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Working Paper

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Würzburg economic papers, No. 9

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Suggested citation: Monissen, Hans G. (1999) : Explorations of the Laffer curve, Würzburg economic papers, No. 9, http://hdl.handle.net/10419/48455

W. E. P.

Würzburg Economic Papers

Nr. 99-09

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1999

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EXPLORATIONS OF THE LAFFER CURVE

Dedicated to James M. Buchanan on the Occasion of His Eightieth Birthday

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1. INTRODUCTION

Arthur Laffer's seminal discussion of the relation between tax revenues and "the" tax rate was an analytical cornerstone of the supply-side economics revolution during the early 1980s (see Canto, Joines, and Laffer [1982]). The conjecture that if tax rates were reduced tax revenues would increase has become a powerful, suggestive policy stand. The surprising policy implication was that public funds could be increased without burdening the private sector by adverse incentive effects or redistributive measures. The Laffer relation provided an important theoretical ingredient for the formulation of a convincing hypothesis about the behavior of a Leviathan government in the guise of a revenue-maximizing bureaucracy. It was as early as 1982 when Buchanan and his collaborators used the Laffer relation to analyze the behavior of political agents and derived the conditions for political equilibrium (see especially Buchanan and Lee [1982a and 1982b]).[1]

However, the Laffer curve – quite similar to the favorite policy toy of the Keynesian economists "the Phillips curve" – has basically remained an intuitively perceptive *ad hoc* relation.[2] Our paper „Explorations of the Laffer curve" aims at clarifying the theoretical ingredients for deriving such a curve. It is our understanding that the Laffer curve should be interpreted as a reduced-form equation of the economic process, an assertion which is only meaningful if the underlying economic structure is explicitly formulated. To illustrate some of the theoretical issues the argument will be simplified by relying on a one-period equilibrium model based on a representative agent. The tax system is as simple as possible: the tax base is easily identified and the tax rate (either income taxes or value-added taxes) is constant and proportionally related to the tax base.

The discussion proceeds as follows. Section 2 restates the simple (basically *ad hoc*) Laffer curve and introduces some analytics to justify the curvature properties by stating the underlying sufficient conditions. In Section 3 the Laffer curve is derived from the equilibrium conditions for the labor market. This semi-reduced form is substantiated by the fact that a wealth effect and thereby a profit term remains excluded. As in the implicit procedure of standard macroeconomics we rely on a so-called no-wealth-effect utility function. The Laffer curve derived is based on the idea that the equilibrium employment level depends on the prevailing wage rate. We demonstrate that income taxes and value-added taxes are equivalent, thereby exemplifying the irrelevance-of-who-pays principle. It is our understanding that the Laffer curve can only be a useful policy instrument if it is derived from an underlying Laffer-type relation between the tax base and the tax rate. Otherwise, the optimal size of government remains zero, which is not a convincing starting point. Section 4 introduces government productive activity in the form of a public good operating parametrically as an infrastructure component. The employment level is constant but can be allocated in variable proportions to the private and the public sectors. The government budget constraint affects this allocation and enables to derive a Laffer curve. The simple model excludes a leisure-income trade-off, which could allow a potential outright confiscation of the total private product by a Leviathan government. We ignore such a theoretical possibility. Government activity in the form of a public good both as an argument of the utility function of the representative consumer and a factor enhancing the productivity of the private sector extends the analysis in a crucial way and makes it possible to derive a multitude of Laffer-type relations, thereby providing a stronger empirical plausibility for the hypothesis of a revenue-maximizing bureaucracy (Section 5). The general equilibrium model supporting this analysis is summarized in an appendix. To complete the analysis, a model of a revenue-maximizing bureaucracy based on the extended Laffer curve is discussed in Section 6. A short summary (Section 7) completes the paper.

2. THE SIMPLE LAFFER CURVE

A familiar theorem from elementary calculus is Rolle's Theorem which can be stated simply as follows: if a curve crosses the abscissa twice then there must be a point between the crossings where the tangent to the curve is parallel to the axis. Of course, the function describing the curve between the points must be continuous and the first derivative must exist. Figure 1 describes a special case which could easily be interpreted as a Laffer curve if the variable on the abscissa denotes the tax rate and the variable on the ordinate the tax revenues. The latter variable is clearly zero if the tax rate as a multiplying factor is zero. If the tax rate is equal to one, one might expect that the return from supplying labor services is zero. The consequence will be that economic agents withdraw from market activities and possibly concentrate on shadow activities. Thus, the two crossings along the abscissa are intuitively substantiated. For the moment, we should ignore the explicit scale along the ordinate of both Figures 1 and 2 discussed below.

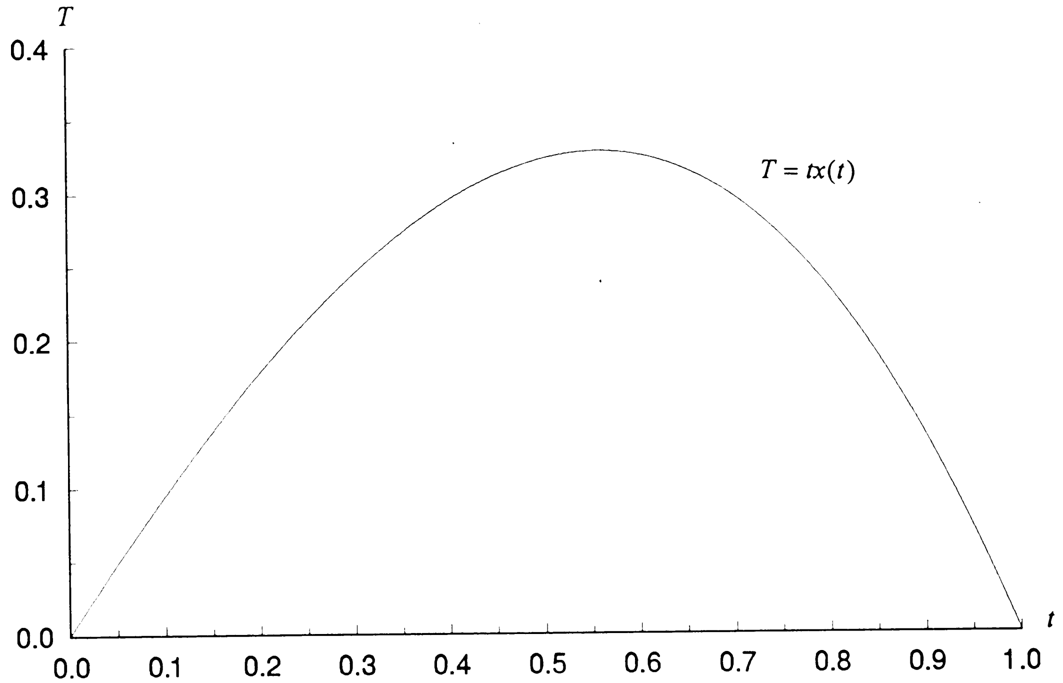

Figure 1. The Laffer Curve

Tax revenues are the product of the tax rate, *t*, and the tax base, *x*, written as a function of the tax rate (see Figure 1). If we assume that the tax base is a decreasing function of the tax rate, the simple Laffer curve seems to be established (see Canto, Joines, and Webb, [1982]).[3]

The two curves are related in a way that is familiar from elementary price theory if we interpret the tax rate as a price variable and the relation between the tax base and the tax rate as a standard demand function. However, this interpretation is misleading because it will be shown that this function is a reduced-form equation and not a structural equation. Thus, switching the axes is no violation of the Marshallian convention. Tax revenues have a maximum where the marginal tax revenue is zero which implies the familiar elasticity condition of minus unity for the underlying curve in Figure 2.

$$T = tx(t),$$

$$\frac{dT}{dt} = x(t) + t\frac{dx}{dt} = x(t)(1 + \frac{t}{x(t)}\frac{dx}{dt}) = 0\,,$$

$$\frac{d^2T}{dt^2} = \frac{dx}{dt} + \frac{dx}{dt} + t\frac{d^2x}{dt^2} < 0\,.$$

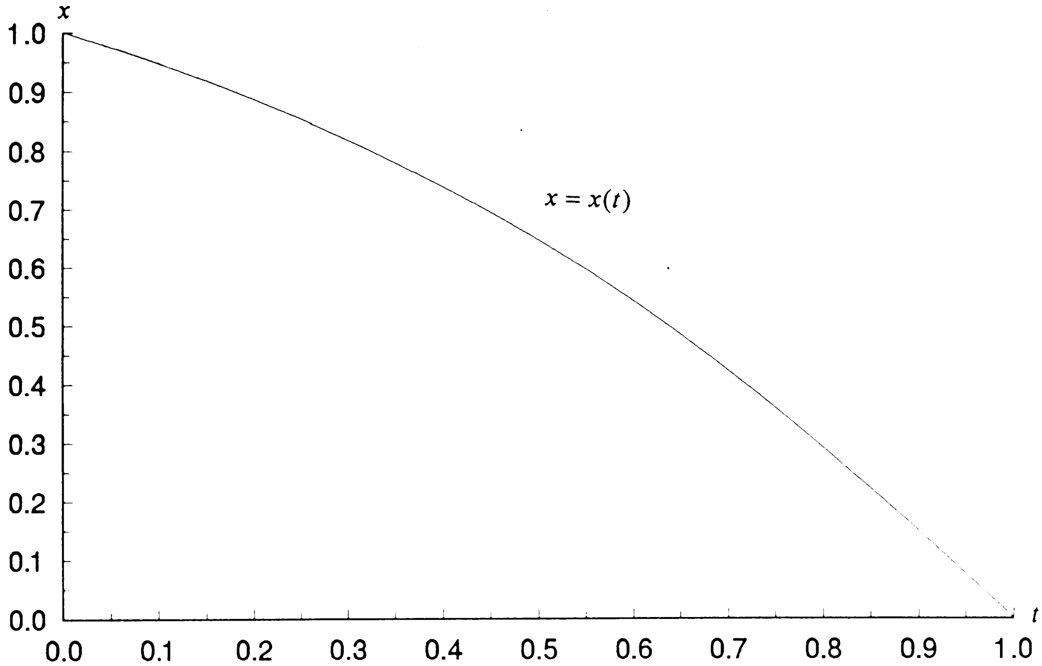

Figure 2. The Relation between the Tax Base and the Tax Rate

The neat curvature of the Laffer curve follows from the concave function between the tax base and the tax rate. A sufficient condition for a unique maximum of the Laffer curve is derived from a theorem noted by Andrew Caplin and Barry Nalebuff (1991):[4] if $1/x(t)$ is convex then $tx(t)$ is quasi-concave. In our case, the function $x(t)$ not only has a negative slope but is concave, too, which *a fortiori* strengthens the theorem.

3. LABOR DEMAND, LABOR SUPPLY, AND THE LAFFER CURVE

One way to derive a Laffer curve is to focus on the labor market. The reasoning is simple: if the marginal (and the average) tax rate is one, the households have no incentive to supply labor because the net wage rate is zero. Similarly, if the marginal tax rate for the producers is equal to one, the corresponding net price is zero, thus preventing a positive supply of goods.

Before we derive a Laffer curve we show that an income tax and a value-added tax are equivalent, thereby illustrating the principle of the-irrelevance-of-who-pays. Of course, this irrelevance presupposes both utility and profit maximizing behavior and price responsiveness for labor demand and supply.

If we start from a so-called no-wealth-effects utility function which excludes a wealth effect from the labor supply function, it is easy to derive a general equilibrium model relating output, *x*, “the” tax rate, *t*, and the employment level, y^w.

The generic type of the underlying utility function is:

$$U = x^p + \frac{(R - y^w)^{1-\theta}}{1-\theta}, \quad 0 < \theta < 1.$$

To simplify further we use the special case of $\theta \to 1$:

$$U = x^p + \ln(R - y^w).$$

x^p denotes the privately absorbed output. The difference between total time endowment, *R*, and work time, y^w, defines time used for leisure. The income-tax model includes the following private budget constraint:

$$(1-t)wy^w + (1-t)\pi = x^p.$$

Here and during the discussion of the paper the consumer price for output will be set equal to one. The gross wage rate is *w* and the profit level π which, given the specific form of the utility function, remains excluded from the labor supply function:

$$y^w = R - \frac{1}{(1-t)w}, \; R = 3.$$

The inverse form of the production function is

$$y^w = Ax^\beta, \; A = 1, \; \beta = 2.$$

The labor demand function equates the gross wage rate and the marginal productivity of labor:

$$w = \frac{1}{A\beta}\left(\frac{y^w}{A}\right)^{\frac{1-\beta}{\beta}}.$$

Profits are defined as a residue which remains excluded from the structure of the labor market:

$$\pi = \left(\frac{y^w}{A}\right)^{\frac{1}{\beta}} - wy^w.$$

Finally, the government budget constraint shows that discretionary government expenditures have to be financed by taxes. Because the model excludes any productive activity of the central government, the government budget constraint does not include a wage component, which is the subject of the next section:

$$tx = x^g .$$

The model comprises seven independent equations to determine seven endogenous variables, (U, x^p, x^g, x, y^w, π, w), given the income tax rate, t. However, the no-wealth-effect utility function allows a simple solution. Equating labor supply and demand after substituting the inverse production function yields:

$$\frac{1}{1-t}\frac{1}{R-Ax^{\beta}} = \frac{1}{A\beta}x^{(1-\beta)} .$$

This equation defines the implicit form of the relation between the tax base and the tax rate behind the Laffer curve.

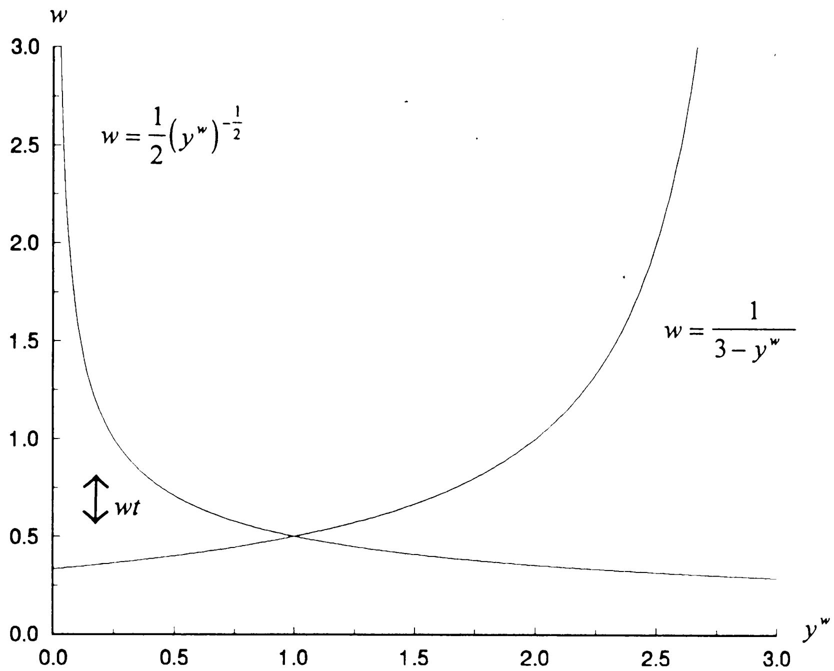

Figure 3. Labor Market Equilibrium: Income-Tax Regime

A value-added tax system is equivalent to the one stated. Multiplying both sides by $(1-t)$, where t will now denote the marginal value-added tax rate yields the same equilibrium condition for the labor market: income taxation and value-added taxation are equivalent regimes and describe what is known as the-irrelevance-of-who-pays principle. Figure 3 shows the labor market equilibrium. Using the numerical values for the parameters, we derive the following explicit form for the relation between the tax rate and the tax base, which is simpler than the inverted form:

$$t = \frac{3 - x^2 - 2x}{3 - x^2} .$$

The graph of this function is shown in Figure 2.

The supply and demand curves in Figure 3 are so-called basic curves excluding the tax rate. Introducing either type of the tax rate will shift the labor market equilibrium to the left by shifting either the demand or the supply curve. The principle of the-irrelevance-of-who-pays allows a simple graphical interpretation. If taxes are included, the equilibrium employment level will decrease. In the case of an income-tax regime, the vertical difference between the two curves identifies the marginal tax rate in value terms, i.e., *wt*. The demand price is the gross wage rate and the supply price is the net wage rate. In the case of a value-added tax regime, *w* identifies the gross (= net) wage rate and (1 - *t*) the net price for the business firms.

From a relation between *x* (via y^w) and *t*, we derive the curve depicted in Figure 2. The corresponding Laffer curve is shown in Figure 1. This curve is based on:

$$T = tx(t) \text{ using } t = \frac{3 - x^2 - 2x}{3 - x^2} .$$

What is the relevance of the Laffer curve for the design of economic policy? Notwithstanding the fact that the curve is often used to explain the Leviathan behavior of a revenue-maximizing bureaucracy, it is not a useful tool for the design of economic policy. We are not able to gain any information about the optimal (or efficient) size of the government sector. The optimal size of the government is simply zero and the relevant tax rate is zero. This situation identifies the Keynesian paradigm. Without evoking multiplier effects of discretionary government expenditure, x^g, there is no positive role for the government. This result is rather paradoxical, if we realize that this type of model is the one enshrined in the standard macro model. Let us therefore try a more promising avenue in order to justify the policy relevance of the Laffer curve.

4. PRODUCTIVE GOVERNMENT ACTIVITY AND THE LAFFER CURVE

The Laffer curve as derived in the preceding section was based on the fact that the level of employment was negatively related to the tax rate. The argument in this section focuses on another structural aspect, namely the possibility of productive government activity: the government produces a public good which may either increase the utility of the representative consumer or enhance the productivity of the private production sector.[5] To simplify, we first concentrate the analysis on the latter factor, which operates as a productive infrastructure provided by the government. The productive input is a government employment component, y^g, to be separated from the employment component in the private sector, y^p. The government pays competitive wages, which have to be financed by raising taxes, i.e., income taxes. An interesting aspect of this model as contrasted to the preceding discussion is that the total employment level, R, is given. Because a leisure-income trade-off remains excluded, welfare may be measured by the production level available for the private sector. The model reads as follows:

$x - z(y^g) f(y^p) = 0,\ z' > 0, z'' < 0,\ f' > 0,\ f'' < 0,$	production function[6]
$y^p + y^g = R,$	allocation of labor
$tx - (1-t)z(y^g) f'(y^p) y^g = 0,$	government budget
$T - tx = 0.$	tax revenues

Substituting the labor supply retains three of the four equations, which may be written in linear approximation as follows:

$$\begin{pmatrix} 1 & -(z'f - zf') & 0 \\ t & -(1-t)[(z'f' - zf'')y^g + zf'] & 0 \\ -t & 0 & 1 \end{pmatrix} \begin{pmatrix} dx \\ dy^g \\ dT \end{pmatrix} = \begin{pmatrix} 0 \\ -(x + z'y^g)dt \\ xdt \end{pmatrix}.$$

The interesting question is whether x as a function of t has a regular maximum. Assuming some regularity conditions of the functions involved, it is easy to demonstrate that the maximum of the derived Laffer curve is located on the falling range of the Laffer-type curve relating output to the tax rate.

Solving the linear two equations model for dx as a function of dt yields:

$$\frac{dx}{dt} = \frac{1}{\Delta}[-(x + zf'y^g)(z'f - zf')], \quad \text{for}$$

$$\Delta = -(1-t)[(z'f' - zf'')y^g + zf'] + t(z'f - zf') \gtreqless 0.$$

The above reduced-form derivative is equal to zero if $z'f$ is equal to zf'. This is an important efficiency condition (see Monissen [1999]): private production is maximized if a marginal shift of employment from the private to the public sector has no effect on output. We assume without proof that the second-order condition is also fulfilled.

A simple model, as useful as it might be, for explaining some aspects of a Leviathan government either in the form of revenue-maximizing bureaucracy or of a surplus-maximizing selfish dictator has one serious conceptual disadvantage: because a leisure-income trade-off remains excluded from the model, a selfish dictator could set the tax rate equal to one and confiscate the total private production. This would be a rational policy after maximizing private production by an appropriate allocation of labor to the two sectors. Thus, the shape of the Laffer curve only follows if we assume that the budget is balanced, i.e., taxes will be raised to cover government expenses for wages in the public sector.

Incorporating the definition of tax revenues into the model yields the reduced-form derivative:

$$\frac{dT}{dt} = x + t\frac{dx}{dt} \quad = x(1 + \frac{t}{x}\frac{dx}{dt}) \ ,$$

$$= x[1 + \varepsilon(x,t)] \ .$$

The qualitative properties of the results are similar to those which we will derive from the extended model in the next section.

5. SOME LAFFER-TYPE CURVES

The final stage of our discussion of the Laffer curve is based on a model extending the productive activity of the government to cover both the productive effect discussed in the preceding section and a standard public good enhancing the utility of the private sector. Thus, it seems appropriate to include a utility function with the leisure-income trade-off in addition to the private and the public good. The structure of the model is presented in an appendix. Some remarks are appropriate. The utility function is now quasi-linear in leisure; thus, the labor supply function includes a wealth term in the form of profits from the private business sector. To eliminate the profit variable from the model, the private production function is linear in the private employment level. Without further discussion we state the reduced-form equation which can be easily derived because the equations of the model are all log-linear.

The solutions for private production, x, and the public good, z, are:

$$x = (\frac{1-t}{A})(\frac{B}{t})^{\frac{\beta_2}{\gamma}} = (\frac{1-t}{0.08})(\frac{0.2}{t})^{-0.05} \ ,$$

$$z = (\frac{t}{B})^{\frac{1}{\gamma}} = (\frac{t}{0.2})^{0.2} \ .$$

The first equation states x as a function of t. In addition we can define national product, NP:

$$NP = x + wy^{g} \ .$$

Tax revenues are the product of the private production volume and the tax rate. Figure 4 depicts all three curves. Private production is maximized for a tax rate of 0.05, national product is maximized for a higher rate of 0.16. As shown earlier, the Laffer curve is maximized for a tax rate of 0.51, which identifies the falling range of the Laffer-type curve for x.

A log-transformation of the Laffer-relation reads:

$$\ln(tx) = \ln t + \ln(1-t) - \ln A - \frac{\beta_2}{\gamma}\ln t + \frac{\beta_2}{\gamma}\ln B.$$

The first-order condition

$$\frac{d\ln(tx)}{dt} = \frac{1}{t} - \frac{1}{1-t} - \frac{\beta_2}{\gamma}\frac{1}{t} = 0$$

yields a tax rate of $t \approx 0.51$ for $\frac{d^2 / \ln(tx)}{dt^2} < 0.$

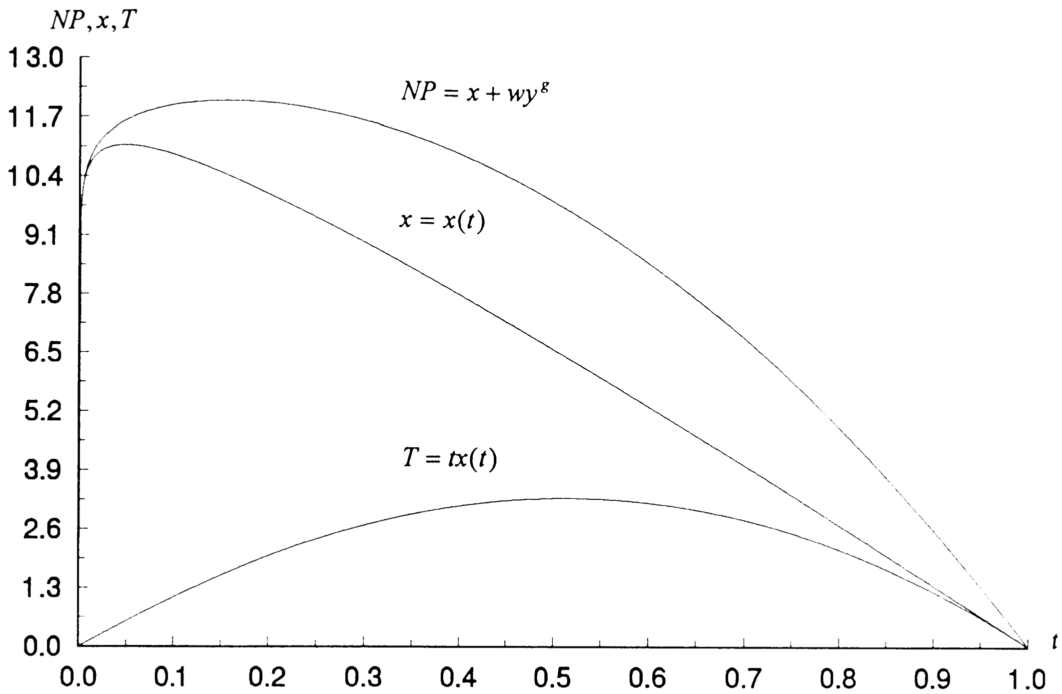

Figure 4. Some Laffer-Type Curves

As a marginal observation we state that the utility level of a maximized NP is higher as compared to maximized private output, x. This result differs from the one stated earlier where private production proved to be the appropriate welfare measure. This apparent contradiction is resolved if we recall that the earlier discussion excluded a public good from the utility function. It may be evident that NP is the appropriate measure if we want to cover the production of the public good in an indirect way.

6. A REVENUE-MAXIMIZING BUREAUCRACY

As in the case of the Phillips curve, the Laffer curve is a popular tool in shaping and analyzing economic policy problems. In both cases a theoretical underpinning came rather late after a long period of *ad hoc* theorizing. The Laffer curve is often used to explain the behavior of a revenue-maximizing bureaucracy. However, it is our understanding that the Laffer curve is a completely useless tool for economic policy advice if either based on the *ad hoc* model or the labor market model because in both cases the optimal size of government is zero. Thus, specific starting points on the Laffer curve cannot be used to rationalize the behavior of a Leviathan government. The situation is completely different if the Laffer curve can be derived from a Laffer-type curve for output. Justifying the selfish behavior of an incumbent bureaucracy is easy if there exists a multitude of Laffer-type curves, which may be difficult to separate and assess empirically.

As mentioned at the beginning, the Laffer curve has provided an important theoretical ingredient for the analysis of a revenue-maximizing bureaucracy. We complete therefore the discussion by a brief analysis of a Leviathan government which materializes in the form of a revenue-maximizing bureaucracy.[7] Starting from the definition of tax revenues we write:

$$U^g = tx = t(\frac{1-t}{0.08})(\frac{t}{0.2})^{0.05}.$$

Upon substitution of the reduced-form solution for the public good, z, the function reads:

$$U^g = t(\frac{1-t}{0.08})z^{0.25}.$$

From this function which states that the utility of the government depends negatively on the tax rate and positively on the quantity of the public good, we may easily derive standard indifference curves which have the elliptic shape marked by U_0^g, U_1^g, U_2^g. The efficiency line reproduces the reduced-form solution for the public good as a function of the tax rate. The solution values for a revenue-maximizing bureaucracy are $t = 0.51$ (indicating the maximum of the Laffer curve) and $z = 1.21$ (see Figure 5).

The three concave curves earmarked by U_0, U_1, U_2 are derived from the utility function of the model. This second-best solution identifies lower values for both the tax rate and the quantity of the public good. The utility solution is thereby simplified by a convenient property of our model namely that the employment level remains constant under a second-best solution.

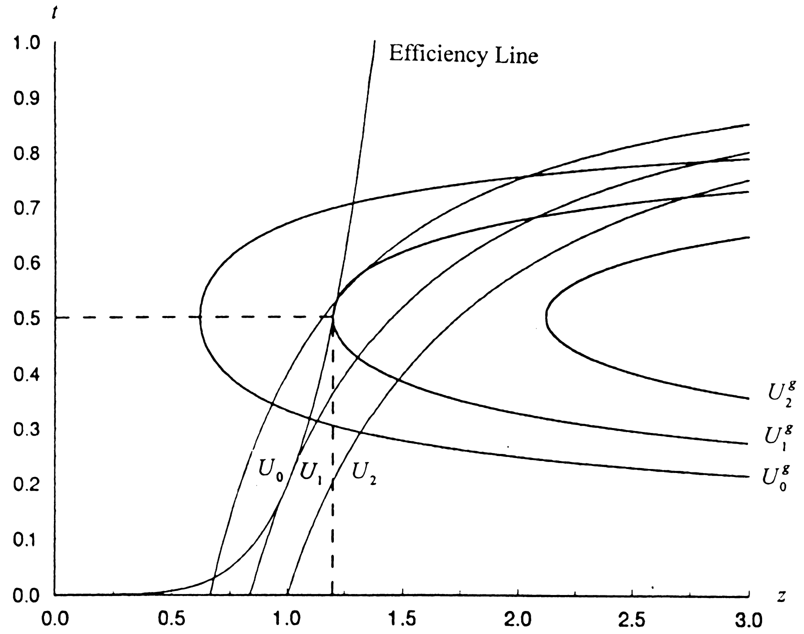

Figure 5. The Budget-Maximizing Bureaucrat

7. SUMMARY

Superficial investigation of the literature confirms the impression that the Laffer curve remains basically a suggestive *ad hoc* relation besides the fact that it is widely referred to as a policy tool and a theoretical input for analyzing bureaucratic behavior. If our interpretation is correct that the Laffer curve (as the Phillips curve) is the geometrical expression of a reduced-form equation we are obliged to state the underlying system. Because the Laffer curve is generally connected with standard macroeconomic analysis it remains an unsatisfactory analytical tool because it tends to conceal the fact that the optimal size of government is zero. In standard macroeconomics the government has no useful role to play if we ignore the existence of likewise unsatisfactory effects of government expenditures on employment via the multiplier. The more traditional theoretical foundations of the Laffer curve may be based on employment effects via tax effects on the net wage rate. Based on such considerations the relation between the tax base and the tax rate has a uniform negative slope throughout. Only by focusing on the productive role of government this relation does take a Laffer-type shape. Maximizing the Laffer curve results in a tax rate that is higher than the one maximizing the tax base or any other welfare indicator. The tax base and the tax revenues are related by a familiar elasticity condition. In this more complex world it is easy for an incumbent bureaucracy to conceal its true preferences by pretending to maximize the welfare of society.

APPENDIX

The structure of the model underlying the extended discussion of the Laffer curve reads as follows (see Monissen, [1999]):

$$U = \ln x + \ln z + (R - y^{w}), \text{ with } R = 3, \tag{1}$$

$$wy^{w} + 0 = x \tag{2}$$

$$\frac{1}{w} = \frac{1}{x}, \tag{3}$$

$$y^{p} = Ax^{\beta_1} z^{\beta_2}, \text{ with A = 0.08, } \beta_1 = 1, \text{ and } \beta_2 = -0.25, \tag{4}$$

$$[\pi = 0], \tag{5}$$

$$\frac{1}{w} = \frac{Az^{\beta_2}}{1-t}, \tag{6}$$

$$y^{g} = Bz^{\gamma}, \text{ with } B = 0.2, \text{ and } \gamma = 5, \tag{7}$$

$$ptx = wBz^{y}. \tag{8}$$

The eight independent equations allow determining the eight endogenous variables, $(U, y^{w}, y^{p}, y^{g}, x, w, z, \pi)$, in terms of the tax rate, t. These are the reduced-form equations of the model.

[*] The author thanks Bettina Monissen for helpful assistance.

[1] The Buchanan-Lee model has become a standard reference in the public choice – public finance literature, cf. John Cullis and Philip Jones (1998).

[2] For an interesting historical inspection of Laffer's idea, cf. Robert Kaleher and William Orzechowski (1982). Needless to emphasize, Stigler's Law applies in the case of the Laffer curve, too.

[3] See the early discussion by Victor A. Canto, Douglas H. Joines, and Robert J. Webb (1982). Similar theoretical considerations substantiate the analysis by James M. Buchanan and Dwight R. Lee (1982a and 1982b).

[4] This source is quoted in Simon P. Anderson, André de Palma, and Jacques-Francois Thisse (1992). I owe this reference to my colleague Norbert Schulz.

[5] The following discussion is based on Hans G. Monissen (1985, 1999) and Ronald Findlay and John D. Wilson (1987). As a general reference to the modern theory of economic growth where similar production functions are used, compare Robert J. Barro and Xavier Sala-i-Martin (1995).

[6] Because the public good is parametrically included, economics of scale may result without suspending the assumptions for a competitive equilibrium, see Chipman (1970).

[7] The following analysis is based on Monissen (1999).

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