Progressive Taxation as an Automatic Stabilizer under Nominal Wage Rigidity and Preference Shocks*

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Abstract

Previous research has shown that in the context of a prototypical New Keynesian model, more progressive income taxation may lead to higher volatilities of hours worked and total output in response to a monetary disturbance. We analytically show that this business-cycle destabilization result is overturned within an otherwise identical macroeconomy subject to impulses to the household's utility formulation. Under a continuously or linearly progressive fiscal policy rule with the symmetric-equilibrium tax burden unchanged, an increase in the positive level of tax progressivity will always raise the degree of equilibrium nominal-wage rigidity, and thus serve as an automatic stabilizer that mitigates cyclical fluctuations driven by preference shocks.

Keywords: Progressive Income Taxation, Automatic Stabilizer, Nominal Wage Rigidity, Preference Shocks.

JEL Classification: E12, E32, E62.

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1 Introduction

The business-cycle stabilization effect of progressive income taxation is a research topic that has attracted much attention in the macroeconomics literature. In the context of a traditional Keynesian macroeconomy, an increase in the tax progressivity operates like an automatic stabilizer that will mitigate the magnitude of cyclical variations in consumption spending and total output. This conventional viewpoint is found to be also valid within one-sector real business cycle models. In particular, Guo and Lansing (1998) and Dromel and Pintus (2007) show that a more progressive fiscal policy rule may stabilize the economy against sunspot-driven macroeconomic fluctuations; whereas Schmitt-Grohé and Uribe (1997) find that equilibrium indeterminacy may arise in a standard representative-agent model with regressive income taxation. In our earlier work, Gabrovski and Guo (2019) report that these previous findings can be overturned in a prototypical New Keynesian macroeconomy, developed by Kleven and Kreiner (2003), driven by shocks to the quantity of nominal money supply. As it turns out, it is straightforward to obtain the qualitatively identical business-cycle destabilization result of more progressive taxation when *ceteris paribus* the Kleven-Kreiner model is subject to technological disturbances to firms' production functions.[1] In this environment, either impulse leads to a shift of the labor demand curve, which in turn will affect the economy's aggregate demand/supply under a monetary/technology shock.

In this follow-up piece, we examine the robustness of Gabrovski and Guo's (2019) theoretical findings in an identical New Keynesian model, but subject to an alternative demand impulse. Specifically, shocks to the marginal utility of consumption *à la* Bencivenga (1992) that influence each household's urge to consume are considered. As a result, this preference disturbance enters the marginal rate of substitution between consumption and hours worked, which in turn will cause the labor supply curve to shift. Under either (i) Guo and Lansing's (1998) continuously progressive tax schedule, or (ii) Dromel and Pintus' (2007) piece-wise linearly progressive fiscal policy rule, we obtain exactly the opposite result to that in Gabrovski and Guo (2019). That is, as in traditional Keynesian macroeconomics, more progressive income taxation is shown to dampen cyclical fluctuations driven by impulses to an agent's utility function. The key insight is that although both preference and monetary disturbances affect the economy's aggregate demand, they will generate very different effects in the labor market: a preference shock shifts the household's labor supply curve, whereas a monetary shock shifts the firm's labor demand curve. In sum, our two papers altogether illustrate that whether a more progressive fiscal policy rule (de)stabilizes the Kleven-Kreiner macroeconomy depends crucially on the driving source of business cycles.

[1] The derivation details for this finding are available upon request.

Under the Guo-Lansing fiscal policy formulation, we analytically show that the economy always exhibits a higher degree of equilibrium nominal-wage rigidity when the tax schedule becomes more progressive.[2] Intuitively, start the model with a given tax progressivity and consider a positive preference shock that shifts the labor supply curve to the right. Regardless of how an individual household responds by maintaining or changing its nominal wage, the resulting symmetric-equilibrium nominal income is found to be the same. In addition, when agents decide to adjust nominal wages, their before-tax real labor income will be higher because of a decrease in the aggregate output price index. Next, consider an increase in the tax progressivity that raises the symmetric-equilibrium marginal tax rate, whereas the corresponding tax burden/payment remains unchanged. Given the aforementioned discussion, each "adjusting" household's after-marginal-tax real wage income may increase or decrease as the tax-slope parameter rises. Our study analytically proves that more progressive taxation will reduce the utility loss from non-adjustment of nominal wages, because the effect of a higher marginal tax rate outweighs the opposite impact of an augment in the gross real income under all feasible parametric configurations. Consequently, agents are less capable of paying the adjustment cost needed for changing their nominal wages, which in turn will enhance the likelihood of fixed nominal wages in equilibrium.

We also find that upon a positive disturbance to the household's marginal utility of consumption, there will be no variability in hours worked when the initial equilibrium nominal wage remains unaltered. On the other hand, when agents decide to decrease their nominal wages because of a lower disutility from working, the new equilibrium will exhibit a higher level of labor hours. Based on the combined results from this and the preceding paragraphs, a reduction in the economy's equilibrium degree of nominal-wage rigidity, captured by an increase in the loss of utility from non-adjustment, will raise the volatilities in hours worked and thus total output. It follows that consistent with the traditional stabilization view, Guo and Lansing's (1998) continuously progressive tax system always serves as an automatic stabilizer against aggregate fluctuations driven by preference shocks within our New Keynesian model.

Under the Dromel-Pintus fiscal policy formulation, we analytically show that the utility loss from not adjusting nominal wages upon a preference disturbance is monotonically decreasing in the degree of tax progressivity at the model's symmetric equilibrium, while keeping the tax burden on households unchanged. The underlying intuition turns out to be qualitatively the same as that in the setting with a continuously progressive tax schedule. As discussed earlier, whether an increase in the tax progressivity that is associated with a higher marginal

[2] By contrast, Gabrovski and Guo (2019, Proposition 2) obtain a sufficient condition under which a higher tax progressivity *à la* Guo and Lansing's (1998) specification may raise the likelihood of fixed nominal wages in equilibrium when the same macroeconomy is driven by monetary shocks.

tax rate will raise or reduce agents' after-marginal-tax real wage income is theoretically ambiguous. We find that since the impact of a higher gross real labor income is outweighed by the opposing effect of an increase in the marginal tax rate, more linearly progressive taxation will decrease the utility loss from non-adjustment of nominal wages. This in turn implies that each household's ability to afford the requests adjustment cost becomes lower, hence fixed nominal wages are more likely to occur. Accordingly, the economy will exhibit a higher degree of equilibrium nominal-wage rigidity as the tax progressivity rises. Per the labor-market analysis described above, the variations of labor hours and total output are relatively higher under fully-adjusted nominal wages. It follows that in accordance with the conventional Keynesian viewpoint, Dromel and Pintus' (2007) piece-wise linearly progressive tax system also always operates like an automatic stabilizer against preference-shock-driven business cycles within the Kleven-Kreiner macroeconomy.

This paper is related to the recent work of Mattesini and Rossi (2012) who also explore the stabilization effects of Guo and Lansing's (1998) progressive fiscal formulation within a New Keynesian macroeconomy. These two studies differ in the following aspects. First, the Mattesini-Rossi model is a dynamic setting with sticky output prices, whereas ours is a static setup with rigid nominal wages. Second, in addition to progressive income taxation, a standard Taylor-type monetary policy rule is incorporated into Mattesini and Rossi's framework, whereas our analysis introduces money through a cash-in-advance constraint. Third, Mattesini and Rossi show that an increase in the tax progressivity will stabilize their model economy against business cycles driven by technology, government spending, and monetary policy shocks. On the contrary, we find that whether a progressive tax scheme functions as an automatic stabilizer or destabilizer within Kleven and Kreiner's (2003) macroeconomy depends crucially on the underlying source of aggregate fluctuations.

The remainder of this paper is organized as follows. Section 2 describes our New Keynesian macroeconomy subject to preference shocks, discusses its equilibrium conditions, and then analytically examines the interrelations between equilibrium nominal-wage rigidity versus business-cycle stabilization under continuously progressive income taxation. Section 3 studies the same macroeconomy under piece-wise linearly progressive taxation. Section 4 concludes.

2 The Economy

As in Kleven and Kreiner (2003) and Gabrovski and Guo (2019), the economy is populated by three types of agents: households, firms, and the government. There is a unit measure of households who derive utility from leisure and their consumption basket of a continuum of differentiated goods that are subject to preference shocks. Each household provides a distinct variety of hours worked to a monopolistically competitive labor market; and faces a cash-in-advance constraint on its consumption expenditures. On the production side of the economy, a unit mass of monopolistically competitive firms produce differentiated consumption goods with a technology that uses labor as the sole input under decreasing returns-to-scale. The government levies labor income taxation through a continuously progressive tax schedule *à la* Guo and Lansing (1998), and distributes its revenue back to households in the form of lump-sum transfers. To facilitate comparison with Gabrovski and Guo (2019), output prices are postulated to be fully flexible and other forms of taxation are not considered.

2.1 Households

Within our model economy, there is a continuum of households that are uniformly distributed over $[0, 1]$ and indexed by i. Household i supplies a differentiated labor input, denoted as l_i, and consumes a basket of goods that firms indexed by $j \in [0, 1]$ produce. The utility function for household i is given by

$$u_i = \Lambda \underbrace{\left(\int_0^1 c_{ij}^{1-\mu} dj \right)^{\frac{1}{1-\mu}}}_{\equiv C_i} - \frac{\gamma}{1+\gamma} l_i^{\frac{1+\gamma}{\gamma}}, \quad 0 < \mu < 1, \quad \Lambda \text{ and } \gamma > 0, \tag{1}$$

where c_{ij} is the consumption of variety j by household i, C_i is the consumption basket, μ is the inverse of the elasticity of substitution between two distinct consumption goods, and γ is the Frisch elasticity of labor supply. Moreover, Λ is a random shock to preferences that affects the household's marginal utility of consumption *à la* Bencivenga (1992). In particular, an increase in Λ represents a positive disturbance to the economy's aggregate demand as it raises agents' urge to consume.

In a monopolistically competitive labor market, household i selects the nominal wage w_i for its labor service. Its gross nominal labor income is $w_i l_i$, which will be taxed at a rate of $t_i \in (0, 1)$. Household i also receives a share of firm j's profit in the form of dividends π_{ij}; as well as lump-sum transfer payments from the government in the amount of $S_i = \int_0^1 \tau_i w_i l_i di$ under the maintained assumption of a balanced budget. It follows that the budget constraint faced by household i is

$$\int_0^1 p_j c_{ij} dj = (1 - t_i) w_i l_i + \int_0^1 \pi_{ij} dj + S_i, \tag{2}$$

where p_j is the market price for variety j, and $t_i w_i l_i$ represents household i's tax burden or payment that will be denoted as TB_i hereafter.

We postulate that the tax scheme is continuously progressive in the spirit of Guo and Lansing (1998), hence the tax rate t_i is specified as

$$t_i = \eta \left(\frac{w_i l_i}{wl} \right)^{\phi}, \quad 0 < \eta < 1, \quad 0 < \phi < 1, \tag{3}$$

where $wl = \int_0^1 w_i l_i di$ is the average level of nominal wage income across all households, and the parameters η and ϕ govern the level and slope (or elasticity) of the tax schedule, respectively. As in much of the previous literature, households are able to rationally anticipate the way in which changes to their income affect the resulting tax burden. As a consequence, each household's economic decisions are governed by its individual marginal tax rate given by

$$t_i^m = \frac{\partial(t_i w_i l_i)}{\partial(w_i l_i)} = \eta(1+\phi) \left(\frac{w_i l_i}{wl} \right)^{\phi}. \tag{4}$$

Our analysis below will focus on an environment in which households have an incentive to provide labor services and the government cannot confiscate productive resources, hence $0 < t_i$, $t_i^m < 1$ is imposed. At the model's symmetric equilibrium with $w_i = w$ and $l_i = l$ for all i, these conditions imply that $\eta \in (0,\, 1)$ and $\phi \in (-1,\, \frac{1-\eta}{\eta})$, where $\frac{1-\eta}{\eta} > 0$. It follows that when $\phi > (<)\ 0$, the tax schedule is said to be progressive (regressive), *i.e.* the marginal tax rate is higher (lower) than the corresponding average tax rate given by (3). When $\phi = 0$, the average and marginal tax rates coincide at the constant level of η, thus the tax scheme is flat. Consequently, the degree of tax progressivity associated with (3) is determined by the elasticity/slope parameter ϕ. We also note that per the observed progressive U.S. federal individual income tax schedule, the listed statutory marginal tax rate t_i^m is an increasing and concave function with respect to taxable-income ($w_i l_i$) brackets. Hence, the tax-progressivity parameter is further restricted to the interval $0 < \phi < 1$.

In addition to the budget constraint (2), household i faces a cash-in-advance (CIA) constraint whereby all consumption purchases must be financed by its nominal money holdings M_i:

$$\int_0^1 p_j c_{ij} dj \leq M_i. \tag{5}$$

Without loss of generality, the economy's aggregate level of nominal money balance is normalized to be one, *i.e.* $\int_0^1 M_i di = 1$. Taking aggregation over each household's first-order condition with respect to c_{ij} yields that the total demand for consumption good j is given by

$$c_j = \int_0^1 c_{ij} di = \left(\frac{p_j}{P} \right)^{-\frac{1}{\mu}} \frac{1}{P}, \quad \text{where } P = \left(\int_0^1 p_j^{\frac{\mu-1}{\mu}} dj \right)^{\frac{\mu}{\mu-1}} \tag{6}$$

denotes the aggregate price index for the consumption basket.

2.2 Firms

The economy's production side consists of a unit mass of firms that are distributed uniformly over $[0, 1]$. Each firm j produces a differentiated output y_j with varieties of labor as the inputs under decreasing returns-to-scale given by

$$y_j = \frac{1}{\alpha}\left(\int_0^1 l_{ij}^{1-\rho} di\right)^{\frac{\alpha}{1-\rho}}, \quad 0 < \alpha,\ \rho < 1, \tag{7}$$

where ρ is the inverse of the elasticity of substitution between labor hours supplied by two distinct households, and α governs the concavity of the production function. The first-order condition for firm j's wage-cost minimization problem leads to the following demand function for labor of type i:

$$l_{ij} = \left(\frac{w_i}{W}\right)^{-\frac{1}{\rho}} (\alpha y_j)^{\frac{1}{\alpha}}, \quad \text{where } W = \left(\int_0^1 w_i^{\frac{\rho-1}{\rho}} di\right)^{\frac{\rho}{\rho-1}} \tag{8}$$

is the aggregate nominal-wage index. Using this optimality condition (8), together with the consumption demand function (6) and the goods-market clearing condition $c_j = y_j$, we find that the indirect profit function for firm j can be expressed as

$$\pi_j = \left(\frac{p_j}{P}\right)^{-\frac{1-\mu}{\mu}} - W\left(\frac{p_j}{P}\right)^{-\frac{1}{\alpha\mu}} \left(\frac{\alpha}{P}\right)^{\frac{1}{\alpha}}, \tag{9}$$

which will be returned to households as lump-sum dividends. From the first-order condition of maximizing (9), it can be shown that the output price p_j is set according to

$$\frac{p_j}{P} = \left[\frac{1}{1-\mu}\frac{W}{P}\left(\frac{\alpha}{P}\right)^{\frac{1-\alpha}{\alpha}}\right]^{\frac{\alpha\mu}{\alpha\mu+1-\alpha}}. \tag{10}$$

2.3 Symmetric Equilibrium

Using the household's budget constraint (2) and the demand function for consumption goods (6), we can rewrite household i's preference formulation (1) as

$$u_i = \Lambda\left[\frac{(1-t_i)w_i l_i}{P} + \int_0^1 \frac{\pi_{ij}}{P} dj + \frac{S_i}{P}\right] - \frac{\gamma}{1+\gamma} l_i^{\frac{1+\gamma}{\gamma}}. \tag{11}$$

Next, substituting (i) the production technology (7), (ii) the demand function for individual labor (8), and (iii) the equilibrium condition of the market for each type of labor $l_i = \int_0^1 l_{ij} dj$ into the above equation yields the following indirect utility function:

$$V(w_i, \Lambda) = \Lambda\left[\frac{(1-t_i)w_i}{P}\left(\frac{w_i}{W}\right)^{-\frac{1}{\rho}}\left(\frac{\alpha}{P}\right)^{\frac{1}{\alpha}} + \int_0^1 \frac{\pi_{ij}}{P} dj + \frac{S_i}{P}\right] - \frac{\gamma}{1+\gamma}\left[\left(\frac{w_i}{W}\right)^{-\frac{1}{\rho}}\left(\frac{\alpha}{P}\right)^{\frac{1}{\alpha}}\right]^{\frac{1+\gamma}{\gamma}}. \tag{12}$$

At the model's symmetric equilibrium with $w_i = w$, $l_i = l$, $t_i = t$, $TB_i = TB$, and $t_i^m = t^m$ for all i, it is straightforward to show that the first-order condition of maximizing (12) leads to the optimal nominal wage w_i given by

$$\frac{w_i}{W} = \left\{ \Lambda(1-\rho)[1 - \underbrace{\eta(1+\phi)}_{= t^m}] \frac{W}{P} \right\}^{-\frac{\gamma\rho}{1+\gamma\rho}} \left(\frac{\alpha}{P}\right)^{\frac{\rho}{\alpha(1+\gamma\rho)}} . \tag{13}$$

2.4 Nominal Wage Rigidity and Business Cycle Stabilization

The main objective of our analysis is to examine theoretical interrelations between the level of tax progressivity versus (i) the degree of equilibrium nominal-wage rigidity, and (ii) the magnitude of fluctuations in labor hours (and thus output) resulting from an aggregate demand disturbance. As in Kleven and Kreiner (2003), Gabrovski and Guo (2019) and many previous New Keynesian studies, we postulate that households must pay a lump-sum cost of adjustment $F > 0$ when they decide to change their nominal wages following a preference shock denoted as $d\Lambda$. Let V^A and V^N be the associated utility levels under flexible (or fully adjusted) and fixed nominal wages, respectively. It follows that $\Delta V \equiv V^A - V^N$ represents the loss of utility from non-adjustment of nominal wages.

Taking a second-order Taylor expansion on the household's indirect utility function (12) around the model's initial symmetric equilibrium yields that

$$\Delta V \approx V_{12} dw_i d\Lambda + \frac{1}{2} V_{11} (dw_i)^2, \tag{14}$$

where $V_{12} = \frac{\partial^2 V}{\partial w_i \partial \Lambda}$ and $V_{11} = \frac{\partial^2 V}{\partial w_i^2}$.[3] Using equations (10), (12) and (13), we can then obtain the analytical expression of ΔV as follows:

$$\Delta V = \frac{\gamma \left\{ \Lambda(1-\rho)(1-\mu)[1-\eta(1+\phi)] \right\}^{\frac{1+\gamma}{1+\gamma(1-\alpha)}}}{2(1+\gamma\rho)\left[1 + \frac{\gamma\eta\phi(1-\rho)(1+\phi)}{(1+\gamma\rho)[1-\eta(1+\phi)]}\right]} \left(\frac{d\Lambda}{\Lambda}\right)^2 > 0 \tag{15}$$

because of $0 < \alpha,\ \mu,\ \rho,\ \eta,\ \phi,\ \eta(1+\phi) < 1$ and $\gamma,\ \Lambda > 0$. It follows that in response to an aggregate demand shock $d\Lambda$, households will adjust their nominal wages if and only if ΔV exceeds the requisite (fixed) menu cost F. This in turn implies that the degree of equilibrium nominal-wage rigidity is governed by the size of ΔV. In particular, if a more progressive

[3] These approximations follow from

$$V^A \approx V^0 + V_1 dw_i + V_2 d\Lambda + \frac{1}{2} V_{11} (dw_i)^2 + \frac{1}{2} V_{22} (d\Lambda)^2 + V_{12} dw_i d\Lambda,$$

$$\text{and} \quad V^N \approx V^0 + V_2 d\Lambda + \frac{1}{2} V_{22} (d\Lambda)^2,$$

where V^0 is the indirect utility function evaluated at the model's initial symmetric equilibrium.

tax scheme increases/decreases the utility loss from non-adjustment ΔV, then the likelihood that nominal wages remain unchanged will be reduced/enhanced since households are now more/less capable of paying the cost of adjustment F. As a result, our model economy is less/more likely to exhibit fixed nominal wages in equilibrium.

Proposition 1. Under a preference shock $d\Lambda$ and continuously progressive income taxation, an increase in the tax progressivity will always lead to a lower utility loss from non-adjustment (*i.e.* $\frac{\partial(\Delta V)}{\partial\phi} < 0$), and thus a higher degree of equilibrium nominal-wage rigidity.

Proof. After taking partial differentiation on (15), it can be shown that

$$\frac{\partial\left(\Delta V\right)}{\partial\phi} = -\Delta V\left\{\Omega + \frac{\gamma\eta(1-\rho)(1+\gamma\rho)\left\{\phi+(1+\phi)[1-\eta(1+\phi)]\right\}}{(1+\gamma\rho)[1-\eta(1+\phi)]\left\{(1+\gamma\rho)[1-\eta(1+\phi)]+\gamma\eta\phi(1-\rho)(1+\phi)\right\}}\right\}, \tag{16}$$

where $\Omega = \frac{\eta(1+\gamma)}{[1+\gamma(1-\alpha)][1-\eta(1+\phi)]}$. Since $0 < \alpha,\, \rho,\, \eta,\, \phi,\, \eta\left(1+\phi\right) < 1$ and $\gamma > 0$, both terms inside the curly brackets on the right hand side of (16) are strictly positive. This result, together with $\Delta V > 0$ per equation (15), yields that $\frac{\partial(\Delta V)}{\partial\phi} < 0$. ■

To help explain the intuition behind this Proposition, Figure 1 is depicted to illustrate how nominal wages and labor hours respond to an utility shock. Consider the labor market that begins at the initial symmetric equilibrium E^* under a given (positive) level of tax progressivity. Upon a positive preference disturbance that raises Λ, each household values its consumption basket more as the associated marginal utility is now higher. This in turn reduces the marginal rate of substitution between consumption and hours worked given by $\frac{l^{1/\gamma}}{\Lambda}$, which will then generate a rightward shift of the labor supply curve. Figure 1 shows that if households decide to adjust their wages, the new symmetric equilibrium is located at $E^{'}$ characterized by a lower nominal wage $w^{'}$ and a higher level of labor supply $l^{'}$. The resulting utility loss from non-adjustment ΔV is graphically represented by the shaded area between the marginal revenue curve and the new labor supply curve over the range of $l \in [l^*, l^{'}]$. It follows that whether the household's nominal income increases or decreases as a consequence of nominal-wage adjustments is theoretically ambiguous.

In order to answer this question, we first combine equations (10) and (13) to find that in response to an utility impulse, the percentage change in the fully-flexible aggregate price index is given by

$$\frac{dP/P}{d\Lambda/\Lambda} = -\frac{\alpha\gamma}{1+\gamma(1-\alpha)} < 0. \tag{17}$$

Next, using (10) and (17) shows that the corresponding response of symmetric-equilibrium nominal wages (falling from w^* to $w^{'}$) is

$$\frac{dw/w}{d\Lambda/\Lambda} = -\frac{\gamma}{1+\gamma(1-\alpha)} < 0. \tag{18}$$

Finally, combining (8), (13) and (17)-(18) yields that the symmetric-equilibrium labor hours will change (rising from l^* to $l^{'}$) according to

$$\frac{dl/l}{d\Lambda/\Lambda} = \frac{\gamma}{1+\gamma(1-\alpha)} > 0. \tag{19}$$

Equations (18) and (19) together indicate that when households decide to adjust their wages after a preference shock takes place, the equilibrium nominal wages and hours worked will move in the opposite direction and by the same percentage. It follows that their nominal labor income remains unchanged, *i.e.* $w^*l^* = w^{'}l^{'}$.[4] In addition, since the resulting equilibrium output prices become lower *à la* (17), each "adjusting" agent's real wage income $\left(= \frac{wl}{P}\right)$ will be higher as a consequence. When households decide not to change nominal wages upon an utility disturbance, their nominal as well as real labor income will remain unaffected.

On the other hand, when the tax schedule becomes more progressive, the symmetric-equilibrium marginal tax rate $\eta(1+\phi)$ becomes higher whereas the corresponding tax burden $TB = tw^*l^* = \eta\alpha(1-\mu)$ stays the same. This outcome, together with the preceding discussion, implies that the after-marginal-tax real income $(1-t^m)\frac{wl}{P}$ when each agent adjusts its nominal wage may increase or decrease as the tax-elasticity parameter ϕ rises under a preference shock. Proposition 1 analytically shows that more progressive taxation will always reduce the utility loss from non-adjustment of nominal wages, *i.e.* $\frac{\partial(\Delta V)}{\partial\phi} < 0$, because the effect of a higher marginal tax rate outweighs the opposite impact of an augment in the gross real labor income under all feasible parametric configurations. As a result, agents are less able to afford the adjustment cost F needed for changing their nominal wages, which in turn raises the economy's equilibrium degree of nominal-wage rigidity.

Proposition 2. Under a preference shock $d\Lambda$ and continuously progressive income taxation, an increase in the tax progressivity $\phi \in (0,\, 1)$ will generate lower volatilities in labor hours and output.

The underlying intuition for this Proposition is straightforward. Using the chain rule, we can decompose the overall effect of a tax-progressivity change on the magnitude of cyclical fluctuations in labor hours as follows:

[4] Alternatively, we can combine equations (6), (8), (10) and (13), together with the goods-market clearing condition $c_j = y_j$, to show that at the model's symmetric equilibrium each agent's nominal labor income is given by $wl = \alpha(1-\mu)$. Since this expression is independent of the preference shock, $w^*l^* = w^{'}l^{'}$ results.

$$\frac{\partial\left(\frac{dl/l}{d\Lambda/\Lambda}\right)}{\partial\phi}=\underbrace{\frac{\partial\left(\frac{dl/l}{d\Lambda/\Lambda}\right)}{\partial\left(\Delta V\right)}}_{\text{Positive}}\underbrace{\frac{\partial\left(\Delta V\right)}{\partial\phi}}_{\text{Negative}}<0, \tag{20}$$

where $\frac{\partial(\Delta V)}{\partial\phi}<0$ is taken from Proposition 1. Next, in response to a positive preference impulse, households can either pay the menu cost F and adjust their wages or keep them fixed. Figure 1 shows that if the nominal wage remains unchanged with its initial equilibrium level w^*, then there is no variability in hours worked at l^*. As a result, $\frac{dl/l}{d\Lambda/\Lambda}=0$ under fixed nominal wages. By contrast, if households decide to decrease their wages to w' because of a lower disutility from working, the new equilibrium $E^{'}$ will exhibit a higher level of labor hours l'. It follows that as shown in (19), $\frac{dl/l}{d\Lambda/\Lambda}>0$ under flexible nominal wages. The above results jointly imply that a reduction in the economy's degree of equilibrium nominal-wage rigidity, captured by an increase in the utility loss from non-adjustment ΔV, will raise the volatilities in hours worked and thus output, *i.e.* $\frac{\partial\left(\frac{dl/l}{d\Lambda/\Lambda}\right)}{\partial(\Delta V)}>0$. Therefore, equation (20) states that more progressive income taxation will lead to lower variations of macroeconomic aggregates within our model economy. In sum, this section finds that Guo and Lansing's (1998) continuously progressive tax policy always operates like an automatic stabilizer against business cycles driven by shocks to the household's consumption basket.

To gain further insights, it is worth emphasizing that Proposition 2 delivers exactly the opposite result to that in Gabrovski and Guo (2019) when the same model is subject to monetary shocks given by dM, where $M=\int_0^1 M_i di$ denotes the total quantity of nominal money supply. As illustrated in Figure 2, a positive monetary disturbance that increases the economy's aggregate demand will shift the labor demand curve to the right. When households decide to maintain wages at the initial level w^*, their labor hours are raised to l'', which is higher than l' under flexible nominal wages; and the resulting loss of utility from their non-adjustment is graphically represented by the shaded region ΔV. It follows that the economy displays a relatively higher output volatility when nominal wages are fixed. On the contrary, Figure 1 shows that a positive preference impulse $d\Lambda$ causes a rightward shift of the labor supply curve and thus there will be no fluctuations in hours worked under fixed nominal wages. Since an increase in the tax progressivity can lead to a higher degree of equilibrium nominal-wage rigidity in both settings (see Proposition 1 versus footnote 2), the Guo-Lansing continuously progressive fiscal policy rule destabilizes/stabilizes the business cycle driven by monetary/preference shocks within our New Keynesian macroeconomy.

3 Linearly Progressive Taxation

In this section, we adopt Dromel and Pintus' (2007) piece-wise linearly progressive tax formulation to analytically examine its business-cycle stabilization effects within the New Keynesian macroeconomy described in section 2. The budget constraint faced by the representative household is modified to

$$\int_0^1 p_j c_{ij} dj = w_i l_i - \underbrace{\tau(w_i l_i - E)}_{= TB_i} + \int_0^1 \pi_{ij} dj + S_i, \quad 0 < E < \alpha(1-\mu), \tag{21}$$

where E represents the exemption level of income which is postulated to be strictly positive such that it is consistent with the actual data of U.S. and many developed countries. The government will then impose a positive tax rate $\tau \in (0, 1)$ on the fraction of agent i's wage income $w_i l_i$ that is higher than this pre-specified threshold E; whereas there is no income taxation $\tau = 0$ when $w_i l_i \leq E$. This parsimonious two-income-bracket specification is able to qualitatively capture the piece-wise linear feature commonly observed in real-world tax systems, and TB_i denotes the associated tax burden or payment for household i. Moreover, the tax schedule under consideration is said to be "progressive" when $w_i l_i > E$, since the resulting average tax rate $ATR_i = \tau(1 - \frac{E}{w_i l_i})$ is lower than the positive and constant marginal tax rate $MTR_i = \tau$. As in Gabrovski and Guo (2019) and the previous section, our analyses below are restricted to the economy's symmetric equilibrium under a progressive fiscal policy rule. This in turn will yield an upper bound on the critical value of income given by $E < \alpha(1-\mu)$.[5]

Given the postulated progressive taxation with $w_i l_i > E > 0$ and $0 < \tau < 1$, we also follow Dromel and Pintus (2007) to define the degree of tax progressivity on household i as

$$\theta_i \equiv \frac{MTR_i - ATR_i}{1 - ATR_i} = \frac{\tau E}{(1-\tau) w_i l_i + \tau E} \in (0, 1), \quad \text{where } \frac{\partial \theta_i}{\partial \tau} > 0 \text{ and } \frac{\partial \theta_i}{\partial E} > 0, \tag{22}$$

i.e. an increase in either the marginal tax rate τ or the threshold income level E will lead to a more progressive tax scheme. In addition, we will maintain the assumption that each household's economic decisions are governed by the common marginal tax rate τ.

Per the same solution procedure of section 2, we find that under linearly progressive income taxation, the equilibrium conditions that characterize the aggregate demand and market price for consumption good j, as in equations (6) and (10), will remain the same; and the indirect utility function for household i now becomes

[5] Using equations (6), (8), (10), and (26) that will be derived later, together with the goods-market clearing condition $c_j = y_j$, it can be shown that each agent's nominal wage income at the model's symmetric equilibrium is given by $wl = \alpha(1-\mu)$, which is invariant with respect to preference shocks. It follows that the tax policy will become progressive when $\alpha(1-\mu) > E > 0$.

$$\hat{V}(w_i, \Lambda) = \Lambda \left[\frac{(1-\tau)w_i}{P} \left(\frac{w_i}{W} \right)^{-\frac{1}{\rho}} \left(\frac{\alpha}{P} \right)^{\frac{1}{\alpha}} + \frac{\tau E + \int_0^1 \pi_{ij} dj + S_i}{P} \right] - \frac{\gamma}{1+\gamma} \left[\left(\frac{w_i}{W} \right)^{-\frac{1}{\rho}} \left(\frac{\alpha}{P} \right)^{\frac{1}{\alpha}} \right]^{\frac{1+\gamma}{\gamma}}, \tag{23}$$

where P and W are given by (6) and (8), respectively. At the model's symmetric equilibrium with $w_i = w$, $l_i = l$, $TB_i = TB$, and $\theta_i = \theta$ for all i, it can be shown that the tax burden/payment and the corresponding tax progressivity on each agent are

$$TB = \tau \left[\alpha (1-\mu) - E \right] \tag{24}$$

and

$$\theta = \frac{\tau E}{\alpha (1-\mu)(1-\tau) + \tau E}; \tag{25}$$

household i's nominal wage w_i is set according to

$$\frac{w_i}{W} = \left[\Lambda (1-\rho)(1-\tau) \frac{W}{P} \right]^{-\frac{\gamma\rho}{1+\gamma\rho}} \left(\frac{\alpha}{P} \right)^{\frac{\rho}{\alpha(1+\gamma\rho)}}; \tag{26}$$

and the utility loss from non-adjustment of nominal wages in response to a preference shock $d\Lambda$ is

$$\Delta \hat{V} \equiv \hat{V}^A - \hat{V}^N = \frac{\gamma \left[\Lambda (1-\rho)(1-\mu)(1-\tau) \right]^{\frac{1+\gamma}{1+\gamma(1-\alpha)}}}{2(1+\gamma\rho)} \left(\frac{d\Lambda}{\Lambda} \right)^2 > 0 \tag{27}$$

because of $0 < \alpha, \mu, \rho, \tau < 1$ and $\gamma, \Lambda > 0$.

For a direct comparison between the results of this versus the preceding section in a transparent manner, we will undertake a qualitatively identical experiment: consider an increase in the symmetric-equilibrium tax progressivity $d\theta > 0$, but without a corresponding change in the households' tax burden TB. Taking total differentiation on equation (24) with $d(TB) = 0$ leads to the parametric relationship

$$d\tau = \left[\frac{\tau}{\alpha(1-\mu) - E} \right] dE, \tag{28}$$

which states that the simultaneous increases of the marginal tax rate τ and the threshold income level E need to proportional to each other.[6] As a result, the ensuing nominal-wage rigidity and business-cycle effects are caused by a higher degree of tax progressivity under the same level of equilibrium tax payment.

[6] Notice that an increase in either the marginal tax rate τ or the exemption level of income E also yields a higher degree of tax progressivity, *i.e.* $\frac{\partial\theta}{\partial\tau} > 0$ and $\frac{\partial\theta}{\partial E} > 0$ from equation (25). However, either variation results in a change in the equilibrium tax burden (24) as well.

Next, we substitute the restriction (28) into the totally differentiated version of (25) to obtain

$$d\theta|_{d(TB)\,=\,0} = \left[\frac{\alpha(1-\mu)\theta}{\tau E}\right] d\tau, \tag{29}$$

which yields the size of the tax-progressivity increment, while keeping the associated tax burden unchanged at its initial equilibrium level. Using equations (27) and (29), together with the chain rule, it is then straightforward to show that

$$\left.\frac{d(\Delta\hat{V})}{d\theta}\right|_{d(TB)\,=\,0} = \underbrace{-\left(\frac{\Delta\hat{V}}{1-\tau}\right)\left[\frac{1+\gamma}{1+\gamma(1-\alpha)}\right]}_{=\,\frac{d(\Delta\hat{V})}{d\tau}}\underbrace{\left[\frac{\tau E}{\alpha(1-\mu)\theta}\right]}_{=\,\frac{d\tau}{d\theta}} < 0 \tag{30}$$

because of $0 < \alpha$, μ, τ, $\theta < 1$ and γ, E, $\Delta\hat{V} > 0$. As in the previous section, since a smaller loss of utility from non-adjustment $\Delta\hat{V}$ enlarges the parametric space that exhibits nominal-wage rigidity, equation (30) shows that an increase in the degree of tax progressivity θ will enhance the likelihood of fixed nominal wages in equilibrium. It follows that

Proposition 3. Under a preference shock $d\Lambda$ and (piece-wise) linearly progressive income taxation with $w_i l_i > E > 0$ in equilibrium, an increase in the tax progressivity $\theta \in (0, 1)$ without a corresponding change in the households' tax burden will always (i) raise the degree of equilibrium nominal-wage rigidity, and (ii) operate like an automatic stabilizer that generates lower volatilities in labor hours and output.

The intuition for this Proposition turns out to be qualitatively the same as that underlying Propositions 1 and 2. Per the earlier discussions associated with Figure 1, consider the economy's labor market under a given degree of tax progressivity θ_1 that is derived from a marginal tax rate $\tau_1 \in (0, 1)$ and an exemption level of income $E_1 > 0$. Upon a positive preference shock that shifts the labor supply curve to the right, it can be shown that agents' nominal income will remain unchanged with $w^* l^* = w' l'$ (see footnote 5), regardless of whether their nominal wages are adjusted or not. This result, together with a reduction in the aggregate price index as shown in (17), leads to an increase in the before-tax real labor income for "adjusting" households. It follows that these agents' after-marginal-tax real income $(1-\tau)\,\frac{wl}{P}$ may rise or fall when the tax progressivity is raised to θ_2 under higher levels of the marginal tax rate τ_2 and the income threshold E_2. Equation (30) analytically shows that since the impact of a higher gross real labor income is outweighed by the opposing effect of an increase in the marginal tax rate, more progressive taxation will always decrease the utility loss from non-adjustment of nominal wages, *i.e.* $\frac{d(\Delta\hat{V})}{d\theta} < 0$ while keeping $d\,(TB) = 0$. This in turn implies that each household is less capable of paying the adjustment cost F needed for changing its nominal wage because of a lower disposable income. Hence, agents are more likely to maintain their initial nominal wages in response to a preference disturbance as the tax progressivity rises.

Next, it is straightforward to show that an increase in the degree of tax progressivity θ will reduce the magnitude of business cycle fluctuations. Figure 1 depicts that when agents decide not to change their nominal wages upon a positive utility impulse, the equilibrium labor hours remain unaffected $\left(\frac{dl/l}{d\Lambda/\Lambda} = 0\right)$; and that when the nominal wage is adjusted to fall, the household also raises its labor supply $\left(\frac{dl/l}{d\Lambda/\Lambda} > 0\right)$ and produce more consumption goods. Based on the preceding paragraph which illustrates that fixed nominal wages are more likely to take place under a higher tax progressivity, the economy will exhibit lower volatilities in hours worked and total output as a consequence. In sum, our analysis finds that a more (piece-wise) linearly progressive tax system always raises the equilibrium degree of nominal-wage rigidity and operates like an automatic stabilizer against cyclical fluctuations driven by preference shocks.

To summarize, this paper has overturned the business-cycle destabilization result of more progressive income taxation *à la* Gabrovski and Guo (2019) within the same New Keynesian model driven by impulses to the household utility (*cf.* the quantity of nominal money supply). Under the Guo-Lansing continuously or the Dromel-Pintus linearly progressive tax schedule with the equilibrium tax burden unchanged, we analytically show that an increase in the (positive) tax progressivity will always enhance the likelihood of fixed nominal wages in equilibrium and mitigate macroeconomic fluctuations caused by preference shocks. The key insight is that although both preference and monetary disturbances affect the economy's aggregate demand, they will generate very different effects in the labor market: a preference shock shifts the household's labor supply curve (see Figure 1), whereas a monetary shock shifts the firm's labor demand curve (see Figure 2). As a result, our analysis concludes that whether a more progressive fiscal policy rule (de)stabilizes the Kleven-Kreiner macroeconomy depends crucially on the driving source of business cycles.[7]

[7] For the sake of theoretical completeness, we have also studied our model economy with flat income taxation whereby the average and marginal tax rates for all households take on the same constant level given by (i) $t_i = t_i^m = \eta \in (0, 1)$ under the Guo-Lansing continuously progressive tax schedule; or (ii) $E = 0$ and $ATR_i = MTR_i = \tau \in (0, 1)$ under the Dromel-Pintus linearly progressive policy rule. In this case, the tax-progressivity parameter ϕ or θ is equal to zero. Moreover, it is straightforward to obtain $\frac{\partial(\Delta V)}{\partial \eta} < 0$ and $\frac{\partial(\Delta \hat{V})}{\partial \tau} < 0$, indicating that a higher tax rate will make agents more willing to keep their nominal wages unchanged in response to a preference shock. This result, together with our earlier discussions on the labor market as shown in Figure 1, implies that a flat tax policy will always stabilize the Kleven-Kreiner macroeconomy with lower volatilities of hours worked and total output driven by utility disturbances.

4 Conclusion

In our previous work, Gabrovski and Guo (2019) find that more progressive income taxation may operate like an automatic destabilizer which generates higher cyclical volatilities of labor hours and total output within a prototypical New Keynesian macroeconomy driven by shocks to aggregate money supply. The current paper demonstrates that this business-cycle destabilization result is not robust to a slight departure whereby the same analytical framework is subject to impulses to the household's marginal utility of consumption. Under either Guo and Lansing's (1998) continuously progressive fiscal policy rule, or Dromel and Pintus' (2007) piece-wise linearly progressive tax scheme, we analytically show that an increase in the (positive) tax progressivity without a corresponding change in the household's tax burden will always raise the economy's equilibrium degree of nominal-wage rigidity upon a positive preference shock, and thus serve as an automatic stabilizer to alleviate the resulting magnitude of cyclical fluctuations. From a policy standpoint, the findings of our two articles altogether illustrate that in the context of Kleven and Kreiner's (2003) model with imperfect competition and sticky nominal wages, whether a more progressive tax schedule (de)stabilizes the business cycle depends crucially on the driving source which leads to variations in macroeconomic aggregates.

Our analyses can be extended in several directions. For example, it would be worthwhile to extend our model economy to an intertemporal setting with capital accumulation dynamics. In addition, we may incorporate features that are commonly adopted in the New-Keynesian literature, such as nominal price rigidities and investment adjustment costs, among others. These possible extensions will allow us to examine the robustness of this paper's theoretical results and policy implications, as well as further enhance our understanding of the business-cycle (de)stabilization effects of progressive income taxation within a New-Keynesian macroeconomy. We plan to pursue these research projects in the near future.

5 Conflict of Interest Statement

The authors declare that they have no conflict of interest that could have appeared to influence the work reported in this paper.

Miroslav Gabrovski and Jang-Ting Guo, 3/1/2021.

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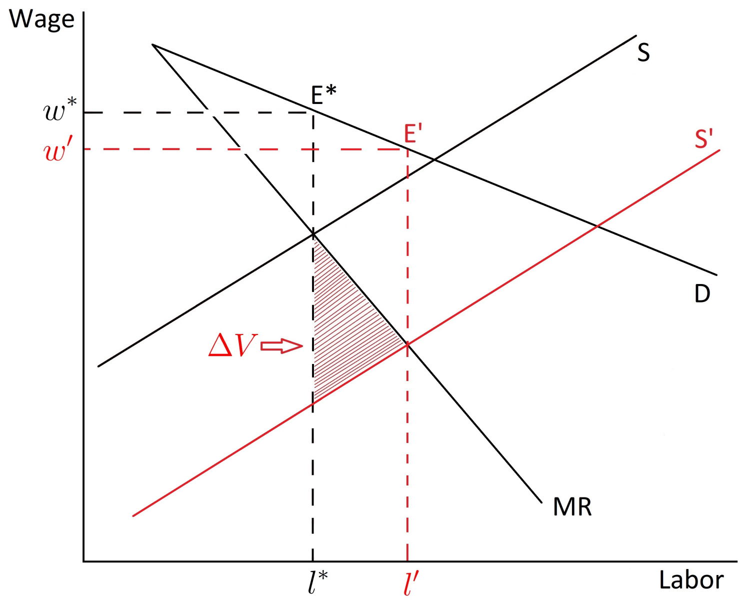

Figure 1: Labor Market under a Positive Preference Shock

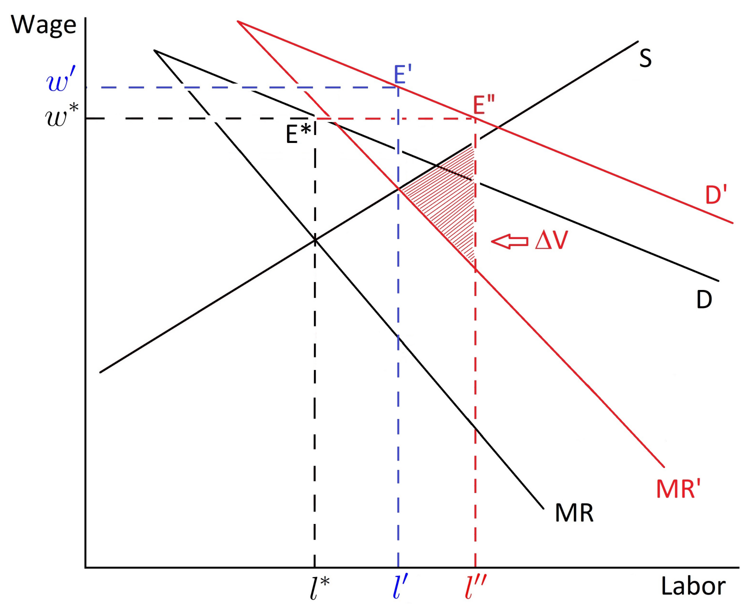

Figure 2: Labor Market under a Positive Monetary Shock