

**RAISING REVENUE WITH TRANSACTION TAXES IN LATIN AMERICA -
OR IS IT BETTER TO TAX WITH THE DEVIL YOU KNOW?**

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ABSTRACT

In recent years, various Latin American governments have resorted to taxes on bank debits and financial transactions as alternative ways of raising revenue. Considerable interest has developed in understanding the consequences of such reforms. This paper constructs a dynamic general equilibrium model to assess the size of distortions and other quantitative implications associated with a transaction tax. The distinctive feature of the model is the non-neutrality property of the tax in the sense that it distorts the structure of relative prices of intermediate transactions, giving rise to tax “pyramidation.” The effective tax rate ultimately borne by the economy is shown to depend on the complexity of the transaction structure. Calibrated for Latin America, the model finds that, contrary to existing evidence and conventional wisdom, a transaction tax is not a particularly burdensome levy in terms of economic growth and efficiency costs. The model also shows that if a government can credibly commit itself to an announced two-step reform in which it first uses a transaction tax temporarily and then replaces it with any other conventional tax, this policy will improve economic welfare relative to a tax reform where a consumption tax (or a labor income tax or a capital earnings tax) is exclusively used from the start to raise the required additional revenue.

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1. INTRODUCTION

A few months before the 2002 collapse of the currency peg, the Argentine government, in an attempt to make the Convertibility Plan more credible, passed a series of reforms including the introduction of a temporary tax on bank account debit and credit transactions. The Colombian government, in the middle of a financial crisis in 1998, introduced a temporary tax on transactions conducted through financial intermediaries to finance the bailout of mortgage, mutual and state-owned banks. In 1993, the Brazilian government created a new temporary tax on financial transactions to provide for universal health care coverage, a right given by a constitutional amendment passed in 1988. In 2002, the Venezuelan government instated a temporary bank debit tax to ease pressing budgetary imbalances. Today, all these countries have a form of tax on financial transactions in their codes, sometimes on a permanent basis (Colombia), sometimes continuously renewed on a temporary basis (Brazil), sometimes scrapped and then reinstated (Argentina and Venezuela) and sometimes earmarked for new purposes (e.g., Colombia).

Other countries in Latin America have resorted to bank debit taxation in the past. To ameliorate the effect of the collapse of world oil prices on the budget, Ecuador abolished its income tax system in 1998 and replaced it with a financial transaction tax, in hopes of increasing revenue. The income tax was soon reinstated and the transaction tax scrapped in 2001. Peru made use of this type of tax at the beginning of the 1990s and a proposal for its reintroduction has recently been approved by the government.

Bank debit taxation has had a bumpy ride in the region. After starting with enormous design problems that literally shut down foreign exchange, interbank and stock markets in some countries, and after numerous reforms directed at converting it into a more palatable levy (for instance, by exempting foreign exchange and stock market trades, transactions with the central bank, the treasury and other government agencies, investment funds, etc.), the most recent versions of the tax have gathered momentum and represent an important source of revenue for governments. In 2002, the contribution of bank debit taxes to federal government tax revenue came to 12.7% in Venezuela, 9.6% in Argentina, 6.1% in Brazil and 5.3% in Colombia. If the yield of other indirect “cascading” taxes is added, turnover taxes represent almost 23% of the government’s tax revenue in Brazil.

Although there is no more than a handful of empirical studies, the policy debate in the region, based on them, has been characterized by unequivocal and definite policy statements. According to the literature, a transaction tax is a particularly burdensome levy (Albuquerque, 2001a and 2001b; Arbeláez et al., 2002; Coelho et al., 2001; Lozano and Ramos, 2000; Koyama and Nakane, 2001), and its costs are higher the longer it remains in place (Kirilenko and Summers, 2003; Tanzi, 2000). It is strongly recommended that the tax be scrapped soon (Coelho, et al. 2001; IMF, 2000; Tanzi, 2000) and replaced with taxes such as the VAT and income taxes (Coelho, et al. 2001). However, the lack of theoretical and empirical analyses backing up such statements is surprising. The existing literature has not been able to address key issues, such as how a transaction tax distorts

the allocation of economic resources, how big the resulting distortion (excess burden) is, how badly a transaction tax fares relative to the VAT and income taxes or how the economy behaves along the transition path of tax reforms involving changes in the transaction tax. This paper attempts to make such analyses, providing quantitative answers rather than conjectures.

A bank debit tax is a convoluted object. Albuquerque (2001a; 2001b) and Kirilenko and Summers (2003) have approached some of the questions at issue from a narrow perspective, understanding it as an excise tax on financial intermediation. In contrast, this paper interprets a bank debit tax more broadly, as a transaction tax, and disregards its effect on financial intermediation to focus on real resource allocation. A bank debit tax - akin to a transaction tax - has features that are similar to conventional taxes like a tax on final expenditures, a tax on labor income and a tax on capital earnings, but it also exhibits the less desirable features of a turnover tax. These latter features are what make a bank debit tax a cascading tax, which is highly objectionable. Long ago, economic theory showed that final good taxation is superior to turnover or transaction taxation because it avoids production inefficiency (Diamond and Mirrlees, 1971). In contrast to a consumer-consumer (financial) transaction tax and a value-added tax applied to all stages of production and distribution, a turnover tax suffers from a non-neutrality property in the sense that it distorts the structure of relative prices of intermediate transactions conducted on the production side of the economy. This explains the strong preference economic theory has for a value-added tax within the class of indirect taxes, and also why policy makers and analysts take for granted the superiority, on efficiency grounds, of other tax instruments and why little is known about the nature and size of the distortionary effects caused by tax “pyramidation.”

This paper introduces into a multisector, dynamic general equilibrium model a transaction tax to assess the size of distortions, the effect on economic growth and the efficiency costs associated with alternative tax reforms involving a transaction tax. The contribution and distinctive feature of the model is the non-neutrality property of the modeled tax that gives rise to tax pyramidation. This feature has not been properly captured by standard tax models, which typically ignore intermediate transactions and, more importantly, unconventional taxes, like a transaction tax. The paper shows that the effective tax burden in the economy depends on the complexity of the transaction structure. The model also constructs a level playing field in which conventional taxes levied on final transactions, such as a consumption tax, and taxes such as labor and capital income taxes, on the one hand, and unconventional taxes levied on both final and intermediate transactions, on the other, can be judiciously compared.

This paper is structured as follows. Section 2 describes the model, first focusing on the properties of transaction taxation and then generalizing it by including consumption, labor income and capital earnings taxes. Section 3 explains the parameterization strategy, the solution algorithm to compute equilibrium allocations and the metric used to compare the effects of alternative tax reforms. Section 4 presents and discusses the main results from numerical experiments and performs some robustness checks. Section 5 presents the results of additional numerical sensitivity analyses. An effort is made to reconcile the

results in this paper with the strikingly opposing conclusions drawn from the existing empirical literature in Section 6. Finally, conclusions are contained in Section 7.

2. THE MODEL

Three general types of transactions are carried out in our economy: one between firms conducting intermediate input trade, one between firms and households buying and selling capital and labor services and finally, one between firms and households exchanging final consumption and investment goods. All these types of transactions are intermediated through the financial system and therefore, subject to a bank debit tax, which is called hereafter, transaction tax (TT). This means that every single trade taking place in either the final good market, or the intermediate good market, or the capital market or the labor market is burdened with a TT. The salient feature of a transaction tax is its potential to cause distortions in trading patterns through the “pyramiding” of nominal rates, i.e., its feature that resembles a turnover tax. In the model economy, this feature is captured by taxing intermediate input transactions. Given the assumed production structure - to be described shortly - the tax rate will pyramid as a good “turns over” from one stage of the production process to the next.

A. Production and Transaction Structures

The production structure is partially inspired by that described by Uribe (1997). There is a fixed, though possibly large, number of sectors n in the economy. The first $n-1$ sectors produce intermediate goods while the final good is produced in the remaining sector, called sector number n . It takes n stages to produce a final homogeneous consumption-investment good and each stage takes place successively from stage 1 in sector 1 to stage n in sector n , within a given time period. Since firms solve static problems, the use of time subscripts will be postponed until the time dimension is no longer trivial.

The production of the final good in sector n requires, in addition to primary factors - capital and labor - an intermediate input produced in sector $n-1$. The production of the (intermediate) good number $n-1$ requires in turn primary inputs and material input produced in sector $n-2$ whose production in turn requires materials from sector $n-3$, in conjunction with capital and labor services, and successively so for the remaining sectors. This does not apply to sector number 1, obviously. Sector number 1 production technology involves solely primary inputs. All payments on the production side of the economy are subject to a transaction tax at a rate of τ^T . Payments include disbursements to pay for primary factor services as well as for the cost of intermediate inputs. This simple structure captures the unpleasant feature of a turnover tax: the tendency of the nominal rate to pyramid.

Value added in sector i , V_i , is measured as the contribution of primary inputs and technology in the production process. In order to have a unique index of value added,

Sato (1976) shows that two assumptions are needed: separability and generalized homogeneity. Thus, primary inputs and technology are jointly separable from intermediate inputs and the production function is homogeneous of degree one in V_i and M_i , where M_i represents intermediate inputs in the production of good i , $i = 2, \dots, n$. The economy's technologies satisfy these requirements. The value added function is described by a standard Cobb-Douglas function, common to all sectors, of the form: $V_i = K_i^\alpha (ZH_i)^{1-\alpha}$ where K_i is capital in place in sector i , H_i is raw labor input and Z is an index of knowledge which is freely available to all sectors and which is acquired through learning-by-doing, as a non-deliberate action. Technical change is endogenously determined by means of this externality effect.

Gross output Y_i is produced according to a Leontief technology the arguments of which are value added V_i and material input M_i . As mentioned above, the latter is produced in sector $i-1$. The production structure is concisely expressed as

$$Y_1 = V_1$$

$$Y_i = \min\{V_i, M_i\} \quad i = 2, \dots, n$$

In sector number 1 gross output and value added are equal. Let p_i , r and w denote the relative price of good i , the rental price of capital and the wage rate all in terms of the final good. Taking prices parametrically, sector i firm chooses K_i and H_i so as to maximize after-tax profits,

$$\max_{K_i, H_i} \Pi_i = (p_i - (1 + \tau^T)p_{i-1})K_i^\alpha (ZH_i)^{1-\alpha} - (1 + \tau^T)(rK_i + wZH_i)$$

Sector i firm pays taxes of $\tau^T \cdot (p_{i-1}M_i)$ on the total transactions conducted in the intermediate input market and of $\tau^T \cdot (rK_i + wZH_i)$ on trades conducted in primary factor markets. From this problem, the following equilibrium pricing functions are obtained. In sector 1:

$$(1 + \tau^T)r = p_1 \alpha \left(\frac{ZH_1}{K_1} \right)^{1-\alpha}$$

$$(1 + \tau^T)w = p_1 (1 - \alpha) \left(\frac{K_1}{ZH_1} \right)^\alpha$$

and in any other sector i , $i \neq 1$,

$$(1 + \tau^T)r = (p_i - (1 + \tau^T)p_{i-1})\alpha \left(\frac{ZH_i}{K_i} \right)^{1-\alpha}$$

$$(1 + \tau^T)w = (p_i - (1 + \tau^T)p_{i-1})(1 - \alpha) \left(\frac{K_i}{ZH_i} \right)^\alpha$$

Both sets of conditions have the usual interpretation of equating the marginal cost of hiring an additional unit of a primary input to the value of its marginal contribution to output. In our new twist, the marginal cost includes a transaction tax and, in addition the marginal contribution of sectoral primary inputs represent their contribution to a quantum index of aggregate value added. Combine first order conditions to get

$$\frac{w}{r} = \left(\frac{1 - \alpha}{\alpha} \right) \frac{K_i}{ZH_i} \quad i = 1, \dots, n$$

an expression that conveys the main message of the separability assumption: the marginal rate of substitution between primary inputs is independent of the material input M_i . The equation says that all sectors utilize the same capital-labor ratio. This key finding is summarized as follows.

Proposition 1. *Consider the described production and transaction structures. Then, given primary factor prices, capital-labor ratios across the economy are independent of the transaction tax rate.*

In equilibrium, factor prices are determined endogenously and through this channel a TT may exert its distortionary effect on allocations. Identical capital-labor ratios along with Leontief technologies imply that all sectors hire the same amounts of capital and labor

$$\begin{aligned} K_i &= K^f & \forall i \\ H_i &= H^f & \forall i \end{aligned}$$

where K^f and H^f stand for equilibrium factor demands. Aggregating over sectors the economy's demand for capital equals nK^f and the demand for efficiency units of labor totals nZH^f .

Proposition 2. *Consider the described production structure and Proposition 1. Then, in equilibrium, intermediate input prices $(p_1, p_2, \dots, p_{n-1})$ are exclusively determined by two parameters: n and τ^T .*

Proof: The first order conditions for the optimal choice problem for the allocation of capital is made up of a system of n equations

$$\frac{1}{\alpha}(1+\tau^T)r\left(\frac{K_1}{ZH_1}\right)^{1-\alpha} = p_1$$

$$\frac{1}{\alpha}(1+\tau^T)r\left(\frac{K_2}{ZH_2}\right)^{1-\alpha} = p_2 - (1+\tau^T)p_1$$

$$\frac{1}{\alpha}(1+\tau^T)r\left(\frac{K_3}{ZH_3}\right)^{1-\alpha} = p_3 - (1+\tau^T)p_2$$

...

$$\frac{1}{\alpha}(1+\tau^T)r\left(\frac{K_n}{ZH_n}\right)^{1-\alpha} = p_n - (1+\tau^T)p_{n-1}$$

Noticing that, in equilibrium, the left-hand side is the same in all equations and using the fact that the final good is the *numéraire* ($p_n = 1$), this system can be transformed into one with $n-1$ equations in $n-1$ relative prices taking the form

$$Ap = b$$

where A is a $(n-1 \times n-1)$ matrix with the following format

$$A = \begin{bmatrix} 2+\tau^T & -1 & 0 & 0 & 0 & \dots & 0 & 0 & 0 \\ -(1+\tau^T) & 2+\tau^T & -1 & 0 & 0 & \dots & 0 & 0 & 0 \\ 0 & -(1+\tau^T) & 2+\tau^T & -1 & 0 & \dots & 0 & 0 & 0 \\ 0 & 0 & -(1+\tau^T) & 2+\tau^T & -1 & \dots & 0 & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & 0 & 0 & \dots & -(1+\tau^T) & 2+\tau^T & -1 \\ 0 & 0 & 0 & 0 & 0 & \dots & 0 & -(1+\tau^T) & 2+\tau^T \end{bmatrix}$$

and b and p are $(n-1)$ -dimensional vectors

$$b = \begin{bmatrix} 0 \\ 0 \\ \dots \\ 0 \\ 1 \end{bmatrix}, \quad p = \begin{bmatrix} p_1 \\ p_2 \\ \dots \\ p_{n-2} \\ p_{n-1} \end{bmatrix}$$

By virtue of this equation, the structure of relative prices can be computed as

$$p = p(n, \tau^T) = A^{-1} b \mathbb{1}$$

To summarize, the structure of equilibrium relative prices depends on two parameters only: the number of sectors n determining array dimensions and the TT rate τ^T determining the contents of matrix A .

Corollary.
$$\sum_{i=1}^{n-1} p_i = \frac{1}{\tau^T} - \left(\frac{n}{(1 + \tau^T)^n - 1} \right)$$

Proof: In the appendix.

The above corollary is very helpful in illustrating the cascading effect of a transaction tax and the difference between it and conventional taxation. Let us focus for a moment on tax collections coming from taxing intermediate and final good purchases.¹ Tax collections involving intermediate input transactions amount to $\tau^T \cdot \left(\sum_{i=2}^n p_{i-1} K_i^\alpha (ZH_i)^{1-\alpha} \right)$ while the tax collection on transactions involving the disposition of the final good equals $\tau^T \cdot p_n \cdot K_n^\alpha (ZH_n)^{1-\alpha}$. In equilibrium, the total tax revenue relative to the economy's GDP, or the effective tax rate τ_e^T , is

$$\tau_e^T = \tau^T \sum_{i=1}^n p_i$$

which, based on proposition 2 and its corollary, depends exclusively on the number of sectors and the transaction tax rate. A closed-form expression relating effective and nominal tax rates can be obtained²

$$\tau_e^T = 1 + \tau^T - \left(\frac{n \tau^T}{(1 + \tau^T)^n - 1} \right)$$

¹ In this example tax collections coming from taxing factor service payments are not taken into consideration. In fact, these correspond to the value-added tax feature of a transaction tax, and therefore, they are irrelevant for illustrating the cascading effect of a transaction tax. Yet, for completeness and future reference, see next footnote.

² If, in addition, taxes on factor service payments are included, the corresponding tax collection amounts to $\tau^T \cdot \left(\sum_{i=1}^n (w Z H_i + r K_i) \right)$, and the general expression for the effective tax rate is now:

$$\tau_e^T = 1 + \tau^T - \left(\frac{1}{1 + \tau^T} \right) \left(\frac{n \tau^T}{(1 + \tau^T)^n - 1} \right)$$

Figure 1 displays the relationship between τ_e^T and τ^T for alternative values of n , $n = \{1, 5, 10, 20\}$. The $n=1$ -line may be interpreted as the case of conventional taxation where taxes are levied on final output (i.e. equivalent to a proportional income tax). A 0.3% nominal tax rate on final output yields revenue equal to exactly 0.3% of GDP (this should be a 45° line), hence effective and nominal rates are equal. When intermediate transactions are taxed ($n > 1$) a wedge between effective and nominal rates appears. In this case, the line in the (τ^T, τ_e^T) -plane rotates counterclockwise and the wedge increases as the transaction and production structures turn more complex (i.e., as n increases). Thus, the overall tax burden expands. The same 0.3% nominal TT rate implies an effective tax rate of 0.9% when the number of production or transaction stages is 5, and of 1.64% and 3.12% when the number of stages are 10 and 20, respectively. The nominal tax rate indeed pyramids in our model economy.

B. The Representative Household's Problem

So far, only the production side of the economy has been described. What follows is the description of how a transaction tax distorts trades in which households and firms interact by exchanging goods and factor services. The representative household's problem is standard. The only minor difference is that households now have to provide capital and labor services to n production sectors in the economy. Following convention, lower case letters (except prices) represent variables under the household's control while capital letters represent their aggregate, *per capita* counterparts.

The representative household maximizes intertemporal utility by choosing time paths for consumption c_t , leisure l_t , labor supply $h_{1,t}, \dots, h_{n,t}$, investment $i_{1,t}, \dots, i_{n,t}$ and capital stocks $k_{1,t}, k_{2,t}, \dots, k_{n,t}$, taking as given initial stocks of capital - assumed equal across sectors - and fiscal policies described by time paths for tax rates and lump-sum government transfers $\{\tau^T, T_t\}_{t=0}^{\infty}$. Mathematically, the household's problem is formulated as choosing $\{c_t, l_t, h_{1,t}, h_{2,t}, \dots, h_{n,t}, i_{1,t}, i_{2,t}, \dots, i_{n,t}, k_{1,t}, k_{2,t}, \dots, k_{n,t}\}_{t=0}^{\infty}$ to maximize

$$W = \sum_{t \geq 0} \beta^t u(c_t, l_t)$$

This objective represents an intertemporal criterion to evaluate alternative time-dated streams of consumption and leisure where β is a subjective discount factor and $u(c_t, l_t)$ is an instantaneous utility function. The following parametric specification satisfies the requirements of a well-behaved utility function³:

$$u(c_t, l_t) = \theta \ln c_t + (1 - \theta) \ln l_t$$

³ See King, et al. (1988).

where $\theta \in (0,1)$ is a preference parameter. The household's time endowment is normalized to one unit per period and can be devoted to work or leisure

$$l_t + \sum_{i=1}^n h_{i,t} = 1$$

The household faces the following flow budget constraint

$$(1 + \tau^T) c_t + (1 + \tau^T) \sum_{i=1}^n i_{i,t} = w_t Z_t \sum_{i=1}^n h_{i,t} + r_t \sum_{i=1}^n k_{i,t-1} + T_t$$

Total labor income and capital income earned in the n production activities are used to finance investment and consumption expenditures as well as the payment of taxes on household outlays. Total tax payments are rebated back to households on a lump-sum basis, so that the government's budget constraint is satisfied in every period.

Capital stocks evolve over time according to the law of motion

$$k_{i,t} = (1 - \delta)k_{i,t-1} + i_{i,t} \quad i = 1, \dots, n$$

where δ is a common constant depreciation rate.

A system of $(4n + 2)$ equations describes the solution to the household's problem. Notice, however, that capital and labor are perfectly mobile across sectors. This assumption implies that households will allocate the same number of work hours and capital to each sector. As a result, the dimensionality of the problem can be substantially reduced since it is isomorphic to one with one sector.

C. Endogenous Growth

Endogenous growth is shored up with an externality effect. Since the empirical literature does not seem to privilege a particular source of technical change, four possible alternative mechanisms for engendering sustained growth are appraised. Three invoke the existence of a human capital accumulation process in which learning may come from work experience (learning by working), or investment experience (learning by investing) or production experience (learning by producing). The remaining one invokes a pure positive externality (Romer, 1986) in which disembodied knowledge is represented by the aggregate capital stock. Formally,

$$Z_t = \begin{cases} \exp(\eta_H H_t) Z_{t-1} \\ \exp\left(\eta_I \frac{I_t}{Z_t}\right) Z_{t-1} \\ \exp\left(\eta_Y \frac{C_t + I_t}{Z_t}\right) Z_{t-1} \\ K_t \end{cases}$$

where η_H , η_I and η_Y are given constants. Showing that the growth rate of the economy is determined by the pace of human capital accumulation, $\eta_t = Z_t/Z_{t-1}$, where η_t is the economy's gross rate of growth, is simple. Taxation, through its distortionary effect on allocations, may affect the long term growth path of the economy. The economy is non-stationary as knowledge can be accumulated without bound. To induce stationarity the common trend is removed by dividing all growing variables by Z_t . The symbol $\hat{\cdot}$ represents transformed variables. For instance,

$$\hat{k}_{i,t} = \frac{k_{i,t}}{Z_t} \quad \hat{k}_t = \frac{k_t}{Z_t} \quad \hat{K}_{i,t} = \frac{K_{i,t}}{Z_t} \quad \hat{K}_t^f = \frac{K_t^f}{Z_t} \quad \hat{K}_t = \frac{K_t}{Z_t}$$

The transformed economy possesses a well-defined steady state. With logarithmic preferences there is no need to transform the subjective discount factor.

D. The Competitive Equilibrium

The competitive equilibrium of a multisector economy with a transaction tax can be defined as follows.

Definition. A competitive equilibrium for a given fiscal policy $\{\tau^T, \hat{T}_t\}_{t=0}^\infty$ and a fixed number of sectors n , is a collection of sequences of relative prices of intermediate inputs $\{p_{1,t}, p_{2,t}, \dots, p_{n-1,t}\}_{t=0}^\infty$, relative rental prices of primary inputs $\{w_t, r_t\}_{t=0}^\infty$, individual household decisions $\{\hat{c}_t, \hat{i}_{1,t}, \dots, \hat{i}_{n,t}, h_{1,t}, \dots, h_{n,t}, \hat{k}_{1,t}, \dots, \hat{k}_{n,t}\}_{t=0}^\infty$, sectoral firm decisions $\{\hat{K}_{1,t}, \dots, \hat{K}_{n,t}, H_{1,t}, \dots, H_{n,t}\}_{t=0}^\infty$ and aggregate outcomes $\{\hat{C}_t, \hat{I}_t, H_t, \hat{K}_t, \eta_t\}_{t=0}^\infty$ such that the following conditions hold:

- 1) Given policies and prices, the sequence of individual decisions solves the representative household's problem;
- 2) Given policies and prices, sectoral firms maximize after-tax profits given their technology and transaction constraints;
- 3) Aggregate consistency is satisfied: $\hat{c}_t = \hat{C}_t$, $h_t = nh_{i,t} = nH_{i,t} = nH_t^f = H_t$, $\hat{i}_t = n\hat{i}_{i,t} = \hat{I}_t$, $\hat{k}_t = n\hat{k}_{i,t} = n\hat{K}_{i,t} = n\hat{K}_t^f = \hat{K}_t$;
- 4) The government budget constraint is satisfied:

$$\hat{T}_t = \tau^T \left[\left(\sum_{i=2}^n p_{i-1} \right) \left(\frac{1}{n} \right) \left(\frac{\hat{K}_{t-1}}{\eta_t} \right)^\alpha H_t^{1-\alpha} + (\hat{C}_t + \hat{I}_t) + \left(w_t H_t + r_t \frac{\hat{K}_{t-1}}{\eta_t} \right) \right]$$

5) Markets clear.

The perfect foresight stationary equilibrium is described by a dynamic, nonlinear, simultaneous equation system involving an infinite set of equations with an infinite number of unknowns

$$g(\hat{K}_{t-1}, \hat{K}_t, \hat{C}_t, \hat{C}_{t+1}, \hat{I}_t, H_t, w_t, r_t, r_{t+1}, \eta_t, \eta_{t+1} \mid n, \tau^T) = 0 \quad t = 0, \dots, \infty$$

\hat{K}_{-1} given
 $\lim_{t \rightarrow \infty} \hat{K}_t < \infty$

In principle, the period t system $g(\cdot)$ includes Euler equations, market clearing conditions, material balances, budget constraints, laws of motion and any other condition defining the equilibrium. The period t set of equations included in $g(\cdot)$ is the following:

$$\left(\frac{\theta}{1-\theta} \right) w_t (1-H_t) = (1+\tau^T) \hat{C}_t \quad (\text{SYS.1})$$

$$\eta_{t+1} \frac{\hat{C}_{t+1}}{\hat{C}_t} = \beta \left[1 + \left(\frac{1}{1+\tau^T} \right) (r_{t+1} - \delta) - \left(\frac{\tau^T}{1+\tau^T} \right) \delta \right] \quad (\text{SYS.2})$$

$$\hat{C}_t + \hat{I}_t = \left(\frac{1}{n} \right) \left(\frac{\hat{K}_{t-1}}{\eta_t} \right)^\alpha H_t^{1-\alpha} \quad (\text{SYS.3})$$

$$\hat{K}_t = (1-\delta) \frac{\hat{K}_{t-1}}{\eta_t} + \hat{I}_t \quad (\text{SYS.4})$$

$$\eta_t = \begin{cases} \exp(\eta_H H_t) \\ \exp(\eta_I \hat{I}_t) \\ \exp(\eta_Y (\hat{C}_t + \hat{I}_t)) \end{cases} \quad (\text{SYS.5})$$

$$r_t = \left(\frac{\tau^T}{1 + \tau^T} \right) \left(\frac{1}{(1 + \tau^T)^n - 1} \right) \alpha \left(\frac{H_t}{\hat{K}_{t-1}} \right)^{1-\alpha} \eta_t \quad (\text{SYS.6})$$

$$w_t = \left(\frac{\tau^T}{1 + \tau^T} \right) \left(\frac{1}{(1 + \tau^T)^n - 1} \right) (1 - \alpha) \left(\frac{\hat{K}_{t-1}}{H_t} \right)^\alpha \eta_t \quad (\text{SYS.7})$$

In the pure externality growth model an additional equilibrium condition replaces (SYS.5): $\hat{K}_t = 1, \forall t$, in which case the law of motion for the capital stock (SYS.4) provides an expression for the economy's endogenous growth rate.

E. Introducing Conventional Taxation

Now generalize the preceding multisector economy by introducing conventional taxation. In addition to a transaction tax, the government may also resort to other distortionary but better known taxes: a consumption tax at rate of τ^C , a labor income tax at rate τ^W and a capital income tax at rate of τ^K . The introduction of these new taxes does not change the set-up on the production side of the economy. At this time, the budget constraint of the representative household is

$$(1 + \tau^T) \left[(1 + \tau^C) \hat{c}_t + \sum_{i=1}^n \hat{i}_{i,t} \right] = (1 - \tau^W) w_t \sum_{i=1}^n h_{i,t} + (1 - \tau^K) r_t \sum_{i=1}^n \frac{\hat{k}_{i,t-1}}{\eta_t} + \tau^K \delta \sum_{i=1}^n \frac{\hat{k}_{i,t-1}}{\eta_t} + \hat{T}_t$$

where the capital income tax base is factor income less depreciation and lump-sum transfer payments are redefined to include the rebate of the total tax revenue.

The period t system of equations describing the equilibrium of the economy with the new tax structure is identical to $g(\cdot)$ except in the first two equations which are now

$$\left(\frac{\theta}{1 - \theta} \right) w_t (1 - H_t) = \left[\frac{(1 + \tau^T)(1 + \tau^C)}{1 - \tau^W} \right] \hat{C}_t \quad (\text{SYS.1'})$$

$$\eta_{t+1} \frac{\hat{C}_{t+1}}{\hat{C}_t} = \beta \left[1 + \left(\frac{1 - \tau^K}{1 + \tau^T} \right) (r_{t+1} - \delta) - \left(\frac{\tau^T}{1 + \tau^T} \right) \delta \right] \quad (\text{SYS.2'})$$

By taking a look at how different taxes enter the system, it can be observed that a transaction tax behaves partly like a combination of conventional taxes, i.e.,

consumption, labor earnings and capital income taxes performing simultaneously. However, the distortionary effect of a transaction tax goes beyond the combination of traditional taxes. In contrast to conventional taxes, a TT distorts further allocations by treating depreciation allowances as taxable income (SYS.2') and by driving a wedge of inefficiency between rental prices and marginal productivities ((SYS.6) and (SYS.7)) thus affecting primary factor pricing. The size of the wedge reflects the expanded tax burden associated with the degree of cascading. Is, then, transaction taxation more distortionary? It is not possible to provide an answer just by examining how a TT distorts different margins in a general equilibrium system. In the following, this paper provides a quantitative answer.

3. CALIBRATION, COMPUTATION AND WELFARE CALCULATION

This section describes the procedure used to select parameter values, the solution method to compute dynamic allocations of an infinite-horizon general equilibrium model and the metric employed for welfare comparisons among economies with alternative tax regimes.

A. Parameter Calibration

The benchmark parameterization is based on data from Brazil, which is the largest economy in the region with a bank debit tax currently in effect. Sensitivity analysis is also performed to check for robustness to alternative parameterizations built on data from other countries that have resorted to this type of unconventional tax.

The parameterization procedure picks parameter values so as to equate Brazilian average aggregate variables to equivalent magnitudes for the steady state of the model economy. Table 1 details the Brazilian information required to calibrate all parameter values. In general, aggregate target variables are calculated as averages of time series over the 1972-1993 period, before the introduction of the bank debit tax into the tax code in 1993-94. Thus, benchmark parameter choices imply that the model economy's steady state and the Brazilian economy prior to the introduction of a transaction tax will share the same capital-GDP ratio, consumption-GDP ratio, capital income tax-GDP ratio, labor income tax-GDP ratio, consumption tax-GDP ratio, real rate of return, growth rate, etc. The model is calibrated so that the length of a model period is one year.

Before proceeding further, notice that an important parameter in the model, n , the number of production sectors which in turn determines the degree of tax pyramidalation, is calibrated differently. Using the expression given in footnote 2 where the left-hand side is renamed as TRO - transaction tax revenue to output ratio - yields a nonlinear equation in n if information on τ^T and TRO is available:

$$(1 + \tau^T)^n = 1 + \left(\frac{\tau^T}{1 + \tau^T} \right) \left(\frac{1}{1 + \tau^T - \text{TRO}} \right)^n$$

This information is taken from Kirilenko and Summers (2003). They report that in 2001 Brazil's bank debit tax yield was 1.45% of GDP with a statutory tax rate of 0.37%. Figure 2 depicts this simple rootfinding problem. The equation has two roots, being $n \approx 5$ the economically meaningful one. Again, sensitivity analysis will be conducted to assess how results are affected by more complex transaction environments.

From the steady state version of the law of motion of the aggregate capital stock, equation (SYS.4), an expression for the rate of depreciation of the stock of physical capital is obtained: $\delta = 1 - (1 - ((1 - \text{COR})/\text{KOR})) \cdot \eta^{\text{ss}}$, where $\eta^{\text{ss}} - 1$ is the steady state growth rate of per capita GDP, COR is the consumption-output ratio and KOR is the capital-output ratio. The rate of growth of per capita GDP is evaluated at 2.22% which corresponds to the average value calculated for the 1972-1993 sample using World Bank data on GDP and population. From the same database and for the same time period, COR is estimated at 73.6%. KOR is fixed at 2.68 which corresponds to the average ratio for the 1972-1990 period using Dhareshwar and Nehru's (1993) data. Thus, δ is set at 7.84%.

Using time series of the Selic rate (return on government bonds) for 1980-2000, Kanczuk (2002) finds that the real interest rate is close to 8% (1.9% on a quarterly basis). This estimate is taken as proxy for the economy's real rate of return RRR. The real rate of return and the marginal product of capital are related simply as $\text{RRR} = r^{\text{ss}} - \delta$. This along with (SYS.6) yields an expression for the capital's share in output, $\alpha = (\text{RRR} + \delta) \cdot (\text{KOR}/\eta^{\text{ss}})$. α is then set equal to 41.55%. τ^{K} is set to 5.57% since, by definition, $\tau^{\text{K}} = \text{KRO}/(\text{RRR} \cdot \text{KOR})$ where KRO is the ratio of capital income tax to output. KRO is calculated as the average ratio of taxes on corporate income, profits and capital gains and nominal GDP for the 1980-1993 period. The sources for tax data are the World Bank's World Development Indicators database and the IMF's Government Finance Statistics (GFS) database. Nominal GDP is taken from World Bank data. The level of government on which tax revenue data is based is what the IMF defines as "consolidated central government." In addition, equation (SYS.2') delivers an expression to compute β , $(\eta^{\text{ss}}/\beta) = 1 + (1 - \tau^{\text{K}}) \cdot \text{RRR}$. This implies $\beta = 0.95$.

On the preference side, an expression for θ in the utility function can be determined from (SYS.1')

$$\frac{\theta}{1-\theta} = \left(\frac{1+\tau^{\text{C}}}{1-\tau^{\text{W}}} \right) \left(\frac{\text{H}^{\text{ss}}}{1-\text{H}^{\text{ss}}} \right) \left(\frac{\text{COR}}{1-\alpha} \right)$$

Values for average tax rates included in the preceding expression are computed from accounting identities, i.e., $\tau^{\text{C}} = \text{CRO}/\text{COR}$ and $\tau^{\text{W}} = \text{WRO}/(1-\alpha)$ where CRO stands for the average collection of consumption taxes relative to GDP and WRO represents a similar ratio for labor income tax revenue. The definition of consumption taxes corresponds to domestic taxes on goods and services in the GFS database while that of

labor income taxes corresponds to the sum of taxes on individual income, profits and capital gains and social security contributions, both of which (taxes and contributions) are interpreted as being levied mainly on labor income. Hence, τ^C is set equal to 7.67% and τ^W to 14.79%. Finally, Ellery et al. (2002), using the National Survey by Household Sample, find that, on average, Brazilian households spend 1/3 of their nonsleeping hours working, implying $H^{ss} = 0.33$. Putting all pieces of information together leads us to calculate $\theta = 0.44$.

The four alternative growth models will exhibit exactly the same benchmark parameterization (with the obvious exception of the parameters in equation (SYS.5)) and associated steady state if the steady state capital stock is normalized to unity, $\hat{K}^{ss} = 1$. Consistent with this normalization, steady state aggregate value added is computed as $\hat{Y}^{ss} = KOR^{-1}$, aggregate consumption as $\hat{C}^{ss} = COR \cdot \hat{Y}^{ss}$ and investment as $\hat{I}^{ss} = (1 - COR) \cdot \hat{Y}^{ss}$. This normalization is at the cost of introducing a scale parameter S on the right-hand side of equations (SYS.3), (SYS.6) and (SYS.7), which is equivalent to redefining an aggregate value added function whose steady state version is $\hat{Y}^{ss} = (1/n) S (\hat{K}^{ss}/\eta^{ss})^\alpha (H^{ss})^{1-\alpha}$. Set $S = 3.58$. Further, the steady states of the marginal product of capital, r^{ss} , and labor, w^{ss} , can be obtained from (SYS.6) and (SYS.7) after including the scale parameter S and noting that $\left(\frac{\tau^T}{1 + \tau^T} \right) \left(\frac{1}{(1 + \tau^T)^n - 1} \right) \rightarrow \frac{1}{n}$ as $\tau^T \rightarrow 0$.

The remaining parameters are estimated using equation (SYS.5). Set $\eta_H = 0.066$, $\eta_I = 0.223$ and $\eta_Y = 0.059$, depending on the growth model being considered. Table 2 summarizes the exact values selected for each of the model parameters following the described parameterization strategy as well as the associated steady state, henceforth referred to as baseline or initial steady state. By construction, both parameter values and the initial steady state are assumed to reflect, whenever possible, features of the economy prior to the introduction of a transaction tax ($\tau^T = 0$), including the pre-existing tax structure.

B. Solution Method

The computation of perfect foresight equilibrium paths of economic variables in our dynamic general equilibrium model is a difficult task because current and future variables are linked and endogenously determined, generating an infinite-dimensional system of nonlinear equations.

To reduce the complexity of the problem, by converting it into a finite-dimensional one, a solution method that exploits the structure of the economy to truncate the domain of the system is used. The solution method employed is somewhat related to Cooley and Hansen's (1992). This particular solution method seems appropriate given the scope of the paper. The experiments in the next section are aimed at assessing the effect of various

tax reforms on resource allocation. To evaluate these responses, transition paths of the economy from the initial steady state (given in Table 2) to final steady states characterized by alternative tax structures are required.

The solution algorithm is as follows. In the first step, the system (SYS) is linearized around the final steady state and solved for the recursive equilibrium law of motion and decision rules using the generalized Schur form or QZ decomposition of a matrix pencil following Klein's (2000) method. In the second step, it is assumed that T periods after having introduced a tax reform, the economy is in the neighborhood of the final steady state. As a result, from that moment on the motion of the economy is properly described by linear rules. Using $\hat{K}_0 = \hat{K}^{ss}$ as an initial condition and the linear decision rules (for \hat{C}_T , r_T and η_T) as terminal or transversality conditions, the transition path of the economy from $t=1$ to $t=T$ can be computed by solving a finite but possibly large nonlinear system of equations

$$g(\hat{K}_{t-1}, \hat{K}_t, \hat{C}_t, \hat{C}_{t+1}, \hat{I}_t, H_t, w_t, r_t, r_{t+1}, \eta_t, \eta_{t+1} | n, \tau^c, \tau^w, \tau^k, \tau^T) = 0, \quad t = 1, \dots, T$$

After period T , equilibrium paths are computed with the help of the law of motion and decision rules. Assume $T = 100$.

C. Welfare Cost of a Tax Reform

Under the benchmark parameterization and corresponding initial steady state, if the baseline tax structure $(\tau^c, \tau^w, \tau^k, \tau^T) = (7.7\%, 14.8\%, 5.6\%, 0\%)$ remains unchanged, it can be shown that the steady state level of welfare equals⁴

$$W^{ss} = \left(\frac{1}{1-\beta} \right) \left(\theta \ln \hat{C}^{ss} + (1-\theta) \ln(1-H^{ss}) + \frac{\beta}{1-\beta} \theta \ln \eta^{ss} \right)$$

This is the reference value against which the welfare cost of alternative tax reforms will be assessed. Specifically, along the transition path from the initial steady state to the final one, the welfare cost of a tax reform is calculated as the value of λ that solves the following nonlinear equation:

$$\sum_{t=1}^{2000} \beta^{t-1} \left[\theta \ln(\hat{C}_t^\tau + \lambda \hat{Y}_t^\tau) + (1-\theta) \ln(1-H_t^\tau) + \theta \ln Z_t^\tau \right] = W^{ss}$$

where $Z_t^\tau = 1$ and the superscript τ identifies the economy's equilibrium allocations along a transition path of 2000 periods under the effect of the alternative tax regime

⁴ This expression is the result of an infinite sum of constant terms. The appropriately adjusted sum over 2000 periods only yields the same total. In deriving this expression, it is assumed, without loss of generality, that $Z_1 = 1$.

introduced in year $t=1$ and kept constant thereafter. $\lambda \cdot \hat{Y}_t^\tau$ is interpreted as a consumption gift, as a compensation, in terms of consumption, required to make the household as well off under the alternative regime τ as under the baseline tax structure. The consumption compensation is rescaled and expressed as percentage of distorted output (distorted under the new regime), as λ .

4. EXPERIMENTAL DESIGN AND SIMULATION RESULTS

Experiment 1. Kirilenko and Summers (2003) report on the productivity of banking transaction taxes in various Latin American countries in effect since 1989. Excluding Ecuador, where the transaction tax was originally intended to replace income taxes and, for that reason, debit and credit transactions were both taxed and the statutory rate as well as the amount of revenue collected were atypically large, the yield of the tax has not surpassed 1.6% of GDP in the region. In Brazil, revenues are in the range of 0.80% to 1.45% of GDP. The first experiment conducted in this section evaluates growth and welfare effects of a reform of the baseline tax structure directed at raising additional revenue for a comparable amount - say equal to 2% of GDP under the steady state of an alternative regime - changing one tax instrument at a time. Notice that in the final steady state the total tax revenue, as a percent of GDP, amounts to: $2\% + KRO + CRO + WRO = 17.49\%$ for all model economies. Results are reported in Table 3.

Panel A of Table 3 shows long-term welfare costs obtained from comparing allocations in the final and initial steady states.⁵ Panel B reports welfare costs computed along a path of 2000 periods in the transition from initial to final steady states. Costs along the transitional path are lower than steady state costs because along the way toward the new steady state, households adjust consumption and leisure plans upwards, hence ameliorating welfare costs, in order to deliver lower capital stock, consumption and work effort for the new long-term growth path as a consequence of higher taxation. The exception is the economy with Romer's (1986) growth engine where transitional and steady state costs are identical. This result simply reflects the fact that that model has no transitional dynamics. Right after a tax reform is introduced, the economy converges to its new balanced growth path. As in Ortigueira's (1998) model, an implausibly large rate of convergence like this one renders unrealistically high growth and welfare costs of taxation. Finally, long-term rates of growth under alternative tax regimes are reported in the last panel.

Independently of the mechanism engendering endogenous growth, the cheapest way to raise the required revenue, not only in terms of welfare costs but also in terms of forgone

⁵ In this case λ solves the following equation:

$$\left(\frac{1}{1-\beta} \right) \left(\theta \ln(\hat{C}^\tau + \lambda \hat{Y}^\tau) + (1-\theta) \ln(1-H^\tau) + \frac{\beta}{1-\beta} \theta \ln \eta^\tau \right) = W^{ss}$$

growth, is to use a consumption tax. For instance, the welfare cost of raising additional revenue equal to 2% of GDP (and rebated back - along with the rest of tax revenue - to households as a lump-sum transfer) is 0.83% of GDP when transitional dynamics are ignored and when growth is driven by work experience. This cost falls to 0.67% of GDP if the transition is taken into account. The effect on the endogenous long-term growth rate is negligible. It falls 4 basis points, from 2.22% in the benchmark steady state to 2.18% under the new tax structure. The exact opposite, the most expensive instrument for raising additional revenue, is a tax on capital income, except in the transitional dynamics of an economy with a work experience externality driving the human capital accumulation process, where a labor income tax turns out to be more damaging.

In contrast to claims that theory and empirical evidence amply substantiate its highly distortionary status, Table 3 shows that a transaction tax imposes an intermediate level of distortions. In some cases, it is the best option after a consumption tax since it causes lower welfare costs than a labor income tax, as in the transitional paths of model economies with human capital technologies driven by work and production experience externalities. Interestingly, in all model specifications, the growth toll of a transaction tax is small, even comparable to that of a consumption tax.

To present a broader perspective, the same type of information - welfare costs and growth losses - is summarized in Figure 3 where targets for additional government revenue fluctuate between 1% and 10% of GDP. The figure shows that the relative ordering of taxes according to their distortionary capabilities does not generally change when revenue requirements are different from 2% of GDP. Relative to the ordering offered by Table 3, only one ordering change is uncovered in Figure 3. When additional revenue requirements are low (2% of GDP for instance) the model with a work experience externality shows that a tax on capital earnings is less distortionary than a TT along the transition path. However, with higher revenue requirements, transaction taxation becomes relatively less distortionary.

Regarding growth effects, results in Figure 3 lend support to Harberger's (1964) superneutrality conjecture (see also Mendoza et al., 1997) according to which, tax reforms around the current tax structure have small or negligible effects on long-term growth. Harberger argues that fiscal policy is superneutral in the sense that this type of reform cannot increase (reduce) the economy's rate of growth more than 0.1 or 0.2 of a percentage point. This conclusion is consistent with Figure 3. Let us look at an extreme case. According to Figure 3, the highest growth sacrifice (difference between initial and final steady state growth rates) is produced by capital income taxation in an economy with human capital accumulation driven by an investment experience externality. If, in this model economy, the baseline capital earnings tax rate increases by 10 percentage points⁶ (from 5.57% to 15.57%), tax revenues increase by 2.27% of GDP and the long-term growth rate falls by only 0.23 of a percentage point - from 2.22% to 1.99% - very close to Harberger's figures. Reported results show that transaction taxation is not an

⁶ Mendoza et al. (1997) use reforms of a similar magnitude to assess Harberger's superneutrality conjecture.

exception to Harberger's superneutrality conjecture. In all model specifications, similar amounts of additional revenue raised with a transaction tax induce very small effects on growth.

Experiment 2. The benefits of giving up taxing transactions as recommended by Tanzi (2000), IMF (2000) and Coelho et al. (2001) are assessed in Experiment 2. This experiment also sheds light on the empirical backing which justifies the popular policy advice to speedily abandon this tax - the claim that the longer the life span of transaction taxation is, the higher its costs will be (see Tanzi, 2000; Coelho et al., 2001; Kirilenko and Summers, 2003).

Current well-known fiscal solvency concerns preclude user countries from simply renouncing much needed revenue. In consequence, a sensible policy experiment is to replace TT revenue with other sources. To that end, a two-step tax reform is designed. In period $t=1$ the baseline tax structure is reformed by introducing a transaction tax that generates additional revenue equal to 2% of GDP under the new steady state. Then, in period $t=10$, which roughly corresponds to the current life span of the Brazilian transaction tax, the government pushes through a new reform which scrapes transaction taxation and increases existing rates on consumption, labor income or capital earnings taxes (one tax at a time) aimed at raising the required additional revenue under the newer steady state.

There are two possible approaches to modeling this nonstationary policy in our perfect foresight environment. First, though agents are endowed with perfect foresight, the government announces an unanticipated two-step reform at the beginning of period $t=1$. From then on, agents are fully aware of the trajectory of the tax system and temporariness of transaction taxation. The announcement of future policy changes (those planned for year $t=10$) does not give rise to credibility concerns. This case is referred to hereafter as the "one shot case." The second approach is the following. At the beginning of period $t=1$ the government passes an unanticipated reform introducing a transaction tax which is expected to stay forever. A few years later, at the beginning of period $t=10$, the government again surprises everyone by abandoning transaction taxation and replacing its proceeds with revenue from other tax instruments. This case is referred to as the "two-shot case" and comes closer to the set-up related to embracing current policy recommendations.

Based on a model economy with a work experience externality engendering endogenous growth and where a consumption tax is brought on as substitute for transaction taxation in period $t=10$, the transition paths of capital stock, investment, work effort, consumption, rate of growth, wage, marginal product of capital and output are depicted in Figure 4 under the two alternative approaches to modeling the specified two-step tax reform. As a point of reference, the figure also plots (dotted lines) transition paths associated with a reform introducing, a permanent consumption tax from the beginning ($t=1$), hence avoiding transaction taxation, which, according to the results in Experiment 1, is the cheapest way to raise the required additional revenue within the

class of one-step stationary reforms. As mentioned above, the welfare cost of this reference policy is 0.67% of GDP (Table 3, panel B). Is there still room for transaction taxation given that consumption taxation is less costly?

When the two-step tax reform is implemented in one shot (first column of Figure 4), the economy, relative to the reference economy, exhibits higher capital and work effort and, as a result, higher economic activity and growth. The welfare cost of using transaction taxation during 10 periods and then replacing it with a higher consumption tax rate, as expected from period $t=1$, is only 0.46% of GDP. This implies that the positive effects of consumption and growth on welfare outweigh the negative effect of reduced leisure along the transition path. When transaction taxation is scrapped unexpectedly, i.e., when the two-step reform is implemented in two shots (second column of Figure 4), the behavior of the economy is very different. Relative to the reference case, the economy enjoys higher leisure, which is good for current welfare but bad for growth, and capital and output are lower. The welfare cost of this policy is 0.74% of GDP. The abandonment policy then brings some welfare gains since maintaining a transaction tax forever costs 0.85% of GDP (Table 3, panel B).

To assess the robustness of these results, further experiments were conducted using alternative tax revenue substitutes, endogenous growth models and transaction taxation life spans (from 0 to 20 years). The corresponding welfare costs are shown in Figure 5. In each plot there are two horizontal lines. The upper one measures the cost of using solely transaction taxation to raise the required additional revenue from the start ($t=1$) while the lower one measures the cost of using consumption taxation instead. The remaining lines show the welfare costs of temporarily using a transaction tax and, at some point (from 0 to 20 years), switching to an increased consumption, labor income and capital income tax. In the case of two-step reforms implemented in two shots (third column), it is important to notice that the transitional cost of using a TT depends on how TT revenues are restored. It is only in the case where these revenues are replaced with consumption tax revenues that we can be certain that a scrapping policy is welfare improving and that the benefit of the policy decreases with the duration of transaction taxation. However, when transaction taxation is replaced with a capital income tax, the scrapping policy generally worsens social welfare and, in that case, it is better to keep transaction taxation for as long as possible. In the case of labor income taxation, results are mixed and depend on the type of mechanism generating endogenous growth.

The welfare costs of two-step tax reforms implemented in one shot describe a U-shaped curve (something not observed in the short horizon of Figure 5, second column) as the duration of transaction taxation is prolonged. If a government can credibly commit itself to abandoning transaction taxation by a certain date in the future, even in the long-term future, for example, 20 years or so, a government financing policy that temporarily uses transaction taxation is less costly than one that finances the required additional revenue by resorting exclusively to a consumption tax. As a generalization, regardless of how TT revenue is replaced and regardless of the growth engine, the welfare cost of any financing policy that involves transaction taxation will eventually fall below the lower horizontal line (not completely shown in Figure 5 for all taxes) for quite a while. In

summary, for suitably long TT life spans, society will be better off temporarily using a transaction tax under nonstationary policies than under one-step stationary policies.

5. SENSITIVITY ANALYSIS

Additional robustness checks are conducted in this section. Information for Argentina, Colombia, Venezuela, Ecuador and Peru is given in Table 4 to experiment with other plausible parameter choices. Using information on TT rates and revenue collections, the calibrated number of production sectors for these countries is lower than the benchmark figure. Lower n , specifically $n = 2$, is associated with only small changes in welfare costs and negligible growth effects.

Furthermore, it has been shown that theory (equation in footnote 2) imposes a constraint relating n , τ^T and the amount of revenue collected as a share of GDP. If it is deemed that there is no sizeable measurement error in tax collection ratios, theory helps us by pinning down a relationship between the other two less precisely measured magnitudes. All pairs (n, τ^T) satisfying $\{(n, \tau^T): n > 1, \tau^T > 0\}$ as well as being consistent with a given TT collection ratio (1.45% of GDP as in the baseline calibration) deliver exactly the same allocations in both experiments under consideration, and therefore, the same welfare and growth assessments. In this sense, results are robust under alternative, more complex, transaction structures. In other words, relative to the benchmark calibration, any higher n requires a lower τ^T to yield the same observed revenue ratio and their effects fully offset each other.

The relatively high level of taxation in Brazil is also underscored in Table 4. Brazilian tax ratios are cut in half in the next sensitivity test to approximate the aggregate tax burden observed in Argentina, Colombia, Ecuador and Peru prior to the introduction of a TT. The effect of a lower preexisting tax burden is to reduce the welfare costs of raising additional revenue (equal to 2% of GDP). The reduction is between 11% and 14% on average for consumption, capital income and transaction taxes and 24% on average for a labor income tax (excluding the model with Romer's (1986) growth mechanism from the analysis). The effect on the long-term growth rate remains next to nil for all tax instruments and growth models. No major qualitative changes are revealed in transitional dynamics nor in the relative distortionary attributes of the tax instruments.

Nor are results sensitive to the time span assumed for an economy to come close to its new steady state after a tax reform is passed. The same results are obtained if $T = 50$ years or $T = 200$ is assumed.

6. COMPARING RESULTS WITH THE LITERATURE

An effort is made in this section to “square the circle” by reconciling the differences between the results in this paper and the strikingly opposing conclusions drawn from the

existing literature. The existing empirical literature on bank debit taxation in Latin America is briefly reviewed in the following paragraphs.

Lozano and Ramos (2000) and Coelho et al. (2001) report anecdotal evidence on the allocational effects of a tax on financial transactions. They conjecture, and sometimes document, a myriad of potentially distortionary effects on activities such as foreign exchange, securities and interbank market transactions, the payment system operation, financial intermediation, monetary aggregates (currency outside banks), underground economy, etc. In addition, Koyama and Nakane (2001) provide econometric evidence for Brazil on the effect of a financial transaction tax on financial intermediation (number of written checks, M1, term deposits and bank intermediation spreads). Overall, this evidence vividly illustrates the point that a financial transaction tax is indeed distortionary. However, the quantitative question of how important these distortionary effects are is left unanswered. The policy recommendation that a bank debit tax should be sidestepped or soon replaced with superior taxes such as the VAT and income taxes (Coelho, et al., 2001) constitutes a non sequitur.

Interpreting a tax on bank debits as an excise tax on financial intermediation, Albuquerque (2001a) and Kirilenko and Summers (2003) measure the deadweight welfare loss associated with this type of taxation using Harberger's triangle method. The former calculates a deadweight loss of 27% of the revenue collected for Brazil while the latter computes deadweight losses of 30% for Venezuela, 35% for Colombia, 45% for Ecuador and nil for Brazil. Though interesting, this evidence about the absolute level of distortions is not enough to dismiss bank debit taxation. With a different analytical approach (dynamic general equilibrium where tax proceeds are rebated back to households), the conclusions in this paper are based on much higher welfare losses. For the benchmark case of Brazil and when growth is driven by a work experience externality, the welfare cost of a transaction tax amounts to 43% (0.85%/2%) of the revenue collected. It comes to 86% (1.71%/2%), 49% (0.97%/2%) and 306% (6.12%/2%) of collected revenue depending on whether the growth engine is an investment externality, a production externality or Romer's (1986) mechanism.

Albuquerque (2001b) develops a dynamic general equilibrium framework to study the economic effects of a tax on bank debits in Brazil.⁷ Unfortunately, instead of using the model to derive quantitative implications, the author estimates an ad hoc regression of the revenue productivity, defined as the revenue to GDP ratio divided by the TT rate, against the statutory TT rate. He, then, computes welfare triangles as in Albuquerque (2001a).

Finally, it is interesting to compare the relationship between the TT revenue as a share of GDP and the TT rate obtained for Brazil using Albuquerque's (2001a, b) econometric estimates⁸ and the same relationship derived from the theoretical model of section 2

⁷ For completeness, Arbeláez et al. (2002) wrongly claim that their appraisal of the bank debit tax in Colombia is based on a general equilibrium model. They offer simple back-of-the-envelope calculations showing an obvious feature: that the nominal rate of a bank debit tax, akin to a turnover tax, may pyramid. But no evidence is offered showing that this has been the case.

⁸ Using Albuquerque's estimates the relation is given by

(equation in footnote 2, for $n = 5$ and $n = 7$). According to Figure 6 the behavior of the observed Brazilian TT collection closely corresponds to what theory predicts. If Albuquerque's partial equilibrium approach had been pursued in this paper, roughly the same welfare losses would have been obtained.⁹

In summary, though theory has argued that a non-neutral tax may be potentially highly distortionary, the existing empirical evidence has been unable to substantiate that claim.

7. SUMMARY AND POLICY IMPLICATIONS

Despite the attractiveness and popularity of views claiming that a bank debit tax as a means of collecting government revenue is very costly for society, thus far empirical work has failed to provide support for that conjecture. The question is tackled in this paper by developing a multisector dynamic general equilibrium model that allows for the pyramiding of the nominal tax rate, the major drawback of a non-neutral tax. The model is used to examine the efficiency implications of a bank debit tax, understood here as a general transaction tax, from a quantitative standpoint; or equivalently, it is assumed that all transactions in the economy are channeled through the banking system and there subject to a bank debit tax. An important aspect of the model is that conventional (consumption, labor income and capital income) taxes can be evaluated and compared with non-neutral taxes on an equal footing.

The findings in this paper manifestly contrast with the existing literature. The results suggest that a transaction tax is not an especially distortionary tax. It introduces lower distortions than a capital earnings tax and, in some cases, depending on the growth engine, lower than a labor income tax. The model shows that a consumption tax is clearly the least distorting instrument. Though a fiscal policy that chooses a consumption tax instead of a transaction tax to raise the required additional revenue will reap the rewards of relatively large efficiency gains, no improvement in the rate of economic growth should be expected. So, the question is whether there is still room for transaction taxation when governments can use a consumption tax, which is the "(...) premier indirect tax from a technical point of view" (Harberger, 1990), instead. This study demonstrates that a government financing policy that temporarily uses transaction taxation and subsequently replaces it with an alternative conventional tax is superior in terms of welfare to any other financing policy that avoids transaction taxation and resorts to a conventional tax to raise the required revenue from the outset. This result depends on the government announcing the two-step tax reform from the outset and credibly committing to it. Finally, the benefits of scrapping transaction taxation as recommended by many analysts are assessed in the paper. The fact that the benefit of the policy hinges on how TT revenue is replaced is also shown. It is only in the case where these revenues are

$$\frac{\text{Revenue}}{\text{GDP}} = 5.04 \cdot \tau^T - 345 \cdot (\tau^T)^2$$

⁹ The reason is that deadweight losses depend on the slope of the depicted relation. Notice that intercepts are zero.

replaced with consumption tax revenues that the TT scrapping policy is welfare improving and where the delay in implementing such a recommendation is costly for society. If the substitute is a capital income tax, the scrapping policy worsens social welfare and, in that case, it is better to keep transaction taxation for as long as possible.

Extending the model to relax some of the assumptions made to obtain a tractable framework seems an interesting avenue for future research. Alternative transaction and production structures, with the number of sectors being determined endogenously in response to incentives to economize on transactions through vertical integration, should throw further light on our understanding of transaction taxation.

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APPENDIX: Proof of Corollary

The system of first order conditions used in the proof of Proposition 2 can be transformed into one involving $n - 1$ equations in n relative prices (p_1, p_2, \dots, p_n)

$$p_2 - (1 + \tau^T)p_1 = p_1$$

$$p_3 - (1 + \tau^T)p_2 = p_1$$

$$p_4 - (1 + \tau^T)p_3 = p_1$$

...

$$p_n - (1 + \tau^T)p_{n-1} = p_1$$

From the first equation note that p_2 can be expressed in terms of p_1 . Using this result and the second equation, p_3 can be written in terms of p_1 too. Following this procedure with the rest of equations, all relative prices can be expressed in terms of p_1 . In particular, the relation between p_n and p_1 is given by

$$p_n = \left\{ 1 + (1 + \tau^T) + (1 + \tau^T)^2 + (1 + \tau^T)^3 + \dots + (1 + \tau^T)^{n-3} + (1 + \tau^T)^{n-2} (2 + \tau^T) \right\} p_1$$

Going back to the original system of first order equations, sum across equations to obtain

$$\tau^T \sum_{i=1}^{n-1} p_i = p_n - n p_1$$

where the first equation of that system has been used to get rid of the term $\frac{1}{\alpha} \cdot (1 + \tau^T) \cdot r \cdot \left(\frac{K^f}{ZH^f} \right)^{1-\alpha}$ on the summation of left-hand sides. Using the relation between p_1 and p_n and the fact that $p_n = 1$, you should have no problem showing that

$$\sum_{i=1}^{n-1} p_i = \frac{1}{\tau^T} - \left(\frac{n}{(1 + \tau^T)^n - 1} \right) \blacksquare$$

Figure 1
Cascading Effect of a Transaction Tax

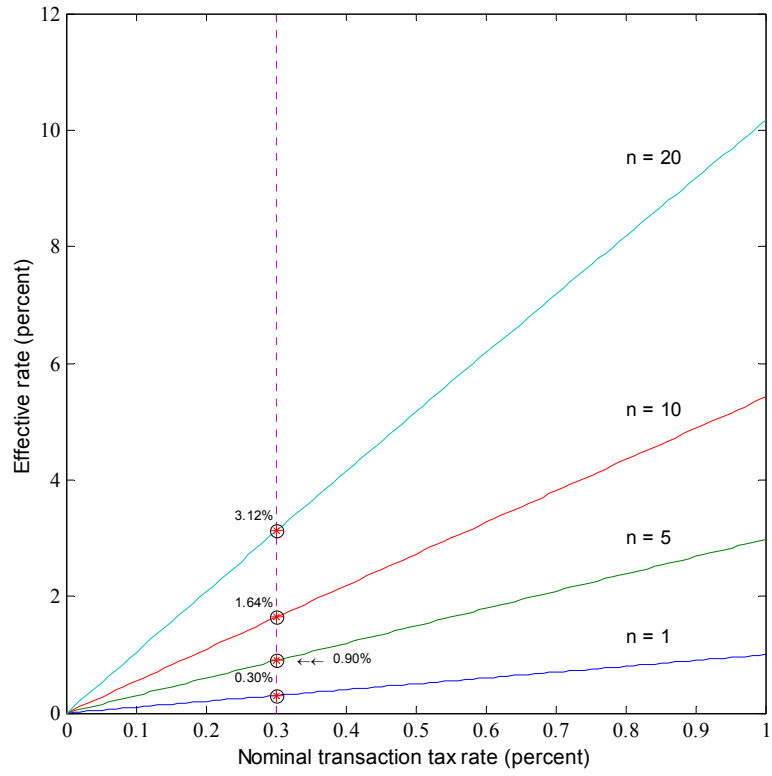


Figure 2
Solving for n

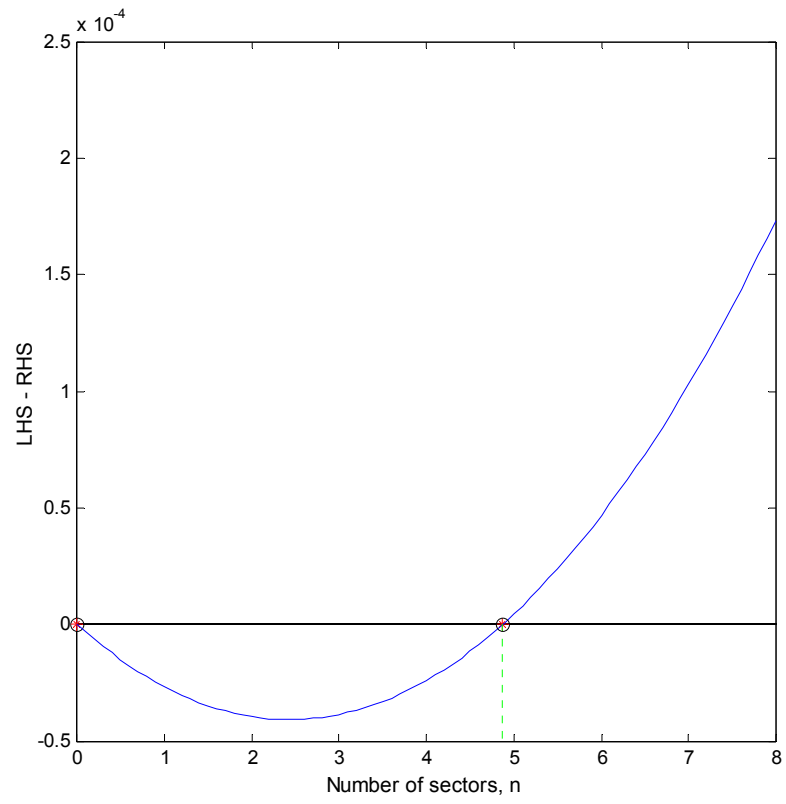


Figure 3
Welfare and Growth Effects of Raising Additional Tax Revenue

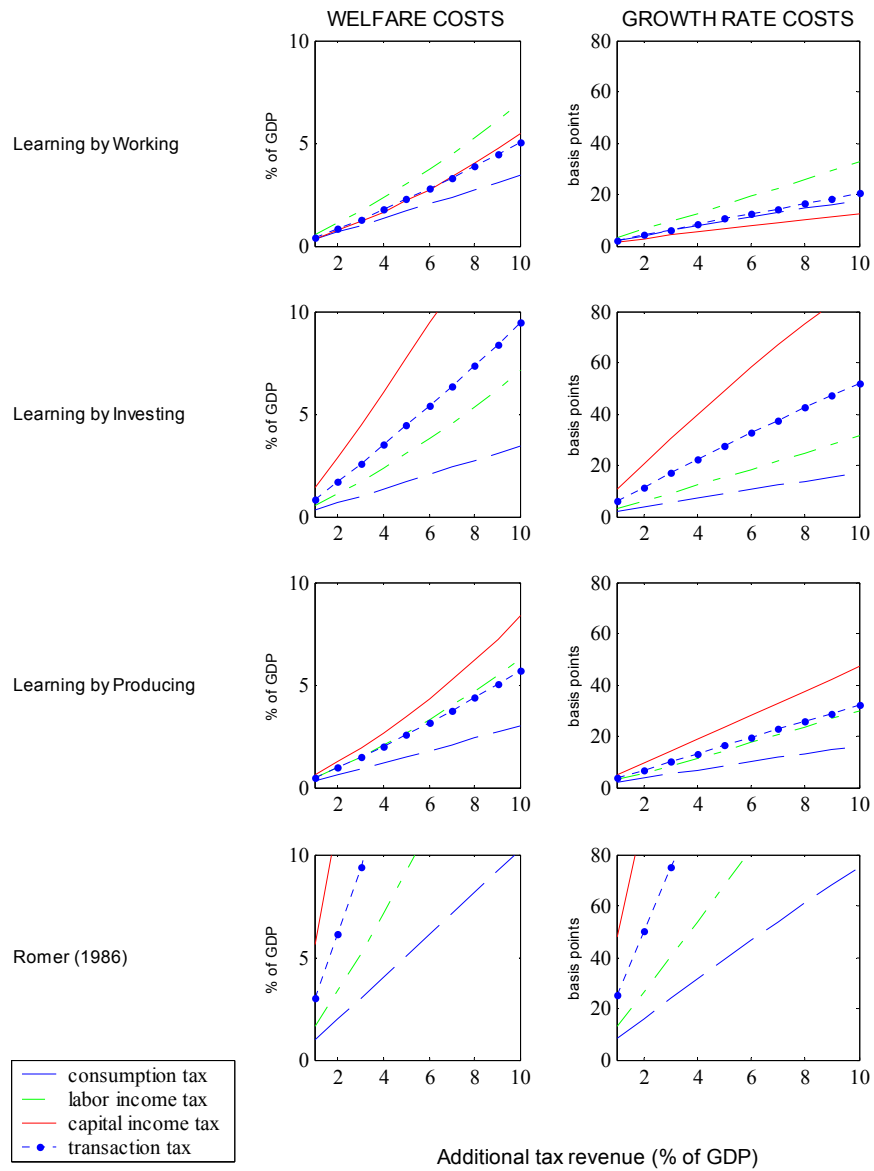


Figure 4
Resource Allocation in Two-Step Tax Reforms
Endogenous Growth Model with a Work Experience Externality
 (% deviations from initial steady state and basis points for growth rates)

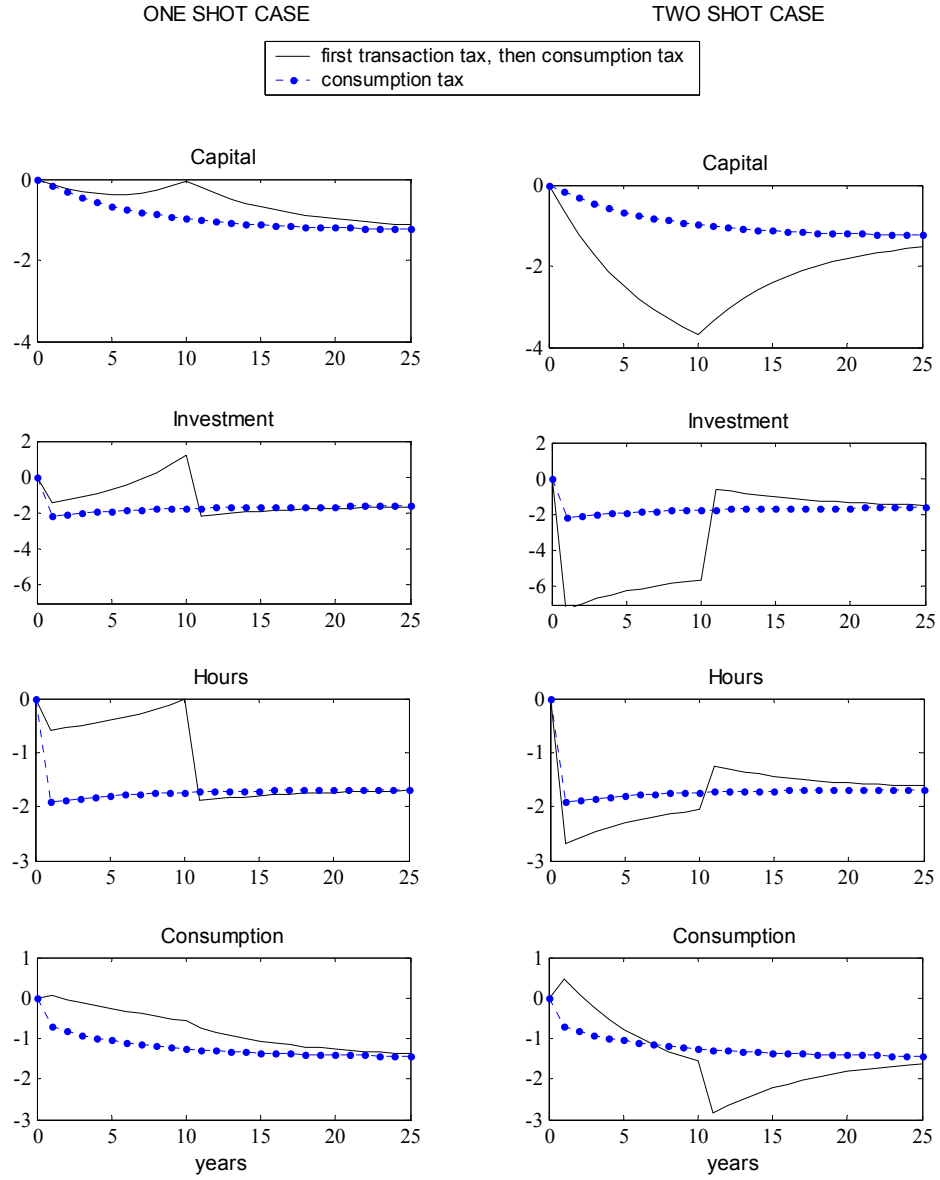


Figure 4 (continued)

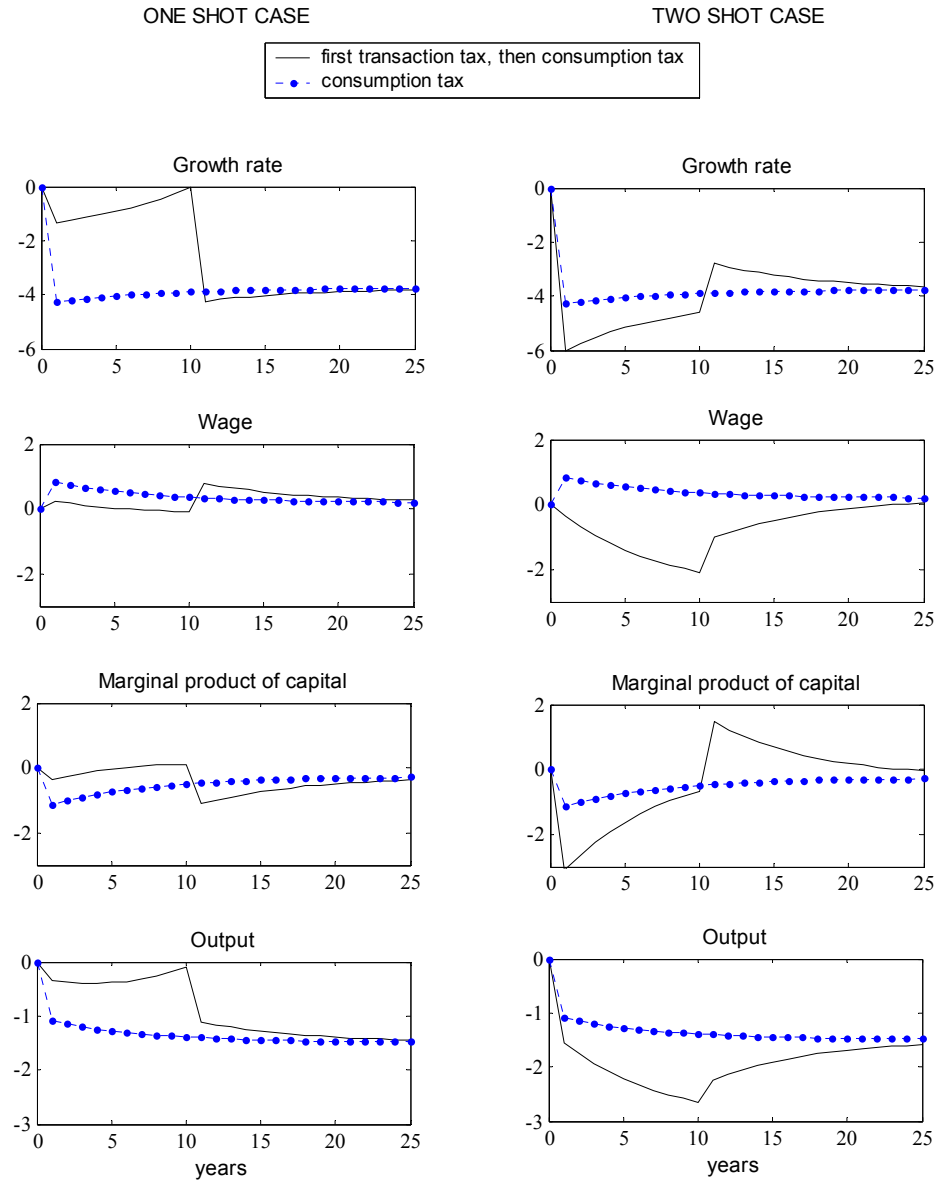


Figure 5
Welfare Costs of Two-Step Tax Reforms

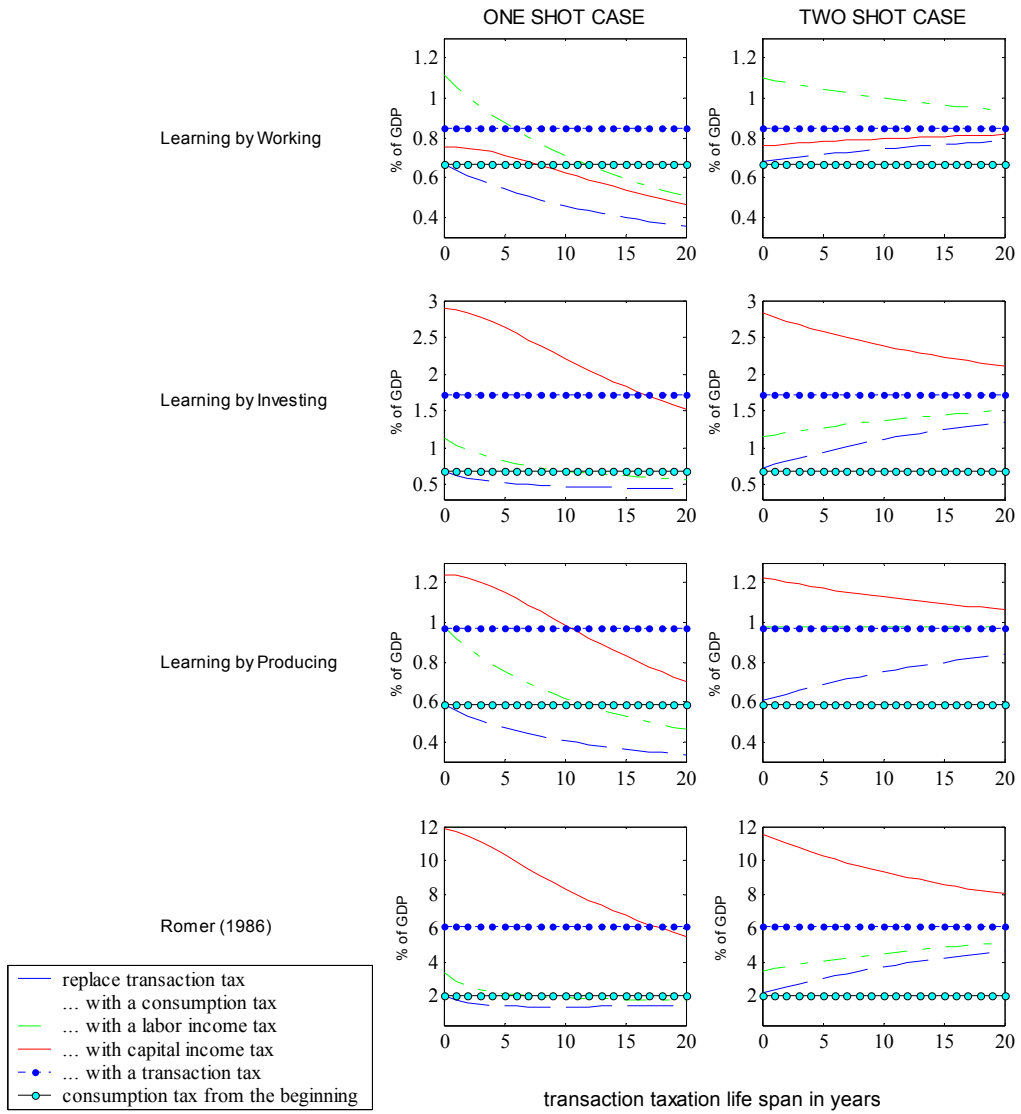


Figure 6
Comparing Results: Nominal and Effective Transaction Tax Rates

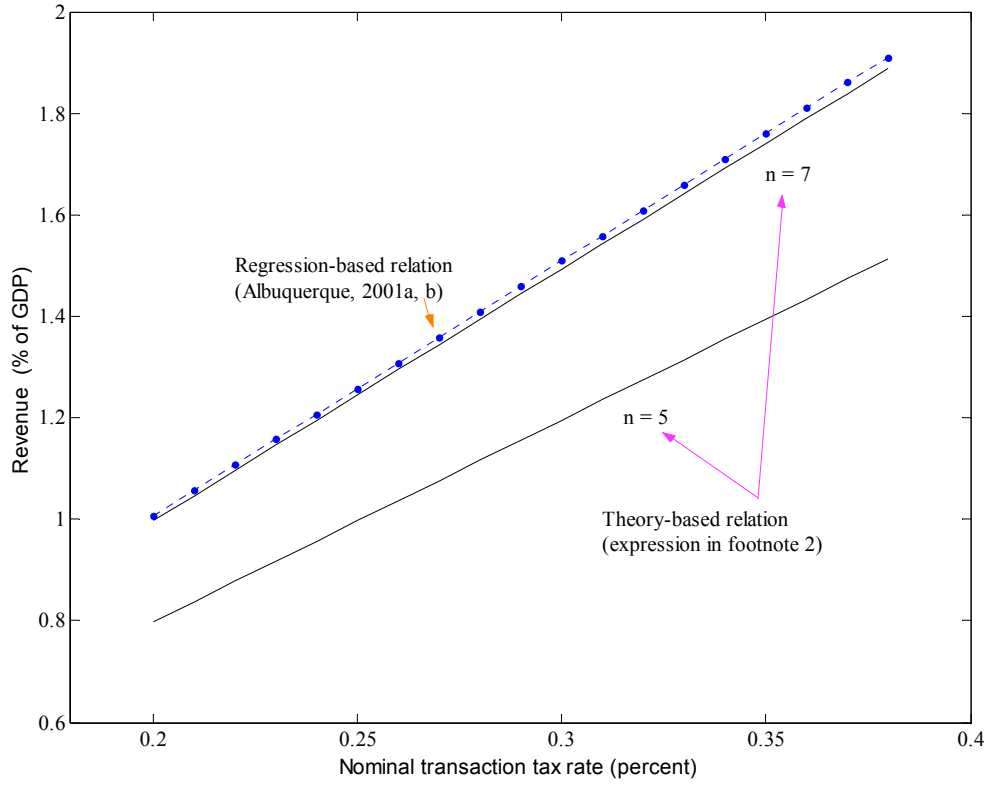


Table 1
Brazil: Information Used in Benchmark Parameterization

τ^T	Statutory transaction tax rate	0.37%
TRO	Transaction tax revenue to output ratio	1.45%
KRO	Capital income tax revenue to output ratio	1.19%
CRO	Consumption tax revenue to output ratio	5.65%
WRO	Labor income tax revenue to output ratio	8.65%
$\eta^{ss} - 1$	Rate of growth per capita GDP	2.22%
H^{ss}	Fraction of time devoted to work	33.3%
COR	Consumption to output ratio	73.6%
KOR	Capital to output ratio	2.68
RRR	Real rate of return	8.00%

Table 2
Benchmark Parameter Values and Initial Steady State

Benchmark Parameterization			Initial Steady State	
α	Capital's share in output	0.4155	\hat{K}^{ss}	1
β	Discount factor	0.9504	\hat{Y}^{ss}	0.3730
δ	Depreciation rate	0.0784	H^{ss}	0.3333
θ	Preference parameter	0.4431	\hat{C}^{ss}	0.2746
S	Scale parameter	3.5774	\hat{I}^{ss}	0.0984
n	Number of sectors	5	η^{ss}	1.0222
τ^C	Consumption tax rate	0.0767	r^{ss}	0.1584
τ^W	Labor income tax rate	0.1479	w^{ss}	0.6541
τ^K	Capital income tax rate	0.0557		
τ^T	Transaction tax rate	0		
η_H	Growth engine parameter	0.0658		
η_I	Growth engine parameter	0.2229		
η_Y	Growth engine parameter	0.0588		

Table 3
Welfare and Growth Effects of a Tax Reform Designed to Raise Additional Revenue Equal to 2% of GDP Under the New Steady State (one tax at a time)
(% of GDP and %)

	Endogenous Growth Mechanism			
	Learning by Working	Learning by Investing	Learning by Producing	Romer (1986)
A. STEADY STATE WELFARE COSTS				
Consumption tax	0.83	0.81	0.79	2.01
Labor income tax	1.38	1.36	1.32	3.37
Capital income tax	1.96	3.77	2.66	11.86
Transaction tax	1.46	2.16	1.70	6.12
B. WELFARE COSTS IN THE TRANSITION PATH				
Consumption tax	0.67	0.67	0.59	2.01
Labor income tax	1.12	1.12	0.98	3.37
Capital income tax	0.75	2.89	1.24	11.86
Transaction tax	0.85	1.71	0.97	6.12
C. STEADY STATE GROWTH RATES (benchmark: 2.22%)				
Consumption tax	2.18	2.18	2.18	2.06
Labor income tax	2.16	2.16	2.16	1.95
Capital income tax	2.19	2.02	2.12	1.27
Transaction tax	2.18	2.11	2.15	1.72

Table 4
Sensitivity Analysis: Information for Alternative Parameterizations

	Benchmark					
	Brazil	Argentina	Colombia	Venezuela	Ecuador	Peru
τ^T	0.37%	0.99%	0.30%	0.85%	1.60%	0.81%
TRO	1.45%	1.08%	0.75%	1.57%	2.37%	0.57%
KRO	1.19%	0.60%	2.37%	13.01%	5.67%	1.77%
CRO	5.65%	3.69%	3.80%	1.30%	3.29%	7.03%
WRO	8.65%	3.16%	2.63%	1.58%	NA	NA
$\eta^{ss} - 1$	2.22%	0.11%	1.77%	Approx. 0%	3.74%	Approx. 0%
H^{ss}	33.3%	30.0%	NA	NA	NA	NA
COR	73.6%	77.6%	81.7%	64.8%	78.3%	82.9%
KOR	2.68	3.03	2.21	3.43	2.98	3.00
RRR	8.00%	10.00%	10.00%	NA	NA	10.30%

Sources and Notes:

NA: not available.

Sources and methodology are as in the benchmark parameterization. For details see section 3.A. Parameter Calibration. Figures are generally calculated as averages over spans of 20-23 years preceding the introduction of bank debit taxation in each country. The different sources are the following. H^{ss} for Argentina is taken from Kydland and Zarazaga (2002). Real rates of return are taken from Kydland and Zarazaga (2002) for Argentina, Harberger (1973) for Colombia and Dancourt et al. (2002) for Peru.