How do state taxes affect the location choice of workers and firms and the total number of available varieties in a multiregion model of monopolistic competition with variable labor supply?

Juan Carlos Lopez

University of Denver

(Very Early Draft: Please Do Not Cite)

January 12, 2018

Abstract

Consider an economy comprised of multiple regions in which households consume a variety of horizontally differentiated goods and choose the quantity of labor to supply. Each region has a distinct set of income and tax rate combinations, which generates revenue used to finance a congestible local public good. Regional tax differences produce regional wage variation due to differences in after tax income and price levels. In this paper we consider how these regional differences in taxes affect the number of workers and firms in each region and the number of varieties produced both within a region and overall when household labor supply is sensitive to the real wage. We solve for the equilibrium number of regional residents and varieties and show that regions with higher relative tax rates may have a larger population and produce a greater number of varieties provided that consumer taste for the public good is sufficiently high, labor supply elasticity is relatively low and congestion effects are not too strong. Finally, we calculate the welfare maximizing tax rate under a cooperative tax policy.

1 Introduction

The basic premise of this paper is fairly simple. If worker's labor supply is sensitive to the real wage, then regional variation in income and sales taxes should lead to regional heterogeneity in the number of workers and the hours supplied by each worker. Furthermore, in an economy defined by a large number of monopolistically competitive firms selling horizontally differentiated products the variation in regional populations and labor supply should, in turn, affect the number of varieties produced in each region and the total number of varieties available in the entire economy. In addition, in a model *a la* Forslid and Ottaviano (2003) where production requires marginal units of low productivity labor, and a fixed costs of high productivity labor, there will no longer be a one-to-one mapping between the number of high productivity workers and the number of varieties. Consider, for example, the restaurant industry, which carries a number of similar varieties and high fixed costs. In a high tax state does a budding restaurateur, who may be facing a lower nominal after tax payoff, choose to take on an additional partner in order to offset some of the fixed labor requirements of the new business?

US states are reliant on tax revenue to fund public services. However, in practice, states utilize different tax instruments to different degrees in order to generate revenue. This paper focus on the two largest sources of state tax revenue: the sales and income tax, which on average make up over 50% of state tax revenue (Tax Foundation, 2013). [1] This paper considers how state level variation in tax rates affects the location choice of households and firms in a spatial model of monopolistic competition. In addition, we consider the implication of the rates on the supply of labor by households, which has implications for the number of varieties produced in each region and over all.

To model this we utilize the framework developed by Forslid and Ottaviano (2003) where production is comprised of two labor components with fixed labor costs associated with the owners of firms and variable labor costs come from hired labor. We add to this framework the specification by Andersson and Forslid (2003) whereby regions collect taxes

[1] On average, the single largest source of tax revenue within a state is the property tax, generating 35% of tax revenues . However, that revenue is generally earmarked primarily for municipal use with only a small share going to the state coffers. For example, in 2013 total state revenue from property taxes was $13 billion compared to $442 billion for municipalities (Tax Policy Center, 2013). In addition, property tax rates vary across municipalities with in a given state.

to fund a public good. A variation that is added is that the public good is congestible. In addition, we introduce a labor supply choice by households similar to two recent papers by Ago *et al.* (2017a, 2017b). However, our formulation extends those models to the case where all workers are mobile. Rather than focusing on transport costs, spatial frictions arise through the differences in sales and income tax rates across regions. Therefore, in a spatial equilibrium, adjustments come through the number of workers in each region and the number of hours supplied which varies by type of worker. This research bears similarities to Murata (2009) who considers how differences in regional technological productivity and labor efficiency determine the number of varieties consumed in each region. In contrast, we consider how regional tax rates determine labor supply and what that implies about the level of production locally and the set of varieties offered globally.

Here we do not consider transport costs in the movement of goods focusing instead on the spatial frictions introduced from cost of living differences that arise from differences in regional tax rates. Empirically within a country, the transport costs for certain industries may be very small. Consider the case of the online book retailer Abebooks.com. When searching for a specific title one receives a list of choices that vary by bookseller location, quality (new or used), price and shipping costs with the price of many books including free shipping When shipping costs exists they are a flat rate and independent of distance. However, once a selection has been made the customer is given a subtotal that is adjusted to take into account the state sales tax rates that must be paid by the consumer in the destination state. This generates differences in the price of final goods by region. Though all consumers face the same pre-tax price, their effective price they pay will depend upon the sales tax rate for the state that they live in.

There is a long literature on the implication of tax rates on labor supply and in measuring labor supply elasticities (summarized in Meghir and Phillips (2009) and Keane (2011)). However, as noted by Peterman (2016) and Chetty *et al.* (2012) there is generally a large discrepancy between the microeconometric estimates of labor supply elasticities and the values used to calibrate models in the macroeconomics literature. In this model this has implications for how tax policy will determine the labor supply and output of each region. For example, we provide a cutoff value for states with higher tax rates to have larger populations and produce a greater number of varieties, however the cutoff value is decreasing in the labor supply elasticity as higher tax rates become more punitive in reducing private consumption relative to the additional public services that are provided from greater tax revenue.

The paper is organized as follows. Section 2 describes and solves the model. Section 3 discusses some results and relative population, labor supply and public good provision when tax rates are exogenous. Section 4 considers a cooperative tax policy and solves for the welfare maximizing tax rates. Finally, Section 5 concludes.

2 The Model

2.1 Households

Consider an economy made up of J countable regions indexed by $j = 1, .., J$. There is a total population of N households consisting of two types of workers indexed by $i = 1, 2$. The exogenous number of each type of worker is given by N_i. Workers are free to locate in any region that they wish, however once a location decision is made they must live and work in that region so that there is no interregional commuting. A type i worker in region j chooses how much labor to supply, h_{ij} at the unit wage w_{ij} given the income tax rate τ_{ij}. Total disposable income is then given by $(1-\tau_{ij})w_{ij}h_{ij}$. Households have preferences over Q_{ij} which is an aggregate over horizontally differentiated variety of consumption goods denoted by $q_{ij}(k)$,where $k \in K$ denotes a type k variety of the total set of varieties K. All consumption goods are freely traded both within and across regions and households can choose to buy a variety locally or from another region. However, it is assumed that the regional government in which a household lives can impose a proportional sales tax t_i on each good no matter the point of sale. The firms that sells the good then distributes any tax revenue back to the regional government. This is consistent with online shopping websites where after a customer completes an order a subtotal is given. Once the customer inputs the shipping address a final total bill is calculated which includes the local sales tax. Therefore the effective price that a household faces is given by $(1 + t_i)p_i(s)$, where

$p_i(k)$ is the price of variety k. A type i household in region j solves the following problem

$$\max_{q_{ij}(s),h_{ij}} G_i(N_{1j}, N_{2j}) \left(Q_{ij} - \frac{\gamma}{1+\gamma} h_{ij}^{(1+\gamma)/\gamma} \right) \tag{1}$$

$$s.t. (1-\tau_{ij}) w_{ij} h_{ij} = (1+t_i) \int_{k \in K} p_i(k) q_{ij}(k) dk \tag{2}$$

$$Q_{ij} = \left(\int_{k \in K} q_{ij}(k)^{(\sigma-1)/\sigma} dk \right)^{\sigma/(\sigma-1)}, \tag{3}$$

where $G_i(N_{1j}, N_{2j})$ is a function representing a congestible, local public good which households take as parametric. We suppose that the function takes the form,

$$G_j(N_{1j}, N_{2j}) = G_j^{\eta} (N_{1j} + N_{2j})^{-\theta}, \quad \eta > 0, \theta > 0 \tag{4}$$

where G_j is the level of the local public good, $(N_{1j}+N_{2j})$ is the size of the local population η represents the elasticity of utility to the public good and θ measures the degree of the congestion effect on the public good. When $\theta = 0$ it is a pure public good, while for $\theta = 1$ it is a publicly provided private good. It is assumed that $\theta > \eta$ so that the congestion effect dominates. This assumption will ensure a unique interior equilibrium. The parameters γ and σ represent the labor supply elasticity and the elasticity of substitution between varieties, respectively. The public good is assumed to use an equal amount of all varieties to produce the good so that the government demand for each variety is then G_j/K. Utility maximization yields the following demand and labor supply functions

$$h_{ij} = \left(\frac{(1-\tau_{ij}) w_{ij}}{(1+t_i) P_i} \right)^{\gamma}, \quad q_{ij}(k) = \frac{p_j(k)^{-\sigma}}{P_j^{1-\sigma}} \left(\frac{(1-\tau_{ij}) w_{ij}}{(1+t_i) P_j} \right)^{1+\gamma}, \quad Q_{ij} = \left(\frac{(1-\tau_{ij}) w_{ij}}{(1+t_i) P_i} \right)^{1+\gamma} \tag{5}$$

where

$$P_j = \sum_j \left(\int_{k \in K} p_j(k)^{1-\sigma} dk \right)^{1/(1-\sigma)} \tag{6}$$

The indirect utility of household can then be written as

$$V_{ij} = G_j^{\eta} (N_{1j} + N_{2j})^{-\theta} \left(\frac{1}{1+\gamma} \left(\frac{(1-\tau_{ij}) w_{ij}}{(1+t_i) P_i} \right)^{1+\gamma} \right) \tag{7}$$

2.2 Production

There is a continuum of monopolistically competitive firms in each region j that employ both types of (local)labor in production. In order to produce the quantity $x_j(k)$ each firm requires β units of type 1 workers per unit of output and a fixed cost of α units of type two workers and face the prices w_{1j} and w_{2j}, respectively. The total cost to a producer is then

$$TC_j(k) = \beta w_{1j} x_j(k) + \alpha w_{2j} \tag{8}$$

and the profit of a firm producing variety k is given by

$$p_j(k)\left(\sum_j (q_{1j}(k) + q_{2j}(k))\right) - \beta w_{1j}\left(\sum_j (q_{1j}(k) + q_{2j}(k))\right) - \alpha w_{2j}. \tag{9}$$

Firms choose the price to maximize profit which yields,

$$p_j(k) = \frac{\sigma}{\sigma - 1}\beta w_{1j} \tag{10}$$

where the price is a constant markup over the marginal cost. In equilibrium is must be the case that the pre-tax prices for all varieties and the wages for type 1 workers are equivalent everywhere. Given that households can look for options outside of their region, firms would want to choose the region with the lowest marginal cost. Therefore if there are a positive number producers in all regions it must be the case that $w_{1j} = w_1$ and that $p_j(s) = p$. The wage of type 1 workers, w_1, is chosen as the numeraire so that $p = \beta\sigma/(\sigma - 1)$ and the regional pre-tax price indices reduce to $P_j = P = K^{1/(1-\sigma)}\beta\sigma/(\sigma - 1)$.

In equilibrium firms make zero profits. Writing the output of a firm as $x_j(k) = \sum_j (q_{1j}(s) + q_{2j}(s) + G_j/K)$ and using (10) we have

$$x_j(k) = \frac{\alpha}{\beta}(\sigma - 1)w_{2j} \tag{11}$$

Define K_j the total number of varieties produced in region j. The market clearing conditions for the labor supply of each type are given by

$$\beta x_j(k)K_j = N_{1j}h_{1j} \tag{12}$$

$$\alpha K_j = N_{2j}h_{2j} \tag{13}$$

Taking ratios of (12) and (13) and using (11) yields an equation for the owners wage as a function of the local supply of workers

$$w_{2j} = \left(\frac{1}{\sigma-1}\frac{N_{1j}}{N_{2j}}\right)^{1/(1+\gamma)} \tag{14}$$

In equilibrium, the total demand for each variety is identical (though individual demands for each variety vary by type and region) implying that $w_{2j} = w_2$ for all j. This further implies that the ratio between type 1 and 2 workers in each region is constant so that $N_{1j} = \frac{N_1}{N_2}N_{2j}$ for all j and we can rewrite (14) as

$$w_2 = \left(\frac{1}{\sigma-1}\frac{N_1}{N_2}\right)^{1/(1+\gamma)} \tag{15}$$

where (15) indicates that the wage is defined by the relative number of type 1 and type 2 workers in the whole economy. We can then solve for the regional and total number of varieties

$$K_j = \frac{1}{\alpha}\left(\frac{1}{\sigma-1}\frac{N_1}{N_2}\right)^{\gamma/(1+\gamma)}\left(\frac{\sigma-1}{\beta\sigma}\right)^{\gamma}K^{\gamma/(\sigma-1)}N_{2j}\left(\frac{1-\tau_j}{1+t_j}\right)^{\gamma} \tag{16}$$

Given that K is common for all regions, summing over j yields

$$K = \left(\frac{1}{\alpha}\left(\frac{1}{\sigma-1}\frac{N_1}{N_2}\right)^{\gamma/(1+\gamma)}\left(\frac{\sigma-1}{\beta\sigma}\right)^{\gamma}\sum_j\left(N_{2j}\left(\frac{1-\tau_j}{1+t_j}\right)^{\gamma}\right)\right)^{(\sigma-1)/(\sigma-1-\gamma)} \tag{17}$$

Note that when $\gamma = 0$, (17) reduces to $K = N_2/\alpha$, which is the standard result with inelastic labor supply. Inserting (17) back into (16) the number of regional varieties is given by

$$K_j = \left(\frac{1}{\alpha} \left(\frac{1}{\sigma - 1} \frac{N_1}{N_2} \right)^{\gamma/(1+\gamma)} \left(\frac{\sigma - 1}{\beta\sigma} \right)^{\gamma} \right)^{(\sigma-1)/(\sigma-1-\gamma)} N_{2j} \left(\frac{1-\tau_j}{1+t_j} \right)^{\gamma} \left(\sum_j N_{2j} \left(\frac{1-\tau_j}{1+t_j} \right)^{\gamma} \right)^{\gamma/(\sigma-1-\gamma)} \tag{18}$$

Turning to the public service level we have that the expenditure on the quantity G_j has to equal the tax receipts so that

$$\begin{aligned} pG_j &= \tau_j (N_{1j} w_{1j} h_{1j} + N_{2j} w_{2j} h_{2j}) + t_j (N_1 P Q_{1j} + N_2 P Q_{2j}) \\ &= \left(\frac{\tau_j + t_j}{1+t_j} \right) \left(\frac{\sigma}{\sigma - 1} \right) N_{1j} h_{1j} \\ &= \left(\frac{\tau_j + t_j}{1+t_j} \right) \left(\frac{\sigma}{\sigma - 1} \right) \left(\frac{1-\tau_j}{1+t_j} \right)^{\gamma} \left(\frac{\sigma - 1}{\beta\sigma} (K^*)^{1/\sigma-1} \right)^{\gamma} N_{1j} \end{aligned} \tag{19}$$

where K^* is represented by (17). Dividing both sides by p we can then write

$$G_j = \left(\frac{\tau_j + t_j}{1+t_j} \right) \left(\frac{1-\tau_j}{1+t_j} \right)^{\gamma} \frac{N_{1j}}{\beta} \left(\frac{\sigma - 1}{\sigma\beta} \right)^{\gamma} (K^*)^{\gamma/(\sigma-1)} \tag{20}$$

We can now combine all of the ingredients to to write down the utility levels

$$V_1 j = \frac{\beta^{-\eta} N_{1j}^{\eta-\theta}}{1+\gamma} \left(\frac{\tau_j + t_j}{1+t_j} \right)^{\eta} \left(\left(\frac{1-\tau_j}{1+t_j} \right) \left(\frac{\sigma - 1}{\sigma\beta} \right) (K^*)^{1/(\sigma-1)} \right)^{1+\gamma(1+\eta)} \left(\frac{N_1}{N_1 + N_2} \right)^{\theta} \tag{21}$$

$$\begin{aligned} V_2 j = &\frac{\beta^{-\eta} N_{1j}^{\eta-\theta}}{1+\gamma} \left(\frac{\tau_j + t_j}{1+t_j} \right)^{\eta} \left(\left(\frac{1-\tau_j}{1+t_j} \right) \left(\frac{\sigma - 1}{\sigma\beta} \right) (K^*)^{1/(\sigma-1)} \right)^{1+\gamma(1+\eta)} \\ &\times \left(\frac{N_1}{N_1 + N_2} \right)^{\theta} \left(\frac{1}{\sigma - 1} \frac{N_1}{N_2} \right) \end{aligned} \tag{22}$$

To close the model, a spatial equilibrium implies that the utility level for each type is equalized across regions so that $V_{ij} = V_i$ for all i. Consider two regions l and j. In a spatial equilibrium, using (21) we can then write

$$N_{1l} = N_{1j} \left(\frac{ \left(\frac{\tau_j + t_j}{1+t_j} \right)^{\eta/(\eta-\theta)} \left(\frac{1-\tau_j}{1+t_j} \right)^{1+\gamma(1+\eta)/(\eta-\theta)} }{ \left(\frac{\tau_l + t_j l}{1+t_l} \right)^{\eta/(\eta-\theta)} \left(\frac{1-\tau_l}{1+t_l} \right)^{1+\gamma(1+\eta)/(\eta-\theta)} } \right) \tag{23}$$

Summing over l yields

$$N_{1j} = N_1 \left(\frac{\left(\frac{\tau_j+t_j}{1+t_j}\right)^{\eta/(\theta-\eta)} \left(\frac{1-\tau_j}{1+t_j}\right)^{1+\gamma(1+\eta)/(\theta-\eta)}}{\sum_{l=1}^{J} \left(\frac{\tau_l+t_j l}{1+t_l}\right)^{\eta/(\theta-\eta)} \left(\frac{1-\tau_l}{1+t_l}\right)^{1+\gamma(1+\eta)/(\theta-\eta)}} \right) \tag{24}$$

Note that under a cooperative tax policy with $\tau_j = \tau$ and $t_j = t$ for all j, (24) reduces to $N_{1j} = N_1/J$ and similarly, $N_{2j} = N_2/J$. Inserting into the total number of varieties yields,

$$K = \left(\frac{1}{\alpha} \left(\frac{1}{\sigma-1} \frac{N_1}{N_2} \right)^{\gamma/(1+\gamma)} \left(\frac{\sigma-1}{\beta\sigma} \right)^{\gamma} N_2 \left(\frac{\sum_j \left(\frac{\tau_j+t_j}{1+t_j}\right)^{\eta/(\theta-\eta)} \left(\frac{1-\tau_j}{1+t_j}\right)^{1+\gamma(1+\theta)/(\theta-\eta)}}{\sum_j \left(\frac{\tau_l+t_j l}{1+t_l}\right)^{\eta/(\theta-\eta)} \left(\frac{1-\tau_l}{1+t_l}\right)^{1+\gamma(1+\eta)/(\theta-\eta)}} \right) \right)^{(\sigma-1)/(\sigma-1-\gamma)} \tag{25}$$

The numerator and denominator of the third fraction in (25) differ in the exponent on the second term with θ in the numerator and η in the denominator. Given that $\theta > \eta$ the fraction is less than unity.

3 Some Results with Exogenous Tax Rates

This sections considers the distribution of economic activity across regions assuming exogenous tax rates. In practice, states tend to use both the sales tax and income tax to generate revenue for local public goods. However, their are a number of states that rely on a single tax. Here we consider the implications of of reliance on a single tax. Consider two region, l and s respectively with region l employing only the income tax τ_l and region s reliant solely on the sales tax t_s with $t_l = \tau_s = 0$. Now, the household utility level is comprised of the product of public and private consumption. Furthermore, an analysis of (19) reveals that the public good is made up of three parts: revenue per unit of income, size of the population and the labor supply of each worker. Taking ratios of the private consumption of workers in regions l and s yields

$$((1-\tau_l)(1+t_s))^{1+\gamma} \tag{26}$$

Private consumption on both regions is equalized when $\tau_l = t_s/(1+t_s) < t_s$. It is straightforward to verify that if this relationship holds $N_{1l} = N_{1s}$, $N_{2l} = N_{2s}$, $G_l = G_s$ and $K_l = K_s$. Therefore the same level of utility, population, public good provision and economic output can be achieved with a lower proportional income tax than sales tax. Suppose the region l is considering an increase in the income tax rate, what would be the implication? When $\tau_l > t_s/(1+t_s)$, private consumption and labor supply are lower in region l while the the revenue per unit of income is higher. We then need to consider what happens to the relative population size. Taking ratios of (24) for regions l and s yields

$$\frac{N_{1l}}{N_{1s}} = \left(\frac{(\tau_l)^{\eta} (1-\tau_l)^{1+\gamma(1+\eta)}}{\left(\frac{t_s}{1+t_s}\right)^{\eta} \left(\frac{1}{1+t_s}\right)^{1+\gamma(1+\eta)}} \right)^{1/(\eta-\theta)} \tag{27}$$

Differentiating (27) with respect to τ_l, holding t_s fixed and evaluating the derivate at $\tau_l = t_s/(1+t_s)$ gives,

$$Sign \frac{\partial \left(\frac{N_{1l}}{N_{1s}}\right)}{\partial \tau_l}\Bigg|_{\tau_l = t_s/(1+t_s)} = Sign \left(\frac{\eta}{t_s} - (1+\gamma(1+\eta)) \right) \gtreqless 0 \iff t_s \lesseqgtr \frac{\eta}{1+\gamma(1+\eta)} \tag{28}$$

This says that the relative populations between region l and s is increasing (decreasing) in the income tax if the initial sales tax rate is sufficiently low (high). This result is more likely to hold if the benefit from public goods for households is high (large η) and the labor supply elasticity (γ) is low (recalling that ratios of type 1 and 2 workers are constant across regions so any increase in one type must generate a proportional increase in the other type).

Next we consider the impact of the same policy changes on the number of varieties produced in each region. From (18), the relative number of varieties can be written as $K_l/K_s = N_{2l}h_{2l}/N_{2s}h_{2s} = N_{1l}h_{1l}/N_{1s}h_{1s}$, where use is made of the fact that ratios of workers are common across regions and $h_{2j} = w_2^{\gamma} h_{1j}$. We can then write

$$\frac{K_l}{K_s} = \left(\frac{(\tau_l)^{\eta} (1-\tau_l)^{1+\gamma(1+\theta)}}{\left(\frac{t_s}{1+t_s}\right)^{\eta} \left(\frac{1}{1+t_s}\right)^{1+\gamma(1+\theta)}} \right)^{1/(\eta-\theta)} \tag{29}$$

Note that all that has changed is the introduction of θ and the loss of η on the exponent of the second term in both the denominator and numerator of the right hand side. Using the same method as above to sign the the change in relative varieties produced in each region yields

$$Sign \frac{\partial \left(\frac{K_{1l}}{K_{1s}}\right)}{\partial \tau_l}\Big|_{\tau_l = t_s/(1+t_s)} = Sign\left(\frac{\eta}{t_s} - (1 + \gamma(1+\theta))\right) \gtreqless 0 \iff t_s \lesseqgtr \frac{\eta}{1+\gamma(1+\theta)} \quad (30)$$

Recall that by assumption $\theta > \eta$, which says that congestion forces are sufficiently strong to offset the increasing returns from the local public good. This implies that the restriction on t_s in (28) is more stringent than that in (30). Intuitively, when tax rates are low so that private consumption is relatively high, the increase in the relatively uncongested public good more than offsets the reduction in household labor supply, inducing new migration and raising the the number of varieties produced. However, when tax rates are high and the population is large so that the public good is highly congested, the effect on private consumption is dominant, reducing the the population and the number of varieties.

This outcome can be summarized in Figure 1. Define $n_{N_{ij}}$ and $d_{N_{ij}}$ as the numerator and denominator, respectively, from Eq. (27) which pins down relative regional populations. Similarly define n_{K_j} and d_{N_j} as the numerator and denominator from Eq.(29) which pins down the relative number of varieties produced in each region. This lines are represented in the top graph in Figure 1. The dotted horizontal line is an arbitrary value. When $n_{N_{ij}}$ or $d_{N_{ij}}$ intersects that line, at those respective tax rates, regional populations are equalized. This holds similarly in the case of varieties. The bottom graph plots the household labor supply functions as tax rates increase, and are represented by the functions $h(\tau_l)$ and $h(t_s)$, respectively. In the figure, we see when $\tau_l = t_s/1 + t_s$ both regions have the same population, produce the same number of varieties and households supply identical quantities of labor. This is represented by the points {A,B,C} for the region that faces the tax rate τ_l and {D,E.F} for the region that faces the rate t_s. Now consider the region that faces the income tax rate $\tau^{'} > \tau_l$. This region will have a larger population, produce a greater number of varieties however, household labor supply will be lower. these points are denoyed by {G,H,I}. Finally, consider a high income tax region with the rate denoted by $\tau^{*} > \tau^{'} > \tau_l$. In this case, the population is the same as the region with the rate τ_l, however the region produces fewer varieties and households have a lower relative labor supply.

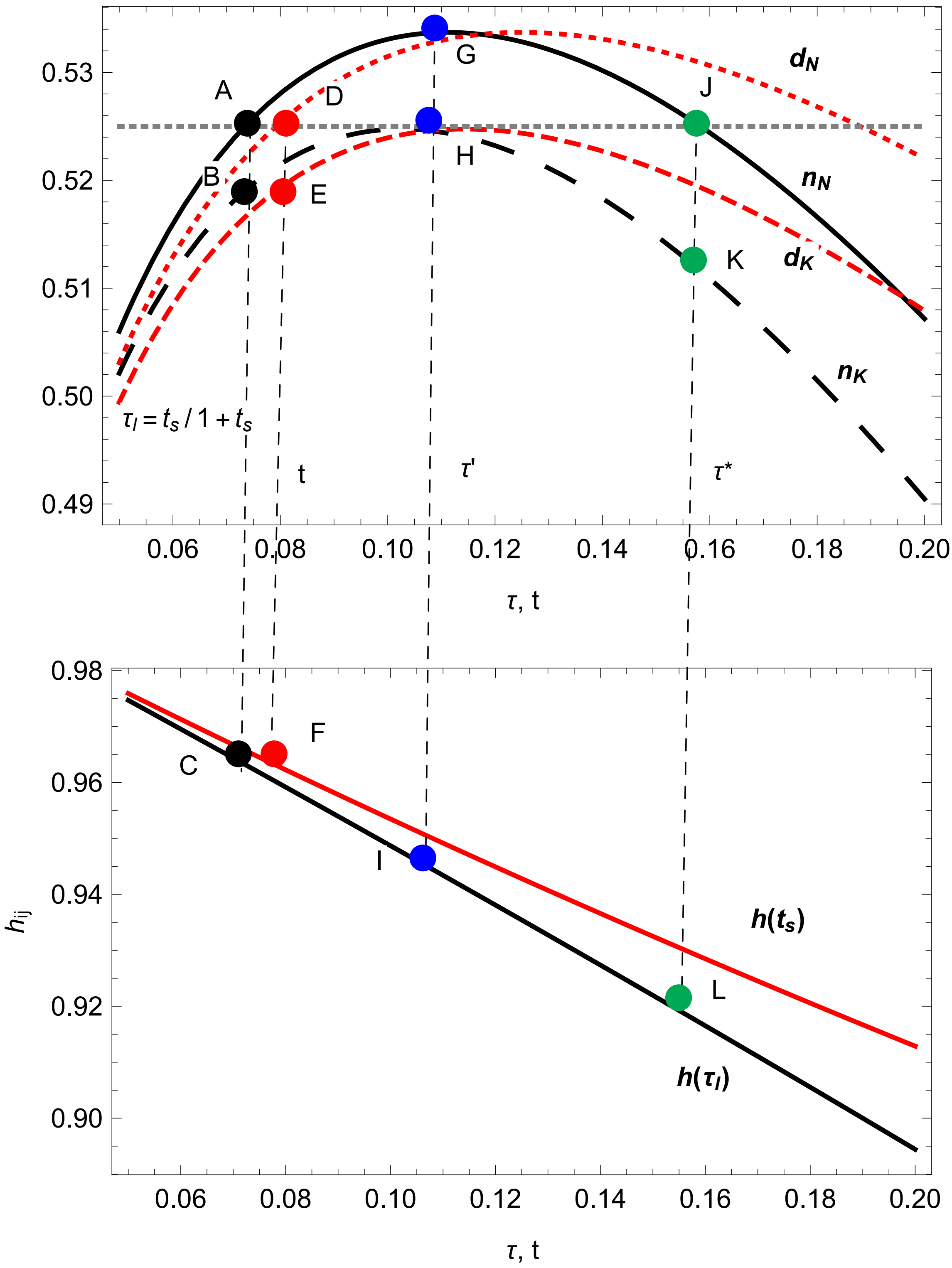

Figure 1: relative regional populations, varieties and labor supply in regions with varying tax rates

4 Welfare maximizing tax rates

In the absence of exogenous regional heterogeneity, any tax rates that maximize welfare should be common for all regions. Therefore, write $\tau_j = \tau$ and $t_j = t$ for all j. In which case $K = \phi((1-\tau)/(1+t))^{\gamma(\sigma-1)/(\sigma-1-\gamma)}$, where ϕ is a bundle of parameters. We assume a utilitarian welfare function which can be written compactly as

$$W(\tau, t) = \Phi(1 + \frac{1}{\sigma - 1}\frac{N_1}{N_2})\,(t+\tau)^{\eta}\,(1-\tau)^{\frac{(\sigma-1)(1+\gamma(1+\eta))-\gamma^2\eta}{\sigma-1-\gamma}}\,(1+t)^{-\frac{(1+\gamma)(\sigma-1)(1+\eta)-\gamma\eta}{\sigma-1-\gamma}} \tag{31}$$

where Φ again, represents a cluster of parameters and the term $(1+\frac{1}{\sigma-1}\frac{N_1}{N_2})$ represents the fact that the utility levels are constant multiples of each other. The first-order conditions after getting rid of the constant terms are given by

$$W_\tau = \frac{\eta}{\tau+t} - \frac{(\sigma-1)(1+\gamma(1+\eta))-\gamma^2\eta}{\sigma-1-\gamma}\frac{1}{1-\tau} = 0 \tag{32}$$

$$W_t = \frac{\eta}{\tau+t} - \frac{(1+\gamma)(\sigma-1)(1+\eta)-\gamma\eta}{\sigma-1-\gamma}\frac{1}{1+t} = 0 \tag{33}$$

The solution is given by

$$t_c = 0, \quad \tau_c = \frac{\eta(\sigma-1-\gamma)}{(1+\gamma)((\sigma-1-\gamma)\eta + (\sigma-1))} \tag{34}$$

where the c subscript denotes a cooperative tax policy. It straightforward to verify that the second order conditions are met. τ_c is increasing in η and σ and decreasing in γ. As an aside we can consider the case were regions are politically limited in their ability to impose an income tax and thus must rely on the sales tax. Setting $\tau = 0$ and using (33) we get,

$$t_l = \frac{\eta(\sigma-1-\gamma)}{(\sigma-1)(1+\gamma(1+\eta))} > \tau_c \tag{35}$$

where the l subscripts denotes the sales tax rate when regions are politically limited.[2] In this case, the unit tax on consumption goods is higher than the welfare maximizing

[2]This is not a trivial assumption. US States are often politically limited in their ability to adjust tax rate. For instance, in Colorado any tax increase must be approved by a voter referendum. In addition, it may be politically infeasible to introduce an income tax in a state that up to that point had no income tax.

income tax. Consider a numerical example. Chetty *et al.* (2011) argue that the Frisch elasticity should be calibrated at $\gamma = 0.5$. Suppose $\sigma = 3$ (Broda and Weinstein) and $\eta = .2$ so that a 10% increase in the public good raises utility by 2% holding all else fixed. This yields $\tau_c = 0.087$ and $t_l = 0.094$.

5 Conclusion

This paper has developed a multiregion spatial general equilibrium model of monopolistic competition to explore the implications of differences in state income and sales tax on the labor supply and location of households and firms and the number of varieties produced. We find that different tax rates can support the production of the same number of varieties in different regions, however the composition of the labor force will differ with higher tax regions having a larger population that work fewer hours. In addition, we calculate a utility maximizing cooperative tax rate. Based on our calibration, the results yield an income tax of roughly 8.7% with no sales tax. When regions are politically limited in implementing an income tax, a sales tax rate of 9.4% maximizes welfare.

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