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Tax Uncertainty and Investment: A Cross-Country Investigation

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TAX UNCERTAINTY AND INVESTMENT
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Abstract:

An empirical investigation of uncertain tax policy and investment is crucial to a fuller understanding of the interplay between taxes and investment, especially given ambiguities in the limited theoretical literature. In this paper we model the time series of effective tax rates in several OECD countries using ARCH-GARCH models. We then incorporate the resulting tax rate volatility estimates in a panel regression model of investment per worker. We find that the volatility of tax rates has a significant negative impact on investment per worker in these countries.

JEL: H25, E62, F21

TAX UNCERTAINTY AND INVESTMENT
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1. Introduction

Spanning a period of nearly one hundred years of economic research, a substantial literature has developed with the goal of explaining the behavior of investment over time. The focus of much of this research has been on tax policy.[1] While most of these studies have considered the implications of tax policy for investment in an uncertain world, most have also implicitly assumed that the tax policy itself does not contribute to the uncertainty. The problem is that tax policy can be very uncertain in many cases,[2] and to date we know little about the consequences, especially from an empirical standpoint.

This paper sets out to fill part of the intellectual void by empirically investigating the impact of volatility in effective tax rates on investment in a cross-section of OECD countries. In doing so, we first undertake an examination of the structure of tax rate volatility in these countries, employing model selection criteria to choose the best fitting parsimonious model for the time series of effective tax rates in each country. The predicted values for tax rate volatility generated from these models are then incorporated in a panel regression model of investment per worker. Within the class of generalized autoregressive conditional heteroscedasticity (GARCH) models, we find that the observed time series of effective tax rates on capital income in a subset of OECD countries are best represented by specifications that vary across countries. We then provide panel regression results which suggest that the volatility of effective tax rates on capital income has a significant negative impact on investment per worker in these countries.

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[1] Hassett and Hubbard (1997) provide a very extensive review of the literature on tax policy and investment.

[2] For a review of post World War II tax changes, see Cummins, Hassett, and Hubbard (1994). See also Auerbach and Hines (1988).

The remainder of the paper proceeds as follows. In section 2 we briefly review the existing literature on tax policy uncertainty and investment. Section 3 then presents a time series analysis of effective tax rates on capital income in OECD countries, followed by an examination of the effects of tax rate volatility on investment per worker in section 4. Section 5 then provides concluding remarks.

2. Theoretical Foundations

Although most of the voluminous literature on tax policy and investment under uncertainty ignores observed randomness in tax policy, a recent literature has begun to explore these issues in some detail, mostly through simulation.[3] The basic premise underlying these studies is that since output price uncertainty tends to retard investment (Pindyck, 1988),[4] tax uncertainty might be expected to harm investment as well (Hassett and Metcalf, 1999). Further credence to a negative relationship between tax uncertainty and investment is given by the business community's mantra that "they cannot make plans if they don't have confidence in the tax structure" (Bizer and Judd, 1989, 223). These simulation studies, however, demonstrate that the impact of tax uncertainty depends crucially on the source and nature of the uncertainty. Contrary perhaps to conventional wisdom, in some cases increased uncertainty can be shown to have positive effects on investment, growth, or welfare.

Bizer and Judd (1989) simulate the economic effects of introducing random tax policy in a dynamic general equilibrium model. They find that if random tax rates or credits are serially

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[3] This is not to say there has been no work in the area of tax uncertainty. A substantial literature has investigated the impact of randomness in tax policy on consumer behavior, work effort, and/or welfare. These include (but are not limited to) Alm (1988), Engen and Gale (1997), Judd (1998), and Alvarez *et al.* (1998), as well as several papers in Aaron and Gale (1996). Auerbach and Hines (1988) were perhaps the first to consider the impact of tax changes on investment, but did not explicitly incorporate the volatility of tax rates and considered policy changes that are anticipated.

[4] Note that earlier work by Hartman (1972) and Abel (1983) suggests that uncertainty about future prices would lead to an increase in the firm's optimal capital stock if the production function is linearly homogeneous. In their models investment is reversible and thus has zero opportunity cost, while Pindyck considers the (more realistic) case of irreversible investment. See Pindyck (1988, 970*n.*) for more details.

correlated, the target capital stock falls when taxes are high and rises when taxes are low. Their more interesting case considers independently and identically distributed random tax shocks. In this case the authors find that randomness in investment tax credits generates large fluctuations in investment which have the effect of reducing both utility and production (because both are concave functions), as well revenue.[5] They find that variance in future tax *rates*, however, is not important for long-term investments and in fact raises nontrivial amounts of revenue at a welfare cost that is never more than the cost associated with raising an equivalent amount of revenue with a permanent increase in a deterministic tax rate.

Dotsey (1990) also considers a stochastic growth model in which tax rates themselves are the outcome of some stochastic process and derives results that are complementary to those of Bizer and Judd (1989). In cases where tax rates are independently and identically distributed, certainty equivalence is shown to obtain, and thus the fraction of output devoted to investment and the time path of consumption and the capital stock are invariant to tax realizations. In the case where tax rates are persistent, however, the property of certainty equivalence no longer holds. Specifically, when tax rates are assumed to follow a two-state Markov process with transition probabilities (π_0, π_1) given by $\pi_0 + \pi_1 > 1$ (they are persistent), a greater fraction of output will be invested in the low-tax state because the low-tax state implies a greater likelihood that taxes will be low in the future.

Hassett and Metcalf (1999) undertake a similar analysis, and like Bizer and Judd (1989) and Dotsey (1990), find that the stochastic process underlying realized tax rates is crucial to understanding the links between tax policy and investment. Specifically, they find that when tax policy uncertainty leads to capital costs following a continuous time random walk in logs,

[5] The explanation for this result is that firms will adjust the timing of their investment to make expanded use of the subsidy when it is relatively large.

increasing uncertainty delays investment. On the contrary, they find that when tax policy follows a jump-diffusion process such as the Poisson (which is likely in the case of investment tax credits), increasing uncertainty actually speeds up investment.

Despite the theoretical work that suggests uncertain tax policy to be an important determinant of investment, there has been surprisingly little empirical work. What has been done does not directly investigate the impact on investment, but instead, tends to look at the impact of random tax policy on economic growth.[6] An empirical investigation of uncertain tax policy and investment is thus crucial to a full understanding of the interplay between taxes and investment, especially given ambiguities in the limited theoretical literature.[7]

3. Modeling Volatility in Effective Tax Rates

In constructing a tax rate series for estimating the impact of tax volatility on investment, it is important to be able to capture not only changes in statutory rates, but also changes in other factors that may substantially alter tax liabilities, such as investment tax credits and other incentives, exemptions, deductions, and/or tax bracket creep. This means that the relevant tax measure is an *effective* tax rate on capital which incorporate all of the factors affecting tax liabilities.

3.1 Measuring Effective Tax Rates on Capital Income

Traditional measures of average effective tax rates, which in many cases have used gross domestic product as the base, are easily computed from aggregate macroeconomic data but provide only very rough estimates of actual tax distortions. At the same time, traditional measures of marginal effective tax rates often are much more precise, but are not tractable for

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[6] See, for example, Skinner (1988).

[7] This paper does not present a theoretical model of investment under tax uncertainty, which has been well-developed in other work and would be repetitive here. Readers are referred to Dotsey (1990) and Hassett and Metcalf (1999) for conceptual details.

constructing a long time series of tax rates over several countries, as required for our analysis. Fortunately, Mendoza *et al.* (1994) provides a method for computing effective tax rates using readily available data from national accounts and revenue statistics that does a good job of reflecting the distortions faced by a representative agent in a general equilibrium framework (Razin and Sadka, 1993). Moreover, despite differences in levels, tax rates calculated in this manner have been shown to be "within the range of [empirical] marginal tax rate estimates and [to] display very similar trends" (Mendoza *et al.*, 1994, 299).[8]

Using a simple general equilibrium representative agent framework, Mendoza *et al.* (1994) derive the following expression for the effective tax rate on capital (*k*):

$$(3.1) \qquad \tau_k = \frac{-q_k y_k - (-p_k y_k)}{-q_k y_k}$$

where q_k is the (pre-tax) producer price of capital, p_k is the (post-tax) consumer price of capital, and y_k is the utilization of the capital input.[9] The numerator thus represents the difference between pre-tax and post-tax valuations of capital, which can be approximated by tax revenues derived from capital, and the denominator is the income derived from capital, which is a measure of the tax base.

As demonstrated by Mendoza *et al.*, for OECD countries, all of the data necessary for calculating the effective tax rate on capital given in (3.1) are provided in the OECD's *Revenue Statistics* and *National Accounts: Volume II, Detailed Tables*. Specifically, the effective tax rate on capital is given by:

$$(3.2) \qquad \tau_k = \frac{\tau_h(OSPUE + PEI) + 1200 + 4100 + 4400}{OS}$$

[8] For other studies employing this methodology, see Mendoza *et al.*, (1997) and Mendoza and Tesar (1998).

[9] The variable y_k is an element of a net output vector $\bar{y}$, and hence is negatively valued.

where 1200 is the OECD's code for taxes on income, profits, and capital gains of corporations; 4100 is recurrent taxes on immovable property, and 4400 is taxes on financial and capital transactions, all of which are provided in the OECD's *Revenue Statistics*. The OECD's *National Accounts* provides the remaining data. *OSPUE* is operating surplus of private unincorporated enterprises, *PEI* is households' property and entrepreneurial income, and *OS* is the total operating surplus of the economy. Finally, τ_h is households' average tax on total income, which is given by:

$$(3.3) \qquad \tau_h = \frac{1100}{OSPUE + PEI + W}$$

where 1100 is taxes on income, profits, and capital gains of individuals (*Revenue Statistics*); and *W* is wages and salaries (*National Accounts*).

3.2 Data on Effective Tax Rates in OECD Countries

Table 1 shows descriptive statistics for effective tax rates on capital income for eight OECD countries over the period 1965-1992, which were calculated using the *Mendoza et al.* (1994) methodology.[10] Mean effective tax rates on capital income range from a low of 23.7 percent in Switzerland to a high of 56.2 percent in the United Kingdom. The mean over all countries over time is 36.8 percent, with a standard deviation of 11.8 percent. As shown in Figure 1, effective tax rates vary considerably not only across countries, but also within countries. In Finland, for example, which saw the greatest variation in effective tax rates relative to its average rate, effective tax rates on capital income ranged from a low of 21.6 percent (1969) to a high of 57.5 percent (1991). While some of the variance is attributable to trend, Figure 1 demonstrates a substantial volatility around that trend. The volatility of effective tax rates over

[10] Data from only eight OECD countries had a time series of effective tax rates on capital income of sufficient length to perform the required time series analyses.

time also varies considerably across countries.

3.3 A Model of Tax Rate Volatility

Effective tax rates on capital income in OECD countries clearly are quite variable, and appear to be much more volatile in some periods than in others. To build a model for examining this volatility, we first conceptually separate the series into its deterministic and stochastic components:

(3.4) $\tau_{i,t} = f(\bullet) + u_{i,t}$

where ($\tau_{i,t}$) is the effective tax rate on capital income in country *i* at time *t*, $f(\bullet)$ is the deterministic component, and $u_{i,t}$ is the stochastic component. We then allow the variance of $u_{i,t}$ to change over time within each country and set out to empirically estimate its structure. To accomplish this, we specify an estimating equation[11]

(3.5) $\Delta\tau_{i,t} = \mu_i + \beta_i t + u_{i,t}$

and consider the class of generalized autoregressive conditional heteroscedasticity (GARCH) specifications for $u_{i,t}$ (Bollerslev, 1986).[12] Specifically, we consider a class of models where

(3.6) $u_{i,t} = v_{i,t}\sqrt{h_{i,t}}$

(3.7) $v_{i,t} \sim IID(0,1)$

and $h_{i,t}$ evolves according to

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[11] Observation of effective tax rates on capital income over time (Figure 1) suggests that the series are nonstationary, and (augmented) Dickey-Fuller tests confirm that the series are characterized by unit roots. Each series was thus first-differenced before proceeding to specification of the model. Additional testing showed the transformed series to be stationary in each case.

[12] See also Hamilton (1994). Bollerslev *et al.* (1992) provide an overview of ARCH-GARCH models and an excellent survey of applications in the literature. For similar applications of GARCH models to estimate predicted volatility, see Turner (2000) and Sheffrin and Turner (2000).

$$(3.8)\quad h_{i,t} = \kappa_i + \sum_{m=1}^{p} \delta_{i,m} h_{i,t-m} + \sum_{j=1}^{q} \alpha_{i,j} u_{i,t-j}^2$$

Several formulations of the GARCH model are possible, depending on the restrictions that are placed on the coefficients. Among those considered here are [1] the standard linear formulation, as shown in (3.8), with non-negativity restrictions $\kappa_i > 0$, $\alpha_{i,j} \geq 0$, and $\delta_{i,m} \geq 0$;[13] [2] the exponential (EGARCH) formulation (Nelson, 1991), where $h_{i,t}$ evolves according to:[14]

$$(3.9)\quad \log h_{i,t} = \zeta + \sum_{j=1}^{\infty} \pi_j \left\{ \left| v_{i,t-j} \right| - E\left| v_{i,t-j} \right| + \chi v_{i,t-j} \right\}$$

and E is the expectations operator; and [3] the integrated GARCH model (IGARCH), where $h_{i,t}$ evolves according to (3.8) and

$$(3.10)\quad \sum_{m=1}^{p} \delta_{i,m} + \sum_{j=1}^{q} \alpha_{i,j} = 1,$$

that is, the ARMA process for $u_{i,t}^2$ has a unit root (Engle and Bollerslev, 1986; Nelson, 1990; Hamilton, 1994). Finally, in all specifications we also consider the GARCH-in-mean (GARCH-M) formulation (Engle *et al.*, 1987), where $h_{i,t}$ itself is included as a regressor in (3.5). Alternative lag lengths (p and q) were considered for each specification, and $h_{i,t}$ was allowed to enter the GARCH-M estimating equation in linear, logarithmic, and quadratic forms. The optimal model was then chosen by means of Akaike's information criterion (AIC).

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[13] It is possible to ensure nonnegativity with slightly less restrictive constraints. The constraints utilized for the linear GARCH model are sufficient, but not necessary conditions. See Nelson and Cao (1992).

[14] For the EGARCH specification, estimation proceeded under the assumption that a shock of given magnitude has the same effect on volatility regardless of direction ($\chi = 0$) and that $v_{i,t}$ is normally distributed, which implies that $E\left| v_{i,t} \right| = \sqrt{2/\pi}$. The parameterized form of (3.9) is then (see Hamilton, 1994):

$$\log h_{i,t} = \gamma_{i,0} + \sum_{m=1}^{p} \gamma_{i,m} \log h_{i,t-m} + \sum_{j=1}^{q} \lambda_{i,j} \left\{ \theta_i v_{i,t-j} + \left| v_{i,t-j} \right| - \sqrt{2/\pi} \right\}.$$

3.4 GARCH Estimation Results

Table 2 provides the final maximum likelihood estimation results for the time series of effective tax rates on capital income. The results suggest that time series heteroscedasticity may be a substantially underappreciated concern in modeling effective tax rates, and that the form of the heteroscedasticity may differ substantially across countries. In all but one of the countries (Canada), the exponential GARCH model was selected as the best-fitting model by the AIC. The Canadian data was best fit with an integrated GARCH model. Further, the optimal model in five of the eight countries was the GARCH-M formulation, where the volatility parameter entered the estimating equation in either linear or square root form. Finally, virtually all of the ARCH and GARCH terms were significant, as well as the trend coefficients (β_i).

The GARCH estimations yielded volatility estimates for each country over a 25-year period, the statistics for which are presented in Table 3. Although effective tax rates on capital income are most volatile in Finland and Japan, as measured in Table 1 and Figure 1, the GARCH results suggest that much of that volatility is likely due to deterministic components, such as trend. After first-differencing the series and controlling for trend, the United Kingdom is shown to have the greatest stochastic volatility with average of 7.2598. Volatility is also most variable in the United Kingdom, where the standard deviation over the period is estimated to be 5.0781. The country with the least estimated stochastic volatility is Switzerland, where the mean was 0.8951 with a standard deviation of 0.6595. These measures of volatility in effective tax rates ($\hat{h}_{i,t}$) serve as the primary data employed in the empirical evaluation of the impact of tax rate volatility on investment per worker.

4. An Empirical Model of Investment with Tax Volatility

4.1 An Empirical Model of Investment

A stylized model of value-maximizing firms who face technology constraints and exogenous prices in an uncertain environment is the basis for the empirical analysis.[15] The objective is to estimate the impact that volatility in effective capital tax rates has on equilibrium capital investment, while controlling for other relevant factors, such as the level of effective tax rates, price levels, and the level of existing capital stock.

Consider a firm with technology $Y_t = F(K_t L_t)$, where Y_t is output in time *t*, K_t is the firm's capital stock, and L_t is the firm's labor utilization. Cash flows in time *t* are then given by

(4.1) $$X_t = (1-\tau_t)[p_t F(K_t, L_t) - w_t L_t] - q_t I_t$$

where p_t, w_t, and q_t are prices of output, labor, and capital goods, respectively, in time *t*, τ_t is the average tax on capital income in time *t*, and I_t is net investment. Net investment is defined as the gross change in capital stock less depreciation:

(4.2) $$I_t = K_t - (1-d)K_{t-1}$$

where *d* is the rate of depreciation. If X_t is linearly homogeneous, then (4.1) can be written as:

(4.3) $$x_t = X_t / L_t = (1-\tau_t)[p_t F(k_t) - w_t] - q_t (I_t / L_t)$$

where k_t is capital per worker. The firm objective is then to maximize the present expected value of its stream of future cash flows:

(4.4) $$V_t = E_t \int x_s \exp(-\rho_s) ds$$

where E_t reflects expectations at time *t* and ρ_s is the firm's discount factor at time *s*. The firm chooses it's investment path to maximize (4.4), yielding

15 See Abel (1990) for a comprehensive review of neoclassical investment models.

(4.5) $I_t / L_t = \phi(k_t, p_t, q_t, w_t, \tau_t; \sigma_t)$

where σ_t is a volatility parameter. Our empirical model is a stylized and aggregated formulation of (4.5), given by:[16]

(4.6) $I_{i,t} / L_{i,t} = \psi_0 + \psi_1 k_{i,t-1} + \psi_2 \tau_{i,t-1} + \psi_3 \log(\dot{p}_{i,t}) + \psi_4 \log(\dot{q}_{i,t}) + \psi_5 \sqrt{\hat{h}_{i,t}} + \varepsilon_{i,t}$

where countries are indexed by *i*, $\dot{p}_{i,t}$ is the rate of inflation in the general price level, $\dot{q}_{i,t}$ is the rate of inflation in capital prices, and $\hat{h}_{i,t}$ is the estimated volatility in effective tax rates on capital income, as measured above. Implicit in (4.6) is an assumption that volatility arises only from the stochastic component of the effective tax rate series.

4.2 Data and Empirical Issues

A panel data set of eight OECD countries over 25 years (1966-1990) was used to estimate the empirical model in (4.6). Table 4 provides descriptive statistics for the data. The dependent variable is investment per worker ($I_{i,t} / L_{i,t}$), which was calculated from data on the investment share of gross domestic product (GDP) and GDP per worker provided in the Penn World Tables, version 5.6 (see Summers and Heston, 1991). As seen in Figure 2, investment per worker has a substantial amount of variation both across countries and over time. The mean level of investment per worker over the period was lowest in Japan at $6,398 and highest in the United States at $13,547. The mean over all countries was $10,388 with a standard deviation of $2,519.

Data on capital per worker ($k_{i,t}$), inflation ($\dot{p}_{i,t}$), and the capital price index ($\dot{q}_{i,t}$) were taken directly from the Penn World Tables. Finally, data on the volatility of effective tax rates were derived from the GARCH estimates, as described above, and were incorporated in the

[16] In an effort to account for any potential endogeneity, we instrument for τ_t with its lagged value.

model as square roots. The average volatility in the sample was 2.9812, and the standard deviation was 3.2070. Tax rate volatility ranged considerably over the sample, from approximately 0.0001 to 15.2780.

The use of panel data presents unique estimation problems in the sense that unobserved heterogeneity may exist both cross-sectionally and over time. To account for these unobservables, we allow for both individual- and time-specific errors, which implies that the random component of (4.6) can be written as

(4.7) $\varepsilon_{i,t} = a_i + b_t + \omega_{i,t}$

where a_i picks up unobservable individual effects, b_t picks up unobserved time effects, and the remaining stochastic error is assumed to follow a distribution $\omega_{i,t} \sim NIID\left(0, \sigma_\omega^2\right)$. Equation (4.6) is then estimated with both fixed effects (a_i and b_t fixed in repeated samples) and random effects $\left\lfloor a_i \sim NIID\left(0, \sigma_a^2\right), b_t \sim NIID\left(0, \sigma_b^2\right) \right\rfloor$ specifications.

4.3 Results

Table 5 provides panel estimation results of (4.6). Row 1 presents results from ordinary least squares (OLS) regression with no accounts for unobserved heterogeneity, rows 2 and 3 present fixed effects results, and the final two rows present random effects results. In models 2 and 4, controls for unobserved heterogeneity are one-way in that only individual-specific effects are considered. In models 3 and 5, both individual- and time-specific effects are considered in the analysis.

Regression results suggest that volatility in effective tax rates on capital income has a significant negative impact on investment per worker. In all of the five models under consideration, the negative effect of tax rate volatility on investment per worker was significant at the 95 percent confidence level or better, and in one case the effect was significant with 99 percent confidence. With the exception of model one (OLS), parameter estimates were also remarkably stable across specification, especially between models 2 and 4 (individual effects only) and models 3 and 5 (time and individual effects). The estimated coefficient on the volatility parameter (ψ_5) ranged from -0.0026 in the two-way fixed effects specification to -0.0030 in one-way random effects specification. This suggests that a unit increase in the volatility of effective tax rates on capital income (square root), will, on average, lead to a decline in investment per worker of between 0.26 percent and 0.30 percent in these OECD countries.[17]

Other parameter estimates were also remarkably stable across models 2-5, and the results confirmed our expectations, with the exception of the capital price index, which was significantly positive in every specification. The rate of change in the general price level had a significant negative impact on investment per worker. The lagged value of the effective capital tax rate was significant and negative in the one-way fixed and random effects specifications, as expected, but the elasticity was very small (-0.0725 to -0.0859). The small elasticity estimates, along with the erosion of significance when time effects are added, suggests that the level of effective tax rates in these OECD countries may not be a very important factor in determining investment, although the certainty of the tax rates is. Finally, investment per worker tended to be increasing in the lagged value of capital per worker, with elasticities that ranged in value from 0.5664 to 0.5976. In general, the inclusion of individual- and time-specific effects lead to substantial improvement in the explanatory power of the empirical model.

[17] Of course, $\psi_5 = \partial \log(I_{i,t} / L_{i,t}) / \partial \sqrt{h_{i,t}}$, which implies that $\log(I_{i,t} / I_{i,t-1}) = \psi_5 \cdot d\sqrt{h_{i,t}}$, or $(I_{i,t} / I_{i,t-1}) - 1 = \exp(\psi_5 \cdot d\sqrt{h_{i,t}}) - 1$. If $d\sqrt{h_{i,t}} = 1$, then it follows that $\%\Delta I_{i,t} = \exp(\psi_5) - 1$, which over the range of estimates (–0.0026 to –0.0030) is approximately equal to ψ_5 $[Note: \lim_{x \to 0} \exp(x) - 1 = x]$.

5. Concluding Remarks

The government sector seems very inclined to believe that tax policy plays a crucial role in investment decisions, despite a large amount of evidence to the contrary (Hassett and Hubbard, 1996). This means that policy makers can be expected to continually tinker with the tax code in an effort to stimulate investment, be it adjusting rates, altering depreciation schedules, or offering a portfolio of tax incentives, many of which are temporary. As a result, effective tax rates on capital, which account for investment tax incentives as well as statutory rates, can be expected to be quite volatile over time. Observations of realized effective capital tax rates have been shown to bear this out, even in the relatively stable countries of the OECD. Further analysis suggests that this volatility deters investment, although the level of tax rates does not seem to be important. Even if tax policy were shown to stimulate investment, and the literature is far from consensus on this point, policy makers would do well to establish some permanence in the tax code.

As a first attempt to empirically examine the effects of random tax policy on investment, this study offers a substantial body of new information on the relationship between taxes and investment. Much work remains to be done, however. The time series analysis of section 3 could be expanded to include a much larger portfolio of stochastic specifications for effective tax rates, including the jump diffusion processes suggested by Hassett and Metcalf (1999). Further, the empirical evidence presented in section 4 would be more convincing with additional studies over a wider range of countries over longer periods of time. This will require much better data collection and compilation than is currently available. Finally, a structural model of investment under random tax policy would likely offer greater insight into the mechanics of firm and government decision making.

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Table 1
Effective Tax Rates on Capital Income
Selected OECD Countries, 1965-1992

Country (Time Period)	Effective Tax Rate Mean (Std. Dev.) [Range]	Country (Time Period)	Effective Tax Rate Mean (Std. Dev.) [Range]
Australia (1965-1991)	40.668 (6.594) [29.282, 50.900]	Japan (1965-1992)	34.913 (11.101) [19.503, 53.473]
Canada (1965-1992)	40.913 (3.756) [35.627, 50.023]	Switzerland (1965-1992)	23.718 (4.961) [13.942, 30.001]
Finland (1965-1992)	34.110 (9.268) [21.614, 57.517]	United Kingdom (1965-1992)	56.150 (9.056) [39.263, 74.332]
Germany (1965-1992)	26.790 (3.923) [20.482, 32.206]	United States (1965-1991)	42.505 (3.285) [36.797, 48.840]
ALL COUNTRIES (1965-1992)	36.799 (11.758) [13.942, 74.332]		

DATA SOURCE: Enrique Mendoza, Department of Economics, Duke University

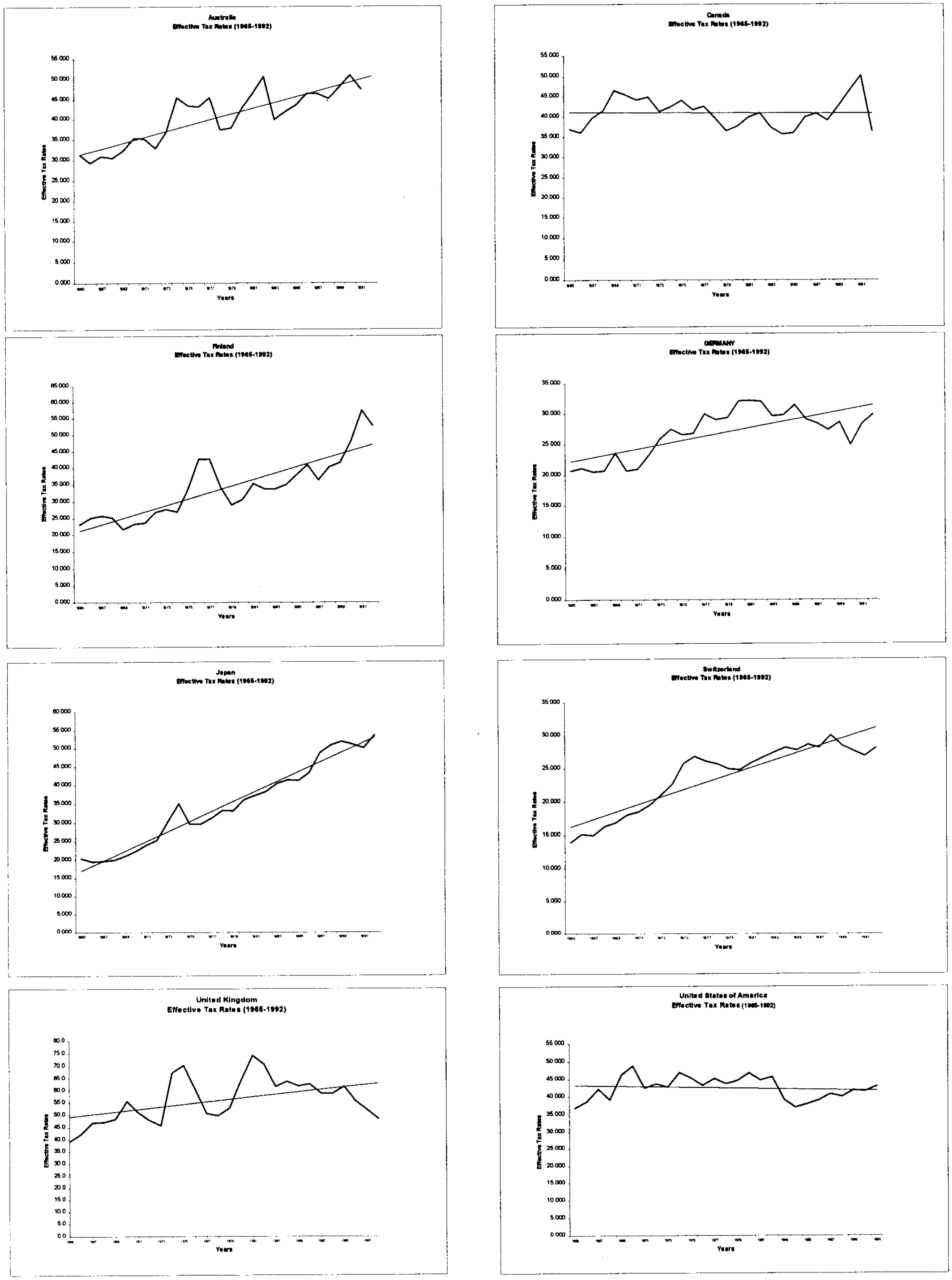

Figure 1: Effective Tax Rates on Capital, Selected OECD Countries, 1965-1992

Table 2
Effective Tax Rates by Country
GARCH Estimation Results /a/

Country	Model /b/	Constant	Trend Parameter	ARCH Parameters			GARCH Parameters		EGARCH Parameter	Volatility Parameter
		μ	β	γ_0	γ_1	γ_2	λ_1	λ_2	θ	δ
Australia	$EG-M$	1.7172*** (0.0062)	0.0233*** (0.0009)	1.9206*** (0.2339)	-2.9411*** (0.4734)		-0.2088*** (0.0313)		-0.9317*** (0.0848)	-0.0776* (0.0464)
Canada	$IG-\sqrt{M}$	-13.1807*** (1.7628)	0.3374*** (0.1192)	0.4399 (1.5739)	0.2510** (0.1135)	0.7315** (0.2867)	0.0080 (0.4656)	0.0095 (0.4256)		5.1951*** (0.3770)
Finland	$EG-\sqrt{M}$	4.2249*** (1.0512)	0.0404** (0.0197)	1.4611** (0.4702)	0.0012 (0.0010)		0.3487* (0.2108)		1096.0 (1028.0)	-1.2007*** (0.4423)
Germany	$EG-\sqrt{M}$	0.2447*** (0.0182)	-0.0064*** (0.0017)	-0.1803** (0.0789)	0.1075*** (0.0232)	-3.8171*** (0.3987)	0.0166*** (0.0059)	-0.0856*** (0.0099)	0.8270*** (0.0307)	0.2084*** (0.0560)
Japan	EG	0.8908*** (0.2621)	0.0082 (0.0634)	1.8637*** (0.2564)	3.2622*** (0.2555)	4.3390*** (0.2565)	-0.6593*** (0.1312)	-0.4960** (0.2242)	-0.0204 (0.2566)	
Switzerland	$EG-M$	1.5163*** (0.0115)	-0.0940*** (0.0013)	-3.2122*** (0.1300)	1.3042*** (0.0487)	2.9660*** (0.0218)	-1.5035*** (0.0176)	-0.6892*** (0.0176)	0.2064*** (0.0425)	0.1943*** (0.0168)
United Kingdom	EG	-1.6869*** (0.0002)	-0.0696*** (0.00002)	0.2157*** (0.0164)	-4.3014*** (0.0516)	4.9220*** (0.0532)	0.8953*** (0.0039)		-0.4818*** (0.0230)	
United States	EG	1.3594*** (0.4851)	-0.0223 (0.0766)	2.1630*** (0.1092)	-0.9535*** 0.0779)	4.2108*** (0.1300)	-0.5464*** (0.0511)	-0.8505*** (0.1626)	-0.0345 (0.3307)	

NOTES: /a/ *** indicates significance at the 99 percent confidence level, ** indicates significance at the 95 percent confidence level, and * indicates significance at the 90 percent confidence level.

/b/ EG indicates exponential GARCH, IG indicates integrated GARCH, M indicates a GARCH-in-mean specification with the GARCH term entering linearly, amd $\sqrt{M}$ indicates a GARCH-in-mean specification with the GARCH term entering as a square root.

Table 3

GARCH Estimates of Tax Rate Volatility $\left(\sqrt{\hat{h}_{i,t}}\right)$

Country	Mean	Standard Deviation	Minimum	Maximum
Australia	3.5478	2.8934	0.0013	9.9504
Canada	1.7944	0.5300	0.9033	2.8283
Finland	3.7288	3.2280	1.0002	14.0125
Germany	2.0186	1.3964	0.0001	4.0739
Japan	2.1787	2.4919	0.0608	9.7661
Switzerland	0.8951	0.6595	0.0805	2.1004
United Kingdom	7.2598	5.0781	0.0054	15.2780
United States	2.4261	1.9703	0.1080	8.2630

Table 4
Descriptive Statistics
Investment Equation

Variable	Mean	Stand. Dev.	Source
Investment Per Worker $(\log I_{i,t})$	10,387.93	2,518.75	Penn World Tables v5.6 (investment)
Capital Per Worker $(\log k_{i,t})$	30,462.96	13,371.70	Penn World Tables v5.6
Lagged ETRK $(\log \tau_{i,t-1})$	36.799	11.758	Enrique Mendoza, Duke University
Log Inflation $(\log \dot{p}_{i,t})$	0.0030	0.2017	Penn World Table v5.6
Log Price of Capital $(\log \dot{q}_{i,t})$	- 0.0947	0.1867	Penn World Tables v5.6
Volatility $\left(\sqrt{h_{i,t}}\right)$	2.9812	3.2070	GARCH Estimates

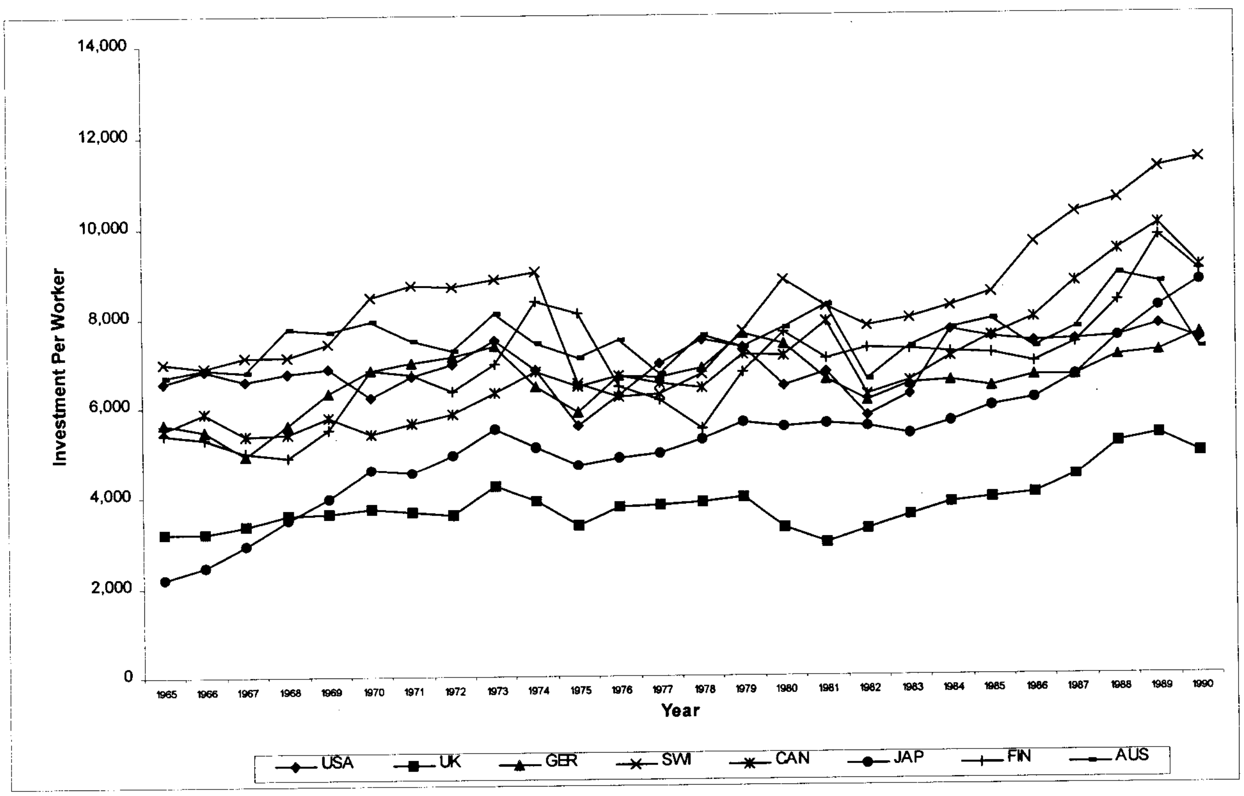

Figure 2: Investment Per Worker, Selected OECD Countries, 1965-1991

Table 5
Panel Regression Results
Investment per Worker

Model	Constant	$\log(k_{i,t})$	$\log(\tau_{i,t-1})$	$\log(\dot{p}_{i,t})$	$\log(\dot{q}_{i,t})$	$\sqrt{h_{i,t}}$	Specification Tests
OLS	1.6205** (0.4105)	0.5976** (0.0356)	0.4340** (0.0373)	-0.6973** (0.1430)	0.3257* (0.1299)	-0.0098* (0.0038)	Adj $R^2 = 0.70$
One-Way Fixed Effects	3.8902** (0.1624)	0.5895** (0.0208)	-0.0859** (0.0296)	-0.3498** (0.0651)	0.3455** (0.0599)	-0.0029* (0.0011)	*H0:* No FE F = 326.75***
Two-Way Fixed Effects	3.9381** (0.2588)	0.5664** (0.0270)	-0.0241 (0.0289)	-0.4028** (0.0592)	0.3755** (0.0536)	-0.0026* (0.0011)	*H0:* No FE F = 102.51***
One-Way Random Effects	3.5549** (0.1791)	0.5828** (0.0208)	-0.0725* (0.0295)	-0.3506** (0.0658)	0.3427** (0.0604)	-0.0030* (0.0012)	*H0:* E(X,ε) = 0 m(2) = 15.96***
Two-Way Random Effects	3.5570** (0.2011)	0.5678** (0.0218)	-0.0294 (0.0277)	-0.3892** (0.0537)	0.3656** (0.0537)	-0.0028** (0.0011)	*H0:* E(X,ε) = 0 m (4) = 98.71***

Standard Errors in Parentheses.
** Significant at 99% Confidence Level
* Significant at 95% Confidence Level

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