 4 Progressive versus proportional taxes in the absence of shocks

The steady-state results generated by the model are consistent with the existing literature. Table 1 reports the steady state values for the main variables of interest. When considering alternative models (i.e. proportional tax and no tax), all model parameters are kept constant except for the marginal tax rates.

Consistently with previous findings in the literature, labor income taxes discourage labor supply and human capital accumulation, and thus lead to a lower output level. The negative impact on output is stronger when the tax is progressive. Switching from a progressive tax system to a proportional tax system would increase GDP by 2%.

Erosa and Koreshkova (2007) show that switching to a proportional tax system would increase GDP by 12.6%. In this paper, instead, the impact is significantly smaller. However, it is worth mentioning that the overlapping generations model developed in Erosa and Koreshkova (2007) had only three periods: childhood, adulthood and old age. Once the full life cycle is introduced, the results tend to be more modest because taxes do not have the same effect on all individuals. Figure 1 helps understand why. The figure shows how individuals respond to different types of taxes. The graphs report the life-cycle profiles for several variables of interest under three scenarios: (i) no taxes (and no lump-sum transfers), (ii) a progressive tax on labor income and (iii) a proportional tax on labor income that raises the same revenue collected under regime (ii). The first graph shows the marginal tax rate

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<tr>
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<th>(Y)</th>
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<th>(\sum n_s \theta_s)</th>
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<td>No tax</td>
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\(H\) denotes aggregate human capital.

### Table 1: Steady state values

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under regimes (ii) and (iii). Since the progressive tax is a function of income, which vary by age, the tax rate varies by age as well. A progressive tax hits more heavily middle-age workers (i.e. wealthier individuals in the population), while a proportional tax hits more heavily very young individuals (age 18-25) and individuals closer to retirement (age 55-65). This result is driven by the inverted U-shape of the earnings profile. Very young individuals and agents close to retirement earn less, and therefore pay a lower marginal tax rate under a progressive tax system. For this reason, switching to a proportional tax would reduce labor supply of these two groups, and would increase labor supply of middle-age individuals. This result suggests that incorporating the full life cycle structure is important if one is interested in quantifying the macroeconomic impact of taxation. Proportional taxation has a positive impact on aggregate labor supply, but this effect is less pronounced when one includes very young people (age 18-25) and individuals close to retirement (age 55-65).

Further, as discussed in Guvenen et al. (2014), progressive taxation discourages human capital accumulation. The third graph confirms that time allocated to learning is lowest
under regime (ii). The intuition is simple, since a progressive marginal tax rate increases with income, agents try to reduce their tax liability by investing less in human capital and lowering their income. In this model, human capital decreases by 0.8%. Instead, a proportional tax generates a life cycle profile for learning that is very similar to the profile under no tax.

Finally, also physical capital accumulation is affected. Despite the fact that the tax is imposed on labor income only, it affects earnings and therefore savings. Compared to a flat tax regime, a progressive tax increases disposable income for young agents, who in turn increase their physical capital, and reduces disposable income for middle-age agents, who in turn accumulate less physical capital. The net impact depends on the magnitude of these two effects and on demographics. In this model, physical capital is higher under a progressive regime. However, the opposite would be true if there was a higher concentration of old individuals in the model.

Despite the distortions they introduce, progressive taxes are common in reality because they reduce inequality. Erosa and Koreshkova (2007) show that switching from a progressive tax system to a proportional system would increase earnings inequality (measured by the Gini coefficient) by roughly 2%. In this model, instead, the effect is more substantial. Again, this may depend on the fact that including more than three generations creates a higher level of heterogeneity and inequality in the economy. Given my calibration, the Gini coefficient for earnings would increase by 20% if the government switched to a proportional tax regime. Progressive taxation reduces inequality by making the labor income profile flatter. With progressive taxation, young and old individuals pay a lower tax rate. This encourages their labor supply and increases their income. The opposite is true for middle-age individuals, whose labor supply and income decrease. This compression effect reduces differences among individuals in the economy and lowers the Gini coefficient. In comparison, a proportional tax system generates a profile for pre-tax earnings with a more pronounced inverted-U shape.

In summary, the steady state results are in line with the literature. However, they are more favorable to progressive taxation compared to the results in existing studies. One possible explanation is that, when the life cycle structure is introduced, the negative impact
of progressive taxes on output is less pronounced, while the positive impact on equality becomes stronger. The next section compares progressive and proportional taxation in the presence of shocks to inputs’ productivity.

5 Progressive and proportional taxation in the presence of shocks

Is progressive taxation a better economic stabilizer? This section investigates the impact of different tax regimes on the volatility of several macroeconomic variables. Note that I do not model cyclical fiscal policy. That is, the paper is not studying how taxes and transfers should change to stabilize the economy. Instead, I am interested in understanding if the economy responds differently to aggregate productivity shocks under different tax regimes. For this reason, the tax rates are fixed and do not respond to the shock. However, the tax revenue collected will change since labor income depends on the shock.

Table 2 reports the change in the volatility of several variables of interest when switching from a progressive tax system to a proportional tax system. This switch could be implemented in several ways and I consider two scenarios. First, I consider a proportional tax rate that is constant over time and collects the same steady state revenue as the progressive tax system. I call this regime “Proportional tax 1”. Second, I consider a proportional tax rate that collects the same tax revenue generated by a progressive tax in every period. In other words, the second scenario shows the impact of a proportional tax that keeps changing in every period to match the revenue that the government would collect with a progressive tax. I call this regime “Proportional tax 2”. This scenario is clearly unfeasible in reality. However, it serves as a benchmark and helps understand the differences between progressive and proportional taxation. Potentially, a progressive tax system may be a better economic stabilizer for two
reasons.

First, the marginal tax rate that a single individual faces may change during business cycles because his/her income changes. Individuals tend to fall in a lower tax bracket during recessions and move to a higher tax bracket during expansions. In this case, the government collects a lower tax revenue not only because incomes are lower but also because individuals pay a lower tax rate. This does not happen with a proportional tax because the tax rate remains constant. Progressive taxation may be a better stabilizer because of this “revenue effect”.

Second, progressive taxation mainly helps individuals who are more vulnerable to business cycles. For example, during a recession, income drops significantly more for low income individuals and inequality rises. A progressive tax would help low income individuals more than others, and should be a more powerful stabilizer than proportional taxation. It should stabilize income and consumption of those who normally experience the largest variation in labor supply. I call this the “tax progressivity effect”.

Therefore, I create two different types of proportional taxes to understand whether the benefits of progressive taxation (if any) depend on the fact that the tax revenue collected under a progressive tax regime changes over time (revenue effect) or on the fact that the tax is more generous to vulnerable individuals (tax progressivity effect).

Table 2 shows that the volatility of output would increase by 2%-6% if the government switched to a proportional tax system. This is driven by both an increase in the volatility of labor supply ($\%\Delta N$) and an increase in the volatility of physical capital investments ($\%\Delta I$). When the government switches to proportional tax 1, both revenue and tax progressivity effects are present. As a result output volatility increases by 6%. When the government switches to proportional tax 2, only the tax progressivity effect is present and output volatility increases by 2% only. This difference suggests that both effects are important. However, the revenue effect appears to be stronger.

The intuition for these results is as follows. The proportional tax rate remains constant,

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5See, for example, Heathcote et al. (2010), Hoover et al. (2009), Maestri and Roventini (2012).
Figure 2: Percentage change in life cycle profiles immediately after the shock

while the progressive tax rate that each individual faces changes as soon as their income changes. Thus, the government taxes more heavily people when proportional tax 1 is in place and volatility of output increases (revenue effect). The impact is smaller if the government is able to change the marginal tax rate in every period in order to generate the same revenue that a progressive tax would generate. Proportional tax 2 increases the volatility by 2% only. However, the fact that this is different than zero suggests that the “tax progressivity effect” also plays a role.

To understand the mechanisms driving these results, it is helpful to study what happens to each individual right after the shock. Figure 2 shows the percentage deviation from the steady state immediately after a negative shock (i.e. a negative one-percent decline in $z$). This snapshot of the economy shows that hourly pay decreases by 0.8% and this decrease is fairly homogeneous across the economy, while the drop in hours worked is more heterogeneous. Everyone experiences a reduction in hours worked. However, the drop is stronger among young and old individuals, especially with proportional tax 1. This partially explains why a
proportional tax increases output volatility. Proportional tax 2 generates results in between those produced by a progressive tax and proportional tax 1. The reason is that the marginal tax rate adjusts in every period and individuals pay a lower tax rate. This is particularly helpful for old individuals whose labor supply becomes less volatile.

These results complement the findings in McKay and Reis (2016), who conducted a similar exercise and showed that switching to proportional taxation increases output volatility by 0.23% only. However, their model is abstracting from age heterogeneity and life cycle considerations. When one introduces these differences, the impact on volatility becomes larger. Figure 3 shows the percentage change in income volatility by age group when switching from progressive to proportional tax 1 (left panel) or proportional tax 2 (right panel). Here income refers to pre-tax income and includes both labor and capital income. The sum of income across all groups yields GDP (Y). The figure shows that switching to a proportional tax increases the volatility of income among young individuals and among agents close to retirement. However, it reduces the volatility of income among middle-age individuals (age 28-47). Consistent with the results in Table 2, the change in volatility is less pronounced if one considers the second proportional tax system. However, under both scenarios, volatility increases substantially among vulnerable individuals (young and old agents) and decreases...
Table 3: %Δσ_Y under alternative scenarios

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Ω = Ω̄</th>
<th>Swedish tax values</th>
<th>η = 2</th>
<th>η = 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportional tax1</td>
<td>5.90</td>
<td>4.87</td>
<td>9.21</td>
<td>5.19</td>
<td>5.63</td>
</tr>
<tr>
<td>Proportional tax2</td>
<td>2.38</td>
<td>0.87</td>
<td>2.18</td>
<td>1.52</td>
<td>0.82</td>
</tr>
</tbody>
</table>

among middle-age workers. This suggests that ignoring age heterogeneity could significantly downplay the impact of taxes on output volatility.

To further investigate the importance of agents’ heterogeneity, I compute the results for a modified version of the model where I replace Ω_s with its average \( Ω = \sum_{s=1}^{A_{ret}} Ω_s \theta(s) \). Thus, all agents are equally productive in learning. This greatly reduces differences among individuals in the economy and therefore inequality. Then, I calculate the percentage increase in output volatility if one switches from a progressive tax system to a proportional tax regime. The results are reported in the second column of Table 3. The difference between proportional and progressive taxes is reduced and the progressivity effect becomes negligible. The first panel of Figure 4 compares the life-cycle profile of labor income in this modified economy and the profile in the baseline economy. When productivity differences are eliminated, the profile becomes very flat and differences among individuals in the economy vanish almost entirely. In this case, the tax progressivity effect is basically zero. The benefit from progressive taxation comes only from the revenue effect. Thus, the stabilizing power of progressive taxation is much smaller compared to the baseline economy. This suggests that if one is interested in assessing the gains and costs from switching between tax systems, it is very important to pay attention to agents’ heterogeneity in the model. Models with agents that are too homogeneous underestimate the stabilizing power of progressive taxation.

I conduct another experiment by changing the degree of progressivity of the tax system. In specific, I change the progressive tax function parameters \( (α_0, α_1, α_2, φ) \) to match the values estimated by Guvenen et al. (2014) for Sweden, which has a more progressive tax system than the US. Then, I re-estimate the percentage change in volatility when switching
from a progressive to a proportional tax. The results are shown in the third column of Table 3. In this case, the cost (in terms of output volatility) from switching to proportional tax 1 is greater. This is mainly due to the revenue effect. Under a more progressive tax system, the tax revenue drops significantly during a recession as people fall into lower tax brackets more rapidly. Thus, the revenue effect is larger. On the other hand, the tax progressivity effect is slightly smaller. The second panel of Figure 4 shows that a more progressive tax (such as a Swedish tax) flattens the life cycle profile of labor income, although the effect is very modest. Similar to the previous experiment, when differences among individuals in the economy are less pronounced, the tax progressivity effect becomes smaller. If the government was able to replace the progressive tax with a very flexible proportional tax (i.e. proportional tax 2), output volatility would increase by 2.18%, which is slightly smaller than the increase observed in the baseline version of the model (2.38%).

Finally, I consider alternative values for the relative risk aversion parameter ($\eta$). The baseline version of the model is based on $\eta = 1.1$ because low values of $\eta$ generate an output volatility that is closer to that observed in the data. However, I also experiment with other values and report the results in the last two columns of Table 3. As $\eta$ increases, the cost of switching to proportional taxation decreases. In particular, the tax progressivity effect is
significantly reduced. This is because a higher value of risk aversion flattens the life cycle profile of income and reduces differences across individuals. The last panel of Figure 4 shows how the life cycle profile of labor income changes as \( \eta \) increases. As risk aversion increases, individuals increase their labor supply and capital investments at the beginning of the life cycle, while they reduce labor supply and investments later on. Thus, the labor income profile becomes flatter. The economy is more homogeneous and the benefits from progressive taxation decrease. The tax progressivity effect becomes significantly smaller as risk aversion increases.

6 Conclusions

This paper revisits the comparison between progressive and proportional labor income taxation within a life cycle framework. Previous studies showed that, compared to a proportional tax, progressive taxation presents two main advantages: (i) it reduces inequality in the economy since income redistribution is higher and (ii) it is a better economic stabilizer because it reduces output volatility. These benefits come with a cost: progressive taxation discourages labor supply and physical capital accumulation, resulting in a lower steady-state output level.

This paper shows that, when age heterogeneity is introduced in the model, the cost (i.e. lower steady state output) of progressive taxation decreases while the benefit (i.e. lower inequality and output volatility) increases. The cost is lower because progressive taxation discourages labor supply of middle-age individuals, while it has a positive effect on labor supply of young and old agents. Thus, introducing age differences mitigates the negative impact of progressive taxation on aggregate labor supply and therefore output.

Further, a progressive tax system reduces income volatility among young and old individuals, who are more vulnerable during business cycles. Thus, the positive effect of progressive taxation on output stability is greater when one introduces age differences among agents in the model economy.

Finally, the model used in this paper is also able to shed light on why progressive taxation
is a better economic stabilizer. *First*, in a proportional tax system, marginal tax rates are constant. Absent cyclical fiscal policy, individuals pay the same tax rate during expansions and recessions. On the contrary, with progressive taxation, individuals tend to fall in a lower tax bracket during a recession and move to a higher tax bracket during expansions. Thus, the marginal tax rate is more flexible and individuals are taxed less (more) heavily during recessions (expansions). *Second*, progressive taxation stabilizes output by helping the most vulnerable individuals: young and old individuals. Earnings are very volatile for these two groups and progressive taxation helps reduce their income volatility.

I show that the first effect tends to be larger. In other words, progressive taxation stabilizes the economy mainly because the marginal tax rates adjust automatically to business conditions. The progressivity itself plays a minor role. This implies that, if the government was able to implement a flexible proportional tax system (i.e. a proportional tax that changes frequently to match the revenue collected with a progressive tax), the differences between progressive and proportional taxation would be significantly reduced.
References


