Taxes and the demand for capital: theory and evidence from Chile

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Abstract

This paper estimates a long-run demand for capital in Chile, and studies the responsiveness of firms' desired capital stock to variations in tax rates. We combine the neoclassical model with a cointegration argument to obtain a long-run demand for capital that is valid for a general cost adjustment structure. The main conclusion of the theoretical analysis is that there is no a priori reason to think that higher taxes reduce the demand for capital. This conclusion is valid whether firms ignore marginal rates faced by their stockholders or incorporate them.

The model is estimated with a panel of Chilean corporations with annual data between 1985 and 1995. Results obtained are consistent with theoretical predictions: an increase in the corporate tax rate from 0 to 20%, reduces the desired capital stock by less than 0.2%. We also find that firms ignore the marginal rates their stockholders pay when they make investment decisions, i.e. there is a corporate veil.

Key words: demand for capital, user cost of capital, corporate veil, adjustment costs.

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1 Introduction

Quite often the relationship between taxes, investment, and economic growth is cause of a heated debate in many developing countries. In Chile, for example, it is usually argued that lower taxes stimulate investment and savings; that the increase in corporate savings since the mid eighties was due to the substantial difference between the highest marginal rate of the personal tax and the rate paid by firms on retained profits; that when income tax rates are raised, capital accumulation is discouraged; and that the increase in the current account deficit during the second half of the nineties was due to the 1990 tax reform. Despite the importance of the subject, few theoretical studies rigorously model the points in dispute, and the empirical evidence that supports statements like the ones above is generally tenuous or non-existent.

The purpose of this paper is to contribute to this debate by examining, theoretically and empirically, the relationship between the demand for long-run capital by Chilean firms and the tax rates paid by those firms and their stockholders. We combine an extension of Jorgenson's 1963 neoclassical model, with no adjustment costs where the demand for capital depends on the user cost of capital, with a cointegration argument by Bertola and Caballero (1990). This enables us to obtain a long-run demand for capital that is valid for a general adjustment cost structure. The model is estimated with a group of relatively large publicly-held firms between 1985 and 1995.[2]

The main conclusions of the paper are the following. First, theory shows that there is no a priori reason to believe that higher taxes necessarily reduce the demand for long-run capital. The commonly-held perception recognizes, correctly, that higher taxes reduce the marginal after-tax profitability of each unit of capital invested in the firm. Nevertheless, it ignores that fact that throughout the life of the asset part of its acquisition cost may be discounted from the taxable base in the form of depreciation and interest paid for the debt contracted to finance it. When those discounts are higher in present value than the acquisition cost of the asset, the acquisition of capital is subsidized and higher taxes *increase* the capital stock demanded by firms in the long run. Simply put, under such conditions, adding a unit of capital enables the firm to receive a subsidy because it reduces total taxes paid.

Second, the preceding conclusion is valid in the case where firms make decisions without considering the personal taxes their stockholders will pay (there is a 'corporate veil') and in the case where they maximize the present value of dividends net of personal taxes. Our theoretical contribution is to extend the work of Hall and Jorgenson (1967) to tax structures like those in Chile, where corporate and personal income taxes are integrated so the tax that is relevant for the firm's investment decisions is only the latter.[3]

Third, we show that in a sample of relativly large publicly held Chilean firms, the long-run aggregate

[2]Data previous to 1985 is not considered, because the only consistent series of the price of capital begins in 1985. There is a previous series which begins in 1977, but the differences with the more recent one are significant, and analysts generally consider the revised series to be significantly more accurate.

[3]See Engel, Galetovic and Raddatz (1999) for a primer on the Chilean Tax System.

demand for capital is not sensitive to the tax rate. For example, for variations in the rate paid on retained profits of 0 to 20% (the so-called first category tax), the desired capital stock decreases by less than 0.2% (and may even increase). This result is not due to the fact the desired capital stock is insensitive to changes in the user cost of capital. In fact, we estimate that the average elasticity of substitution between capital and labor across sectors is equal to -0.62. The irrelevance of taxes stems from the fact that discounts for depreciation and interest are similar to the acquisition cost of assets, so taxes do not affect the long-run demand of capital. In other words, taxes are irrelevant because they do not affect the relevant price—the user cost of capital.

Fourth, although taxes do not affect the user cost of capital very much, we show that variations in the price of capital and in the interest rate do. Between 1985 and 1995 they explain more than 90% of the variance in the user cost of capital.

Finally, we find evidence that a corporate veil does exist, that is, firms ignore the marginal rates paid by their stockholders when they make investment decisions.

Some of the theoretical and empirical results we present suggest that taxes are irrelevant. That is why it is necessary to define the scope of this conclusion precisely and explain what we are doing and what we are not doing in this paper. First, we do not estimate the demand for investment (the flow), we estimate the demand for capital (the stock). Second, this is a partial equilibrium analysis. In both the theoretical derivation and estimation we suppose the interest rate is exogenous and does not depend on taxes.[4] This seems appropriate in view of the fact that during the period the interest rate was determined basically by the monetary policy of the Central Bank of Chile. Third, we do not study the effect of taxes on decisions about financing, since we suppose the long-run debt-capital ratio of each firm is a constant whose determinants (presumably agency problems) we do not model.[5]

The effects of taxes on firms' financing decisions has been a constant concern in Chile. For example, one of the main reasons for the 1984 tax reform was to encourage retained profits, which is why taxes on retained profits were reduced. The idea was to increase the capitalization of firms and, more generally, private saving. Certainly, our conclusion that the effects of taxes on the demand for capital are very small does not necessarily extend to firms' financing decisions. Last, it is important to bear in mind that the sample of firms we used to estimate the demand for capital is limited to publicly held firms. Since it is probably easier for a firm of that kind to go into debt, it is reasonable to think that its debt-capital ratio will be higher *ceteris paribus*. On the other hand, the fraction of assets that medium and small firms finance with debt will be smaller and, consequently, the discount of interest from the taxable base will also be smaller. For those firms the effect on the user cost of capital of taxes faced by retained profits will be somewhat stronger.

[4] See Lucas (1990) for a model of general equilibrium that examines the effect of taxes on decisions on consumption and accumulation.

[5] Budnevich and Jara (1997) examine corporate decisions on saving between 1984 and 1992.

The rest of the paper is organized as follows. The theoretical model is developed in section 2. Section 3 describes the empirical model and the data. Results are presented in section 4, and section 5 concludes.

2 Theory

2.1 The model

Following Jorgenson (1963) and Hall and Jorgenson (1967), we model a neoclassical firm that takes prices as given and produces the nummerary good Y using capital (K) and labor (L) with a constant returns to scale production function $Y(K,L)$. Employment can be adjusted instantaneously. The capital stock is a state variable that evolves at instant t according to

$$\dot{K}_t = I_t - \rho K_t. \tag{1}$$

Where I_t is gross investment, $\dot{K}_t$ the instantanteous variation of the capital stock, and ρ the (constant) rate of depreciation. We also assume that the firm can arbitrarily choose its initial capital stock, K_0. Finally, we assume that all profits that are not distributed are reinvested in physical capital, so that the debt-capital ratio, b, is constant and exogenous.

At each moment in time accounting pretax profits are equal to

$$Y(K_t, L_t) - wL_t - rD_t - \Delta_t.$$

Where w is the wage, r is the interest rate at which the firm borrows (which is supposed to be constant and exogenous), $D_t \equiv \int_0^t b p_s I_s ds$ is the debt the firm has acquired from instant 0 until instant t to finance gross investment, p_t is the relative price of capital goods at t and $\Delta_t \equiv \int_0^t \delta_{t-s} p_s I_s ds$ is the sum of the depreciations that the tax law allows at instant t for capital goods acquired by the firm up to that instant. We suppose that a capital good acquired t periods ago can depreciate at t a fraction δ_t of its initial acquisition value, $p_0 I_0$, and that $\int_0^\infty \delta_s ds = 1$. For future reference it is useful to define an expression of the present value of the discounts for depreciation when \$1 are invested today. This corresponds to

$$z \equiv \int_0^\infty e^{-rs} \delta_s ds,$$

an amount which, as a result of the preceding assumptions, is less than one.

The cash flow generated by the firm at t, before investing, is equal to $(1-\tau)[Y(K_t, L_t) - wL_t - rD_t] + \tau\Delta_t$, where τ is the corporate tax rate paid on profits returned by the firm; henceforth we will call τ the ‘corporate tax. Since profits that are retained are reinvested in the firm, dividends paid at t are equal to

$$\text{div}_t \equiv (1-\tau)[Y(K_t, L_t) - wL_t - rD_t] + \tau\Delta_t - (1-b) p_t I_t.$$

2.2 The firm maximizes the present value of its dividend payments

The first case we examine is a firm that maximizes the present value of the dividends it pays, ignoring that stockholders pay personal taxes.[6] The firm chooses K_0 and the trajectories of L and I to maximize

$$\int_0^\infty e^{-rt} \text{div}_t dt,$$

or

$$\int_0^\infty e^{-rt} \{(1-\tau)[Y(K_t,L_t) - wL_t - rD_t] + \tau\Delta_t - (1-b)p_t I_t\} \, dt, \tag{2}$$

subject to (1).

Solving the firm's optimization problem (see Appendix) yields:

$$Y_K = \frac{[1-\tau(b+z)]}{1-\tau}[(r+\rho)p_t - \dot{p}_t] \equiv \upsilon_t^V. \tag{3}$$

In expression (3) Y_K is the instantaneous marginal income from adding one unit to the capital stock. The right hand side is the so-called *user cost of capital*, which we shall denote by υ^V.[7]

When $\tau = 0$ and $p_t = 1$, the user cost of each dollar invested is equal to the sum of its opportunity cost, r, and the loss from depreciation of that unit of capital, ρ. Capital gains resulting from changes in its price must be deducted. The corporate tax affects the user cost of capital for two reasons. First, part of the interest for the debt that generates an additional dollar of investment can be discounted as cost, which saves the firm τb in present value for each peso invested;[8] moreover, a fraction z of the value that was invested can be discounted as depreciation, generating a tax saving equivalent to τz. These discounts *reduce* the user cost. On the other hand, the corporate tax reduces the additional income per extra unit of capital to $Y_K(1-\tau)$; this effect appears in the denominator of υ^V, and *increases* the user cost. Since these two effects go in opposite directions, the conclusion is that the overall effect is ambiguos. For example, if the corporate tax is increased, it will not necessarily reduce the desired capital stock. There are four consequences that should be pointed out:

1. When the firm is completely financed with internal funds ($b = 0$) and the present value of the discounts for depreciation permitted by law is equal to the amount invested ($z = 1$), the level of the tax rate on firms is irrelevant, since in this case $Y_K = (r+\rho)p - \dot{p}$. In other words, both effects cancel out exactly.

2. The same applies when the firm is allowed to discount as a cost all disbursements for investment at the time they take place (this is equivalent to $z = 1$), and it is not allowed to discount any of the interest it

[6]The derivation that follows is standard in this literature; we include it to facilitate the comprehension of the case where personal taxes are added.

[7]Supraindex V refers to the fact this is user cost *with* corporate veil.

[8]Note that this means the firm would like to choose $b = 1$. However, in practice firms cannot finance themselves exclusively with debt, presumably because of agency problems that are not modeled here.

pays on the debt (which is the equivalent to making $b = 0$ for tax purposes). This is the so-called cash flow tax.

3. When $b + z > 1$, the user cost is lower the *higher* the tax rate. This occurs because in this case the firm can discount as cost more than one dollar for each dollar invested. Therefore, the higher the tax rate, the higher the value of the discounts and, consequently, the desired capital stock. (Note that in this case the demand for capital is not infinite because diminishing returns set in).

4. The foregoing implies that one cannot say a priori that higher tax rates on retained profits reduce the desired capital stock.

2.3 Personal taxes

The preceding subsection assumed that firms ignore the personal taxes paid by their stockholders when making investment decisions (the so-called *corporate veil*). Clearly, the stockholders of a firm are interested in maximizing the present value of the dividends they receive *after* paying *all* their taxes which, in Chile, include the corporate taxes and their personal taxes.[9] In this section we solve the model, assuming that the firm chooses its investment path to maximize the present value of dividends net of all taxes. To simplify the calculations, we suppose the firm has just one owner whose only source of income are dividends paid by the firm.

To define the objective function of the owner of the firm it is necessary to consider that in the Chilean tax system the corporate tax paid by the firm is a credit against the personal income tax. This credit operates as follows: if τ is the tax rate on profits and τ^{m} is the marginal tax rate on personal income, then a dividend of div_t will pay taxes of:[10]

$$\frac{\tau^{\mathrm{m}} - \tau}{1 - \tau}\mathrm{div}_t. \tag{4}$$

The objective function of the owner then becomes:

$$\int_0^\infty e^{-rt}\left[1 - \frac{\tau^{\mathrm{m}} - \tau}{1 - \tau}\right]\mathrm{div}_t dt = \frac{1}{(1-\tau)}\int_0^\infty e^{-rt}(1-\tau^{\mathrm{m}})\mathrm{div}_t dt. \tag{5}$$

In a general formulation, the average personal tax rate that an individual pays depends on his income level, credits received, and the progressivity of the tax rate. Let $\tau_t^{\mathrm{P}}: \mathbb{R}^+ \rightarrow [0,1]$ denote the progressive marginal tax schedule at t and $\overline{\tau}_t^{\mathrm{P}}: \mathbb{R}^+ \rightarrow [0,1]$ the corresponding average tax rate schedule. We assume the two functions are differentiable with respect to income and time.

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[9] Unlike the United States, there is no separate tax on corporate profits in Chile.

[10] Before 1990, the rate was not $\frac{\tau^{\mathrm{m}}-\tau}{1-\tau}$, but $\tau^{\mathrm{m}} - (\tau_{1a} + \tau_a)$, where τ_{1a} and τ_a denote the so-called First Category and Additional taxes, which determined the tax on profits. The following derivation is valid for the two expressions of the personal marginal tax rate.

Thus, the firm selects the L and I trajectories to maximize

$$\int_0^\infty e^{-rt}(1-\overline{\tau}_t^{\mathrm{P}})\mathrm{div}_t dt \tag{6}$$

subject to (1).[11] (Henceforth we will write $\overline{\tau}_t^{\mathrm{P}}$ for $\overline{\tau}_t^{\mathrm{P}}(\mathrm{div}_t)$.) In this case it is not possible to directly transform (6) into an expression analogous to (19), which would permit the application of the Hamiltonian method. The reason is that the average rates paid by the owner of the firm may depend on the moment when dividends are paid. In that case the timing of tax savings due to depreciation and interest payments matters.

To simplify we will assume that the tax savings generated by depreciation and interest on the debt increase the firm's cash flow *at the time the investment takes place*.[12] Under this assumption:

$$\mathrm{div}_t = (1-\tau)[Y_t - wL_t] - [1-\tau(b+z)]p_t I_t. \tag{7}$$

In principle, personal taxes add two new effects. First, the optimal trajectory of dividend payments will depend on how the relevant marginal rate for the owner of the firm is expected to vary. For example, if a fall in rates is expected in the future, it will become more profitable to postpone dividends and reinvest more today. The second effect is that, assuming that the firm can borrow against future tax savings to finance current investment, the owner can choose when it is most advantageous to pay dividends. The assumption that leads to (7) captures the first effect but ignores the second, by forcing the firm to include the saving on future taxes in the cash flow of the period when the investment is made. In exchange for this simplification one obtains an expression that can be estimated econometrically.[13]

Under the assumption mentioned, the associated Hamiltonian is

$$\mathcal{H} = e^{-rt}(1-\overline{\tau}_t^{\mathrm{P}})\mathrm{div}_t + \lambda_t(I_t - \rho K_t).$$

Where div_t is now given by (7). The first order conditions are

$$\frac{\partial \mathcal{H}}{\partial L_t} \equiv e^{-rt}(1-\tau_t^{\mathrm{P}})(1-\tau)(Y_L - w) = 0; \tag{8}$$

$$\frac{\partial \mathcal{H}}{\partial I_t} \equiv -e^{-rt}(1-\tau_t^{\mathrm{P}})[1-\tau(b+z)]p_t + \lambda_t = 0; \tag{9}$$

$$\frac{\partial \mathcal{H}}{\partial K_t} + \dot{\lambda}_t \equiv e^{-rt}(1-\tau_t^{\mathrm{P}})(1-\tau)Y_K - \rho\lambda_t + \dot{\lambda}_t = 0. \tag{10}$$

[11] By omitting the factor $1/(1-\tau)$ on the right side of (5), we are assuming that changes in τ are not anticipated by the owner of the firm.

[12] This is equivalent to assume that at the time one dollar is invested, the firm goes to a bank, borrows against the future tax saving generated by the debt and discounts for depreciation and pays dividends with the borrowed funds.

[13] Moreover, this simplification does not affect results when the marginal rate paid on the income remains constant over time.

Where we have used the fact that the *marginal* rate paid on the income of the owner of the firm, τ_t^{P}, is equal to $\bar{\tau}_t^{\mathrm{P}} + \frac{\partial \bar{\tau}_t^{\mathrm{P}}}{\partial \mathrm{div}_t}\mathrm{div}_t$. Note that it is evident from condition (8) that $Y_L = w$. Therefore, at the margin personal taxes (and the corporate tax) do not affect the decision on how much labor to hire.

On the contrary, condition (9) suggests that personal taxes *reduce* the cost of adding an additional unit to the capital stock: leaving one dollar in the firm reduces dividends net of tax received by only $1-\tau_t^{\mathrm{P}}$ dollars, and that is why it differs from (23) by a factor of $1-\tau_t^{\mathrm{P}}$. However, to determine the effect of personal taxes on the user cost of capital it is also necessary to include the benefit of adding an additional unit of capital, which is given by the shadow price of capital, λ_t. To do this, we start by differentiating the condition (9) with respect to time, obtaining

$$\dot{\lambda}_t = \left[-r + \frac{d}{dt}\log(1-\tau_t^{\mathrm{P}}) + \frac{\dot{p}_t}{p_t}\right]\lambda_t.$$

Substituting in (10) and rearranging one obtains

$$Y_K = \frac{[1-\tau(b+z)]}{1-\tau}\left[\left\{r+\rho-\frac{d}{dt}\log(1-\tau_t^{\mathrm{P}})\right\}p_t - \dot{p}_t\right] \equiv \upsilon_t^{NV}. \tag{11}$$

Where υ_t^{NV} denotes the user cost of capital when firms take into account the marginal rates their stockholders pay (cost *without* veil). Expression (11) differs from (3) only in one term,$-\frac{d}{dt}\log(1-\tau_t^{\mathrm{P}})$, which reflects the changes in the marginal rate of the owner overtime. These can be broken into two components: the first one captures the changes that originate in variations in the individual's income level, $\frac{\frac{\partial \bar{\tau}_t^{\mathrm{P}}}{\partial \mathrm{div}_t}\frac{d(\mathrm{div}_t)}{dt}}{(1-\tau_t^{\mathrm{P}})}$, and the second reflects exogenous changes in the structure of marginal rates, $\frac{\frac{d\bar{\tau}_t^{\mathrm{P}}}{dt}}{(1-\tau_t^{\mathrm{P}})}$. Thus, the first term depends on the dividend policy chosen by the firm while the second can be interpreted as the *expectation* of how much the marginal rate will change in the next instant.

Two results follow from equation (11). First, when the marginal rate does not change over time, the user cost is independent of the personal tax and equal to υ^V. What is the intuition? It can seen from condition (10) that the personal tax reduces the benefit of investing an additional unit of capital in t by a factor of $(1-\tau_t^{\mathrm{P}})$. When $\frac{d}{dt}\log(1-\tau_t^{\mathrm{P}}) = 0$ this cancels out exactly the lower cost of leaving one dollar in the firm and retiring it one instant later, and personal taxes do not affect the desired capital stock. This result is more general. Note that personal taxes are paid only when the firm pays dividends. In that sense, it differs from the corporate tax, which is paid as soon as taxable profits accrue. Since taxable profits do not necessarily coincide with economic profits in present value, the corporate tax affects the desired capital stock. By contrast, the personal tax is proportional to profits paid and therefore it does not affect the problem's optimality conditions or the desired capital stock.

The second result—closely related to first—is that personal taxes affect the user cost only when the marginal rate paid on dividends changes over time, either because the optimal dividend policy changes the tax bracket of the firm's owner, or because the marginal rate changes exogenously over time. For example, if the marginal rate is falling at t the cost of postponing dividends falls, because the marginal rate will fall in the future. This implies a lower user cost. The opposite occurs when the marginal rate increases over time. Consequently personal taxes affect the desired capital stock only when a change in marginal rates is expected in the immediate future, or when the owners of the firm change their tax bracket over time because of variations in their income. In the model presented here this can only occur if the owner of the firm chooses a dividend policy that makes his marginal rate vary. But more generally, the change will also depend on the evolution of the rest of his income. For example, if the rest of his income increases over time and that pulls him into a higher tax bracket, the user cost will be higher, which, *ceteris paribus*, will make him postpone investments. However, the model suggests that the effect of personal taxes on desired capital stock is small, because major changes in income tax rates ("tax reforms") are infrequent and changes in bracket, besides averaging out over time, only will be relevant for entrepreneurs or stockholders with relatively low income, since the rest are always in the top bracket.

3 Estimation

At all times, we can obtain the desired capital stock as a function of the user cost from (3) or from (11). To estimate this function it is necessary to specify the functional form of Y. The production function is assumed to have constant elasticity of substitution (CES), so $Y_{K,t} \equiv \alpha(K_t/Y_t)^{-1/\sigma}$, where $-\sigma$ is the elasticity of substitution (thus $\sigma > 0$), Y_t is the production level, and α is the distribution parameter. Substituting into (3) (or (11)) yields

$$K_t = (\frac{\upsilon_t}{\alpha})^{-\sigma} Y_t,$$

where it follows that

$$\log \frac{K_t}{Y_t} = \sigma \log \alpha - \sigma \log \upsilon_t, \tag{12}$$

an equation that can be estimated econometrically with series of K, Y and υ.

Nevertheless the variable K_t, which appears in (12), is the capital stock firms desire, which is not observable if there are adjustment costs. To replace K_t with an observed variable, we apply the cointegration argument of Bertola and Caballero (1990). We denote the observed capital stock by K_t^{obs}, and define ε_t by

$$\varepsilon_t \equiv \log K_t^{\text{obs}} - \log K_t. \tag{13}$$

Where ε_t captures transitory discrepancies between both capital measures due to adjustment costs. Substituting (13) in (12) yields:

$$\log \frac{K_t^{\text{obs}}}{Y_t} = \sigma \log \alpha - \sigma \log \upsilon_t + \varepsilon_t. \tag{14}$$

The economic interpretation of ε_t allows us to assume both capital measures cointegrate so that estimating (14) by OLS gives a consistent estimator of the long-run substitution rate between capital and labor,

σ.[14]

In principle, equation (14) can be estimated with aggregate data from National Accounts or with information from firms. However, in the case of Chile it is not possible to use data from National Accounts because no series of the private product and the aggregate private capital stock is available. Therefore, we estimated (14) using a group of publicly held firms that published Standardized Quarterly Financial Reports (Spanish acronym: FECUs) between 1985 and 1995.

If firms ignore personal taxes in their decisions, the user cost of capital to firm i in period t will be

$$\upsilon_{it}^{V} = \frac{[1-\tau_t(b_i+z_{it})]}{1-\tau_t}\left[(r_t+\rho)p_t-\dot{p}_t\right]$$

(see equation [3]). On the other hand, if the marginal rates paid by their stockholders are considered, the user cost of capital is

$$\upsilon_{it}^{NV} = \frac{[1-\tau_t(b_i+z_{it})]}{1-\tau_t}\left[\left\{r_t+\rho-\frac{d}{dt}\log(1-\tau_t^{\mathrm{P}})\right\}p_t-\dot{p}_t\right].$$

It should be noted that the user cost varies among firms (due to terms b_i and z_{it}) and over time.[15] Then we will have

$$\log\frac{K_{it}^{\mathrm{obs}}}{Y_{it}} = \alpha_{0i} - \sigma\log\upsilon_{it}^{*} + \varepsilon_{it}. \qquad (15)$$

Where α_{0i} is equal to the sum of $\sigma\log\alpha_i$ and a constant equal to the average difference between the logarithms of capital stocks with and without adjustment costs[16] and * in υ_{it}^{*} is equal to V in the case with veil and equal to NV in the case without veil.

To test for a corporate veil, we estimate the following model:

$$\frac{K_{it}^{\mathrm{obs}}}{Y_{it}} = \alpha_{0i} - \sigma[\theta\log\upsilon_{it}^{V} + (1-\theta)\log\upsilon_{it}^{NV}] + \varepsilon_{it}. \qquad (16)$$

Parameter θ can be interpreted as the fraction of change in the capital-output ratio that is due to changes in the user cost with veil. As a result, a fraction $(1-\theta)$ of these changes are due to changes in the user cost without veil.

The preceding formulation incorporates fixed effects (the α_{0i} parameters), because the intensity of capital use varies across firms, among other reasons. For example, *ceteris paribus*, the capital-output ratio is higher for a steel mill than it is for a supermarket.

[14] Both series of (log) capital can differ on average by a constant, so the estimated value of the constant does not converge to $\sigma\log\alpha$. Note also that this argument makes it possible to rigorously derive an error term for the regressions that follow.

[15] The reason we do not permit parameter b to vary over time for a specific firm is that the proxy available to us for this variable is not very accurate, leading us to work with its average over the sample years.

[16] See footnote 14.

We will consider two possibilities for parameter σ. First we will assume it is constant in the sample, and then we will let it vary in the eight sectors (at two CIIU digits) included in the sample. On the other hand, parameter θ will be supposed to be common to all firms.

For a description of the sources of data used in estimations see the Appendix.

4 Results

4.1 What results can be expected?

Before reporting the results from estimations it is advisable to look at the data. Figure 1 shows the average (of the firms) of υ_{it} for the 11−year period with and without veil. The two costs differ in only three years, particularly in 1987. In those years the top marginal tax rate had sharpest decline, from 0.56 to 0.50. In both cases the highest value during the period is 0.225 while the minimum value is 0.153 in the case with veil and 0.048 in the case without veil.

To determine the source of the variations in the user cost with veil, Figure 2 breaks its logarithm into three components (indicated in the figure as Comp. 1, Comp. 2, and Comp. 3, respectively):

$$\log \upsilon_{it}^{V} \equiv \log \frac{1-\tau_t(b_i+z_{it})}{1-\tau t} + \log p_t + \log\left(r_t+\rho-\frac{\dot{p}_t}{p_t}\right). \tag{17}$$

To facilitate the comparison, the average value has been subtracted from each component in the figure. Note that only the first term depends on the corporate tax rate. Figure 2 is categorical: variations in the user cost are basically caused by changes in the relative price of capital and variations in the interest rate.[17] By contrast, the first term in (17) shows a much smaller variation. Since the demand for capital depends on the corporate tax rate only through the user cost of capital, the conclusion is that most of the fluctuations in the demand for capital do not come from variations in the corporate tax rate. Figure 2 shows the breakdown of the variance of $\log \upsilon_{it}^{V}$ into the variance and covariance of the three components. The sum of the variance of the first component (where the corporate tax rate matters) and the covariances of that component with the other two only explain 7% of the total variance.

Figure 3 shows another interesting aspect: the average value (weighted by the firms' assets) of $b_i + z_{it}$ is near one —in fact, slightly above one— throughout the period under consideration. It fluctuates between 0.99 in 1989 an 1.12 in 1995. The simple average —which corresponds to the dotted line in the figure— takes values even closer to 1. This suggests that even larger changes of the corporate tax rate should not have significantly affected user cost and aggregate capital stock. As we will see later, our econometric results corroborate this conjecture.

[17] If the user cost without veil is considered, there is also an important contribution from the variations in the marginal personal tax rate.

4.2 Regresions

The second column of Table 3 shows the estimated parameters when σ and θ are assumed to be the same across firms in (16). The estimated value of σ was 0.18 with a standard deviation of 0.04. On the other hand, the estimated value of θ was 0.93, with a standard deviation of 0.30.

Adjustment costs mean that in small samples the estimated values of σ will be biased towards zero (Caballero, 1994).[18] To correct this bias either leads or lags of the independent variables considered are added to the regressors. The third and fourth column show the coefficients estimated this way. The estimated value of σ grows significantly when a lead is incorporated,[19] rising to 0.42 with a standard deviation of 0.14. It should also be noted that estimated values of θ remain near one.

The magnitude estimated for the elasticity of substitution indicates that changes in the user cost may significantly affect the desired capital stock. To get an idea of the relevant orders of magnitude, consider the example of a firm with a user cost equal to 0.225 (the average of υ_{it}^{V} in 1990), a capital-output ratio equal to 2.64 (the aggregate ratio in 1990),[20] and sales of $100 million per year. Since the relative price of capital in 1990 is $p_{90} = 0.926$, the firm's desired capital stock is $244.5 million.[21] If the user cost drops 10% to 0.202, production remains constant, and the elasticity of substitution is $\sigma = 0.42$, the capital stock desired by the firm will grow 4.2% or $10.3 million to $254.8 million.[22]

However, the fact that elasticity of substitution is considerable does not mean that variations in the corporate tax rate affect the desired long-run capital stock very much, because its impact will depend on the magnitude of $b_i + z_{it}$. In fact, for our sample of firms the effect is very small. The second column of Table 4 shows how the sum of the capital stocks desired by firms varies (i.e., how our measure of aggregate capital stock varies) with the corporate tax rate in 1990. (To make it easier to read, we have made the aggregate capital stock that would have been demanded, had the corporate tax rate been 0, equal to 100). Note that when $\tau = 0.2$ the desired capital stock is only 0.12% lower than when $\tau = 0$. In other words, for the levels usually referred to in discussions about the ideal corporate tax rate, the effect is very small. The third column of Table 4 repeats the exercise for 1995. The novelty in this case is that the higher the tax rate the *more* capital stock is desired ($z > 1$); but, in any case, the effect is still very small.

What explains this small and the apparently counterintuitive result, that higher taxes can lead to a higher desired capital stock? As seen in Figure 3, the average annual value of $b_i + z_{it}$ is near one. In fact, in 1990

[18] Note that this does *not* contradict the statement made previously, according to which the estimators in question are consistent, since the latter property is asymptotic (big samples).

[19] Unlike Caballero (1994) where this happens when a lag is incorporated. The difference may be due to the fact that our proxy for the b_i in period t includes information from the whole period in our sample. It was necessary to work with this proxy to avoid the big fluctuations in annual values of this variable.

[20] In other words, $\sum_i K_{i90}^{\text{obs}} / \sum_i Y_{i90}$.

[21] $244.5 = $100 million $\times$ 2.64 $\times$ 0.926.

[22] Hereafter, all the exercises will suppose we are moving throughout the same isoquant.

this sum varies from a minimum of 0.43 and a maximum of 1.47, with an average of 0.90 (standard deviation of 0.28).[23] Therefore, it is not surprising that the aggregate effect is very small, because, as we have already mentioned, when $b_i + z_{it} = 1$ the desired capital stock does not depend on τ. Moreover, the fact that some firms are bigger than others and that in many of them $b_i + z_{it} > 1$ indicates it is possible that an increase in τ leads to higher desired capital stock. Finally, note that even though our results indicate the *aggregate* capital stock should not vary significantly when τ changes, the dispersion of $b_i + z_{it}$ suggests that in many firms the corporate tax has a bigger effect than the aggregate figure might suggest.

4.3 Robustness

To check whether the explanatory power of the user cost term mainly comes from changes in prices and the interest rate, equation (16) was reestimated for the case with corporate veil, but this time separating the contributions of the three components that make up the user cost:

$$\log \frac{K_{it}^{\text{obs}}}{Y_{it}} = \alpha_{0i} - \sigma_1 log \frac{1-\tau_t(b_i+z_{it})}{1-\tau_t} - \sigma_2 \log p_t - \sigma_3 \theta \log\left(r_t + \rho - \frac{\dot{p}_t}{p_t}\right) - \sigma_3(1-\theta)\log\left(r_t + \rho - \frac{\dot{p}_t}{p_t} - \frac{d}{dt}\log(1-\tau_t^{\text{P}})\right). \tag{18}$$

Table 5 shows the results, which indicate that $b+z$ plays a significant role in estimating σ in Table 3. Actually, in the case with a correction with a lead, an estimated value of σ_1 of 0.38 is obtained, which does not differ greatly from the one obtained by making all the σ_i equal (Table 3).[24]

Finally, Table 6 shows the estimated coefficients when variations of σ are allowed among sectors at the two-digit level. The second column shows the estimated parameters for the group of 83 firms, using Non Linear Weighted Least Squares, with the respective weights estimated in the first stage with homoscedastic errors. The nonlinear parameter is θ. Fixed effects and the Cochrane-Orcutt correction with an autocorrelation parameter common to all the firms are considered. The third and fourth columns show the results when a lag and a lead are incorporated, respectively, to correct the bias in the estimated values of σ. Standard deviations are indicated in parentheses.

Again, elasticities are larger when working with a lead to correct the small sample bias.[25] The comments that follow refer to this case. The largest elasticity of substiution between capital and labor is obtained in the mining sector, where it is 1.60, whereas the lowest elasticities are in the financial and service sectors, which are estimated at 0.14 and 0.15, respectively. The estimated value of θ varies between 0.82 (when working with a lead) and 1.01 (when working with a lag) thus confirming the findings in Table 3.

[23] In the case of 1995 the minimum is 0.56 and the maximum is 1.53, with an average of 1.00.

[24] Moreover, estimated values of σ_1 are more stable among specifications than the ones of σ.

[25] Also in OLS regressions (second column) and with a lag (fourth column) there are estimated values of σ with the wrong sign, which does not occur when working with a lead.

5 Conclusion

The conclusions suggested by the preceding analysis are the following:

1. Theory does not support the widely held a priori belief that firms' desired capital stock is lower when corporate or personal taxes are higher. For example, when the tax law allows depreciation of assets and discount of interest, and the present value of the discounts is higher than the cost of the capital good, higher taxes on retained profits *reduce* the user cost and *increase* the desired capital stock.

2. Personal tax rates affect the user cost and capital stock desired by firms only when stockholders expect their marginal rate to change from one period to another. When an individual's marginal rate does not vary over time, personal taxes do not affect the desired capital stock.

3. In Chile, variations in the price of capital and the interest rate are the main factors affecting the user cost of capital. Corporate taxes, by contrast, are far less important.

4. The corporate tax are less important, because Chilean tax law allows discounts for interest and depreciation. For the average of the firms considered in this paper, the discounts are close to the cost of capital goods, in present value.

5. From the preceding point it follows that the demand for capital is not sensitive to variations in the corporate tax rate. This is not because the desired capital stock is insensitive to changes in the user cost of capital. In fact, using a group of 83 firms with annual data for the 1985-1995 period, average (across sectors) substitution elasticities between capital and labor of 0.62 was found.

6. Although on average taxes do not significantly affect the firms' desired capital stock at the aggregate level, there is a good deal of heterogeneity among firms. In several cases the effects at the individual level are greater than the ones suggested by the aggregate effects.

7. Evidence was found that firms ignore the marginal rates their stockholders pay when they make investment decisions. In other words, evidence suggests the existence of a *corporate veil*.

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APPENDIX

A Proofs

Derivation of equation (3)

Before solving the firm's problem, it is convenient to rewrite the objective function (2) as

$$\int_0^\infty e^{-rt}\left\{(1-\tau)[Y(K_t,L_t)-wL_t]-[1-\tau(b+z)]p_tI_t\right\}dt. \tag{19}$$

Where $b_t pI_t = rbp_tI_t\int_t^\infty e^{-r(s-t)}ds$. We have also used the two following identities (which are derived later in this appendix):

$$\int_0^\infty e^{-rt} rD_t dt \equiv \int_0^\infty e^{-rt} bp_tI_t dt; \tag{20}$$

$$\int_0^\infty e^{-rt}\Delta_t dt \equiv \int_0^\infty e^{-rt} zp_tI_t dt. \tag{21}$$

It is important to note the equality between (2) and (19) does not imply the integrands are equal. The advantage of (19) lies in the fact it does not include values of I preceding t, unlike (2); in that case both D_t and Δ_t involve investments made before t so the Hamiltonian method cannot be used to solve the dynamic optimization problem. The Hamiltonian associated with (19) is

$$H \equiv e^{-rt}\left\{[(1-\tau)[Y(K_t,L_t)-wL_t]-[1-\tau(b+z)]p_tI_t]\right\}+\lambda_t(I_t-\rho K_t).$$

Where λ_t is the shadow price of capital. The first order conditions are

$$\frac{\partial H}{\partial L} \equiv e^{-rt}(1-\tau)(Y_L-w)=0, \tag{22}$$

$$\frac{\partial H}{\partial I} \equiv -e^{-rt}[1-\tau(b+z)]p_t+\lambda_t=0, \tag{23}$$

$$\frac{\partial H}{\partial K}+\dot{\lambda}_t \equiv e^{-rt}(1-\tau)Y_K-\rho\lambda_t+\dot{\lambda}_t=0. \tag{24}$$

Condition (22) says that at all time labor will be hired until its marginal product is equal to the wage. Note that the corporate tax rate does not affect the labor hiring decision.

Condition (23) gives the optimal amount of investment. The benefit of adding one unit of capital to the stock at t is λ_t, the shadow value of one unit of capital. The cost of adding that unit at t is the present value of the interest that has to be paid for that debt, $[1-\tau]bp_t$, plus the profits that have to be retained to finance the purchase of that unit of capital, $[1-b]p_t$, minus the present value of the discounts for depreciation that can be made for the unit of capital bought at t, τz.

Finally, we analyze condition (24) in greater detail. To do that, we note first that totally differentiating condition (23) with respect to time gives

$$\dot{\lambda}_t = \left(\frac{\dot{p}_t}{p_t} - r\right)\lambda_t.$$

Substituting in (24), implies that at the optimum

$$(1-\tau)Y_K - [1-\tau(b+z)][(r+\rho)p_t - \dot{p}_t] = 0.$$

Rearranging, it follows that at all times t

$$Y_K = \frac{[1-\tau(b+z)]}{1-\tau}[(r+\rho)p_t - \dot{p}_t] \equiv \upsilon_t^V.$$

Proposition 1
$\int_0^\infty e^{-rt} rD_t dt \equiv \int_0^\infty e^{-rt} bp_t I_t dt$

Proof: Writing D_s explicitly, gives

$$\int_0^\infty e^{-rt} rD_t dt = r\int_0^\infty e^{-rs}\left[\int_0^s bp_t I_t dt\right] ds.$$

Making a change of variable for the second integral (Tonelli's Theorem) gives

$$\int_0^\infty \left[\int_t^\infty e^{-rs} p_t I_t ds\right] dt.$$

Finally, factorizing the second integral by $e^{-rt} p_t I_t$ one obtains

$$rb\int_0^\infty e^{-rt} p_t I_t \left[\int_t^\infty e^{-r(s-t)} ds\right] dt,$$

which can be written as the product of two integrals:

$$b\int_0^\infty e^{-rt} p_t I_t dt \times r\int_t^\infty e^{-r(s-t)} ds,$$

and as $\int_t^\infty e^{-r(s-t)} ds = \frac{1}{r}$ one gets

$$\int_0^\infty e^{-rt} bp_t I_t dt,$$

which was what we wanted to prove. ∎

Proposition 2
$\int_0^\infty e^{-rt}\Delta_t dt = \int_0^\infty e^{-rt} z p_t I_t dt$

Proof: Rewriting Δ_t, the expression $\int_0^\infty e_t^{-rt}\Delta_t dt$ is

$$\int_0^\infty e^{-rt}\left[\int_0^t \delta_{t-s} p_s I_s\right] ds.$$

Changing variables in the second integral leads to

$$\int_0^\infty \left[\int_0^\infty \delta_s e^{-r(s+t)} p_t I_t ds\right] dt.$$

Factorizing the second integral by $e^{-rt} p_t I_t$ the expression is

$$\int_0^\infty \left[\int_0^\infty \delta_s e^{-rs} ds\right] e^{-rt} p_t I_t dt = \int_0^\infty z e^{-rt} p_t I_t dt,$$

because $\int_0^\infty \delta_s e^{-rs} ds \equiv z$. ∎

B The data

As mentioned, estimates were made using a group of publicly held firms that issued Standardized Quarterly Financial Reports (Spanish acronym: FECUs) between 1985 and 1995. No information prior to 1985 was considered, because the recent review of capital prices by the Central Bank, which involved important changes, only covered the period starting in 1985. FECUs were obtained from the Santiago Stock Exchange. The group includes 83 firms that published FECUs during each one of the 11 years (which we call "continous firms"). The following information was also extracted from the FECUs:

Capital stock (K_{it}^{obs}): Corresponds to fixed assets in the balance sheet each firm deflated by the price of capital obtained from the National Accounts.

Production (Y_{it}): Corresponds to operating income from each firm's income statement deflated by the implicit GDP deflator.

Fraction of gross investment financed with debt (b_i): The average value over the sample of the Debt/Asset ratio was used for each firm; the information was obtained from each firm's balance sheet.[26]

The remaining variables necessary to make estimates were obtained from the following sources:

[26] Other proxies were tested like Debt/Equity, obtaining more irregular series (including negative values).

Interest rate (r_t): Corresponds to the average interest rate for loans in the banking system. It was obtained from the *Monthly Bulletin* of the Central Bank.[27]

Economic depreciation of capital (ρ): It was assumed equal to 10%.

Present value of discounts for depreciation (z_{it}): The fraction of economic value that can be discounted as cost at present value is calculated from the expression

$$z = \int_0^T \frac{e^{-rs}}{T} ds = \frac{(1 - e^{-rT})}{rT}.$$

Where T is the period of depreciation of the asset. According to tax law, different assets have different periods of linear depreciation. Raddatz (1997) estimated the period of depreciation of three categories of assets, buildings (15 years), machinery and equipment (3 years), and vehicles (3 years). A different z was calculated for each one of the three kinds of assets described above, and then, using the FECU of each firm, the fraction of assets in each one of the categories for each year was calculated.

Relative price of capital (p_t): This is the quotient of the capital stock deflator and the GDP deflator. It was obtained from the National Accounts prepared by the Central Bank of Chile, revised in 1998.

Expected variations in the price of capital ($\dot{p}_t$): Each year the average of the variations of $\log p$ in preceding years was taken as a prediction of the following $\dot{p}/p$. This assumption is consistent with assuming that the $logp$ series follows a random walk, an assumption consistent with the data.

Corporate tax (τ): This tax corresponds to what a firm pays when it retains one dollar of profits. It is a function of two specific tax rates, the First Category tax rate, τ_{1a} and the Additional tax rate, τ_{1a}

$$\tau = 1 - (1 - \tau_{1a})(1 - \tau_a).$$

The information to build this series was obtained from Lehmann (1991) and the Internal Revenue Service. Table 1 shows the series of the corporate tax rates.

Personal tax (τ_t^{P}): The top marginal rate of the income tax, τ_t^{Max}, were taken, discounting credits received in the same period of time for the First Category and the Additional tax, and it was assumed the owner of the firm is informed at least one year in advance of any changes in the rate.[28]

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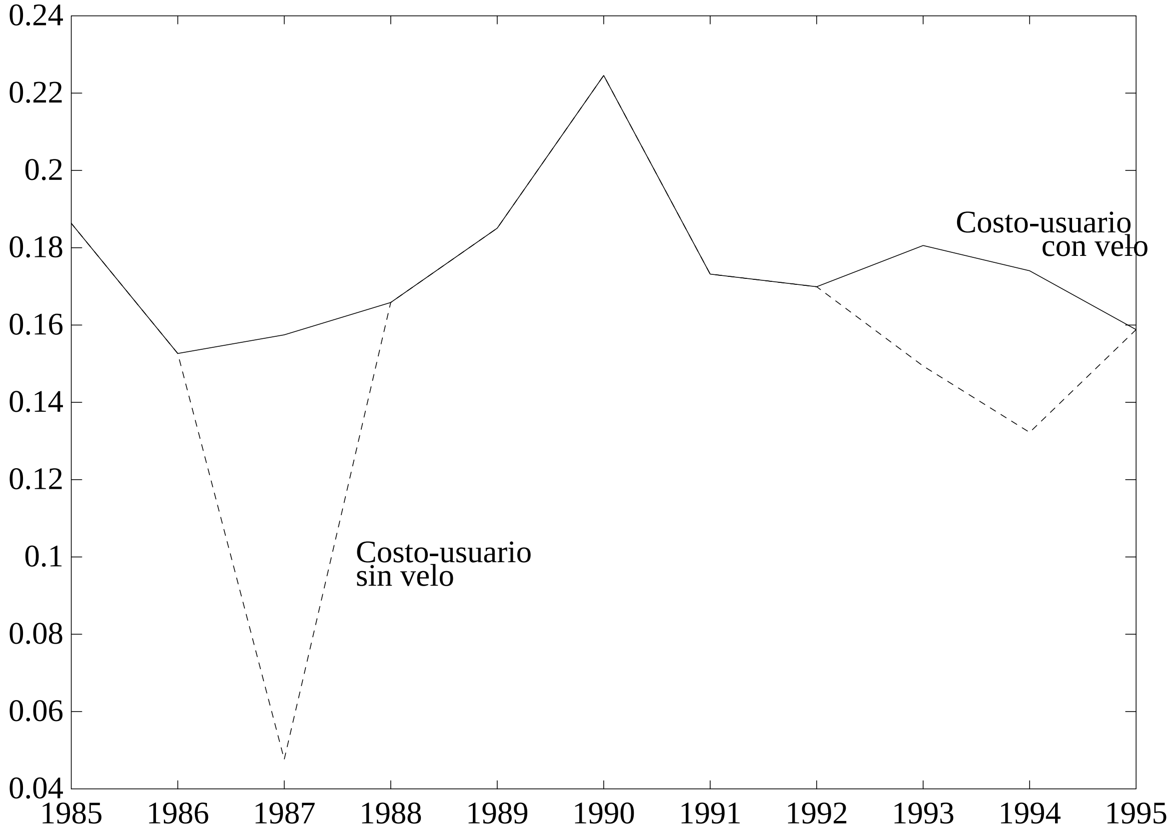
[27] As of 1990, a group of Chilean firms used foreign debt to finance their investments. To test the significance of this fact, estimates were made assuming that a fraction of the firms μ (unknown), would have been financed at LIBOR + risk premium as of that year. μ was considered constant and varying annually, and the breakdown was maintained for firms with and without corporate veil. The values estimated for μ were not significant and the estimated substitution rate between capital and labor was, in general, lower than the rates reported in the paper, which explains why only results considering domestic financing are presented.

[28] The fact that credits for the first category tax and the additional rate are not modified when there are changes in rates simplifies the respective calculations, where $\frac{d\tau_t^{\mathrm{P}}}{dt}$ is equal to $\frac{d\tau_t^{\mathrm{Max}}}{dt}$.

Figure 1

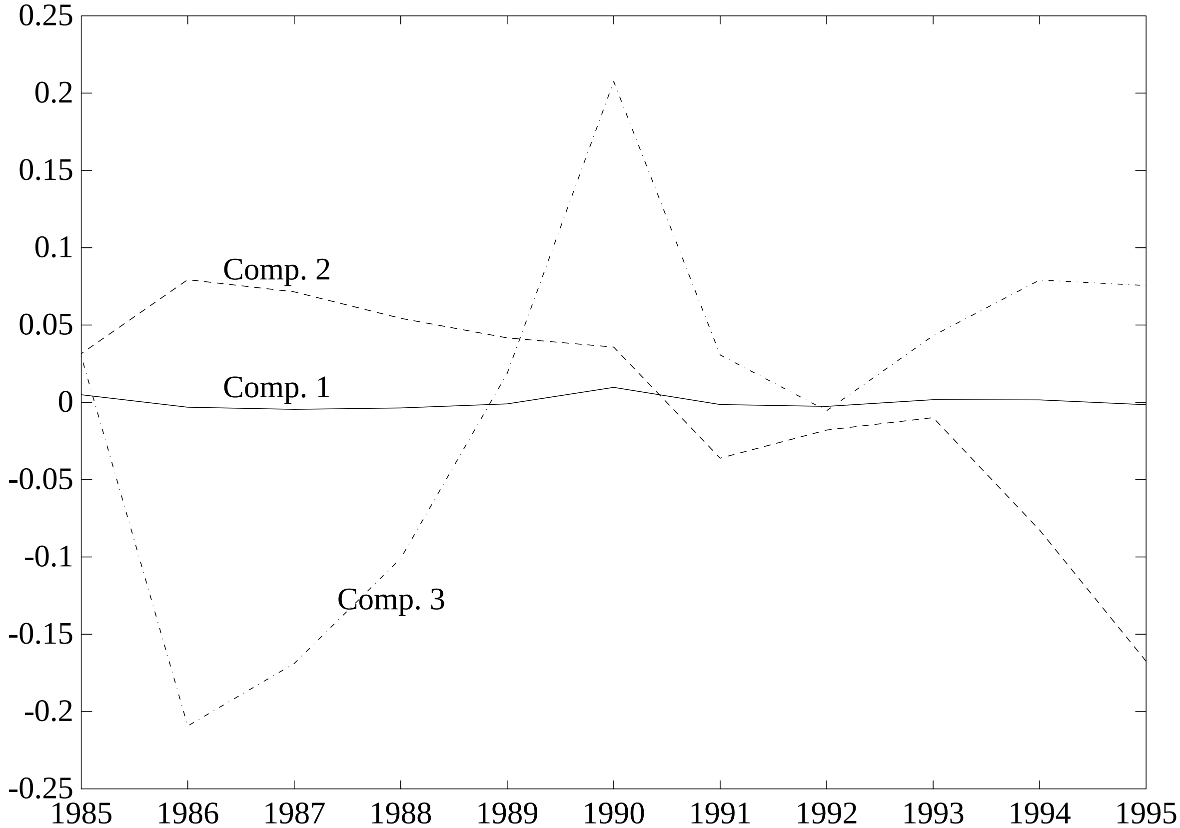
AVERAGE USER COST OF CAPITAL



Notes on Figure 1: The figure shows the average (simple) annual user cost of capital between 1985 and 1995 for the 83 firms in the sample, with and without corporate veil.

Figure 2

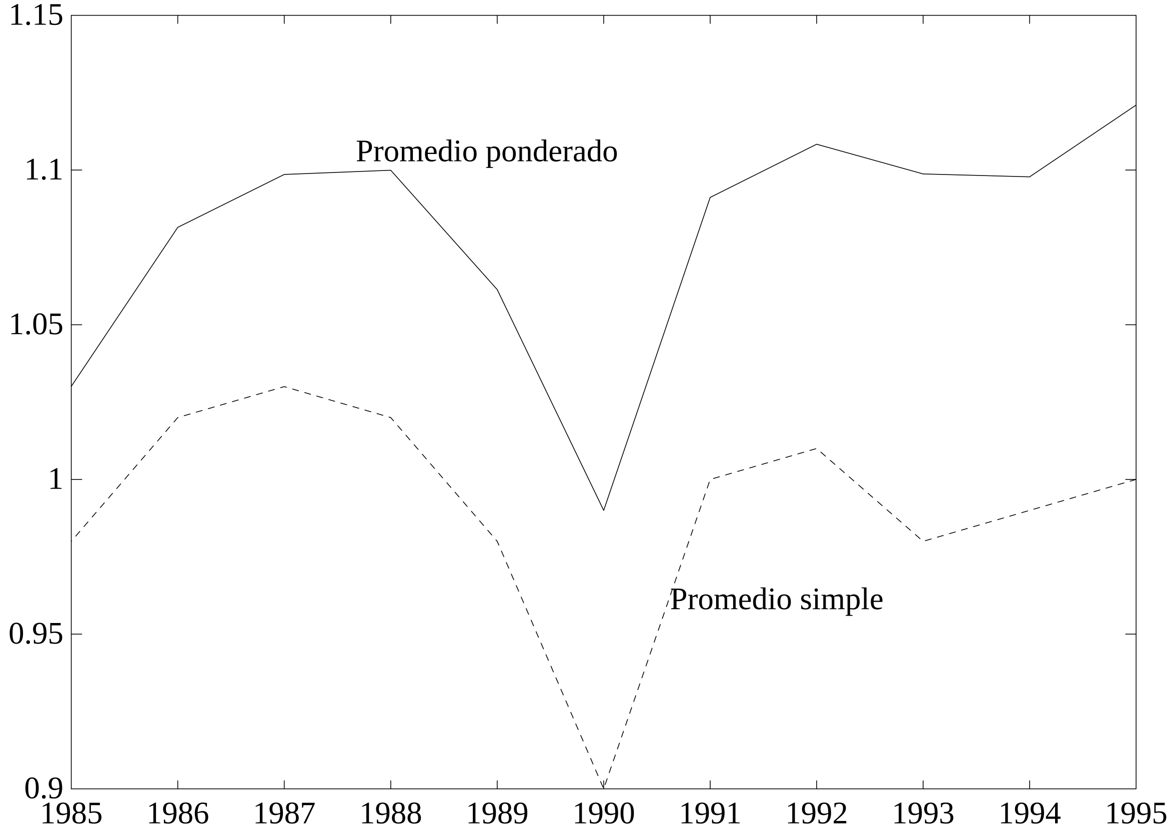
BREAKDOWN OF THE LOGARITHM OF THE USER COST OF CAPITAL



Notes on Figure 2: The figure shows the three components of the user cost of capital with corporate veil. Logarithms have been broken down as in the text, between 1985 and 1995.

Figure 3

AVERAGE VALUES OF $b+z$.



Notes on Figure 3: The figure shows weighted and simple averages of $b_i + z_{it}$ for the 83 firms in the sample, between 1985 and 1995.

Table 1

CORPORATE TAX RATES

Year	τ_{1a}	τ_a	τ
1985	0.1	0.15	0.24
1986	0.1	0	0.10
1987	0.1	0	0.10
1988	0.1	0	0.10
1989	0	0	0
1990	0.15	0	0.10
1991	0.15	0	0.15
1992	0.15	0	0.15
1993	0.15	0	0.15
1994	0.15	0	0.15
1995	0.15	0	0.15

Notes: τ_{1a} is the First Category tax; τ_a is the Additional tax that was in effect only in 1985 and $\tau = 1-(1-\tau_{1a})(1-\tau_a)$ is the corporate tax.

Table 2

BREAKDOWN OF VARIANCE

Component	Share (%)
Comp. 1: Tax	0.16
Comp. 2: Price of capital	48.53
Comp. 3: Interest rate and $\dot{p}$	125.07
$2\text{Cov}(\text{Comp. }1, \text{Comp. }2)$	-0.19
$2\text{Cov}(\text{Comp. }1, \text{Comp. }3)$	7.03
$2\text{Cov}(\text{Comp. }2, \text{Comp. }3)$	-80.60
Total:	100.00

Notas: Contribution by component to the variance in the user cost without veil. Comp. 1 = $\log \frac{1-\tau_t(b_i+z_{it})}{1-\tau_t}$; Comp. 2 = $\log p_t$; Comp. 3 = $\log(r_t + \rho - \frac{\dot{p}_t}{p_t})$.

Table 3

MODEL WITH COMMON σ

Parameter	Simple	1 Lead	1 Lag
σ	0.18	0.42	0.14
	(0,04)	(0.14)	(0.07)
θ	0.93	1.06	0.75
	(0.30)	(0.26)	(0.61)

Notes: Estimation for a group of 83 firms, fixed effects, annual data, 1985–1995, by WLS with the respective weights estimated in the first stage with OLS and with a Cochrane-Orcutt correction with a self-correlation parameter common to all the firms. Delta method was used to get the standard deviations of σ and θ from the standard deviations of the linearly estimated parameters ($\sigma\theta$ and $\sigma(1-\theta)$). Standard deviations are in parentheses. The "Simple" column refers to the estimate of model (16). Columns "1 Lead" and "1 Lag" consider corrections for bias in small samples of a lag and a lead, respectively, of the user cost logarithm with and without veil.

Table 4

CAPITAL STOCK AND CORPORATE TAX

Corporate tax	Capital stock 1990	Capital stock 1995
0%	100	100
5%	99.97	100.25
10%	99.93	100.54
15%	99.90	100.87
20%	99.88	101.25

Notes: Variation of the aggregate desired capital stock. Desired stock when $\tau = 0$ has been normalized to 100.

Table 5

MODEL BREAKING DOWN THE LOGARITHM OF THE USER COST INTO THREE COMPONENTS

Parameter	Simple	1 Lead	1 Lag
σ_1	0.34	0.39	0.38
	(0.05)	(0.06)	(0.06)
σ_2	0.63	0.74	0.69
	(0.03)	(0.04)	(0.03)
σ_3	0.31	0.31	0.31
	(0.11)	(0.08)	(0.08)

Notes: Results of the estimation of (18). The used sample and estimation techniques are the same of Table 3.

Table 6

MODEL WITH SECTORAL σ

Parameter	Simple	1 Lead	1 Lag
σ Agriculture and fishing	−0.31	0.71	0.02
	(0.21)	(0.35)	(0.32)
σ Mining	0.18	1.60	0.68
	(0.37)	(0.46)	(0.52)
σ Manufacturing	0.22	0.59	0.16
	(0.06)	(0.10)	(0.09)
σ Electricity, gas and water	0.32	0.51	0.50
	(0.08)	(0.07)	(0.06)
σ Retail	0.32	0.74	0.56
	(0.21)	(0.28)	(0.24)
σ Transportation and communications	0.11	0.48	−0.19
	(0.16)	(0.15)	(0.21)
σ Finance, insurance, etc.	0.09	0.14	0.11
	(0.06)	(0.08)	(0.08)
σ Communal, social and personal services	0.18	0.15	−0.11
	(0.08)	(0.12)	(0.11)
σ average	0.14	0.62	0.22
θ	0.93	0.82	1.01
	(0.04)	(0.05)	(0.04)

Notas: Estimation for a group of 83 firms, fixed effects, annual data, 1985–1995, by WLS with the respective weights estimated in the first stage with OLS and with a Cochrane-Orcutt correction with a self-correlation parameter common to all the firms. Standard deviations are in parentheses. The ”Simple” column refers to the estimate of model (16). Columns “1 Lead” and “1 Lag” consider corrections for bias in small samples of a lag and a lead, respectively, of the user cost logarithm with and without veil.