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The Impact of Tax Risk and Persistence on Investment Decisions

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Abstract

There is evidence that tax rates have varied considerably through time. In the postwar years, changes in business taxation in the U.S. have occurred at a pace of approximately every three years. The purpose of this research is to examine the implications of tax risk and persistence on irreversible investment decisions.

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1 Introduction

Governments frequently modify tax laws, be it with the intent of stimulating the level of investment, of changing its composition or of reducing its volatility. There are numerous tax provisions which affect corporate investment, three of the most noteworthy being the statutory corporate profits tax rate, the investment tax credit first introduced in the US in 1962, and accelerated depreciation allowances first introduced in 1954. These tax instruments have been altered frequently. For example, in the US there were 13 important changes in the corporate tax code from 1962 to 1988. A specific investment tax credit lasts on average 3.67 years, while on average the tax credit is abolished for 3 years.[1]

The impact of alternative tax policies on investment behavior has been the topic of numerous studies. The approach taken in these studies has been typically based on the cost of capital approach pioneered by Hall and Jorgenson (1967) or the Q-theory approach based on the cost of adjustment model. For example, Summers (1981) and Auerbach and Hassett (1992) both use the adjustment cost model for analysing the impact of taxation on investment. Yet, for a number of theoretical and empirical reasons, the cost of adjustment model has come under criticism. Furthermore, most studies of taxation have typically abstracted from the context of uncertainty surrounding tax policy.[2] In this paper we present results regarding tax risk and policy volatility in a framework where investment is irreversible. Unlike much of the taxation literature, however, we focus on the effects of the investment tax credit versus other tax variables separately. A large literature analyzes irreversible investment under uncertainty and demonstrates that investment is particularly sensitive to risk and uncertainty.[3] We consider the effect of increases in risk on investment. We provide sufficient conditions for increases in tax risk to reduce investment. We also investigate the impact of having a more persistent fiscal policy relative to one which is more erratic. We consider both the positively and negatively correlated cases. In the case of a positively serially correlated tax credit, we show that lower persistence (or greater volatility) in policy will lead to greater variability in investment.

2 The Basic Model

Our analysis is based on the profit-maximization problem of a risk neutral monopolistically competitive firm under uncertainty which makes variable input and investment decisions in each period. At time t, it produces output Y_t using capital K_t (which is predetermined at t), and variable inputs L_t. The firm operates under constant returns

[1]See Cummins, Hassett and Hubbard (1994) who document postwar tax changes.

[2]Notable exceptions include Auerbach and Hasset (1992), Bizer and Judd (1989), and Hassett and Metcalf (1999).

[3]See, for example, Demers (1991), Bertola and Caballero (1994), Dixit and Pindyck (1994), Caballero (1997) and Altug, Demers and Demers (1999).

to scale. It has a production function $F(K_t, L_t)$ that is twice continuously differentiable, increasing, concave, and satisfies the Inada conditions. Let p_t denote the output price. The inverse market demand function is given by $p_t = (\alpha_t)^{-1/\varepsilon}(Y_t)^{1/\varepsilon}$, where $\varepsilon < -1$ is the price elasticity of demand, and α_t is the state of demand.

The optimal choice of variable factors involves static optimization under certainty. Define the short-run profit function at time t, $\Pi(K_t, \alpha_t, w_t)$, as $\Pi(K_t, \alpha_t, w_t) \equiv \max_{L_t > 0}\{p_t F(K_t, L_t) - w_t \cdot L_t\}$, where w_t is the nonstochastic variable input price vector.[4] Letting I_t denote the firm's rate of gross investment measured in physical units and p_t^k the purchase price of investment goods, the firm's after-tax cash flow at time t, R_t, is defined as

$$R_t = (1 - \tau_t)\,\Pi(K_t, \alpha_t, w_t) + \tau_t \sum_{x=1}^{T} D_{x,t-x} p_{t-x}^k I_{t-x} - (1 - \gamma_t)\,p_t^k I_t, \tag{1}$$

where τ_t is the corporate tax rate at time t, γ_t is the investment tax-credit at time t as a percentage of the price of the investment good, $D_{x,t-x}$ is the depreciation allowance per dollar invested for tax purposes for capital equipment of age x on the basis of the tax law effective at time $t - x$, and T is the life of the equipment. Let r denote the real rate of interest, and define z_t as the present value of tax deductions on new investment, where $z_t = \sum_{n=1}^{T} \tau_{t+n} D_{n,t}(1 + r)^{-n}$. Also define p_t^I as the tax-adjusted price of investment goods, $p_t^I = (1 - \gamma_t - z_t)\,p_t^k$.

We assume that investment projects undertaken in period t yield productive capital next period. Thus, the law of motion of the capital stock is given by

$$K_{t+1} = (1 - \delta)\,K_t + I_t, \tag{2}$$

where δ, $0 < \delta < 1$, be the deterministic depreciation rate. Finally, we assume that investment is irreversible:

$$I_t \geq 0. \tag{3}$$

2.1 Characterizing the Optimal Solution

The firm's problem involves maximizing the expected discounted value of after-tax cash flows subject to the law of motion for capital (2), the irreversibility constraint (3), and given the initial condition K_1. This problem may be expressed recursively using dynamic programming. Let $V(K_t, \gamma_t)$ denote the value function as a function of the state variables at date t and let V_K denote the partial derivative of V with respect to K.

The first-order necessary and sufficient condition for the optimization problem at time t are

$$-p_t^I + \beta E_t V_K(K_{t+1}, \gamma_{t+1}) \begin{array}{ll} = 0 & \text{if } I_t^* > 0 \\ \leq 0 & \text{if } I_t^* = 0. \end{array} \tag{4}$$

[4]The short-run profit function, $\Pi(K_t, \alpha_t, w_t)$ is continuous in K_t, α_t, and w_t, increasing in K_t and α_t, decreasing in w_t, and strictly concave in K_t. We assume that $\Pi(K_t, \alpha_t, w_t)$ is bounded for finite K_t, α_t, and w_t.

Assuming that an interior solution obtains in period t, the first-order condition (4) for time t can be rearranged as

$$(1-\tau_{t+1})\Pi_K\left(K_{t+1},\alpha_{t+1},w_{t+1}\right) = c_t + (1-\delta)\Big\{E_t\widetilde{p}^I_{t+1} \\ -E_t \min\Big[\widetilde{p}^I_{t+1},(1+r)^{-1}E_{t+1}V_K\left((1-\delta)K_{t+1},\gamma_{t+1}\right)\Big]\Big\}, \tag{5}$$

where Π_K is the partial derivative of Π with respect to K_{t+1}, and where $c_t = p^I_t(r+\delta) - (1-\delta)(E_t\widetilde{p}^I_{t+1} - p^I_t)$ is the firm's cost of capital. The second term on the right-hand side of equation (5) is a risk premium that the firm requires for the loss of flexibility that it incurs since it cannot disinvest. It represents a positive marginal adjustment cost arising endogenously from the irreversibility of investment. In contrast to the exogenous adjustment costs which are assumed in the standard model, the adjustment costs in our irreversibility model will vary through time in response to information that is relevant for predicting future values of tax rates, the price of capital, the state of demand, and other variables that enter the firm's problem. Hence, increases in risk and changes in the volatility of tax policy will alter adjustment costs, the level of irreversibility as well as the probability of investing.

3 Increases in Risk

We consider the impact on irreversible investment of stochastic changes in the investment tax credit (ITC) in the sense of first-order stochastic dominance (FSD) and of a mean-preserving spread (MPS).[5]

When $\widetilde{\gamma}_{t+1}$ is positively serially correlated, for all $\gamma' \geq \gamma$ and for all t, the distribution function $G(\gamma_{t+1} \mid \gamma'_t)$ dominates $G(\gamma_{t+1} \mid \gamma_t)$ by FSD. This condition can be interpreted to mean that the future resembles the present. The higher the current value of γ_t, the higher is the probability of observing a high value of the investment tax credit next period. Under this condition, the shadow price of capital, V_K, is decreasing in γ_t. As a consequence, a FSD shift which lowers the probability of low values of $\widetilde{\gamma}_t$ and which increases the prospect of facing a higher ITC next period will increase the marginal adjustment cost, and induce the firm to lower current investment.

It is also instructive to investigate how a MPS in the distribution function of $\widetilde{\gamma}_{t+1}$ affects investment. If $\widetilde{\gamma}_{t+1}$ is i.i.d., a MPS unambigously reduces investment. In this case, an increase in risk in the investment tax credit depresses the expected future marginal value of capital and raises the marginal endogenous adjustment cost, thereby reducing current investment. If $\widetilde{\gamma}_{t+1}$ is positively serially correlated, a sufficient condition for investment to fall is that the distribution function, $G(\gamma_{t+1} \mid \gamma_t)$, be concave in γ_t. Greater variability of the ITC in the sense of a MPS increases the marginal adjustment cost and makes it more likely that the firm will be constrained some time

[5]Proofs of all results described in this section and the next are provided by Altug, Demers, and Demers (2001).

in the future. Thus, the firm's optimal response is to lower investment. Finally, we also show that firms facing a more variable (in the sense of MPS) investment tax credit will have a lower capital stock in the steady-state.

4 Changes in Persistence

To understand the implications of changes in *persistence* in the process generating the investment tax credit, first suppose that $\tilde{\gamma}_t$ follows a positively serially correlated process. Consider two possible distributions for $\tilde{\gamma}_t$ such that the distribution (G^2) is *more persistent* than the original distribution (G^1) and where $\gamma_t \in [\gamma^L, \gamma^H]$.[6] For example, for discrete distributions, this amounts to requiring $Prob^2(\gamma_{t+1} = \gamma' | \gamma_t = \gamma') > Prob^1(\gamma_{t+1} = \gamma' | \gamma_t = \gamma')$ and $Prob^2(\gamma_{t+1} = \gamma'' | \gamma_t = \gamma') < Prob^1(\gamma_{t+1} = \gamma'' | \gamma_t = \gamma')$ $\forall \gamma'' \neq \gamma'$.

Let us first assume that $\gamma_t = \gamma^L$. Note that conditional on observing γ^L at time t the distribution function exhibiting greater persistence (G^2) attaches greater probability to lower realizations of $\tilde{\gamma}_{t+1}$ than G^1. Hence, $G^1(\gamma_{t+1}|\gamma^L)$ dominates $G^2(\gamma_{t+1}|\gamma^L)$ by first order stochatic dominance. In Altug, Demers, and Demers (2001), we show that $V_K(K_t, \gamma_t)$ is decreasing in γ_t when γ_t follows a positively correlated process. Using this result, we can show that $I(K_t, (1-\gamma^L-z_t)p_t^k, G^1) < I(K_t, (1-\gamma^L-z_t)p_t^k, G^2)$. Let us now assume instead that $\gamma_t = \gamma^H$.[7] Conditional on observing γ^H, the distribution function exhibiting greater persistence (G^2) attaches higher probability to high realizations of $\tilde{\gamma}_{t+1}$ than G^1 and hence, dominates the latter by FSD. Therefore, proceeding similarly, we can show that $I(K_t, (1-\gamma^H-z_t)p_t^k, G^1) > I(K_t, (1-\gamma^H-z_t)p_t^k, G^2)$. Since the policy function $I(K_t, (1-\gamma_t-z_t)p_t^k, G^1)$ is continuous in γ_t, this implies that there exists some value of $\gamma_t \equiv \hat{\gamma}$ such that $I(K_t, (1-\hat{\gamma}-z_t)p_t^k, G^1) = I(K_t, (1-\hat{\gamma}-z_t)p_t^k, G^2)$, $I(K_t, (1-\gamma-z_t)p_t^k, G^1) < I(K_t, (1-\gamma-z_t)p_t^k, G^2)$ for $\gamma^L \leq \gamma < \hat{\gamma}$, and $I(K_t, (1-\gamma-z_t)p_t^k, G^1) > I(K_t, (1-\gamma-z_t)p_t^k, G^2)$ for $\hat{\gamma} < \gamma \leq \gamma^H$.

Next, we need to determine how current investment responds to a larger value of γ_t. If an interior solution exists at time t, we obtain from the first-order condition

$$\frac{\partial I_t}{\partial \gamma_t} = \frac{\left\{p_t^k + \beta \lim_{\epsilon \to 0} \frac{1}{\epsilon} \int V_K[dG(\gamma_{t+1}|\gamma_t + \epsilon) - dG(\gamma_{t+1}|\gamma_t)]\right\}}{-\beta \int V_{KK} dG(\gamma_{t+1}|\gamma_t)}. \tag{6}$$

This condition shows that there are two effects of a higher tax credit on the level of investment I_t. The first is the cost-reducing effect, summarized by the first term in (6), whereas the second is an information effect, summarized by the second term in (6). In the case where the tax credit is independently distributed, tax policy is not

[6]The following discussion draws upon Donaldson and Mehra (1983) and Danthine, Donaldson and Mehra (1983).

[7]Note that the two distributions are rankable by first order stochastic dominance only when $\gamma_t = \gamma^H$ or $\gamma_t = \gamma^L$. When $\gamma_t = \gamma'$, with $\gamma' \neq \gamma^H$ and $\gamma' \neq \gamma^L$, the two distributions are not rankable by FSD (nor by higher orders of stochastic dominance).

predictable, and therefore, there is no information effect attached to the current value of γ_t. The only effect is the cost-reducing effect, which implies that the effect of a higher investment tax credit on current investment is positive, i.e., $\partial I_t/\partial\gamma_t > 0$.

By contrast, the impact of a higher tax credit on current investment cannot be determined analytically for the case of positive serial correlation. In this case, the second term is negative since V_K is decreasing in γ. Thus, the information effect tends to depress investment since a higher tax credit today heralds a higher tax credit tomorrow so that investment should better be postponed. Thus, the sign of $\partial I_t/\partial\gamma_t$ will depend on whether or not the (positive) cost-reducing effect of a higher current tax credit overcomes the (negative) information effect. If $\partial I_t/\partial\gamma_t > 0$, lower persistence in the tax credit induces greater variability of investment, and thus, of the stationary distribution for the capital stock. Conversely, greater persistence reduces the variability of investment. By contrast, if $\partial I_t/\partial\gamma_t < 0$, greater persistence in the tax credit induces greater variability of investment, and thus, of the stationary distribution for the capital stock. Similarly, lower persistence decreases the variability of investment.

The analysis of the negatively serially correlated case is complicated by the fact that the sign of $\partial V_K(K_t, \gamma_t)\partial\gamma_t$ is not determinate. If $V_K(K_t, \gamma_t)$ is decreasing in γ_t, it is straightforward to show that under the assumption that a higher value of γ_t is associated with a decreased likelihood of facing a high tax credit tomorrow, the information effect (described by the second term in (6)) will be positive. Thus, both the cost effect and the information effect are conducive to stimulate current investment so that a higher tax credit today has an unambiguously positive effect on current investment ($\partial I_t/\partial\gamma_t > 0$). As a result, greater persistence in the investment tax credit leads to lower variability in investment. This is the same result as with positive correlation. Finally, the results obtained when $V_K(K_t, \gamma_t)$ is increasing in γ_t are the reverse of those when $V_K(K_t, \gamma_t)$ is decreasing in γ_t.

5 Conclusion

In this paper, we have analyzed the impact of increases in risk in the investment tax credit as well as changes in policy volatility on irreversible investment. We have assumed that there exist no subjective uncertainty with respect to tax policy. However, an examination of U.S. tax policy since World War II suggests that learning may also be an important issue surrounding tax policy. In our ongoing research, we will examine the implications of learning and of tax volatility on investment behavior. Among other issues, we will consider sufficient conditions for an increase in risk to reduce investment in a Bayesian learning context, and analyze learning about tax policy when tax changes follow a Poisson process. We will also generate quantitative results regarding the impact of tax risk, persistence, and learning about tax policy using data on the determinants of taxes for the U.S.

6 References

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