Resource Misallocation and Aggregate Productivity under Progressive Taxation∗

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Abstract

This paper quantitatively examines the long-run macroeconomic effects of resource misallocation in an otherwise standard one-sector neoclassical growth model with heterogeneous establishments, characterized by different ages and productivity levels, that are subject to progressive taxation as well as endogenous entry decisions. Under a progressive fiscal policy rule, capital and labor inputs move from more productive to less productive establishments because the latter face a lower tax rate. When the tax progressivity rises, the economy’s overall production will fall since low-productivity establishments use an inefficiently high level of productive resources (the intensive margin). On the other hand, more progressive taxation reduces the economy’s total number of operating establishments, which in turn further decreases aggregate output (the extensive margin). Under the benchmark parameterization, we find that the measured aggregate productivity also falls when the tax schedule becomes more progressive. For the sensitivity analyses, we consider alternative specifications with fixed labor supply or different returns-to-scale in production.

Keywords: Resource Misallocation, Aggregate Productivity, Progressive Taxation, Idiosyncratic Distortions.

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1 Introduction

There has been a growing literature that explores the effects of resource misallocation on a macroeconomy’s output and measured total factor productivity (TFP).\(^1\) Moreover, several recent studies have found that varying entry costs may help explain the substantial cross-country income differences.\(^2\) In the context of a dynamic general equilibrium model with heterogeneous establishments, aggregate TFP depends not only on the productivity level of each individual firm, but also on how productive factors are allocated across these production units. As a result, government policies that distort the relative prices faced by heterogeneous establishments will influence the resource allocations and thus generate considerable effects on aggregate economic activity. These policies also affect the expected value of incumbent establishments, which in turn will impact the entry decision of potential entrants, as well as the total number of establishments in operation and the resulting overall output. Motivated by this strand of previous research, our paper quantitatively examines the long-run effects of resource misallocation on the economy’s aggregate variables within an otherwise standard one-sector neoclassical growth model in which output is carried out by heterogeneous establishments, characterized by different ages and productivity levels, that are subject to a progressive tax policy \textit{à la} Guo and Lansing (1998) together with endogenous entry decisions.

Given the progressive fiscal policy rule under consideration, below-average productive establishments face lower tax rates whereas above-average counterparts within the same age-cohort are subject to heavier taxation. In terms of across-cohort distortions, since older establishments tend to be larger and more productive than their younger counterparts, progressive taxation will disproportionally hurt more mature firms. Our nonlinear tax formulation therefore affects macroeconomic aggregates through the channels of both intensive and extensive margins. On the one hand, capital and labor inputs will move from more productive to less productive establishments within as well as across cohorts. When the tax progressivity rises, resource misallocation exacerbates the overall production as low-productivity establishments use an inefficiently high level of productive resources – this is the adjustment along the intensive margin. On the other hand, since establishments may freely enter the market upon the payment of an entry cost, progressive taxation decreases the expected value of an incumbent establishment. This discourages potential entrants to enter the market, which in turn further reduces aggregate production – this is the

\(^1\)See, for example, Hopenhayn and Rogerson (1993), Lagos (2006), Restuccia and Rogerson (2008), Guner, Ventura and Xu (2008), Hsieh and Klenow (2009), Buera, Kaboski and Shin (2011), Caselli and Gennaioli (2013), and Buera and Shin (2013), among others.
\(^2\)See, for example, Barseghyan (2008), Barseghyan and DiCecio (2011), and Boedo and Mukoyama (2012), among others.
For the quantitative analyses, we calibrate the tax-progressivity parameter to match with Hsieh and Klenow’s (2014) empirical estimate on the elasticity of distortion with respect to productivity for the U.S. economy. Together with this baseline degree of tax progressivity, we also calibrate the returns-to-scale parameters and firm-level productivities in the model economy to match with the age and size distributions across U.S. establishments, as reported in Boedo and Mukoyama (2012); and then postulate the benchmark specification to feature variable labor supply. We focus on the model’s stationary competitive equilibrium and analyze the macroeconomic impacts of changes in the level of tax progressivity. Relative to the “baseline tax distortion” case, our benchmark model exhibit decreases in the numbers of entrants as well as incumbents, ranging from 0.13 to 0.20 percent, when the fiscal policy rule becomes more progressive. Moreover, there are decreases in both labor (by 0.94 to 3.20 percent) and capital (by 2.08 to 7.16 percent) inputs, hence total output falls by 1.21 to 4.26 percent. Finally, we find that the economy’s aggregate total factor productivity will slightly fall (by 0.06 to 0.28 percent) as the tax progressivity rises. In sum, these results demonstrate the quantitative interrelations between resource misallocations and the decrease in the total number of incumbent establishments.

To obtain further insights about the proceeding tax-change outcomes, we decompose the total effects into adjustments along the intensive margin (the average employment level across operating establishments) and the extensive margin (the total number of producing firms). Specifically, the extensive-margin changes are suppressed by adjusting the parameter value of entrance cost such that the stationary productivity distributions over establishments under different levels of tax progressivity are identical to that in our “baseline tax distortion” case. As a result, the resource-misallocation or the intensive-margin effects across incumbent firms can be singled out. Based on this decomposition exercise for our benchmark model, the intensive margin, i.e. effects due to resource misallocation, accounts for a quantitatively larger fraction of falls in aggregate output (by 1.19 to 4.22 percent), aggregate consumption (by 1.13 to 4.05 percent), aggregate capital (by 2.06 to 7.12 percent), aggregate labor (by 0.94 to 3.20 percent), equilibrium wage (by 1.12 to 4.05 percent) and aggregate TFP (by 0.04 to 0.25 percent).

For the sensitivity analyses, we first consider an alternative formulation by postulating the number of working employees to be a fixed constant over time. Under the presence of endogenous entry decisions, more progressive taxation generates smaller decreases in capital (by 1.15 to 4.09 percent) and output (by 0.28 to 1.10 percent) than those in our benchmark model. However, the total numbers of new entrants and operating incumbents increase by 0.82 to 3.10 percent when
the fiscal policy becomes more progressive. These turn out to be qualitatively opposite to those in our baseline specification with endogenous labor supply. Moreover, this positive effect along the extensive margin dominates the negative effect of resource misallocation from the intensive margin. Therefore, the measured aggregate TFP will rise (by 0.08 to 0.18 percent).

Next, since the returns-to-scale parameters play an important role in affecting the number of producing establishments and thus the economy’s aggregate variables, we examine two alternative calibrations that are all higher or lower than those in our benchmark formulation. In the former case, the optimal scale for each operating establishment becomes relatively higher, hence progressive taxation generates a larger negative effect from misallocation of productive resources. On the other hand, the expected value of an incumbent producer rises as the fiscal policy rule becomes more progressive, which in turn will encourage more potential entrants to enter the market and more establishments to produce. We also find that as the tax progressivity rises, the measured aggregate TFP initially rises by 0.006 percent, and then gradually falls by 0.05 percent, which reflects the interactions between the positive effects from the extensive margin versus the negative effects from misallocation of productive resources. Finally, when incumbent establishments of all age categories exhibit a relatively lower degree of returns-to-scale in production, we find that the tax-change outcomes are all qualitatively identical to those within our benchmark model.

This paper is closely related to Restuccia and Rogerson (2008) who also quantitatively investigate the effects of establishment-level distortions on aggregate production and productivity. Our analyses differ from theirs in four aspects. First, we allow the household’s labor supply decision to be endogenous, which turns out to yield substantial impacts along the intensive as well as the extensive margins; and thus can exert significant qualitative and quantitative effects on the economy’s aggregate TFP when the tax policy becomes more progressive. Second, we incorporate firm life-cycle dynamics by gradually expanding the capacity constraint with an establishment’s years in operation, which in turn captures the empirical regularities that (i) age is related to firms’ size and (ii) young firms are smaller and grow faster than old firms. Third, we consider the establishment-level distortions with a progressive feature that is commonly observed in industrialized countries. Finally, we take into account the dynamic changes of factor prices and their corresponding general equilibrium effects as the tax progressivity changes, whereas Restuccia and Rogerson’s study focuses on the case in which the relative prices remain unchanged.3

The remainder of the paper is organized as follows. Section 2 describes our benchmark model in

3Restuccia and Rogerson (2008) examine various combinations of idiosyncratic distortions that do not affect the steady-state level of aggregate capital stock. Since labor supply is fixed in their setting, this is equivalent to setting equilibrium prices constant.
which production is carried out by heterogeneous establishments, and the household’s labor supply as well as establishments’ entry decisions are endogenously determined. We then derive the optimal conditions that characterize the economy’s stationary equilibrium prices and allocations. Section 3 quantitatively compares and contrasts the model’s steady states under alternative specifications. Section 4 concludes.

2 The Economy

We examine a one-sector dynamic general equilibrium model that builds upon the work of Hopenhayn (1992) and Hopenhayn and Rogerson (1993) with two important departures: (i) introduction of progressive taxation on incumbent establishments’ output, and (ii) abstraction of establishment-level productivity dynamics, as in Restuccia and Rogerson (2008), such that each operating establishment’s productivity remains constant over time. Our model economy consist of a representative household, heterogeneous establishments with different levels of total factor productivity (TFP), and the government. Households live forever, and derive utilities from consumption and leisure. Establishments produce the unique consumption good with a decreasing returns-to-scale technology that is subject to a progressive fiscal policy rule whereby more productive establishments face a relatively higher tax rate. Moreover, in order to characterize the plant life-cycle dynamics, we divide producing establishments into three age categories indexed by \( j \in \{1, 2, 3\} \), which respectively corresponds to young, middle-aged, and mature firms. The government balances its budget each period by returning all its tax revenue to the representative household as a lump-sum transfer.

2.1 Households

The economy is populated by a unit measure of identical infinitely-lived households. Each household is endowed with \( T > 0 \) units of time and maximizes its present discounted lifetime utility

\[
\max_{\{C_t, N_t, K_{t+1}\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t), \quad 0 < N_t < 1,
\]

where \( E_0(\cdot) \) is the conditional expectation operator, \( \beta \in (0, 1) \) is the discount factor, \( C_t \) is consumption at period \( t \), and \( N_t \) is the labor hours supplied to the market. Since there is no distinction between hours and employment in our model, \( N_t \) also represents the number of working employees. The budget constraint faced by the representative household is given by

\[
C_t + K_{t+1} - (1 - \delta)K_t + TR_t = r_t K_t + w_t N_t + \Pi_t, \quad K_0 > 0 \text{ given},
\]
where $K_t$ is capital stock, $\delta \in (0, 1)$ is the capital depreciation rate, $r_t$ is the capital rental rate, $w_t$ is the real wage, $\Pi_t$ represents total profits from the household’s ownership of all operating establishments, and $TR_t$ is a lump-sum transfer payment made by the government. The first-order conditions for the household’s dynamic optimization problem are:

\[
-\frac{U_N(C_t, N_t)}{U_c(C_t, N_t)} = w_t, \quad (3)
\]

\[
U_c(C_t, N_t) = \beta E_t \{U_c(C_{t+1}, N_{t+1})[1 - \delta + r_{t+1}]\}, \quad (4)
\]

\[
\lim_{t \to \infty} \beta^t U_c(C_t, N_t) K_{t+1} = 0, \quad (5)
\]

where $U_c(\cdot) > 0$ is the marginal utility of consumption and $U_N(\cdot) < 0$ is the marginal disutility of hours worked. In addition, (3) equates the slope of the household’s indifference curve to the real wage rate, (4) is the standard Euler equation for intertemporal consumption choices, and equation (5) is the transversality condition.

### 2.2 Establishments

There are two types of establishments in the economy: operating incumbents and potential entrants. Upon payment of a fixed entrance cost $c_e > 0$, a potential entrant will become a young establishment indexed by $j = 1$. The age category $j \in \{1, 2, 3\}$ is a function of an establishment’s years in operation or age denoted as $a$. As in Davis, Haltiwanger, and Schuh (1996, p.225), we postulate that young establishments, indexed by $j = 1$, correspond to those with 1 year in operation, i.e. $a = 1$; middle-aged establishments, indexed by $j = 2$, corresponding to those operating for 2-10 years, i.e. $a \in \{2, 3, ..., 9, 10\}$; and that mature/old establishments, indexed by $j = 3$, corresponding to those with 11 years or more in operations, i.e. $a \in \{11, 12, ..., \infty\}$. A young establishment, after its operation for one year, will becomes a middle-aged enterprise. Similarly, a middle-aged establishment will become mature after 9 years in operation. As a result, the relationship between $j$ and $a$ can be expressed as follows:

\[
j(a) = 1, \quad \text{for} \quad a = 1; \quad (6)
\]

\[
j(a) = 2, \quad \text{for} \quad a = 2, 3, ..., 9, 10; \quad (7)
\]

\[
j(a) = 3, \quad \text{for} \quad a = 11, 12, ..., \infty. \quad (8)
\]

Each producing firm $i$ has access to the following Cobb-Douglas production function that exhibits decreasing return-to-scale:
\[
y_{at}(s_i, j(a)) = \begin{cases} 
  s_i \left[ k_{at} (s_i)^\alpha n_{at} (s_i)^{1-\alpha} \right]^{\gamma_j(a)} & \text{for } j(a) = 1, a = 1 \\
  s_i \left[ k_{at} (s_i)^\alpha n_{at} (s_i)^{1-\alpha} \right]^{\gamma_j(a)} & \text{for } j(a) = 2, a = [2, 10] \\
  s_i \left[ k_{at} (s_i)^\alpha n_{at} (s_i)^{1-\alpha} \right]^{\gamma_j(a)} & \text{for } j(a) = 3, a \geq 11 
\end{cases}
\] (9)

where \(a\) is an establishment’s years in operation, \(0 < \alpha < 1\) governs the capital elasticity, \(\{\gamma_j(a)\}_{j(a) \in \{1,2,3\}} \in (0, 1)\) determine the age-dependent degrees of returns-to-scale in production, \(k_{at} (s_i)\) and \(n_{at} (s_i)\) are the capital and labor inputs, and \(s_i\) represents the establishment-level total factor productivity that is randomly drawn from an exogenously specified distribution. Since there is one to one mapping between \(j(a)\) and \(a\), as shown in (6)-(8), we can drop the index \(j(a)\) from (9) and rewrite firms’ production technologies as a function of age and productivity level whereby\(^4\)

\[
y_{at} (s_i) = s_i \left[ k_{at} (s_i)^\alpha n_{at} (s_i)^{1-\alpha} \right]^{\gamma_j} .
\] (10)

Given our objective is to analyze the cross-sectoral heterogeneity among incumbent producers, we follow Restuccia and Rogerson (2008) and postulate that the value of \(s_i\) is constant over time for a given establishment. Moreover, since the degree of returns-to-scale \(\gamma_j\) depends on a firm’s years in operation, age is related to both firms’ size and growth. In order to parsimoniously capture the firm life-cycle dynamics, \(\gamma_j\) is postulated to evolve in the following simple first-order fashion until reaching a “mature” level for old-aged firms:

\[
\gamma_{j+1} = \gamma_j (1 + g), \quad j \in \{1, 2\} \quad \text{and} \quad g > 0,
\] (11)

such that young enterprises are smaller and grow faster than old establishments as documented in the actual data. Notice that (11) will allow our model to accommodate the realism of (due to age differences) two same-sized firms with different labor productivities, as well as two same-TFP firms having different sizes. Our formulation of firm life cycle also provides a plausible justification for the fiscal authority to set policies that alleviate the tax burden on low-income establishments, which turn out to be disproportionately young and small.

2.2.1 Incumbent Establishments

The optimal decision of an operating establishment with productivity \(s_i\) and age \(a\) is hiring capital and labor services to maximize its current profit

\(^4\)Similarly, to simplify the notations below, we will suppress \(a\) as the input argument of the \(j\) functions (6)-(8) whenever there is no confusion.
\[ \pi_{at}(s_i) = [1 - \tau_{at}(s_i)] y_{at}(s_i) - w_t n_{at}(s_i) - r_t k_{at}(s_i), \]  

where \( \tau_{at}(s_i) \in (0, 1) \) is the output tax rate, and \( y_{at}(s_i) \) is given by (10). Similar to Guo and Lansing (1998), we postulate that \( \tau_{at}(s_i) \) takes the functional form

\[ \tau_{at}(s_i) = 1 - \eta \left[ \frac{\bar{y}_t}{y_{at}(s_i)} \right]^{\phi}, \quad 0 < \eta < 1 \text{ and } \phi > 0, \]  

where \( \bar{y}_t \) is the average level of output produced by all incumbent enterprises across productivities and over ages at period \( t \); and the parameters \( \eta \) and \( \phi \) govern the level and slope of the tax schedule. Using (13), we obtain the expression for the marginal tax rate \( \tau_{at}^m(s_i) \), which is defined as the change in taxes paid by an incumbent divided by the change in its output level, as follows:

\[ \tau_{at}^m(s_i) \equiv \frac{\partial [\tau_{at}(s_i) y_{at}(s_i)]}{\partial [y_{at}(s_i)]} = 1 - \eta (1 - \phi) \left[ \frac{\bar{y}_t}{y_{at}(s_i)} \right]^{\phi}. \]  

It is then immediately clear that when \( \phi \) is positive, the marginal tax rate (14) is higher than the average tax rate given by (13). In this case, the tax schedule is said to be “progressive”, which is an empirically realistic feature in U.S. and many industrialized countries.

Operating establishments are postulated to take into account the way in which the tax schedule affects their production levels when they decide the amount of capital and labor inputs to employ. Consequently, it is the marginal tax rate \( \tau_{at}^m(s_i) \) that governs an incumbent firm’s economic decisions. Under the assumption that factor markets are perfectly competitive, the optimal decisions for establishment \( i \) whose age being \( a \)’s choices of capital \( \hat{k}_{at}(s_i) \) and labor \( \hat{n}_{at}(s_i) \) are

\[ \hat{k}_{at}(s_i) = \left[ \frac{\alpha}{\gamma_j} \right]^{1 - (1 - \phi)(1 - \alpha) \gamma_j} \left( \frac{1 - \alpha}{w_t} \right)^{(1 - \alpha)(1 - \phi) \gamma_j} \eta (1 - \phi) s_i^{1 - \phi \gamma_j} \frac{\bar{y}_t^{\phi \gamma_j}}{\gamma_j^{1 - \gamma_j(1 - \phi)}}, \]  

\[ \hat{n}_{at}(s_i) = \frac{1 - \alpha}{\alpha} r_t \hat{k}_{at}(s_i). \]  

Finally, we assume that all incumbents face the same constant probability of exit \( \lambda \in (0, 1) \) each period. Since the degree of returns-to-scale \( \gamma_j \) for an establishment depends on its age or years in operation, it will have access to different production technologies as time goes on (see equation 9). It follows that the discounted life-time value for an incumbent \( i \) of age \( a \) can be expressed as

\[ W_{at}(s_i) = \sum_{t=a}^{\infty} \left( \frac{1 - \lambda}{1 + R} \right)^{t-a} \pi_{at}(s_i), \]  

where \( \pi_{at}(s_i) \) is given by (12) and \( R \left( = \frac{1}{\beta} - 1 \right) \) is the real interest rate.
2.2.2 Entering Establishments

A potential entrant makes its entry decision based on the comparison of the entrance cost \( c_e \) versus the expected post-entry value after becoming an incumbent establishment with the randomly-drawn total factor productivity \( s_i \). As a result, the present discounted value of a potential entrant \( W_{et} \) is

\[
W_{et} = -c_e + \int \max_{\tilde{\chi}_t(s_i) \in \{0,1\}} \left\{ \tilde{\chi}_t(s_i)W_{1t}(s_i)h(s_i)ds_i \right\},
\]

where \( W_{1t}(s_i) \) is the value of an entrant (i.e., a young producing establishment), given by (17), with productivity \( s_i \); \( h(s_i) \) is the probability density function of \( s_i \), and \( \tilde{\chi}_t(s_i) \) denotes the optimal decision rule for an entering establishment about whether to engage in production or not. Specifically, \( \tilde{\chi}_t(s_i) = 1 \) means that entrepreneur \( i \) enters the market at period \( t \). If the productivity draws are all positive among producing establishments, they will remain in operation as time moves on. Moreover, firms will continue to enter as long as \( W_{et} \) is strictly positive, which in turn implies that the free-entry condition \( W_{et} = 0 \) will hold in equilibrium.

Using \( \mu_{j,a,t}(s_i) \) to denote the distribution of age-index \( j \) with \( a \) years in operation and establishment-level productivity \( s_i \) in period \( t \), it is straightforward to derive the following laws of motion:

\[
\mu_{1,a,t}(s_i) = \tilde{\chi}_t(s_i)h(s_i)E_t, \text{ for } a = 1; \tag{19}
\]
\[
\mu_{2,a+1,t+1}(s_i) = (1 - \lambda)\mu_{2,a,t}(s_i), \text{ for } a = 2, 3, \ldots, 9; \tag{20}
\]
\[
\mu_{3,a+1,t+1}(s_i) = (1 - \lambda)\mu_{3,a,t}(s_i), \text{ for } a = 11, 12, \ldots \infty, \tag{21}
\]

where \( E_t \) denotes the mass of potential entrants, \( \mu_{2,2,t}(s_i) = (1 - \lambda)\mu_{1,1,t}(s_i) \), and \( \mu_{3,11,t}(s_i) = (1 - \lambda)\mu_{2,10,t}(s_i) \).

2.3 Government

The government is postulated to balance its budget every period. Since a given distribution of establishment-level taxes does not necessarily lead to a balanced budget, we postulate that the government levies lump-sum transfers \( TR_t \) on the representative household. Hence, its period budget constraint is given by

\[
\sum_{a=1}^{\infty} \int \tau_{at}(s_i)\hat{y}_{at}(s_i)\mu_{j,a,t}(s_i)ds_i = TR_t, \tag{22}
\]
where $\hat{y}_{jt}(s_i)$ is the optimal level of output that establishment $i$ produces with $\hat{k}_{jt}(s_i)$ and $\hat{n}_{jt}(s_i)$ à la (15)-(16) as factor inputs.

2.4 Market Clearing

The equalities of demand by operating establishments and supply by households in the capital and labor markets are

\[
K_t = \sum_{a=1}^{\infty} \int \hat{k}_{at}(s_i) \mu_{j,a,t}(s_i) ds_i, \quad (23)
\]

\[
N_t = \sum_{a=1}^{\infty} \int \hat{n}_{at}(s_i) \mu_{j,a,t}(s_i) ds_i. \quad (24)
\]

Next, the economy’s total output $Y_t$ is defined as

\[
Y_t = \sum_{a=1}^{\infty} \int \hat{y}_{at}(s_i) \mu_{j,a,t}(s_i) ds_i, \quad (25)
\]

and the aggregate resource constraint is given by

\[
C_t + X_t + c_e E_t = Y_t, \quad (26)
\]

where $X_t$ is gross investment that is governed by the following aggregate law of motion for capital stock:

\[
K_{t+1} = (1 - \delta)K_t + X_t. \quad (27)
\]

2.5 Stationary Equilibrium

As in Restuccia and Rogerson (2008), our analysis is focused on the model’s stationary competitive equilibrium with a time-invariant distribution of productivity levels across different incumbent establishments. Variables without time subscripts are used to denote their steady-state values.

Per the consumption Euler equation (4), the steady-state rental rate for capital services is

\[
r = \frac{1}{\beta} - (1 - \delta) = R + \delta, \quad (28)
\]

where $R$ represents the real interest rate (see equation 17). In addition, using this equation (4), the zero-profit equilibrium condition for entrants $W_e = 0$ will determine the corresponding real wage rate $w$. From the laws of motion (19)-(21), the resulting invariant distributions for producing establishments are given by
\[
\begin{align*}
\mu_{1,1}(s) &= \frac{1}{\lambda} \bar{\chi}(s) h(s) E, \\
\mu_{j,a+1}(s) &= (1 - \lambda) \mu_{j,a}(s), \quad j = 2 \text{ and } 3.
\end{align*}
\] (29) (30)

Substituting (29) into the stationary equilibrium version of the labor-market clearing condition (24) yields

\[
E = \frac{\lambda N}{\sum_{a=1}^{\infty} \int \hat{n}_a(s) \bar{\chi}(s) h(s) ds},
\]
where \(N\) is the steady-state number of working employees or level of aggregate labor supply. Furthermore, the steady-state expression for the mass of operating establishments is given by

\[
M = \sum_{a=1}^{\infty} \int \mu_{j,a}(s) ds.
\]
(31) (32)

Since the establishment-level productivity is constant over time, the discounted present value of an incumbent producer at the stationary equilibrium is

\[
W_a(s) = \pi_a(s) + \frac{1 - \lambda}{1 + R} W_{a+1}(s), \quad \text{for all } a,
\]
(33)

where \(\frac{1 - \lambda}{1 + R}\) is the effective discount rate. Finally, the steady-state level of aggregate consumption is given by

\[
C = Y - \delta K - c_E E.
\]
(34)

3 Quantitative Results

This section quantitatively examines the long-run macroeconomic effects of fiscal policy distortions in our model economy under parameter values that are consistent with post Korean-war U.S. time series data. As is commonly adopted in the real business cycle literature, the household’s period utility function is given by

\[
U(C_t, N_t) = \log C_t - \psi N_t, \quad \psi > 0,
\]
(35)

where the linearity in hours worked draws on the formulation of indivisible labor á la Hansen (1985) and Rogerson (1988). As in Restuccia and Rogerson’s (2008, Table 1) baseline calibration, each period in the model is taken to be one year with the discount factor \(\beta\) set to be 0.96; the
capital depreciation rate $\delta$ fixed at 0.08; the exit probability $\lambda$ chosen to be 0.1; the capital share of national income set to be $1/3$; and the entrance-cost parameter $c_e$ normalized to be 1. In addition, we set the steady-state ratio of transfer payment to output $\frac{TR}{Y}$, evaluated at the model’s symmetric equilibrium with $y_{at}(s_t) = \bar{y}_t$, to be to 0.2. This implies that $\eta = 0.8$, where $\eta$ is the level parameter of the tax schedule (13).

Next, we set the degree of returns-to-scale in production for young establishments $\gamma_1$ to be 0.83; the growth rate $g$ that governs the first-order process (11) to be 0.0272; the tax progressivity $\phi$ to be 0.0032; the preference parameter $\psi$ in (35) to be 0.033; and the probability density function $h(s_i)$ for young establishments in order to jointly match with the following calibration targets in accordance with the U.S. data: (i) the average number of employees for entering establishments being 8.3, (ii) the average employment level of all establishments being 17.6 (corresponding to the steady-state number of employees $N$ in the model),\(^5\) (iii) the point estimate for the elasticity of distortion with respect to productivity being 0.09,\(^6\) and (iv) the size distribution of across employment levels for young establishments.\(^7\) In addition, the calibrated values of $\gamma_1$ and $g$ leads to $\gamma_2 = 0.85$ and $\gamma_3 = 0.88$. Finally, there is a simple mapping between establishment-level productivity and employment in the benchmark economy where the relative demand for labor between young enterprises with $s_i$ and $s_i'$ is

$\frac{n_1(s_i')}{n_1(s_i)} = \left(\frac{s_i'}{s_i}\right)^{\frac{1-\phi}{1-(1-\phi)\gamma_1}}. $ (36)

Given our calibrations of $\gamma_1$ and $\phi$, together with normalizing the lowest firm-level productivity to one, the resulting probability density function $h(s_i)$ which matches with the U.S. data on the number of employees at the establishment levels shows that the maximum possible value of $s_i$ is equal to 4.93.

Our quantitative analyses begin with the benchmark specification, described in section 2, that exhibits variable labor supply coupled with endogenous entry decisions and $\phi = 0.0032$. We then obtain the stationary equilibrium prices and allocations for the “baseline tax distortion” case. Different levels of tax progressivity, with $\phi = 0.005$ and 0.01, are considered to explore how adjustments along the intensive and extensive margins respectively affect the macroeconomy.

---

5These summary statistics in (i) and (ii) are taken from a 2003-2004 Statistics of U.S. Business dataset, which can also be found in Table 3 of Boedo and Mukoyama (2012, p. 154).

6See Hsieh and Klenow (2014, p. 1072). Under our postulated fiscal policy rule, the analytical expression for the symmetric-equilibrium elasticity of distortion with respect to productivity is given by $\sum_j \frac{\theta_j \eta \phi}{1 - \eta_j (1 - (1-\phi)\gamma_j)}$ where $j = \{1, 2, 3\}$ and $\theta_j = \sum_k \mu_k \mu_j$ represents the fraction of establishments in age-category $j$. Using the calibrated values of $\gamma$’s and $\eta$ discussed above, the tax progressivity of $\phi = 0.0032$ results.

7The size distribution of entrants is documented in Table 1 of Boedo and Mukoyama (2012, p. 153).
For sensitivity analysis, we examine alternative formulations with fixed labor supply or different parametrizations on degree of returns-to-scale in production.

### 3.1 Benchmark Model

Table 1 presents the steady-state effects of progressive taxation within our benchmark model. Its second column presents the stationary equilibrium levels of macroeconomic aggregates when the tax-slope parameter $\phi$ is equal to 0.0032; and columns 3-4 report the resulting percentage changes, relative to the baseline counterpart, as the degree of tax progressivity becomes higher. As it turns out, the economy’s total output, consumption, capital stock, labor hours, real wage, as well as the numbers of entrants and incumbents all fall under more progressive taxation.\(^8\)

<table>
<thead>
<tr>
<th></th>
<th>$\phi = 0.0032$</th>
<th>$\phi = 0.005$</th>
<th>$\phi = 0.01$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Y</td>
<td>53.40</td>
<td>-1.21 %</td>
<td>-4.26 %</td>
</tr>
<tr>
<td>Relative TFP</td>
<td>2.39</td>
<td>-0.06 %</td>
<td>-0.28 %</td>
</tr>
<tr>
<td>Relative E</td>
<td>3.92</td>
<td>-0.13 %</td>
<td>-0.20 %</td>
</tr>
<tr>
<td>Relative M</td>
<td>39.22</td>
<td>-0.13 %</td>
<td>-0.20 %</td>
</tr>
<tr>
<td>Relative w</td>
<td>1.37</td>
<td>-1.15 %</td>
<td>-4.09 %</td>
</tr>
<tr>
<td>Relative K</td>
<td>99.51</td>
<td>-2.08 %</td>
<td>-7.16 %</td>
</tr>
<tr>
<td>Relative N</td>
<td>17.60</td>
<td>-0.94 %</td>
<td>-3.20 %</td>
</tr>
<tr>
<td>Relative C</td>
<td>41.51</td>
<td>-1.15 %</td>
<td>-4.09 %</td>
</tr>
</tbody>
</table>

Note: We report the stationary equilibrium levels when $\phi = 0.0032$, and all the remaining entries are in terms of percentage changes when $\phi = 0.005$ and 0.01 respectively.

To help understand the preceding quantitative results, we decompose the total effects reported in Table 1 into adjustments along the intensive margin (the average employment level across operating establishments) and the extensive margin (the total number of producing firms). Specifically, the extensive-margin changes are suppressed by adjusting the value of entrance cost $c_e$ such that the stationary productivity distributions of firms under different levels of tax progressivity are identical to that in our “baseline tax distortion” specification with $\phi = 0.0032$. As a result, the resource-reallocation or the intensive-margin effects among incumbent firms can be isolated and clearly identified.

---

\(^8\)Notice that equations (29), (30) and (32) together imply that the percentage changes in total numbers of new entrants $E$ and producing establishment $M$ will be identical. In addition, this feature will continue to hold in the subsequent Tables 2 – 6.
Figure 1 plots the tax rates versus young establishments’ (i.e. \( j = 1 \) and \( \gamma_1 = 0.83 \)) productivity levels under different tax progressivities. In terms of adjustments along the intensive margin, we note that more (less) productive establishments face higher (lower) tax rates as the fiscal policy becomes more progressive. This outcome distorts the relative prices faced by heterogeneous enterprises, which in turn leads to resource misallocation that reduces (raises) factor demands for more (less) productive establishments\(^9\) – this is a distortion within the same age cohort. On the other hand, Figure 2 presents the tax rates versus productivity levels with different age categories under the baseline level of tax progressivity \( \phi = 0.0032 \). Since older establishments (with \( \gamma_2 = 0.85 \) and \( \gamma_3 = 0.88 \)) tend to be larger and more productive in using any given input mix than their younger counterparts, they will face higher tax rates under a progressive tax policy – this is a distortion across age cohorts. Consequently, Figures 1 and 2 together imply that progressive taxation will disproportionately hurt establishments that are more productive and/or older. As an illustration, Figure 3 depicts operating establishments’ truncated aggregate labor demand with different productivity levels under various values of \( \phi \)\(^{10}\). It shows that employment will move from more to less productive, as well as from older to younger, establishments when the fiscal policy rule becomes more progressive. This result can be understood as follows. Consistent with the U.S. data, incumbents with lower (higher) levels of productivity in our model account for a larger (smaller) share in the total number of establishments and a smaller (larger) fraction of usage in productive services. It follows that the decrease in labor demand from more productive incumbents will quantitatively dominate the corresponding increase from less productive establishments. As a result, the economy’s aggregate labor, and thus real wage, capital, output and consumption, all fall along the intensive margin.

Next, we examine adjustments along the extensive margin. When the tax schedule becomes more progressive, we find that the mass distribution of producing establishments moves down,\(^{11}\) which implies that the equilibrium number of establishments in operation is lower. Intuitively, our postulated fiscal policy that imposes lower tax rates on below-average productive establishments will decrease the expected value of an incumbent firm as the tax progressivity rises. This in turn discourages potential entrants to enter the market until the free entry condition \( W_{et} = 0 \) is obtained for middle-aged and mature firms respectively.

\(^9\)Although not shown here due to space consideration, qualitatively identical patterns to those in Figure 1 can be obtained for middle-aged and mature firms respectively.

\(^{10}\)To visualize the changes in aggregate labor demand across different tax progressivities, we have truncated firms’ productivity levels up to \( s_i = 2.8 \). Otherwise, the increase in labor demand would be hardly seen as the scale of the rise in labor demand is relatively small compared to the corresponding decreases.

\(^{11}\)For example, at the lowest firm-level productivity of \( s_i = 1 \), the steady-state levels for the mass of operating establishments under \( \phi = 0.0032 \), 0.005 and 0.01 are 1.8834, 1.8809 and 1.8797, respectively. In addition, the same pattern continues to hold for all feasible values of \( s_i \).
satisfied. As a result, the economy’s total numbers of entrants and incumbents, as well as aggregate production, will decrease along the extensive margin.

Overall, Table 1 shows that in response to a higher tax progressivity, the decreases in capital and labor services from the intensive margin due to resource misallocation will enhance the reductions of factor demands from the extensive margin due to the lower number of producing establishments. It follows that total output and total consumption will fall. Table 1 also illustrates that the economy’s measured TFP decreases slightly (by 0.06 to 0.28 percent) when the tax scheme becomes more progressive. In particular, since operating establishments have access to different technologies, we define the aggregate TFP as a weighted average of TFP’s across various age categories given by $\sum_j \theta_j \frac{Y_j}{(N_j - \alpha_j K_j)^\gamma}$, where $Y_j$, $N_j$, $K_j$ and $\theta_j = \frac{\mu_j}{\sum_j \mu_j}$ denote the total output, labor, capital and the fraction of producing firms with $j = \{1, 2, 3\}$. Generally speaking, the economy’s aggregate productivity is affected by the total number of firms engaging in production as well as how productive factors are allocated across heterogeneous establishments. As it turns out, the negative impacts due to resource misallocation alongside with the decrease in the total number of operating firms within our benchmark specification leads to the fall in the aggregate TFP.

Table 2 presents the decomposition of total effects in aggregate variables, as shown in Table 1, into adjustments along the intensive/extensive margins (the first/second numbers) as the tax schedule becomes more progressive. When computing the intensive-margin changes, the steady-state numbers of entrants $E$ and incumbents $M$ will remain the same, regardless of the levels of tax progressivity. This is achieved by lowering the entrance-cost parameter $c_e$ to 0.99899 and 0.99848 when $\phi = 0.005$ and 0.01, respectively. Consequently, all the changes in the number of entering and producing firms are generated from the extensive margin.
Table 2. Benchmark Model: Intensive/Extensive Margins

<table>
<thead>
<tr>
<th>( \phi )</th>
<th>0.005</th>
<th>0.01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Y</td>
<td>-1.19 %/-0.02 %</td>
<td>-4.22 %/-0.04 %</td>
</tr>
<tr>
<td>Relative TFP</td>
<td>-0.04 %/-0.02 %</td>
<td>-0.25 %/-0.03 %</td>
</tr>
<tr>
<td>Relative E</td>
<td>0.00 %/-0.13 %</td>
<td>0.00 %/-0.20 %</td>
</tr>
<tr>
<td>Relative M</td>
<td>0.00 %/-0.13 %</td>
<td>0.00 %/-0.20 %</td>
</tr>
<tr>
<td>Relative w</td>
<td>-1.12 %/-0.02 %</td>
<td>-4.05 %/-0.04 %</td>
</tr>
<tr>
<td>Relative K</td>
<td>-2.06 %/-0.02 %</td>
<td>-7.12 %/-0.03 %</td>
</tr>
<tr>
<td>Relative N</td>
<td>-0.94 %/-0.001 %</td>
<td>-3.20 %/-0.001 %</td>
</tr>
<tr>
<td>Relative C</td>
<td>-1.13 %/-0.02 %</td>
<td>-4.05 %/-0.04 %</td>
</tr>
</tbody>
</table>

Note: We report the percentage changes compared to those in the second column of Table 1 when \( \phi = 0.0032 \).

Based on Table 2, we find that the intensive margin, \textit{i.e.} effects due to resource misallocation, accounts for a quantitatively larger fraction of falls in aggregate output (by 1.19 to 4.22 percent), aggregate consumption (by 1.13 to 4.05 percent), aggregate capital (by 2.06 to 7.12 percent), aggregate labor (by 0.94 to 3.20 percent), equilibrium wage (by 1.12 to 4.05 percent), and the economy’s aggregate TFP (by 0.04 to 0.25 percent) within our benchmark model.

### 3.2 Alternative Model: Fixed Labor Supply

For the sensitivity analysis, we first consider an alternative formulation by postulating the household’s labor supply to be a fixed constant \( \hat{a} \) \textit{à la} Restuccia and Rogerson (2008). In this case, the labor market equilibrium condition is changed to

\[ N_t = \sum_{a=1}^{\infty} \int \hat{n}_{at}(s_i)\mu_{jat}(s_i)ds_i = 17.6, \text{ for all } t \text{ and } \phi > 0. \]  

Moreover, since productive inputs can move freely across establishments and every firm faces identical relative prices, the equilibrium capital-to-labor ratio will be the same across operating establishments in each period. It follows that at the model’s stationary equilibrium with fixed labor supply and constant interest rate

\[ \frac{\hat{n}_a(s_i)}{\hat{k}_a(s_i)} = \frac{r}{w} = \frac{\sum_{a=1}^{\infty} \int \hat{n}_a(s_i)\mu_{ja}(s_i)ds_i}{\sum_{a=1}^{\infty} \int \hat{k}_j(s_i)\mu_{ja}(s_i)ds_i} = \frac{17.6}{K}, \]

which in turn implies that the percentage change of real wage \( w \) will be the same as that in aggregate capital stock \( K \). Table 3 presents the resulting steady-state effects of progressive taxation within
this alternative model.\footnote{12Since the postulated constant labor supply ($N = 17.6$) here is identical to the steady-state number of working employees in the benchmark case under $\phi = 0.0032$, the stationary equilibrium levels of all remaining endogenous variables will be the same, as shown in the second columns of Tables 1 and 3.}

As can be seen in Tables 1 and 2 under variable labor supply, the steady-state level of employment falls as the tax progressivity $\phi$ rises. By contrast, hours worked always remain unchanged within the current formulation, hence they are higher than the corresponding varying-labor counterparts. Since capital and labor are complementary factors in establishments’ production technology, the reductions in aggregate capital, and thus total output, will be relatively lower. On the other hand, the total numbers of new entrants and operating incumbents both increase, ranging from 0.82 to 3.10 percent because of adjustments along the extensive margin. In this case, it can be shown that the mass distribution of operating establishments will move up when the fiscal policy rule becomes more progressive, which in turn encourages potential entrants to enter the market.

Table 3. Alternative Model with Fixed Labor Supply: Total Effects

<table>
<thead>
<tr>
<th>$\phi$</th>
<th>0.0032</th>
<th>0.005</th>
<th>0.01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Y</td>
<td>53.40</td>
<td>-0.28 %</td>
<td>-1.10 %</td>
</tr>
<tr>
<td>Relative TFP</td>
<td>2.39</td>
<td>0.08 %</td>
<td>0.18 %</td>
</tr>
<tr>
<td>Relative E</td>
<td>3.92</td>
<td>0.82 %</td>
<td>3.10 %</td>
</tr>
<tr>
<td>Relative M</td>
<td>39.22</td>
<td>0.82 %</td>
<td>3.10 %</td>
</tr>
<tr>
<td>Relative w</td>
<td>1.37</td>
<td>-1.15 %</td>
<td>-4.09 %</td>
</tr>
<tr>
<td>Relative K</td>
<td>99.51</td>
<td>-1.15 %</td>
<td>-4.09 %</td>
</tr>
<tr>
<td>Relative N</td>
<td>17.60</td>
<td>0.00 %</td>
<td>0.00 %</td>
</tr>
<tr>
<td>Relative C</td>
<td>41.51</td>
<td>-0.21 %</td>
<td>-0.92 %</td>
</tr>
</tbody>
</table>

Note: We report the stationary equilibrium levels when $\phi = 0.0032$, and all the remaining entries are in terms of percentage changes when $\phi = 0.005$ and 0.01 respectively.

Per our earlier discussion, the measured aggregate TFP depends on the number of establishments in operation as well as the resource allocation across establishments with different levels of productivity. Table 3 shows that in the economy with fixed labor supply, the positive effect from a higher number of producing establishments dominates the negative effects from misallocation of resources. As a result, the economy’s TFP increases (by 0.08 to 0.18 percent) as the tax schedule becomes more progressive.

Finally, Table 4 disentangles the tax-change outcomes on our model’s steady state into adjustments along the intensive versus extensive margins. We find that the extensive and intensive
margins for aggregate output, aggregate TFP, aggregate consumption, together with real wage and aggregate capital all move in opposite directions. In addition, the intensive margin accounts for a larger fraction of falls in aggregate output (by 0.43 to 1.67 percent), real wage and aggregate capital (by 1.30 to 4.64 percent) in the specification with fixed labor supply. For the aggregate TFP, the positive effect from the number of producing establishments (by 0.12 to 0.43 percent) dominates the negative counterpart from resource misallocation (by 0.04 to 0.25 percent) as the tax schedule becomes more progressive. This result indicates that the response in aggregate TFP is sensitive to the setting of whether the households’ labor supply decision is endogenous or inelastic. As for the aggregate consumption, the negative effect from resource misallocation (by 0.36 to 1.48 percent) quantitatively dominates the positive effect from the extensive margin (by 0.15 to 0.56 percent) for all different degrees of tax progressivity under consideration. Therefore, the aggregate consumption will fall as the tax progressivity become higher.

### Table 4. Alternative Model with Fixed Labor Supply: Intensive/Extensive Margins

<table>
<thead>
<tr>
<th></th>
<th>( \phi = 0.005 )</th>
<th>( \phi = 0.01 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Y</td>
<td>-0.43 % / 0.15 %</td>
<td>-1.67 % / 0.57 %</td>
</tr>
<tr>
<td>Relative TFP</td>
<td>-0.04 % / 0.12 %</td>
<td>-0.25 % / 0.43 %</td>
</tr>
<tr>
<td>Relative E</td>
<td>0.00 % / 0.82 %</td>
<td>0.00 % / 3.10 %</td>
</tr>
<tr>
<td>Relative M</td>
<td>0.00 % / 0.82 %</td>
<td>0.00 % / 3.10 %</td>
</tr>
<tr>
<td>Relative w and K</td>
<td>-1.30 % / 0.15 %</td>
<td>-4.64 % / 0.55 %</td>
</tr>
<tr>
<td>Relative N</td>
<td>0.00 % / 0.00 %</td>
<td>0.00 % / 0.00 %</td>
</tr>
<tr>
<td>Relative C</td>
<td>-0.36 % / 0.15 %</td>
<td>-1.48 % / 0.56 %</td>
</tr>
</tbody>
</table>

Note: We report the percentage changes compared to those in the second column of Table 3 when \( \phi = 0.0032 \).

### 3.3 Alternative Model: Different Returns-to-Scale in Production

Since the returns-to-scale parameters \( \gamma \)'s play an important role in affecting the number of operating establishments and thus the economy’s aggregate variables, this subsection examines two alternative calibrations for our sensitivity analysis. In particular, we set the growth parameter in (11) to be the same as that in the benchmark model, i.e. \( g = 0.0272 \); while considering the degree of returns-to-scale in production for young establishments \( \gamma_1 \) to be either 0.88 or 0.75, which are around the upper and lower bounds reported by existing empirical studies. Table 5 presents the quantitative results for these parameterizations under different levels of tax progressivity. When \( \gamma_1 = 0.88 \), incumbent establishments of all age categories exhibit a higher degree of returns-to-
scale in production than that in our benchmark formulation with $\gamma_1 = 0.82$. In this case, the optimal scale for each producing firm becomes relatively higher, hence progressive taxation will generate a larger negative effect from misallocation of productive resources. It follows that under the baseline tax distortion of $\phi = 0.0032$, the economy’s aggregate output, aggregate TFP, total numbers of entrants and operating establishments, aggregate consumption and aggregate capital are all lower than their counterparts in the benchmark model (see the second columns of Tables 1 and 5). Table 5 also shows that when $\gamma_1 = 0.88$, the expected value of an incumbent producer rises as the tax policy rule becomes more progressive, which in turn will encourage more potential entrants to enter the market and more establishments to produce. As a result, both the numbers of new entrants and operating establishments increase by 0.88 to 4.06 percent. We also find that as the tax progressivity rises, the measured aggregate TFP initially rises by 0.006 percent, and then gradually falls by 0.05 percent, which reflects the interactions between the positive effects from the extensive margin versus the negative effects from misallocation of productive resources. In addition, more progressive taxation leads to decreases in aggregate output (by 1.83 to 6.27 percent), equilibrium wage (by 1.72 to 5.98 percent), aggregate capital (by 3.07 to 10.22 percent), aggregate labor (by 1.38 to 4.52 percent), and aggregate consumption (by 1.71 to 5.97 percent).

When $\gamma_1 = 0.75$, the optimal scale of each incumbent producer will be lower than that within our benchmark model with $\gamma_1 = 0.83$. As a result, the steady-state levels of all aggregate variables are relatively higher because of a smaller negative effect from resource misallocation. Moreover, Table 5 shows that in this case, all the tax-change outcomes are qualitatively identical to those under the benchmark model with $\gamma_1 = 0.83$. In particular, the numbers of entrants and producing establishments fall (by 0.77 to 2.67 percent) when the tax schedule becomes more progressive, indicating a lower expected value of an incumbent firm that discourages potential establishments to enter and operate in the market. Finally, we find that the economy’s aggregate total factor productivity will fall (by 0.20 to 0.74 percent) as the tax progressivity rises. In sum, these results demonstrate the quantitative interrelations between resource misallocations and the decrease in the total number of incumbent establishments.
Table 5. Alternative Model with Different Returns-to-Scale in Production: Total Effects

<table>
<thead>
<tr>
<th>φ</th>
<th>0.0032</th>
<th>0.005</th>
<th>0.01</th>
</tr>
</thead>
<tbody>
<tr>
<td>γ₁ = 0.88</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative Y</td>
<td>45.96</td>
<td>-1.83%</td>
<td>-6.27%</td>
</tr>
<tr>
<td>Relative TFP</td>
<td>1.77</td>
<td>0.006%</td>
<td>-0.05%</td>
</tr>
<tr>
<td>Relative E</td>
<td>1.68</td>
<td>0.88%</td>
<td>4.06%</td>
</tr>
<tr>
<td>Relative M</td>
<td>16.83</td>
<td>0.88%</td>
<td>4.06%</td>
</tr>
<tr>
<td>Relative w</td>
<td>1.22</td>
<td>-1.72%</td>
<td>-5.98%</td>
</tr>
<tr>
<td>Relative K</td>
<td>90.78</td>
<td>-3.07%</td>
<td>-10.22%</td>
</tr>
<tr>
<td>Relative N</td>
<td>18.08</td>
<td>-1.38%</td>
<td>-4.52%</td>
</tr>
<tr>
<td>Relative C</td>
<td>37.01</td>
<td>-1.71%</td>
<td>-5.97%</td>
</tr>
<tr>
<td>γ₁ = 0.75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative Y</td>
<td>84.46</td>
<td>-1.04%</td>
<td>-3.74%</td>
</tr>
<tr>
<td>Relative TFP</td>
<td>4.43</td>
<td>-0.20%</td>
<td>-0.74%</td>
</tr>
<tr>
<td>Relative E</td>
<td>10.79</td>
<td>-0.77%</td>
<td>-2.67%</td>
</tr>
<tr>
<td>Relative M</td>
<td>107.91</td>
<td>-0.77%</td>
<td>-2.67%</td>
</tr>
<tr>
<td>Relative w</td>
<td>2.06</td>
<td>-0.96%</td>
<td>-3.49%</td>
</tr>
<tr>
<td>Relative K</td>
<td>142.12</td>
<td>-1.72%</td>
<td>-6.11%</td>
</tr>
<tr>
<td>Relative N</td>
<td>16.82</td>
<td>-0.77%</td>
<td>-2.72%</td>
</tr>
<tr>
<td>Relative C</td>
<td>62.30</td>
<td>-0.96%</td>
<td>-3.49%</td>
</tr>
</tbody>
</table>

Note: We report the stationary equilibrium levels when φ = 0.0032, and all the remaining entries are in terms of percentage changes when φ = 0.005 and 0.01 respectively.

Table 6 decomposes the total effects in aggregate variables into their respective intensive and extensive margins. It shows that under both alternative returns-to-scale parameters, the intensive-margin effect accounts for a larger fraction of falls in aggregate output, equilibrium wage, aggregate capital, aggregate labor and aggregate consumption. However, for the economy’s measured TFP, the extensive margin quantitatively dominates when γ₁ = 0.75, whereas the reverse holds true under γ₁ = 0.88 and φ = 0.01. Intuitively, since the quantitative impact of changing the number of operating establishments on aggregate TFP is a decreasing function of firms’ returns-to-scale in production, a higher γ₁ will lead to a relatively weaker extensive-margin effect.
Table 6. Alternative Model with Different Returns-to-Scale in Production: Intensive/Extensive Margins

<table>
<thead>
<tr>
<th>$\phi$</th>
<th>0.005</th>
<th>0.01</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma_1 = 0.88$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative Y</td>
<td>-1.81 %/0.09 %</td>
<td>-6.39 %/0.41 %</td>
</tr>
<tr>
<td>Relative TFP</td>
<td>-0.07 %/0.07 %</td>
<td>-0.41 %/0.36 %</td>
</tr>
<tr>
<td>Relative E</td>
<td>0.00 %/0.88 %</td>
<td>0.00 %/4.06 %</td>
</tr>
<tr>
<td>Relative M</td>
<td>0.00 %/0.88 %</td>
<td>0.00 %/4.06 %</td>
</tr>
<tr>
<td>Relative w</td>
<td>-1.81 %/0.09 %</td>
<td>-6.39 %/0.41 %</td>
</tr>
<tr>
<td>Relative K</td>
<td>-3.17 %/0.09 %</td>
<td>-10.63 %/0.41 %</td>
</tr>
<tr>
<td>Relative N</td>
<td>-1.38 %/0.002 %</td>
<td>-4.54 %/0.01 %</td>
</tr>
<tr>
<td>Relative C</td>
<td>-1.81 %/0.09 %</td>
<td>-6.38 %/0.41 %</td>
</tr>
<tr>
<td>$\gamma_1 = 0.75$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative Y</td>
<td>-0.81 %/-0.23 %</td>
<td>-2.95 %/-0.79 %</td>
</tr>
<tr>
<td>Relative TFP</td>
<td>-0.02 %/-0.17 %</td>
<td>-0.13 %/-0.60 %</td>
</tr>
<tr>
<td>Relative E</td>
<td>0.00 %/-0.77 %</td>
<td>0.00 %/-2.67 %</td>
</tr>
<tr>
<td>Relative M</td>
<td>0.00 %/-0.77 %</td>
<td>0.00 %/-2.67 %</td>
</tr>
<tr>
<td>Relative w</td>
<td>-0.73 %/-0.23 %</td>
<td>-2.70 %/-0.78 %</td>
</tr>
<tr>
<td>Relative K</td>
<td>-1.50 %/-0.23 %</td>
<td>-5.34 %/-0.77 %</td>
</tr>
<tr>
<td>Relative N</td>
<td>-0.77 %/-0.002 %</td>
<td>-2.72 %/-0.005 %</td>
</tr>
<tr>
<td>Relative C</td>
<td>-0.73 %/-0.23 %</td>
<td>-2.70 %/-0.78 %</td>
</tr>
</tbody>
</table>

Note: We report the percentage changes compared to those in the second column of Table 5 when $\phi = 0.0032$.

4 Conclusion

We have quantitatively examined the long-run general equilibrium effects of progressive taxation in an otherwise standard one-sector neoclassical growth model with heterogeneous establishments characterized by different ages and levels of productivity. Our postulated fiscal policy rule affects key macroeconomic variables through the channels of both intensive and extensive margins. Along the intensive margin, more progressive taxation shifts resources from more-productive and/or older to less-productive and/or younger establishments. This in turn decreases the economy’s total output, consumption, capital stock, labor hours and real wage. Along the extensive margin, the expected value of an incumbent establishment becomes lower as the tax progressivity rises. This discourages potential entrants to enter the market, thus lowers the total number of establishments in operation as well as aggregate production. In the benchmark model with variable labor supply together with endogenous entry decisions, we find that the adjustment effects from the intensive
margin associated with resource misallocation alongside with the extensive margin due to a contraction of producing firms lead to the fall in the measured aggregate TFP when the tax schedule becomes more progressive. For the sensitivity analyses, we consider alternative specifications with fixed labor supply or different returns-to-scale in production.

This paper can be extended in several directions. For example, progressive taxation may distort firms’ technology adoption decisions, and thus influence the aggregate productivity. In addition, financial frictions might as well affect resource misallocation and the entry decisions of potential firms. Hence, the interplay between different distortions and their consequent impacts on macroeconomic aggregates would be worth exploring. Finally, while this paper analyzes the effects of within-sector distortions at the establishment level, cross-sector frictions may also play an important role within a macroeconomy. We plan to pursue these research projects in the future.
References


Figure 1. Tax Rates versus Young Establishments’ Productivity Levels
Figure 2. Tax Rates versus Establishments’ Productivity Levels across Cohorts under $\phi = 0.0032$
Figure 3. Intensive Margin: Truncated Aggregate Labor Demand