ECONOMIC RESEARCH CENTER
at THE BUCKEYE INSTITUTE

Methodology for Analyzing State Tax Policy

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Introduction

To analyze how changes to tax policy impacts not only government revenues but also economic activity and decisions made by businesses and citizens, economists at The Buckeye Institute's **Economic Research Center** (ERC) developed a dynamic scoring model that predicts the effects of policy changes on gross domestic product, jobs creation or loss, and revenue.

Buckeye's dynamic scoring model is in keeping with current economic practices at the federal level, which uses dynamic analysis and dynamic scoring to analyze major federal tax policy proposals. This modeling simulates changes in the economy that result from changes in tax policy and shows how those changes impact tax revenues.

Using this dynamic scoring model, calibrated for Louisiana with publicly available data, economists with the ERC are able to predict how proposals by policymakers will impact the state's economy and state revenues.

A proposal analyzed using the model sees how the policy affects the choices of households and businesses in the economy. For example, the proposal to increase the sales tax in Louisiana reduces how much the citizens spend on goods and services. As a result of people spending less, businesses hire fewer workers. This interaction cannot be captured using a static analysis. Each section of the model incorporates the proposed tax policy and reveals the resulting changes in behavior of people and businesses. The dynamic process allows the model to simulate how a policy affects all aspects of the economy.

The Basic Model

Time is discrete and lasts forever. Every period, the economy is populated by heterogeneous households specialized in the production of one of (s) types of goods. Since the Bureau of Economic Analysis reports macroeconomic data for US states in yearly intervals, a period is assumed to be a year in this framework. Each sector (s) is populated by a large number of identical firms. The economy also features a government sector that collects taxes and purchases goods from all sectors. A share $q^e \in (0,1)$ of households has earning ability $e = \{1, \dots, E\}$.

These shares are such that the total population is $\sum q^e = 1$. The share of households with the required skills to work in sector s is $\mu_{e,s} \in (0,1)$ such that $\sum \mu_{e,s} = 1$.

The Household Problem

Each household chooses consumption $c_{e,t}$, savings $k_{e,t}(s)$, how much to borrow $d_{e,t}(s)$ and market hours $l_{e,t}(s)$, to solve the following problem:

$$V_{e,t}(s) = max_{c_{e,t}(s), l_{e,t}(s), k_{e,t}(s)} \; U(c_{e,t}) - \varphi_e \;\; l_{e,t}(s)^{(1+\frac{1}{\sigma_e})} + \beta E[V_{e,t+1}(s)]$$

subject to the following constraints:

$$d_{e,t} = \zeta(1+\tau_t^c) \sum_{s=1}^{S} c_{e,t}(s) + (1-\zeta) \sum_{s=1}^{S} c_{e,t}(s) + \sum_{s=1}^{S} x_{e,t}(s) + (1+i_{r,t-1}) d_{e,t-1} + \tau_t^k \sum_{s=1}^{S} k_{e,t-1}(s) + [\tfrac{\phi}{2}(\sum_{s=1}^{S} k_{e,t}(s) - \sum_{s=1}^{S} k_{e,t-1}(s$$

$$k_{e,t}(s) = x_{e,t}(s) + (1-\delta) k_{e,t-1}(s)$$

$$c_{e,t}(s) \geq 0, \; l_{e,t}(s) \in [0,1], \; k_{e,0}(s) \geq 0, \;\; k_{e,T+1}(s) = 0$$

$$U(c_{e,t}) = \sum_{s=1}^{S} \alpha_s ln(c_{e,t}(s))$$

where δ is the depreciation rate of capital $V_{e,t}(s)$ defines expected utility discounted at a patient factor $\beta \in [0,1]$. As in Mendoza (1991) ϕ denotes a capital adjustment cost. Households weigh consumption goods according to $\alpha_s \in (0,1)$. The parameter that regulates the Frisch elasticity of labor supply is denoted σ_e and φ_e is a scaling factor that helps match hours worked observed in the data. The return on capital lent to firms is $r_t(s)$. The wage paid to workers in sector s is $w_t(s)$. Consumption is denoted $c_t(s)$, $x_t(s)$ denotes gross investment, and $k_t(s)$ denotes physical capital lent to firms in sector s. $i_{r,t}$ denotes the interest rate at which domestic residents can borrow from international markets in period t, and d_t is household debt.

We assume $i_{r,t} = i_{r,w} + \eta(exp\,(D_t - D) - 1)$ where $i_{r,w}$ is the world interest rate faced by domestic agents and is assumed to be constant, η and D are also constant parameters. $\eta(exp\,(D_t - D) - 1)$ is the state specific interest rate premium that increases with the level of debt. The assumption of a debt elastic interest rate is taken from Schmitt-Grohé and Uribe (2003). D_t represents the aggregate level of debt.

τ_t^c is the tax on household consumption purchases. ζ is the share of consumption goods subject to the sales tax, and $\tau_{e,t}^{i,s}$ is the individual income tax collected by the state. $\tau_{e,t}^{i,f}$ is the individual income tax collected by the federal government. Income tax rates depend on the individual earning ability. τ_t^k is a tax on fixed assets owned by households. τ_t^{corp} is the corporate income tax faced by the owners of capital. τ_t^o is the share of income paid to all other taxes, fees, and revenue sources for the state government not included specifically in the model.

Individuals choose $\{c_{e,t}, x_{e,t}, l_{e,t}, k_{e,t+1}, d_{e,t}\}_{t=0}^{\infty}$ so as to maximize the utility function subject to the resource constraint and a no-Ponzi scheme constraint that implies that the household's debt position must be expected to grow at a rate lower than the interest rate in the long-run.

Firms

In each sector s, a large number of competitive firms produce goods according to the following production function:

$$y_t(s) = a_t(k_{t-1}(s))^{\theta_s} \left(\sum_e z_e\, l_{e,t}(s)\right)^{(1-\theta_s)}$$

These firms solve the following profit maximization problem:

$$\Pi_t = (1-\tau_t^{cat})a_t(k_{t-1}(s))^{\theta_s} \left(\sum_e z_e\, l_{e,t}(s)\right)^{(1-\theta_s)} - \sum_e w_{e,t}(s)l_{e,t}(s) - r_t(s)k_{t-1}(s)$$

where a_t is total factor productivity (TFP), θ is associated with the capital share of total output. z_e is labor productivity specific to a household member's earning ability. It is important to note that the demand for labor is sector s specific. τ_t^{cat} is a commercial activity tax, modeled as a tax on a firm's revenues.

The representative firm in sector s hires labor according to the following condition:

$$(1-\tau_t^{cat})(1-\theta_s)a_t(k_{t-1}(s))^{\theta_s} \left(\sum_e z_e\, l_{e,t}(s)\right)^{(-\theta_s)} z_e = w_{e,t}(s),$$

where $w_{e.t}(s)$ is the wage rate for group e in sector (s). The demand for capital is such that:

$$(1-\tau_t^{cat})a_t(k_{t-1}(s))^{\theta_s-1} \left(\sum_e z_e\, l_{e,t}(s)\right)^{(1-\theta_s)} = r_t(s),$$

We assume a_t follows a stationary mean zero autoregressive process of order 1 in the log. The shock innovation $\epsilon_{A,t}$ is drawn from a standard normal distribution.

$$(a_t) = \rho_A(a_{t-1}) + \epsilon_{A,t}$$

The Government Sector

The government contributions to the "rainy-day" fund $\{RF_t\}$ is the excess of tax revenue plus federal government transfers net of government spending added to the previous period's balance.

$$RF_t = T_t + FF_t - g_t$$

Deficits - negative contributions - to the rainy-day fund reduce the fund's balance.

The state government's tax revenues T_t are given by:

$$T_t = \sum_e^E \sum_s^S (\tau_t^{cat} y_t(s) + \tau_t^c \zeta c_t(s) + \tau_t^e \zeta c_t(s) + \tau_{e,t}^{i,s} w_t(s) l_t(s) + \tau_{e,t}^{i,s} r_t(s) k_{t-1}(s) + \tau_t^k k_{t-1}(s) + \tau_t^o y_t(s))$$

Government spending policy is assumed to evolve according to:

$$\kappa_t = (1 - \rho_{g,h})(\kappa) + \rho_{g,h}(\kappa_{t-1}) + \epsilon_g$$

where κ is the state share of income spent by the government sector in the long-run, the steady-state equilibrium. This specification implies that $g_t = \kappa y_t$ which means that the size of government reflects changes in GDP. It also implies that government is assumed to grow as the economy grows. Variables without the time subscript denote steady-state values.

The tax instruments follow the exogenous processes:

$$\begin{aligned}
\tau_t^{i,s} &= (1 - \rho_{i,s})\tau^{i,s} + \rho_{i,s}\tau_{t-1}^{i,s} + \epsilon_{i,s} \\
\tau_t^c &= (1 - \rho_c)\tau^c + \rho_c\tau_{t-1}^c + \epsilon_c \\
\tau_t^e &= (1 - \rho_e)\tau^e + \rho_e\tau_{t-1}^e + \epsilon_e \\
\tau_t^{corp} &= (1 - \rho_{corp})\tau^{corp} + \rho_{corp}\tau_{t-1}^{corp} + \epsilon_{corp} \\
\tau_t^{cat} &= (1 - \rho_{cat})\tau^{cat} + \rho_{cat}\tau_{t-1}^{cat} + \epsilon_{cat} \\
\tau_t^k &= (1 - \rho_k)\tau^k + \rho_k\tau_{t-1}^k + \epsilon_k \\
\tau_t^o &= (1 - \rho_o)\tau^o + \rho_o\tau_{t-1}^o + \epsilon_o \\
\tau_t^{i,f} &= (1 - \rho_{i,f})\tau^{i,f} + \rho_{i,f}\tau_{t-1}^{i,f} + \epsilon_{i,f}
\end{aligned}$$

As in Schmitt-Grohé and Uribe, we write the trade balance to GDP ratio (TB) in steady-state as:

$$TB = 1 - \frac{[c+x+g]}{y}$$

The Competitive Equilibrium
A competitive equilibrium is such that given the set of exogenous processes, households solve the household utility maximization problem, firms solve the profit maximization problem, the capital and labor markets clear.

The Deterministic Steady-State
The characterization of the deterministic steady state is of interest for two reasons. First, the steady-state facilitates the calibration of the model. This is because, to a first approximation, the deterministic steady-state coincides with the average position of the model economy. In turn, matching average values of endogenous variables to their observed counterparts (e.g., matching predicted and observed average values of the labor share, the consumption shares, or the trade-balance-to-output ratio) can reveal information about structural parameters that can be exploited

in the calibration of the model. Second, the deterministic steady-state is often used as a convenient point around which the equilibrium conditions of the stochastic economy are approximated (see Schmitt-Grohe and Uribe, 2003). For any variable, we denote its steady-state value by removing the time subscript.

Using the solution from the households and firms' choice problems, the steady-state implies that:

$$1 = \beta[(1 - \tau^{i,s} - \tau^{o} - \tau^{i,f} - \tau^{corp})r + 1 - \delta - \tau^{k}]$$
$$y = k^{\theta_s}\, l^{(1-\theta_s)}$$
$$\theta_s \left(\tfrac{k}{l}\right)^{\theta_s - 1} = r$$

These expressions deliver the steady-state capital-labor ratio, which we denote ω

$$\omega \equiv \frac{k}{l} = \left(\frac{\beta^{-1} - 1 + \delta + \tau^{k}}{\theta_s(1 - \tau^{i,s} - \tau^{o} - \tau^{i,f} - \tau^{corp})}\right)^{1/(\theta_s - 1)}$$

The steady-state level of capital is:

$$k = \omega l$$

Finally, the steady-state level of consumption can be obtained by evaluating the resource constraint at the steady-state:

$$c = y - \delta k - g - TBy$$

which implies: $y = c + x + g + TBy$

As for the parameter that dictates households' preference for leisure:

$$\varphi_e = \frac{\alpha_s}{(1+\tau_t^{c}+\tau_t^{e})c_{e,t}(s)} \times \frac{(1-\tau_{e,t}^{i,s}-\tau_t^{o}-\tau_{e,t}^{i,f})w_{e,t}(s)}{(1+\frac{1}{\sigma_e})l_{e,t}(s)^{\frac{1}{\sigma_e}}}$$

Calibration

Typically, a calibration assigns values to the model parameters by matching first and second moments of the data that the model aims to explain.

The depreciation rate of capital δ and the world interest rate $i_{r,w}$ are based on parameter values widely used in the related business-cycle literature and on the average annual depreciation rate taken from the Bureau of Economic Analysis, $\delta = 0.1$ and $i_{r,w} = 0.04$.

The sector specific parameter θ_s is set to match the observed average labor shares for each of nine production sectors in Louisiana. In the present model, the labor share is given by the ratio of labor income to output which is $1 - \theta_s$ at all times.

The parameter D is set to match the observed average trade-balance to output ratio in Louisiana since $TB = i_{r,w}\, D/y$

Table A-1: Baseline Calibration Louisiana			
Variable	**Value**	**Description**	**Restriction**
ϑ	0.023	Annual average growth rate of GDP	BEA
C/Y	0.56	Consumption to GDP ratio	BEA
I/Y	0.22	Investment to GDP ratio	BEA
G/Y	0.12	Government spending to GDP ratio	BEA
NX/Y	0.10	Net exports to GDP ratio	BEA
N	0.25	Hours worked/available hours (1975-2015)	CPS
χ	4.5	Disutility of labor	Set to match hours worked
r	0.04	Avg. annual real interest rate (1950-2015)	FRED
δ	0.10	Annual depreciation rate of capital	BEA
σ	0.4	Elasticity of Labor Supply	Reichling and Whalen (2012)

Note: BEA data represents long-run averages for 1963-2015.

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Labor and capital income tax rates represent average marginal rates per income group for 2002-2014.
STC refers to "the US Census Bureau's Annual Survey of State Tax Collections."
Income tax rates represent effective tax rates for each AGI group.
Sales tax rate represent the long-run average statutory rate for all consumption expenditures subject to the tax.
All other tax rates represent long-run average effective tax rates for taxes paid to the state if not mentioned otherwise.

Table A-2: Louisiana Tax Rates			
Variable	**Value**	**Description**	**Restriction**
$\tau^{i,n,s}$ $AGI1$	0.0089	State individual labor income tax rate	STC/LA DOR
$\tau^{i,r,s}$ $AGI1$	0.0093	State individual capital income tax rate	STC/LA DOR
$\tau^{i,s}$ $AGI2$	0.0129	State individual labor income tax rate	STC/LA DOR
$\tau^{i,s}$ $AGI2$	0.0135	State individual capital income tax rate	STC/LA DOR
$\tau^{i,s}$ $AGI3$	0.0155	State individual labor income tax rate	STC/LA DOR
$\tau^{i,s}$ $AGI3$	0.0163	State individual capital income tax rate	STC/LA DOR
τ^{c}	0.04	General sales tax rate	LA Stat. Rate
τ^{e}	0.028	Excise tax rate	STC
τ^{s}	0.035	Severance tax rate	STC/Sector Specific
τ^{Corp}	0.0029	Corporate income tax rate	STC/LA DOR
τ^{k}	0.001	Franchise tax rate	STC
ζ	0.70	Share of Consumption Expenditures subject to sales tax	See appendix B
TR1/Y	0.04	State Tax Revenues	STC
τ^{o}	0.01	Other State collections	STC/LA DOR
FF/Y	0.04	Transfers from the federal government	STC

Note: BEA data represents long-run averages for 1963-2015.

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Sales tax rate represent the long-run average statutory rate for all consumption expenditures subject to the tax.
All other tax rates represent long-run average effective tax rates for taxes paid to the state if not mentioned otherwise.

Table A-3: Federal Tax Rates			
Variable	**Value**	**Description**	**Restriction**
$\tau^{i,n,f}\ AGI1$	0.1049	Federal individual labor income tax rate	IRS-SOI
$\tau^{i,r,f}\ AGI1$	0.0571	Federal individual capital income tax rate	IRS-SOI
$\tau^{i,f}\ AGI2$	0.1517	Federal individual labor income tax rate	IRS-SOI
$\tau^{i,f}\ AGI2$	0.0824	Federal individual capital income tax rate	IRS-SOI
$\tau^{i,f}\ AGI3$	0.1820	Federal individual labor income tax rate	IRS-SOI
$\tau^{i,f}\ AGI3$	0.1160	Federal individual capital income tax rate	IRS-SOI

Note: BEA data represents long-run averages for 1963-2015.

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Income tax rates represent effective tax rates for each AGI group.
Sales tax rate represent the long-run average statutory rate for all consumption expenditures subject to the tax.
All other tax rates represent long-run average effective tax rates for taxes paid to the state if not mentioned otherwise.

Table A-4: Earning Ability Specific Calibration Variables					
		Value			
Variable	**Description**	**e=1**	**e=2**	**e=3**	**Restriction**
z_e	Labor productivity	1.000	3.5875	11.1209	LA DOR by AGI
$q^{h,e}$	Share of household members	0.6834	0.1864	0.1302	LA DOR by AGI

Note: Values based on IRS-SOI data represent averages for 1996-2015

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Table A-5: Sector Specific Shares of Output and Employment			
Sector		**Output Share**	**Employment Share**
1	Agriculture, forestry, fishing, and hunting	$\alpha_1 = 0.01$	0.02
2	Mining	$\alpha_2 = 0.10$	0.03
3	Utilities, transportation, and warehousing	$\alpha_3 = 0.07$	0.05
4	Construction	$\alpha_4 = 0.05$	0.09
5	Manufacturing	$\alpha_5 = 0.23$	0.08
6	Trade	$\alpha_6 = 0.13$	0.17
7	Services	$\alpha_7 = 0.23$	0.40
8	Real estate and rental and leasing	$\alpha_8 = 0.11$	0.04
9	Health care and social assistance	$\alpha_9 = 0.07$	0.12

Note: Values represent averages for 1997-2015, calculations based on data from the BEA Regional Income Division.

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	Table A-6: Sector Specific Shares in Income		
	Sector	**Labor Share**	**Capital Share**
1	Agriculture, forestry, fishing, and hunting	0.308	θ_1 =0.692
2	Mining	0.470	θ_2 =0.530
3	Utilities, transportation, and warehousing	0.643	θ_3 =0.357
4	Construction	0.580	θ_4 =0.420
5	Manufacturing	0.687	θ_5 =0.313
6	Trade	0.646	θ_6 =0.354
7	Services	0.607	θ_7 =0.393
8	Real estate and rental and leasing	0.531	θ_8 =0.469
9	Health care and social assistance	0.609	θ_9 =0.391

Note: Values represent averages for 1997-2015, calculations based on data from the BEA Regional Income Division.

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	Table A-7: Summary of Tax Policy Scenarios		
		Effective Tax Rates	
Scenario	**Description**	**Baseline**	**Scenario**
I	Increase general sales tax by 0.25%	$\tau^c = 0.04$	$\tau^c = 0.0425$
II	Increase general sales tax by 0.5%	$\tau^c = 0.04$	$\tau^c = 0.045$
III	Shrink top two state income brackets	$\tau^{i,n,s}AGI1 = 0.0089$, $\tau^{i,r,s}AGI1 = 0.0093$	$\tau^{i,n,s}AGI1 = 0.0098$, $\tau^{i,r,s}AGI1 = 0.0099$
	Baseline: 2%: \$0-\$12,500; 4%: \$12,500-\$50,000; 6%: >\$50,000	$\tau^{i,n,s}AGI1 = 0.0129$, $\tau^{i,r,s}AGI1 = 0.0135$	$\tau^{i,n,s}AGI1 = 0.0152$, $\tau^{i,r,s}AGI1 = 0.0159$
	Scenario: 2%: \$0-\$12,500; 4%; \$12,500-\$25,000; 6%: >\$25,000	$\tau^{i,n,s}AGI1 = 0.0155$, $\tau^{i,r,s}AGI1 = 0.0162$	$\tau^{i,n,s}AGI1 = 0.0160$, $\tau^{i,r,s}AGI1 = 0.0172$
IV	Reduce allowable deduction to state income tax from excess federal income tax deductions, estimated \$79,000,000 in revenue	$\tau^{i,n,s}AGI1 = 0.0089$, $\tau^{i,r,s}AGI1 = 0.0093$	$\tau^{i,n,s}AGI1 = 0.0091$, $\tau^{i,r,s}AGI1 = 0.0095$
		$\tau^{i,n,s}AGI1 = 0.0129$, $\tau^{i,r,s}AGI1 = 0.0135$	$\tau^{i,n,s}AGI1 = 0.0132$, $\tau^{i,r,s}AGI1 = 0.0139$
		$\tau^{i,n,s}AGI1 = 0.0155$, $\tau^{i,r,s}AGI1 = 0.0162$	$\tau^{i,n,s}AGI1 = 0.0159$, $\tau^{i,r,s}AGI1 = 0.0166$

Note: The fact that our model assumes multiple AGI groups that face a group specific tax burden makes our model inputs consistent with marginal tax rates.

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