Vol. 30, No. 4

ECONOMIC REVIEW

1994 Quarter 4

Tax Structure, Optimal Fiscal Policy, and the Business Cycle 2
by Jang-Ting Guo and Kevin J. Lansing

Cross-Lender Variation in Home Mortgage Lending 15
by Robert B. Avery, Patricia E. Beeson, and Mark S. Sniderman

The Efficiency and Welfare Effects of Tax Reform: Are Fewer Tax Brackets Better than More? 30
by David Altig and Charles T. Carlstrom

FEDERAL RESERVE BANK OF CLEVELAND

ECONOMIC REVIEW

1994 Quarter 4
Vol. 30, No. 4

Tax Structure, Optimal Fiscal Policy, and the Business Cycle 2
by Jang-Ting Guo and Kevin J. Lansing

The real business cycle (RBC) approach to the study of aggregate fluctuations is now a well-established paradigm in macroeconomics. Most RBC models abstract from government fiscal policy altogether or treat it as some exogenous stochastic process. This article develops an RBC model in which government fiscal variables such as tax rates and public expenditures are *endogenous*. The authors characterize the "optimal" behavior of fiscal policy over the business cycle for two different tax structures and relate this behavior to movements in private-sector variables like output, consumption, labor hours, and investment. As a benchmark, they also provide a comparison between the model and U.S. data.

Cross-Lender Variation in Home Mortgage Lending 15
by Robert B. Avery, Patricia E. Beeson, and Mark S. Sniderman

This study evaluates the feasibility of using information collected under the Home Mortgage Disclosure Act (HMDA) to form quantitative measures of lender activity for use in enforcement. By evaluating three firm-level measures—loan application, approval, and origination rates—the authors find that cross-lender variation in minority and low-income originations primarily reflects differences in home mortgage application rates, not in approval rates. The authors also compare gross measures of lender performance with indices controlling for property location and loan applicant characteristics and determine that they perform similarly. This suggests that most of the variation in lender behavior is idiosyncratic and cannot be attributed to variance in applicant characteristics reported in the HMDA data or to differences in the geographic markets served by the lenders.

The Efficiency and Welfare Effects of Tax Reform: Are Fewer Tax Brackets Better than More? 30
by David Altig and Charles T. Carlstrom

On the wish list of many members of the new Congress is an income tax system characterized by constant marginal tax rates, typically referred to as a flat-tax system. In reality, what we are likely to see is a continuation of the worldwide trend toward replacing systems with high marginal-rate progressivity with those that have a smaller number of rates that are flat over relatively broad income ranges. In this article, the authors compare a simple two-bracket tax code with an approximation to traditional structures that entail steeply rising marginal tax rates. Their conclusion — that the simpler rate structures are not necessarily more efficient than alternatives with numerous, highly progressive brackets — serves as a cautionary note to potential reformers.

Economic Review is published quarterly by the Research Department of the Federal Reserve Bank of Cleveland. Copies of the *Review* are available through our Corporate Communications and Community Affairs Department. Call 1-800-543-3489, then immediately key in 1-5-3 on your touch-tone phone to reach the publication request option. If you prefer to fax your order, the number is 216-579-2477.

ISSN 0013-0281

Tax Structure, Optimal Fiscal Policy, and the Business Cycle

by Jang-Ting Guo and Kevin J. Lansing

Jang-Ting Guo is an assistant professor of economics at the University of California, Riverside, and Kevin J. Lansing is an economist at the Federal Reserve Bank of Cleveland. For helpful comments and suggestions, the authors thank David Altig, Charles T. Carlstrom, Jagadeesh Gokhale, Joseph G. Haubrich, Finn Kydland, Peter Rupert, and an anonymous referee.

Introduction

The real business cycle (RBC) approach to the study of aggregate fluctuations is now a well-established paradigm in macroeconomics. The early groundbreaking articles in this area (Kydland and Prescott [1980a, 1982] and Long and Plosser [1983]) completely abstracted from government behavior, yet were reasonably successful in capturing the broad comovements and relative variabilities of the economic aggregates that characterize the business cycle.

More recently, researchers have introduced elements of government fiscal policy into these models to help match various business cycle facts. For example, Christiano and Eichenbaum (1992) include stochastic government spending in the household utility function to help explain the low observed correlation between labor hours and real wages (as measured by average labor productivity) in postwar U.S. data. This works in their model because shocks to government spending impact the marginal utility of private consumption and thereby induce shifts in the household labor supply. These interact with labor demand shifts (caused by technology shocks) to produce a low correlation between wages and hours. Braun (1994) and McGrattan (1994) show that a similar result can be obtained by introducing stochastic distortionary taxes to shift the labor supply curve. A common feature of these studies is that government policy is viewed as exogenous.

In this paper, we develop an RBC model in which government fiscal variables such as tax rates and public expenditures are *endogenous*. Our objective is to characterize the "optimal" behavior of these policy variables over the business cycle and to relate this behavior to movements in private-sector variables like output, consumption, labor hours, and investment. As a benchmark, we also provide a comparison between the model and U.S. data.

We build on the recent work of Chari, Christiano, and Kehoe (1994), who develop a competitive RBC model in which a government policymaker chooses an optimal sequence of distortionary taxes on labor and capital income in a dynamic version of the Ramsey (1927) optimal tax problem. Our model differs from theirs in three main respects. First, we introduce monopoly profits into the production sector of the economy such that the optimal steady-state tax on capital is positive, consistent with U.S. observations. In a competitive model, this tax rate is zero (see Judd [1985] and Chamley [1986]). Second, our model incorporates the "indivisible labor" specification of Rogerson (1988) and Hansen (1985). In standard RBC models (which abstract from government), the indivisible labor specification serves to increase the variability of hours relative to the real wage to a value that is more in line with U.S. data. Third, we endogenize the time series of government spending by including in household preferences a separable term that represents the utility provided by public goods. In the Chari, Christiano, and Kehoe model, government spending follows an exogenous stochastic process.

We compare simulations from our model to post–WWII, annual U.S. data and an otherwise similar model with nondistortionary lump-sum taxes. Our results can be summarized as follows: For a given stochastic process of the technology shock, we find that optimal distortionary taxes reduce the variability of output and labor hours, but increase the relative variability of household investment, compared to the model with lump-sum taxes. This result can be traced to the behavior of the optimal distortionary tax rates on labor and capital income. The optimal labor tax in the model is procyclical, which reduces the variability of hours (and output) by providing households with an implicit insurance mechanism against variations in their after-tax wage. The optimal capital tax in the model is countercyclical and displays a high standard deviation relative to the labor tax. This tends to increase the variability of household investment relative to output, but provides an efficient means of absorbing shocks to the government's budget (which are caused by changes in the size of the tax base over the business cycle).

In addition, we find that the distortionary tax model underpredicts the variability of hours worked relative to the real wage in U.S. data, despite our specification of indivisible labor. This result is due to the procyclical optimal labor tax, which tends to reduce the variability of hours worked in comparison to a standard RBC model with indivisible labor. Finally, both model versions capture the procyclical behavior of government spending in annual U.S. data, but underpredict its variability over the business cycle. We find that this comparison, as well as comparisons along some other dimensions, are substantially improved if we exclude U.S. data prior to 1954 to avoid the influence of the Korean War. However, a few comparisons, such as the correlation between government spending and output, become worse.

The remainder of the paper is organized as follows: Sections I and II describe the model and the solution method. The choice of parameter values is discussed in section III. Section IV examines the business cycle characteristics of the two tax structures and compares them to U.S. data. Concluding remarks are presented in section V.

I. The Model

The model economy consists of three types of agents: households, firms, and the government. Households obtain direct utility from government-provided public goods, which are financed by taxes on households and firms. Following Benhabib and Farmer (1994), we postulate that firms which produce intermediate goods exhibit some degree of monopoly power such that they realize positive economic profits even though the final-goods sector of the economy is perfectly competitive. The profits are equal to the difference between the value of output and the payments made to inputs. The reason for introducing profits is to obtain a positive optimal tax rate on capital under the distortionary tax structure, consistent with U.S. observations.[1]

As owners of the firms, households receive net profits in the form of dividends. It is assumed that profits are initially taxed at the firm level, then distributed as dividends and taxed again at the household level. This formulation is intended to capture the double taxation of corporate dividends in the U.S. economy. Furthermore, under the distortionary tax structure, we assume that the government can distinguish between labor and capital income, but cannot distinguish between the various categories of capital income, such as profits, dividends, bond interest, and capital rental income. Therefore, this version of the model includes only two types of distortionary taxes: a labor tax and a capital tax.

■ 1 Jones, Manuelli, and Rossi (1993) show that the existence of profits and a restriction on the menu of available tax instruments (the absence of a separate profits tax) is one method of obtaining a positive optimal tax rate on capital in the steady state. Without profits, the optimal steady-state tax on capital is zero.

The Household's Problem

There is a continuum of identical, infinitely lived households, each of which maximizes a stream of discounted utilities over sequences of consumption and leisure:

$$(1) \qquad \max_{c_t,\, h_t,\, k_{t+1},\, b_{t+1}} E_0 \sum_{t=0}^{\infty} \beta^t \left(\ln c_t - A\, h_t + B \ln g_t \right)$$

$$0 < \beta < 1, \quad A, B > 0 .$$

In this utility function, β is the household discount factor and c_t represents private consumption goods. The symbol E_t is the expectation operator conditional on information available at time t. Each household is endowed with one unit of time each period and works h_t hours during period t. The fact that utility is linear in hours worked draws on the formulation of *indivisible labor* described by Rogerson (1988) and Hansen (1985). This means that all fluctuations in labor hours are due to changes in the number of workers employed, as opposed to variations in hours per worker.[2] Household preferences also include a term representing the utility provided by aggregate public consumption goods g_t. The separability in c_t and g_t implies that public consumption does not affect the marginal utility of private consumption, a specification supported by parameter estimates in McGrattan, Rogerson, and Wright (1993). Households view g_t as outside their control. Examples of public consumption goods that might affect household utility are national defense, police protection, and government provision of food and shelter during natural disasters. Public goods are assumed to be noncongestable and free of specific user charges.

The representative household faces the following within-period budget constraint:

$$(2) \qquad c_t + x_t + b_{t+1} \leq (1 - \tau_{ht})\, w_t h_t + (1 - \tau_{kt})\,(r_t k_t + \hat{\pi}_t + r_{bt} b_t) + \tau_{kt} \delta k_t + b_t - T_t,$$

$$k_0, b_0 \text{ given,}$$

where x_t is investment, k_t is the stock of physical capital, and b_{t+1} represents one-period, real government bonds carried into period $t+1$ by the household. Households derive income by supplying labor and capital services to firms at rental rates w_t and r_t, and pay taxes on labor and capital income at rates τ_{ht} and τ_{kt}, respectively. Two additional sources of household income are the firm's net profits, $\hat{\pi}_t$ (which are distributed to households as dividends), and the interest earned on government bonds, $r_{bt} b_t$. Dividends and interest are taxed at the same rate as capital rental income, $r_t k_t$. The term $\tau_{kt} \delta k_t$ represents the depreciation allowance built into the U.S. tax code, and T_t is a lump-sum tax.

The following equation describes the law of motion for the capital stock, given a constant rate of depreciation δ:

$$(3) \qquad k_{t+1} = (1 - \delta)\, k_t + x_t, \quad 0 < \delta < 1 .$$

Households view tax rates, wages, interest rates, and dividends as determined outside their control.

Household Optimality

The household first-order conditions with respect to the indicated variables and the associated transversality conditions (TVC) are

$$(4a) \qquad c_t: \quad \lambda_t = \frac{1}{c_t}$$

$$(4b) \qquad h_t: \quad \lambda_t (1 - \tau_{ht})\, w_t = A$$

$$(4c) \qquad k_{t+1}: \quad \lambda_t = \beta E_t \lambda_{t+1} \left[(1 - \tau_{kt+1})(r_{t+1} - \delta) + 1 \right]$$

$$(4d) \qquad b_{t+1}: \quad \lambda_t = \beta E_t \lambda_{t+1} \left[(1 - \tau_{kt+1})\, r_{bt+1} + 1 \right]$$

$$(4e) \qquad \text{TVC:} \quad \lim_{t \to \infty} E_0 \beta^t \lambda_t k_{t+1} = 0, \qquad \lim_{t \to \infty} E_0 \beta^t \lambda_t b_{t+1} = 0,$$

where λ_t is the Lagrange multiplier associated with the budget constraint (2) in period t. The interpretation of λ_t is that it represents the

2 The linearity of (1) in h_t implies that the effective labor-supply elasticity of the representative household is infinite. In a decentralized economy, both Rogerson and Hansen show that this utility function can be supported by a lottery that randomly assigns workers to employment or unemployment each period, with the firm providing full unemployment insurance. Wage contracts call for households to be paid based on their expected (rather than actual) number of hours worked. RBC models with indivisible labor are better able to match some key characteristics of aggregate labor market data. Specifically, U.S. data display a large variability of hours worked relative to the real wage, and a weak correlation between hours and the real wage (see Christiano and Eichenbaum [1992]).

marginal utility of an additional unit of after-tax income received in period t. The transversality conditions ensure that the household's within-period budget constraint (2) can be transformed into an infinite-horizon, present-value budget constraint.

The Firm's Problem

This section closely follows the model developed by Benhabib and Farmer (1994). Suppose there exists a continuum of intermediate goods y_{it}, $i \in [0,1]$ and a unique final good y_t that is produced using the following constant-returns-to-scale technology:

$$(5) \quad y_t = \left[\int_0^1 y_{it}^{\chi} di \right]^{1/\chi}, \quad 0 < \chi \leq 1 .$$

We assume that the final-goods sector is perfectly competitive, but that intermediate-goods producers exert a degree of monopoly power that is captured by the parameter χ. In the special case when $\chi = 1$, all intermediate goods are perfect substitutes in the production of the final good, and the intermediate sector becomes perfectly competitive.

Each intermediate good is produced using the *same* technology, with labor and capital as inputs:

$$(6) \quad y_{it} = \exp(z_t)\, k_{it}^{\alpha_1} h_{it}^{\alpha_2},$$

$$0 < \alpha_i < 1, \ \alpha_1 + \alpha_2 = 1$$

$$(7) \quad z_{t+1} = \rho_z z_t + \varepsilon_{t+1}, \quad 0 < \rho_z < 1,$$

$$\varepsilon_t \sim \text{i.i.d.}\,(0, \sigma_\varepsilon^2), \quad z_0 \text{ given},$$

where (7) is the law of motion for aggregate technology shocks z_t, which are revealed to agents at the beginning of period t and which generate business cycle fluctuations in the model. Under the assumptions that firms maximize profits and factor markets are competitive, Benhabib and Farmer show that in a *symmetric* equilibrium ($k_{it} = k_t$ and $h_{it} = h_t$ for all i), the aggregate production function, the rental rate on capital, and the real wage are

$$(8a) \quad y_t = \exp(z_t) k_t^{\alpha_1} h_t^{\alpha_2},$$

$$(8b) \quad r_t = \theta_1 \frac{y_t}{k_t}, \ \theta_1 \equiv \chi\alpha_1, \text{ and}$$

$$(8c) \quad w_t = \theta_2 \frac{y_t}{h_t}, \ \theta_2 \equiv \chi\alpha_2 .$$

Due to their monopoly power, intermediate-goods producers earn an economic profit that is taxed at rate τ_{kt}. The firm's after-tax profits, distributed to households in the form of dividends, are

$$(9a) \quad \hat{\pi}_t = (1 - \tau_{kt})(y_t - r_t k_t - w_t h_t).$$

$$(9b) \quad \hat{\pi}_t = (1 - \tau_{kt})(1 - \theta_1 - \theta_2)\, y_t .$$

The Government's Problem

The government chooses an optimal program of taxes, borrowing, and public expenditures in order to maximize the discounted utility of the household. This is a dynamic version of the Ramsey (1927) optimal tax problem, where τ_{ht}, τ_{kt}, r_{bt}, g_t, and T_t summarize government policy implemented at time t. To set up this problem, we begin by spelling out some important assumptions. First, we assume that the government can *commit* to a set of time-invariant decision rules that specify policy variables as a function of state variables. This is done to avoid the complicating issue of *time inconsistency*, which arises in policy design problems when the tax base includes fixed assets (such as capital or bonds) that cannot be quickly adjusted in response to a change in the level of the tax. In these situations, the government has an incentive to deviate from its originally announced, optimal policy by implementing surprise increases in asset taxes in order to obtain nondistortionary tax revenue. Because households understand that the original policy is time inconsistent, it cannot be supported as an equilibrium unless the government can commit itself (and all successor governments) to carrying out the plan.[3]

Second, given that the initial stocks of capital and bonds are fixed, we rule out any confiscatory taxes on assets at $t = 0$ that might be used to finance all future expenditures. This case is not very interesting because no taxes beyond the initial period are required. With these assumptions, the government's problem is

■ 3 The time inconsistency problem does not arise under the lump-sum tax structure because taxes are nondistortionary. See Chari (1994) for a summary of the issues and a review of the literature dealing with time inconsistency problems and optimal policy design.

$$(10)\quad \max_{\substack{g_t,\ \tau_{ht},\ \tau_{kt}\\ r_{bt},\ T_t}} \quad E_0 \sum_{t=0}^{\infty} \beta^t (\ln c_t - Ah_t + B\ln g_t)$$

subject to

(i) household first-order conditions and the budget constraint,

(ii) firm profit-maximization conditions,

(iii)
$$g_t = b_{t+1} - b_t(1 + r_{bt})$$
$$+ \tau_{ht} w_t h_t + \tau_{kt} [(r_t - \delta) k_t + r_{bt} b_t]$$
$$+ [1 - (1 - \tau_{kt})^2] (1 - \theta_1 - \theta_2) y_t + T_t,$$

(iv) $T_t = 0$ for the distortionary tax structure,

(v) $\tau_{ht} = \tau_{kt} = 0$ for the lump-sum tax structure,

(vi)
$$\lim_{t \to \infty} \frac{b_t}{\prod_{i=1}^{t} [1 + (1 - \tau_{ki-1}) r_{bi-1}]} = 0.$$

As a condition for equilibrium, government policy must take into account the rational responses of households and firms, as summarized by constraints (i) and (ii). The chosen policy must also satisfy the government's within-period budget constraint (iii), where the squared term on the right-hand side reflects the double taxation of firm dividends. Constraints (iv) and (v) impose the restrictions associated with the two tax structures we intend to analyze. For the distortionary tax structure, we rule out the possibility of lump-sum taxes. For the lump-sum tax structure, we set τ_{ht} and τ_{kt} equal to zero. Finally, (vi) is a transversality condition ensuring that the government budget constraint is satisfied in present-value terms. The summation of the household budget constraint and the government budget constraint yields the following resource constraint for the economy:

$$(11)\quad y_t = c_t + x_t + g_t.$$

Because the resource constraint and the government budget constraint are not independent equations, equation (11) will be used in place of (iii) in solving the government's problem.

II. Solving the Model

Our approach to solving the government's problem is to find the allocations c_t, h_t, k_{t+1}, and b_{t+1} that maximize household utility subject to the constraints, where allocations are expressed as functions of the economy's state variables. The appropriate set of prices r_t and w_t and the policy variables τ_{ht}, τ_{kt}, r_{bt}, g_t, and T_t that decentralize the optimal allocations can be computed using the profit-maximization conditions (8), the household first-order conditions (4), the household budget constraint (2), and the resource constraint (11).[4] For example, the optimal allocations uniquely determine λ_t and w_t through equations (4a) and (8c). Given λ_t and w_t, the household's first-order condition for h_t, equation (4b), uniquely determines the government's optimal choice for τ_{ht}. The government has much more flexibility, however, in choosing the optimal capital tax and the optimal interest rate on government debt. The expectation operators in the household's first-order conditions for k_{t+1} and b_{t+1}, equations (4c) and (4d), imply that the after-tax returns on capital and bonds (weighted by marginal utility) must be the same "on average." In response to a series of shocks, the government can satisfy this ex ante arbitrage condition and implement the optimal allocations using many different combinations for the period-by-period values of τ_{kt} and r_{bt}. Consequently, the stochastic version of the model does not uniquely pin down the time-series behavior of these policy variables (see Zhu [1992] and Chari, Christiano, and Kehoe [1994] for a more complete description).

To facilitate a comparison with U.S. data, we make a particular assumption about the way in which the government picks τ_{kt} and r_{bt} to decentralize a set of allocations. Specifically, we employ the certainty versions of (4c) and (4d) to identify τ_{kt} and r_{bt} each period. Requiring the government to satisfy the certainty versions of these constraints guarantees that the uncertainty versions will also be satisfied. Essentially, we are restricting the policy instruments available to the government by ruling out fully flexible, state-contingent capital taxes and bond interest rates. This might be interpreted as reflecting the political infeasibility of some types of policy regimes. The restriction we impose has an impact on the behavior of the allocations in response to stochastic shocks, as does any other restriction

■ 4 This method of solving the government's problem is described as the "primal" approach by Atkinson and Stiglitz (1980), chapter 12.

on the set of available policy instruments (such as ruling out lump-sum taxes). Consequently, the allocations we compute in response to shocks are different from the "Ramsey allocations" that could be supported in an unrestricted environment.[5] In the restricted case, the government's decision rules for τ_{kt} and r_{bt} are identical to those for an economy with no uncertainty. It is important to note that this result follows from a particular decentralization scheme. However, our solution method also employs a linear-quadratic approximation of the problem. Thus, the decision rules governing household allocations also display the property of certainty equivalence.[6]

Given these assumptions, the government's problem with distortionary taxes can be solved using a recursive algorithm developed by Kydland and Prescott (1980b). The problem with lump-sum taxes can be solved by adopting the view of a social planner for an appropriately defined "pseudo-economy" in which the planner cannot exploit the monopoly power of firms. The government's problem under lump-sum taxes is not equivalent to a standard social planning problem because when $\chi < 1$, the decentralized equilibrium is not Pareto optimal. The pseudo-economy approach is an indirect method of obtaining the equilibrium allocations (see Stokey and Lucas [1989], chapter 18). Government debt does not appear in the pseudo-planner's problem. This reflects the well-known "Ricardian proposition," which states that government debt policy is irrelevant to the determination of equilibrium allocations in an economy with lump-sum taxes (see Sargent [1987], chapter 3). Since debt doesn't matter in this case, we arbitrarily set it equal to zero each period such that $g_t = T_t$. The pseudo-planner's problem is recursive and can be solved using standard methods.[7]

III. Calibrating the Model to the U.S. Economy

To explore the quantitative predictions of the model, we assign parameter values based on empirically observed features of post–WWII U.S. data. The time period in the model is taken to be one year, which is consistent with both the time frame of most government fiscal decisions and the frequency of available data on average marginal tax rates. The discount factor β (= 0.962) implies an annual rate of time preference of 4 percent. The parameter A in the household utility function is chosen such that the fraction of time spent working is close to 0.3 in the steady state for each tax structure. This coincides with time-use studies, such as Juster and Stafford (1991), which indicate that households spend approximately one-third of their discretionary time in market work. The value of B is chosen to yield a steady-state value of g/y near 0.22 for each tax structure, the average ratio of government spending to GNP for the U.S. economy from 1947 to 1992.[8] The steady-state level of government debt is chosen to yield a steady-state ratio of b/y equal to 0.45. This is the average value of U.S. federal debt held by the public as a fraction of GNP from 1947 to 1992.[9]

The exponents in the Cobb–Douglas production function are chosen on the basis of two criteria. First, the selected values of θ_1 (= 0.31) and θ_2 (= 0.60) are in the range of the estimated shares of GNP received by capital and labor in the U.S. economy (see Christiano [1988]). Second, the model's share of output devoted to monopoly profits (= $1 - \theta_1 - \theta_2$) is chosen to yield a reasonable value for the steady-state tax on capital (τ_k) under the distortionary tax structure. Because a separate profits tax is not available in this case, the government uses the tax on private capital to recapture a portion of the profits. In the model, the steady-state ratio of profits to output is 0.09, and the

■ 5 See Chari, Christiano, and Kehoe (1994) for examples of decentralizations that support the Ramsey allocations. See Cassou (forthcoming) for a case where policy instruments are restricted to follow a univariate Markov process in response to government spending shocks.

■ 6 The approximate version of the problem involves the maximization of a quadratic objective function subject to linear constraints. Since the first-order conditions are linear in all variables, the expectation operator can be passed through the expressions, dropping out stochastic terms associated with the technology shock innovation ε_{t+1} in equation (7). See Sargent (1987), p. 36.

■ 7 A technical appendix to this paper, available from the authors upon request, describes the details of our solution procedure.

■ 8 The specific parameter values used in the computations are $A = 2.50$, $B = 0.350$ for the distortionary tax structure, and $A = 3.48$, $B = 0.381$ for the lump-sum tax structure.

■ 9 The model does not pin down a unique value for the steady-state level of government debt (see Chamley [1985]). Rather, steady-state debt is a function of the initial level of debt, b_0, and the entire transition path of taxes and spending from $t = 0$ until the steady state is reached. As an alternative to performing this difficult computation, we follow the approach of Lucas (1990) and simply choose the level of steady-state debt to reflect a debt-to-GNP ratio consistent with the data. We assume that b_0 and the transition path are set such that the government budget constraint is satisfied in present-value terms. Data on U.S. federal debt held by the public are from *Federal Debt and Interest Costs,* Congressional Budget Office, 1993, table A-2.

resulting steady-state tax on capital is 0.31. This value of τ_k approximates the average effective corporate tax rate in the United States from 1947 to 1980, as estimated by Jorgenson and Sullivan (1981).[10] The steady-state tax on labor (τ_h) turns out to be 0.25. This is close to the average marginal tax rate on labor income from 1947 to 1983, as estimated by Barro and Sahasakul (1986). The U.S. tax rate estimates can be viewed as summarizing the various elements of the tax code that impact the behavior of agents. These include not only the statutory rate, but also the many types of exemptions, deductions, credits, and allowances.

The monopoly power parameter χ is chosen such that the aggregate production technology demonstrates constant returns to scale. Given the values chosen for θ_1 and θ_2, a value of $\chi = 0.91$ yields $y_t = \exp(z_t)\, k_t^{0.34}\, h_t^{0.66}$. The capital depreciation rate δ (= 0.07) is consistent with values commonly used in the RBC literature. Together with the values of β and θ_1, this depreciation rate implies a steady-state ratio of capital to output ranging from 2.4 (under the distortionary tax structure) to 2.8 (under the lump-sum tax structure), and a ratio of investment to output ranging from 0.17 to 0.20. The corresponding average ratios for the U.S. economy from 1947 to 1992 are 2.58 and 0.21. The process governing technology shocks is estimated using annual data from 1947 to 1992. The series for z_t was constructed by computing the changes in output not accounted for by changes in the productive inputs.[11] The parameter estimates, $\rho_z = 0.85$ and $\sigma_\varepsilon = 0.015$, are close to those estimated by other studies using annual data, such as Benhabib and Jovanovic (1991).

IV. Simulation Results

In this section, we describe the model's predictions for the behavior of fiscal policy over the business cycle and provide a comparison with U.S. data. The simulation results are shown in tables 1–2 and figures 1–5. Note that the distortionary tax structure makes predictions for a larger set of variables than does the lump-sum tax structure. The additional variables are the stock of real government debt, b_t, and the average marginal tax rates on labor and capital income, τ_{ht} and τ_{kt}.[12]

In comparison to the full sample of U.S. data from 1947 to 1992, both tax structures underpredict the standard deviation of output (y_t), consumption (c_t), government expenditures (g_t), and hours (h_t), but overpredict the standard deviation of investment (x_t). Since we employ a general-equilibrium framework, the behavior of one variable cannot be viewed in isolation, because it is linked by the equilibrium conditions to the behavior of other variables in the model. For example, the low variability of output is linked to the low variability of hours, because the production technology is labor intensive.[13] Likewise, the low variability of consumption is linked to the high variability of investment, because changes in household saving (which correspond to changes in investment) act as a buffer against earnings shocks, thereby allowing households to smooth their consumption over the business cycle. Consistent with standard RBC models (see Kydland and Prescott [1982]), both model versions capture the fact that output is more variable than consumption, but less variable than investment, over the U.S. business cycle.

In comparison to the lump-sum tax structure, the distortionary tax structure displays a lower standard deviation of output and hours and a higher variability of investment relative to output. This behavior can be traced to the movement of the optimal distortionary tax rates on labor and capital income. Specifically, the optimal labor tax is procyclical (positively correlated with output), while the optimal capital tax is countercyclical. The procyclical labor tax operates to smooth households' after-tax income from labor. For example, a positive technology shock (which shifts the production frontier outward and raises the real wage) is accompanied by an *increase* in τ_{ht}. The higher tax rate tends to offset the higher real wage and thus provides households with an implicit insurance mechanism against

■ **10** Higher profit levels imply a higher steady-state tax on capital in our model. When profits are zero ($\theta_1 + \theta_2 = 1$), the optimal steady-state tax on capital is zero. If a separate profits tax were available, the government would choose to tax profits at 100 percent and other capital income at 0 percent in the steady state (see footnote 1).

■ **11** The production function residual was measured as $z_t = \ln GNP_t - 0.34\ln k_t - 0.66\ln h_t$. The private capital stock k_t is defined as fixed private capital + stock of consumer durables + residential capital from *Fixed Reproducible Tangible Wealth in the United States*, U.S. Department of Commerce, 1993. Real GNP and the labor input (h_t = LHOURS) are from Citibase.

■ **12** In all figures, model variables are the realizations from a single simulation (based on randomly drawn shocks) to compare volatility and persistence properties with the corresponding U.S. variables. There is no intention to predict the actual time path of U.S. variables.

■ **13** This can be readily observed from the aggregate production function (equation [8a]), where the coefficient on the labor input, $\alpha_2 = 0.66$, is nearly double the coefficient on the capital input, $\alpha_1 = 0.34$.

TABLE 1

Business Cycle Statistics for Models and the U.S. Economy

	Standard Deviation (percent)			
	Distortionary Tax Structure[a]	Lump-Sum Tax Structure[a]	U.S. Economy[b]	
Variables			1947–92	1954–92
y_t	2.11	2.39	2.46	2.16
c_t	0.69	0.96	1.14	1.19
g_t	1.66	1.00	6.45	3.04
k_t	1.05	1.03	0.75	0.74
x_t	9.10	9.00	5.96	6.14
h_t	1.19	1.60	1.76	1.86
y_t/h_t	1.09	0.96	1.45	0.90
b_t	2.72	—	4.54	4.80
Tax rates				
τ_{ht}	1.71	—	6.42	4.08
τ_{kt}	13.91	—	17.76	19.28
Rev/y_t	3.61	1.62	2.65	1.88

	Contemporaneous Correlation with Output			
	Distortionary Tax Structure[a]	Lump-Sum Tax Structure[a]	U.S. Economy[b]	
Variables			1947–92	1954–92
c_t	0.67	0.89	0.71	0.87
g_t	0.98	0.85	0.62	0.40
k_t	0.03	−0.01	0.62	0.63
x_t	0.97	0.97	0.69	0.89
h_t	0.93	0.96	0.81	0.91
y_t/h_t	0.92	0.89	0.71	0.52
b_t	0.03	—	0.23	0.36
Tax rates				
τ_{ht}	0.97	—	0.39	−0.10
τ_{kt}	−0.93	—	0.08	−0.15
Rev/y_t	−0.91	−0.95	0.39	0.11

a. Model statistics are means over 100 simulations, each 46 periods long, after dropping the first 50 periods. The symbol Rev/y_t is the economywide average tax rate, defined as total tax revenue as a fraction of output.

b. The following quarterly series from Citibase were annualized before computing the statistics: y_t = GNPQ, c_t = GCNQ + GCSQ (nondurables + services), g_t = GGEQ, h_t = LHOURS (household survey), and y_t/h_t = GNPQ/LHOURS. The series for x_t is business fixed investment + consumer durable expenditures + residential investment. The series for k_t is fixed private capital + stock of consumer durables + residential capital. Both x_t and k_t are annual series from *Fixed Reproducible Tangible Wealth in the United States*, U.S. Department of Commerce, 1993. The series for b_t is federal debt held by the public from *Federal Debt and Interest Costs*, Congressional Budget Office, 1993, table A-2, where nominal debt has been converted into real debt by dividing by the GNP deflator for each year. Rev/y_t is total government receipts (federal, state, and local) as a fraction of GNP from *Economic Report of the President*, 1991, 1994, table B-80. Data on average marginal tax rates do not extend over the full sample: τ_{ht} is from Barro and Sahasakul (1986) for 1947–83, and τ_{kt} is from Jorgenson and Sullivan (1981), table 11, for 1947–80.

NOTE: Before computing the statistics, all series were logged and detrended using the Hodrick–Prescott filter (see Prescott [1986]). The smoothing parameter for the filter was set at 100, since all data are at annual frequency.

SOURCE: Authors' calculations.

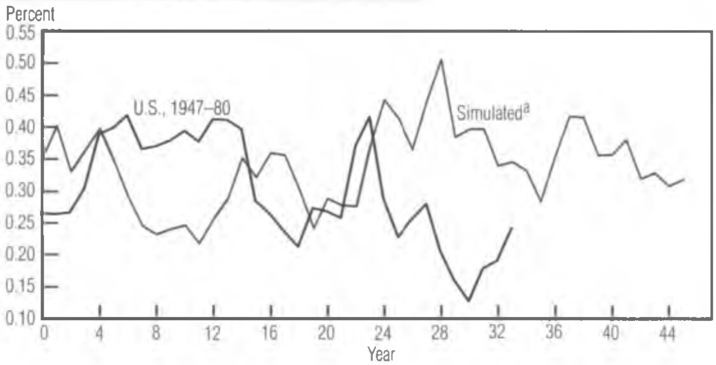
variability in the *after-tax* wage $(1 - \tau_{ht})\, w_t$. Since labor supply decisions depend on the quantity $(1 - \tau_{ht})\, w_t$ (see equation [4b]), a lower variability in the after-tax wage leads to a lower variability in hours worked. With a labor-intensive production technology, this also leads to lower variability in output.

Zhu (1992) shows theoretically that the cyclical behavior of the optimal labor tax depends on the degree of risk aversion (or curvature) exhibited by the household utility function. The optimal labor tax is procyclical for low-risk-aversion (less curved) utility functions, such as the logarithmic case used here, but countercyclical for high-risk-aversion (more curved) functions. Chari, Christiano, and Kehoe (1994) provide a quantitative demonstration of this result. In general, the level of risk aversion determines the amount by which households are willing to adjust their labor supply in response to a change in the real wage. With low risk aversion, the substitution effect of an increase in w_t (caused by a positive technology shock) results in a relatively large increase in labor hours. The government takes advantage of this greater willingness to work by *raising* the tax on labor, thereby collecting additional revenue, but still allowing an increase in labor to spur output during this period of high labor productivity. With high risk aversion, however, the substitution effect is much smaller; that is, households are less willing to increase their labor supply in response to the higher real wage. The government's optimal response now is to *lower* the tax rate on labor. This stimulates labor supply in order to boost output while labor productivity is high. Our results are consistent with the findings of these researchers.

The capital tax in the model moves countercyclically and displays high variability relative to the labor tax (see table 1 and figures 1–2). This serves to increase the variability of household investment relative to output under the distortionary tax structure. Ordinarily, a positive technology shock raises the real rate of interest and motivates an increase in investment because the rate of return becomes more attractive. However, when a positive technology shock is accompanied by a *decrease* in τ_{kt}, the *after-tax* return on investment becomes even more appealing, leading to a larger rise in investment. From the government's perspective, a countercyclical capital tax is optimal because it serves as an efficient means of absorbing shocks to the government's budget constraint. These shocks are caused by changes in the size of the tax base over the the business cycle. For example, a positive technology shock generates more tax

FIGURE 1

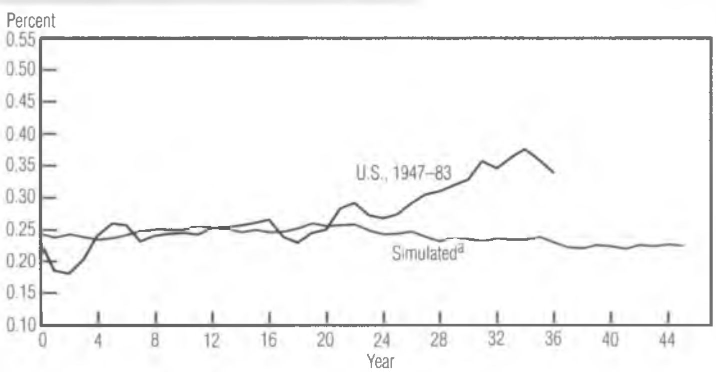
Capital Tax Rates



a. Distortionary tax structure.
SOURCES: Jorgenson and Sullivan (1981); and authors' calculations.

FIGURE 2

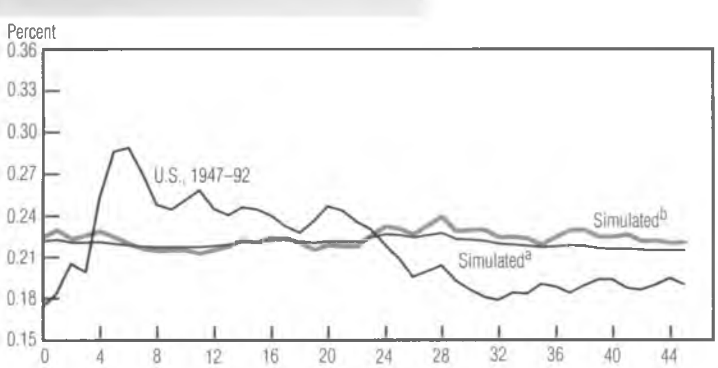
Labor Tax Rates



a. Distortionary tax structure.
SOURCES: Barro and Sahasakul (1986); and authors' calculations.

FIGURE 3

Government Expenditures as a Fraction of GNP



a. Distortionary tax structure.
b. Lump-sum tax structure.
SOURCES: Citibase; and authors' calculations.

revenue because GNP and household incomes (the tax base) increase. This motivates a reduction in τ_{kt} because government spending requirements can be met using a lower tax rate. A similar argument holds in reverse for the case of a negative technology shock. Absorbing shocks mainly by changes in τ_{kt}, as opposed to changes in τ_{ht}, is efficient because the capital stock cannot be quickly adjusted in response to a change in the capital tax. In contrast, the household can instantaneously adjust labor supply in response to a change in the labor tax. The shock-absorbing feature of τ_{kt} allows the government to maintain a very smooth time series for g_t / y_t, as compared to the lump-sum tax structure (see figure 3).[14]

We experimented with varying the level of monopoly profits by adjusting the values of the parameters θ_1, θ_2, and χ. In general, we found that as profits declined, the standard deviation of τ_{kt} increased. The intuition for this result is straightforward. Recall that dividends (equal to after-tax profits) do not distort household decisions because profits are determined outside households' control. A lower level of profits implies a smaller and more elastic tax base for the capital tax. Consequently, larger changes in the tax rate are needed to produce the same revenue effect when responding to technology shocks.

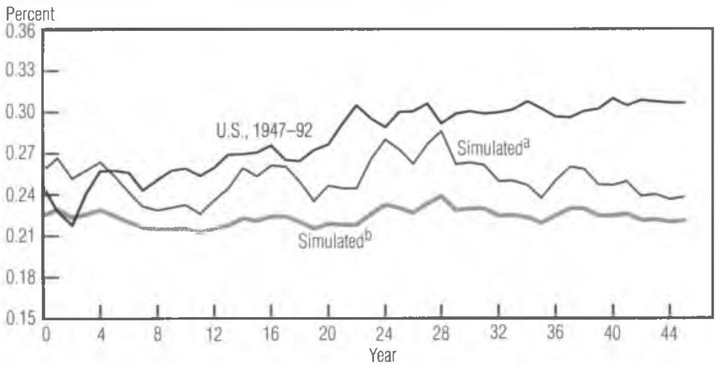
The model's prediction that the capital tax should display more variability than the labor tax is consistent with the U.S. tax-rate estimates we have chosen for comparison.[15] Note, however, that the correlation coefficients between U.S. tax rates and real GNP display a change in sign, depending on the sample period. The labor tax and the capital tax are weakly *procyclical* using data on average marginal tax rates that begin in 1947, but weakly *countercyclical* for data that begin in 1954. The model, on the other hand, predicts a strongly procyclical labor tax and a strongly countercyclical capital tax. Thus, there is a sharp negative correlation

■ **14** The optimality of using a state-contingent capital tax to absorb budget shocks has been shown previously by Judd (1989) and Chari, Christiano, and Kehoe (1994). Our quantitative results are not directly comparable because Judd does not explicitly model household behavior, and Chari, Christiano, and Kehoe employ a different decentralization scheme for τ_{kt} and r_{bt}.

■ **15** The figures display the tax-rate series *before* detrending. For quantitative comparisons (table 1), detrending is necessary because the U.S. labor tax displays a distinct upward trend, while the U.S. capital tax displays a downward trend. These trends have no counterpart in the model. The trend in τ_{ht} is possibly linked to the phenomenon of "bracket creep," which existed before tax schedules were indexed for inflation in 1985. Auerbach and Poterba (1988) argue that the downward trend in τ_{kt} is due to increasingly generous investment tax credits and accelerated depreciation schedules.

FIGURE 4

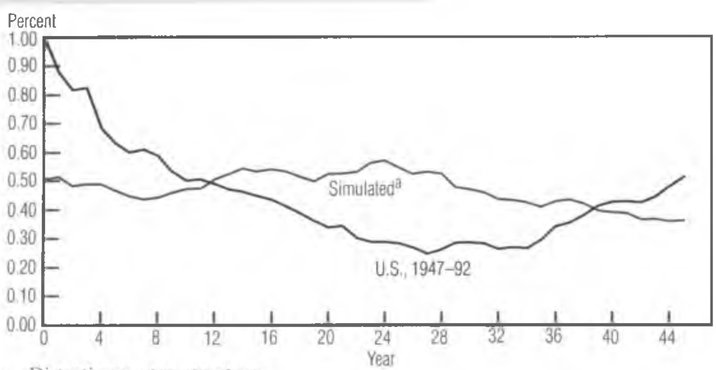
Total Tax Revenue as a Fraction of GNP



a. Distortionary tax structure.
b. Lump-sum tax structure.
SOURCES: *Economic Report of the President*, 1991, 1994; and authors' calculations.

FIGURE 5

Government Debt as a Fraction of GNP



a. Distortionary tax structure.
SOURCES: Congressional Budget Office, *Federal Debt and Interest Costs*, 1993; and authors' calculations.

between τ_{kt} and τ_{ht} in the model, while the corresponding correlation in the data is weakly positive.[16] Figure 4 displays the economywide average tax rate, defined as total tax revenue as a fraction of output. This rate is countercyclical in both versions of the model, but weakly procyclical in the U.S. data. Thus, the model does not capture some important features of U.S. tax-rate movements. This highlights the difficulty of summarizing the entire U.S. tax code using only one or two broadly defined rates.

The predicted standard deviations for g_t are substantially lower than the U.S. value of 6.45 percent computed using the full sample. Starting the sample in 1954 to avoid the influence of the Korean War reduces the standard deviation of g_t in the data by half, to a value of 3.04 percent, which is much closer to model predictions. Although we have no theoretical justification for excluding the Korean War years (since we include the Vietnam War), the fact that our model contains only one type of shock limits its ability to explain large movements associated with a war. Incorporating an additional shock to households' preference for public goods to simulate high demand during wars would increase the variability of g_t in the model (see Lansing [1994]). Both model versions capture the procyclical behavior of government spending in annual U.S. data, but the correlations from the model are much stronger than observed in the data. When the years prior to 1954 are excluded, the correlation between government spending and real output in the U.S. data drops from 0.62 to 0.40, worsening the comparison with the model.

In the distortionary tax structure, government debt is essentially acyclical (it behaves similarly to capital in this respect), but is less variable than U.S. government debt (see figure 5). We experimented with an alternate version of this model in which the government is required to balance its budget each period. For this experiment, we retained the decentralization scheme described in section II, whereby the government is required to satisfy the certainty version of equation (4c). Qualitatively, the results are similar to those reported in table 1. However, the variability of the labor tax goes up, since government debt is no longer available to help cushion budget shocks. The insurance effect of the procyclical labor tax thus becomes more significant, leading to lower variability in hours and output. Interestingly, our model implies that a balanced-budget amendment can help smooth business cycle fluctuations, provided the government sets tax rates in the manner we have described.

The lump-sum tax structure does a reasonably good job of matching the relative standard deviations of hours and the real wage, where the real wage is measured by average labor productivity y_t / h_t (see table 2). This behavior is typical of standard RBC models with indivisible labor (see Hansen [1985]). In the distortionary tax structure, however, the standard deviation of hours relative to the real wage is too low, despite the specification of indivisible labor. The insurance effect of the procyclical labor tax

16 In the U.S. data, the correlation coefficient between (logged and detrended) τ_{ht} and τ_{kt} equals 0.36 from 1947 to 1980, the period for which estimates of both tax rates are available. For the years 1954 to 1980, the correlation coefficient is 0.34. In the model, the correlation coefficient is −0.97.

TABLE 2

Comparison of Labor Market Statistics

Variables	Distortionary Tax Structure[a]	Lump-Sum Tax Structure[a]	U.S. Economy[b]	
			1947–92	1954–92
$\sigma_h / \sigma_{y/h}$	1.09	1.67	1.22 2.10	2.07 2.43
corr (h, y/h)	0.72	0.72	0.16 −0.02	0.13 −0.21

a. Model statistics are means over 100 simulations, each 46 periods long, after dropping the first 50 periods.
b. The first number denotes hours worked from the household survey in Citibase (LHOURS), and the second denotes hours worked from the establishment survey (LPMHU).
NOTE: Before computing the statistics, all series were logged and detrended using the Hodrick–Prescott filter (see Prescott [1986]). The smoothing parameter for the filter was set at 100, since all data are at annual frequency.
SOURCE: Authors' calculations.

is responsible for the reduced variability of hours. Again, we note that the model includes only one type of shock. Aiyagari (1994) uses a variance decomposition analysis to argue that the behavior of hours in U.S. data is driven by multiple shocks.

Finally, the predicted correlations between hours and productivity in table 2 are much higher than the corresponding U.S. values. Braun (1994) shows that an RBC model with *exogenous* stochastic tax rates is capable of matching both of the U.S. labor market statistics in the table. Our simulations show that a model with endogenous tax rates can produce very different results.[17]

V. Conclusion

We have constructed a model that combines elements from the theory of optimal public finance with an RBC view of aggregate fluctuations. Our aim is to develop a framework that is useful for carrying out realistic policy experiments with regard to both the structure of the U.S. tax system and the composition and financing of government expenditures. In two related papers (see Guo and Lansing [1994a,1994b]), we employ models similar to this one to explore the welfare effects of various tax structures and find that these effects can be quite dramatic. In this paper, our model meets with varying degrees of success in matching the observed behavior of tax rates, government spending, and aggregate economic variables in the U.S. economy. Nonetheless, this exercise is useful in that it provides information on how models of government fiscal policy might be improved.

■ 17 See Chari, Christiano, and Kehoe (1994) for a more extensive comparison between an RBC model with exogenous stochastic tax rates and one with optimal Ramsey tax rates.

References

Aiyagari, S. Rao. "On the Contribution of Technology Shocks to Business Cycles," Federal Reserve Bank of Minneapolis, *Quarterly Review*, vol. 18, no. 1 (Winter 1994), pp. 22–84.

Atkinson, Anthony B., and Joseph F. Stiglitz. *Lectures on Public Finance*. McGraw-Hill: New York, 1980.

Auerbach, Alan J., and James M. Poterba. "Why Have Corporate Tax Revenues Declined?" in E. Helpman, A. Razin, and E. Sadka, eds., *Economic Effects of the Government Budget*. Cambridge, Mass.: MIT Press, 1988.

Barro, Robert J., and Chaipat Sahasakul. "Average Marginal Tax Rates from Social Security and the Individual Income Tax," *Journal of Business*, vol. 59, no. 4 (October 1986), pp. 555–66.

Benhabib, Jess, and Roger E.A. Farmer. "Indeterminacy and Increasing Returns," *Journal of Economic Theory*, vol. 63, no. 1 (June 1994), pp. 19–41.

________, **and Boyan Jovanovic.** "Externalities and Growth Accounting," *American Economic Review*, vol. 81, no. 1 (March 1991), pp. 82–113.

Braun, R. Anton. "Tax Disturbances and Real Economic Activity in the Postwar United States," *Journal of Monetary Economics*, vol. 33, no. 3 (June 1994), pp. 441–62.

Cassou, Steven P. "Optimal Tax Rules in a Dynamic Stochastic Economy with Capital," *Journal of Economic Dynamics and Control*, 1995 (forthcoming).

Chamley, Christophe. "Efficient Taxation in a Stylized Model of Intertemporal General Equilibrium," *International Economic Review,* vol. 26, no. 2 (June 1985), pp. 451 – 68.

_______ . "Optimal Taxation of Capital Income in General Equilibrium with Infinite Lives," *Econometrica,* vol. 54, no. 3 (May 1986), pp. 607 – 22.

Chari, V.V. "Time Consistency and Optimal Policy Design," in P.J. Miller, ed., *The Rational Expectations Revolution: Readings from the Front Line.* Cambridge, Mass.: MIT Press, 1994.

_______ , **Lawrence J. Christiano, and Patrick J. Kehoe.** "Optimal Fiscal Policy in a Business Cycle Model," *Journal of Political Economy,* vol. 102 (August 1994), pp. 617 – 52.

Christiano, Lawrence J. "Why Does Inventory Investment Fluctuate So Much?" *Journal of Monetary Economics,* vol. 21 (March/May 1988), pp. 247 – 80.

_______ , **and Martin Eichenbaum.** "Current Real-Business-Cycle Theories and Aggregate Labor-Market Fluctuations," *American Economic Review,* vol. 82, no. 3 (June 1992), pp. 430 – 50.

Guo, Jang-Ting, and Kevin J. Lansing. "The Welfare Effects of Tax Simplification: A General Equilibrium Analysis," Federal Reserve Bank of Cleveland, Working Paper 9409, September 1994a.

_______ , and _______ . "Tax Structure, Welfare, and the Stability of Equilibrium in a Model of Dynamic Optimal Fiscal Policy," Federal Reserve Bank of Cleveland, Working Paper 9410, September 1994b.

Hansen, Gary D. "Indivisible Labor and the Business Cycle," *Journal of Monetary Economics,* vol. 16, no. 3 (November 1985), pp. 309 – 27.

Jones, Larry E., Rodolfo Manuelli, and Peter E. Rossi. "On the Optimal Taxation of Capital Income," National Bureau of Economic Research Working Paper No. 4525, November 1993.

Jorgenson, Dale, and Martin A. Sullivan. "Inflation and Corporate Capital Recovery," in C.R. Hulten, ed., *Depreciation, Inflation, and the Taxation of Income from Capital.* Washington, D.C.: Urban Institute Press, 1981.

Judd, Kenneth L. "Redistributive Taxation in a Simple Perfect Foresight Model," *Journal of Public Economics,* vol. 28 (October 1985), pp. 59 – 83.

_______ . "Optimal Taxation in Dynamic Stochastic Economies: Theory and Evidence," Hoover Institution, unpublished manuscript, May 1989.

Juster, F. Thomas, and Frank P. Stafford. "The Allocation of Time: Empirical Findings, Behavioral Models, and Problems of Measurement," *Journal of Economic Literature,* vol. 29, no. 2 (June 1991), pp. 471 – 522.

Kydland, Finn E., and Edward C. Prescott. "A Competitive Theory of Fluctuations and the Feasibility and Desirability of Stabilization Policy," in S. Fischer, ed., *Rational Expectations and Economic Policy.* Chicago: University of Chicago Press, 1980a.

_______ , and _______ . "Dynamic Optimal Taxation, Rational Expectations, and Optimal Control," *Journal of Economic Dynamics and Control,* vol. 2, no. 1 (February 1980b), pp. 79 – 91.

_______ , and _______ . "Time to Build and Aggregate Fluctuations," *Econometrica,* vol. 50, no. 6 (November 1982), pp. 1345 – 70.

Lansing, Kevin J. "Optimal Fiscal Policy When Public Capital Is Productive: A Business Cycle Perspective," Federal Reserve Bank of Cleveland, Working Paper 9406, April 1994.

Long, John B. Jr., and Charles I. Plosser. "Real Business Cycles," *Journal of Political Economy,* vol. 91, no. 1 (February 1983), pp. 39 – 69.

Lucas, Robert E., Jr. "Supply-side Economics: An Analytical Review," *Oxford Economic Papers,* vol. 42, no. 2 (April 1990), pp. 293 – 316.

McGrattan, Ellen R. "The Macroeconomic Effects of Distortionary Taxation," *Journal of Monetary Economics,* vol. 33, no. 3 (June 1994), pp. 573 – 602.

________ , **Richard Rogerson, and Randall Wright**. "Household Production and Taxation in the Stochastic Growth Model," Federal Reserve Bank of Minneapolis, Staff Report No. 166, December 1993.

Prescott, Edward C. "Theory ahead of Business Cycle Measurement," Federal Reserve Bank of Minneapolis, *Quarterly Review,* Fall 1986, pp. 9 – 22.

Ramsey, Frank P. "A Contribution to the Theory of Taxation," *Economic Journal,* vol. 37 (March 1927), pp. 47 – 61.

Rogerson, Richard. "Indivisible Labor, Lotteries, and Equilibrium," *Journal of Monetary Economics,* vol. 21 (1988), pp. 3 – 16.

Sargent, Thomas J. *Dynamic Macroeconomic Theory.* Cambridge, Mass.: Harvard University Press, 1987.

Stokey, Nancy L., and Robert E. Lucas, Jr. *Recursive Methods in Economic Dynamics.* Cambridge, Mass.: Harvard University Press, 1989.

Zhu, Xiaodong. "Optimal Fiscal Policy in a Stochastic Growth Model," *Journal of Economic Theory,* vol. 58, no. 2 (December 1992), pp. 250 – 89.

Cross-Lender Variation in Home Mortgage Lending

by Robert B. Avery,
Patricia E. Beeson,
and Mark S. Sniderman

Robert B. Avery is an associate professor in the Department of Consumer Economics and Housing, Cornell University, and Patricia E. Beeson is an associate professor of economics at the University of Pittsburgh; both are visiting scholars at the Federal Reserve Bank of Cleveland. Mark S. Sniderman is senior vice president and director of research at the Federal Reserve Bank of Cleveland. The authors thank Glenn Canner, Charles Carlstrom, John Duca, Stuart Gabriel, Jagadeesh Gokhale, John Ham, Joseph Haubrich, Stuart Rosenthal, Peter Rupert, and Peter Zorn for helpful comments and suggestions.

Introduction

Federal fair housing and credit legislation addresses two major requirements. First, depository institutions must help meet the credit needs of their communities in a manner consistent with safe and sound lending practices (Community Reinvestment Act of 1977 [CRA]). Second, lenders must not discriminate against individual applicants on the basis of race, ethnic origin, gender, or religion (Equal Credit Opportunity Act of 1974 [ECOA]) and Fair Housing Act of 1968 [as amended in 1988]). Government agencies charged with regulating depository institutions are responsible for monitoring individual lenders' compliance with these statutes.

Historically, enforcement of the CRA and fair lending statutes has relied on qualitative, nonstatistical methods. CRA examinations, for example, have focused primarily on procedural issues. With rare exception, regulators have considered the actions of individual complainants to enforce the other fair lending statutes. In the past year, both community activists and lenders have called for strategies to move toward more quantitative, outcome-based enforcement procedures. These calls stem, in part, from a belief that CRA and fair lending policy guidelines are unclear and often counterproductive, and perhaps more likely to generate paperwork than loans and services.

A recent change in the reporting requirements of the Home Mortgage Disclosure Act (HMDA) makes the move toward outcome-based enforcement procedures seem much more feasible. Since 1990, lenders in urban mortgage markets have been required to report to regulators the neighborhood (census tract) and a limited number of other characteristics (such as loan size, applicant race and income, and government guarantee) of all applications for mortgage credit during each calendar year. These data permit the quantitative comparison of a number of lending activities across lenders. Indeed, recent proposals by the bank regulatory agencies call for the use of HMDA data in evaluating CRA and fair lending compliance for lenders.[1]

The objective of this study is to evaluate the feasibility of using HMDA data to form quantitative measures of lender activity for use in enforcement. We consider three potential measures of firm-level mortgage lending activity:

■ 1 See "Community Reinvestment Act Regulations," *Federal Register*, October 7, 1994 (59 FR 51232).

loan application rates, loan approval rates, and loan origination rates. We examine the extent to which the three measures can differentiate among banks with respect to how they serve four subpopulations cited in the fair lending laws: minority loan applicants, applicants for loans in minority neighborhoods, low-income loan applicants, and applicants for loans in low-income neighborhoods. Using national filings for the first year of the new HMDA regulations, 1990, we compare the performance of measures adjusted and unadjusted for local conditions and borrower characteristics.

Several conclusions emerge. We find that variation across lenders in loan originations to each of the four subpopulations is driven primarily by variation in application rates, not by variation in lender approval rates. This finding holds when both unadjusted and adjusted measures are examined and for a wide variety of lender groups sorted by size and type of institution. Furthermore, we find virtually no correlation between application rates and approval rates, so using indices based only on approval rates can be potentially misleading when evaluating individual lenders' compliance with the CRA. Indeed, variation in application rates appears to play a much more significant role in explaining variation in credit flows. Furthermore, focusing on approval rates may lead to outcomes that are counter to the intent of the legislation: To improve their minority-to-white approval rates, some lenders may discourage applications from all but the most creditworthy minority applicants, thereby reducing credit originations to minority and low-income communities.

One objection that has been raised to the use of application rates in evaluating lender compliance is that these rates are determined primarily by the neighborhoods that lenders serve. Our evidence suggests that this is not the case. Most of the variation in application rates stems from differences in the applicants that lenders attract *within* neighborhoods and not from the general racial characteristics of the neighborhoods as a whole. Finally, we also find that controlling for the economic characteristics and neighborhoods of the loan applicants provides relatively little power in explaining cross-lender differences. This suggests that gross application and approval-rate measures may give relatively good rankings of bank performance.

I. Background of Fair Housing Legislation

In response to community concerns about the flow of housing credit to minority and low-income communities and about the extent to which individual lenders were meeting the credit needs of their communities, Congress passed a series of laws during the 1970s. The ECOA of 1974 and the Fair Housing Act of 1968 (as amended in 1988) mandate that lenders do not discriminate against individual applicants on the basis of race, ethnic origin, gender, or religion. Two other laws were enacted primarily to fight geographic discrimination. HMDA, enacted in 1975, requires certain lenders to report annually the number and dollar value of mortgage loans they make in their communities according to census tract. Under the terms of the CRA, enacted in 1977, depository institutions must help meet the credit needs of their communities, including low- and moderate-income neighborhoods, in a manner consistent with safe and sound lending practices.

Monitoring individual lenders for compliance with these fair lending statutes is problematic. The standard for compliance with the ECOA is relatively well defined—other things equal, lenders cannot discriminate on the basis of race or property location. This implies that lenders must treat "comparable" applications from members of different racial groups and neighborhoods equally. Problems arise, however, in determining what types of behavior are considered discriminatory and in measuring whether two applications are the same except for the applicant's race and the property location.[2] Moreover, focus on the treatment of formal applications sidesteps the issue of indirect screening, whereby applicants are screened out before they formally apply. These concerns have shifted much of the focus in current enforcement of ECOA from procedures to outcomes. If the outcome of the process differs across racial groups or neighborhoods, then the burden of proof is on the lender to demonstrate that its procedures are not biased. For example, the lender can show that the differences arise from variables other than race and that the use of these variables in loan screening can be justified by their relationship to costs or loan performance. If differential outcomes in origination rates create the prima facie case for

■ 2 See Wienk (1992) for a discussion of conceptual and measurement problems related to assessing the degree of discrimination in credit markets.

bias, the lender could face an examination of its application and approval rates, as both affect originations.

CRA is concerned with the extent to which individual lenders extend credit to various groups within their market areas. While Congress did not articulate the standards for compliance beyond "meeting the credit needs of the community," the bank regulatory agencies responsible for enforcement issued joint policy statements in 1980 and 1989 reflecting their procedures. Apart from periodic examinations for compliance, regulators are required to take account of an institution's CRA record in assessing applications for regulatory actions such as mergers. Since 1990, lenders have also been required to give the public access to their examination assessments. Enforcement of CRA has generally focused on procedures rather than outcomes. Regulators have given significant weight to evidence of affirmative action—for instance, the location of loan offices, number of minority loan officers, methods of advertising, participation in community development banks, and availability of special low- to moderate-income housing programs.

On the surface, ECOA and CRA appear to address different aspects of the lending process. ECOA is concerned primarily with individuals, equal treatment, and race; CRA involves neighborhoods, credit flows, and income. More recently, though, enforcement of both acts has begun to evolve along quite similar lines. Regulators consider fair lending practices a critical factor in assigning CRA ratings. Moreover, as a practical matter, CRA enforcement has begun to place more weight on racial issues rather than focusing exclusively on income.

HMDA was instituted to provide regulators and the public with information on how lenders were serving low-income areas. Data reported under HMDA are now integral to enforcement efforts for both ECOA and CRA. Initially, depository institutions were required to report mortgage lending totals by census tract with no disaggregation by race, but concerns arose about the dearth of data available to analyze the reasons for differential mortgage credit flows and individual discrimination in mortgage lending. Amendments to HMDA in 1989 now require most mortgage lenders to collect and report information on all individual loan applications taken, whether approved or not. In addition, some applicant information is now recorded, most notably income, loan amount requested, property location, gender, and race.

Many informative HMDA-based studies addressing issues concerning both ECOA and CRA have appeared during the past 15 years. Because the pre-1990 HMDA data contain no information about the individual applicants or about applications that were not approved, most of the early studies focus on the flow of credit to various neighborhoods (CRA), as opposed to a consideration of discrimination against particular loan applicants (ECOA). These studies ask whether mortgage lenders in an area, *taken collectively,* provided mortgage credit in predominantly minority or low-income neighborhoods at diminished rates relative to predominantly white or higher-income neighborhoods. Although researchers generally find disparate lending patterns between white and minority (or low-income) neighborhoods, they do not consider differences in lending patterns across individual lenders: Are these neighborhoods receiving less credit because each lender originates only a few loans in these areas, or because there are only a few lenders operating in these areas?[3] In addition, the data do not allow a clean investigation of the roles of credit supply and credit demand: Are these neighborhoods receiving less credit because of lender bias, or because lenders are not receiving comparable numbers of qualified applications from the various neighborhoods examined?

The expanded HMDA data set has spawned a number of new analyses of individual and neighborhood discrimination. Using information from a special survey that supplemented HMDA data for Boston, Munnell et al. (1992) examine the role of individual characteristics, particularly race, in loan approval. Avery, Beeson, and Sniderman (1993) discuss similar issues using 1990 and 1991 HMDA data drawn from the whole country. The role of neighborhood racial composition in generating applications and approving loans is explored in Avery, Beeson, and Sniderman (1994).

Many questions remain as to the appropriate methods of CRA and ECOA enforcement and the nature of the data collected to support this effort. Critics of the CRA, in particular, have argued that enforcement efforts need to focus

■ 3 Using pre-1990 HMDA data, Canner (1981), Avery and Buynak (1981), Avery and Canner (1983), and Bradbury, Case, and Dunham (1989) contrast the differences in mortgage credit originations between predominantly white and predominantly minority neighborhoods in various metropolitan statistical areas (MSAs). One of the few studies to look at lenders is Calem (1993). He contrasts the experiences of individual lenders participating in a Philadelphia area mortgage-lending plan with those who did not participate. However, his paper does not document the existence of lender differences in the penetration of minority communities; his primary focus is on the characteristics of the voluntary mortgage plan operated by *a group of lenders.* Avery (1989) notes the differences between studies based on lending in a neighborhood and the procedures adopted by individual lenders.

BOX 1

HMDA Data and Methodology

Overall, HMDA reported information on 6,595,089 loan applications and purchases in 1990. Of these, 1,137,741 were purchased from other institutions and 1,523,429 were applications received for properties outside an MSA. Excluding these left 3,933,919 applications (59.6 percent) to reporting institutions for properties within an MSA in which the lender had an office. Of these applications, 787,952 were for home improvement loans, 716,595 were for refinancing of one- to four-family home loans, and 32,176 were for multifamily home loans. An additional 241,295 applications were never acted on because they were either withdrawn by the applicant or closed due to incompleteness. Eliminating these from our sample left a total of 1,984,688 loan applications that met the study criteria.

Not surprisingly, the initial HMDA filings contained many errors and inconsistencies that required extensive editing by the receiving federal agencies. Unfortunately, these procedures do not appear to have been uniformly applied, requiring additional cleaning and editing for this study. In addition, smaller institutions were not required to report race, income, and gender for loan applicants. We decided to deal with missing data using a "hot deck" imputation procedure similar to that used by the U.S. Census Bureau. Applications with missing data were statistically matched to applications in the same census tract that came closest to them in reported characteristics (race, loan action, income, and loan amount). Missing values were filled in using the variable value of the matched observation. Applications with implausible reported values were treated as missing and imputed in the same way. Overall, income was imputed for 4.9 percent, loan amount for 1.5 percent, gender for 4.0 percent, and race for 5.6 percent of the study sample applications.

more on performance and less on process. In this spirit, the bank regulatory agencies have recently called for comments on a comprehensive reform of CRA regulations and enforcement procedures. The proposed reforms would institute a new system of evaluation based primarily on performance. The data reported under HMDA are critical to the success of such an effort, both for quantifying an institution's own performance and for providing a benchmark of what other institutions are doing.

Because the new regulations encompass an expanded role for HMDA data, it is natural to ask how capable the data are for meeting this task. The new regulations call for only a mild expansion of HMDA, so the current data are representative of what would be available in the future. In this paper, we use the existing data to examine their effectiveness in providing the quantitative measures of institutional performance called for by the proposed new regulations. We examine three potential outcome measures: loan origination rates, loan application rates, and application approval rates. These are used to compare institutions' performance in serving four subpopulations cited by CRA: minority individuals, minority neighborhoods, low-income individuals, and low-income neighborhoods. In each case, we compare the rankings implied by gross outcome measures with those adjusted for neighborhood and applicant characteristics.

II. Data Description

Amendments to HMDA in 1989 now require most depository institutions (and certain other mortgage lenders) to collect and report information on all individual loan applications taken for home purchase, mortgage refinance, and home improvements, whether approved or not. This study makes use of the HMDA data for 1990 — the first release of the new data — which represent the most comprehensive survey of mortgage lending in the United States.[4] All commercial banks, savings and loan associations, credit unions, and other mortgage lending institutions (primarily mortgage bankers) that have assets of more than $10 million, make one or more one- to four-family home purchase loans, and have an office in a metropolitan statistical area (MSA) are required to meet HMDA reporting requirements.

For each mortgage application received or mortgage loan purchased from another institution during the calendar year, the lender must report the loan amount; the location of the property (state, county, and 1980 census tract number); whether the property is owner-occupied; the loan purpose (home purchase, home improvement, or refinancing for one- to four-family or multifamily unit); the type of loan (conventional, FHA, VA, guaranteed by Farmers Home Administration [FmHA]); the action taken by the lender (loan approved and originated, application approved but withdrawn, application denied, application withdrawn before lender action, file closed for incompleteness, loan purchased from another institution); the race and gender of the loan applicant (and co-applicant, if

4 At the time this paper was published, 1991 and 1992 HMDA data were also available. Although not reported here, analysis of data from these later years suggests similar conclusions to those presented here.

TABLE 1

Characteristics of Home Mortgage Applications, 1990 HMDA

	Percent of Sample	Percent of Loan Dollars	Approval Rate
Race of Applicant			
Native American	0.6	0.6	80.7
Asian (or Pacific Islander)	4.6	6.8	85.6
Black	6.2	4.8	70.6
Hispanic	6.6	6.4	77.9
White	81.4	80.5	86.9
Other	0.7	1.0	80.2
Race of Co-applicant			
No co-applicant	28.4	24.1	82.7
Same race as applicant	69.4	73.4	86.2
Different race than applicant	2.2	2.5	84.4
Loan Type			
Conventional	75.1	82.9	85.1
FHA	20.4	13.7	85.5
VA	4.5	3.5	84.2
FmHA	0.0	0.0	98.0
Lender Action			
Loan denied	14.8	13.1	
Loan accepted and withdrawn	2.9	3.5	
Loan originated	82.3	83.4	
Loan kept by originator[a]	44.9	47.7	
Loan sold to FNMA[a]	14.5	14.4	
Loan sold to GNMA[a]	10.5	7.6	
Loan sold to FHLMC[a]	9.0	9.1	
Loan sold elsewhere[a]	21.1	21.2	
Memo Items			
Median income		$48,000	
Median loan request		$77,000	
Number of loans		1,984,688	

a. Percent of originations.
SOURCE: Authors' calculations.

any); and the income relied on by the lending institution in making the loan decision.[5]

In total, 9,333 financial institutions filed HMDA reports in 1990 on more than 6 million loan applications and loan purchases. Our analysis focuses on a subset of these filings: applications for one- to four-family home purchase loans that were acted upon (approved or denied) by the lender. This sample includes 1,984,688 loan applications made to 8,745 separate lenders operating in 40,008 census tracts in all 340 of the U.S. MSAs defined as of 1990 (see box 1 for details).

The study sample has a substantial degree of representation from applicants of different races and income levels (table 1). Overall, however, applicants for home purchase mortgages are a select sample of American households. Applicants' median income ($48,000) is substantially higher than the median income of families in MSAs ($37,918) as reported in the 1990 decennial census.[6] The racial composition of the study sample also appears to differ somewhat from that of all U.S. families. Blacks filed 6.2 percent of the HMDA housing loan applications, yet were 7.7 percent of the homeowners and headed 11.4 percent of the MSA households. Asian loan applicants (4.6 percent), however, were overrepresented compared with their numbers in the census (2.5 percent of MSA household heads and 2.2 percent of homeowners). The share of white (81.4 percent) or Hispanic (6.6 percent) applicants is approximately representative of their numbers (78.1 percent of household heads and 84.8 percent of homeowners for whites and 7.5 percent of household heads and 5.0 percent of homeowners for Hispanics).[7]

Also worth noting is the substantial presence of the federal government in mortgage lending. One-quarter of the mortgages issued were directly guaranteed by the federal government (FHA, VA, or FmHA), with an additional quarter purchased in the secondary market by one of the federal housing credit agencies (FNMA and FHLMC).[8] Indeed, 55 percent of all mortgages issued were sold in the secondary market, suggesting that the study of mortgage lending patterns is more an analysis of a brokered industry than one where participants buy for their own portfolios.

Sample characteristics are broken down by type of lender and applicant in table 2. Lender here is defined at the MSA level. Thus, a lender reporting loans for two different MSAs is treated as two different lenders.[9] Lenders, shown in the rows, are grouped by size and

5 See Canner and Smith (1991, 1992) for a full description of the HMDA data. Information on income, race, and sex of the applicant does not have to be supplied by reporting institutions with assets less than $30 million or for purchased loans.

6 In the HMDA data, household income may be slightly understated because it reflects only the portion of an applicant's income needed for mortgage qualification.

7 The percent Hispanic in the HMDA sample is slightly higher than the share for the overall U.S. population, due in part to the inclusion of Puerto Rico.

8 These acronymns represent, respectively, the Federal Housing Administration, Veterans Administration, Farmers Home Administration, Federal National Mortgage Association, and Federal Home Loan Mortgage Corporation.

9 The 8,745 financial institutions with loans in the study sample operated in an average of 2.4 MSAs. This translated into 20,695 study lenders when lenders were defined at the MSA level.

TABLE 2

Minority and Low-Income Individuals and Tracts Relative to Total Mortgage Lending, 1990 HMDA

		Minority[a]				Low-Income[b]			
	Overall Approval Rate	Percent Applications[c]	Percent Originations[c]	Approval Rate	Relative Approval Rate	Percent Applications[c]	Percent Originations[c]	Approval Rate	Relative Approval Rate
Type of Institution									
Commercial banks	0.82	11.2	9.1	0.67	0.81	20.5	17.4	0.69	0.85
Thrift institutions	0.87	13.9	12.5	0.78	0.90	11.0	9.6	0.76	0.87
Credit unions	0.89	9.0	7.7	0.77	0.86	15.6	13.4	0.77	0.86
Bank subsidiaries	0.84	12.7	11.1	0.73	0.87	17.9	14.5	0.68	0.81
Thrift subsidiaries	0.86	14.2	12.0	0.72	0.84	14.5	12.6	0.74	0.87
Other mortgage banks	0.87	15.9	14.3	0.79	0.90	12.0	11.1	0.81	0.92
Size of Institution									
> 500 applications	0.86	17.1	15.3	0.77	0.90	12.1	10.4	0.74	0.86
100 – 500 applications	0.85	10.9	9.2	0.72	0.85	17.0	14.5	0.73	0.85
< 100 applications	0.84	9.5	8.1	0.71	0.85	17.6	14.7	0.70	0.83
Market Share of Institution									
> 5 percent	0.86	14.2	12.3	0.74	0.87	16.9	14.5	0.73	0.86
1–5 percent	0.85	13.2	11.7	0.76	0.89	14.2	12.0	0.72	0.85
< 1 percent	0.84	11.6	10.1	0.73	0.87	12.4	10.4	0.70	0.84
Size of MSA									
> 25,000 applications	0.86	18.1	16.5	0.78	0.91	8.6	7.4	0.74	0.86
< 25,000 applications	0.85	10.9	9.2	0.72	0.85	18.2	15.4	0.72	0.85
Percent Minority Applications									
> 22 percent	0.80	31.8	29.5	0.75	0.93	12.8	9.6	0.66	0.82
< 22 percent	0.86	10.3	8.9	0.75	0.87	15.5	13.2	0.73	0.85
Total	0.85	13.3	11.7	0.75	0.88	15.0	12.7	0.72	0.85

		Minority Census Tracts[d]				Low-Income Census Tracts[e]			
	Overall Approval Rate	Percent Applications[c]	Percent Originations[c]	Approval Rate	Relative Approval Rate	Percent Applications[c]	Percent Originations[c]	Approval Rate	Relative Approval Rate
Type of Institution									
Commercial banks	0.82	11.0	9.3	0.69	0.85	22.5	20.1	0.76	0.93
Thrift institutions	0.87	13.2	12.1	0.80	0.92	10.4	9.4	0.79	0.90
Credit unions	0.89	8.5	7.7	0.80	0.90	18.0	16.5	0.82	0.92
Bank subsidiaries	0.84	11.7	10.2	0.73	0.87	17.7	15.3	0.72	0.86
Thrift subsidiaries	0.86	13.3	11.3	0.73	0.85	17.0	14.9	0.75	0.88
Other mortgage banks	0.87	14.9	13.6	0.80	0.91	12.7	11.9	0.82	0.94
Size of Institution									
> 500 applications	0.86	16.7	15.2	0.78	0.91	10.8	9.4	0.75	0.88
100 – 500 applications	0.85	9.8	8.4	0.73	0.86	18.8	17.1	0.77	0.91
< 100 applications	0.84	8.9	7.8	0.74	0.88	19.8	18.0	0.76	0.90
Market Share of Institution									
> 5 percent	0.86	13.1	11.5	0.76	0.88	18.7	16.7	0.77	0.90
1–5 percent	0.85	12.5	11.3	0.77	0.90	14.4	12.9	0.76	0.90
< 1 percent	0.84	11.8	10.5	0.75	0.89	11.0	9.9	0.75	0.89
Size of MSA									
> 25,000 applications	0.86	18.8	17.3	0.79	0.92	5.7	5.1	0.77	0.90
< 25,000 applications	0.85	9.5	8.2	0.73	0.86	20.4	18.4	0.76	0.90
Percent Minority Applications									
> 22 percent	0.80	40.2	38.2	0.77	0.88	12.5	10.7	0.69	0.86
< 22 percent	0.86	8.0	7.1	0.75	0.95	16.0	14.4	0.77	0.90
Total	0.85	12.6	11.2	0.76	0.89	15.5	13.9	0.76	0.90

a. Native Americans, blacks, and Hispanics.
b. Applicant income below $25,000.
c. Percent of applications received (loans originated) by each class of lender from minority applicants or low-income tracts.
d. Census tracts with more than 30 percent of loan applications from minority applicants.
e. Census tracts with more than 30 percent of loan applications from low-income applicants.
SOURCE: Authors' calculations.

type of institution and by the size and minority population of their MSA as shown in the rows of the table. Applicants are grouped into five categories shown in the columns: 1) overall; 2) minority (native American, black, and Hispanic, about 13 percent of applicants); 3) low-income (family income of $25,000 or less, roughly the bottom 15 percent of applicants); 4) residents of minority census tracts (those with more than 30 percent of loan applications from minority applicants, roughly 13 percent of applicants); and 5) residents of low-income census tracts (those with more than 30 percent of loan applications from low-income applicants, again roughly 15 percent of applicants).[10] For each applicant category, we show the percent of the lender-type's loan applications or originations made to members of the category.[11] We also present the category approval rate (the portion of all loan applications from members of the category that are approved) and the relative approval rate (the ratio of the category approval rate to the overall approval rate for all applicants), shown in column 1.

There is little evidence that specific types of lenders, such as commercial banks or thrifts, specialize in minority lending. On the other hand, at least superficially, it would appear that there is specialization by *size* of lender. About 17 percent of the applicants to lenders receiving more than 500 home purchase loan applications were minorities, with a similar percentage from minority tracts. Smaller lenders (those with less than 100 applicants) took in only 9 percent of their applications from these categories. However, much of this difference may simply reflect the concentration of large lenders in large MSAs, where there is also a high concentration of minority applicants and minority tracts. Within MSAs, the difference in minority share between the larger institutions (those with market shares exceeding 5 percent) and small institutions is much less.

The picture looks somewhat different for low-income applicants. Commercial banks and their subsidiaries receive a disproportionately large share of low-income applications; on the other hand, a disproportionately small percentage of thrift business comes from low-income borrowers or tracts. Larger lenders also receive disproportionately fewer low-income loan applications. Again, though, this appears to be a result of the between-MSA distribution of applicants. Within MSAs, the largest lenders tend to receive *more* low-income applications.

Finally, we note that the specific measure used to compare minority and nonminority lending or low-income and high-income lending has little impact on the distribution across lenders. The same patterns are found when minority lending is measured by the number of minority applications, the number of applications from minority census tracts, the dollar value of minority applications (not shown), or the dollar value of applications from minority tracts (not shown). Similarly, for low-income lending, the cross-lender distribution is the same whether lending is measured by the number or dollar value of loans or whether income is measured by the applicant or tract.

III. Variance in Lending Patterns

The sample statistics reported in the previous section reflect the *average* percentage of loan applications from minority and low-income individuals (or tracts) and the *average* approval rate on those applications by various types of lending institutions. These statistics could be thought of as describing the prototypical lender in the mortgage market, not the actions of any individual lender operating in that market, and as ignoring the variation across these individual lenders. In this section, we compare three measures of individual lender performance: 1) minority and low-income origination rates (the share of loans originated going to minorities or low-income individuals or tracts), 2) application rates (the share of applications received from minorities or low-income individuals or tracts), and 3) relative approval rates (differences in the actions taken on applications).

We first address the relationship among these three measures. Because origination rates are equal to the product of application rates and relative approval rates, we would like to know the extent to which credit origination differences among lenders stem from the former factor versus the latter. That is, if we are concerned about credit flows to minority and

10 The decision to treat Asians and "other race" applicants as nonminorities was somewhat arbitrary. As shown in table 1, the overall acceptance rate for Asian home purchase loan applicants is much closer to the white acceptance rate than to acceptance rates for blacks, Hispanics, or native Americans. We note, though, that the acceptance rates for Asian refinance and home improvement loan applicants are closer to those of Hispanic applicants than to those of whites.

11 We count all applications approved by the lender as "originations." In fact, some applications (2.9 percent) are approved by the lender but are subsequently withdrawn by the borrower. In these cases, the loan will not actually be made.

TABLE 3

Analysis of Variance in Origination Rates across Lenders, 1990 HMDA

	Number of Lenders	Number of Applications	Origination Rate: Mean	Origination Rate: Standard Deviation[a]	Regression R-Squared[a]	Percent Attributable to Variance in:[b] Minority/Low-Income Application Rate	Percent Attributable to Variance in:[b] Relative Approval Rate
Minority							
Number	11,598	1,867,211	0.16	0.18	0.92	86.7–90.7	9.3–13.3
Dollar value	11,598	1,867,211	0.14	0.18	0.91	87.4–91.1	8.9–12.6
Center city	8,548	745,161	0.23	0.22	0.93	82.5–88.5	11.5–17.5
Minority Tracts							
Number	8,846	1,624,207	0.20	0.19	0.91	88.7–91.9	8.1–11.3
Dollar value	8,846	1,624,207	0.17	0.19	0.91	89.7–92.2	7.8–10.3
Low-Income Applicants							
Number	13,651	1,918,018	0.21	0.19	0.91	85.4–87.8	12.2–14.6
Dollar value	13,651	1,918,018	0.16	0.19	0.92	88.4–90.7	9.3–11.6
Center city	9,668	764,423	0.26	0.23	0.93	81.7–85.8	14.2–18.3
Low-Income Tracts							
Number	11,024	1,566,699	0.32	0.24	0.94	90.2–92.6	7.4–9.8
Dollar value	11,024	1,566,699	0.27	0.23	0.94	93.3–95.3	4.7–6.7

a. Expressed as deviation around MSA means.
b. Minimum and maximum contributions to variance based on deviations around MSA means.
SOURCE: Authors' calculations.

low-income applicants and neighborhoods, does variation across lenders arise primarily from differences in treatment or in application rates?

An approximate answer to this question can be obtained by estimating the following equation:

$$(1)\quad \textit{Origination rate}_L = \beta_1 MSA_L + \beta_2\ \textit{application rate}_L + \beta_3\ \textit{relative approval rate}_L + e_L,$$

where the origination rate for lender L equals minority (or low-income) originations as a portion of total originations, MSA_L is a vector of dummy variables indicating the metropolitan area in which lender L operates, application rate is minority (or low-income) applications as a share of total applications, and relative approval rate is the minority (or low-income) approval rate divided by the overall approval rate. The MSA fixed effects control for differences in the mortgage lending market that are common to all lenders in that market but may vary across markets, such as the size of the minority population or lending practices.

Fitting equation (1) provides an estimate of the relative importance of application rates and approval rates in explaining variation in origination rates. Unfortunately, as with any regression, because application rates and relative approval rates are likely to be correlated, we cannot compute a precise estimate of the contribution of each component to the variation in origination rates. However, several approximate estimates are possible. We determine a lower bound on the contribution of each component by estimating its marginal contribution; that is, the additional variation in origination rates explained by adding the component to a model containing the other component. We compute an upper bound on the contribution of each component from its univariate fit — the proportion of the variation in origination rates that it explains by itself. The difference in the lower and upper bound estimates derives from how the impact of the covariance between the two components is assigned. The lower bound estimate assigns the covariance to the other component, and the upper bound assigns the full effect of the covariance to the variable in question.

Table 3 reports the allocation of variance for estimates of equation (1) for several different origination rates. The variance associated with MSAs is removed from the total before we measure the contributions of the application and relative approval rates. Thus, we are decomposing the variance in the deviations about MSA means. Row 1 shows the variance in decomposition across lenders for the origination rate of minority individuals. Row 4 shows the decomposition for originations in minority tracts. Rows 6 and 9 show the decomposition for low-income individuals and tracts, respectively. Rows 2, 5, 7, and 10 report decompositions for origination rates weighted by dollars. Finally, decompositions for minority and low-income individuals applying in central cities are shown in rows 3 and 8.

For each decomposition estimated, the sample includes all lenders for which the origination rate, application rate, and relative approval rate are defined. We note that this reduces the sample of lenders substantially from the full sample reported in tables 1 and 2. For example, the sample used for minority individuals includes only 11,598 of the 20,695 HMDA-reporting lenders (40 percent were dropped because they had no minority applicants and 3 percent because they had no originations of any type). However, these lenders received 1,867,211 of the 1,984,688 full sample applications (94 percent). Moreover, the percentage of applications made by minorities in the decomposition sample (14.1 percent) is only slightly higher than in the full sample (13.3 percent).

For each decomposition, we present several statistics. In columns 3 and 4, we show the mean and standard deviation of the origination rate across lenders. Note that the mean origination rate across lenders is generally higher than the sample average, indicating that smaller lenders make more of their loans to minorities or low-income individuals. In column 5, we show the R-squared of the estimated equation (1). Both the R-squared and standard deviations are adjusted for deviations about MSA means. Finally, in columns 6 and 7, we show the percentage of the total variation of the origination rate that can be attributed to the application rate or relative approval rate, adjusted for MSA fixed effects.

We find that the overwhelming majority of the cross-lender variance in minority originations is attributable to differences in minority application rates. Differential approval rates by race account for a relatively small portion of the variance. For example, after controlling for MSA differences, 87 to 90 percent of the variance in originations to minority individuals is captured by lender-specific differences in minority application rates; only 10 to 13 percent stems from different approval rates for these applications. This narrow range suggests that the contribution of the covariance is quite small, which greatly enhances our ability to identify the importance of the application rates.

Our results concerning low-income lending are much the same as those for minority lending. The only difference is that the ranges for low-income lending are somewhat larger than those for minority lending, indicating that the covariance between application rates and relative approval rates contributes more to the cross-lender variance in low-income originations than it does to the cross-lender variance in minority origination rates. The results are virtually identical when dollar values are used or when census tracts rather than individual applicant characteristics are examined. Restriction of the sample to central cities does little to alter the results, other than showing a slight increase in the variance that may be attributable to relative approval rates.

To examine the robustness of these results further, table 4 reports the allocation of the variance across lenders in minority originations for lenders grouped by type, size, and market share of institution, and by MSA size and percent minority. The dominance of differences in application rates as the source of lender differences in minority origination rates holds across all types of lenders, all sizes of lenders (measured in terms of both the volume of applications received by the lender and the lender's market share), and types of MSAs. Even for mortgage banks (subsidiaries of depository institutions as well as independents), where the contribution is smallest, cross-lender differences in application rates account for at least three-quarters, and may account for as much as 90 percent, of the variance in minority originations.

The contribution of minority application rates to the variance in originations is smallest among small lenders, regardless of the type of lender. For the largest lenders (those with 500 or more applications), differences in application rates account for 93 to 99 percent; for lenders with less than 100 applications, they account for 85 to 89 percent. This is also true when size is measured by market share. Differences in lender minority application rates account for 96 to 97 percent of the variance across those with 5 percent or more of the market, and for 84 to 89 percent across lenders with less than 1 percent of the market. Although not presented here, similar conclusions hold for the decomposition of minority tracts and low-income individuals and tracts by lender types and size.

TABLE 4

Allocation of Variance in Minority Origination Rates by Type and Size of Lender, 1990 HMDA

	Origination Rate			Percent Attributable to Variance in:[b]	
	Mean	Standard Deviation[a]	Regression R-Squared[a]	Minority/Low-Income Application Rate	Relative Approval Rate
Type of Institution					
Commercial banks	0.13	0.19	0.91	86.5–91.1	8.9–13.5
Thrift institutions	0.11	0.14	0.93	92.0–93.9	6.1–8.0
Credit unions	0.18	0.29	0.97	85.2–93.1	6.9–14.8
Bank subsidiaries	0.13	0.15	0.88	80.4–83.4	16.6–19.6
Thrift subsidiaries	0.13	0.18	0.90	74.2–81.7	18.3–25.8
Other mortgage banks	0.16	0.18	0.94	86.5–90.2	9.8–13.5
Size of Institution					
More than 500 applications	0.13	0.09	0.99	92.8–98.8	1.2–7.2
100 to 500 applications	0.09	0.08	0.96	96.5–98.0	2.0–3.5
Less than 100 applications	0.15	0.21	0.92	85.0–89.3	10.7–15.0
Market Share of Institution					
More than 5 percent	0.10	0.07	0.95	95.7–97.3	2.7–4.3
1 to 5 percent	0.11	0.09	0.93	92.8–94.1	5.9–7.2
Less than 1 percent	0.20	0.22	0.92	84.0–88.7	11.3–16.0
Size of MSA					
More than 25,000 applications	0.15	0 20	0.94	86.4–91.0	9.0–13.6
Less than 25,000 applications	0.18	0.17	0.91	86.6–90.4	9.6–13.4
Percent Minority Applications					
More than 22 percent	0.36	0.24	0.94	76.6–86.8	13.2–23.4
Less than 22 percent	0.13	0.17	0.92	87.7–91.0	9.0–12.2
Total	0.16	0.18	0.92	86.7–90.7	9.3–13.3

a. Expressed as deviation around MSA means.
b. Minimum and maximum contributions to variance based on deviations around MSA means.
SOURCE: Authors' calculations.

We conclude that differences in the relative approval rates of minority and low-income loans account for only a small portion of the variance across institutions in the portion of originations going to minority and low-income applicants. In the following section, we examine various factors that may be contributing to the cross-lender variance in application and approval rates.

IV. Sources of Cross-Lender Variance in Lending Patterns

The outcome measures presented in the previous section are gross measures of lender performance. As such, they do not control for exogenous market factors that affect lender performance but that are beyond the lender's control. The effects of any such exogenous factors should be removed before constructing measures of lender performance to be used in CRA and fair lending evaluation. Although it by no means contains an exhaustive list, HMDA includes information on a number of applicant characteristics that arguably should be controlled for: loan size, applicant income, loan type (FHA/VA or conventional), and property location. To the extent that these factors are correlated with race, this specialization will contribute to the observed cross-lender variance in minority application rates. Similarly, to the extent that they are correlated with creditworthiness, these applicant characteristics may also be contributing to the observed differences in relative approval rates. In this section, we examine the effect of removing these factors on our assessment of various measures of lender performance. We focus on individual minority application rates and relative approval rates, although our results hold for low-income and neighborhood taxonomies as well.

We compute adjusted indices as the lender average for each variable after the effects of property location and applicant characteristics are removed. For the application and overall approval rate, this is estimated directly from a fixed-effects linear probability model, where the fixed effects are, by construction, the average of the dependent variable after the effects of other variables are removed. The fixed-effects linear probability models used to compute the adjusted indices were estimated with the full 1,984,688 loan sample, and have the following form:

$$(2) \quad APPLICATION_{iMTL} = \beta_A AC_i + \beta_M MSA_M + \beta_T TRACT_T + \beta_L LENDER_L + u_{iMTL},$$

$$(3) \quad APPROVAL_{iMTL} = \Gamma_A AC_i + \Gamma_R RACE_i + \Gamma_M MSA_M + \Gamma_T TRACT_T + \Gamma_L LENDER_L + v_{iMTL},$$

where *APPLICATION* is coded one if the ith applicant using the Lth lender in the Mth MSA and Tth census tract is a minority (native American, black, or Hispanic) and zero otherwise; and *APPROVAL* is coded one if the ith applicant loan using the Lth lender in the Mth MSA and Tth census tract is approved and zero otherwise. *AC* is a vector of application characteristics reported in the HMDA data, including gender, marital status, occupancy, income, loan amount, income-to-loan ratio, loan type, and interactions among these variables. *RACE* includes dummy variables for six applicant and two co-applicant racial categories. The racial dummies are also interacted with FHA and VA loan dummies. *MSA, TRACT,* and *LENDER* are dummy variables indicating which of the 340 MSAs, 40,008 census tracts, and 20,695 lenders the application relates to, and u and v are residuals. By construction, the MSA effects are normalized to have an overall mean of zero, and within each MSA, the lender and tract effects are normalized to have means of zero.[12]

Adjusted indices for the minority and relative approval rates are more complicated to estimate because they involve the ratio of predictions for two groups. For these calculations, we used variants of the fixed effects, computed by averaging lender residuals from the overall approval rate model separately for minorities and nonminorities. Thus, the adjusted lender indices were taken either as the direct LENDER fixed effects estimated in equations (2) and (3) or computed as lender residuals averaged over the minority and nonminority subgroups. Finally, we were also interested in computing the average lender "quality" of applicants as measured by their average *AC* and *TRACT* effects. The exact construction of each of the variables used in this portion of the analysis is

1) the average economic characteristic effects of the Lth lender's applicants,

$$AC_{app} = \Sigma_{i \in L} \beta_A AC_i / N,$$

$$AC_{apr.\ minority} = \Sigma_{j \in L} \Gamma_A AC_j / N_j, \text{ for all minority applicants } j,$$

$$AC_{apr.\ nonminority} = \Sigma_{k \in L} \Gamma_A AC_k / N_k, \text{ for all nonminority applicants } k;$$

2) the average census tract effects of the lender's applicants,

$$TRACT_{app} = \Sigma_{i \in L} \beta_T TRACT_i / N,$$

$$TRACT_{apr.\ minority} = \Sigma_{j \in L} \Gamma_T TRACT_j / N_j, \text{ for all minority applicants } j,$$

$$TRACT_{apr.\ nonminority} = \Sigma_{k \in L} \Gamma_T TRACT_k / N_k, \text{ for all nonminority applicants } k;$$

3) and the adjusted lender indices, estimated directly as fixed effects or averaged separately for minorities and nonminorities,

$$LENDER_{app} = \beta_L,$$

$$LENDER_{apr} = \Gamma_L,$$

$$LENDER_{apr.\ minority} = MINORITY\ APPROVAL\ RATE - AC_{apr.\ minority} - TRACT_{apr.\ minority} - \Sigma_{j \in L} \Gamma_R\ RACE_j / N_j - \Gamma_M, \text{ for all minority applicants } j,$$

$$LENDER_{apr.\ nonminority} = NONMINORITY\ APPROVAL\ RATE - AC_{apr.\ nonminority} - TRACT_{apr.\ nonminority} - \Sigma_{k \in L} \Gamma_R\ RACE_k N_k - \Gamma_M, \text{ for all nonminority applicants } k,$$

where N, N_j, and N_k are, respectively, the total, minority, and nonminority number of applicants to the lender and M is the MSA of the lender.

Four different measures of lender loan activity were regressed against these constructs, and a variance decomposition similar to that

12 Estimates of these regressions are available from the authors upon request.

TABLE 5

Allocation of Institutional Differences, Percent Deviations around MSA Means, 1990 HMDA

	Minority Application Rate	Relative Approval Rate	Minority Approval Rate	Overall Approval Rate
Applicant economic characteristics	0.8–2.6	2.4–4.6	2.5–5.7	3.5–10.9
Census tract	21.9–28.9	4.0–5.9	3.6–4.2	2.0–3.2
Overall lender effect	—	—	26.4–38.3	—
Unexplained lender effect	70.7–74.8	91.0–92.7	53.8–65.9	88.7–91.1

SOURCE: Authors' calculations.

performed in the previous section was undertaken. The four measures were

1) the minority application rate, which was regressed against AC_{app} and $TRACT_{app}$;

2) the relative approval rate, which was regressed against $AC_{apr,\ minority}$, $AC_{apr,\ nonminority}$, $TRACT_{apr,\ minority}$, $TRACT_{apr,\ nonminority}$, $LENDER_{apr,\ minority}$, and $LENDER_{apr,\ nonminority}$;

3) the minority approval rate, which was regressed against $AC_{apr,\ minority}$, $AC_{apr,\ nonminority}$, $TRACT_{apr,\ minority}$, $TRACT_{apr,\ nonminority}$, and $LENDER_{apr,\ nonminority}$;

4) the overall approval rate, which was regressed against $AC_{apr\ minority}$, $AC_{apr\ nonminority}$, $TRACT_{apr\ minority}$, and $TRACT_{apr\ nonminority}$.

Each regression was run with MSA dummies; thus, we analyze within-MSA variation. The contribution of each component to the overall variance in minority application rates is identified using the same variance decomposition procedure as in the previous section. Again, because we are looking at a decomposition of variance, the amount attributable to each source can only be approximated. As in the previous section, lenders used in these regressions were limited to the 11,598 lenders for whom all dependent variables were defined (at least one minority applicant and one approved loan).

The *AC* and *TRACT* components can be thought of as exogenous factors, potentially beyond the lender's control. The adjusted lender effects in minority application and approval rates constructed above ($LENDER_{app}$, $LENDER_{apr}$, $LENDER_{apr\ minority}$, and $LENDER_{apr\ nonminority}$) can be interpreted as lender-specific differences in application and approval rates controlling for applicant characteristics and property location. The variance decomposition allows us to compare the unadjusted measures of lender performance, as represented by the gross minority application and relative approval rates, with the adjusted indices, as measured by the *LENDER* variables. If the *LENDER* variables account for most of the variation in the gross measures, then regulators may be able to use gross performance measures without serious cost. If, on the other hand, *AC* and *TRACT* account for a substantial portion of the variation in the gross measures, this may be an inappropriate decision.

Table 5, column 1 shows the decomposition of the cross-lender variance in minority application rates. Differences in application characteristics account for 1 to 3 percent of the within-MSA variance across lenders. Much more surprisingly, differences in the census tracts from which lenders receive applications account for only 22 to 29 percent of the variation, with 71 to 75 percent of the variation across lenders attributable to the unexplained pure *LENDER* effect. This means that most of the variation across lenders in the number of minority applications they receive does not stem from the fact that they serve different neighborhoods, *but from how they draw applicants within neighborhoods.* This result is robust to a number of variations, such as ignoring MSA effects or weighting the regression by the number of applications received by the lender, and runs counter to the conventional wisdom that variation in the racial composition of the neighborhoods served by lenders is the major source of cross-lender variation in the proportion of minority applications received.[13]

Column 2 of table 5 shows the decomposition of the within-MSA variance in relative approval rates. Between 2 and 5 percent of the difference across lenders can be attributed to variation in the application characteristics, and between 4 and 6 percent can be attributed to census tract location. The overwhelming majority of variation (91 to 93 percent) cannot be explained by these factors and is attributable to the pure lender effect.

Similar conclusions are reached when we use the same methodology to examine sources of cross-lender variation in minority approval rates (table 5, column 3). Applicant economic and census tract effects are small. The overall standard of the institution, measured by the nonminority lender effect, explains about one-third of the within-MSA variation (that is, minorities who apply to institutions with low approval rates for all applicants tend to be approved at lower rates, ceteris paribus). However, more than half of the variation in minority approval rates cannot be explained by any of these factors. These remaining differences may reflect differential treatment of minority applications or differences in the unobserved characteristics of the loan application; without additional information, it is impossible to make a determination.

It appears that this large component of unexplained variation is consistent with evidence of significant idiosyncratic lender behavior. Column 4 of table 5 reports the decomposition of the cross-lender variance in overall approval rates (minority and nonminority) based on the same methodology used above. About 90 percent of the within-MSA variation in overall lender approval rates cannot be explained either by applicant characteristics (as we measure them) or by census tract.

These results suggest that the adjusted measures of lender performance account for the vast majority of variation in the gross measures. This finding is further examined in table 6, which reports the differences in gross and adjusted performance measures across various lender groups arranged by type, size, and market share, and by size and percent minority in the MSA. The difference between the gross and adjusted standard deviations for each group reflects the importance of the control factors, *AC* and *TRACT*.

The first column of table 6 is the cross-lender variance in minority application rates; the second column is the variance in the pure lender effect on the application rate. For the full sample of lenders, cross-lender variance before controlling for the applicant characteristics and property location is 0.20; after controlling for these factors, the variance is 0.14. Thus, about 30 percent of the cross-lender variance in minority application rates is explained by control factors. These factors account for a larger portion of the variance across commercial banks than for other types of lenders. They also account for more of the variance across lenders with large market shares, and those in MSAs with large numbers of minority applicants.

The control factors explain relatively little of the cross-lender variance in overall approval rates (columns 5 and 6) or in minority approval rates (columns 7 and 8). However, they do explain a sizable portion of the cross-lender variance in relative approval rates (minority approval rate/overall approval rate). Before controlling for the factors in our model, the cross-lender variance in relative approval rates is 0.37; after controlling for them, the variance is 0.26 — almost 30 percent lower. As was the case with application rates, control factors account for relatively more of the variation in approval rates for commercial banks and their mortgage subsidiaries, for lenders with large market shares, and for lenders in MSAs with larger numbers of minority applicants than other institutions.

It is also interesting to examine the relationship between the pure lender effect on minority application rates and the pure lender effects on absolute and relative minority approval rates. Overall, those lenders with higher-than-expected minority application rates (positive lender effects) are associated with slightly higher-than-expected minority approval rates, both absolute and relative. However, the correlations are surprisingly small (0.001 and 0.024, respectively), suggesting that minority applicants do not seem to be applying to lenders where their probability of approval is higher.

■ **13** The potential contribution of census tracts is larger when the regression is weighted by the number of applications each lender received. Since this decomposition focuses on within-MSA variation and gives most weight to the largest lenders within the MSA, it is difficult to separate the lender effect from the census tract effect. As a result of the covariance between the two, the range of the contribution of each is quite large (27 to 69 percent for census tracts and 30 to 63 percent for lender effects). We note that even in this decomposition—the most favorable case for census tract effects—at least 30 percent of the variance across lenders cannot be explained by loan application characteristics or by the racial composition of the neighborhood from which the lender draws applications.

TABLE 6

Standard Deviation of Minority Lending across Lenders Controlling for Applicant Characteristics and Property Location

	Minority Application Rate		Minority Origination Rate		Overall Approval Rate		Minority Approval Rate		Relative Approval Rate	
	Gross[a]	Adj.[b]	Gross[a]	Adj.[b]	Gross[a]	Adj.[b]	Gross[a]	Adj.[b]	Gross[a]	Adj.[b]
Type of Institution										
Commercial banks	0.23	0.14	0.18	0.15	0.17	0.16	0.34	0.32	0.41	0.28
Thrift institutions	0.18	0.11	0.15	0.11	0.12	0.11	0.27	0.25	0.29	0.23
Credit unions	0.28	0.26	0.19	0.26	0.16	0.16	0.32	0.31	0.38	0.27
Bank subsidiaries	0.16	0.12	0.14	0.12	0.20	0.18	0.32	0.30	0.40	0.27
Thrift subsidiaries	0.19	0.15	0.14	0.15	0.19	0.18	0.30	0.28	0.38	0.27
Other mortgage banks	0.19	0.15	0.17	0.15	0.17	0.16	0.28	0.27	0.33	0.23
Size of Institution										
More than 500 applications	0.13	0.05	0.13	0.05	0.11	0.09	0.16	0.13	0.12	0.07
100 to 500 applications	0.12	0.05	0.11	0.05	0.13	0.11	0.21	0.20	0.21	0.16
Less than 100 applications	0.23	0.17	0.19	0.17	0.19	0.18	0.35	0.34	0.43	0.31
Market Share of Institution										
More than 5 percent	0.16	0.05	0.16	0.05	0.12	0.10	0.23	0.10	0.24	0.18
1 to 5 percent	0.14	0.06	0.14	0.06	0.15	0.13	0.27	0.13	0.30	0.22
Less than 1 percent	0.23	0.18	0.25	0.19	0.19	0.18	0.35	0.18	0.43	0.30
Size of MSA										
More than 25,000 applications	0.20	0.14	0.21	0.14	0.17	0.16	0.31	0.27	0.38	0.24
Less than 25,000 applications	0.20	0.14	0.21	0.15	0.17	0.16	0.29	0.29	0.32	0.27
Percent Minority Applications										
More than 22 percent	0.28	0.18	0.30	0.18	0.19	0.19	0.28	0.27	0.32	0.21
Less than 22 percent	0.17	0.14	0.18	0.14	0.16	0.15	0.31	0.30	0.37	0.27
Total	0.20	0.14	0.21	0.15	0.17	0.16	0.31	0.29	0.37	0.26

a. Gross cross-lender variation not controlling for applicant characteristics or property location.
b. Adjusted cross-lender variation controlling for applicant characteristics and property location.
SOURCE: Authors' calculations.

V. Conclusion

This paper uses recently released HMDA data to examine differences in minority and low-income lending patterns across lending institutions. The new data allow us to identify both the application and the action taken on that application by the lender, thus enabling us to sort out lender behavior from applicant behavior to a greater extent than allowed by previous data. We therefore can determine the extent to which the differences across lenders in minority (low-income) originations found in earlier studies reflect differences in minority (low-income) application rates across lenders as opposed to differences across institutions in their minority (low-income) approval rates relative to their overall approval rates.

Our examination of the HMDA data reveals the following patterns related to lender differences in minority lending. First, lender differences in minority approval rates account for only about 10 percent of lender differences in minority loan originations: Differences across lenders in minority application rates account for the remaining 90 percent. Second, we find that very little of the lender variation in either minority application rates or approval rates can be attributed to applicant characteristics. Third, somewhat surprisingly, we determine that while property location explains a nontrivial portion of the cross-lender variance in application rates, most variation stems from differences in the applicants that lenders attract *within* the neighborhoods they serve. Finally, the correlation across lenders between minority application rates and minority approval rates is quite small. Minorities do tend to apply to lenders with low overall approval rates, but within this class of lenders, minority application rates are highest at those lenders with relatively large minority approval rates.

These results suggest that gross measures of lender performance may work fairly well in implementing a more quantitative regulatory evaluation system. They also suggest that application rate measures should play a particularly important role if increased credit flows to selected groups are the desired objective. Interestingly, even here, gross application rate measures may work fairly well in differentiating among lenders. We caution, however, that even though our research indicates that lenders vary enormously in terms of their relationships with minority and low-income applicants, we can say little about the reasons for this variation. Differences may result from illegal practices, or simply from economic factors on both sides of the market. Furthermore, because a number of financial institutions have initiated new lending practices during the last few years, the observed variation among lenders may be narrowing. Regulators and the public should attain a better understanding of the variation in lenders' practices before reaching definitive conclusions about how to use measures of such variation in enforcement of the CRA or fair lending laws.

References

Avery, Robert B. "Making Judgments about Mortgage Lending Patterns," Federal Reserve Bank of Cleveland, *Economic Commentary,* December 15, 1989.

________ , **and Thomas M. Buynak.** "Mortgage Redlining: Some New Evidence," Federal Reserve Bank of Cleveland, *Economic Review,* Summer 1981, pp. 18–32.

________ , **and Glenn B. Canner.** "Mortgage Redlining: A Multicity Cross-Section Analysis," Board of Governors of the Federal Reserve System, unpublished working paper, 1983.

________ , **Patricia E. Beeson, and Mark S. Sniderman.** "Accounting for Racial Differences in Housing Credit Markets," Federal Reserve Bank of Cleveland, Working Paper 9310, December 1993. Also forthcoming in *Proceedings of a Conference on Discrimination and Mortgage Lending,* U.S. Department of Housing and Urban Development.

________ , ________ , **and** ________ . "Underserved Mortgage Markets: Evidence from HMDA," Federal Reserve Bank of Cleveland, working paper, December 1994 (forthcoming).

Bradbury, Katharine L., Karl E. Case, and Constance R. Dunham. "Geographic Patterns of Mortgage Lending in Boston, 1982–1987," Federal Reserve Bank of Boston, *New England Economic Review,* September/October 1989, pp. 3–30.

Calem, Paul S. "The Delaware Valley Mortgage Plan: Extending the Reach of Mortgage Lenders," *Journal of Housing Research,* vol. 4, no. 2 (1993), pp. 337–38.

Canner, Glenn B. "Redlining and Mortgage Lending Patterns," in J. Vernon Henderson, ed., *Research in Urban Economics.* Greenwich, Conn.: JAI Press, 1981, pp. 67–101.

________ , **and Dolores S. Smith.** "Home Mortgage Disclosure Act: Expanded Data on Residential Lending," *Federal Reserve Bulletin,* vol. 77, no. 11 (November 1991), pp. 859–81.

________ , **and** ________ . "Expanded HMDA Data on Residential Lending: One Year Later," *Federal Reserve Bulletin,* vol. 78, no. 11 (November 1992), pp. 801–24.

Munnell, Alicia H., Lynne E. Browne, James McEneaney, and Geoffrey M.B. Tootell. "Mortgage Lending in Boston: Interpreting HMDA Data," Federal Reserve Bank of Boston, Working Paper No. 92-7, October 1992.

Wienk, Ronald E. "Discrimination in Urban Credit Markets: What We Don't Know and Why We Don't Know It," *Housing Policy Debate,* vol. 3, no. 2 (1992), pp. 217–40.

The Efficiency and Welfare Effects of Tax Reform: Are Fewer Tax Brackets Better than More?

by David Altig and Charles T. Carlstrom

David Altig is an assistant vice president and economist and Charles T. Carlstrom is an economist at the Federal Reserve Bank of Cleveland. For helpful comments, the authors thank Zsolt Besci, Finn Kydland, Eric Rasmussen, and seminar participants at Indiana University and the Federal Reserve Banks of Cleveland, Minneapolis, and St. Louis. Susan Byrne provided valuable research assistance.

Introduction

The 1980s was the decade of tax reform. The American economy experienced two major changes in federal personal income-tax legislation, the Economic Recovery Tax Act of 1981 (ERTA) and the Tax Reform Act of 1986 (TRA86). But significant change was not limited to the United States. By 1989, tax legislation had been passed in Australia, Canada, Denmark, New Zealand, Japan, Sweden, and the United Kingdom, with proposals for reform pending in many other nations (see Tanzi [1987], Boskin and McLure [1990], and Whalley [1990b]).

Although actual and proposed tax legislation within each of these countries was multifaceted, sometimes with substantial variance in details, the reform proposals shared certain broad characteristics across countries. Most striking among these was the uniform tendency toward lower top marginal tax rates, fewer rate brackets, and "base broadening." For example, in the latest rounds of reform, top statutory marginal rates in the federal personal tax codes fell from 34 to 29 percent in Canada, 83 to 40 percent in the United Kingdom, and 50 to 31 percent in the United States.[1] Corresponding to these changes were reductions in the number of rate brackets from 10 to 3 (Canada), 11 to 2 (United Kingdom), and 15 to 3 (United States). These examples and others are summarized in table 1.

A major motivation for these changes was the growing perception that the distortionary effects of high marginal tax rates had resulted in substantial inefficiencies.[2] Consequently, an essential impulse for tax reform was — and is — the desire to create more efficient income tax systems by substituting base-broadening measures for high marginal tax rates. Reductions in the

■ 1 Effective marginal tax rates can differ from statutory rates due to special treatment of credits, deductions, and exemptions at certain threshold income levels. An obvious example is the TRA86 provision for phasing out personal exemptions for high-income taxpayers.

■ 2 In its 1984 report on early tax proposals, the Joint Committee on Taxation identified three major objectives of comprehensive reform: equity, efficiency, and simplicity. With respect to efficiency, the Committee wrote that "... a widely accepted goal of tax policy is that taxes should interfere as little as possible with the incentives to engage in specific types of economic activity, except to the extent that Congress intends such effects ... [A] major goal of tax policy is to reduce [inefficiencies] to as low a level as possible." Furthermore, they indicated that "... in all [pending] proposals, marginal tax rates are substantially reduced. This reduction appears to be motivated by efficiency and equity considerations." See Joint Committee on Taxation (1984).

TABLE 1

Specific Elements of World Tax Reform

Country	Top Marginal Tax Rate, Pre-Reform	Pre-Reform Year(s)	Number of Pre-Reform Brackets	Top Marginal Tax Rate, Post-Reform	Post-Reform Year(s)	Number of Post-Reform Brackets
Australia	60%	1980–86	5	49%	1987–88	4
				47	1992	5
Austria	62	1982–88[a]	10[b]	50	1989	5
Belgium	72	1983–88	13[b]	50	1989–92	7
Canada	34	1987[a]	10	29	1988–92	3
Italy	65	1983–87	9	56	1988	8
				51	1992	7
Japan	70	1984–86	15	60	1987	12
				50	1988–92	5
Netherlands	72	1982–86[a]	9	66	1987–88	5
				60	1990–92	4
New Zealand	66	1979–85	5	48	1986	3
				33	1988–92	2
Sweden	80	1985[a]	11	72	1986	4
				50	1991–92[c]	4
United Kingdom	83	1978[a]	11	60	1979	6
				40	1988–92	2
United States	50	1983–85	15	33	1986	3
				31	1992	3

a. Rate may have been in effect prior to earliest date indicated.
b. Figures refer to number of rate brackets in 1988.
c. From 0 to 186,600 kronor (SEK), the national tax is a flat SEK 100. For incomes in excess of SEK 186,600, the tax is SEK 100 plus 20 percent of the excess.
SOURCES: Platt (1985); Tanzi (1987); Boskin and McLure (1990); Whalley (1990a, 1990b); various issues of the Organisation for Economic Co-operation and Development's *Economic Survey*; and the 1982 and 1992 editions of Price Waterhouse's *Individual Taxes: A Worldwide Summary*.

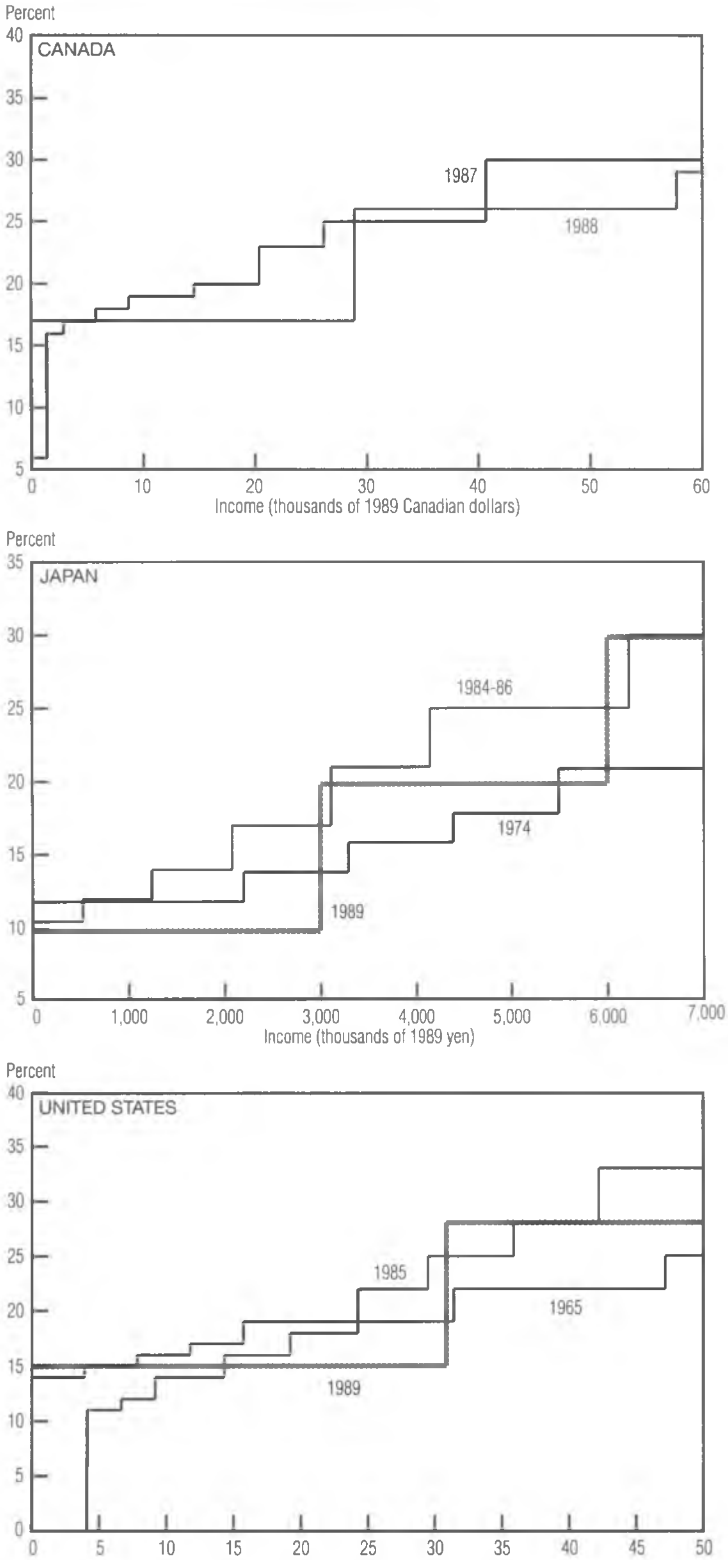
number of rate brackets are presumably meant to reinforce this goal by simplifying the tax code and minimizing distortions through the creation of broad classes of income over which marginal tax rates are essentially flat. Although often implicit, this motivation for reducing the number of rate brackets is sometimes explicit in discussions of specific tax reform proposals. For example, in discussing the Takeshita reforms in Japan, Noguchi (1990, p. 118) describes the U.K. and U.S. changes in rate structures as "developments ... toward flat-rate income taxes," while Ishi (1989) refers to the rate structure implemented in Japan as a "modified flat-tax" system.

However, a brief glance at figure 1, which depicts various vintages of Canadian, Japanese, and U.S. personal income-tax rate structures, reveals the problematic nature of concluding that a smaller number of rate brackets is less distortionary than a larger number. Although recent rate structures have wider bands of income over which the marginal tax rate is flat, jumps in the marginal rate are much more significant for some taxpayers. It is unclear, a priori, which structure will most significantly distort household consumption and work-effort decisions on net. Given the almost universal tendency toward reforms that simultaneously reduce the number of brackets and increase the distance between them, it is surprising that these issues have not been given more attention.

That, then, is the goal of this paper. Using the well-known dynamic fiscal policy framework pioneered by Auerbach and Kotlikoff (1987), we examine the welfare and efficiency implications of shifting from linear to discrete

FIGURE 1

Marginal Tax Rates



NOTE: Figures are scaled to a maximum of $50,000 equivalent U.S. dollars.

SOURCES: Whalley (1990b); Ishi (1989); Boskin and McClure (1990); Internal Revenue Service, *Statistics of Income, Individual Tax Returns*, 1965–89; and International Monetary Fund, *International Financial Statistics*, July 1992.

marginal tax-rate structures. In other words, we consider the pure distortionary effects of replacing a tax structure with many (infinitely small) steps between marginal tax rates with one defined by two large bands of flat tax rates connected by a single, large discrete jump.

We find that when our model is calibrated to match the main features of the U.S. economy, a hypothetical two-bracket code (roughly patterned after the rate structure in the 1989 U.S. personal income tax code) is *less* efficient than alternative linear-rate codes with similar average-tax progressivity and present-value revenue implications. By less efficient, we mean that there is no sequence of lump-sum transfers the government could feasibly implement that would make the shift from the linear to the discrete rate structure Pareto-improving.[3] This finding is generally robust to parameter assumptions and to the chosen method for equalizing revenues. This central message should serve as a cautionary note in the midst of growing political sentiment for further changes in the U.S. income tax code: Without disputing the merits of completely flat marginal tax rates, our results do not support the position that a modified flat-tax system is necessarily superior to all alternatives with steeply sloped marginal rate structures.

I. The Simulation Model

The model specification includes mathematical representations of the preferences and constraints of utility-maximizing households, the production technology available to profit-maximizing firms, a government budget constraint, and a specification for the income tax code, all of which are described in this section. In combination with labor-, capital-, and goods-market-clearing conditions, a competitive equilibrium is constructed by finding aggregate quantities and prices that are, given the government's behavior, consistent with the decentralized decisions of individual households and firms.

■ 3 We argue only that a rate structure with revenue and progressivity properties similar to TRA86 is less efficient than the specific alternative we consider — not that *all* discrete marginal-rate schemes are less efficient. Although we believe that requiring the same revenue collections and average-rate progressivity is a sensible constraint on the alternative tax codes, our results should be interpreted in light of these particular restrictions.

Households and Preferences

Our model economy is populated by a sequence of distinct cohorts (individuals born on the same date) that are, with the exception of size, identical in every respect. Each generation lives, with perfect certainty, for 55 periods (interpreted as adult years) and is $1 + n$ times larger than its predecessor. One can think of life as beginning at age 21 and ending at age 75.

Individuals "born" at calendar date b choose perfect-foresight consumption (c) and leisure (l) paths to maximize a time-separable utility function of the form

$$(1) \qquad U_b = \sum_{t=1}^{55} \beta^{t-1} u(c_{t,\, b+t-1}, l_{t,\, b+t-1}),$$

where $u_i > 0$, $u_{ii} < 0$, $\lim_{i \to \infty} u_i = \infty$, and u_i is the partial derivative of the function $u(\cdot)$ with respect to argument i. The preference parameter β is the individual's subjective time-discount factor. We assume that $\beta > 0$, but do not strictly require that $\beta < 1$.

Letting $a_{t\,s}$ equal the sum of capital and government debt holdings for age t individuals at time $s = b + t - 1$, maximization of equation (1) is subject to a sequence of budget constraints given, at each time s, by

$$(2) \qquad a_{t\,s} = (1 + r_s)\, a_{t-1,\, s-1} + \varepsilon_t w_s (1 - l_{t\,s}) + v_{t\,s} - T(y^*_{t\,s}) - c_{t\,s},$$

where w_s is the real pre-tax market wage at time s, r_s is the real return to assets held from time $s-1$ to s, ε_t is an exogenous labor-efficiency endowment in the t^{th} period of life, and $v_{t\,s}$ refers to lump-sum transfers received by age t individuals at time s.[4]

The function $T(y^*_{t\,s})$ defines the amount of income tax paid, which depends on the tax base given by $y^*_{t\,s} = r_s a_{t-1,\, s-1} + \varepsilon_t w_s (1 - l_{t,\,s}) - d$. The constant d represents a fixed level of deductions and exemptions used to convert gross income to taxable income. In the linear marginal-rate case, the function $T(\cdot)$ is defined as

$$(3a) \qquad T^{Linear}_{t,\,s} = \int_{y=d}^{y^*_{t\,s}} \tau(y)\, dy,$$

where

$$(3b) \qquad \tau(y) = a + b y_{t\,s}, \quad a, b > 0$$

defines the marginal tax rate as a linear function of taxable income. In the discrete tax case, the function is defined as

$$(4) \qquad T^{Discrete}_{t,\,s} = \begin{cases} \tau^L y^*_{t,\,s} & \text{if } y^*_t \leq \tilde{y}, \\ \tau^L \tilde{y} + \tau^H (y^*_{t,\,s} - \tilde{y}) & \text{if } y^*_t > \tilde{y}. \end{cases}$$

Note that at any time s, there are three distinct possibilities with respect to the budget constraint in the discrete tax case, corresponding to the cases where $y^*_{t,\,s} < \tilde{y}$, $y^*_{t,\,s} > \tilde{y}$, and $y^*_{t,\,s} = \tilde{y}$. The latter applies when individuals are at the kink in the budget constraint.

In addition to equation (2), we impose the initial condition that all individuals are born with zero wealth and the terminal condition that the present value of lifetime consumption plus tax payments cannot exceed the present value of lifetime resources. In the absence of a bequest motive and lifetime uncertainty, this wealth constraint implies that $a_{55\,s} = 0$.

The Government

The government in our model raises revenue through a combination of distortionary income taxes, debt issues, and lump-sum taxes. Government purchases of output equal zero at all times, and all government revenue is eventually redistributed to households in the form of lump-sum transfers. We specifically require that revenue raised from the income tax be rebated in the form of lump-sum payments to the individuals from whom it is collected. This allows us to isolate the efficiency losses due to the distortionary nature of marginal tax-rate changes.

Initially, we assume that D_0, the amount of government debt at the beginning of time, is zero, and that the individual transfer payments, $v_{t\,s}$, equal the amount of income tax revenue collected for all individuals age t at all times s. These assumptions, which we relax to calculate efficiency measures in section V, imply that debt issues are zero for all s.

Firms and Technology

Output in the model is produced by competitive firms that combine capital (K) and labor (L) using a neoclassical, constant-returns-to-scale

4 Capital and government debt are assumed to be perfect substitutes in households' portfolios.

production technology. Aggregate capital and labor supplies (in per capita terms) are obtained from individual supplies as

$$(5)\qquad K_s = \sum_{t=1}^{55} \frac{a_{t,\,s-1}}{(1+n)^{t-54}} - \frac{D_{s-1}}{1+n}$$

and

$$(6)\qquad L_s = \sum_{t=1}^{55} \frac{\varepsilon_t (1 - l_{t,\,s})}{(1+n)^{t-55}}.$$

Note that the capital stock at time s is given by private and public saving decisions at time $s-1$. Also, recall that we initially assume $D_s = 0$ for all s.

The production function is written in terms of the capital–labor ratio k as

$$(7)\qquad q_s = f(k_s),$$

where q_s is per capita output and $f(\cdot)$ is defined such that $f' > 0$, $f'' < 0$, $\lim_{k\to\infty} f' = 0$, and $\lim_{k\to 0} f' = \infty$. The competitive wage rate and (gross) interest rate are given by

$$(8)\qquad w_s = q_s - kf'(\cdot)$$

and

$$(9)\qquad r_s = f'(\cdot) - \delta,$$

where δ is the depreciation rate on physical capital.

II. Model Calibration

In order to quantify the model, it is necessary to choose particular values for the model's parameters. In this section, we describe the choices that result in our benchmark model and discuss their rationale.

Technology

The simulation exercises reported in section IV assume an aggregate production technology given by

$$(10)\qquad q_s = Ak_s^{\theta},$$

where θ is capital's share in production and A is an arbitrary scale factor. Our benchmark value for θ is 0.36, following Kydland and Prescott (1982). The value of A is chosen to scale steady-state cohort incomes to values consistent with average household income in 1989, the year for which the tax code is calibrated. We discuss this choice in more detail below.

In the benchmark model, we assume that the depreciation rate of physical capital is 10 percent per period, a choice that, again, is motivated by the arguments in Kydland and Prescott. The population growth rate is set to the postwar U.S. average of 1.3 percent per year, and the life-cycle labor efficiency profile $\{\varepsilon_t\}_{t=1}^{55}$ is calculated by interpolating estimates in Hansen (1986).

Preferences

We assume that preferences are isoelastic, specializing equation (1) to

$$(11)\qquad U_b = \sum_{t=1}^{55} \beta^{t-1} \left(\frac{c_{t,\,b+t-1}^{1-\frac{1}{\sigma_c}}}{1-\frac{1}{\sigma_c}} + \alpha \frac{l_{t,\,b+t-1}^{1-\frac{1}{\sigma_l}}}{1-\frac{1}{\sigma_l}} \right),$$

where the preference parameters σ_c, σ_l, and α represent the intertemporal elasticities of substitution in consumption and leisure and the utility weight of leisure, respectively. In our benchmark model, we assume $\sigma_c = 1$, so that equation (11) becomes

$$(11')\qquad U_b = \sum_{t=1}^{55} \beta^{t-1} \left(\ln(c_{t,\,b+t-1}) + \alpha \frac{l_{t,\,b+t-1}^{1-\frac{1}{\sigma_l}}}{1-\frac{1}{\sigma_l}} \right).$$

This form has the special property, not generally exhibited by specification (11), that the capital–labor ratio is invariant to the scale factor A in equation (10).[5] Also, evidence from state-level data reported by Beaudry and van Wincoop (1992) suggests preferences that are logarithmic in consumption.[6]

■ 5 Scale invariance follows from the fact that changes in the level of wages have offsetting wealth and substitution effects on individual labor supply decisions. Since scale invariance also implies that average hours worked will not change with growth, preferences similar in form to those in equation (11′) often appear in the real business cycle literature (see King, Plosser, and Rebelo [1988]).

■ 6 Further, Beaudry and van Wincoop find no evidence supporting either nonseparabilities between consumption and leisure or the absence of time separability in consumption, results that generally support the specification in equation (11). However, it should be noted that their empirical findings are based on a different model of aggregate consumption behavior than the one presented here.

We base the choice of σ_l, the intertemporal elasticity of substitution of leisure, on the extensive empirical literature devoted to estimating the wage elasticity of the labor supply. This elasticity, which we denote η_L, is related to σ_l by

$$(12)\quad \eta_L = \frac{l_{i,s}}{1-l_{i,s}}\sigma_l \approx 2\sigma_l.$$

MaCurdy's (1981) study of men's labor supply suggests values for η_L in the range of 0.1 to 0.45, a result that is largely confirmed in related studies (see Pencavel [1986]). However, Rogerson and Rupert (1991) argue that, because of corner conditions, estimates of the degree of intertemporal substitution obtained from conventional analyses of male labor supply are likely to be understated. Furthermore, despite greater disparity in estimates obtained from studies of female labor supply, there is broad agreement that the elasticity is higher for women (see Killingsworth and Heckman [1986]). Based on this evidence, in our benchmark model we set $\sigma_l = 0.25$ and choose the parameter α so that steady-state hours worked by an individual at peak productivity are slightly greater than one-third of total time endowment, which we take to be 16 hours per day.

Most empirical studies find values for the subjective discount factor β at annual frequencies to be in the neighborhood of 1.0 — sometimes slightly lower (Hansen and Singleton [1982]), sometimes slightly higher (Eichenbaum and Hansen [1990]). We choose a benchmark value of 0.99. Together with the other parameter choices, this value results in a steady-state real pre-tax interest rate of about 3.7 percent (which corresponds closely to the [apparent] historical average of real pre-tax returns on long-maturity riskless bonds in the United States[7]) and in a steady-state capital output ratio of 2.63 (which corresponds closely to the ratio of total capital to GDP in the United States over the 1959–90 period[8]).

The Tax Code

The benchmark tax code is patterned after the statutory U.S. personal tax code for 1989. Over the income region that is relevant in our simulations, the 1989 schedule was given by

$$(13)\quad T^{Discrete}_{i,s} = \begin{cases} 0.15 & \text{if } y^*_{i,s} \leq \$30{,}950, \\ 0.28 & \text{if } y^*_{i,s} > \$30{,}950. \end{cases}$$

We refer to this tax code as the "tax-reform" case.

The income levels obtained from the model are scaled to match those in the 1989 tax code as follows: The scale parameter A in the production function of equation (10) is chosen so that the highest income in the model matches the average income level for the highest-paid age group found in 1988 Census Bureau data.[9] We calculate the average for this group, which consists of persons aged 45–54, to be \$44,217 in 1989 dollars.[10] This value of A is then used in all subsequent simulations. To obtain taxable income, we subtract exemptions and deductions of \$11,206.

III. Welfare Effects

In this section, we examine the effects of shifting to the tax-reform code from an alternative linear-rate code, under the maintained assumption of revenue neutrality. Holding the structure of the discrete code constant, two natural approaches to achieving revenue neutrality are 1) choosing the intercept of the linear-rate code to equalize revenues, and 2) adjusting deductions to equalize revenues.

In each of our experiments, we consider an initial steady state under the linear-rate regime and examine the transition to a new steady state under the tax-reform regime.[11] Thus, under an intercept-adjusted approach, we parameterize the function $\tau(y)$ in equation (3b) as

■ **7** See Siegel (1992), which reports average rates for the 1800–1990 period. We note, for the record, that average real rates appear to differ significantly across particular subperiods. Specifically, real returns to long-term bonds averaged 1.46 percent between 1889 and 1978, but are 5.76 percent outside that interval.

■ **8** The measure used to construct the U.S. capital stock is the constant-cost net stock of fixed reproducible tangible wealth reported in the January 1992 *Survey of Current Business*, compiled by the U.S. Department of Commerce. This measure includes consumer durables and government capital.

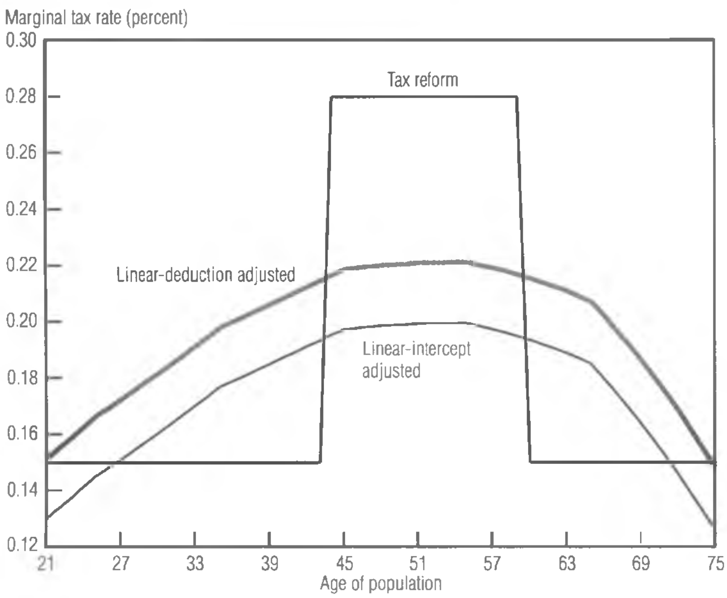
■ **9** Recall from our previous discussion that household utility functions are chosen so that real outcomes are unaffected by the choice of A.

■ **10** The data used in constructing this variable were taken from the Bureau of Labor Statistics' *Current Population Reports*, series P-60, no. 166. The cohort mean is obtained by multiplying the median income of families with household heads aged 45–54 by the ratio of average to median family income for the entire population. All money values in this paper are quoted in 1989 dollars.

■ **11** The experiments we report involve unanticipated changes in the tax regime. We have also conducted analyses (not reported) with anticipated regime shifts and found that our conclusions are robust.

FIGURE 2

Marginal Tax Rates (Benchmark Parameters)



SOURCE: Authors' calculations.

TABLE 2

Average Tax-Rate Comparisons: Steady-State, Benchmark Parameters (percent)

	Low Income	Median Income	High Income
Tax reform code	4.1	10.9	11.8
Linear-rate code, intercept adjusted to equalize revenues	3.3	10.8	11.9
Linear-rate code, deductions adjusted to equalize revenues	0.1	10.7	12.1

SOURCE: Authors' calculations.

$$(14)\quad \tau_{t,s}^{Linear}(y) = \psi + 0.0000024y_{t,s}$$

and choose the intercept ψ so that the present value of income tax revenues generated by the linear-rate code is acceptably close to the present value of revenues generated by the tax-reform transition path and steady state.[12] Under the alternative deduction-adjusted approach, we set $\psi = 0.146$ and choose the deduction to match the revenue levels.[13] For the benchmark model, this approach yields deductions of $14,561 in the initial steady state.

Figure 2 shows the steady-state, life-cycle path of marginal tax rates for the tax-reform and two linear-rate regimes. For the intercept-adjusted linear-rate code, approximately 55 percent of the population, accounting for an equal amount of steady-state income, face lower marginal tax rates than they would under the tax-reform system. The highest marginal tax rate in the linear-rate case is approximately 20 percent, as opposed to 28 percent in the tax-reform regime. For the deduction-adjusted linear-rate code, things are slightly different: Approximately 35 percent of the population, accounting for 42 percent of steady-state income, face lower marginal tax rates than they would in the tax-reform case. Furthermore, the rate reductions are concentrated — and especially pronounced — at high income levels. The highest marginal tax rate in the deduction-adjusted linear-rate scenario is approximately 22 percent.

In addition to the revenue implications, the progressivity of each tax structure is a key element in considering the comparability of the different tax codes. Information on average tax-rate progressivity, provided in table 2, is one convenient way of examining progressivity. Although no more than an informal summary of the nature of a particular tax code, this measure does provide a sense of how average tax liabilities are related to income, highlighting the sort of comparisons often invoked in discussions of alternative tax regimes. As claimed above, the results in table 2 do suggest that in the long run, the tax-reform and linear-rate codes (especially the intercept-adjusted variant) exhibit

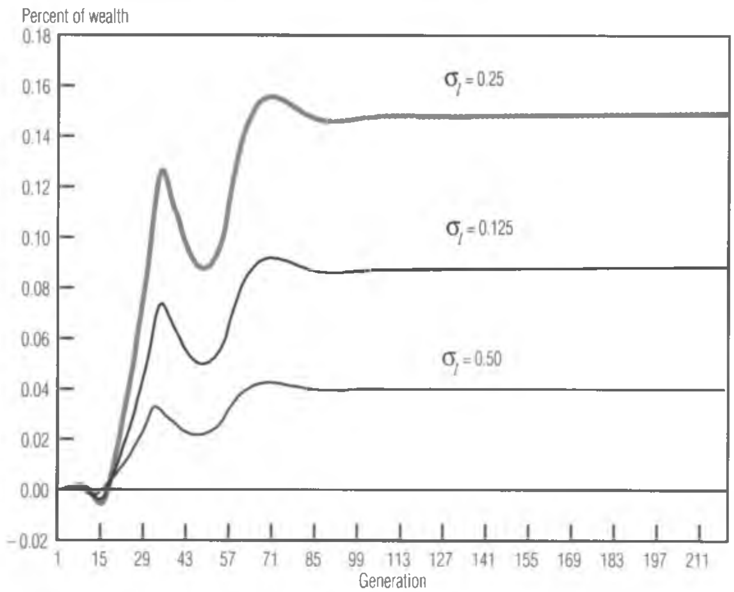
■ 12 By "close," we specifically mean within 0.001 percent. The slope of the function in equation (14) is obtained by fitting a linear regression to the 1965 statutory tax code. The 1965 schedule was chosen as representative of the marginal rate structure in place over much of the 1964–78 period. Over the income range $0–$54,000, which covers the incomes generated by our model, a linear function is a reasonably good approximation of this statutory schedule.

Present values are calculated as the interest rates realized under tax reform, that is, along the transition path and in the new steady state. Measuring revenue neutrality under a fixed assumption about interest rates, while not strictly consistent with ex post neutrality, seems consistent with the fashion in which tax legislation is actually contemplated. Furthermore, because the final, tax-reform steady state is the same in all simulations conducted under a particular parameterization of the model, our choice delivers a common discount factor across like experiments.

■ 13 The choice of 0.146 is motivated by the same regressions used to determine the slope of the linear code. See footnote 12.

FIGURE 3

Welfare Loss Due to Tax Reform: Basic Results



NOTE: Each x on the horizontal axis corresponds to the oldest generation alive x periods after the tax regime change.
SOURCE: Authors' calculations.

similar degrees of progressivity, subject of course to the usual caveats about the validity of the average tax measure.

Armed with these observations, we turn next to examining the welfare implications of shifting from a linear-rate regime to the tax-reform regime. Throughout, we calculate welfare losses as the percentage increase in full wealth that must be *given* to an individual in the tax-reform regime in order to compensate him for the switch to the linear code.[14] Negative numbers therefore represent welfare gains associated with tax reform.

Figure 3 illustrates welfare losses for different age cohorts arising from an unanticipated change from the intercept-adjusted linear-rate regime to the tax-reform regime. Cohorts in figure 3 are identified by year of death. Thus, the welfare number for period 1 of the transition path represents the loss by an individual age 75 (fifty-fifth year of life) at the time the tax-reform regime becomes effective. All cohorts alive in the initial (linear-rate) steady state have died by period 55 of the transition path. The three sets of losses shown in figure 3 are calculated from the benchmark model and from two alternative parameterizations with different choices for the intertemporal elasticity of substitution in leisure.

In the long run, tax reform generates welfare losses, with the magnitude of the loss positively related to individuals' willingness to shift leisure intertemporally. The intuition for this relationship between welfare costs and σ_l can be appreciated by recalling that, because heterogeneity in the steady state is due strictly to life-cycle characteristics, the highest incomes in the model are earned by individuals who are at their peak levels of labor productivity. As shown in figure 2, this is exactly the period of the life cycle for which tax reform implies higher marginal tax rates relative to the linear-rate regime. The distortions on labor supply created by this fact are magnified for higher degrees of willingness to substitute leisure across periods of life. Thus, an apparently important factor in the relative efficiency of the linear-rate structure is that, for roughly the same degree of progressivity, the marginal tax rate faced by the highest-income individuals is lower than in the tax-reform case.

The welfare effects apparent in figure 3 arise primarily from the direct distortions of the tax-reform code vis-à-vis the hypothesized linear-rate code, not from general equilibrium effects associated with changes in interest rates and wages.[15] In figure 4, we compare the welfare effects for the benchmark model with the effects obtained when the entire path of interest rates and wages is held fixed at the initial steady-state values. Although general equilibrium effects mitigate the welfare losses, the picture that emerges is little changed by the partial equilibrium assumption, especially in the long run. Note, however, that general equilibrium effects have a significantly greater impact on older cohorts alive at the time of the regime change.

Finally, we consider the welfare consequences when the linear-rate structure is chosen according to the deduction-based method for equalizing revenues. Figure 5 shows the results of welfare calculations for these experiments. Relative to the intercept-adjusted experiments, the long-run welfare losses of tax reform are

14 Full wealth, Ω, is defined as the present value of wage income when the entire time endowment is allocated to labor. Thus,

$$\Omega = \varepsilon_1 w_b + \sum_{t=2}^{55} \frac{\varepsilon_t w_{b+t-1}}{\prod_{i=2}^{t} (1 + r_{b+i-1})}$$

15 Recall that for the simulations in this section, we assume that lump-sum taxes and transfers maintain zero net tax payments for every cohort at every point in time. Therefore, wealth effects arise only as a result of changes in the aggregate levels of capital and labor, which are in turn reflected in interest rates and wages.

FIGURE 4

Welfare Loss Due to Tax Reform: Partial versus General Equilibrium

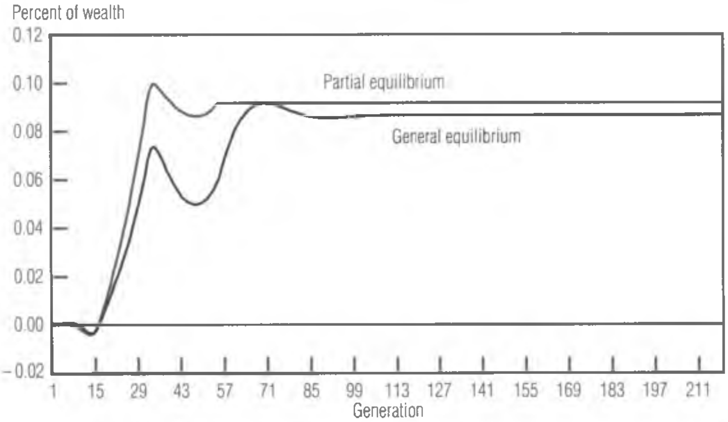


FIGURE 5

Welfare Loss Due to Tax Reform: Deduction-Adjusted Results

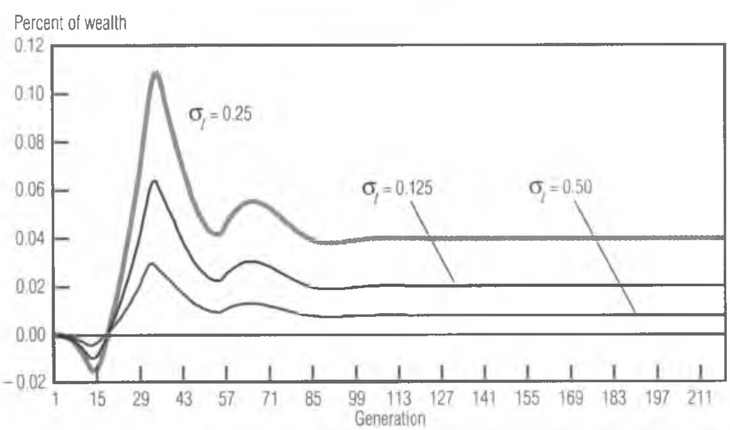
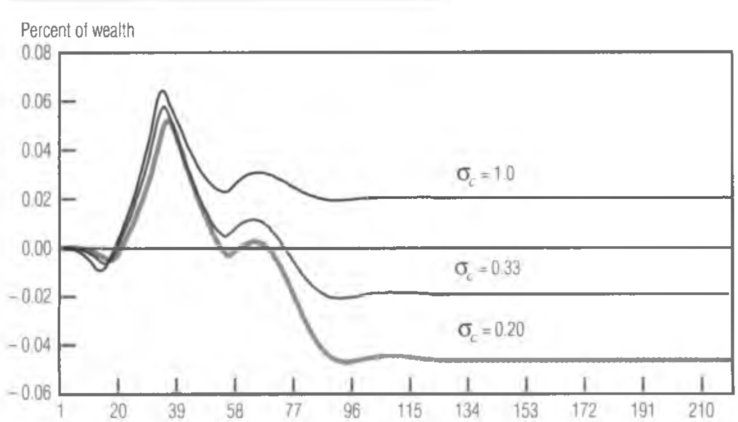


FIGURE 6

Welfare Loss Due to Tax Reform: Alternative Consumption Elasticities



NOTE: Each x on the horizontal axis corresponds to the oldest generation alive x periods after the tax regime change.
SOURCE: Authors' calculations.

somewhat lower when revenues are equalized in the linear-rate code by adjusting deductions. However, as reported in table 2, equalizing revenues by deduction adjustments results in greater average-tax progressivity than does either the intercept-adjusted linear code or the tax-reform code. Essentially, the increase in marginal rates on high-productivity/high-asset cohorts associated with tax reform is smaller when taxes are equalized by increasing deductions in the linear code, resulting in smaller long-run welfare losses.

This last observation underscores a critical point that bears reemphasizing. The relative welfare effects of each of the tax structures we consider are dependent on the relative levels of marginal tax rates necessary to preserve revenue neutrality. The discrete code examined here generates welfare losses because a linear-rate code with similar average-tax progressivity (or less progressivity, for that matter) allows the application of lower rates to the critical high-income cohorts.

Finally, figure 6 presents the same experiments for different degrees of intertemporal elasticity of substitution for consumption.[16] Note especially that as consumers become less willing to substitute consumption across time, tax reform actually generates long-run welfare gains. However, welfare losses persist for the early years following the introduction of tax reform. This observation raises the interesting question of whether, for certain parameter choices, long-run welfare gains are large enough to offset short-run losses. We turn to this issue next.

IV. Efficiency Effects

The pattern of welfare effects in figures 3–5 clearly indicates that the contemplated shifts from the tax-reform regime result in efficiency losses. However, the welfare calculations presented do not provide a simple measure that summarizes the economic cost of such changes. Furthermore, as shown in figure 6, there are long-run welfare *gains* for some plausible alternatives to the benchmark model. For these cases, the question is open regarding whether the shift to the tax-reform regime can be con-

16 Recall that, given the preference specification in equation (11), equilibrium outcomes in the model are not invariant to the scale of the model when $\sigma_c \neq 1$. There are, however, other utility functions that allow more flexibility in the choice of the intertemporal consumption elasticity while preserving scale invariance, albeit at the cost of less flexibility in choosing intertemporal leisure elasticity.

TABLE 3

Efficiency Losses Due to Tax Reform (percent of wealth)

	Revenues Equalized by Adjusting Intercept in the Linear-Rate Code	Revenues Equalized by Adjusting Deductions in the Linear-Rate Code
Benchmark	0.139	0.058
σ_l = 0.17	0.065	0.027
= 0.50	0.235	0.103
β = 1.005	0.080	0.030
= 0.976	0.211	0.088
σ_c = 0.20	0.162	0.074
= 0.33	0.151	0.069
δ = 0.07	0.160	0.066
σ_l = 0.20	0.362	0.165
β = 0.971	0.362	0.165
δ = 0.07	0.362	0.165

SOURCE: Authors' calculations.

structed to maintain positive long-run welfare gains for some generations without diminishing the lifetime utility of any other.

In this section, we develop a measure of the efficiency costs of shifting from the hypothesized linear-rate codes. Furthermore, for cases that generate gains for some generations, we ask whether there exists a set of transfers that preserves positive long-run gains while eliminating all welfare losses of cohorts alive along the post-reform transition path.

To these ends, we calculate an efficiency measure in the spirit of the one introduced in Auerbach, Kotlikoff, and Skinner (1983). Specifically, let $s=1$ be the time at which tax reform is introduced. To obtain our efficiency measure, we ask how much wealth can be taken away from cohorts born on or after $s=1$ following the implementation of a fiscal policy with the following characteristics:[17]

(a) The government first introduces lump-sum taxes and transfers so that the lifetime utility of all generations is maintained at the steady-state level realized in the initial, linear-rate regime. For instance, in figure 6, cohorts experiencing welfare losses would receive transfers while those enjoying welfare gains would be taxed.

(b) Following the policy in (a), the government's long-run budget will be in surplus if the present value of taxes exceeds the present value of transfers, or in deficit if the converse is true. Because the long-run budget must balance, the government must choose a sequence of other transfers (for the surplus case) or taxes (for the deficit case) so that the present value of taxes less transfers equals zero. For the purpose of constructing our efficiency measure, we assume that the budget is balanced by imposing lump-sum taxes, or by granting lump-sum transfers, that are a constant fraction of the full wealth of all generations born after the tax reform.

If, after policy steps (a) and (b), generations along the transition path and in the new steady state are worse off, our efficiency measure is negative and equal to the percentage wealth loss suffered by each. A more detailed sketch of our procedure is offered in the appendix.

Table 3 reports the results of efficiency calculations for alternative parameterizations of the model. Losses are associated with all of the cases considered, even those in which there is a long-run welfare gain from shifting to tax reform. Thus, the short-run losses that occur in figure 6 dominate the long-run gains.

For the benchmark model, the shift to the tax-reform code results in an efficiency loss of 0.14 percent of full wealth when revenues are equalized by adjusting the intercept of the linear-rate schedule. More generally, calculated losses range from 0.08 to 0.36 percent, depending on the chosen parameters. When revenues are equalized by adjusting deductions, the efficiency losses are uniformly smaller, but still range from 0.03 to 0.17 percent of full wealth. As shown, losses increase with individuals' willingness to shift resources intertemporally, again reflecting the fact that high-tax periods correspond to periods of high relative saving rates and high labor productivity.

To put some perspective on the magnitude of the efficiency losses, full wealth for each cohort in the tax-reform steady state is about 63 percent of total output. Thus, a reduction in full wealth of 0.14 percent represents an annual loss equal to about 0.09 percent of output in the model. Converting full wealth in the model to 1989 dollars implies an efficiency loss equivalent to roughly $1,418 per person born (or reaching working age) after the regime change.

17 Auerbach, Kotlikoff, and Skinner refer to the hypothetical government agency that implements these policies as the "Lump Sum Redistribution Authority."

V. Concluding Remarks

Significant reductions in the number of marginal tax-rate brackets — that is, a trend toward structuring systems of personal income taxation such that there exist wide bands of income over which marginal tax rates are flat — have been a striking characteristic of worldwide tax reform over the past decade. In this paper, we argue that this trend is not obviously accounted for by appealing to the efficiency gains inherent in tax codes with just a few brackets separated by discrete-rate jumps. Relative to revenue-neutral linear-rate structures, changing to a simple two-bracket discrete-rate structure creates efficiency losses in all of the numerical experiments we conduct. Furthermore, in most cases welfare gains are uniformly negative, even in the long run.

Two explanations come immediately to mind for the discrepancy between the reality of recent tax reforms and the results of our analysis. First, our analysis is conducted in a purely life-cycle framework. Hence, in steady-state equilibria, all cohorts face exactly the same life-cycle profile of relatively high taxes during periods of peak productivity and saving. The inefficiency of the discrete code that we consider follows in important ways from the fact that, holding average-tax progressivity constant, shifting from an equal-revenue linear code requires marginal tax-rate increases during this phase of the life cycle.

It is reasonable to conjecture that these effects would be mitigated in a more general framework that included intracohort heterogeneity. For instance, suppose that there existed two types of agents, "rich folks" and "poor folks." It is conceivable that the two-bracket tax code could be structured so that the shift from the linear tax would result in poor folks facing only the lower rate and rich folks facing only the higher rate over their entire lives. In this event, the discrete tax code would be equivalent to a flat-tax regime, which would almost certainly create welfare and efficiency gains. In a slightly less extreme case, some portion of each cohort would face the life-cycle pattern of rates on which we have focused, while for others, the poor-folk/rich-folk scenario would be relevant.

We have, however, conducted experiments in which we relax the representative life-cycle agent characteristic of the model presented in this article. In particular, we have replicated several of our welfare experiments in a framework that includes 13 distinct life-cycle agent types with varying degrees of lifetime wealth and income. The qualitative aspects of our results are unchanged by this extension.

A second explanation for the widespread adoption of rate-bracket reductions is that, perhaps for administrative or political reasons, they are a necessary concomitant to lowering the level of tax rates and to the various base-broadening measures that also characterized tax reform in the 1980s. In this case, the approach advocated by Slemrod (1990), which emphasizes the broad institutional framework in which tax policy is chosen, may ultimately be necessary to fully understand the consequences of the income tax systems that have undeniably come to dominate industrialized economies.

Appendix

Notes on Calculating Efficiency Gains

Our efficiency calculations require extending the government sector so that an individual's budget constraint becomes

$$\text{(A1)}\quad a_{t,s} = (1+r_s)a_{t-1,s-1} + \varepsilon_t w_s(1-l_{t,s}) + v_{t,s} - T(y^*_{t,s}) + z_{t,s} - c_{t,s}.$$

The only difference between the above equation and equation (2) in the text is the addition of $z_{t,s}$, which represents the net lump-sum transfers (negative numbers represent taxes) in excess of those necessary to offset income tax collections. Given this definition, the per capita level of debt evolves according to the relationship

$$\text{(A2)}\quad D_s = (1+r_s)\frac{D_{s-1}}{1+n} - Z_s,$$

where

$$\text{(A3)}\quad Z_s = \sum_{t=1}^{55}(1+n)^{55-t} z_{t,s}.$$

Letting $s = 1$ be the first period of the transition path and normalizing the population at $s = 1$ to unity, intertemporal budget balance for the government requires that

$$(A4)\quad D_1 = Z_1 + \sum_{s=2}^{\infty} \frac{Z_s(1+n)^{s-1}}{\prod_{i=2}^{s}(1+r_i)}$$

The algorithm for obtaining our efficiency measure proceeds in the following steps:

(i) Conjecture a sequence of interest rates for the transition path and the new (tax-reform) steady state.

(ii) Calculate the present value of lump-sum taxes, net of lump-sum transfers, that would be needed to maintain all cohorts at the initial steady-state level of utility. Refer to the resulting number as the "utility-compensation surplus," or UCS. If positive, the UCS determines the present value of transfers that can redistributed by the government while maintaining long-run budget balance. If negative, the UCS determines the present value of taxes that must be raised to maintain budget balance.

(iii) Maintain the utility level of all cohorts alive at the time of the tax regime change, so that the government budget balance is satisfied by solving for the constant tax or transfer (as a percentage of each cohort's full wealth) that can be applied to all subsequent cohorts while just exhausting the UCS.

(iv) Use the path of taxes and transfers from steps (ii) and (iii), along with the associated path of government debt implied by equation (A2), to recalculate the entire problem, as described in section II.

(v) Update interest rates and the UCS until the procedures converge to an equilibrium that satisfies public and private budget constraints, all market-clearing conditions, and the first-order conditions governing individual consumption and leisure choices. Once the problem has converged, the efficiency gain is the percentage of full wealth that is redistributed to (or taken from) all cohorts born after the change in tax regime, as calculated in step (iii).

References

Auerbach, Alan J., and Laurence J. Kotlikoff. *Dynamic Fiscal Policy.* Cambridge: Cambridge University Press, 1987.

________, ________, **and Jonathan Skinner.** "The Efficiency Gains from Dynamic Tax Reform," *International Economic Review,* vol. 24, no. 1 (February 1983), pp. 81–100.

Beaudry, Paul, and Eric van Wincoop. "Alternative Specifications for Consumption and the Estimation of the Intertemporal Elasticity of Substitution," Federal Reserve Bank of Minneapolis, Institute for Empirical Macroeconomics, Discussion Paper 69, July 1992.

Boskin, Michael J., and Charles E. McLure, Jr., eds. *World Tax Reform: Case Studies of Developed and Developing Countries.* San Francisco: ICS Press, 1990.

Eichenbaum, Martin, and Lars Peter Hansen. "Estimating Models with Intertemporal Substitution Using Aggregate Time Series Data," *Journal of Business and Economic Statistics,* vol. 8, no. 1 (January 1990), pp. 53–69.

Hansen, Gary D. "Three Essays on Labor Indivisibility and the Business Cycle," University of Minnesota, Ph.D. dissertation, 1986.

Hansen, Lars Peter, and Kenneth J. Singleton. "Generalized Instrumental Variables Estimation of Nonlinear Rational Expectations Models," *Econometrica,* vol. 50, no. 5 (September 1982), pp. 1269–86.

Ishi, Hiromitsu. *The Japanese Tax System.* Oxford: Oxford University Press, 1989.

Joint Committee on Taxation. *Analysis of Proposals Relating to Comprehensive Tax Reform.* Washington, D.C.: U.S. Government Printing Office, September 1984.

Killingsworth, Mark R., and James J. Heckman. "Female Labor Supply: A Survey," in O. Ashenfelter and R. Layard, eds., *Handbook of Labor Economics,* vol. 1. New York: North-Holland, 1986.

King, Robert G., Charles I. Plosser, and Sergio T. Rebelo. "Production, Growth, and Business Cycles," *Journal of Monetary Economics,* vol. 21, nos. 2/3 (March/May 1988), pp. 195–232.

Kydland, Finn E., and Edward C. Prescott. "Time to Build and Aggregate Fluctuations," *Econometrica,* vol. 50, no. 6 (November 1982), pp. 1345–70.

MaCurdy, Thomas E. "An Empirical Model of Labor Supply in a Life-Cycle Setting," *Journal of Political Economy,* vol. 89, no. 6 (December 1981), pp. 1059–85.

Noguchi, Yukio. "Tax Reform Debates in Japan," in Michael J. Boskin and Charles E. McLure, Jr., eds., *World Tax Reform: Case Studies of Developed and Developing Countries*. San Francisco: ICS Press, 1990, pp. 111–25.

Pencavel, John H. "Labor Supply of Men: A Survey," in O. Ashenfelter and R. Layard, eds., *Handbook of Labor Economics*, vol. 1. New York: North-Holland, 1986.

Platt, C. J. *Tax Systems of Western Europe*, 3d ed. Brookfield, Vt.: Gower Publishing Company, 1985.

Rogerson, Richard, and Peter Rupert. "New Estimates of Intertemporal Substitution: The Effect of Corner Solutions for Year-Round Workers," *Journal of Monetary Economics*, vol. 27, no. 2 (April 1991), pp. 255–69.

Siegel, Jeremy J. "The Real Rate of Interest from 1800–1990: A Study of the U.S. and the U.K.," *Journal of Monetary Economics*, vol. 29 (April 1992), pp. 227–52.

Slemrod, Joel. "Optimal Taxation and Optimal Tax Systems," *Journal of Economic Perspectives*, vol. 4, no. 1 (Winter 1990), pp. 157–78.

Tanzi, Vito. "The Response of Other Industrialized Countries to the U.S. Tax Reform Act," *National Tax Journal*, vol. 40, no. 3 (September 1987), pp. 339–55.

Whalley, John. "Foreign Responses to U.S. Tax Reform," in Joel Slemrod, ed., *Do Taxes Matter? The Impact of the Tax Reform Act of 1986*. Cambridge, Mass.: MIT Press, 1990a, pp. 286–314.

________. "Recent Tax Reform in Canada: Policy Responses to Global and Domestic Pressures," in Michael J. Boskin and Charles E. McLure, Jr., eds., *World Tax Reform: Case Studies of Developed and Developing Countries*. San Francisco: ICS Press, 1990b, pp. 73–91.

Fourth Quarter Working Papers

Current *Working Papers* of the Cleveland Federal Reserve Bank are listed in each quarterly issue of the *Economic Review.* Copies of specific papers may be requested by completing and mailing the attached form below.

Single copies of individual papers will be sent free of charge to those who request them. A mailing list service for personal subscribers, however, is not available.

Institutional subscribers, such as libraries and other organizations, will be placed on a mailing list upon request and will automatically receive *Working Papers* as they are published.

■ **9411**
Similarities and Dissimilarities in the Collapses of Three State-Chartered Private Deposit Insurance Funds
by Walker F. Todd

■ **9412**
The Burden of German Unification: A Generational Accounting Approach
by Jagadeesh Gokhale, Bernd Raffelhüschen, and Jan Walliser

■ **9413**
The Annuitization of Americans' Resources: A Cohort Analysis
by Alan J. Auerbach, Jagadeesh Gokhale, Laurence J. Kotlikoff, John Sabelhaus, and David N. Weil

■ **9414**
Loan Sales: Pacific Rim Trade in Nontradable Assets
by Joseph G. Haubrich and James B. Thomson

■ **9415**
Bankruptcy Rules and Debt Contracting: On the Relative Efficiency of Absolute Priority, Proportionate Priority, and First-Come, First-Served Rules
by Stanley D. Longhofer

■ **9416**
Executive Compensation: A Calibration Approach
by Joseph G. Haubrich and Ivilina Popova

Please complete and detach the form below and mail to:
Research Department
Federal Reserve Bank of Cleveland
P.O. Box 6387
Cleveland, Ohio 44101

Check item(s) requested

Please send the following Working Paper(s):

☐ **9411** ☐ **9413** ☐ **9415**
☐ **9412** ☐ **9414** ☐ **9416**

Send to:
Please print

Name

Address

City State Zip

The Federal Reserve Bank of Cleveland and the *Journal of Money, Credit and Banking*

Announce:

Derivatives and Intermediation

November 2–3, 1995
Cleveland, Ohio

The Federal Reserve Bank of Cleveland and the *Journal of Money, Credit and Banking* are jointly sponsoring a conference on Derivatives and Intermediation: Theory and Evidence.

The growing derivatives market poses several challenges for policymakers. The first is to understand the sources of financial innovation resulting in the proliferation of these products. What economic forces make derivatives viable instruments? What gains do rational participants obtain from these contracts, and why do they dominate transactions in the cash securities markets? To what extent does regulatory policy—bankruptcy rules, capital requirements, accounting rules, and deposit insurance—affect the market? In other words, does derivative-related financial innovation stem from changes in the marketplace, or from changes in the regulatory environment? The answer is crucial to understanding both derivatives and intermediation. The second challenge for policymakers is to understand how derivatives impact regulatory concerns in the areas of bank risk, payments system reform, and intermediary powers.

Call for Papers

The conference proceedings will be published in the *Journal of Money, Credit and Banking,* and authors will receive an honorarium. Prospective contributors are invited to send a completed paper or detailed abstract by May 30, 1995 to:

Joseph G. Haubrich
Research Department
Federal Reserve Bank of Cleveland
P.O. Box 6387
Cleveland, OH 44101–1387