Indeterminacy with Progressive Taxation and Sector-Specific Externalities

Jang-Ting Guo*
University of California, Riverside

Sharon G. Harrison†
Barnard College, Columbia University

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Abstract

We examine a real business cycle (RBC) model, modified to include two sectors of production: consumption and investment, and increasing returns to scale from externalities in the investment sector. In our version of the model, utility can be separable or non-separable. We also add a progressive tax on income, calibrated to match that in the US. This lowers the threshold returns to scale for indeterminacy in the model. In fact, with the progressive tax, both the labor supply elasticity and the returns to scale needed for indeterminacy are empirically plausible. Hence, instability due to self-fulfilling expectations may in fact be a feature of the US economy.
Keywords: Indeterminacy, Progressive Taxation, Sector-Specific Externalities.

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*Department of Economics, 3133 Sproul Hall, University of California, Riverside, CA, 92521, (951) 827-1588, Fax: (951) 827-5685, e-mail: guojt@ucr.edu.

†Corresponding Author. Barnard College, Department of Economics, 3009 Broadway, New York, NY 10027, (212) 854-3333, Fax: (212) 854-8947, e-mail: sh411@columbia.edu.

1 Introduction

Starting with the work of Benhabib and Farmer (1994) and Farmer and Guo (1994), there is now a large literature in macroeconomics that explores indeterminacy and sunspots in real business cycle (RBC) models.[1] The original Benhabib-Farmer-Guo one-sector economy displays indeterminate equilibria driven by sunspot shocks, or self-fulfilling expectations, with separable preferences and sufficiently strong increasing returns to scale in production. However, the returns to scale needed for indeterminacy are implausibly high in this model.

Much progress has been made since in asserting the empirical plausibility of self-fulfilling expectations. In this paper, we contribute to this progress. In particular, we work with a two-sector model, an empirically plausible labor supply elasticity, and a progressive tax calibrated to match that in the US. In addition, we allow for utility to be either separable or non-separable. In both cases, we find that indeterminacy results with empirically plausible returns to scale a la Harrison (2003). Hence, our main result is that instability due to self-fulfilling expectations may in fact be a feature of the US economy.

Benhabib and Farmer (1996), Harrison (2001) and Weder (2000) modify the original Benhabib-Farmer-Guo model to include two sectors of production: consumption and investment. They find that the required returns to scale for indeterminacy are much lower than in the original model, and in the range of empirical plausibility. However, all of these models work with an infinite labor supply elasticity. Other recent work has examined the occurrence of indeterminacy in models with more realistic values for this parameter. For example, Guo and Harrison (2001) use a labor supply elasticity of 4 while Harrison and Weder (2012) use 2.2.

In addition, other recent work has addressed the role that fiscal policy might play in determining the (in)stability of equilibria of these models. One example of many is Guo and Harrison (2001), who find that progressive taxes can be destabilizing, i.e. lead to indeterminacy. On the other hand, in some models, indeterminacy is completely ruled out. Meng and Yip (2008) and Jaimovich (2008), hereafter MYJ, show that a one-sector RBC model, with non-separable preferences, always exhibits saddle-path stability and equilibrium uniqueness when there is no income effect on

[1] See Benhabib and Farmer (1999) for an excellent survey.

the demand for leisure.

In this paper we build upon all of these strands of literature. In particular, we examine a two sector model in which utility can be either separable or non-separable; and we include a tax policy as in Guo and Harrison (2001). Our results are interesting along several dimensions. First, we find that in both cases a progressive tax can lead to indeterminacy. That is, as in Guo and Harrison (2010), the no indeterminacy results in MYJ are overturned. Second, we find that indeterminacy is easier to obtain in the economy with a progressive tax. By this we mean that inclusion of a progressive tax lowers the threshold returns to scale required for indeterminacy. Lastly, we calibrate the progressive tax to match that in the US. We find that the returns to scale required for indeterminacy are empirically plausible, even with a low labor supply elasticity. Hence, while the aforementioned work has not attempted to illustrate such plausibility, our results indicate that instability due to self-fulfilling expectations may in fact be a feature of the US economy.

The rest of this paper proceeds as follows. In Section 2 we outline the model. In Section 3 we calibrate and examine its stability properties. Section 4 concludes.

2 The Model

Our model economy consists of households, firms and the government. In particular, we consider two preference formulations in a discrete-time two-sector real business cycle (RBC) model with the progressive tax policy *a la* Guo and Lansing (1998). Households live forever, and derive utility from consumption and leisure. In Model 1, the household utility is postulated to be additively separable in consumption and hours worked, as in Harrison (2001), and Guo and Harrison (2001, 2010). Model 2 examines a non-separable preference that does not exhibit income effect in labor supply, as in Jaimovich (2008) and Guo and Harrison (2010). The economy also includes two distinct production sectors, consumption and investment. For expositional simplicity, firms in each sector produce output using identical technologies, but increasing returns-to-scale are limited to the investment sector. We further assume that there are no fundamental uncertainties present in the economy.

2.1 The Firms' Problems

In the consumption sector, output is produced by competitive firms using the following constant returns-to-scale technology:

$$Y_{ct} = K_{ct}^{\alpha} L_{ct}^{1-\alpha}, \quad 0 < \alpha < 1, \tag{1}$$

where K_{ct} and L_{ct} are the capital and labor inputs used in the production of consumption goods. Under the assumption that factor markets are perfectly competitive, the first-order conditions for firms' profit maximization are

$$r_t = \frac{\alpha Y_{ct}}{K_{ct}} \quad \text{and} \quad w_t = \frac{(1-\alpha)\, Y_{ct}}{L_{ct}}, \tag{2}$$

where r_t is the capital rental rate and w_t is the real wage.

Similarly, investment goods are produced by competitive firms with the technology

$$Y_{It} = A_t K_{It}^{\alpha} L_{It}^{1-\alpha}. \tag{3}$$

Here, K_{It} and L_{It} are capital and hours worked in the investment sector, and A_t represents productive externalities that each individual firm takes as given. In addition, A_t is specified as

$$A_t = (\bar{K}_{It}^{\alpha} \bar{L}_{It}^{1-\alpha})^{\theta}, \quad \theta \geq 0, \tag{4}$$

where $\bar{K}_{It}$ and $\bar{L}_{It}$ denote the economy-wide average levels of capital and labor devoted to producing investment goods, and θ measures the degree of sector-specific externalities in the investment sector. In a symmetric equilibrium, all firms in the investment sector make the same actions such that $K_{It} = \bar{K}_{It}$ and $L_{It} = \bar{L}_{It}$, for all t. As a result, (4) can be substituted into (3) to obtain the following aggregate production function for investment that may display increasing returns-to-scale:

$$Y_{It} = K_{It}^{\alpha(1+\theta)} L_{It}^{(1-\alpha)(1+\theta)}, \tag{5}$$

where $\alpha(1+\theta) < 1$ to rule out the possibility of sustained economic growth. The first-order conditions that govern the firms' demand for capital and labor in the investment sector are

$$r_t = p_t \frac{\alpha Y_{It}}{K_{It}} \quad \text{and} \quad w_t = p_t \frac{(1-\alpha)\, Y_{It}}{L_{It}}, \tag{6}$$

where p_t denotes the relative price of investment to consumption goods at time t. Notice that firms in each sector face the same equilibrium factor prices since capital and labor inputs are assumed to be perfectly mobile across the two sectors.

2.2 The Household's Problem

The economy is populated by a unit measure of identical infinitely-lived households. Each household is endowed with one unit of time and maximizes its present discounted lifetime utility

$$\sum_{t=0}^{\infty} \beta^t U(C_t, L_t), \quad 0 < \beta < 1 \tag{7}$$

where β is the discount factor, and C_t and L_t are the representative household's consumption and hours worked, respectively. In this paper, we consider the following two specifications of the period utility function $U(\cdot)$ that are commonly used in the real business cycle literature:

$$U_1 = \log C_t - A\frac{L_t^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}, \quad A > 0, \tag{8}$$

and

$$U_2 = \log(C_t - \Lambda\frac{L_t^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}), \quad \Lambda > 0, \tag{9}$$

where $\gamma \geqslant 0$ denotes the wage elasticity of labor supply. The "indivisible labor" formulation of Hansen (1985) and Rogerson (1988) corresponds to the case of $\gamma = 0$ whereby fluctuations in aggregate labor hours are caused by the household's extensive-margin responses (entering or out of employment). When $\gamma > 0$, agents are able to adjust continuously along the intensive margin on the number of their hours worked.

The budget constraint faced by the representative household is

$$C_t + p_t I_t \leq (1-\tau_t)(r_t K_t + w_t L_t) + TR_t, \tag{10}$$

where I_t is gross investment, K_t is the household's capital stock, TR_t denotes transfer payments, and τ_t represents the income tax rate. The law of motion for the capital stock is given by

$$K_{t+1} = (1-\delta)K_t + I_t, \quad K_0 > 0 \quad \text{given}, \tag{11}$$

where $\delta \in (0,1)$ is the capital depreciation rate.

As in Guo and Lansing (1998), we postulate that τ_t takes the form

$$\tau_t = 1 - \eta \left(\frac{Y}{Y_t} \right)^{\phi}, \quad \eta \in (0,1] \quad \text{and} \quad \phi \in [0,1), \tag{12}$$

where $Y_t = r_t K_t + w_t L_t$ is the household's taxable income, and Y denotes the steady-state level of per capita income that is taken as given by each household. The parameters η and ϕ govern the level and slope of the tax schedule, respectively. Using (12), we obtain the expression for the marginal tax rate of income τ_t^m, which is defined as the change in taxes paid by the household divided by the change in its taxable income, as follows:

$$\tau_t^m \equiv \frac{\partial \left(\tau_t Y_t \right)}{\partial Y_t} = 1 - \eta \left(1 - \phi \right) \left(\frac{Y}{Y_t} \right)^{\phi}. \tag{13}$$

Households are postulated to take into account the way in which the tax schedule affects their earnings when they decide how much to work, consume and invest over their lifetimes. Consequently, it is the marginal tax rate of income that governs the household's economic decisions.

In this paper, our analyses are restricted to environments in which $0 < \tau_t < 1$ and $0 < \tau_t^m < 1$ such that (i) the government does not have access to lump-sum taxes, (ii) the government can not confiscate all productive resources, and (iii) households have an incentive to provide labor and capital services to firms. Moreover, in order to guarantee the existence of an interior steady state, the economy's equilibrium after-tax interest rate, $(1 - \tau_t^m)\, r_t$, must be a monotonically decreasing function of K_t, which imposes a lower bound on τ_t^m. In the steady state, the above considerations imply that $\eta \in (0,1)$ and $\phi \in \left(\frac{\alpha(1+\theta)-1}{\alpha(1+\theta)}, 1 \right)$, where $\frac{\alpha(1+\theta)-1}{\alpha(1+\theta)} < 0$.

Given these restrictions on η and ϕ, it is straightforward to show that when ϕ is positive, the marginal tax rate (13) is higher than the average tax rate given by (12). In this case, the tax schedule is said to be "progressive". When ϕ is equal to zero, the average and marginal tax rates coincide at the level of $1 - \eta$, thus the tax schedule is "flat". When ϕ is negative, the tax schedule is said to be "regressive". Since the U.S. federal individual income tax schedule is progressive as it is characterized by several tax "brackets" (branches of income) that are taxed at progressively higher rates, the specification of $\phi > 0$ will be the focus of our model calibrations. To provide a useful benchmark for the subsequent quantitative results, we also examine the economy under laissez-faire without income taxation ($\eta = 1$ and $\phi = 0$). As a result, the parametric constraints of $0 < \eta \leq 1$ and $0 \leq \phi < 1$ are imposed in (12).

The first-order conditions for the household's dynamic optimization problem are given by

$$AC_t L_t^{\frac{1}{\gamma}} = (1 - \tau_t^m)\, w_t, \tag{14}$$

$$\Lambda L_t^{\frac{1}{\gamma}} = (1 - \tau_t^m)\, w_t, \tag{15}$$

$$\frac{1}{C_t} = \frac{\beta}{C_{t+1}} \left[\frac{\left(1 - \tau_{t+1}^m\right) r_{t+1} + (1-\delta) p_{t+1}}{p_t} \right], \tag{16}$$

$$\frac{1}{C_t - \frac{\Lambda L_t^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}} = \frac{\beta}{C_{t+1} - \frac{\Lambda L_{t+1}^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}} \left[\frac{\left(1 - \tau_{t+1}^m\right) r_{t+1} + (1-\delta) p_{t+1}}{p_t} \right], \tag{17}$$

$$\lim_{t \to \infty} \beta^t \frac{K_{t+1}}{C_t} = 0, \tag{18}$$

$$\lim_{t \to \infty} \beta^t \frac{K_{t+1}}{C_t - \frac{\Lambda L_t^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}} = 0, \tag{19}$$

where (14) and (15) equate the slope of the household's indifference curve to the after-tax real wage under U_1 and U_2, respectively. Since C_t is missing from equation (15), there is no income effect associated with the household's labor supply decision in Model 2. Furthermore, (16) and (17) are the standard Euler equations for intertemporal consumption choices; and equations (18) and (17) are the transversality conditions.

2.3 The Government

The government chooses the tax policy τ_t, and returns all its tax revenues to households as a lump-sum transfer TR_t.[2] Hence, its period budget constraint is given by

$$TR_t = \tau_t Y_t. \tag{20}$$

Finally, combining (10) and (20) leads to the following aggregate resource constraint for the economy:

$$C_t + p_t I_t = Y_t. \tag{21}$$

[2] See the Corrigendum to Guo and Harrison (2001) at http://faculty.ucr.edu/~guojt/.

2.4 Equilibrium and Local Dynamics

Since firms use identical production technologies and face the same factor prices across the two sectors, the fractions of capital and labor used in the consumption sector are equal,

$$\frac{K_{ct}}{K_t} = \frac{L_{ct}}{L_t} \equiv \mu_t. \tag{22}$$

We focus on symmetric perfect-foresight equilibria that consist of a set of prices $\{p_t, r_t, w_t\}_{t=0}^{\infty}$ and quantities $\{C_t, L_t, K_{t+1}\}_{t=0}^{\infty}$ that satisfies the household's and firms' first-order conditions. The equalities of demand by households and supply by firms in the consumption and investment sectors are given by $C_t = Y_{ct}$ and $I_t = Y_{It}$. In addition, both the capital and labor markets will clear whereby

$$K_{ct} + K_{It} = K_t, \tag{23}$$

$$L_{ct} + L_{It} = L_t. \tag{24}$$

It is straightforward to show that our model possesses a unique interior steady state. Specifically, the steady-state transfer payments to output ratio, fraction of factor inputs allocated to the consumption sector, and capital rental rate are given by

$$\frac{TR}{Y} = 1 - \eta, \quad \mu = 1 - \frac{\alpha\delta\eta(1-\phi)}{\frac{1}{\beta} - 1 + \delta} \quad \text{and} \quad r = \frac{\mu^{\theta}\left(\frac{1}{\beta} - 1 + \delta\right)}{\eta\,(1-\phi)\,(1-\mu)^{\theta}}, \tag{25}$$

where time subscripts are left out to denote steady-state values. Given (25), the steady-state expressions of all other endogenous variables can be easily derived. We then take log-linear approximations to the model's equilibrium conditions in the neighborhood of this steady state to obtain the following dynamic system:

$$\begin{bmatrix} \hat{K}_t \\ \hat{C}_t \end{bmatrix} = J \begin{bmatrix} \hat{K}_{t+1} \\ \hat{C}_{t+1} \end{bmatrix}, \quad \hat{K}_0 \quad \text{given}, \tag{26}$$

where hat variables denote percentage deviations from their steady-state values, and J is the Jacobian matrix of partial derivatives of the transformed dynamic system. The economy exhibits saddle-path stability and equilibrium uniqueness when one eigenvalue of J lies inside and the other outside the unit circle. When both eigenvalues are outside the unit circle, the steady state is an indeterminate sink. When both eigenvalues are inside the unit circle, the steady state becomes a totally unstable source.

3 Quantitative Analysis

Our goal is to evaluate the stability properties of each model using parameters whose values are consistent with post-war US data. Each period in the model is taken to be one quarter. As is common in the real business cycle literature, the capital share of national income, α, is chosen to be 0.3; the discount factor, β, is set equal to 0.99; and the capital depreciation rate, δ, is fixed at 0.025. Under both types of preferences, we choose Λ so that the steady state value of labor is equal to 1/3.

We will compare the results with no tax ($\eta = 1$, $\phi = 0$) to those with a tax schedule representative of that in the post-war US economy. We calibrate η and ϕ based on Chen and Guo (2012), who use individual data covering the period 1966-2005. As do Cassou and Lansing (2004), they estimate these parameters by assuming that the empirical counterpart to $\frac{Y}{Y_t}$ is mean income divided by household taxable income. Here, mean income is defined as the mean of taxable income for married taxpayers who filed joint returns. They regress the average tax rate, τ_t, on this income ratio for 1,000 data points with equal increments in taxable income, with a resulting $R^2 = 0.867$.We parametrize the progressive tax using $\eta = 0.8$, their point estimate. Their point estimate of ϕ is 0.12, with a standard deviation of 0.055. Here we examine a *less progressive* parametrization using $\phi = 0.12$; and one that is *more progressive*, $\phi = 0.23$, which is the upper bound of the 2-standard deviation band.

As far as labor supply elasticity, while early work beginning with Benhabib and Farmer (1994) and Farmer and Guo (1994) assumed that it was infinite, more recent work has assumed lower values. For example, Guo and Harrison (2001) use 4 while Harrison and Weder (2011) use 2.2. Recent work by Keane and Rogerson (2012) argues that inconsistencies in previous work estimating the labor supply elasticity at the micro versus macro level are based on erroneous assumptions. They conclude that a macro labor supply elasticity between 1 and 2 is empirically plausible.

Our goal is to demonstrate that indeterminacy can result in this model with these empirically plausible values for the tax parameters, the labor supply elasticity, $1/\chi$, and for returns to scale, θ. Harrison (2003) estimates the external effect for investment to be 0.15, with a standard deviation of 0.023. Hence, the top of the 2-standard deviation band, the maximum threshold value of θ we are looking for, is $\theta = 0.196$.

In the following analysis, we examine the stability properties of each model, allowing for varying values of the labor supply elasticity, $1/\chi$, and the externality in the investment sector, θ. We compare the empirical plausibility of indeterminacy across models, and across tax scenarios. Some key results are summarized in Table 1, which illustrates the threshold values of θ necessary for indeterminacy in different cases.

Table 1: Threshold values of θ

		Model 1: Separable Utility	Model 2: Non separable Utility
ϕ	χ		
0	6	0.250	0.325
0	15	0.269	0.300
0.12	6	0.166	0.203
0.12	15	0.179	0.193
0.23	6	0.143	0.173
0.23	15	0.153	0.165

The results for Model 1 can be summarized as follows. As is well known (see for example, Benhabib and Farmer 1994), with separable utility and no tax ($\phi = 0$), a higher χ (lower labor supply elasticity) makes indeterminacy harder to obtain, in that higher returns to scale are needed. Hence, the rise in the threshold θ from 0.250 to 0.269. The last four rows of this column illustrate that this result carries through to the case with taxes. For example, with *less progressive* taxation, returns to scale of 1.179 are needed for indeterminacy when $\chi = 15$, as opposed to only 1.166 when $\chi = 6$. Of interest to us here is the empirical plausibility, or lack thereof, of these figures. When $\chi = 6$ (15), and under progressive taxation, the threshold values of $\theta = 0.166$ (0.179) and 0.143 (0.153) are much lower than the corresponding threshold in the model with no tax, $\theta = 0.250$ (0.269). The thresholds without taxes are not empirically plausible, but those under progressive taxes are. And, the more progressive the tax, the more destabilizing in that lower returns to scale results in indeterminacy.

The results for Model 2 are somewhat different. With separable utility, and no tax ($\phi = 0$), a higher χ (lower labor supply elasticity) makes indeterminacy **easier** to obtain, in that **lower** returns to scale are needed. (Guo and Harrison, 2010, explains the intuition for this result.) Hence, the fall in the threshold θ from 0.325 to 0.300. The last four rows of this column illustrate that this result again carries through to the case with taxes. With $\phi = 0.12$,returns to scale of 1.203 are needed for indeterminacy when $\chi = 6$, as opposed to only 1.193 when $\chi = 15$. These results mimic those of Table 1, however, in that the threshold values with a tax are lower than those without a tax, and are the lowest with the most progressive taxes. In this case, the threshold values for both progressive taxes are again empirically plausible.

More detail is show in Figures 1 and 2. Figure 1 illustrates the stability properties of Model 1, with separable utility. With χ on the horizontal axis and θ on the vertical axis, we see that a lower labor supply elasticity (higher χ) requires a higher level of increasing returns to scale for indeterminacy. In addition, the curve for $\phi = 0.12$ is below that of $\phi = 0$.(The curve for $\phi = 0.23$ is not shown.) That is, indeterminacy results with lower threshold returns to scale when the progressive tax is present. Figure 2 illustrates the stability properties of Model 2, with non separable utility. Again, as Guo and Harrison (2010) explain, a lower labor supply elasticity (higher χ) now requires a lower level of increasing returns to scale for indeterminacy. In addition, the curve for $\phi = 0.12$ is again below that of $\phi = 0$. The values in Table 1 can be read off of these curves.

Of particular interest here is the empirical plausibility of indeterminacy in both of these models. Guo and Harrison (2001) study a two sector model with separable utility. They find that regressive taxes stabilize against the indeterminacy that arises with increasing returns to scale in the investment sector. In that model, labor supply is infinitely elastic, which allows for the lowest possible returns to scale necessary for indeterminacy. Nevertheless, the authors do not focus on the empirical plausibility of any results. In this paper, we find that the threshold level of returns to scale for indeterminacy falls when we add progressive taxes to the laissez-faire model. The intuition for this is therefore the other side of the coin of Guo and Harrison (2001). However, here we examine cases with low labor supply elasticities, and a tax rate that matches in the US.

In the model with non separable utility, lower labor supply elasticities require lower returns to scale for indeterminacy, as in Guo and Harrison (2010). However, the intuition from Guo and Harrison (2001) carries through: indeterminacy is more easily reached under progressive taxes than it is under laissez faire here as well. And again, with the tax calibrated to match that in the US, and empirically plausible returns to scale, indeterminacy results.

Hence, we interpret our results as follows. This model, when calibrated to match the progressive tax rates in the US, results in equilibrium indeterminacy for empirically plausible values of the labor supply elasticity and of returns to scale. This indeterminacy of equilibria is often interpreted as self-fulfilling expectations. Hence, instability due to self-fulfilling expectations may in fact be a feature of the US economy.

4 Conclusion

We have examined a real business cycle (RBC) model, modified to include two sectors of production: consumption and investment. With sufficiently high increasing returns to scale from externalities in the investment sector, indeterminacy is possible. In our version of the model, utility can be separable or non-separable, and a progressive tax on income is imposed by the government. We have found that in both versions of the model indeterminacy remains, and we examine its empirical plausibility. In particular, allowing for a low labor supply elasticity and calibrating the tax to match that in the US, we find that the threshold returns to scale for indeterminacy are empirically plausible. Hence, instability due to self-fulfilling expectations may in fact be a feature of the US economy. The reader might assume that such instability is welfare-reducing, and hence that the government should consider insulating the economy from such fluctuations. As we have not conducted any welfare analysis here, we leave that question for future research.

References

[1] Benhabib, J. and R.E.A. Farmer, 1994, "Indeterminacy and Increasing Returns," *Journal of Economic Theory* 63, 19-41.

[2] Benhabib, J. and R.E.A. Farmer, 1996, "Indeterminacy and Sector-Specific Externalities," *Journal of Monetary Economics* 37, 421-444.

[3] Benhabib, J. and R.E.A. Farmer, 1999, "Indeterminacy and Sunspots in Macroeconomics," in J. Taylor and M. Woodford, eds., *Handbook of Macroeconomics,* Vol. 1, North Holland: Amsterdam, 387-448.

[4] Cassou, S.P. and K.J. Lansing, 2004, "Growth Effects of Shifting from a Graduated-Rate Tax System to a Flat Tax," *Economic Inquiry* 42, 194-213.

[5] Farmer, R.E.A. and J.-T. Guo, 1994, "Real Business Cycles and the Animal Spirits Hypothesis," *Journal of Economic Theory* 63, 42-72.

[6] Chen, S.-H., and Guo, J.T., 2012, "Progressive Taxation and Macroeconomic (In)stability with Productive Government Spending," *Journal of Economic Dynamics and Control*, forthcoming.

[7] Guo, J-T. and K.J. Lansing, 1998, "Indeterminacy and Stabilization Policy," *Journal of Economic Theory* 82, 481-490.

[8] Guo, J-T. and S.G. Harrison, 2001, "Tax Policy and Stability in a Model with Sector-Specific Externalities," *Review of Economic Dynamics* 4, 75-89.

[9] Guo, J.-T. and S.G. Harrison, 2010, "Indeterminacy with No-Income-Effect Preferences and Sector-Specific Externalities," *Journal of Economic Theory* 145, 287-300.

[10] Hansen, G.D. ,1985, "Indivisible Labor and the Business Cycle," *Journal of Monetary Economics* 16, 309-327.

[11] Harrison, S.G., 2001, "Indeterminacy in a Model with Sector-Specific Externalities," *Journal of Economic Dynamics and Control* 25, 747-764.

[12] Harrison, S. G., 2003, "Returns to Scale and Externalities in the Consumption and Investment Sectors. *Review of Economic Dynamics* 6**,** 963-976.

[13] Jaimovich, N., 2008, "Income Effects and Indeterminacy in a Calibrated One-Sector Growth Model," *Journal of Economic Theory* 143, 610-623.

[14] Keane, M., and R. Rogerson, 2012, "Micro and Macro Labor Supply Elasticities: A Reassessment of Conventional Wisdom," *Journal of Economic Literature*, 50(2): 464-76.

[15] Meng, Q. and C.K. Yip, 2008, "On Indeterminacy in One-Sector Models of the Business Cycle with Factor-Generated Externalities," *Journal of Macroeconomics* 30, 97-110.

[16] Rogerson, R., 1988, "Indivisible Labor, Lotteries, and Equilibrium," *Journal of Monetary Economics* 21, 3-16.

[17] Weder, M., 2000. "Animal Spirits, Technology Shocks and the Business Cycle," *Journal of Economic Dynamics and Control* 24, 273-295.

Figure 1

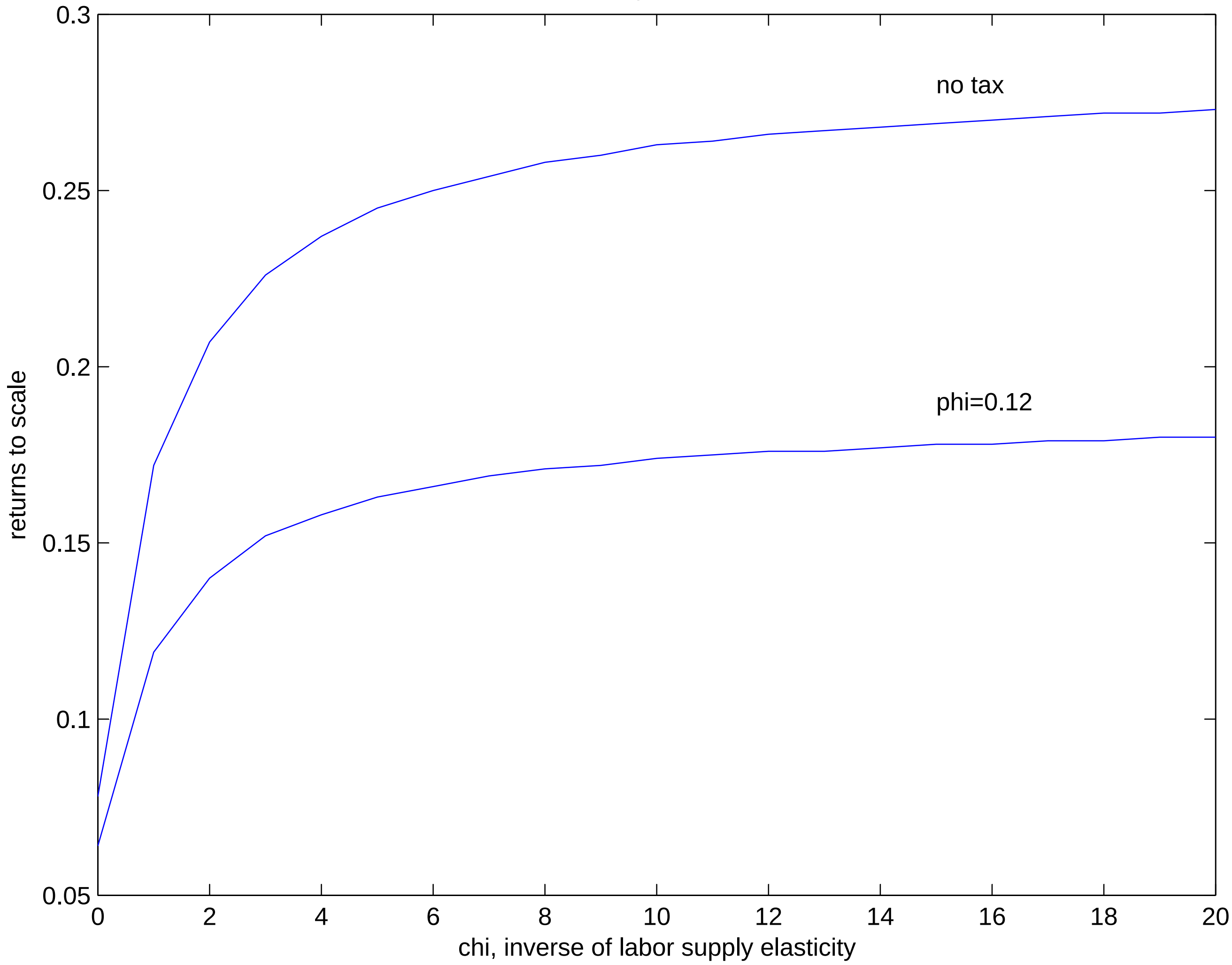
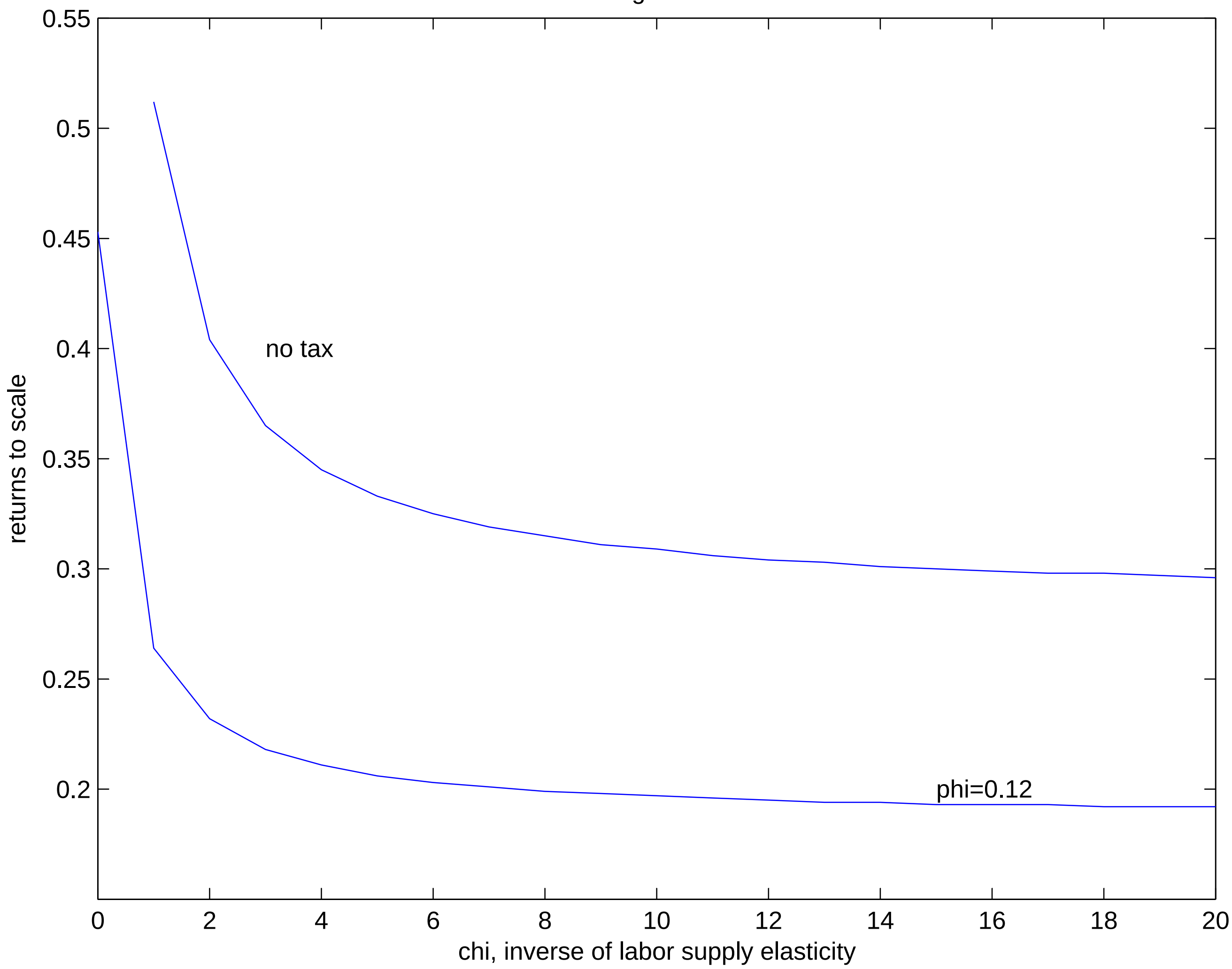

0.3
0.25
0.2
0.15
0.1
0.05
returns to scale
no tax
phi=0.12
0
2
4
6
8
10
12
14
16
18
20
chi, inverse of labor supply elasticity

Figure 2



0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
returns to scale
no tax
phi=0.12
0
2
4
6
8
10
12
14
16
18
20
chi, inverse of labor supply elasticity