Corporate taxation and capital accumulation: evidence from sectoral panel data for 14 OECD countries

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Abstract

We present new empirical evidence that sector-level capital-output ratios are strongly influenced by corporate tax incentives, as summarised by the tax component of a standard user cost of capital measure. We use sectoral panel data for the USA, Japan, Australia and eleven EU countries over the period 1982-2007. Our panel combines internationally consistent data on capital stocks, value-added and relative prices from the EU KLEMS database with corporate tax measures from the Oxford University Centre for Business Taxation. Our results for equipment investment are particularly robust, and strikingly consistent with the basic economic theory of corporate investment.

Key words:
corporate taxation, capital accumulation, user cost of capital

JEL category: H25, E22, D92

1. Introduction

The last three decades have seen substantial changes to corporate income taxes in many OECD countries, starting with major reforms to corporate tax rates and allowances in the UK in 1984 and in the USA in 1986. Similar rate-cutting, base-broadening reforms have followed in other countries, with the statutory corporate tax rate in the Netherlands, for example, falling from 48% in 1982 to 26% in 2007. Conveniently, these changes to corporate income taxes have occurred at different times and to differing degrees in different jurisdictions. This paper exploits the resulting variation across countries and over time to study the impacts of corporate taxation on fixed investment in the short run and on fixed capital accumulation in the long run. These effects are important in assessing the welfare implications of taxes on corporate income. Reliable evidence on their nature and magnitude is also important for the design of fiscal incentives that are intended to stimulate private sector business investment.

One innovation in this study is that we exploit the recently developed EU KLEMS database, which provides sectoral data on capital, output and relative prices for the USA, Japan, Australia and most of the EU countries. The key advantage of EU KLEMS is the availability of internationally comparable capital stock measures, constructed from the underlying investment series using consistent procedures across countries. This contrasts with different methodologies which are used to construct capital stock series in different national accounts and inherited, for example, in OECD datasets based on national accounts sources. We combine EU KLEMS with tax measures from the Oxford University Centre for Business Taxation's corporate tax database, which provides detailed information on corporate tax regimes for developed countries. Combining these sources and focusing on countries with data available before 1995 gives annual observations for 11 manufacturing sectors in 14 OECD countries over the period 1982-2007, which is the main sample used in our econometric analysis. We focus mainly on sectors within manufacturing because most manufacturing investment is undertaken by private sector companies that are subject to corporation tax; this would not be the case if we included other sectors such as health and education in our analysis, although we find broadly similar results when we extend our sample to include non-manufacturing sectors. We use sectoral data because we can exploit within-country sectoral variation in the measures of output and relative prices, although we also find similar results when we restrict our sample to aggregate manufacturing in each country.

We consider a standard econometric model in which, consistent with the basic economic theory of investment, sectoral capital-output ratios depend inversely in the long run on the tax-adjusted user cost of capital. Our data allow us to consider separately the corporate tax and relative price components of a standard user cost measure, and the main focus of our empirical analysis is on the relationship between capital accumulation and tax incentives as summarised by the tax component of the user cost of capital. Short-run capital stock adjustment dynamics are estimated from the data. We present empirical results using a range of dynamic specifications and econometric methods.

Our main finding is that tax incentives matter for the evolution of sector-level capital stocks. Our preferred specifications suggest long-run elasticities of capital-output ratios with respect to the tax component of the user cost of around -0.4 in the case of total capital, and around -0.7 if we focus on equipment. These are well within the rather wide range of estimates suggested by previous empirical research. Specifications which allow for rich cross-sectional heterogeneity in parameters also suggest quite rapid adjustment of capital stocks to changes in the user cost of capital. Our results for equipment are strikingly consistent with the basic economic theory of corporate investment in two respects: (i) the theoretical prediction that the tax and relative price components of the user cost have the same long run effect on capital-output ratios is supported by the data; (ii) the prediction that tax effects are summarised by the tax component of the user cost of capital is also consistent with the evidence. For total capital, however, we estimate a larger effect from the relative price of capital than from the tax component of the user cost. Perhaps related to this, if we focus only on structures, we find no significant tax effect in our preferred dynamic specifications. We discuss further below why our specifications may not be well suited to modelling investment in structures.

The remainder of the paper is organised as follows. Section 2 briefly outlines the basic neoclassical investment model. Section 3 presents the data that we use in our empirical analysis and illustrates the sample variation in our measures of the corporate tax factors suggested by the basic neoclassical framework. Section 4 discusses our econometric specifications, and section 5 presents our empirical results. Section 6 concludes.

2. Investment model

Our econometric model is based on the value-maximising investment behaviour of a firm with a Constant Elasticity of Substitution production technology and an isoelastic demand schedule. We assume that investment in year t adds to the stock of productive capital in the same year, which depreciates at the constant rate δ. In the absence of any adjustment costs, the optimal capital stock in year t (K_t^*) can be expressed as:[1]

$$K_t^* = \alpha Q_t^{\left(\sigma + \frac{1-\sigma}{v}\right)} C_t^{-\sigma} \tag{1}$$

where Q_t is value-added and C_t is the user cost of capital. The parameters σ and ν are respectively the elasticity of substitution between capital and labour and the returns to scale in the production function, and α also depends on the production function parameters. In the case of constant returns to scale ($\nu = 1$), this implies an inverse proportional relationship between the desired capital-output ratio (K_t^*/Q_t) and the user cost of capital.[2]

If we assume that marginal investment is financed using retained earnings, and that the corporate income tax rate (τ_t), other parameters of the tax system, relative prices and inflation rates are expected to remain constant over time, the user cost of capital can be expressed as:

$$C_t = \frac{P_t^K}{P_t\left(1 - \frac{1}{\eta}\right)} \frac{(1 - A_t)}{(1 - \tau_t)} \frac{(r_t + \delta)}{(1 + r_t)} \tag{2}$$

where P_t^K is the price of capital goods, P_t is the price of output, A_t is the net present value of current and future tax depreciation allowances associated with a unit of investment in year t, r_t is the real discount rate, and η is the price elasticity of demand. We focus

[1] Appendix A provides details.

[2] This also holds for any returns to scale if the production technology is Cobb-Douglas ($\sigma = 1$), in which case the elasticity of the capital-output ratio with respect to the user cost is -1.

on this case since the vast majority of corporate investment in developed countries is financed using retained earnings.[3] Below we refer to the term $[(1 - A_t)/(1 - \tau_t)]$ as the tax component of the user cost of capital. This basic theoretical framework predicts that the elasticity of the capital-output ratio with respect to the tax component, the relative price (P_t^K/P_t) and other components of the user cost should be the same, and that the effects of corporate taxation on capital-output ratios should be summarised by this tax component of the user cost.

The underlying model of production assumes that value-added is produced using labour and a single capital input. Interpreting this input as the total capital stock measured in the data requires very strong assumptions, for example, that different assets such as equipment and structures contribute to production in technologically fixed proportions, or that they are perfect substitutes.[4] Interpreting this input as the total stock of equipment requires that structures do not contribute directly to production and treats costs related to structures as fixed costs. Neither approach is compelling, and we present results from both specifications for comparison. We note that the former approach is standard in studies which use firm-level data, where measures of investment and capital disaggregated by asset type are rarely available. Interpreting the single capital input as the stock of structures makes little sense in this context, and we present results from this specification mainly to shed light on some differences between our results for equipment and for total capital.

Before considering further details of our econometric specifications, we first present the datasets used in this study. We illustrate the variation over time and across countries in our measures of some of the key variables suggested by this basic theoretical framework, with a particular focus on the tax component of the user cost of capital.

3. Data

We combine sector-level panel data on production, investment and price variables obtained from the EU KLEMS database with tax variables provided by the Oxford University Centre for Business Taxation.[5] Our merged dataset includes data for 14 OECD countries covering the period 1982-2007.[6] Our main sample consists of 11 sectors within manufacturing for each of these countries. For comparison, we also present results for a broader sample of 19 sectors, excluding financial intermediation, utilities, and other sectors with substantial public sector influence, as well as results for the complete sample of 27 sectors available in the EU KLEMS database, covering the whole economy. The

[3] See, for example, Corbett and Jenkinson (1997). Abstracting from personal taxation of shareholder income, the same expression for the tax-adjusted user cost applies in the case of new equity finance. For debt finance, the user cost is lower, reflecting the deductibility of interest payments in a standard corporate income tax. See, for example, Devereux and Griffith (2003).

[4] See, for example, Epstein (1983).

[5] More information on the EU KLEMS data is provided by O'Mahony and Timmer (2009). More details on the construction of the tax variables can be found in Devereux, Griffith and Klemm (2002) and Loretz (2008). We thank Simon Loretz for providing updated series for use in this study.

[6] These 14 countries are: Australia, Austria, Czech Republic, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, the United Kingdom and the United States. We exclude countries for which data becomes available only after 1995. The time coverage for each country is listed in Appendix B.

sectors included in each of these samples are listed in Appendix B.

3.1. Capital stock and output

A major advantage of the EU KLEMS data is that this provides comparable capital stock measures for 8 different types of assets across sectors and countries, constructed using a common Perpetual Inventory Method (PIM). We exclude residential structures from the total capital stock reported in EU KLEMS, as residential housing is not primarily used as an input into production in the business sector. The remaining types of capital assets are aggregated into three broad categories, namely, equipment, structures, and other assets.[7]

The real capital stock ($K_{k,t}$) for asset k is defined as a weighted sum of past real investments (measured in 1995 prices) with weights given by the relative efficiencies of capital goods at different ages according to the formula below (sector and country subscripts are suppressed for convenience):[8]

$$K_{k,t} = \sum_{\tau=0}^{\infty} \theta_{k,\tau} I_{k,t-\tau} = \sum_{\tau=0}^{\infty} (1-\delta_k)^{\tau} I_{k,t-\tau} = (1-\delta_k) K_{k,t-1} + I_{k,t} \quad (3)$$

where $I_{k,t-\tau}$ is real investment in asset k in year $t-\tau$ and $\theta_{k,\tau} = (1-\delta_k)^{\tau}$ is the efficiency of a capital good of age τ relative to the efficiency of a new capital good, assuming a constant rate of depreciation δ_k for each asset type k. The depreciation rates δ_k are obtained from the US Bureau of Economic Analysis (BEA). They differ by asset type and sector, but are assumed to be common across countries and constant over time for a particular type of asset in a particular sector.[9]

As a comparison, in Appendix C (Figure C.1), we plot the time series of the total real capital stock for total manufacturing industry over the period 1982-2007 for 11 countries for which this information is available in both the EU KLEMS and the OECD STAN databases. Figure C.1 reveals that these two measures of the real capital stock for the manufacturing sector in these countries are close in magnitude and they also show similar patterns over time.[10]

We use the real value-added measure of output from EU KLEMS, also measured in 1995 prices. Figure 1 plots the time series of the average capital-output ratio in logarithms ($\ln(K/Q)$), separately for equipment and structures, for our sample of manufacturing industries.[11] Over time, there is an upward trend in the capital-output ratio

[7] Equipment includes transport equipment, computing equipment, communications equipment, and other machinery and equipment. Structures refers to non-residential structures. Other assets include software and others.

[8] For more details on the implementation of the Perpetual Inventory Method to construct the real capital stock series in the EU KLEMS database, see Timmer, O'Mahony and Van Ark (2007).

[9] An advantage of using the BEA depreciation rates is that the depreciation patterns are based on empirical evidence about used asset prices in resale markets wherever possible.

[10] Additional advantages of the EU KLEMS database over the OECD STAN database for our study are that the former provides real capital stock measures disaggregated by asset type, and covers more countries.

[11] Each series here, and in Figure 2 below, is calculated as the unweighted average of the log of the corresponding variable for all 11 manufacturing sectors in all countries for which data is available for that year. The sample covers all 14 countries between 1995 and 2006.

for equipment. In contrast, the capital-output ratio for structures declined towards the end of the sample period.

3.2. Relative price of investment goods

EU KLEMS also provides, for each sector in each country, the price index for gross fixed capital formation (by asset type) and the price index for value-added. The ratio of these two indices provides a measure of the price of investment goods relative to the price of output. The base years for these price indices are both 1995.[12] Figure 2 shows the average relative price of investment goods in logarithms ($\ln P^K/P$), separately for equipment and structures, over the sample period.[13]

A striking feature shown in Figure 2 is that, while the relative price of equipment assets declined gradually from the middle of the 1990s, the relative price of structures remained stable until the late 1990s and then began to increase sharply.[14] The common components (across countries and sectors) of the variation in capital-output ratios and relative prices shown in Figures 1 and 2 are not used in the estimation of our econometric models. Nevertheless, the association between a rising capital-output ratio and a falling relative price for equipment during the second half of our sample period is consistent with the inverse relationship predicted by the basic neoclassical model of investment.

3.3. The tax component of the user cost of capital

The tax component of the user cost of capital, $\frac{(1-A)}{(1-\tau)}$, reflects varying tax rules and tax rates in different countries and over time. Data on the statutory corporate income tax rates (τ) and the net present value (NPV) of depreciation allowances (A) are provided by the Oxford University Centre for Business Taxation. Statutory tax rates are common to all sectors within a country; they vary across countries and over time, with tax reforms being the sole source of variation over time within a country.[15]

Tax depreciation allowances typically distinguish between equipment and structures, with some countries such as the USA having finer distinctions between various types of equipment and structures. We have separate measures of the NPV of depreciation allowances for equipment and structures. For each asset, these measures are common to all sectors within a country. Variation across countries and over time partly reflects differences in tax laws; additionally, this reflects differences in inflation rates which affect

[12] As the base year is 1995 for all price indices, differences in the level of relative prices between countries and sectors are not fully reflected in these measures. This provides one motivation for including country-sector specific fixed effects in our specifications, as the fixed effects can control for price level differences across countries and sectors in the base year.

[13] For each sector in each country, we construct a price index for equipment as the weighted average of those reported in EU KLEMS for each of the four types of equipment assets, with weights given by the share of each asset in the total stock of equipment in the corresponding sector, country and year. For our econometric models of total capital, we construct a similar weighted average of the price indices for equipment, structures and other assets.

[14] The declining relative price of equipment is documented in other studies, such as Greenwood, Hercowitz and Krusell (1997) and Hsieh and Klenow (2005). The rapid increase in the relative price of structures is observed in almost every country in our sample since the late 1990s, and is particularly evident in Australia, Czech Republic, Spain, Sweden and the United States.

[15] For federal countries with state-level as well as federal corporate income taxes, our measure of the statutory tax rate includes either an average of local tax rates for larger countries, or a representative local tax rate for smaller countries. Loretz (2008) provides more details.

the nominal discount rates used in the NPV calculations, in line with the unindexed nature of tax depreciation provisions in our sample countries.[16] For total capital, we construct a weighted average of the NPV measures for equipment and structures, with weights given by the share of each asset in total capital in the corresponding sector, country and year.[17] This introduces a modest amount of variation across sectors within a country in our measure of the tax component of the user cost for total capital, but this is not an important source of variation for the econometric results that we present in section 5 below.[18]

Pooling this tax data across countries provides rich variation in the tax component of the user cost of capital, which greatly facilitates the identification of the effects of tax incentives on capital accumulation. Figure 3 plots the time series for this summary measure of the effects of corporate taxation on the incentive to invest, in logarithms ($\ln\left(\frac{1-A}{1-\tau}\right)$), separately for equipment and structures, and separately for each country in our sample. Corporate taxation generally raises the user cost of capital,[19] and in each country this effect is larger for structures than for equipment, reflecting the presence of more generous depreciation provisions for equipment. In most countries, and particularly for structures, this effect is smaller at the end of our sample period than at the beginning, which reflects the general downward trend in statutory corporate tax rates over this period.[20] For individual countries, we observe sharp reductions associated with rate-cutting reforms at different times: for example, in Australia the tax rate fell from 49% to 39% in 1988; in Austria the rate fell from 61% to 39% in 1989, and again from 34% to 25% in 2005; in Denmark the rate fell from 50% to 40% in 1990, and then declined more gradually to 21% by 2007; in Italy the rate fell from 53% to 41% in 1998; and in Germany the rate fell from 50% to 36% in 2001. These developments are described in more detail in Devereux, Griffith and Klemm (2002) and in Loretz (2008), for example. Importantly, we observe considerable within-country variation over time, with different profiles in different countries, and also considerable variation around linear trends in most of these countries. This allows us to control for country-specific fixed effects, common time effects and country-specific linear trends in all of our econometric specifications.[21]

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[16] The one-period nominal discount rate $(1 + \rho_t)$ between year t and year $t + 1$ is constructed as $(1 + r_t)(1 + \pi_t)$, where the real interest rate (r_t) is assumed fixed at 10% and the expected inflation rate (π_t) is assumed to be the actual CPI inflation rate between year $t - 1$ and year t. The s-period nominal discount factor between year t and year $t + s$ is constructed as $(1 + \rho_t)^{-s}$.

[17] For this purpose, one half of the EU KLEMS category ‘other assets’ is allocated to equipment and one half to structures. The share of ‘other assets’ in total capital is 3% on average in our sample.

[18] That is, we find very similar results in our specifications for total capital if we combine the NPV measures for equipment and structures using common weights for each sector within a country.

[19] The exception is equipment investment in the UK before the reform of 1984, which was eligible for a 100% first-year allowance.

[20] We can note that for the UK reform in 1984, the effect of a reduction in the tax rate from 52% to 35% was more than offset by reductions in the NPV of depreciation allowances. This was also the case for structures, although not for equipment, for the US reform in 1986.

[21] In fact, our specifications control for fixed effects and linear trends separately for each sector in each country.

4. Specifications

As discussed in the preceding section, our data provides measures of the relative price and tax components of the user cost of capital. We assume that any variation either across countries, across sectors or over time in the real discount rate (r_t), depreciation rate (δ) and demand elasticity (η) components of the logarithm of the user cost of capital can be controlled for using a combination of common year dummies, country-sector specific intercepts ('fixed effects'), and country-sector specific linear trends. We also assume that the production technology satisfies constant returns to scale ($\nu = 1$). Combining equations (1) and (2), and taking logarithms of both sides, we then obtain a convenient log-linear relation between the desired capital-output ratio (in the absence of any adjustment costs or frictions) and the measured components of the user cost of capital:

$$\ln\left(\frac{K_t^*}{Q_t}\right) = d_t - \sigma \ln\left(\frac{P_t^K}{P_t}\right) - \sigma \ln\left(\frac{1-A_t}{1-\tau_t}\right) \tag{4}$$

in which the vector d_t contains the deterministic components (i.e. intercepts, year dummies and linear trends).

All of our econometric specifications are based on this characterisation of the long-run relationship between capital-output ratios and the relative price and tax components of the user cost. Our specifications differ in their treatment of short-run adjustment dynamics. The presence of any form of adjustment costs or frictions introduces a wedge between the observed capital stock (K_t) and the (frictionless) desired capital stock (K_t^*). This arises partly because, at any point in time, observed capital stocks may be in the process of adjusting, and also because costly adjustment may influence the targets towards which actual capital stocks adjust. Letting $e_{i,c,t} = \ln K_{i,c,t} - \ln K_{i,c,t}^*$ denote the logarithm of this difference for sector i in country c in year t, we obtain the static specification for the observed capital-output ratio:

$$\ln\left(\frac{K_{i,c,t}}{Q_{i,c,t}}\right) = a_{i,c} + b_{i,c}t + \gamma_t - \sigma \ln\left(\frac{P_{i,c,t}^K}{P_{i,c,t}}\right) - \sigma \ln\left(\frac{1-A_{i,c,t}}{1-\tau_{i,c,t}}\right) + e_{i,c,t} \tag{5}$$

in which $a_{i,c}$ is the intercept for sector i in country c, $b_{i,c}$ is the coefficient on a linear trend for that country-sector pair, and γ_t denotes the coefficient on a dummy variable for year t. For any finite adjustment costs, the error term $e_{i,c,t}$ will be stationary,[22] although complex forms of serial correlation are expected in theory and commonly found in empirical studies.[23] For most forms of adjustment costs, we would not expect $\ln K$ and $\ln K^*$ to be equal on average; a non-zero mean value of $e_{i,c,t}$ over time can be absorbed in the country-sector specific intercepts, with the year dummy and trend terms further allowing for some variation over time in these means.

[22] See Bloom, Bond and Van Reenen (2007). In the case where $\ln Q$, $\ln K^*$ and $\ln K$ are non-stationary, I(1) processes, this implies that observed $\ln K$ and frictionless $\ln K^*$ are cointegrated. If $\ln(P^K/P)$ and $\ln[(1-A)/(1-\tau)]$ are stationary, our framework requires that observed $\ln(K/Q)$ should also be stationary. We consider the time series properties of these variables in our sample in section 5.1 below.

[23] Recent structural estimates using firm-level data suggest that both convex and non-convex forms of adjustment costs are required to rationalise the observed investment dynamics. See, for example, Cooper and Haltiwanger (2006) and Bloom (2009).

While we present some estimates of the static specification (5), our main focus will be on dynamic specifications which seek to model the capital adjustment process empirically up to a serially uncorrelated error term. The primary reason for this emphasis is that we are interested not only in *how large* is the eventual effect of tax incentives on capital-output ratios, as reflected in estimates of the elasticity parameter (σ), but also in *how quickly* capital-output ratios adjust to changes in tax incentives; a dynamic specification is needed to study the sensitivity of investment rates to tax changes in the short term. Estimates of the long-run elasticity parameters may also be biased if either the relative price or the tax variables in year t are correlated with *any of the past shocks* which are cumulated in the autocorrelated error term ($e_{i,c,t}$) in the static specification.

One possibility is to include additional lagged values of these explanatory variables, in which case we obtain a distributed lag specification of the form:

$$\ln\left(\frac{K_{i,c,t}}{Q_{i,c,t}}\right) = \widetilde{a}_{i,c} + \widetilde{b}_{i,c}t + \widetilde{\gamma}_t - \sum_{s=0}^{p}\lambda_s \ln\left(\frac{P^K_{i,c,t-s}}{P_{i,c,t-s}}\right) - \sum_{s=0}^{q}\theta_s \ln\left(\frac{1-A_{i,c,t-s}}{1-\tau_{i,c,t-s}}\right) + \epsilon_{i,c,t} \quad (6)$$

where the first three terms on the right-hand side again denote country-sector specific intercepts and linear trends, and common year dummies. The lagged terms capture straightforwardly the idea that, when adjustment is costly, capital-output ratios may not respond fully and immediately to changes in the user cost. The long-run elasticities of the capital-output ratio with respect to the relative price and tax components of the user cost are then given by the sums $\sum_{s=0}^{p}\lambda_s$ and $\sum_{s=0}^{q}\theta_s$ respectively. The lag lengths p and q can be determined empircally.

A more general specification additionally includes lagged values of the dependent variable, giving an autoregressive-distributed lag model of the form:

$$\begin{aligned}\ln\left(\frac{K_{i,c,t}}{Q_{i,c,t}}\right) &= a^*_{i,c} + b^*_{i,c}t + \gamma^*_t + \sum_{s=1}^{r}\rho_s \ln\left(\frac{K_{i,c,t-s}}{Q_{i,c,t-s}}\right) \\ &\quad - \sum_{s=0}^{p}\lambda_s \ln\left(\frac{P^K_{i,c,t-s}}{P_{i,c,t-s}}\right) - \sum_{s=0}^{q}\theta_s \ln\left(\frac{1-A_{i,c,t-s}}{1-\tau_{i,c,t-s}}\right) + \varepsilon_{i,c,t}\end{aligned} \quad (7)$$

in which the long-run elasticities of the capital-output ratio with respect to the relative price and tax terms are given by the ratios $\sum_{s=0}^{p}\lambda_s/\left(1-\sum_{s=1}^{r}\rho_s\right)$ and $\sum_{s=0}^{q}\theta_s/\left(1-\sum_{s=1}^{r}\rho_s\right)$ respectively. The capital adjustment dynamics can be represented by a linear dynamic model of this form if the serial correlation in $e_{i,c,t}$ can be approximated by a low-order stationary autoregressive process, in which case there should be little or no autocorrelation remaining in the error term $\varepsilon_{i,c,t}$.

This specification can also be re-parameterised in the form of an error correction model, which conveniently separates the parameters related to the short-run adjustment dynamics from the long-run elasticities.[24] Our preferred empirical specifications set the lag lengths $p = q = r = 2$ and further relax the restrictions that the coefficient on each lagged $\ln K_{i,c,t-s}$ is equal to that on the corresponding lagged $\ln Q_{i,c,t-s}$, so that we impose the restriction implied by constant returns to scale only in the long run. This

[24] An error correction specification was first used to model short-run investment dynamics by Bean (1981).

gives our preferred error correction specification as:

$$\begin{aligned}\Delta \ln K_{i,c,t} \;=\;& a^{*}_{i,c} + b^{*}_{i,c}t + \gamma^{*}_{t} + \beta_1 \triangle \ln K_{i,c,t-1} + \beta_2 \triangle \ln Q_{i,c,t} \\ & + \beta_3 \triangle \ln Q_{i,c,t-1} + \beta_4 \triangle \ln \left(\frac{P^{K}_{i,c,t}}{P_{i,c,t}} \right) + \beta_5 \triangle \ln \left(\frac{P^{K}_{i,c,t-1}}{P_{i,c,t-1}} \right) \\ & + \beta_6 \Delta \ln \left(\frac{1 - A_{i,c,t}}{1 - \tau_{i,c,t}} \right) + \beta_7 \Delta \ln \left(\frac{1 - A_{i,c,t-1}}{1 - \tau_{i,c,t-1}} \right) \\ & - \phi \left[\ln \left(\frac{K_{i,c,t-2}}{Q_{i,c,t-2}} \right) - \alpha_1 \ln \left(\frac{P^{K}_{i,c,t-2}}{P_{i,c,t-2}} \right) - \alpha_2 \ln \left(\frac{1 - A_{i,c,t-s}}{1 - \tau_{i,c,t-s}} \right) \right] + \varepsilon_{i,c,t}\end{aligned} \tag{8}$$

in which the 'error correction' term in square brackets corresponds to the form of the long-run relationship derived in equation (5), and α_1 and α_2 are the long-run elasticity parameters. We test but do not impose the theoretical restriction that these two long-run elasticities should be equal in magnitude.

We present empirical estimates of these specifications separately for models in which the capital stock term is measured as total capital (excluding residential structures) and as total equipment in the EU KLEMS data. In robustness checks based on the error correction specification, we consider relaxing the (long-run) constant returns to scale restriction, omitting explanatory variables from year t which may be correlated with the (serially uncorrelated) error term $\varepsilon_{i,c,t}$, including the statutory corporate tax rate (τ) as an additional explanatory variable, and allowing for heterogeneity across countries and sectors in the short-run adjustment parameters (ϕ and β_j for $j = 1, 2, ..., 7$).

5. Results

5.1. Time series properties

We use standard estimation and inference methods for regression models which, given the long time series dimension of our panels, require the variables to be stationary. This is one motivation for imposing the constant returns to scale restriction in our main specifications, and working with the log of the capital-output ratio rather than with the logs of the capital stock and output variables individually.

Table D.1 in Appendix D presents the results of formal tests of the null hypothesis that these series are non-stationary (integrated of order one). We report results for the Fisher-type panel unit root test proposed by Maddala and Wu (1999), which is suitable for unbalanced panels and allows for heterogeneous slope coefficients across the observations for each country-sector pair.[25] Focusing on the specification which allows for common year effects and country-sector specific linear trends, we find that the logs of the capital stock and output series appear to be non-stationary (I(1)), while the log of the capital-output ratio and all the remaining variables used in our models for total capital and for equipment appear to be stationary (I(0)).[26] As always, the results of these formal unit root tests should be interpreted with caution.

[25] The tests are computed using the command *xtfisher* in Stata. The test procedure is outlined in the note to Table D.1.

[26] For structures only, this test suggests that the relative price series may be non-stationary; although curiously the same test rejects the null of non-stationarity for the relative price series for total capital, which is a weighted average of those for equipment and structures.

5.2. Baseline specifications

Table 1 presents the results of estimating equation (5) using our main sample of 11 manufacturing industries in 14 countries.[27] Measuring the capital stock either as total capital excluding residential structures (column 1) or as total equipment (column 2), we estimate a significant, negative (long-run) elasticity of the capital-output ratio with respect to the tax component of the user cost of capital, of about -0.3. We also find a significant, negative (long-run) elasticity of the capital-output ratio with respect to the relative price component of the user cost, which is estimated to be somewhat larger in absolute value in both models. Column 3 indicates that broadly similar results are obtained using this static specification if the capital stock is measured as the total stock of non-residential structures. However the reported serial correlation tests provide very strong evidence that the residuals from these static models are positively autocorrelated, which may make these estimates of the (long-run) elasticities unreliable.[28] We thus proceed to consider dynamic econometric specifications.

Table 2 presents the results of estimating a distributed lag model of the form shown in equation (6), with both lag lengths p and q set to three.[29] We estimate significant coefficients on the lagged values of both explanatory variables in all three specifications using different measures of the capital stock. For both the total capital and the total equipment models, the inclusion of these lagged explanatory variables increases the absolute value of the estimated long-run elasticity with respect to the tax component of the user cost, to around -0.4 in each case. We continue to find strong evidence of positive serial correlation in the residuals of these distributed lag models.

Table 3 presents the estimates of our preferred error correction specifications, as in equation (8). These models also suggest gradual adjustment of sectoral capital-output ratios to changes in the tax and relative price components of the user cost of capital, but here we find no significant evidence of residual autocorrelation. In the model for total equipment, the inclusion of autoregressive dynamics further increases the absolute value of the estimated long-run elasticity of the capital-output ratio with respect to the tax component of the user cost, to around -0.7. Moreover the theoretical prediction that the long-run elasticities with respect to both the tax and relative price components of the user cost should be equal in magnitude is not rejected in this more general dynamic model for equipment capital. In the model for total capital, we continue to estimate a significant but smaller long-run elasticity with respect to the tax component of the user

[27] In Table 1 and the following tables, the subscripts i and c are suppressed. The term $\ln[(1-A_t)/(1-\tau_t)]$ is denoted by $\ln TAX_t$. These results are computed using the fixed effects option of the command *xtreg* in Stata. Standard errors are clustered at the country-sector level and hence allow for serial correlation in the error term.

[28] To illustrate, suppose that the error term $e_{i,c,t}$ in (5) has the first-order autoregressive form $e_{i,c,t} = \rho e_{i,c,t-1} + v_{i,c,t} = v_{i,c,t} + \rho v_{i,c,t-1} + \rho^2 v_{i,c,t-2} + ...$, where $v_{i,c,t}$ is a serially uncorrelated shock. Least squares estimates of the parameters in (5) will be consistent only if the explanatory variables $\ln(P^K/P)_{i,c,t}$ and $\ln TAX_{i,c,t}$ are uncorrelated with all past $v_{i,c,t-s}$ shocks which are cumulated in the error term $e_{i,c,t}$; this is a much stronger condition than merely requiring $\ln(P^K/P)_{i,c,t}$ and $\ln TAX_{i,c,t}$ to be uncorrelated with the current innovation $v_{i,c,t}$. The stronger orthogonality condition would fail if, for example, current corporate tax policy is influenced by recent investment outcomes in some of our sample countries.

[29] Including further lags of the explanatory variables made no material difference to the results that we discuss here.

cost, of about -0.4.

This difference between the long-run elasticities estimated in our models for total equipment and for total capital suggests that our measure of the tax component of the user cost of capital may be less informative for explaining investment in non-residential structures. Consistent with this, column 3 of Table 3 shows that we find no significant effects from this tax measure in an error correction specification where the capital stock is measured as the total stock of non-residential structures. There are several factors that could account for this difference between our results for structures and our results for equipment. First, our measures of the tax component of the user cost assume that current tax rates, tax rules and nominal discount rates will remain constant over time. This static expectations assumption may be adequate for equipment assets with relatively short lives, but not for longer term investments in structures. Second, micro data shows that lumpy patterns of adjustment suggested by non-convex forms of adjustment costs are more important for structures than for equipment, with zero annual investment ('inaction') observed far more frequently for structures in plant-level data.[30] Our econometric specifications may do less well in capturing these more complex adjustment dynamics, even with data aggregated up to the sectoral level. More fundamentally, as discussed in section 2, our convenient log-linear models for the desired capital-output ratio are based on the assumption that a single capital good contributes directly to production. This approach yields a model for total equipment under the assumption that costs related to structures can be treated as fixed costs, but does not yield a similar model for total structures under any reasonable assumptions.

At this point, we can conclude that the simple approach adopted here has not produced robust evidence of a relationship between investment in non-residential structures and a standard measure of the tax component of the user cost of capital for structures, perhaps for some of the reasons noted above. In contrast, our results for total equipment are strikingly consistent with predictions derived from the basic neoclassical model of investment, and for total capital we also find evidence of a significant, negative long-run relationship with the tax component of the user cost. In the remainder of this section we present further evidence on the robustness of these results for equipment and total capital.

5.3. Robustness checks

Returns to scale

Our preferred specifications in Table 3 restrict the long-run elasticity of the capital stock with respect to output to be unity, as implied by constant returns to scale in the underlying production technology. This restriction is partly motivated by our finding that sectoral capital-output ratios, as well as the measured components of the user cost of capital, appear to be stationary time series, while the capital stock and output series appear to be non-stationary. These properties suggest that the logarithms of the capital stock and output series are cointegrated with a long-run parameter close to unity, consistent with constant returns to scale.

Table 4 presents estimates of a more general dynamic specification which relaxes

[30] See, for example, Bloom, Bond and Van Reenen (2007).

this restriction.[31] For both the equipment and total capital models, the point estimates of the long-run elasticities of the capital stock measures with respect to output are smaller than unity, and suggest implausibly high returns to scale.[32] We also find positive autocorrelation in the residuals, which casts further doubt on the adequacy of this specification. Nevertheless, for both equipment and total capital, we still find significant, negative long-run elasticities with respect to the tax component of the user cost; and for equipment, the prediction of equal long-run elasticities with respect to the tax and relative price variables is again not rejected.[33]

Samples

Our main results are presented for the sample which comprises the 11 EU KLEMS sub-sectors within manufacturing. Our specifications impose the restriction that the elasticity of substitution between capital and other inputs is common across countries and sectors, which may be more reasonable for sectors within manufacturing than more broadly. Moreover, most manufacturing investment is undertaken by private sector firms which are subject to corporation tax, while investment by public sector corporations and other government agencies may be subject to very different influences.

Tables D.2 and D.3 in Appendix D nevertheless present estimates of our preferred error correction specifications using two broader samples. The sample of 19 industries used in Table D.2 excludes financial services and sectors where public sector investment is likely to be important, while the sample used in Table D.3 includes all 27 sectors covered in the EU KLEMS database.[34] For both equipment and total capital, we estimate significant, negative long-run elasticities of the capital-output ratio with respect to the tax component of the user cost in each of these larger samples; indeed, here we do not reject the theoretical prediction of equal long-run elasticities with respect to the tax and relative price components of the user cost of capital for either equipment or for total capital.

Table D.4 presents estimates of the same specifications using panel data for the manufacturing sector as a whole in our 14 sample countries over the same time period.[35] Neglecting variation across sectors within countries in the relative price component of the user cost results in less precise estimates of the long-run relative price elasticity here, but otherwise the results are very similar to those reported in Table 3. The similarity of both the point estimates and the standard errors for the long-run tax elasticity parameter, in the models for both equipment and total capital, does not suggest that the statistical significance of our main estimates is seriously overstated, notwithstanding that our measure of tax component of the user cost of capital has little or no variation

[31] In terms of equation (8), the single term $\ln(K/Q)_{i,c,t-2}$ is replaced by two separate terms, $\ln K_{i,c,t-2}$ and $\ln Q_{i,c,t-2}$.

[32] The reported standard error for the long-run elasticity with respect to output will be inappropriate if the capital stock and output series are indeed non-stationary, and should thus be viewed with caution.

[33] The reported standard errors for these long-run elasticity parameters will be appropriate provided that the non-stationary capital and output variables are cointegrated and the tax and relative price variables are stationary, as suggested by our results in Table D.1.

[34] Appendix B provides details of the sectors included in each of these samples.

[35] Data on capital stocks, value-added and the price series for aggregate manufacturing are obtained directly from EU KLEMS. For total capital, the NPV of depreciation allowances is again constructed as a weighted average of those for equipment and structures, with weights appropriate for aggregate manufacturing in each country and year.

across sectors within the same country and year.

Endogeneity

Our preferred dynamic specifications have residuals which are found to be serially uncorrelated. Consistency of our least squares estimates still requires that all the included explanatory variables are uncorrelated with these shocks. While this is unlikely to be a concern for the lagged values of any of the explanatory variables, the inclusion of the current-dated terms $\Delta \ln Q_{i,c,t}$, $\Delta \ln(P^K/P)_{i,c,t}$ and $\Delta \ln TAX_{i,c,t}$ could be problematic if any of these terms are correlated with the (serially uncorrelated) error term $\varepsilon_{i,c,t}$ in equation (8). For example, an outward shift in the demand for the product of a particular country-sector pair could plausibly increase current output (and hence $\Delta \ln Q_{i,c,t}$) as well as current investment.

One way to explore this concern is simply to omit these current-dated explanatory variables. Table 5 presents estimates of this restricted dynamic specification for our main sample of 11 manufacturing sectors. As in Table 3, we find no significant evidence of serial correlation in the residuals from this specification. For both equipment and total capital, the estimates of the long-run elasticity parameters remain very similar to those discussed previously. This suggests that our results in Table 3 are unlikely to be seriously biased by the inclusion of endogenous explanatory variables.

Additional tax variables

The neoclassical investment model makes the strong prediction that the effects of corporate taxation on capital accumulation are summarised by the tax component of the user cost of capital. However there are good reasons to suspect that corporate taxes may influence investment through other channels: for example, if discrete location decisions by multinational companies play an important role in sectoral investment outcomes (Devereux and Griffith, 1998); if the investment expenditure of a significant proportion of firms is affected by financing constraints (Keuschnigg and Ribi, 2013); or if statutory tax rates are simply more salient than depreciation allowances or other aspects of the tax base.

We test this theoretical prediction by including additional explanatory variables $\Delta \ln \tau_{i,c,t}$, $\Delta \ln \tau_{i,c,t-1}$ and $\ln \tau_{i,c,t-2}$ in our error correction specifications, where $\tau_{i,c,t}$ is the statutory corporate income tax rate in country c in year t.[36] The results are summarised in Table 6. In our model for equipment, the coefficients on these additional tax rate terms are insignificantly different from zero, both individually and jointly. After controlling for the effects implied by the tax component of the user cost, we thus find no 'excess sensitivity' of sector-level equipment capital-output ratios to variation in statutory tax rates. In our model for total capital, we also find no significant long-run effect of statutory tax rates on sector-level capital-output ratios, beyond that summarised by the tax component of the user cost. In the total capital specification, we do find a small and significant positive coefficient on the $\Delta \ln \tau_{i,c,t}$ term, which suggests that adjustment following changes in the tax rate may be slower than adjustment following changes in depreciation allowances.[37] The inclusion of these additional tax rate terms also has little

[36] Very similar results are found if we use $\tau_{i,c,t}$ or $\ln(1 - \tau_{i,c,t})$ terms in place of the $\ln \tau_{i,c,t}$ terms.

[37] The statutory tax rate terms are more significant in the model for structures, which is reported for completeness in Table 6. As discussed in section 5.2, our econometric model of the capital-output ratio is not expected to be appropriate when capital is measured using data on the stock of non-residential

effect on the estimates of long-run elasticities with respect to the tax and relative price components of the user cost.[38]

Heterogeneous parameters

Our main specifications allow for unrestricted heterogeneity across countries and sectors in coefficients on the intercept and linear trend terms, but impose common coefficients on the remaining explanatory variables. In principle it is possible to allow for heterogeneous coefficients on all the explanatory variables, for example by estimating separate time series regressions for each country-sector pair, and then considering the average value across country-sector pairs for each parameter of interest.[39] In practice we have too many coefficients in our dynamic models for this approach to give useful results.[40]

An intermediate specification imposes common coefficients for the long-run elasticity parameters (α_1 and α_2 in equation (8)), but allows for unrestricted heterogeneity in all the remaining parameters which describe the short-run adjustment dynamics. This model can be estimated using the maximum likelihood Pooled Mean Group estimator of Pesaran, Shin and Smith (1999). We implement this approach for a more parsimonious dynamic specification, which is detailed in the note to Table 7. Here we control approximately for common shocks to capital-output ratios by expressing all variables in the form of deviations from year-specific sample means, which are calculated using all the observations available for the same variable in the same year.[41]

Table 7 summarises these Pooled Mean Group estimates for our sample of 11 manufacturing industries in 14 countries.[42] We report the pooled (common) estimates of the two long-run elasticity parameters. We also report the average value (across the 154 country-sector pairs) of the estimated coefficients on the lagged level of the capital-output ratio ($-\phi$ in equation (8)), which summarises the speed of adjustment of the capital-output ratio towards its long-run target for a typical country-sector pair. For equipment, this specification gives an estimate of the long-run elasticity with respect to the tax component of the user cost of capital of about -0.55, which is significantly different from zero, though somewhat smaller in absolute value compared to the more standard 'fixed effects' estimate reported in Table 3. Again we find that the theoretical prediction of equal long-run elasticities with respect to the tax and relative price com-

structures only.

[38]In Bond and Xing (2013), we also considered a measure of the effective average tax rate (EATR) suggested by Devereux and Griffith (1998, 2003). Here we include a full set of country-sector specific linear trend terms in all specifications. After controlling for country-sector trends, we find that the tax component of the user cost and the EATR measure are too collinear for any decisive results to be obtained.

[39]This procedure leads to the Mean Group estimator of parameter values for a typical country-sector pair, proposed by Pesaran and Smith (1995).

[40]For the error correction specifications reported in Table 3, this would require us to estimate 12 coefficients from each time series regression, while for 2 of our 14 countries we have only 13 annual observations. In Bond and Xing (2013, Tables 9 and 10) we report Mean Group estimates for a restricted model which imposes equal coefficients on the two measured components of the user cost of capital.

[41]This transformation is equivalent to including a set of year dummies in models with common slope parameters, but not in models with heterogeneous slope parameters.

[42]These results are computed using the *xtpmg* command in Stata.

ponents of the user cost is not rejected in this specification for equipment capital. Also noteworthy is that the more general specification, with heterogeneous short-run adjustment dynamics, suggests faster adjustment of capital-output ratios, on average, than the pooled specification in Table 3. For total capital, we also estimate a long-run tax elasticity which is negative and significantly different from zero, although this parameter is estimated with much less precision in the model for total capital.

6. Discussion

We have used the variation over time in the corporate tax regimes of 14 developed countries to study the relationship between sector-level capital-output ratios and the tax component of the user cost of capital. Our econometric models combine a long-run specification which is derived from the basic neoclassical model of investment with a Constant Elasticity of Substitution production technology, and short-run adjustment dynamics which are freely estimated from the data. Combining data from several jurisdictions provides much richer variation in the tax measures than would be available for any single country, but requires capital stock measures which are comparable across countries. Until recently, this requirement was prohibitive, but the EU KLEMS database used in this study overcomes methodological differences in the capital stock measures available from national accounts sources. To the best of our knowledge, this paper is the first to exploit such variation in cross-country panel data to estimate the impact of corporate taxation on sector-level capital-output ratios.[43]

For both total capital (excluding residential structures) and total equipment, we find very robust evidence of a significant, negative, long-run effect of the tax component of the user cost of capital on sector-level capital-output ratios. Our estimates of the long-run tax elasticity are mostly in the range -0.3 to -0.5 for total capital, and -0.3 to -0.7 for total equipment. These estimates are well within the range of previous findings using US firm-level data and various econometric approaches in, for example, Chirinko, Fazzari and Meyer (1999), Cummins, Hassett and Hubbard (1994) and Caballero, Engel and Haltiwanger (1999).[44]

To illustrate the implications of these results, we estimate that at the end of our sample period, the introduction of a cash flow corporation tax or an Allowance for Corporate Equity (ACE) would reduce the user cost of capital for equipment by about 10%, on average across our sample countries.[45] In the long run, our estimates suggests that such tax reform could increase capital-output ratios by 3%-7%. For equipment, the

[43] Djankov et al. (2010) use cross-section data for a much larger sample of 85 countries to estimate models for aggregate gross fixed investment as a share of GDP. They also find a significant, negative effect from an effective average corporate tax rate measure. By using panel data, we can control for country-sector level fixed effects, and our specifications and tax measures are more closely related to standard investment theory. Bloom, Griffith and Van Reenen (2002) use cross-country panel data and specifications which are much closer to ours in an empirical study of the relationship between corporate taxation and R&D investment.

[44] Hassett and Hubbard (2002) provide a useful survey of this literature. Most previous studies have also combined the tax and non-tax components of the user cost to estimate a single long-run elasticity parameter. While theoretically reasonable, this approach does not specifically reveal the sensitivity of capital-output ratios to tax variation.

[45] A cash flow tax with expensing of investment sets $A_t = \tau_t$ and hence $(1 - A_t)/(1 - \tau_t) = 1$. The ACE allowance is equivalent to the expensing treatment in present value terms; see, for example, Bond

estimated adjustment dynamics for our main specification in Table 3 suggest a half-life of the adjustment process of about 4.5 years, with 75% of the adjustment completed after 9 years. The Pooled Mean Group estimates in Table 7 suggest that the adjustment may be somewhat faster, at least for the typical country-sector pair.

For equipment, our empirical results are also strikingly consistent with the basic neoclassical model of investment. We do not reject the theoretical prediction that the tax and relative price components of the user cost of capital have the same long-run effect on capital-output ratios, and we find that the effects of corporate taxation on sector-level equipment capital-output ratios are summarised by the tax component of the user cost. For total capital, however, we find some deviations from these predictions, which seem to be driven mainly by investment in structures. Our analysis does not provide robust evidence of a link between investment in structures and the tax component of the user cost for structures, and this presents a challenge for future research.

Nonetheless, at least for equipment investment, our results contribute to a growing body of evidence which suggests that corporate taxation does matter, and influences capital accumulation in much the way suggested by the basic economic theory of investment.

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and Devereux (2003). Belgium and Italy have recently introduced a form of the ACE allowance, in 2008 and in 2011 respectively.

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Figure 1: Average capital-output ratio (in logs): manufacturing industries

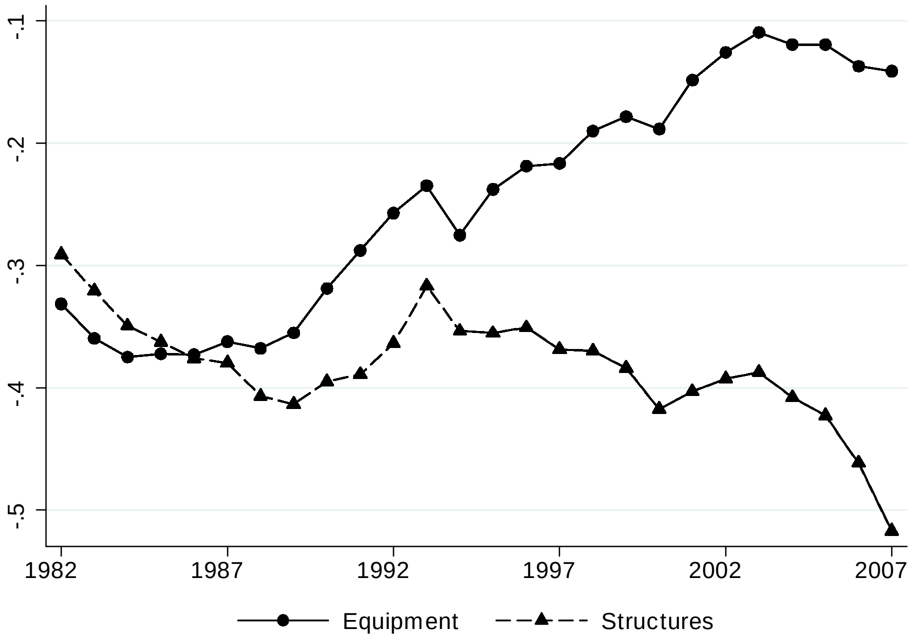

Figure 2: Average relative price of assets (in logs): manufacturing industries

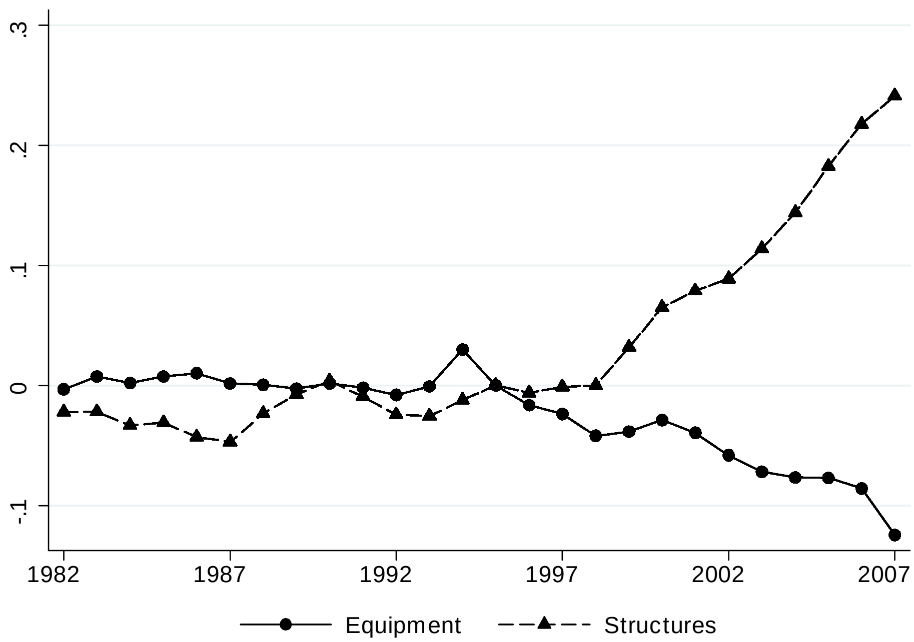

Figure 3: Tax component of the user cost of capital, by country

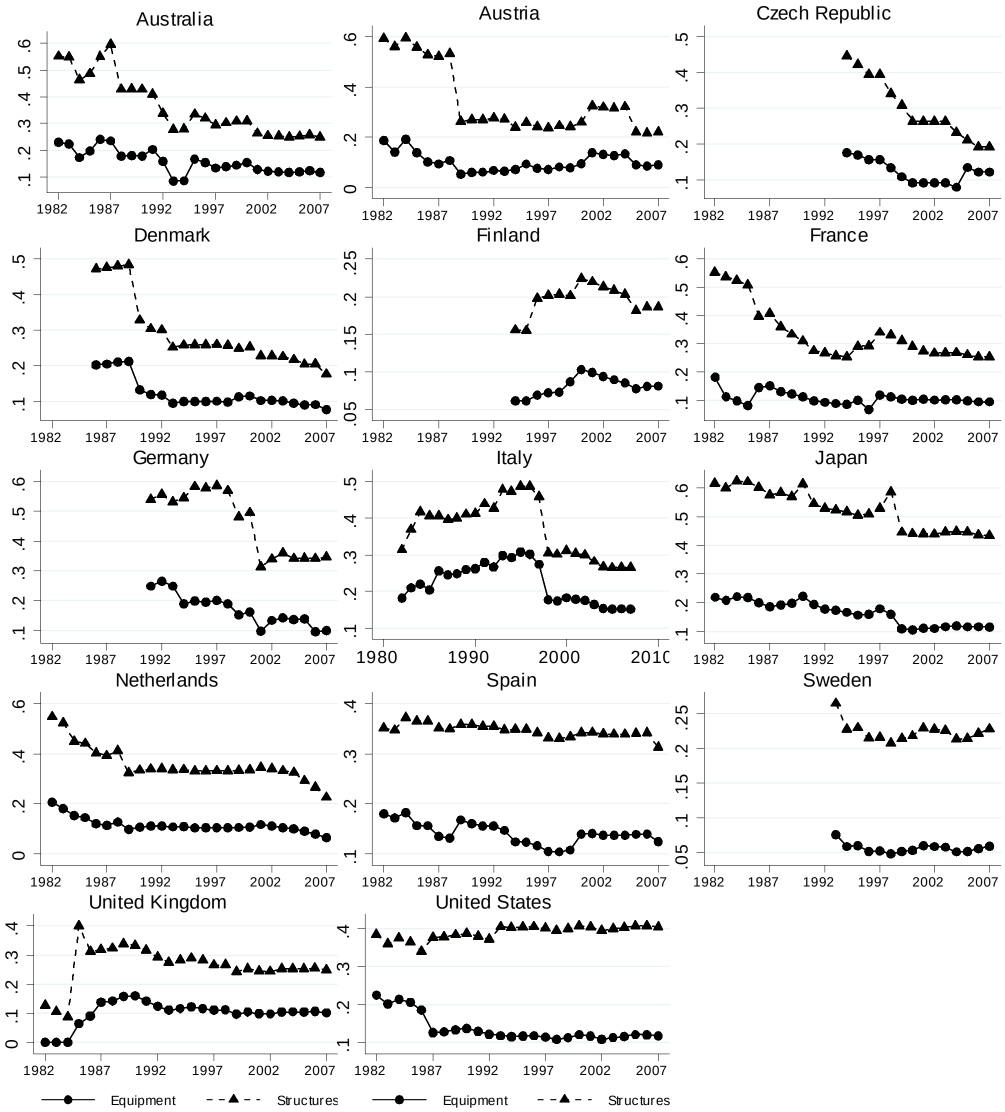

Table 1:Static models

Dependent variable: $\ln(K_t/Q_t)$	(1) Total capital	(2) Equipment	(3) Structures
Coefficients			
$\ln(P_t^K/P_t)$	-0.027***	-0.056***	-0.013***
	(0.004)	(0.008)	(0.002)
$\ln TAX_t$	-0.028***	-0.065***	-0.013***
	(0.004)	(0.009)	(0.002)
Test of equal coefficients:			
(p-value)	0.061	0.004	0.117
Serial correlation tests			
AR(1)	7.96	7.90	7.68
AR(2)	5.59	6.01	5.82
Year dummies	Yes	Yes	Yes
Country-sector trends	Yes	Yes	Yes
No. of groups	154	154	154
Observations	3,146	3,143	3,141
R^2	0.842	0.844	0.837

[1]Standard errors in brackets are robust and clustered over time within country-industry pairs.

[2]*** p<0.01, **p<0.05, * p<0.1.

[3]Arellano-Bond (1991) test statistics for no first-order and no second-order serial correlation are distributed as standard normal under the null hypothesis of no serial correlation

Table 2: Distributed lag models

Dependent variable: $\ln(K_t/Q_t)$	(1) Total capital	(2) Equipment	(3) Structures
Coefficients			
$\ln(P^K/P)_t$	-0.368***	-0.488***	-0.348***
	(0.044)	(0.050)	(0.063)
$\ln(P^K/P)_{t-1}$	-0.070***	-0.096***	-0.068**
	(0.024)	(0.030)	(0.033)
$\ln(P^K/P)_{t-2}$	-0.096***	-0.110***	0.002
	(0.022)	(0.026)	(0.025)
$\ln(P^K/P)_{t-3}$	-0.058	-0.055	-0.075
	(0.046)	(0.044)	(0.062)
$\ln TAX_t$	-0.279***	-0.108	-0.085
	(0.075)	(0.125)	(0.054)
$\ln TAX_{t-1}$	0.067*	0.028	0.051*
	(0.038)	(0.061)	(0.026)
$\ln TAX_{t-2}$	-0.094**	-0.179***	-0.073**
	(0.041)	(0.062)	(0.032)
$\ln TAX_{t-3}$	-0.072	-0.167**	-0.142***
	(0.050)	(0.067)	(0.044)
Long-run elasticities			
$\ln(P^K/P)$	-0.591***	-0.749***	-0.489***
	(0.065)	(0.055)	(0.127)
$\ln TAX$	-0.378***	-0.426***	-0.249***
	(0.104)	(0.160)	(0.098)
Test of equal long-run elasticities: (p-value)	0.102	0.068	0.171
Serial correlation tests			
AR(1)	7.46	7.14	6.85
AR(2)	4.54	4.86	4.69
Year dummies	Yes	Yes	Yes
Country-sector trends	Yes	Yes	Yes
No. of groups	154	154	154
Observations	3,146	3,143	3,141
R^2	0.854	0.859	0.839

[1]Standard errors in brackets are robust and clustered over time within country-industry pairs.

[2]*** p<0.01, **p<0.05, * p<0.1.

[3]Arellano-Bond (1991) test statistics for no first-order and no second-order serial correlation are distributed as standard normal under the null hypothesis of no serial correlation

Table 3: Error correction models

Dependent variable: $\Delta \ln K_t$	(1) Total capital	(2) Equipment	(3) Structures
Coefficients			
$\ln(K/Q)_{t-2}$	-0.092***	-0.151***	-0.048***
	(0.010)	(0.017)	(0.006)
$\ln(P^K/P)_{t-2}$	-0.070***	-0.129***	-0.035***
	(0.010)	(0.021)	(0.007)
$\ln TAX_{t-2}$	-0.035***	-0.110***	-0.005
	(0.012)	(0.026)	(0.008)
$\Delta \ln K_{t-1}$	0.329***	0.218***	0.404***
	(0.041)	(0.073)	(0.037)
$\Delta \ln Q_t$	0.094***	0.151***	0.037***
	(0.011)	(0.019)	(0.007)
$\Delta \ln Q_{t-1}$	0.091***	0.144***	0.046***
	(0.009)	(0.015)	(0.007)
$\Delta \ln(P^K/P)_t$	-0.088***	-0.146***	-0.019***
	(0.010)	(0.020)	(0.006)
$\Delta \ln(P^K/P)_{t-1}$	-0.074***	-0.126***	-0.030***
	(0.010)	(0.018)	(0.006)
$\Delta \ln TAX_t$	-0.030**	-0.031	0.004
	(0.013)	(0.025)	(0.007)
$\Delta \ln TAX_{t-1}$	-0.032**	-0.041	0.001
	(0.014)	(0.033)	(0.007)
Long-run elasticities			
$\ln(P^K/P)$	-0.760***	-0.852***	-0.728***
	(0.082)	(0.080)	(0.153)
$\ln TAX$	-0.375***	-0.727***	-0.108
	(0.115)	(0.170)	(0.173)
Test of equal long-run elasticities (p-value)	0.009	0.521	0.012
Serial correlation tests			
AR(1)	-1.22	-1.53	-1.11
AR(2)	1.41	1.57	0.25
Year dummies	Yes	Yes	Yes
Country-sector trends	Yes	Yes	Yes
No. of groups	154	154	154
Observations	3,146	3,143	3,141
R^2	0.571	0.507	0.546

[1]Standard errors in brackets are robust and clustered over time within country-industry pairs.

[2]*** p<0.01, **p<0.05, * p<0.1.

[3]Arellano-Bond (1991) test statistics for no first-order and no second-order serial correlation are distributed as standard normal under the null hypothesis of no serial correlation

Table 4: Error correction models, not imposing long-run constant returns to scale

Dependent variable: $\Delta \ln K_t$	(1) Total capital	(2) Equipment	(3) Structures
Coefficients			
$\ln K_{t-2}$	-0.168***	-0.191***	-0.119***
	(0.015)	(0.019)	(0.012)
$\ln Q_{t-2}$	0.065***	0.100***	0.020***
	(0.009)	(0.019)	(0.007)
$\ln(P^K/P)_{t-2}$	-0.077***	-0.120***	-0.026***
	(0.011)	(0.021)	(0.007)
$\ln TAX_{t-2}$	-0.031**	-0.073***	-0.004
	(0.013)	(0.027)	(0.008)
$\Delta \ln K_{t-1}$	0.305***	0.207***	0.387***
	(0.044)	(0.075)	(0.040)
$\Delta \ln Q_t$	0.073***	0.120***	0.019***
	(0.011)	(0.019)	(0.007)
$\Delta \ln Q_{t-1}$	0.068***	0.111***	0.026***
	(0.008)	(0.015)	(0.007)
$\Delta \ln(P^K/P)_t$	-0.086***	-0.138***	-0.012**
	(0.010)	(0.021)	(0.006)
$\Delta \ln(P^K/P)_{t-1}$	-0.069***	-0.116***	-0.019***
	(0.010)	(0.018)	(0.006)
$\Delta \ln TAX_t$	-0.024**	-0.012	0.006
	(0.012)	(0.024)	(0.006)
$\Delta \ln TAX_{t-1}$	-0.024*	-0.011	0.003
	(0.014)	(0.033)	(0.007)
Long-run elasticities			
$\ln Q$	0.388***	0.523***	0.172***
	(0.053)	(0.082)	(0.056)
$\ln(P^K/P)$	-0.455***	-0.627***	-0.216***
	(0.051)	(0.084)	(0.073)
$\ln TAX$	-0.183**	-0.380***	-0.031
	(0.072)	(0.143)	(0.068)
Test of equal long-run tax and relative price elasticities (p-value)	0.003	0.136	0.070
Serial correlation tests			
AR(1)	-3.01	-1.97	-3.21
AR(2)	2.05	1.85	0.93
Year dummies	Yes	Yes	Yes
Country-sector trends	Yes	Yes	Yes
No. of groups	154	154	154
Observations	3,146	3,143	3,141
R^2	0.571	0.507	0.546

[1]Standard errors in brackets are robust and clustered over time within country-industry pairs.

[2]*** p<0.01, **p<0.05, * p<0.1.

Table 5: Error correction models, omitting current-dated explanatory variables

Dependent variable: $\Delta \ln K_t$	(1) Total capital	(2) Equipment	(3) Structures
Coefficients			
$\ln(K/Q)_{t-2}$	-0.062***	-0.113***	-0.038***
	(0.009)	(0.015)	(0.005)
$\ln(P^K/P)_{t-2}$	-0.043***	-0.084***	-0.029***
	(0.009)	(0.018)	(0.006)
$\ln TAX_{t-2}$	-0.020**	-0.062***	-0.005
	(0.010)	(0.010)	(0.007)
$\Delta \ln K_{t-1}$	0.342***	0.242***	0.402***
	(0.045)	(0.076)	(0.036)
$\Delta \ln Q_{t-1}$	0.073***	0.122***	0.024***
	(0.009)	(0.014)	(0.005)
$\Delta \ln(P^K/P)_{t-1}$	-0.055***	-0.099***	-0.023***
	(0.010)	(0.015)	(0.006)
$\Delta \ln TAX_{t-1}$	-0.030**	-0.046	-0.003
	(0.014)	(0.032)	(0.006)
Long-run elasticities			
$\ln(P^K/P)$	-0.702***	-0.741***	-0.747***
	(0.122)	(0.111)	(0.160)
$\ln TAX$	-0.321**	-0.884***	-0.131
	(0.155)	(0.200)	(0.181)
Test of equal long-run elasticities (p-value)	0.082	0.557	0.019
Serial correlation tests			
AR(1)	-0.82	-1.34	-0.58
AR(2)	1.17	1.37	-0.09
Year dummies	Yes	Yes	Yes
Country-sector trends	Yes	Yes	Yes
No. of groups	154	154	154
Observations	3,146	3,143	3,141
R^2	0.490	0.437	0.507

[1]Standard errors in brackets are robust and clustered over time within country-industry pairs.

[2]*** p<0.01, **p<0.05, * p<0.1.

[3]Arellano-Bond (1991) test statistics for no first-order and no second-order serial correlation are distributed as standard normal under the null hypothesis of no serial correlation

Table 6: Error correction models, with additional statutory tax rate terms

Dependent variable: $\Delta \ln K_t$	Total capital (1)	Equipment (2)	Structures (3)
Long-run elasticities			
$\ln(P^K/P)$	-0.763***	-0.853***	-0.761***
	(0.081)	(0.079)	(0.154)
$\ln TAX$	-0.429***	-0.687***	-0.451***
	(0.192)	(0.222)	(0.198)
$\ln \tau$	-0.011	-0.129	0.773***
	(0.102)	(0.195)	(0.289)
Selected coefficients			
$\Delta \ln \tau_t$	0.018**	0.005	0.015***
	(0.009)	(0.010)	(0.006)
$\Delta \ln \tau_{t-1}$	0.010	0.001	0.010
	(0.010)	(0.013)	(0.006)
Joint test (p-value)	0.025	0.728	0.017
Year dummies	Yes	Yes	Yes
Country-sector trends	Yes	Yes	Yes
No. of groups	154	154	154
Observations	3,143	3,143	3,143
R^2	0.546	0.492	0.520

[1]Standard errors in brackets are robust and clustered over time within country-industry pairs.

[2]*** p<0.01, **p<0.05, * p<0.1.

[3]We report the joint test of the null hypothesis that none of the coefficients on the statutory tax rate terms $\Delta \ln \tau_t, \Delta \ln \tau_{t-1}$, or $\ln \tau_{t-2}$ is significantly different from zero.

Table 7: Error correction models, pooled mean group estimates

Dependent variable: $\Delta \ln K_t$	Total capital (1)	Equipment (2)	Structures (3)
Long-run elasticities			
$\ln(P^K/P)$	-0.465***	-0.414***	-0.000
	(0.030)	(0.037)	(0.007)
$\ln TAX$	-1.491***	-0.549***	-0.033
	(0.531)	(0.064)	(0.035)
Average speed of adjustment			
$-\phi$	-0.367***	-0.345***	-0.336***
	(0.026)	(0.025)	(0.028)

[1]We estimate the parsimonious model $\Delta \ln K_{i,c,t} = -\phi_{i,c}[\ln(K/Q)_{i,c,t-2} - \alpha_1 \ln(P^K/P)_{i,c,t-2} - \alpha_2 \ln TAX_{i,c,t-2}] + \beta_{1_{i,c}} \Delta \ln K_{i,c,t-1} + \beta_{2_{i,c}} \Delta \ln Q_{i,c,t} + \beta_{3_{i,c}} \Delta \ln(P^K/P)_{i,c,t} + \beta_{4_{i,c}} \Delta \ln TAX_{i,c,t} + a_{i,c} + b_{i,c}t + \epsilon_{i,c,t}$ using demeaned data. Demeaned variables are expressed as deviations from year-specific sample means, where these means are calculated using observations for all available country-sector pairs in that year.

[2]We report the common long-run elasticities of the capital-output ratio with respect to the relative price and tax components of the user cost of capital (α_1, α_2), and the mean estimate of the convergence rate ($-\phi$) across the 154 country-sector pairs.

[3]Robust standard errors in parentheses.

[4]*** p<0.01, **p<0.05, * p<0.1.

Appendix A: Derivation of the user cost of capital

In this Appendix, we derive the tax-adjusted user cost of capital for the case in which investment is financed by retained earnings, as in equation (2).

Allowing for corporate taxation, we write the net revenue (Π_t) generated by the firm in period t as

$$\Pi_t = (1-\tau_t)\, P_t F\,(K_t, L_t) - (1-\tau_t\phi_t) P_t^K I_t - (1-\tau_t)\, W_t L_t + \widetilde{A}_t \tag{9}$$

where $F\,(K_t, L_t)$ denotes output (value-added) produced using capital (K_t) and labour (L_t), P_t is the output price, I_t denotes real gross investment, P_t^K is the price of capital goods, and W_t is the wage rate. Among the tax parameters, τ_t is the statutory corporate income tax rate, ϕ_t is the fraction of a unit of investment spending that can be deducted from taxable profits in the same year, so that $\tau_t\phi_t$ is the value of the first year allowance on a unit of investment in period t, and $\widetilde{A}_t$ is the value of writing-down allowances on past investments that can be claimed in period t.

With no debt finance, we have

$$\Pi_t = D_t - N_t \tag{10}$$

where D_t denotes dividends paid in period t and N_t denotes revenue raised from new share issues, so that Π_t is also the net cash distribution to shareholders.

Abstracting from personal taxation, this gives the value of the firm as

$$V_t = E_t\left[\sum_{j=0}^{\infty}\beta_{t+j}\Pi_{t+j}\right] \tag{11}$$

where $E_t\,[.]$ denotes the conditional expectation based on information available in period t, and β_{t+j} is the discount factor which gives the value in period t of an expected payoff in period $t+j$. Letting r_t denote the *ex ante* real discount rate between period t and period $t+1$, and π_t denote the expected inflation rate between period t and period $t+1$, the nominal discount rate (ρ_t) satisfies $(1+\rho_t) = (1+r_t)(1+\pi_t)$, and the nominal discount factors are given by

$$\beta_t = 1; \quad \beta_{t+1} = \frac{1}{1+\rho_t}; \quad \beta_{t+j} = \prod_{i=0}^{j-1}(1+\rho_{t+i})^{-1} \text{ for } j = 2, 3, ... \tag{12}$$

Following Hayashi (1982), we can also express the value of the firm as

$$\begin{aligned} V_t &= E_t\left[\sum_{j=0}^{\infty}\beta_{t+j}\Pi^*_{t+j}\right] + E_t\left[\sum_{j=0}^{\infty}\beta_{t+j}A^*_{t+j}\right] \\ &= V_t^* + E_t\left[\sum_{j=0}^{\infty}\beta_{t+j}A^*_{t+j}\right] \end{aligned} \tag{13}$$

where

$$\Pi^*_{t+j} = (1-\tau_{t+j})\, P_{t+j} F\,(K_{t+j}, L_{t+j}) - (1-A_{t+j}) P^K_{t+j} I_{t+j} - (1-\tau_{t+j})\, W_{t+j} L_{t+j}, \tag{14}$$

A_{t+j} is the present value in period $t+j$ of current and future tax allowances associated with a unit of new investment in period $t+j$, and A^*_{t+j} is the component of $\widetilde{A}_{t+j}$ associated with investments made before period t.

Choosing investment (I_t) in period t to maximise V_t is then equivalent to maximising V_t^*, as the final term in (13) does not depend on I_t. Here the optimisation problem can be written recursively as

$$V_t^*\left(K_{t-1}\right) = \left\{ \max_{I_t} \; \Pi_t^*(K_t,\; I_t) + \beta_{t+1} E_t \left[V_{t+1}^*\left(K_t\right)\right] \right\} \tag{15}$$

subject to the capital accumulation constraint

$$K_t = (1-\delta)K_{t-1} + I_t \tag{16}$$

where δ is the rate of depreciation. To ensure that the firm's value maximisation problem has a solution in the absence of adjustment costs, we assume that there is some degree of monopolistic competition in the product market and the firm faces a downward sloping demand curve for its output of the isoelastic form

$$P_t\left(Q_t\right) = Q_t^{-\frac{1}{\eta}} \tag{17}$$

where $\eta > 1$ is the price elasticity of demand. This gives

$$\frac{\partial \Pi_t^*}{\partial K_t} = \left(1-\tau_t\right) P_t \left(1 - \frac{1}{\eta}\right) \frac{\partial F_t}{\partial K_t}. \tag{18}$$

Treating input prices as given, we also have

$$\frac{\partial \Pi_t^*}{\partial I_t} = -(1-A_t)P_t^K. \tag{19}$$

Differentiating equation (15) with respect to I_t yields

$$\frac{\partial V_t^*}{\partial I_t} = \frac{\partial \Pi_t^*}{\partial K_t} + \frac{\partial \Pi_t^*}{\partial I_t} + \beta_{t+1} E_t \left[\frac{\partial V_{t+1}^*}{\partial K_t} \right] = 0 \tag{20}$$

and differentiating equation (15) with respect to K_{t-1} yields

$$\frac{\partial V_t^*}{\partial K_{t-1}} = (1-\delta) \frac{\partial \Pi_t^*}{\partial K_t} + (1-\delta)\, \beta_{t+1} E_t \left[\frac{\partial V_{t+1}^*}{\partial K_t} \right] \tag{21}$$

Combining equations (20) and (21), we obtain

$$\frac{\partial V_t^*}{\partial K_{t-1}} = -\left(1-\delta\right) \frac{\partial \Pi_t^*}{\partial I_t} \tag{22}$$

and hence

$$\beta_{t+1} E_t \left[\frac{\partial V_{t+1}^*}{\partial K_t} \right] = -\left(1-\delta\right) \beta_{t+1} E_t \left[\frac{\partial \Pi_{t+1}^*}{\partial I_{t+1}} \right]. \tag{23}$$

Substituting (18), (19), and (23) into equation (20), we can rearrange the first-order condition for optimal investment to obtain

$$\frac{\partial F_t}{\partial K_t} = \frac{P_t^K (1 - A_t)}{P_t(1 - \frac{1}{\eta}) (1 - \tau_t)} \left(1 - (1 - \delta)\beta_{t+1} E_t \left[\frac{P_{t+1}^K (1 - A_{t+1})}{P_t^K (1 - A_t)} \right] \right) \tag{24}$$

Assuming that relative prices, inflation rates, tax rates and tax depreciation schedules are expected to remain constant, we have $E_t[P_{t+1}^K(1 - A_{t+1})/P_t^K(1 - A_t)] = 1 + \pi_t$. In this case equation (24) simplifies to give a familiar expression for the tax-adjusted user cost of capital, similar to Jorgenson (1963), Hall and Jorgenson (1967) and Devereux and Griffith (2003), as:[46]

$$\frac{\partial F_t}{\partial K_t} = \frac{P_t^K}{P_t \left(1 - \frac{1}{\eta}\right)} \frac{(1 - A_t)}{(1 - \tau_t)} \frac{(r_t + \delta)}{(1 + r_t)} = C_t, \tag{25}$$

which is equation (2) in the text.

Finally for the CES production function

$$Q_t = F(K_t, L_t) = (a_K K_t^\rho + a_L L_t^\rho)^{\frac{\nu}{\rho}},$$

where $\sigma = 1/(1 - \rho)$ is the elasticity of substitution and ν is the returns to scale, we have

$$\frac{\partial F_t}{\partial K_t} = a_K \nu Q_t^{\frac{1}{\sigma}\left(\sigma + \frac{1-\sigma}{\nu}\right)} K_t^{\frac{-1}{\sigma}}. \tag{26}$$

Combining equations (25) and (26) then gives an expression for the optimal capital stock in this case as:

$$K_t = (a_K \nu)^\sigma Q_t^{\left(\sigma + \frac{1-\sigma}{\nu}\right)} C_t^{-\sigma},$$

which has the form of equation (1) in the text.

[46] Jorgenson (1963), Hall and Jorgenson (1967) and Devereux and Griffith (2003) assume that firms take output prices as given, so they have $\left(1 - \frac{1}{\eta}\right) = 1$. We assume that investment in period t generates additional output in period t, while Devereux and Griffith (2003) assume that investment in period t generates additional output only in period $t+1$. This timing difference accounts for the additional term $(1 + r_t)$ in the denominator of equation (25).

Appendix B: List of industries and countries

- Sample 1: 11 manufacturing industries

This sample includes the following manufacturing industries: 1) Basic metals and fabricated metal; 2) chemicals, rubber, plastics and fuel; 3) electrical and optical equipment; 4) food, beverages and tobacco; 5) machinery not elsewhere classified; 6) manufacturing not elsewhere classified and recycling; 7) other non-metallic minerals; 8) pulp, paper and printing; 9) textiles, leather and footwear; 10) transport equipment; 11) wood and cork.

- Sample 2: 19 industries

This sample includes the 11 manufacturing industries in sample 1, plus the following sectors: 12) agriculture, hunting, forestry and fish; 13) mining and quarrying; 14) construction; 15) wholesale and retail trade; 16) hotels and restaurants; 17) transport and storage; 18) real estate; 19) post and telecommunications.

- Sample 3: 27 industries.

In addition to the 19 industries included in sample 2, we include the following sectors: 20) electricity, gas and water supply; 21) financial intermediation; 22) education; 23) public administration, defence and compulsory social security; 24) health and social work; 25) other community, social and personal services; 26) private households with employed persons; 27) extra-territorial organisations and bodies.

- Country coverage

Country	Coverage	Country	Coverage
Australia	1982-2007	Italy	1982-2007
Austria	1982-2007	Japan	1982-2006
Czech Republic	1995-2007	Netherlands	1982-2007
Denmark	1986-2007	Spain	1982-2007
Finland	1995-2007	Sweden	1993-2007
France	1982-2007	UK	1982-2007
Germany	1991-2007	US	1982-2007

Appendix C: EU KLEMS and OECD STAN

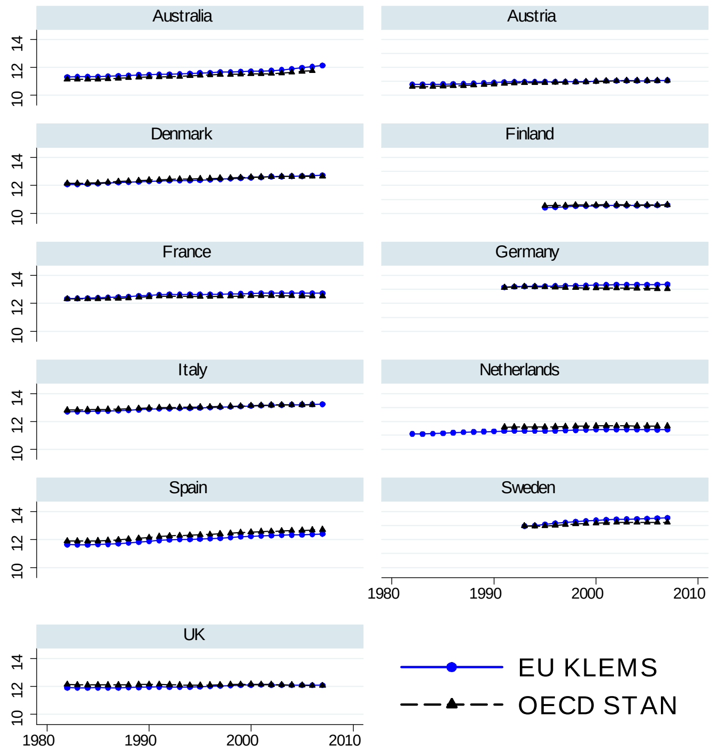

Figure C.1: Total real capital stock (in logs): total manufacturing industry

Appendix D

Table D.1: Panel unit root test results (p-values): 14 countries, 11 manufacturing industries

	Total capital	Equipment	Structures
Raw data			
$\ln K$	0	0	0
$\ln Q$	0.011	0.011	0.011
$\ln(K/Q)$	0.008	0.002	0.007
$\ln(P^K/P)$	0.044	0	0.999
$\ln TAX$	0	0	0.048
With linear trends			
$\ln K$	0.539	0.998	0.135
$\ln Q$	0.266	0.266	0.266
$\ln(K/Q)$	0.008	0.058	0.016
$\ln(P^K/P)$	0.021	0	0.92
$\ln TAX$	0	0	0
Demeaned data			
$\ln K$	1	1	1
$\ln Q$	1	1	1
$\ln(K/Q)$	0	0.025	0
$\ln(P^K/P)$	0.891	0	0.003
$\ln TAX$	0	0	0
Demeaned data with linear trends			
$\ln K$	1	1	1
$\ln Q$	1	1	1
$\ln(K/Q)$	0	0	0.001
$\ln UC$	0.056	0	0.002
$\ln(P^K/P)$	0.035	0	0.308
$\ln TAX$	0.005	0	0

Notes: This table presents p-values from the Fisher-type test for unit roots in heterogeneous panels (Maddala and Wu, 1999). Suppose the stochastic process, $y_{i,t}$, is generated by an autoregressive process:

$$\Delta y_{i,t} = \alpha_i + \beta_i y_{i,t-1} + \delta_i t + \sum_{j=1}^{p} \gamma_{i,j} \Delta y_{i,t-1} + \epsilon_{i,t}$$

where t is a linear trend. The null hypothesisis is $H_0 : \beta_i = 0$ for all i, and the alternative is $H_1 : \beta_i < 0$, $i = 1, 2, ...N_1$, $\beta_i = 0$, $i = N_1+1,\ N_2+1, ...N$, $0 < \lim_{N\to\infty}(N_1/N) \leq 1$. The Fisher test first computes the p-value π_i for each group using the Phillips-Perron unit-root test. Then it computes the statistic $-2\sum \log\pi_i$, which follows a χ^2 distribution with 2N degrees of freedom under the null. We report the p-values of the χ^2 statistics in this table. Results are reported for the lag length p=3, but are not highly sensitive to this choice. 'Demeaned' series are expressed as deviations from year-specific sample means, where these means are calculated using observations for all available groups in that year. These tests are computed using the command *xtfisher* in Stata.

Table D.2: Error correction models, sample of 19 industries

Dependent variable: $\Delta \ln K_t$	(1) Total capital	(2) Equipment	(3) Structures
Coefficients			
$\ln(K/Q)_{t-2}$	-0.079***	-0.136***	-0.060***
	(0.008)	(0.012)	(0.006)
$\ln(P^K/P)_{t-2}$	-0.026***	-0.088***	-0.025***
	(0.007)	(0.014)	(0.006)
$\ln TAX_{t-2}$	-0.030***	-0.096***	-0.010
	(0.010)	(0.026)	(0.008)
$\Delta \ln K_{t-1}$	0.420***	0.281***	0.408***
	(0.031)	(0.049)	(0.032)
$\Delta \ln Q_t$	0.085***	0.143***	0.045***
	(0.009)	(0.015)	(0.006)
$\Delta \ln Q_{t-1}$	0.074***	0.125***	0.054***
	(0.007)	(0.012)	(0.006)
$\Delta \ln(P^K/P)_t$	-0.035***	-0.117***	-0.012*
	(0.009)	(0.019)	(0.007)
$\Delta \ln(P^K/P)_{t-1}$	-0.021***	-0.085***	-0.021***
	(0.007)	(0.012)	(0.005)
$\Delta \ln TAX_t$	-0.006	-0.016	0.019**
	(0.009)	(0.022)	(0.008)
$\Delta \ln TAX_{t-1}$	-0.042***	-0.070**	-0.013
	(0.010)	(0.028)	(0.008)
Long-run elasticities			
$\ln(P^K/P)$	-0.331***	-0.650***	-0.412***
	(0.080)	(0.071)	(0.101)
$\ln TAX$	-0.387***	-0.705***	-0.168
	(0.123)	(0.174)	(0.140)
Test of equal long-run elasticities (p-value)	0.713	0.748	0.148
Serial correlation tests			
AR(1)	-0.39	-1.81	-2.10
AR(2)	0.13	1.12	0.46
Year dummies	Yes	Yes	Yes
Country-sector trends	Yes	Yes	Yes
No. of groups	247	246	247
Observations	4,905	4,914	4,959
R^2	0.569	0.541	0.527

[1]Standard errors in brackets are robust and clustered over time within country-industry pairs.

[2]*** p<0.01, **p<0.05, * p<0.1.

[3]Arellano-Bond (1991) test statistics for no first-order and no second-order serial correlation are distributed as standard normal under the null hypothesis of no serial correlation

Table D.3: Error correction models, sample of 27 industries (whole economy)

Dependent variable: $\Delta \ln K_t$	(1) Total capital	(2) Equipment	(3) Structures
Coefficients			
$\ln(K/Q)_{t-2}$	-0.074***	-0.125***	-0.057***
	(0.007)	(0.010)	(0.008)
$\ln(P^K/P)_{t-2}$	-0.023***	-0.087***	-0.020***
	(0.006)	(0.012)	(0.006)
$\ln TAX_{t-2}$	-0.022***	-0.073***	-0.008
	(0.008)	(0.024)	(0.007)
$\Delta \ln K_{t-1}$	0.417***	0.302***	0.397***
	(0.030)	(0.040)	(0.056)
$\Delta \ln Q_t$	0.081***	0.143***	0.042***
	(0.008)	(0.014)	(0.006)
$\Delta \ln Q_{t-1}$	0.075***	0.117***	0.056***
	(0.007)	(0.011)	(0.007)
$\Delta \ln(P^K/P)_t$	-0.028***	-0.124***	-0.003
	(0.009)	(0.017)	(0.011)
$\Delta \ln(P^K/P)_{t-1}$	-0.028***	-0.080***	-0.024***
	(0.007)	(0.012)	(0.005)
$\Delta \ln TAX_t$	-0.001	-0.013	0.019**
	(0.008)	(0.019)	(0.008)
$\Delta \ln TAX_{t-1}$	-0.031***	-0.061**	-0.012*
	(0.008)	(0.024)	(0.006)
Long-run elasticities			
$\ln(P^K/P)$	-0.314***	-0.694***	-0.347***
	(0.076)	(0.075)	(0.099)
$\ln TAX$	-0.298***	-0.582***	-0.145
	(0.101)	(0.177)	(0.121)
Test of equal long-run elasticities (p-value)	0.901	0.521	0.167
Serial correlation tests			
AR(1)	-0.88	-2.26	-1.78
AR(2)	0.24	1.29	0.66
Year dummies	Yes	Yes	Yes
Country-sector trends	Yes	Yes	Yes
No. of groups	325	323	325
Observations	6,468	6,417	6,525
R^2	0.565	0.551	0.547

[1]Standard errors in brackets are robust and clustered over time within country-industry pairs.

[2]*** p<0.01, **p<0.05, * p<0.1.

[3]Arellano-Bond (1991) test statistics for no first-order and no second-order serial correlation are distributed as standard normal under the null hypothesis of no serial correlation