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Feedback Effects and the Laffer Landscape

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Abstract

This paper combines the dynamic scoring literature with Laffer curve analysis to reveal the relationship between feedback effects and the shape of the Laffer curve. A Neoclassical growth model with multiple government expenditures and revenues is used and the conditions under which a tax cut can be self-financing are explored. Steady state results indicate that fiscal regimes with a greater reliance on debt financing or lump-sum transfers are more likely to be self-financing than those with larger expenditures on government consumption and productivity-enhancing public capital.

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1. INTRODUCTION

Measuring the impact of tax cuts on government revenues has received renewed interest from politicians and economists alike since the 2001 and 2003 Bush tax cuts. Supply-side economists claim that U.S. tax rates were so high that the growth effects from tax cuts to national output will result in higher tax revenues. These growth effects include higher saving, investment and labor supply. Conventional measures of revenues changes from tax cuts, however, yield the opposite result in which tax cuts necessarily lead to lower tax revenues. These measures, such as those used by the Congressional Budget Office (CBO) and the Congressional Joint Committee on Taxation (JCT), incorporate a variety of behavioral effects but neglect the macroeconomic feedback effects.[1] Two analytical devices have received particular attention of late, dynamic scoring and Laffer curve analysis. This paper expands upon the previous work in at least three ways. First, the model assumes a government that provides multiple expenditures, including public capital investment, and multiple revenue sources, including deficit financing. Second, the feedback effects from tax cuts to revenue growth are reduced to the microeconomic level to reveal substitution, income and budget effects. Third, the linkage between these feedback effects and the corresponding Laffer curves is created. The overriding conclusion from the paper is that how a government spends its revenues is as important as how it generates its revenues when estimating how a tax cut will affect government revenues.

Recent models of dynamic scoring, such as Mankiw and Weinzierl (2006) and Leeper and Yang (2006), use the standard Neoclassical growth model to measure the macroeconomic *feedback effects* by separating the static effects from the dynamic effects of tax cuts. The feedback effects measure the degree to which tax cuts may be self-financing. The literature on Laffer curve analysis attempts to specify the shape of the tax revenue function under various government tax and spending regimes. Early work on the theoretical underpinnings of the Laffer curve include Gahvari (1989) and Gahvari (1990) which use a static general equilibrium model with a wage tax to examine how the shape of the Laffer curve is affected by government expenditures on a utility-enhancing good and cash transfers. Two results that arise are that greater provision of transfers increases the likelihood that a wage tax cut is self-financing and that it is possible for Laffer curves to have discontinuities at tax rates of 100% and be upward-sloping over the remainder of the region. These results are supported and extended in the model in this paper. More recent theoretical studies use the neoclassical growth model to examine the steady state impacts of tax

[1] Details on how microeconomic, but not macroeconomic, behavior is incorporated into JCT and CBO estimates can be found in Joint Committee on Taxation (2005) and Auerbach (2005).

changes under different government financing and fiscal regimes. Becsi (2000) and Becsi (2002), for example, use a simple general equilibrium macro-model with a single income tax and government expenditures on consumption, transfers, and investment in public capital. This paper expands on the Besci tax regime by including taxes on dividend and corporate income, in addition to allowing deficit financing. On the fiscal side, this paper uses the Besci setup but examines the stock, rather than just the flow, of public capital. This setup allows for a greater generalization of the Laffer curve results. One interesting result is that the fiscal regimes reduce to two general forms: a transfer regime and an expenditure regime. The *transfer regime* is representative of a government that spends the majority of its revenues on debt payments and/or transfer payments while the *expenditure regime* is representative of a government that spends the majority of its revenues on government consumption and/or pubic capital. Moreover, the analysis of the various tax rates show that the different tax regimes reduce to either a wage tax or a capital tax. These reductions enable us to separate the feedback effects into their constituent substitution, income and budget effects for the different tax regimes and fiscal regimes.

The paper is organized as follows. Section 2 presents the basic model with inelastic labor supply and previews the analytical results. Section 3 extends the basic model to include labor-leisure choice. Section 4 concludes.

2. THE BASIC MODEL

We begin with a simple neoclassical growth model for an infinitely-lived representative household in a decentralized closed economy. Households produce output, Y, using private capital, K, public capital per-effective-worker, g_I, and effective labor, AN where A represents labor-augmenting technology that grows exponentially at rate z, i.e., $A = A_0 e^{zt}$. N, the size of the workforce, is normalized to one. Public capital is complementary to private factors, non-excludable and proportionally congestible in AN. The latter implies that the more effective workers are, the more intensively they use public capital. The production function has constant returns to scale in private capital and effective labor of the form

$$Y = F(K, g_I) = K^{\beta}(AN)^{1-\beta} g_I^{\alpha} \tag{1}$$

The production function in per-effective-worker terms is

$$y = f(k, g_I) = k^{\beta} g_I^{\alpha} \tag{2}$$

Given constant returns to scale, competitive input and output markets, profits are exhausted by payments to capital and labor and firms have the familiar input demands

$$r = \beta k^{\beta-1} g_I^{\alpha} \tag{3}$$

$$w = (1-\beta) k^{\beta} g_I^{\alpha} \tag{4}$$

Given $\alpha + \beta < 1$, the aggregate production function produces steady state growth in which the per-effective-worker growth rate is equal to zero.

Government outlays (in per-effective worker terms) consist of investment in public capital, i_g, government consumption, g_c, lump-sum transfers, g_T, and interest payments on its debt, br_2. The first two are the expenditures that appear in NIPA because they affect the resources of the economy. Government consumption affects the demand side of the economy by reducing the amount of resources available to individuals. Government investment affects the demand side in the same manner but also affects the supply side by increasing overall productivity. Transfers and interest payments, on the other hand, do not appear in NIPA because both represent a transfer from one individual to another which, in and of themselves, do not directly affect the resources available in the economy. This distinction proves important when examining the feedback effects and Laffer curves. Outlays are financed from debt issues, $\dot{b}$ and tax revenues, R. Tax revenues come from wage taxes, $t_w w$, dividend taxes, $t_d rk$, and taxes on firm earnings $t_e E$. Taxable firm earnings net of the return on capital are $E = f(k, g_I) - w$. After-tax profit is given by $(1 - t_e)[f(k, g_I) - w] - rk$ and is distributed to investors as dividends. In per-effective worker terms, the government budget constraint is given by

$$\dot{b} + zb + t_d(1-t_e)rk + t_w w + t_e E = g_T + i_g + br_2 + g_c.$$

Under perfect competition, economic profits are zero and $E = rk$.[2] Using this result, the government budget constraint may be simplified to

$$\dot{b} + zb + t_k rk + t_w w = g_T + i_g + br_2 + g_c. \tag{5}$$

where $t_k = t_e + t_d(1 - t_e)$. Because the analysis of a one percent change in t_e is the same for t_d, combining them into t_k proves to be a very useful simplification for examining feedback effects and Laffer curves. Public investment per-effective worker is a function of the growth rate of the economy, z, given by $i_g = \dot{g}_I + zg_I$.

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[2] For more detail see Barro, Robert J. and Sala-i-Martin, Xavier, *Economic Growth 2nd Edition* (2004) pp.143-144.

Government outlays are linked to revenues via fiscal *allocation parameters* that specify how the government allocates its revenues to its outlays. The fiscal policy is represented by the following four equations

$$
\begin{aligned}
i_g &= \mu_b(\dot{b} + zb) + \mu_R(t_k rk + t_w w) \\
g_c &= \phi_b(\dot{b} + zb) + \phi_R(t_k rk + t_w w) \\
g_T &= \chi_b(\dot{b} + zb) + \chi_R(t_k rk + t_w w) \\
r_2 b &= \nu_b(\dot{b} + zb) + \nu_R(t_k rk + t_w w).
\end{aligned} \tag{6}
$$

Fiscal policy is completely characterized by the terms μ_i, ϕ_i, χ_I, ν_i, t_d, t_e and t_w where $i = b$, R. In this framework, the government directly chooses the proportion of its outlays and only indirectly chooses the level of outlays. Though the allocation parameters appear in the solutions for the steady state variables, we will see that none of them appear in the feedback effects for the inelastic labor supply model.

The economy is populated by an infinitely-lived household that derives utility from consumption, C, in the isoelastic form, $U(C) = \frac{C^{1-\gamma}}{1-\gamma}$ where the parameter γ is the inverse of the intertemporal elasticity of substitution. Converting to per-effective-worker terms, discounted utility over an infinite time period is given by

$$
\int_0^{\infty} e^{-\rho t} \frac{(ce^{zt})^{1-\gamma}}{1-\gamma}\, dt \tag{7}
$$

The discount factor for this model combines the household's rate of time preference, ρ with the exogenous growth rate, z, and the elasticity factor, γ, for a total discount factor of $e^{zt(1-\gamma)-\rho t}$. To ensure a well-defined, infinite stream of discounted utility, $\rho - z(1-\gamma) > 0$ or $\rho > z(1-\gamma)$. To finance consumption, the household faces a budget constraint that incorporates the existing fiscal regime. Disposable income is derived from after-tax wages, $(1 - t_w)w$, transfers from the government, g_T, interest payments on government bonds, $r_2 b$ and after-tax returns on private investment, $(1 - t_d)(1 - t_e)rk$. To conform to the simplification in the government budget constraint, the last expression can be rewritten in terms of t_k as $(1 - t_k)rk$. Input prices w and r are taken as given along with government outlays. Per-effective-worker disposable income is divided among consumption, investment in capital, i_k and bond purchases, i_b. The consumer's budget constraint is

$$(1 - t_w)w + (1 - t_k)rk + br_2 + g_T = c + i_k + i_b \qquad (8)$$

where $i_k = \dot{k} + zk$ and $i_b = \dot{b} + zb$.

2A. FEEDBACK EFFECTS AND LAFFER CURVES

The representative household maximizes utility by maximizing discounted consumption, equation (7), subject to the budget constraint, equation (8), and the standard transversality condition for capital and debt.

$$Max_c \int_0^\infty e^{-\rho t} U(c) dt$$

$$\text{subject to } \dot{k} + \dot{b} = (1 - t_w)w + (1 - t_k)rk + br_2 + g_T - c - zk - zb$$

$$lim_{t\to\infty}\, \lambda e^{-(\rho + z)t}k = lim_{t\to\infty}\, \lambda e^{-(\rho + z)t}b = 0 \qquad (9)$$

where λ represents the shadow price of private capital. The steady state for the economy occurs where per-effective-worker consumption, private capital, public capital and output are constant and is described by the following six equations.

$$\frac{\dot{c}}{c} = \frac{1}{\gamma}[(1 - t_k)r - (\rho + z\gamma)]$$

$$\dot{k} + \dot{b} = (1 - t_w)w + (1 - t_k)rk + br_2 + g_T - c - zk - zb$$

$$i_g = \mu_b(\dot{b} + zb) + \mu_R(t_k rk + t_w w)$$

$$g_c = \phi_b(\dot{b} + zb) + \phi_R(t_k rk + t_w w)$$

$$g_T = \chi_b(\dot{b} + zb) + \chi_R(t_k rk + t_w w)$$

$$r_2 b = \nu_b(\dot{b} + zb) + \nu_R(t_k rk + t_w w). \qquad (10)$$

The first equation is derived from the first-order conditions in the maximization problem. The remaining equations come from the budget constraint and the government's rules of allocation. These equations constitute a system that can be solved for optimal values of per-effective worker private capital, k^*, and public capital, g_I^* in terms of the fiscal allocation, production and preference parameters. A dynamic revenue function is created by substituting k^* and g_I^* and equations (3) and (4) into the static revenue function, $R = t_w w + t_k rk$.

$$R = t_w(1 - \beta)k^{*\beta}g_I^{*\alpha} + t_k\beta k^{*\beta}g_I^{*\alpha}. \tag{11}$$

The dynamic effect of a marginal cut in profit, dividend and wage tax rates on tax revenues is examined by taking derivatives of equation (11) with respect to t_e, t_d and t_w, respectively. The results from each derivative can be dissected into a static effect, dynamic effect, feedback effect and growth effect. The *static effect* represents the conventional scoring method in which national income and other macroeconomic variables are unaffected by changes in tax rates. The static effect on revenues from a dividend, profit and wage tax cut are

$$\frac{dR}{dt_k}\Big|_{\text{Static}} = rk = \beta y \qquad \text{and} \qquad \frac{dR}{dt_w}\Big|_{\text{Static}} = w = (1 - \beta)y.$$

These equations indicate that the static effect is unambiguously positive: when tax rates decrease, tax revenues decrease by an amount equal to the tax base of the respective tax. Using the standard measure of capital's share of $\beta = ⅓$, these results indicate that a one percent decrease in either t_d or t_e will decrease revenues by 0.33 percent.[3] The *dynamic effect* takes the same derivatives but with respect to the steady state revenue function, R^*. For example, the dynamic effect of a wage tax cut on government revenue is given by the derivative of R taken with respect to t_w at the steady state, given by

$$\frac{dR}{dt_w}\Big|_{\text{Dynamic}} = [\underbrace{1 + \overbrace{\frac{\alpha}{(1 - \alpha - \beta)}}^{\textit{public capital effect}}}_{\textit{feedback effect}}]\,\frac{dR}{dt_w}\Big|_{\text{Static}} \tag{12}$$

The term preceding $\frac{dR}{dt_w}\Big|_{\text{Static}}$ represents the *feedback effect* from tax cuts to economic growth in the dynamic setting. The feedback effect measures the amount of the static revenue effect that is actually incurred. A feedback effect of one implies that tax cuts produce no additional economic growth to offset the decline in tax revenues; in other words, the dynamic revenue loss equals the static revenue loss.[4] A feedback effect of zero implies tax cuts induce enough growth to keep tax revenues constant. The feedback effect for the inelastic labor model exceeds one, implying the dynamic effect of a cut in wage

[3] If we substitute $t_e + t_d(1 - t_e)$ for the aggregate capital tax, t_k the static effects are $\frac{dR}{dt_d}\Big|_{\text{Static}} = (1 - t_e)rk = (1 - t_e)\beta y$ and $\frac{dR}{dt_e}\Big|_{\text{Static}} = (1 - t_d)rk = (1 - t_d)\beta y$.

tax rates amplifies, rather than mitigates, the negative static effect. This occurs for two reasons: the public capital effect and the inelastic labor supply. The *pubic capital effect*, $\frac{\alpha}{(1-\alpha-\beta)}$, captures the negative impact from tax cuts to g_I: decreases in tax rates, lower tax revenues thereby decreasing investment in public capital. Less public capital, ceteris paribus, lowers steady state output and revenues. The higher the productivity of public capital, the larger the feedback effect. The inelastic labor supply means that lower wage taxes do not induce more labor supply. At the microeconomic level, the labor substitution effect cancels the income effect leaving labor supply unchanged. To quantify these effects, assume a private capital output elasticity of $\beta = 1/3$, a public capital elasticity of $\alpha = 0.10$.[5] Under these conditions, the feedback effect on revenue of a wage tax cut generates a feedback effect of 1.1765. In other words, the long-run impact on revenue of a wage tax cut is 117.65% of its static impact so that the dynamic effect lowers tax revenues by an additional 17.65% of the static effect. The Laffer curve associated with this feedback effect is illustrated as an upward-sloping line with a discontinuity at t_w = 100% as seen in Figure 1. Equation (13) reveals that total revenue with respect to the wage tax rate is an upward-sloping line without a peak. With a positive public capital effect and the absence of t_w in the feedback effect, the Laffer curve has a constant upward slope as shown in Figure 1.[6] The linkage between the Laffer curve and feedback effect exists because the slope of the Laffer curve is the derivative of the dynamic revenue function with respect to tax rates or the feedback effect.

The dynamic effect for capital tax cuts is derived by taking the derivative of the dynamic revenue function with respect to t_k.[7]

$$\frac{dR}{dt_k}\Big|_{\text{Dynamic}} = \underbrace{\Big[1 + \overbrace{\frac{\alpha}{(1-\alpha-\beta)}}^{\textit{public capital effect}} - \underbrace{\frac{1}{(1-t_k)}}_{\textit{substitution effect}} \overbrace{\frac{T}{(1-\alpha-\beta)}}^{\textit{incremental tax base effect}}\Big]}_{\textit{feedback effect}} \frac{dR}{dt_k}\Big|_{\text{Static}} \tag{12}$$

---

[4] Such a result obtains when $\alpha = 0$, which is the standard result in the theoretical literature which ignores public capital.
[5] Estimates of β are typically between 0.25 and 0.36 while those for α are between 0.05 and 0.15. For a survey of the latter see Glomm and Ravikumar (1997).
[6] This is the same result derived in Gahvari (1988).
[7] Because derivatives with respect to firm profits and the capital taxes are the same; i.e., $\frac{dR}{dt_d}\big|_{\text{Dynamic}} = \frac{dR}{dt_e}\big|_{\text{Dynamic}} = \frac{dR}{dt_k}\big|_{\text{Dynamic}}$, the feedback effects for either tax are the same.

Unlike the wage tax feedback effect, a second term appears in the capital tax feedback effect that represents the positive impact from capital tax cuts to revenue growth as given by $-\frac{1}{(1-t_k)}\frac{T}{(1-\beta-\alpha)}$.

The term, $-\frac{1}{(1-t_k)}$ represents the capital substitution effect which is always negative and, as such, reduces the feedback effect. This substitution effect exists because lower t_k leads to a higher after-tax return on capital and thereby induces agents to substitute away from consumption toward investment. The substitution effect is attenuated by an *incremental tax base effect*, $\frac{T}{(1-\beta-\alpha)}$. The term $T = (1-\beta)t_w + \beta t_k$ and represents the incremental tax base because it indicates the amount revenues rise for a one-unit increase in output.[8] The size of the tax base also indicates the size of the tax distortion. The larger this distortion, the more likely it is that a decrease in taxes will raise revenues. The incremental tax base is magnified by the capital elasticities, β and α, that appear in the denominator. The higher these elasticities, the greater the incremental tax base effect.[9] To quantify these effects, assume a private capital output elasticity of $\beta = 1/3$, a public capital elasticity of $\alpha = 0.10$ and $t_k = t_w = ¼$. Under these conditions, the feedback effect on revenue of a capital tax cut is only 58.8% of its static impact or, put differently, the growth from capital tax cuts covers 41.2% of the static loss. If one uses the recent Feldstein's (2006) estimates of capital and wage tax rates of $t_w = 0.45$ and $t_k = 0.45$, capital tax cuts can pay for themselves with a feedback effect of –0.258. The negative feedback effect of -0.258 implies a positive growth effect of 1.258. Not only does a tax cut pay for itself at these rates, it actually raises government revenue by 25.8 percent of the static revenue loss. The Laffer curve for t_k is shown in Figure 2.

[8] Total government revenues (i.e., the total tax base) may be written as $R = Ty$.

[9] Note that α positively impacts the third term meaning that the overall impact of an increase in α is ambiguous. It is easily shown, however, that the overall impact of α on the feedback effect is negative so long as $t_k > (1-\beta)(1-t_w)$ and nonnegative otherwise.

LAFFER CURVES FOR INELASTIC LABOR SUPPLY MODEL

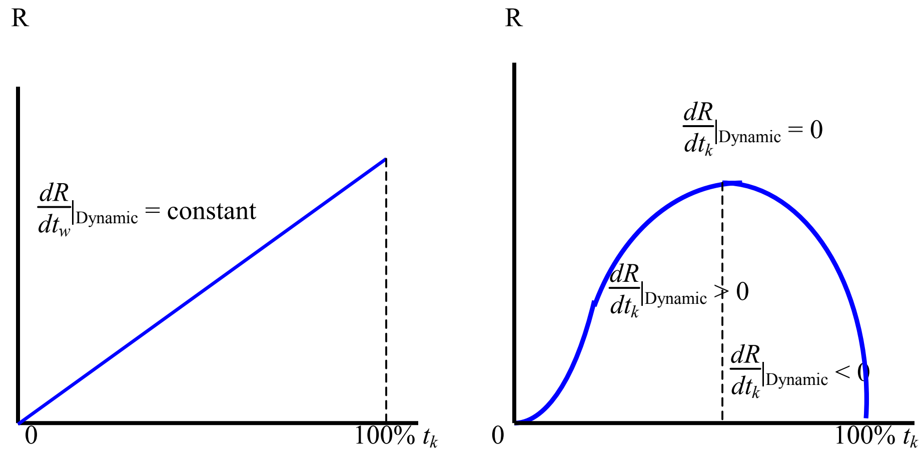

Figure 1: WAGE TAX LAFFER CURVE   Figure 2: CAPTIAL TAX LAFFER CURVE

The capital tax Laffer curve has the more familiar inverted-hyperbola shape. As with the wage tax Laffer curve, the slope of the curve, $\frac{dR}{dt_k}|_{\text{Dynamic}}$, is equivalent to the feedback effect. The most significant point of the Laffer curve is its peak where $\frac{dR}{dt_k}|_{\text{Dynamic}} = 0$, where the feedback effect is the smallest (and the growth effect the largest). Incremental cuts in tax rates on the left-side of the peak decrease revenues because the substitution effect from lower capital tax rates to higher investment is overwhelmed by the static effect and public capital effect. These latter effects are overwhelmed, however, by the substitution effect for capital tax rate cuts that occur on the right-side. The rates are so high and the inducement to investment so great, that revenues actually increase from the tax cut. In other words, tax cuts from a point on the right of the peak are self-financing. The peak of the curve occurs where $t_k = (1 - \beta)(1 - t_w)$. The capital tax peaks with M-W and Feldstein parameter values are 0.5 and 0.367, respectively.

The peak rates for the Laffer curves are derived by setting the feedback terms equal to zero and solving for the relevant tax rate. For example, setting the feedback equation in (12) equal to zero and solving for t_k reveals that total revenue with respect to the capital tax rate peaks at $t_k^{peak} = (1 - \beta)(1 - t_w)$. Unlike capital taxes, wage taxes do not have peaks in the simple elastic labor supply model. The assumption of an inelastic labor supply means that a change in wage tax rates will not alter the feedback effect and there is no point at which a wage tax cut is self-financing. Thus, the basic model of the inelastic labor supply has limited use in elucidating the mechanisms by which feedbacks from tax cuts affect macroeconomic aggregates. This problem is resolved for the model, however, by introducing an elastic labor supply.

Neither the growth rate of labor-augmenting technology nor the allocation parameters appears in the result. Only when the labor supply can respond to a tax cut do government decisions on what to spend on and how to finance it matter. The feedback effect is only influenced by the tax rates, t_e, t_d and t_w, and output elasticities, β and α.

3. THE ELASTIC LABOR SUPPLY MODEL

A common argument for the growth effects of tax cuts is that they stimulate labor supply. A decrease in wage tax rates increases the after-tax wage received by workers and thus induces greater work effort if the substitution effect of a wage increase outweighs the income effect. To analyze this important potential effect, labor effort is incorporated into the production function and utility function. In per-effective worker terms, the production function takes the Cobb-Douglas form

$$y = f(k, n, g_I) = k^{\beta} n^{1-\beta} g_I^{\alpha}$$

where n represents hours worked. The utility function takes a form proposed by King, Plosser, and Rebelo (1988) in which the uncompensated elasticity of labor supply is zero resulting in a constant steady state value for leisure. Preferences over consumption and labor are given by

$$U(c, n) = \frac{(ce^{zt})^{1-\gamma} e^{-v(n)(1-\gamma)} - 1}{1-\gamma}$$

where γ represents the inverse of the intertemporal elasticity of consumption. The utility function is appealing in that it generates hours worked that are constant in the steady state but may increase or decrease along transition paths from one steady state to the next. The maximization problem for labor-leisure choice follows the same setup as the inelastic labor case.

$$Max_{c,n} \int_{t=0}^{\infty} e^{-\rho t} U(c, n) dt$$

subject to $\dot{k} + \dot{b} = (1 - t_w)wn + (1 - t_k)rk + br_2 + g_T - c - zk - zb$

and $lim_{t\to\infty}\ \lambda e^{-(\rho+z)t}(k + g_I) = limit_{t\to\infty}\ \lambda e^{-(\rho+z)t} b = 0$ (14)

The steady state equations are the same as in the inelastic case with an additional equation representing steady state labor and a modification of the equation for consumption growth which include labor supply.

$$\frac{\dot{c}}{c} = \frac{1}{\gamma}\,[(1-\gamma)v'(n)\,\dot{n} + (1-t_k)r - (\rho + z\gamma)] \tag{15}$$

$$v'(n) = \frac{(1-t_k)w}{c} \tag{16}$$

Equation (16) determines the allocation of time between work and leisure in all periods. From this, the constant-consumption elasticity of labor supply, denoted σ, is derived as $\sigma = \frac{v'(n)}{v''(n)n}$. The functional form used here is $v(n) = \psi n^{(1+\sigma)/\sigma}$ where ψ is a scalar. For $\sigma = 0$, labor supply is unresponsive to changes in the after-tax wage and the model reduces to the inelastic version. For $\sigma > 0$, higher values imply a higher disutility from each hour worked leading to a lower total amount of hours worked. This parameter will have an important impact on the feedback effect and corresponding Laffer curves.

The static effects on revenues from a capital tax cut and wage tax cut are the same as the inelastic case in which $\frac{dR}{dt_k}|_{\text{Static}} = rk = \beta y$, and $\frac{dR}{dt_w}|_{\text{Static}} = wn = (1-\beta)y$. The feedback effects, however, differ from the inelastic cases by the inclusion of an elastic labor supply term. For the case of a capital tax cut,

$$\frac{dR}{dt_k}|_{\text{DYN}} = [\underbrace{1 + \frac{\alpha}{(1-\alpha-\beta)} - \frac{1}{(1-t_k)}\frac{T}{(1-\alpha-\beta)}}_{\text{inelastic feedback effect}} + \underbrace{\{\overbrace{-\underbrace{\frac{(1-\beta)z}{P}}_{\text{sub effect}} + \underbrace{\frac{(1-\beta)(P-zT)G}{P(WP-TG)}}_{\text{income/budget effect}}}^{\text{allocation effect}}\}\overbrace{\frac{\sigma}{(1+\sigma)}}^{\text{labor elasticity effect}}\frac{T}{(1-\alpha-\beta)}}_{\text{elastic labor supply effect}}]\frac{dR}{dt_k}|_{\text{Static}} \tag{17}$$

This feedback effect is equal to the *inelastic feedback effect* plus an *elastic labor supply effect*. The elastic labor supply effect, $\{-\frac{(1-\beta)z}{P} + \frac{(1-\beta)(P-zT)G}{P(WP-TG)}\}\frac{\sigma}{(1+\sigma)}\frac{T}{(1-\alpha-\beta)}$, is divided into three separate parts. The first part, the *allocation effect*, varies by the type of fiscal regime and contains the substitution effect and income/budget effect for labor. The substitution effect, $-\frac{(1-\beta)z}{P}$, contains the worker's preference parameters in $P = \rho + z\gamma$ and is unambiguously negative. As a negative value, the substitution effect represents the inducement toward more investment (less consumption) which reduces the feedback effect. Increases in the household's impatience, represented by its rate of time preference, ρ, or by γ, the inverse of intertemporal elasticity, decrease work effort and output, thereby increasing the feedback effect. The substitution effect is invariant to regime type. The sign of the income/budget effect,

$\frac{(1-\beta)(P-zT)G}{P(WP-TG)}$, depends upon the type of government regime as determined by G.[10] G represents allocations of debt and tax revenues to government consumption, g_c, and public capital investment, i_g; the greater the allocation, the larger is G. Conversely, the greater the allocation toward transfers (either g_T or r_2b) the smaller is G. Because G is nonnegative for all reasonable parameter values, increases in G increase the allocation effect.

To understand the budget/income effect, consider two polar cases: a government transfer regime and a government expenditure regime. A *government transfer regime* is one in which all government revenues are devoted to transfers where transfers consist of interest payments on government bonds, r_2b and lump-sum transfer payments, g_T. A government regime that allocates all resources towards transfers has $G = 0$. Under this regime, a reduction in the capital tax rate means fewer transfers to the household causing an increase in the labor supply. This response of labor supply is referred to as a *budget effect* because it is determined by government's spending, or budgetary, decisions. Under the government transfer regime, the budget effect is exactly offset by a negative *income effect*. The income effect states that decreases in tax rates and government spending leave more resources available for the household, and more resource availability makes the household wealthier causing a reduction in labor supply. The two effects cancel out one another and the allocation effect reduces to the substitution effect alone.[11] Another interesting feature of this regime is that the particular combination of tax and deficit-financing to fund interest payments and lump-sum transfers has no effect on variable values. In essence, interest payments on the debt and lump-sum transfers are equivalent. This result occurs because each acts a pure transfer as evidenced by neither one appearing in NIPA. The dynamic effect for this regime is as follows.[12]

$$\frac{dR}{dt_k}\Big|^{\text{TRANS}}_{\text{DYN}} = [1 + \frac{\alpha}{(1-\alpha-\beta)} - \frac{1}{(1-t_k)}\frac{T}{(1-\alpha-\beta)} - \frac{(1-\beta)z}{P}\frac{\sigma}{(1+\sigma)}\frac{T}{(1-\alpha-\beta)}]\,\frac{dR}{dt_k}\Big|_{\text{Static}}$$

To quantify the effect, the Mankiw-Weinzierl (M-W) parameters ($t_k = t_w = 0.25$) are used along with the Feldstein (shown in parentheses) parameters ($t_k = 0.5$, $t_w = 0.45$). The elastic feedback effect for t_k is

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[10]Specifically, $G = zv_RM + JPW$ where $J = \mu_R + \phi_R$ and represents the amount of tax revenues allocated to investment in public capital, μ_R, and government consumption, ϕ_R; $M = \mu_b + \phi_b$ and represents the amount of deficit financing allocated to investment in public capital, μ_b, and government consumption, ϕ_b. P, M and J are unambiguously nonnegative. The term $W = 1 - \frac{zv_b}{P}$ and is positive for all reasonable parameter values.

[11] This result conforms to Gahvari (1988) who shows the transfer model implies income and budget effects "essentially wash out" leaving only the substitution effect.

[12] With regard to the rules of allocation, the government transfer regime requires $\chi_R + v_R = 1$ and $\chi_b + v_b = 1$ with all other allocation parameters set to zero (i.e., $\varphi_R = \mu_R = \varphi_B = \mu_B = 0$).

0.558 (-0.321). The Laffer peak occurs at $t_k = 0.365$ (0.348). These numerical results are listed in Table 1 and the Laffer curve for the M-W parameters is illustrated in Figure 3.

A government regime that allocates all resources towards government NIPA expenditures, a *government expenditure regime*, has $G > 0$. The labor substitution effect is the same as under the transfer regime, but the income/budget effect reduces to $\frac{(1-\beta)(P-zT)}{P(1-T)}$.[13] The allocation parameters cancel out indicating that the feedback effects are invariant to the allocation between g_c and i_g. This occurs because the government takes the same amount of resources out of the economy whether it is funding a unit of government consumption or government investment.

Like the transfer regime, a reduction in the capital tax rate and government spending leaves more income available for the household and reduces the labor supply. A reduction in the labor supply decreases output (increases the feedback effect) as seen by a positive income effect.[14] Unlike the transfer regime, government expenditures do not return to the household implying no offsetting budget effect exists. Without a budget effect, it can be easily proved that the income effect exceeds the substitution effect for this regime making the allocation effect positive.[15] Any increase in the allocation effect, such as from an increase in P or G, increases the feedback effect. The dynamic effect for this regime is as follows.

$$\frac{dR}{dt_k}\Big|^{\text{GOV}}_{\text{DYN}} = [1 + \frac{\alpha}{(1-\alpha-\beta)} - \frac{1}{(1-t_k)}\frac{T}{(1-\alpha-\beta)} + \{-\frac{(1-\beta)z}{P} + \frac{(1-\beta)(P-zT)}{P(1-T)}\}\frac{\sigma}{(1+\sigma)}\frac{T}{(1-\alpha-\beta)}]\frac{dR}{dt_k}\Big|_{\text{Static}}$$

The existence of the income effect means the feedback effect, and corresponding slope of the Laffer curve, is larger for the government expenditure regime than the government transfer regime for any given tax rate. This means that the peak of the capital tax Laffer curve for the former is to the right of the latter as show in Figure 3. A larger range of tax cuts will be self-financing under the government transfer regime than under the government expenditure regime. The elastic feedback effect for t_k is 0.691 (-0.0141) and the Laffer peak occurs at $t_k = 0.542$ (0.446).

Note that the government expenditure regime is separated into a regime that devotes all expenditures to investment in public capital, I_g *regime* and one that devotes all expenditures to public consumption, g_c *regime*. Though they share the same peak t_k, the I_g regime generates much higher revenues because of the positive contribution from public capital to economy-wide production. Public

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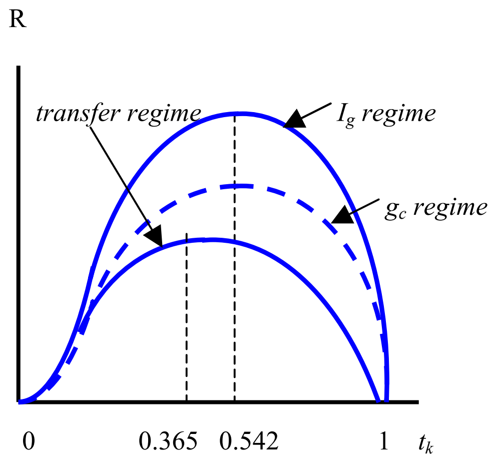
[13] It is easily shown that in this polar case, $G = P$ and $W = 1$.

[14] The positive income effect requires $\rho + z\gamma > zT$ which holds for all reasonable parameter values.

[15] The income effect > substitution effect as long as the after-tax interest rate exceed the growth rate which must hold for bounded consumption growth.

consumption, on the other hand, only affects economy-wide demand. Thus, the composition of government consumption and investment expenditures does not affect the skew of the Laffer curves but does affect their height.[16]

LAFFER CURVES FOR GOVERNMENT TRANSFER AND GOVERNMENT EXPENDITURE MODELS



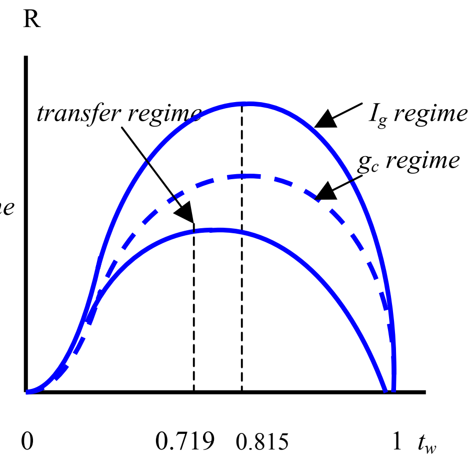


Figure 3: CAPITAL TAX LAFFER CURVE   Figure 4: WAGE TAX LAFFER CURVE

The remaining sub-effects are unambiguously positive and easy to interpret. The second sub-effect, $\frac{\sigma}{(1+\sigma)}$, is the *labor elasticity effect* that captures the response of labor supply to wage increases. It is both positive and increasing in σ as higher values imply a greater labor supply increase for any given wage increase. The third sub-effect, $\frac{T}{(1-\alpha-\beta)}$, appeared in the inelastic case and represents the size of the tax distortion or the incremental tax base effect. The incremental tax base effect is always positive and increasing in tax rates (contained in T) and the public and private capital elasticities, α and β, respectively. Increases in the labor elasticity effect and incremental tax base effect magnify the allocation effect thereby decreasing (increasing) the feedback effect for the government transfers (government expenditures) model.

Similar to the capital tax case, the dynamic effect of a wage tax cut has an inelastic feedback effect and elastic labor supply effect. Moreover, the wage tax allocation effect (which contains the

[16] It is interesting to note that different allocations between i_g and g_c cause different levels of c, g_I, and k, but do not affect their ratios to GDP. In other words, $\frac{c}{y}$, $\frac{k}{y}$ and $\frac{g_I}{y}$ are invariant to the allocation.

allocation parameters) can also be separated into a substitution and income/budget effect. The dynamic effect of a wage tax cut is given as

$$\frac{dR}{dt_w}\Big|_{\text{DYN}} = [1 + \underbrace{\frac{\alpha}{(1-\alpha-\beta)}}_{\textit{inelastic labor supply effect}} + \underbrace{\overbrace{\{\underset{\textit{sub effect}}{-\frac{1}{(1-t_w)}} + \underset{\textit{income/budget effect}}{\frac{(1-\beta)G}{(W(P-z\beta(1-t_k))-TG)}}\}}^{\textit{allocation effect}} \overbrace{\frac{\sigma}{(1+\sigma)}}^{\textit{labor elasticity effect}} \frac{T}{(1-\alpha-\beta)}}_{\textit{elastic labor supply effect}}]\frac{dR}{dt_w}\Big|_{\text{Static}} \quad (18)$$

The substitution effect, $-\frac{1}{(1-t_w)}$, is unambiguously negative: lower wage tax rates induce a substitution toward more work, higher output and a smaller feedback effect. The substitution effect is invariant to regime type. The sign of the income/budget effect, $\frac{(1-\beta)G}{(W(P-z\beta(1-t_k))-TG)}$, depends upon the type of government regime. As with the capital tax feedback effect, the budget and income effects cancel one another under the *government transfer regime*. The dynamic effect for this regime is as follows.[17]

$$\frac{dR}{dt_w}\Big|^{\text{TRANS}}_{\text{DYN}} = [1 + \frac{\alpha}{(1-\alpha-\beta)} - \frac{1}{(1-t_w)}\frac{\sigma}{(1+\sigma)}\frac{T}{(1-\alpha-\beta)}]\frac{dR}{dt_w}\Big|_{\text{Static}}$$

The elastic feedback effect for t_w is 0.98 (0.695) and the Laffer peak occurs at $t_w = 0.719$ (0.694). These numerical results are listed in Table 1 and the Laffer curve for M-W parameters is illustrated in Figure 4.

Under the *government expenditure regime*, the income/budget effect reduces to $\frac{(1-\beta)P}{(P(1-T)-z\beta(1-t_k))}$. Like the capital tax case, the allocation parameters cancel out and the feedback effects are invariant to the allocation between g_c and i_g. Though the sign of the income/budget effect appears ambiguous, it is positive for all reasonable parameter values as economic logic dictates. To wit, a reduction in the labor tax rate – and, correspondingly, government spending – leaves more income available for the household inducing a reduction in labor supply. This budget effect is reinforced by the income effect in which a decrease in labor tax rates raises the after-tax wage thereby magnifying the reduction in labor supply. The income/budget effect reduces output and increases the feedback effect.[18] The dynamic effect for this regime is as follows.

[17] With regard to the rules of allocation, the government transfer regime requires $\chi_R + \nu_R = 1$ and $\chi_b + \nu_b = 1$ with all other allocation parameters set to zero (i.e., $\varphi_R = \mu_R = \varphi_B = \mu_B = 0$).
[18] The positive income effect requires $\rho + z\gamma > zT$ which holds for all reasonable parameter values.

$$\frac{dR}{dt_w}\Big|^{\text{GOV}}_{\text{DYN}} = [1 + \frac{\alpha}{(1-\alpha-\beta)} + \{-\frac{1}{(1-t_w)} + \frac{(1-\beta)P}{(P(1-T) - z\beta(1-t_k))}\}\frac{\sigma}{(1+\sigma)}\frac{T}{(1-\alpha-\beta)}]\frac{dR}{dt_w}\Big|_{\text{Static}}$$

The elastic feedback effect for t_w is 1.125 (1.05) and the Laffer peak occurs at $t_w = 0.815$ (0.819).

Actual economies and their feedback effects fall in between the baseline models and provide a combination of government expenditures and transfers. As an economy increases its transfers at the expense of government expenditures, government revenues decline along with the feedback effects. Graphically, the Laffer curve skews down and to the left. Though revenues for any given tax rate will decrease, the ability of a tax cut to be self-financing increases. Consider allocating tax revenues equally to interest payments on debt, government consumption and government investment ($\nu_R = \phi_R = \mu_R = 1/3$) and allocating half of the debt issues to government investment and one quarter to both interest payments on debt and government consumption ($\mu_b = ½$, $\nu_b = \phi_b = 1/4$). The M-W parameter values yield feedback effects for t_w of 0.771 and 0.524 for t_k with revenues of 0.253. Using the Feldstein parameter values yield feedback effects for t_w is 0.758 and 0.409 for t_k with revenues of 0.506.

FEEDBACK EFFECTS AND LAFFER PEAKS FOR ALTERNATIVE FISCAL REGIMES				
ALTERNATE FISCAL REGIMES	$\frac{dR}{dt_k}$ **Feed back Effect M-W (Feldstein)**	$\frac{dR}{dt_w}$ **Feedback Effect M-W (Feldstein)**	**Laffer Curve Peak for t_k M-W (Feldstein)**	**Laffer Curve Peak for t_w M-W (Feldstein)**
Transfer Model	0.558 (-.321)	0.98 (0.695)	0.365 (0.348)	0.719 (0.694)
Government Expenditure Model	0.691 (–0.0141)	1.125 (1.05)	0.542 (0.446)	0.815 (0.819)
Combination Model	0.649 (-0.136)	1.079 (0.909)	0.524 (.409)	0.771 (0.758)

Table 1 (Parameter Values: $\alpha = 0.1$, $\beta = 0.33$, $\sigma = 0.5$, $z = 0.02$, $\rho = 0.05$, $\psi = 3$, and $\gamma = 1$.)

General rules for the effects of the other parameter values on the Laffer curves and feedback effects exist. First, increases in the output elasticity of public capital, α, increase the height and rightward skew of the Laffer curves for all relevant parameter values. The Laffer curves rise because higher capital stimulates output in the economy and generates greater tax revenues. The rightward skewing occurs because a decrease in tax rates lowers the amount of funding available for public capital investment. The more productive public capital is, the more this decrease in public capital investment lowers output. In addition, decreases in public capital lower the marginal productivity of private capital and labor which induce less private investment and hours worked further lowering output. Thus an increase in the effectiveness of public capital leads to larger tax revenues for any given tax rate but decreases the ability of tax cuts to be self-financing. This effect is illustrated in Figure 5 as a movement from the Laffer curve L_1 (α_{low}) to the L_0 (α_{high}).

Second, increases in the output elasticity of private capital, β, increase the height and leftward skew of the Laffer curves. The leftward skewing occurs for increased β because a decrease in tax rates raises the marginal product of private capital inducing more investment and higher output. Though lower taxes imply lower public capital, this effect is overwhelmed by the positive effects from the tax decrease. Thus an increase in the effectiveness of private capital leads to larger tax revenues for any given tax rate and increases the ability of tax cuts to be self-financing.

Third, increases in the consumption-compensated elasticity of labor supply, σ decrease the height of the Laffer curves and cause a rightward skew for capital tax Laffer curves but a leftward skew for wage tax Laffer curves. Increases in σ decrease the height because higher σ implies a higher disutility from each hour worked leading to a lower total amount of hours worked. Fewer hours worked generate lower tax revenues. This is represented graphically by a decrease in the height of the Laffer curves for any given tax rate. For the capital tax Laffer curve, increases in σ cause a rightward skew because the lower labor supply decreases the marginal product of capital and hence investment. Lower investment leads to lower output and thus reduces the ability of capital tax cuts to be self-financing. For the wage tax Laffer curve, increases in σ cause a leftward skew because the lower labor supply results in a higher marginal product of labor and higher after-tax wage for any given wage tax. The higher after-tax wage makes labor more sensitive to any given wage tax cut, so that the marginal labor supply is higher though the total amount of labor supplied is lower. Any given tax cut will raise the after-tax wage and generate a large labor response raising the ability of tax cuts to be self-financing. This effect is illustrated in Figure 5 as a movement from L_0 (σ_{low}) to L_1 (σ_{high}).

The fourth factor affecting Laffer curves is the size of the alternate tax rate. For example, the larger is t_w, the more leftward-skewed the capital tax Laffer curves. Similarly, the larger is t_k, the more leftward-skewed is the wage tax Laffer curve. This effect is illustrated in Figure 2 as a movement from L_0 (t_j^{low}) to L_1 (t_j^{high}). In other words, the larger the alternate tax rate, the more likely that a cut in the other tax will be self-financing.

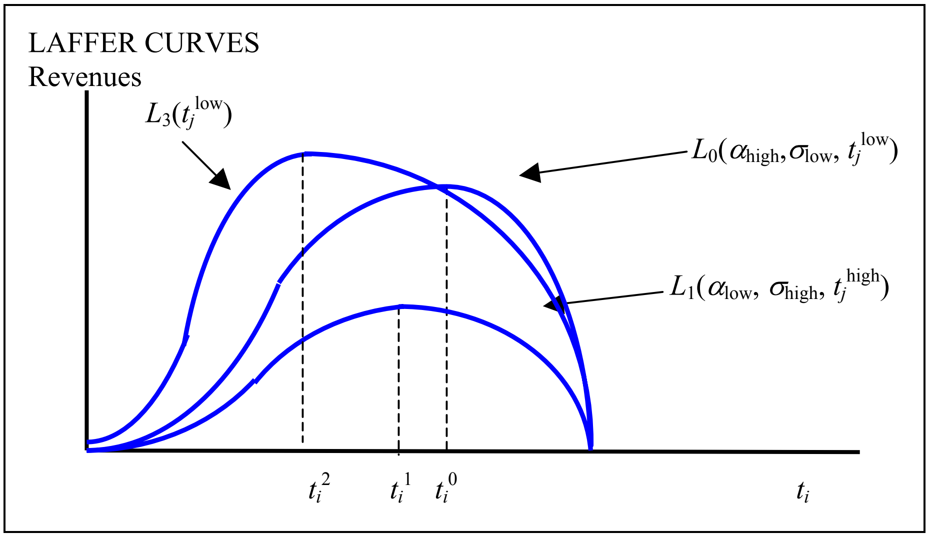


Figure 5

To examine the feedback effects and Laffer curves for the U.S. economy, the appropriate allocation parameter values must be determined. Though we have limited data on the allocation parameters themselves, we know values for g_c, i_g, g_T and r_2b. Calibrating the model to average of these values for the past decade gives allocation parameters of $\nu_R = 0.1$, $\mu_R = 0.1$, $\phi_R = 0.4$, $\chi_R = 0.4$, $\mu_b = 0.1$ and $\nu_b = 0.9$. The feedback effects with the M-W tax rates are 1.042 for t_w and 0.615 for t_k. This implies that only 38.5% of a capital tax cut is self-financing and that wage tax cuts actually exacerbate, rather than diminish, the static revenue loss by approximately 4%. If the Feldstein (2006) tax rates are more accurate for the United States only 18.1% of a wage tax cut is self-financing while capital tax cuts actually increase capital tax revenues above the estimated static loss by approximately 21%. Clearly, the initial tax rates matter.

4. CONCLUSIONS

Determining the linkage from tax cuts to changes in output and revenues is crucial to evaluating the impact of fiscal policy. This paper contributes to the literature by detailing the links between the feedback effects in the dynamic scoring literature with the position and shape of the Laffer curve within the dynamic Laffer analysis literature. By examining the feedback effects at the microeconomic level, the substitution, income and budget effects on both labor and capital have been elucidated. It is shown that how a government spends its revenues is just as important as how those revenues are generated. More transfer-oriented fiscal policy leads to a greater likelihood that a give tax cuts will be self-financing but will generate less revenue than more expenditure-oriented policy. These latter allocations, however, result in higher overall revenues for any given tax rate. Mankiw and Weinzierl (2006) use a simple neoclassical growth model to illuminate some of the private-sector mechanisms by which tax cuts can spur economic growth, expand the tax base and offset part of the revenue loss. They conclude that the growth effects of capital tax cuts and wage tax cuts can offset of revenue losses by 53 and 17 percent, respectively. This paper has built upon their model by introducing a government that provides transfers, government consumption and government investment in public capital along with deficit financing. The addition of multiple outlays and financing significantly affects the M-W results. This paper has shown that, at best, only a small percentage of a wage tax cut can be self-financing; at worst, wage tax cuts can actually exacerbate the static revenue loss. Capital tax cuts, on the other hand, may actually pay for themselves if the appropriate marginal tax rates are closer to Feldstein (2006) than Mankiw and Weinzierl (2006).

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