INVESTMENT RATES AND THE AGGREGATE PRODUCTION FUNCTION

Fernando García-Belenguer
Universidad Autónoma de Madrid

Manuel S. Santos
University of Miami

February 15, 2011

Abstract

In this paper we consider a simple version of the neoclassical growth model, and carry out an empirical analysis of the main determinants of aggregate investment across countries. More specifically, we study the effects on aggregate investment of income growth, capital income shares, the relative price of capital, and various market distortions. This exercise also sheds light into the shape of the neoclassical production function. We check these investment patterns for both OECD and non-OECD countries. We also decompose investment data into equipment and structures, and explore major factors affecting their relative prices.

JEL classification: O41; O47

Keywords: Investment rates; Aggregate production function; Relative price of investment

1 Introduction

In this paper we are concerned with the determinants of aggregate investment across countries. We follow closely the analytical framework of the neoclassical growth model – a cornerstone in studies of economic growth since the early work of Solow (1956). Various quantitative exercises have singled out capital accumulation as a major factor in accounting for income levels [cf. Barro (1999) and Hall and Jones (1999)]. There is, however, much more controversy about the influence of some other forces [e.g., Caselli (2005) and McGrattan and Schmitz (1999)] such as human capital and investments in technology adoption – which may affect total factor productivity (TFP). In most of this research the stock of physical capital is taken as given; that is, physical capital is usually computed by a permanent inventory method using aggregate investment data as a primitive element in the analysis. Here we want to delve into the ultimate reasons underlying world investment patterns.

A basic tenet in the economic growth literature is that domestic investment rates seem pretty constant across countries [cf. Summers and Heston (1991) and Hsieh and Klenow (2007)]. Another well-known empirical regularity (cf. *opt. cit.*) is that there is a pronounced variability across countries in the relative price of capital which is inversely correlated with the income level. Hence, when adjusting GDP data by a common set of prices, real investment rates are much higher in rich countries. Therefore, rich countries display comparable nominal investment rates that get translated into higher real investment rates. The efficiency of capital accumulation is of course considered to be a major source of income disparity across countries.

In agreement with the data, the neoclassical growth model predicts that nominal investment rates should be uncorrelated with income levels – provided that other fundamental forces stay the same. Given the low variability of nominal investment rates across countries a key question is whether or not taxes or some other factors matter for investment. The importance of these other forces cannot be ruled out since there could be some countervailing effects that make countries experience similar nominal investment rates. Indeed, taxes are usually higher in OECD countries, but non-OECD countries may endure more detrimental non-pecuniary distortions. Furthermore, when decomposing investment data into equipment and structures we do not see a strong correlation between these two sub-aggregates. There is substantial variation in the relative price of equipment across countries, but much less variation in the relative price of structures. Then, more detailed data may unmask some other trends shaping these stable investment patterns.

The behavior of investment rates and relative prices can shed light into the form of the neoclassical production function. First, we find weak evidence of additional external effects coming from human capital, public investment, and expenditures in R&D. Second, the elasticity of substitution between capital and labor is slightly less than one, and hence the Cobb-Douglas assumption seems a good approximation. Third, by dividing aggregate investment into equipment and structures we try to unveil complementarities with labor. If the Cobb-Douglas assumption prevails, then capital income shares should be stable over time, and strongly correlated with nominal investment rates. Surprisingly, we find that there is a weak correlation between investment rates and capital income shares across countries. This is the most puzzling fact that works against the aggregate production function. As already pointed out there is also a weak connection between expenditures in equipment and structures – which cannot just be attached to the variability of the relative prices of equipment and structures. Hence, some other factors outside the the simple version of the neoclassical growth model may also influence investment such as the relative weights of the various sectors composing production, dynamic adjustment costs, or time-to-build.

We then analyze the variability of the relative prices of equipment and structures. The relative price of equipment displays much more variability than the relative price of structures. Hence, aggregation of these two prices into a single index may not always be adequate. Early studies [Jones (1994), De Long and Summers (1991) and Restuccia and Urrutia (2001)] focus on the influence of relative prices and investment on economic growth. Again, we are just concerned here with the ultimate determinants of relative prices. This may enhance our understanding of the various channels through which factors of production may affect either TPF or the efficiency of capital accumulation. From our empirical analysis we find that R&D investments may have a weak influence on TFP but may impinge on the efficiency of capital accumulation. This latter effect may actually be more apparent for non-tradable investments. We also find that the Balassa-Samuelson effect (negative correlation of the price of capital with the income level) is only present in the relative price of equipment. Likewise, human capital is only effective to reduce the relative price of equipment. Investments in R&D, however, seem to affect symmetrically both prices.

The paper is organized as follows. Section 2 lays out an extended version of the neoclassical growth model in which the efficiency of investment can vary across countries. Section 3 considers a balanced sample of 50 countries, and carries out an empirical implementation of this model. In Section 4 we extend the original model to include two capital goods. This two-sector model is then confronted with the data in Section 5. Section 6 performs an exploratory econometric analysis of the relative prices of equipment and structures. Some concluding remarks are gathered in Section 7.

2 The model with aggregate investment

This section puts forward a theoretical framework for assessing the determinants of investment rates. The final outcome of this exercise are three linear equations that will guide our empirical investigation. To simplify matters, we assume that each country operates in a competitive-markets setting of a closed economy with identical households that supply capital and labor. To this simple version of the standard neoclassical growth model, we append a country-specific relative price of capital and various types of taxes and non-pecuniary distortions. A two-sector extension of this model will be deferred to Section 4.

The representative household is concerned with the optimization of a discounted stream of utility given by

$$\sum_{t=0}^{\infty} \beta^t u(C_t) \tag{1}$$

where C_t is aggregate consumption, β is the discount factor, and $u(C_t)$ is a standard utility function. The production sector is represented by an aggregate technology as given by a C^2 concave production function with aggregate capital and labor,

$$Y_t = A_t(x_t)F(K_t, B_tL_t). \tag{2}$$

Here, K_t denotes the total stock of physical capital in the country, and $A_t(x_t)$ denotes the level of TFP assumed to depend on a vector of variables x_t. Vector x_t gathers external effects which may come from physical capital and non-tangible investments (e.g., public capital, R&D, and human capital); for instance, see Aschauer (1989), Barro (1990) and Lucas (1988). Regarding the labor input, B_t is the average level of education or productive skills, and L_t is the total amount of workers in the economy. Hence, B_tL_t denotes the effective units of labor in the country. We will often refer to B_t as the average level of human capital, which grows according to the law of motion $B_t = B_0(1+g_b)^t$ for a constant growth rate $g_b > 0$ over all dates t.

At all times, output in the economy may be either consumed or invested subject to physical feasibility,

$$Y_t = C_t + q_t I_t. \tag{3}$$

The process q_t represents the evolution of the price of investment in terms of the consumption good. This relative price is governed by a deterministic law $q_t = q_0(1+g_q)^t$ for $g_q \leq 0$ and for all t. Physical capital is subject to constant depreciation rate δ. Hence,

$$K_{t+1} = I_t + (1-\delta_K)K_t. \tag{4}$$

For convenience of the presentation, the various distortions affecting this competitive economy are gathered in the sequence of budget constraints of the representative household:

$$(1+\tau_C)C_t + \varphi^q q_t(1+\tau_I)I_t = (1-\tau_Y)[(\varphi^R R_t - \delta_K)K_t + \varphi^w w_t] + \delta_K K_t + T_t, \text{all } t \geq 0 \tag{5}$$

where R_t is the marginal productivity of physical capital and w_t is the competitive wage. This budget set incorporates flat-rate taxes on consumption, τ_C, investment, τ_I, and income, τ_Y. (Tax proceeds are rebated back to the representative household as lump-sum transfers, T_t.) Further, φ^R, φ^q, and φ^w represent some non-pecuniary costs inherent in the economic environment or legal restrictions. For instance, φ^q could stand for some non-tangible costs over the price of investment such as government permits, licenses, or property rights – the possibility of stealing or losing the property.

Our fundamental equilibrium condition is summarized in the following Euler equation,

$$\frac{u'_C(C_t)}{\beta u'_C(C_{t+1})} = \frac{(1-\tau_Y)(\varphi^R R_{t+1} - \delta_K) + \delta_K}{\varphi^q q_t(1+\tau_I)} + (1+g_q)(1-\delta_K).$$

Our analysis will be restricted to a stationary solution or *balanced growth path* where C_t and K_t grow at constant rates. As is well known, the existence of a balanced growth path (BGP) imposes stringent conditions on the utility and production functions. We assume a CES utility function $u(C_t) = \frac{C_t^{1-\sigma}}{1-\sigma}$, $\sigma > 0$, and let L_t and q_t remain constant. We could allow for negative growth in q at the expense of a Cobb-Douglas production function, but we temporarily want to explore the implications of a more general technology.

2.1 A CES technology

Let us assume a CES production function $Y_t = A_t(x_t)[\alpha K_t^\rho + (1-\alpha)(B_t L)^\rho]^{1/\rho}$, for $-\infty < \rho \leq 1$. As is well known, $\rho = 1$ corresponds to a linear technology, the limiting case $\rho \to 0$ corresponds to a Cobb-Douglas production function, and $\rho \to -\infty$ corresponds to a Leontief technology. Accordingly the elasticity of substitution between the two factors of production is $\frac{1}{1-\rho}$.

Now, consider the income share of capital, $\gamma_t = \frac{R_t K_t}{Y_t}$. Then, letting the rental rate R equal the marginal productivity of capital[1] we have

$$\gamma_t = \frac{1}{1 + \frac{1-\alpha}{\alpha}(\frac{B_t L}{K_t})^\rho}.$$

Note that in the Cobb-Douglas case ($\rho \to 0$) we obtain the well known result that $\gamma_t = \alpha$; in general, the capital income share is affected by the capital-labor ratio. Along the BGP the income share γ_t is constant and given by

$$\gamma^* = \alpha^{1/(1-\rho)} \left(\frac{R^*}{A_t(x_t)} \right)^{\frac{\rho}{\rho-1}}$$

where

$$R^* = \frac{1}{\varphi^R} \left\{ \frac{\varphi^q q_0 (1+\tau_I) - \delta_K}{(1-\tau_Y)} \left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_K) \right] + \delta_K \right\}.$$

The nominal investment share is defined as $s_t = q_t I_t (1+\tau_I)/Y_t$. Then, imposing the steady-state condition $I^* = (\delta_K + g_b)K^*$ from equation (4) and rearranging terms, we obtain

$$s^* = (\delta_K + g_b)(1+\tau_I)\gamma^* \frac{q_0}{R^*}. \tag{6}$$

Substituting out the previous values for R^* and γ^* leads to

$$s^* = (\delta_K + g_b)(1+\tau_I) q \alpha^{\frac{1}{1-\rho}} A_t(x_t)^{\frac{\rho}{1-\rho}} \left\{ \frac{1}{\varphi^R} \left\{ \frac{\varphi^q q (1+\tau_I) - \delta_K}{(1-\tau_Y)} \left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_K) \right] + \delta_K \right\} \right\}^{\frac{1}{\rho-1}}. \tag{7}$$

[1]In the case of a CES production function $R_t = A_t(x_t)\alpha \left[\alpha + (1-\alpha) \left(\frac{B_t L}{K_t} \right)^\rho \right]^{(1-\rho)/\rho}$.

If the income tax τ_Y does not allow for depreciation then this equation simplifies to

$$s^* = (\delta_K + g_b)[(1+\tau_I)q]^{\rho/(\rho-1)}\alpha^{\frac{1}{1-\rho}} A_t(x_t)^{\frac{\rho}{1-\rho}} \left\{ \frac{\varphi^q}{\varphi^R(1-\tau_Y)} \left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_K) \right] \right\}^{\frac{1}{\rho-1}}. \tag{8}$$

These last two equations summarize the quantitative effects of distortions and other variables on the nominal investment rate. Let us simply consider equation (8). Then, non-pecuniary frictions φ^q and φ^R have the expected sign: An increase in the cost of investment (a higher φ^q) or a drop in the marginal productivity of capital (a decline in φ^R) have negative effects on the nominal investment rate, s. Also, an increase in the income tax τ_Y lowers s. Some other variables, however, have ambiguous effects on s depending on parameter ρ. Thus, if the technology is close to linear, $\rho > 0$, then an increase in the investment tax, τ_I, or in the relative price q would have a negative influence on s. The direction of causation reverses if the technology close to the Leontief case, $\rho < 0$. The productivity term $A_t(x_t)$ also has ambiguous effects albeit with the opposite sign. It follows that τ_I, q, and A, fade out of the investment equation as we approach the Cobb-Douglas case, where expression (8) reduces to

$$s^* = \frac{(\delta_K + g_b)\alpha}{\frac{\varphi^q}{\varphi^R(1-\tau_Y)} \left[\frac{1}{\beta(1+n)^{-\sigma}} - (1-\delta_K) \right]}.$$

Finally, the labor market friction, φ^w, and the flat-rate consumption tax, τ_C, remain neutral in all the scenarios considered.

2.2 Investment equations

This analysis suggests the following empirical tests for the determinants of nominal investment rates.

1st empirical formulation (EFM1)

The first scenario originates from the definition of the nominal investment rate (6), after imposing steady state conditions for the expression $\frac{R^*}{q}$. Note that this formulation does not rely on the CES production function.

$$s^* = (\delta_K + g_b)\gamma^* \frac{\varphi^R(1-\tau_Y)}{\varphi^q} \left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_K) \right]^{-1}.$$

Taking logs we get the following expression:

$$log(s^*) = log[(\delta_K + g_b)] + log(\gamma^*) + log(\varphi^R) + log[(1-\tau_Y)] - log(\varphi^q) - log(r^* + \delta_K), \tag{9}$$

where r^* is the real interest rate.

2nd empirical formulation (EFM2)

In the second scenario we substitute out the value of the capital income share γ^* as given by (8). Taking logs we get the following expression:

$$log(s^*) = \text{constant} + log[(\delta_K + g_b)] + \rho/(\rho - 1)log[(1 + \tau_I)] + \rho/(\rho - 1)log(q) + \frac{\rho}{1-\rho}log[A_t(x_t)] + \frac{1}{\rho - 1}\{log(\varphi^q) - log(\varphi^R) - log[(1 - \tau_Y)] + log(r^* + \delta_K)\}. \quad (10)$$

3rd empirical formulation (EFM3)

In the third scenario we assume that $A_t(x_t)$ is determined by the stocks of public capital, R&D, and human capital. Hence, this is an expanded version of the previous formulation.

3 Empirical findings on aggregate investment

In preparation for our empirical results, we first go over our sample of OECD and non-OECD countries, the available data variables that may best represent their model counterparts, and our econometric methods. In the Appendix below we provide further details on our data sources.

3.1 Data sample

3.1.1 Countries

Our empirical exercise covers the period 1960-2000 and includes a set of 50 countries. This group of countries has been selected on the grounds of data availability, data quality, and geographical and economic considerations. The time period rules out some countries such as ex Soviet Republics where data is roughly available after 1990. There are also newly-formed countries such as the Czech Republic and those stemming from the former Yusgoslavia. Our sample contains all countries graded A in the Penn World Table (PWT) but Luxembourg that has a population of less than one million. It also includes all countries graded B in the PWT but Iceland (because of population size) and Israel (high military expenditure). Singapore has been kept in the sample, even though this country only has one ICP benchmark. After all these considerations, we get a balanced sample of 26 major OECD countries and 24 major non-OECD countries which are listed in the Appendix.

3.1.2 Economic variables

When it comes to the economic variables, it is important to realize some severe measurement issues. In particular, most tax measures do not reflect the marginal rates required in the model, and relative prices may not be well adjusted for quality. Measurement errors may play a prominent role in our results below.

Notation and data sources for our variables are listed in the Appendix. Some variables in the model like the relative price of investment and output growth are obtained from the PWT. Other variables in the model do not have a close counterpart in the data. This is the case of taxes and non-pecuniary distortions.

For taxes, we consider taxes on income, profits, and capital gains (TAXIN), and taxes on goods and services (TAXGS). As a proxy for TAXIN we also include the share of government expenditures for purchases of goods and services (GVMC). These variables are available in the World Development Indicators of the World Bank. For non-pecuniary distortions, we have considered the economic freedom index (ECOF) from the Fraser Institute and the degree of openness (OPEN) which is the ratio of exports plus imports on GDP. As stressed below, OPEN may reflect country size rather than distortions.

There exits a large literature examining the role of financial development in growth [e.g., King and Levine (1993) and Levine and Zervos (1993)]. However, Benhabib and Spiegel (2000) argue that these results are sensitive to the inclusion of country fixed effects. Thus, in order to understand the role played by financial distortions on saving decisions, we have considered the lending rate charged by banks (LEND) and the domestic credit to the private sector (CRED).

Besides, we have constructed series for three types of capital stocks: The human capital stock (HUM), the research and development capital stock (R&D), and the public capital stock (PUB). All these latter variables are computed as stocks rather than as investment flows.

The size and cross-country variability of factor income share has been an issue of great debate. Gollin (2002) argues that the usual calculation of income shares fails to account for labor income of the self-employed and others entrepreneurs. If this adjustment is taken into account he finds that factor shares are approximately constant across time and space. Unfortunately, for many of the non-OECD countries in our sample there is not enough data available to construct a panel with these adjustments, thus our capital income shares are adjusted for self-employment only for the OECD countries. Nonetheless, our results are invariant to the choice of the data set. Even if our factor shares are substituted by Gollin's data, no significant results are found.

3.2 Econometric method

Panel data techniques have become increasingly popular in growth empirics since Islam (1995) implemented a panel data approach for studying growth convergence. More recently, Coe, Helpman and Hoffmaister (2009) used panel cointegration techniques to estimate the importance of international R&D spillovers. A panel data structure allows to deal with the problem of unobserved time-invariant individual heterogeneity. If there are omitted characteristics correlated with both dependent and independent variables, regression estimates may be biased. To tackle this problem two types of data specifications are usually considered: Fixed effects and random effects. In the fixed effect model both the dependent and the independent variables are expressed in differences so that the time-invariant idiosyncratic regressors are removed. This specification is always consistent; however, if the time-invariant characteristic is not correlated with the independent regressors the random effects model is more efficient. In our empirical investigation we have considered both specifications, and to choose between them we run a Hausman test. Furthermore, we have also checked that OLS estimates for various benchmark years do not significantly differ from our panel data results. Finally, to filter out business cycle effects, all our variables considered in our exercise are computed over 5-year moving averages. They are also expressed in logs.

3.3 Results

3.3.1 EFM1: The role of income growth, capital income shares, and distortions

Our results for aggregate investment as the dependent variable for the OECD and the non-OECD are gathered in Tables 1a and 1b respectively. EMF1 comes from equation (9) which includes income growth, capital income shares, and distortions.

From this equation we should expect that the growth rate of output has a positive effect on nominal investment rates. This is actually confirmed for both the OCDE and non-OECD samples since Y_{gr} is highly significant with a sizable coefficient. The positive correlation between nominal investment rates and economic growth has been amply documented in the literature; see Edwards (1996) and references therein.

In (9) the neoclassical growth model predicts that an increment in the capital income share should increase the nominal investment rate in the same proportion. Surprisingly, the OECD coefficient is close to zero and the non-OECD coefficient is not significant. As already pointed out, we have tried with other sets of data, but the coefficients were never statistically different from zero.

Regarding taxes, the evidence is also not so clear. This could also be blamed to our data set. Taxes on income (TAXIN) should be a good proxy for taxes on capital rents but it does not appear significative. Indirect taxation (TAXGS) should be neutral, but it appears to have a negative effect on OECD data. Both findings go against our original model. Because the quality of the data for TAXIN may be low, we have included government consumption (GOVC) as a good substitute for income taxes. Again, GOVC has the expected effects for the OECD group, and has no influence for the non-OECD group. Regarding indirect taxation, as discussed later this type of taxation will have negative effects on models with differentiated inputs, but has no effect on aggregate models. Hence, we cannot discard the negative effects of TAXGS, which are only present in the OECD group.[2]

Finally, we try to gather the effects of non-pecuniary distortions by the degree of economic freedom (ECOF), the degree of openness to international trade (OPEN), and the financial variables. Mauro (1995) analyzes a set of indices of corruption in a cross-section of countries and finds that it lowers investment and economic growth. To exploit the advantages of panel data we use the economic freedom index. ECOF is only significative in the non-OECD group and seems to be a much bigger barrier for investment in less developed countries. On the other hand, OPEN seems important for both groups. Levine and Renelt (1992) argue that the correlation between OPEN and investment is quite robust. As already pointed out, variable OPEN may reflect country size or other considerations beyond non-tangible barriers to investment. The financial variables, LEND and CRED, were hardly significative or not significative at all. Besides, the low number of observations available for these variables conditioned the sign and significance of the rest of the variables and we do not report them in the results.

[2]The model in section 2 predicts that taxes on consumption τ_C have no influence on savings rates in the BGP. Even if we introduce leisure in the model, this result still holds for the most standard utility functions. Hence, according to this aggregate model we should not expect value added taxes to have any influence on savings rates. As shown in the Appendix, variable TAXGS includes other distortionary taxes apart from value added taxes.

3.3.2 EFM2: The role of relative prices

The third column of Tables 1a and 1b is obtained by substituting out the steady state value of γ^* by primitive elements. The main implication is that now the relative price of investment q appears in the investment equation. It can be observed that both for the OECD and the non-OECD sample the slope estimate for q is significant with a positive sign – higher prices of investment lead to higher investment rates. These values can be used to obtain estimates for the elasticity of substitution between capital and labor, since in equation (10) the slope estimate for q is given by $\frac{\rho}{\rho-1}$. Duffy and Papageorgiou (2000) find evidence against the Cobb-Douglas production function and in favor of an elasticity of substitution between capital and labor considerably higher than in the Cobb-Douglas case. The estimated value in our EFM2 for $\frac{\rho}{\rho-1}$ is 0.02 in the OECD, and 0.06 in the non-OECD. This produces an estimate of $\rho = -0.02$ for the OECD and $\rho = -0.064$ for the non-OECD. Therefore, the Cobb-Douglas assumption ($\rho \to 0$) is rejected for both samples. However, our implied value for ρ entails a lower degree of substitutability between capital and labor than in the Cobb-Douglas production function, but quite close to this benchmark case.

3.3.3 EFM3: The role of external effects

We consider externality effects of $A_t(x_t)$ as embedded in the human capital, R&D and public capital stocks. We then want to test for the potential external effects that these stocks may have on savings rates and aggregate productivity.[3] Previous works have emphasized the importance of external effects coming from capital stocks; Aschauer (1989) finds evidence of external effects coming from infrastructure capital while Coe, Helpman and Hoffmaister (2009) conclude that R&D and human capital have a strong influence on TFP. As already discussed in section 2, human capital parameter B_t has no influence on the nominal investment rate. Therefore, in this version of the neoclassical growth model, the stocks of human capital, R&D, and public capital can influence the investment rates only through its effect on $A_t(x_t)$. From equation (10) the coefficient attached to $A_t(x_t)$ is $\frac{\rho}{1-\rho}$, which has the opposite sign of the coefficient of q. Thus, if $\rho < 0$ the expected sign of the A-coefficient in (EFM3) has to be negative, and becomes zero as $\rho \to 0$. Turning to the estimates of Tables 1a and 1b we find no evidence of external effects for

[3] Data for the R&D and public capital stocks are limited to the period 1980-2000.

the OECD countries and some evidence of external effects of R&D for the non-OECD countries. Human capital and public capital seem to have no effect on aggregate productivity. Therefore, the influence of external effects seem to be small on investment rates. This is to be expected if the aggregate production function is close to being Cobb-Douglas, as for this latter case the A-coefficient equals zero.

3.3.4 EFM4: Cross-country regressions for the whole sample

Finally, Table 1c reports the same exercises for the whole sample. The results are in line with those obtained for the two groups of countries. The capital share has no influence, the tax variables have a negative impact on savings rates while ECOF and OPEN have a positive effect. The coefficient for q is positive although not far from zero. Regarding the externality effects, it turns out now that public capital decreases the savings rates which implies positive external effects on aggregate productivity. Therefore, when pooling all these countries in a single group we get that both taxes and non-pecuniary distortions are significative, whereas in reality taxes matter for the OECD group, and ECOF matters only for the non-OECD group. This is a problem of performing regressions over comprehensive country groups. We have therefore identified certain differences between the OECD and non-OECD groups.

4 The model with equipment and structures

In order to make further progress on some of the issues raised above, we now proceed to a more detailed modelling of the investment sector. As in the previous framework the representative household is concerned with the optimization of a discounted stream of utility (1). The aggregate production function contemplates external effects for TFP, two types of capital, and qualified labor:

$$Y_t = A_t(x_t)F(K_{et}, K_{st}, B_tL). \tag{11}$$

Here, K_{et} denotes the stock of physical capital in equipment, and K_{st} denotes the stock of physical capital in structures. At all dates, output in the economy may be either consumed or invested:

$$Y_t = C_t + q_{et}I_{et} + q_{st}I_{st}. \tag{12}$$

The process q_{et} reflects the evolution of the relative price of equipment, and q_{st} reflects the evolution of the relative price of structures. These two prices may not share the same growth properties [cf., Greenwood, Hercowitz and Krusell (1997), and Gort, Greenwood and Rupert (1999)]. Hence, we let $q_{et} = q_{e0}(1+g_e)^t$ and $q_{st} = q_{s0}(1+g_s)^t$, for some constants $g_e, g_s \leq 0$, and all t.

The capital stocks, K_e and K_s, follow the laws of motion:

$$K_{et+1} = I_{et} + (1-\delta_e)K_{et}, \tag{13}$$

$$K_{st+1} = I_{st} + (1-\delta_s)K_{st}, \tag{14}$$

under constant depreciation rates, $\delta_e, \delta_s > 0$. Accordingly, we also expand the household budget constraint to include investment flat-rate taxes, τ_{I_e} and τ_{I_s}, and the non-pecuniary distortions, φ^{q_e} and φ^{q_s}, for investments in equipment and structures:

$$\begin{aligned}(1+\tau_C)C_t + \varphi^{q_e}q_{et}(1+\tau_{I_e})I_{et} + \varphi^{q_s}q_{st}(1+\tau_{I_s})I_{st} = (1-\tau_Y)[(\varphi^{R_e}R_{et}-\delta_e)K_{et} \\ +(\varphi^{R_s}R_{st}-\delta_s)K_{st} + \varphi^w w_t] + \delta_e K_{et} + \delta_s K_{st} + T_t.\end{aligned} \tag{15}$$

Note that R_{et} and R_{st} represent the marginal productivities of the stocks of equipment and structures, respectively.

There are now two state variables, K_e and K_s; accordingly, the first-order conditions yield two Euler equations:

$$\frac{u'(C_t)}{\beta u'(C_{t+1})} = \frac{(1-\tau_Y)(\varphi^{R_e}R_{et+1}-\delta_e)+\delta_e}{\varphi^{q_e}q_{et}(1+\tau_{I_e})} + (1+g^e)(1-\delta_e),$$

$$\frac{u'(C_t)}{\beta u'(C_{t+1})} = \frac{(1-\tau_Y)(\varphi^{R_s}R_{st+1}-\delta_s)+\delta_s}{\varphi^{q_s}q_{st}(1+\tau_{I_s})} + (1+g^s)(1-\delta_s).$$

As is well known, inspection of these two equation reveals that for interior solutions and a constant relative price ratio q_{et}/q_{st} the fraction of rental rates R_{et+1}/R_{st+1} remains constant for both the BGP and along the transitional dynamics. This is a simple consequence of the postulated linear accumulation process for both types of capital as given by equations (12)-(14). It follows that for the benchmark case of a Cobb-Douglas production function the capital ratio

K_{et+1}/K_{st+1} is constant along the transition. This ratio would be approximately constant for small departures from the Cobb-Douglas postulate.

In summary, this simple model predicts roughly that investments in equipment and structures are linearly correlated for both the BGP and along the transition dynamics. We now explore the determinants of the ratio of these expenditures over the BGP for some CES technologies. Hence, as before we face the choice of either letting the relative prices q_e and q_s stay constant or assuming a Cobb-Douglas production function. We temporarily consider the implications of more general technologies.

4.1 Symmetric elasticity of substitution with labor

Let us first consider the following family of aggregate production functions:

$$Y_t = A_t(x_t)(\alpha(\mu K_{et}^{\varepsilon} + (1-\mu)K_{st}^{\varepsilon})^{\rho/\varepsilon} + (1-\alpha)(B_t L)^{\rho})^{1/\rho}.$$

Note that the elasticity of substitution between these capital stocks is equal to $1/(1-\varepsilon)$. As in the previous model, the elasticity of substitution between the nested capital aggregate and labor is equal to $1/(1-\rho)$.

Let γ_{et} denote that equipment income share, $\gamma_{et} = \frac{R_{et}K_{et}}{Y_t}$. From the first-order conditions of the maximization problem we get

$$\gamma_{et} = \frac{\alpha\mu}{\left[\alpha + (1-\alpha)\left(\frac{B_t L}{(\mu K_{et}^{\varepsilon}+(1-\mu)K_{st}^{\varepsilon})^{1/\varepsilon}}\right)^{\rho}\right]\left[\mu + (1-\mu)\left(\frac{K_{st}}{K_{et}}\right)^{\varepsilon}\right]}.$$

Let s_{et} denote the nominal investment rate of equipment, $s_{et} = q_{et}(1+\tau_{I_e})I_{et}/Y_t$. Imposing the steady-state condition $I_e^* = (g_b + \delta_e)K_e^*$ and rearranging terms, we then have

$$s_e^* = (g_b + \delta_e)(1 + \tau_{I_e})q_{e0}\gamma_e^* \frac{1}{R_e^*}.$$

Plugging in the steady-state value γ_e^* in terms of the marginal productivity of equipment R_e^*, we obtain

$$s_e^* = q_e(g_b+\delta_e)(1+\tau_{I_e})(\alpha\mu)^{1/(1-\rho)} A^{\rho/(1-\rho)} (R_e^*)^{1/(\rho-1)} \left\{\mu + (1-\mu)\left[\frac{(1-\mu)R_e^*}{\mu R_s^*}\right]^{\varepsilon/(1-\varepsilon)}\right\}^{\frac{\varepsilon-\rho}{\varepsilon(\rho-1)}}. \tag{16}$$

Following a similar procedure we obtain the nominal investment rate of structures

$$s_s^* = q_s(g_b+\delta_s)(1+\tau_{I_s})[\alpha(1-\mu)]^{1/(1-\rho)} A^{\rho/(1-\rho)} \left(R_s^*\right)^{1/(\rho-1)} \left\{(1-\mu) + \mu \left[\frac{(1-\mu)R_e^*}{\mu R_s^*}\right]^{\varepsilon/(\varepsilon-1)}\right\}^{\frac{\varepsilon-\rho}{\varepsilon(\rho-1)}}. \tag{17}$$

From these two equations we can see that the term A cancels out, and hence the level of TFP and associated external effects will have no bearing on the ratio s_e^*/s_e^*. Moreover, substituting out the steady state-values R_e^* and R_s^* from the first-order conditions, and assuming no depreciation allowances for the income tax, the above two expressions become

$$\begin{aligned} s_e^* \quad = \quad & (g_b+\delta_e)[q_e(1+\tau_{I_e})]^{\rho/(\rho-1)}(\alpha\mu)^{1/(1-\rho)} A^{\rho/(1-\rho)} \left\{\left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_e)\right] \frac{\varphi^{q_e}}{(1-\tau_Y)\varphi^{R_e}}\right\}^{1/(\rho-1)} \\ & \left\{\mu + (1-\mu)\left\{\frac{(1-\mu)\left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_e)\right]\frac{\varphi^{q_e} q_e(1+\tau_{I_e})}{(1-\tau_Y)\varphi^{R_e}}}{\mu\left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_s)\right]\frac{\varphi^{q_s} q_s(1+\tau_{I_s})}{(1-\tau_Y)\varphi^{R_s}}}\right\}^{\varepsilon/(1-\varepsilon)}\right\}^{\frac{\varepsilon-\rho}{\varepsilon(\rho-1)}} \end{aligned} \tag{18}$$

$$\begin{aligned} s_s^* \quad = \quad & (g_b+\delta_s)[q_s(1+\tau_{I_s})]^{\rho/(\rho-1)}[\alpha(1-\mu)]^{1/(1-\rho)} A^{\rho/(1-\rho)} \left\{\left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_s)\right] \frac{\varphi^{q_s}}{(1-\tau_Y)\varphi^{R_s}}\right\}^{1/(\rho-1)} \\ & \left\{(1-\mu) + \mu\left\{\frac{(1-\mu)\left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_e)\right]\frac{\varphi^{q_e} q_e(1+\tau_{I_e})}{(1-\tau_Y)\varphi^{R_e}}}{\mu\left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_s)\right]\frac{\varphi^{q_s} q_s(1+\tau_{I_s})}{(1-\tau_Y)\varphi^{R_s}}}\right\}^{\varepsilon/(\varepsilon-1)}\right\}^{\frac{\varepsilon-\rho}{\varepsilon(\rho-1)}} \end{aligned} \tag{19}$$

The Cobb-Douglas/CES case

For $\varepsilon \to 0$ we have a Cobb-Douglas production function nested into a CES-technology.

$$Y_t = A_t(x_t)\left\{\alpha(K_{et}^{\mu}K_{st}^{1-\mu})^{\rho} + (1-\alpha)(B_tL)^{\rho}\right\}^{1/\rho}.$$

From the above equations (18) and (19), the ratio $\frac{s_e^*}{s_s^*}$ simplifies to

$$\frac{s_e^*}{s_s^*} = \frac{\mu(g_b+\delta_e)\left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_s)\right]\frac{\varphi^{q_s}}{\varphi^{R_s}}}{(1-\mu)(g_b+\delta_s)\left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_e)\right]\frac{\varphi^{q_e}}{\varphi^{R_e}}}. \tag{20}$$

It follows that in the Cobb-Douglas/CES case the relative prices q_e and q_s do not enter into the expression s_e^*/s_s^*. These prices are only present in the more general setting of equations (18) and (19). Note, however, from equation (20) that the ratios $\varphi^{R_e}/\varphi^{R_s}$ and $\varphi^{q_e}/\varphi^{q_s}$ for the non-pecuniary distortions are still present,.

4.2 Asymmetric elasticity of substitution with labor

There is a second family of functions in which equipment and structures do not have the same degree of substitution with labor. It is often postulated in the literature that equipment is complementary with qualified labor [cf. Heckman *et al*. (1997) and Krusell *et al*. (2000)]. In our simple framework, this type of complementarity would take the form:

$$Y_t = A_t(x_t)\left\{\alpha K_{et}^{\rho} + (1-\alpha)[\mu K_{st}^{\varepsilon} + (1-\mu)(B_t L)^{\varepsilon}]^{\rho/\varepsilon}\right\}^{1/\rho}.$$

For the purposes of our analysis we could also allow for complementarities between structures and qualified labor:

$$Y_t = A_t(x_t)\left\{\alpha K_{st}^{\rho} + (1-\alpha)[\mu K_{et}^{\varepsilon} + (1-\mu)(B_t L)^{\varepsilon}]^{\rho/\varepsilon}\right\}^{1/\rho}.$$

In the sequel we just present the nominal investment rates for the first of these two production functions. Interchanging the roles of equipment and structures one can readily compute the results for the remaining production function.

Following the same steps as in (16)-(17), we must have

$$s_e^* = q_e(g_b+\delta_e)(1+\tau_{I_e})\alpha^{1/(1-\rho)}A^{\rho/(1-\rho)}(R_e^*)^{1/(\rho-1)} \tag{21}$$

$$s_s^* = q_s(g_b+\delta_s)(1+\tau_{I_s})[(1-\alpha)\mu]^{1/(1-\varepsilon)}A^{\varepsilon/(1-\varepsilon)}(R_s^*)^{1/(\varepsilon-1)}\left\{\alpha\left\{\left[\left(\frac{R_e^*}{\alpha A}\right)^{\rho/(1-\rho)} - \alpha\right]\frac{1}{1-\alpha}\right\}^{-1} + 1 - \alpha\right\}^{\frac{\varepsilon-\rho}{\rho(1-\varepsilon)}}. \tag{22}$$

Note that now the TFP variable A has differential effects for equipment and structures. If there are no depreciation allowances for income taxes and after substituting out for the steady-state values for R_e^* and R_s^*, these two equations can be rewritten as

$$s_e^* = (g_b+\delta_e)[q_e(1+\tau_{I_s})]^{\rho/(\rho-1)}\alpha^{1/(1-\rho)}A^{\rho/(1-\rho)}\left\{\left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_e)\right]\frac{\varphi^{q_e}}{(1-\tau_Y)\varphi^{R_e}}\right\}^{1/(\rho-1)} \tag{23}$$

$$\begin{aligned} s_s^* \quad = \quad & (g_b+\delta_s)[q_s(1+\tau_{I_s})]^{\varepsilon/(\varepsilon-1)}[(1-\alpha)\mu]^{1/(1-\varepsilon)}A^{\varepsilon/(1-\varepsilon)}\left\{\left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_s)\right]\frac{\varphi^{q_s}}{(1-\tau_Y)\varphi^{R_s}}\right\}^{1/(\varepsilon-1)} \\ & \left\{\alpha\left\{\left\{\left\{\left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_e)\right]\frac{\varphi^{q_e}(1+\tau_{I_e})q_e}{(1-\tau_Y)\varphi^{R_e}\alpha A}\right\}^{\rho/(1-\rho)} - \alpha\right\}\frac{1}{1-\alpha}\right\}^{-1} + 1 - \alpha\right\}^{\frac{\varepsilon-\rho}{\rho(1-\varepsilon)}} \end{aligned} \tag{24}$$

Therefore, the nominal investment rate for equipment does not depend on the relative price of structures.

The Cobb-Douglas/CES case

Again, letting $\varepsilon \to 0$ we get the following production function:

$$Y_t = A_t \left\{ \alpha K_{et}^{\rho} + (1-\alpha)[K_{st}^{\mu}(B_t L)^{1-\mu}]^{\rho} \right\}^{1/\rho}.$$

Then, the above two investment equations (23)-(24) simplify to

$$s_e^* = (g_b+\delta_e)[q_e(1+\tau_{I_e})]^{\rho/(\rho-1)} \alpha^{1/(1-\rho)} A^{\rho/(1-\rho)} \left\{ \left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_e) \right] \frac{\varphi^{q_e}}{(1-\tau_Y)\varphi^{R_e}} \right\}^{1/(\rho-1)}$$

$$s_s^* = \frac{\mu(g_b+\delta_s) \left\{ 1 - \alpha^{1/(1-\rho)} A^{\rho/(1-\rho)} \left\{ \left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_e) \right] \frac{\varphi^{q_e}(1+\tau_{I_e})q_e}{(1-\tau_Y)\varphi^{R_e}} \right\}^{\rho/(\rho-1)} \right\}}{\left[\frac{1}{\beta(1+g_b)^{-\sigma}} - (1-\delta_s) \right] \frac{\varphi^{q_s}}{(1-\tau_Y)\varphi^{R_s}}}$$

It follows that the relative price of structures does not alter any of the steady-state nominal investment rates, s_e^* and s_s^*; only the relative price of equipment influences these rates. Moreover, parameter A no longer affects the ratio s_e^*/s_s^*.

4.3 Summary of main results

Before embarking on our empirical investigation let us gather our main results on the predictions of this simple two-sector model:

(1) *Nominal investment rates*: Under a Cobb-Douglas production function nominal investment rates of equipment and structures, s_e and s_s, are linearly correlated at the BGP and over the transitional dynamics. This robust result holds approximately true for small departures of the Cobb-Douglas assumption.

(2) *TFP externalities*: Parameter A that may involve TFP externalities is only supposed to influence the steady-state ratio s_e^*/s_s^* in the case of asymmetric elasticities of substitution of the two capital factors with labor, provided that the elasticities of substitution $1/(1-\varepsilon)$ and $1/(1-\rho)$ are different from one and different from each other.

(3) *Relative prices*: The weights of relative prices of equipment and structures, q_e and q_s may uncover deviations from the Cobb-Douglas assumption, and asymmetries in the elasticities of substitution between the two types of capital and labor.

(4) *Distorsions*: Taxes and specially some non-pecuniary distortions, $\varphi^{q_e}/\varphi^{R_e}$ and $\varphi^{q_s}/\varphi^{R_s}$, may have differential effects on s_e and s_s.

(5) *Economic growth*: Even though economic growth has often been linked to investment in equipment [De Long and Summers (1991)], economic growth rates g_b should have similar effects on s_e and s_s.

5 Empirical findings on nominal investment rates of equipment and structures

The countries and years considered are the same as before provided data availability. For most variables we take five-year moving averages in order to smooth out cyclical volatility. We also make use of the panel data techniques described above.

In the national accounts aggregate investment (Gross Fixed Capital Formation) is divided into producer durables and construction. Producer durables is composed of transportation and machinery; we group these two entries into equipment investment. Construction includes residential, non residential, and other construction; we group all these latter items into structures investment.[4]

The modelling of aggregate investment rests upon the basic presumption that investments in equipment and structures share similar statistical properties. This turns out not to be true in the data: Nominal investment rate of equipment are not highly correlated with those of structures. Before providing a more detailed econometric analysis, we begin with a few basic facts that we would like to highlight. Some of these facts are known [cf., Bens (2008), Eaton and Kortum (2001), Hsieh and Klenow (2007) and De Long and Summers (1991)], or just follow from our more detailed analysis below: (i) As in the case of aggregate investment, nominal investment rates of equipment and structures are hardly correlated with income levels [cf. *op. cit.*]; (ii) As shown in Table 2 below, when investment in equipment is regressed against investment in structures the slope coefficient is about 0.3 for the OECD and 0.26 for the non OECD countries. These coefficients are significant and are robust to the addition of other regressors; hence, the linear correlation suggested by our original model is not confirmed by our data; (iii) When the nominal ratio s_e/s_s is regressed against the price ratio q_e/q_s we get a slope coefficient of 0.09 for OECD countries and 0.2973 for non-OECD countries; these univariate correlations become

[4] Depending on the year and country sometimes the entries *Land improvement and plantation and orchard development* and *breeding stocks, draught animals, dairy cattle and the like* are available. We have included these items when possible although their size is quite small as compared with aggregate investment.

smaller upon the introduction of other regressors (see below); and (iv) For non-OECD countries, the relative price of structures has a very minor influence on the nominal investment rates of both equipment and structures. These results point out at the production function with symmetric elasticity of substitution for the two capital goods discussed above.

Our theoretical analysis of the above two-sector model suggests that external effects should play a minor role in the determinants of the ratio s_e/s_s. Indeed, those effects were also absent in Section 3 for our empirical findings on aggregate investment, and hence they will not be considered here. Regarding distortions, note that taxes were prominent for OECD countries, and non-pecuniary distortions were affecting non-OECD countries. We are now in a position to analyze if these distortions have differential effects on equipment and structures. Analogously, growth has primarily been linked to some types of equipment investment [e.g., De Long and Summers (1991)]; hence, using our data set we can check if the correlation of income growth with nominal investment in structures is certainly more tenuous. Finally, the decomposition of the aggregate price (q) into the relative prices of equipment and structures will allow us to check how these prices affect equipment and structures. As discussed later the relative price of equipment is much more volatile than the relative price of structures.

Our results are displayed in Table 2 for both OECD and non-OECD countries. Note that the dependent variable is either s_e or s_s. As already discussed, the correlation between these two variables in positive, but much less than one, for both univariate and expanded regressions. Regarding the effects of the relative prices of equipment and structures, they all point out to small departures from the Cobb-Douglas assumption. As in Section 3, the aim of this exercise is twofold; first, we want to study how these prices affect investment rates, and second we want to explore their implications for the shape of the production function. For the OECD countries, investment in equipment is generally affected by the price of structures, and investment in structures is affected by the price of equipment but with the opposite sign. For the non-OECD countries, the coefficients of the price of structures are much smaller than those of the price of equipment. These results suggest that for the OECD sample the relation between relative prices and investment in equipment/structures is symmetric, leading us to the model with symmetric elasticity of substitution with labor. For the non-OECD countries, the results are more complex, but the signs of the coefficients are not consistent with complementarities between equipment and labor as postulated in the above production function with asymmetric elasticity of substitution. At any rate, these coefficients are small, and hence the elasticities of substitution are close to one.

In order to proceed more formally we performed several tests. First, equation (20) states that for the first family of production functions the Cobb-Douglas assumption implies that the ratio of savings rates is independent of the prices of investment goods. In the first entries of Table 2 we regress the ratio of investment rates s_e/s_s against the ratio of prices q_e/q_s. For the OECD the slope coefficient is not significant which supports our claim, however, for the non-OECD countries the coefficient for q_e/q_s is significant and equals 0.3. In all the other regressions shown in Table 2 both samples show coefficients for the relative prices of equipment and structures, q_e and q_s, not too far from zero. We may thus conclude that for the OECD the symmetric elasticity of substitution with labor and a nested Cobb-Douglas production function for equipment and structures fit well. For the non-OECD group, the symmetric elasticity of substitution still seems to hold. Although the estimated coefficients for q_e and q_s are not far from zero, we find some evidence of the elasticity of substitution between equipment and structures to be different from 1. Unfortunately, (18) and (19) are highly non-linear, and hence it is no possible to obtain direct estimates for ε. We can nevertheless compute a lower bound for the elasticity of substitution. From equation (18), the relative price q_s has a negative effect on s_e^*. Hence, the exponents of q_s must have an overall negative effect, that is, $\frac{\varepsilon-\rho}{(1-\varepsilon)(\rho-1)} > 0$. Since one can check that $\rho < 0$, it must be that $\varepsilon > \rho$.

More clear-cut evidence appears for the correlation between nominal investment rates and economic growth. Both the one-sector and two-sector models sector imply that at the BGP the growth variable g_b has a positive influence on nominal investment rates. De Long and Summers (1991) focus on equipment investment as a potentially key factor for growth. Jones (1994) has pointed out that a negative strong relationship emerges in the data between the relative price of machinery and economic growth, whereas the the relative price of nonmachinery enters insignificantly in growth regressions. In Table 2 below we see that the growth variable has a positive influence in *both* equipment and structures. Of course, since in our nominal investment variables we have filtered out for the business cycle component we cannot make inferences about the timing of these effects. Our previous discussion on the influence of relative prices on nominal investment rates attaches a symmetric role to both equipment and structures in a nested Cobb-Douglas production function within a nested CES technology, and this symmetric role is confirmed in the empirical correlations of these two components of investment with economic growth.

Finally, for economic policy it becomes of interest to see how distortions may affect different components of investment. As seen from Section 3, for the OECD countries income taxes have a weak effect on investment, but GOVC and TAXGS had a much stronger influence. In Table 2 we can see that for the OECD sample GOVC has a negative effect on structures, whereas TAXGS only affects the equipment investment rate. These results may accord with common intuition. GOVC (which has no theoretical counterpart in our model) may affect public investment, which in turn may condition investment of other types of structures. In our simple aggregate model, indirect taxation has neutral effects. But indirect taxation may have distortionary effects in models with differentiated inputs and multiple capital goods. For instance, a tax on gasoline would have a negative effect on the demand for cars. Therefore, indirect taxation may have negative effects on investment but these effects are not captured in our aggregate model. Regarding the non-OECD sample, we see from Table 2 that ECOF has a positive effect on investment. This result suggests that barriers and non-pecuniary distortions seem to affect equipment investment, which is usually related to trade, technology, and innovation. Therefore, lack of property rights and other nonpecuniary distortions may hamper equipment investment for developing countries. These effects, however, are not apparent in OECD countries.

In summary, in this section we analyzed the decomposition of investment into equipment and structures. There is a relatively weak correlation between these two components of investment, which is reflected in the slope coefficients and in the reported R^2 of all regressions of Table 2. The coefficients of the relative prices of equipment and structures reflect small departures from the Cobb-Douglas assumption. Our variable economic growth has strong positive effects for both expenditures in equipment and structures. Taxes and non-pecuniary distortions have different effects when considering OECD and non-OECD countries, and equipment and structures. This may be relevant for the optimal design of economic policies.

6 Relative prices of investment goods

There is low correlation between expenditures in equipment and structures, but the data also show a low correlation between the relative prices of equipment and structures. As is well known from the Penn World Table [Summers and Heston (1991)] the relative price of equipment displays much more variability than the price of structures. Regarding the relative price of equipment, Eaton and Kortum (2001) summarize the evidence as follows: " While the relative price of equipment is substantially lower in rich countries, the reported price of equipment itself is, if anything, higher in rich countries ... The ICP measure of equipment certainly varies across countries, but the numbers do not show that it is systematically higher in the net importers than in the net exporters."

Therefore, the relative price of equipment in terms of consumption seems to vary because of the variability of the price of consumption. Then, there should be a simple connection between the relative price of equipment and the relative price of structures. The data, however, shows that both prices are only mildly correlated. This leads us to the following question: What are the determinants of the relative prices of equipment and structures? The question is relevant for theories of sectoral TFP [Hsieh and Klenow (2007), Herrendorf and Valentinyi (2010)] that infer sectoral productivities across countries from relative prices of investment. Also, the question is relevant for policy purposes. Jones (1994) finds a strong correlation between the relative price of machinery and economic growth. Restuccia and Urrutia (2001) attribute the volatility of relative prices to different barriers to economic growth, and emphasize that the disparity of such prices will affect income levels rather than growth rates.

Table 3 presents various results for the OECD and non OECD countries. As in the previous sections all the regressions use panel data models to deal with the possible bias generated by the existence of unobserved time-invariant heterogeneity.

The first two regressions of Table 3 show the slope coefficients when the relative price of equipment is regressed against the relative price of structures for both the OECD and the non-OECD countries. The slope estimate is not significative for the non OECD countries, and it is significative for the non-OECD countries but with a a value much below 1. The small coefficient may reflect that the relative price of equipment is much more volatile.

We now explore the determinants of the relative prices of equipment and structures. By the Balassa-Samuelson effect [e.g.., Balassa (1964), Samuelson (1964) and Jones (1994)] the relative price of capital goods is usually higher in poor countries because in these countries consumption goods and services are usually cheaper. Again, the effect comes from the denominator of the definition of the relative price of capital. From Table 3 we can see that the slope coefficient for Y is negative for the relative price of equipment for OECD countries, but it is positive for the relative price of structures. Hence, within our OECD sample we obtain evidence of the Balassa-Samuelson effect for the relative price of equipment but not for the relative price of structures. In this analysis we have restricted the sample to the OECD countries because we presume that data quality may be an issue , but similar results are available for non-OECD countries. The introduction of human capital confirms this same result: Human capital helps decrease the relative price of equipment but has a non-significative effect on the relative price of structures. This story may be justified along the lines of Nelson and Phelps (1966) where the level of technology adoption may depend on the level of education. As already pointed out, Greenwood, Hercowitz and Krusell (1997), and Gort, Greenwood and Rupert (1999) report much faster technological progress for equipment than for structures. García-Belenguer (2007) considers a two-sector growth model in which the level of human capital is assumed to have a positive external effect on the adoption of new technologies.

Besides the level of human capital, there may be other factors that can help to adopt new technologies more efficiently and reduce the price of investment goods. One obvious candidate is the level of the technology already available in the country. To evaluate this effect we consider the capital stock for R&D. We also want to evaluate the effects of public investment and indirect taxation. It is seen that R&D has a strong, significative effect on both types of capital with the expected sign. Public capital and indirect taxation, do not have a significative effect on the relative price of equipment. It is certainly possible for public capital to affect marginal productivities of other types of capital without having a substantial influence on their own prices. Also, indirect taxation may leave the relative price of equipment unchanged, although in a world of multiple equipment goods it may reduce the demand for investment. The effects of indirect taxation are only patent in the relative price of structures. Indeed, production of this capital good uses a variety of inputs.

Finally, reflecting the economic environment in this econometric study we have also included the degree of economic freedom. Our findings go in the direction that ECOF does not appear significative on the relative price of equipment but affects the relative price of structures with the expected sign. Again, this is is what one would expect since investment in structures requires domestic production over a variety of inputs.

We started this section with the basic idea from Eaton and Kortum (2001) that in accounting for the relative price of equipment what matters is the denominator – the relative price of consumption. This would suggest a strong link between the relative price of equipment and the relative price of structures, which is not confirmed by the empirical evidence. Hence, theories that relate relative prices with sectoral TFPs [Hsieh and Klenow (2007), Herrendorf and Valentinyi (2010)] would have to conclude that sectoral TFPs are highly volatile across countries. This is therefore a very complex topic. Because of data availability, we mostly reported empirical estimates for the OECD sample, and confirmed the importance of certain distortions such as indirect taxation and the degree of economic freedom. Besides, the Balassa-Samuelson effect seems only present in the relative price of equipment.

7 Concluding Remarks

Guided by the neoclassical growth model, in this paper we inquire into the determinants of real investment rates across countries. This question is of fundamental interest for studies of economic growth since physical capital accumulation appears to be a major factor in accounting for income level differences. The real investment rate is defined as the nominal investment rate over the relative price of capital. Then, the analysis of real investment rates can be subsumed into the determinants of nominal investment rates and relative capital prices.

Nominal investment rates are barely correlated with the level of income, which accords with the basic prediction of the neoclassical model. This does not mean, however, that no other factor can account for investment. Indeed, from our analysis of the neoclassical growth model we can uncover certain trends. First, some factors are uncorrelated with income levels and hence when integrated in our empirical analysis they are expected not to affect the weak correlation between nominal investment rates and the level of income. There are two major factors in this category: Income growth and economic distortions. As suggested by our steady-state analysis of the neoclassical growth model, income growth has a positive effect on investment. Taxes are more prominent in OECD countries, whereas less developed countries seem to be affected by non-pecuniary distortions.

There is a second category of factors including the relative price of capital and the capital income share that are inversely correlated with the level of income. These two forces, however, seem to have a small effect in nominal investment rates. The small effect of the relative price of capital supports the Cobb-Douglas assumption for the aggregate production function, which entails stable capital income shares moving *in tandem* with nominal investment rates. What it is puzzling is that for both OECD and non-OECD countries, capital income shares are a weak explanatory factor of nominal investment rates.

Our paper also points out at some of the complexities involved in cross-county studies of aggregate investment. First, when all countries are included in our sample we find that both taxes and non-pecuniary distortions affect nominal aggregate investment. But as already stressed, taxes are only relevant in OECD countries, whereas non-pecuniary distortions are only relevant in non-OECD countries. Second, it seems surprising that expenditures in equipment and structures are weakly correlated. There must then be other forces outside our simple model that are driving these two components of investment. We are guessing that cross-country sectoral differences [see, however, Gollin (2002, p. 464)], as well as dynamic factors (time to build and adjustment costs) may be responsible for these scattered patterns of investment. And third, the relative price of equipment displays much more variability than the relative price of structures; hence, aggregation into a single price index may actually be misleading. In our case, this type of aggregation is not problematic because the relative prices of both equipment and structures have a small influence on both nominal aggregate investment and on each of the two components – equipment and structures.

Related empirical studies of economic growth on physical capital accumulation [e.g., Edwards (1996), Kormendi and Meguire (1985) and Levine and Renelt (1992)] do not follow as closely the analytical framework of the neoclassical growth model. We also distinguish between OECD and non-OECD countries, and between investment in equipment and structures. From these studies, it is not clear that additional financial, monetary, or real economic variables have a sizable influence on investment. Testing more general models of economic growth with monetary and financial frictions and overlapping generations should be worth further investigation.

References

Aschauer, D. A. (1989): "Is public expenditure productive?," *Journal of Monetary Economics*, 23, pp. 177-200.

Balassa, B. (1964): "The purchasing power parity doctrine: A reappraisal," *Journal of Political Economy*, 72, pp. 584-596.

Barro, R. J. (1990): "Government spending in a simple model of endogenous growth," *Journal of Political Economy,* 98, pp. 103-125.

Barro, R. J. (1999): "Notes on growth accounting," *Journal of Economic Growth,* 4, pp. 119-137.

Barro, R. J. and J.-W. Lee (1993): "International comparisons of educational attainment," *Journal of Monetary Economics*, 32, pp. 363-394.

Barro, R. J. and , J.-W. Lee (1996): "International measures of schooling years and schooling quality," *American Economic Review*, 86, pp. 218-223.

Bems, R.(2008): "Aggregate investment expenditures on tradable and nontradable goods," *Review of Economic Dynamics*, 11, pp. 852-883.

Benhabib, J. and M. Spiegel (2000): "The role of financial development in growth and investment," *Journal of Economic Growth*, 5, pp. 341-360.

Caselli, F. (2005): "Accounting for cross-country income differences," *Handbook of Economic Growth* (P. Aghion and S. Durlauf, eds.), North-Holland.

Chari, V. V., Kehoe, P. and E. McGrattan (1997): "The poverty of nations: A quantitative investigation," Research Department Staff Report 204, Federal Reserve Bank of Minneapolis.

Coe, D. T., Helpman, E. and A. W. Hoffmaister (2009): "International R&D spillovers and institutions," *European Economic Review*, 53, pp. 723-741.

DeLong, J. and L. Summers (1991): "Equipment investment and economic growth," *Quarterly Journal of Economics*, 106, pp. 445-503.

Duffy J. and C. Papageorgiou (2000): "A cross-country empirical investigation of the aggregate production function specification," *Journal of Economic Growth*, 5, pp. 87-120.

Edwards, S. (1996): "Why are Latin America's savings rates so low? An international comparative analysis," *Journal of Development Economics*, 51, pp. 5-44.

García-Belenguer, F. (2007): "Stability, global dynamics and Markov equilibrium in models of endogenous economic growth," *Journal of Economic Theory*, 136, pp. 392-416.

García-Belenguer, F. and M. Santos (2010) "A quantitative exploration in economic growth," *mimeo.*

Gollin, D. (2002): "Getting income shares right," *Journal of Political Economy*, 110, pp. 458-474.

Greenwood, J., Hercowitz, Z. and P. Krusell (1997): "Long-run implications of investment-specific technological change," *American Economic Review*, 87, pp. 342-362.

Gort, M., Greenwood, J. and P. Rupert (1999): "Measuring the rate of technological progress in structures," *Review of Economic Dynamics*, 2, pp. 207-230.

Hall, R. E. and C. I. Jones (1999): "Why do some countries produce so much more output per worker than others?" *Quarterly Journal of Economics*, 114, pp. 83-116.

Heckman, J. J., Lochner, L. and C. Taber (1998) "Explaining rising wage inequality: Explorations with a dynamic equilibrium model of labor earnings with heterogeneous agents," *Review of Economic Dynamics*, 1, pp. 1-58.

Herrendorf, B. and A. Valentinyi (2010):"Which sectors make the poor countries so unproductive?," *Journal of the European Economic Association*, forthcoming.

Hsieh, C.-T. and P. Klenow (2007):" Relative prices and relative prosperity," *American Economic Review*, 97, pp.562-585.

Islam, N. (1995): "Growth empirics: A panel data approach," *Quarterly Journal of Economics*, 110, pp. 1127-1170.

Jones, C. I. (1994): "Economic growth and the relative price of capital," *Journal of Monetary Economics*, 34, pp. 359-382.

King, R. and R. Levine (1993): "Finance, entrepreneurship and growth: Theory and evidence," *Journal of Monetary Economics,* 32, pp. 513-542.

Kormendi, R. C. and P. G. Meguire (1985):" Macroeconomic determinants of growth: Cross-country evidence," *Journal of Monetary Economics*, 16, pp. 141-163.

Krusell, K., Lee E. O., Ríos-Rull, J.-V. and G. L. Violante (2000) "Capital-skill complementarity and inequality: A macroeconomic Analysis," *Econometrica*, 68, pp. 1029-1054.

Levine, R. and D. Renelt (1992):"Sensitivity analysis of cross-country growth regressions," *American Economic Review*, 82, pp. 942-963.

Levine, R. and S. J. Zervos (1993):"What have we learned about policy and growth from cross-country regressions?," *American Economic Review*, 83, pp. 426-430.

Lucas, R. E. (1988): "On the mechanics of economic development," *Journal of Monetary Economics*, 22, pp. 3-42.

Mauro, P. (1995): "Corruption and growth," *Quarterly Journal of Economics*, 110, pp. 681-712.

McGrattan, E. R. and J. A. Schmitz (1999): "Explaining cross-country income differences," *Handbook of Macroeconomics* (J. B. Taylor and M. Woodford, eds.), North-Holland.

Nelson, R. R. and E. S. Phelps (1966): "Investment in humans, technological diffusion, and economic growth," *American Economic Review,* 56, 69-75.

Restuccia, D. and C. Urrutia (2001) "Relative prices and investment rates," *Journal of Monetary Economics,* 47, pp. 93-121.

Samuelson, P. A. (1964): "Theoretical Notes on Trade Problems," *Review of Economic Studies*, 46, pp. 145-154.

Santos, M. S. (2001): “Economic growth with physical and human capital,” mimeo.

Solow, R. M. (1956): “A contribution to the theory of economic growth,” *Quarterly Journal of Economics*, 70, pp. 65-94.

Solow, R. M. (1957): “Technical change and the aggregate production function,” *Review of Economics and Statistics*, 39, pp. 312-320.

Summers, R. and A. Heston (1991): “The Penn World Table (Mark 5): An expanded set of international comparisons, 1950-1988,” *Quarterly Journal of Economics*, 106, pp. 327-368.

8 Appendix

8.1 Countries

Our sample contains all countries graded A in the PWT but Luxembourg that has a population of less than one million. It also includes all countries graded B in the PWT but Iceland (because of population size) and Israel (high military expenditure). Singapore has been kept in the sample, even though this country only has one ICP benchmark.

Our sample contains most countries graded C in the PWT with two ICP benchmarks. For several reasons, the following countries were not included: (a) Bahamas, Barbados, Grenada, St. Lucia, Trinidad & Tobago, and Mauritius have all populations less than one million people. (b) Benin, Bangladesh, Ivory Coast, Congo, Madagascar, Mali, and Senegal do not have good (separate) data for equipment and structures. (Although these countries have either two or three benchmarks, the data seem good only for the benchmark years.) (c) Along the same lines, Ethiopia, Malawi, Nepal, Swaziland do not seem to have good data for equipment and structures separately. Nigeria and Ethiopia are not in the Barro-Lee data set, which is an input of our human capital series. (d) Cameroon, Sierra Leone, Tanzania, Zambia and Zimbabwe have been engaged in major confrontations over the period 1960-2000. (e) Finally, Bolivia, Jamaica, Romania (data starting 1970) and Syria show very low quality in the National Accounts.

After these considerations, the following countries do comprise our sample:

(i) OECD countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary (data starting 1970), Ireland, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland (data starting 1970), Portugal, Spain, Sweden, Switzerland, Turkey, UK, USA.

(ii) NON-OECD countries: Argentina, Brazil, Chile, China (data starting 1975), Colombia, Ecuador, Egypt , Hong Kong, India, Indonesia, Iran , Kenya, Malaysia, Morocco, Pakistan, Panama, Peru, Philippines, Sri Lanka, Singapore, Thailand, Tunisia, Uruguay, Venezuela.

Therefore, this is a total sample of 50 countries over the period 1960-2000 with 26 countries that belong to the OECD. The sample keeps a balanced representation of all major economic areas. Some further non-OECD countries could be added to this sample at the cost of lowering our data quality demands.

8.2 Economic variables

In our empirical investigation we use the nominal investment rate and its two components, equipment and structures investment rates. These shares are computed at domestic prices using the data and definitions available in the United Nations National Accounts Statistics. Equipment includes electrical and non-electrical machinery as well as transportation equipment while structures comprises residential, non-residential and other construction. These estimates have been taken from our previous work García-Belenguer and Santos (2010) and cover the period 1960 to 2000. The relative prices of aggregate investment are taken from the Penn World Table 6.2 (PWT) while the disaggregated values are provided by the benchmark studies of the International Comparison Program (ICP). They include the relative price of equipment and structures investment with respect to output and consumption. In this exercise we use the benchmark studies for the years 1970, 1975, 1980, 1985, 1990 and 1996.

Regarding the explanatory variables different sources have been used. The human capital stock and the R&D and public physical capital stocks were constructed in our previous work García-Belenguer and Santos (2010). The R&D and public capital stocks are computed as a share of the GDP. Output per worker measured at international prices is taken from the PWT. Many of the variables representing the economic environment and the economic policy are from the World Bank World Development Indicators (WDI). Although we have considered many of the variables available in the WDI for our exercise, many of them did not turn out to be significant and are not reported in our regressions. Among them are the consumer price index, Definitions of explanatory variables.

Variable§	Description
γ	The capital income share for the OECD countries comes from the OECD statistics. For the non-OECD countries factor shares have been computed with data from the United Nations National Accounts Statistics.
q	Price of investment over price of consumption. Source: Benchmark studies (UN) and PWT.
q_e	Price of equipment over price of consumption. Source: Benchmark studies (UN).
q_s	Price of structures over price of consumption. Source: Benchmark studies (UN).
s	Gross fixed capital formation over GDP at domestic prices. Source: National Accounts Statistics (UN).
s_e	Producers' durable goods over GDP at domestic prices. Source: National Accounts Statistics (UN).
s_s	Total construction over GDP at domestic prices. Source: National Accounts Statistics (UN).
CRED	(% of GDP) Domestic credit to private sector refers to financial resources provided to the private sector, such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment. For some countries these claims include credit to public enterprises. Source: World Develop. Indicators (WB).
ECOF	The economic freedom index includes measures on the size of government, the legal structure and the security of property rights, access to sound money, freedom to trade and the regulation of credit, labor and business. Source: Fraser Institute.
GVMC	(% of GDP) Includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditures on national defense and security, but excludes government military expenditures that are part of government capital formation. Source: World Develop. Indicators (WB).
HUM	Level of human capital. These series are adjusted for quality and have been computed with data on investment in education constructed by the authors. Enrollment and educational systems data has been obtained from the UNESCO Statistical Yearbooks.
LEND	Rate charged by banks on loans to prime customers. Source: World Develop. Indicators (WB).
OPEN	Exports plus imports divided by GDP at current international prices. Source: Penn World Tables.
Y	Real GDP chain per worker (RGDPW) measured at international prices of year 2000. Source: Penn World Tables.
Y_{gr}	Growth rate of income per worker at international prices. Source: Penn World Tables.
R&D	The Research and Development capital stock has been computed with data on investment expenditure on R&D available at the UNESCO Statistical Yearbooks.
PUB	The public capital stock has been computed with data on public investment available at the Government Finance Statistics Yearbook of the International Monetary Fund.
TAXGS†	(% of GDP) Taxes on goods and services include all taxes and duties levied by central governments on the production, extraction, sale, transfer, leasing, or delivery of goods and rendering of services, or on the use of goods or permission to use goods or perform activities. These include value added taxes, general sales taxes, single-stage and multistage taxes (where "stage" refers to stage of production or distribution), excise taxes, and motor vehicle taxes, and taxes on the extraction, processing, or production of minerals or other products. Source:World Develop. Indicators (WB)
TAXIN†	(% of GDP) Taxes on income, profits, and capital gains are levied on wages, salaries, tips, fees, commissions and other compensation for labor services; interest, dividends, rent, and royalties; capital gains and losses; and profits of businesses, estates, and trusts. Social security contributions based on gross pay, payroll, or number of employees are not included, but taxable portions of social security, pension, and other retirement account distributions are included. Source: World Develop. Indicators (WB)

† Includes only central government.
UN=United Nations. WB=World Bank.

the exchange rate, the lending interest rate, the spread interest rate and the share of import duties on GDP. All the variables from the World Bank WDI are introduced as a share of GDP.

The capital income share for the OECD countries is taken from the OECD statistics, for the non OECD countries we have used data available at the United Nations National Accounts Statistics with the proper adjustments to have homogeneous data. Finally the economic freedom index and OPEN are provided by the Fraser Institute and the PWT respectively. A detailed description of the variables and sources used is provided in the next table.

Table 1a: Aggregate investment rate at domestic prices. OECD

Explanatory variables	EFM1	EFM1	EFM2	EFM3
Y_{gr}	0.4793	0.4037	0.4842	0.5604
	(7.0083)	(6.1000)	(7.5846)	(7.7569)
γ	0.0233	0.0159		
	(3.1633)	(2.2600)		
TAXIN	-0.0601			
	(-0.7983)			
GOVC		-0.4128	-0.5202	-0.6199
		(-4.9900)	(-6.5172)	(-4.6438)
TAXGS		-0.3674		
		(-3.6800)		
ECOF	-0.0110	-0.0004	0.0168	0.0218
	(-0.5518)	(-0.0200)	(0.8671)	(0.8668)
OPEN		0.0718		
		(2.5100)		
q			0.0231	0.0094
			(2.0364)	(0.6225)
HUM				0.1384
				(1.8184)
R&D				0.4484
				(1.2627)
PUB				0.0338
				(0.7988)
R^2	0.2754	0.3450	0.3116	0.3368

t-statistics in parentheses.

Table 1b: Aggregate investment rate at domestic prices. Non-OECD

Explanatory variables	EFM1	EFM1	EFM2	EFM3	EFM3
Y_{gr}	0.7513	0.5758	0.5992	0.5700	0.7046
	(8.6278)	(6.9200)	(10.6350)	(10.2032)	(9.6405)
γ	0.0105	0.0119			
	(0.8994)	(1.0100)			
TAXIN	0.6683				
	(4.3172)				
GOVC		-0.0206	0.0832	-0.0046	-0.1667
		(-0.1600)	(1.3063)	(-0.0703)	(-2.0044)
TAXGS		0.4110			
		(1.6300)			
ECOF	0.0645	0.1243	0.0470	0.0514	0.0394
	(3.1528)	(6.5600)	(3.2233)	(3.5891)	(1.9093)
OPEN		0.2332			
		(6.4300)			
q			0.0664	0.0657	0.0592
			(6.4523)	(6.5111)	(4.2445)
HUM				-0.2289	-0.0495
				(-4.9805)	(-0.5963)
R&D					-2.0460
					(-2.2117)
PUB					0.0306
					(0.8387)
R^2	0.5022	0.5588	0.3365	0.3613	0.3997

t-statistics in parentheses.

Table 1c: Aggregate investment rate at domestic prices. Whole sample

Explanatory variables	EFM1	EFM1	EFM2	EFM2	EFM3	EFM3
Y_{gr}	0.5810	0.4996	0.5316	0.5254	0.5139	0.5394
	(11.3213)	(10.1932)	(11.1988)	(10.8946)	(10.6623)	(9.6718)
γ	0.0097	0.0066	0.0048	0.0025	0.0042	-0.0085
	(1.5457)	(1.0914)	(0.8080)	(0.4112)	(0.7056)	(-0.9766)
TAXIN	0.1068					
	(1.5063)					
TAXGS		-0.2897		-0.3039	-0.2772	-0.4013
		(-3.0914)		(-3.3091)	(-3.0144)	(-3.8259)
ECOF	0.0512	0.0605	0.0709	0.0728	0.0686	0.0576
	(3.8359)	(4.8717)	(5.6422)	(5.8928)	(5.5334)	(4.3984)
GOVC		-0.4150	-0.3208	-0.3555	-0.3405	-0.3708
		(-6.3492)	(-5.1356)	(-5.4816)	(-5.2543)	(-4.3735)
OPEN		0.1131		0.1166	0.1091	0.0529
		(5.4247)		(5.7100)	(5.3161)	(2.2847)
q			0.0495	0.0538	0.0564	0.0303
			(5.1606)	(5.7753)	(6.0497)	(2.6962)
HUM					-0.1359	-0.0033
					(-2.7715)	(-0.0445)
R&D						0.2154
						(0.5955)
PUB						-0.0783
						(-2.4940)
R^2	0.2733	0.3499	0.3178	0.3769	0.3831	0.4212

t-statistics in parentheses.

Table 2a: Equipment and structures investment rates at domestic prices. OECD

Explanatory variables	Dependent variable							
	s_e/s_s	s_e/s_s	s_e	s_e	s_e	s_s	s_s	s_s
q_e/q_s	0.0904							
	(1.3296)							
q_e		0.3787	0.0046	-0.0004	-0.0060	-0.0491	-0.0506	-0.0574
		(4.4191)	(0.6964)	(-0.0637)	(-0.8900)	(-7.2031)	(-6.9472)	(-7.2545)
q_s		0.1027	0.0180	0.0314	0.0334	0.0002	0.0007	0.0171
		(1.3603)	(3.1594)	(5.2041)	(5.4990)	(0.0404)	(0.1068)	(2.4010)
Y_{gr}			0.3396	0.2766	0.2611	0.3932	0.3556	0.3441
			(7.7285)	(6.0876)	(5.7113)	(8.4224)	(7.2461)	(6.4233)
s_s			0.1979	0.1509				
			(4.3178)	(3.2326)				
GOVC				0.0639	0.0082		-0.4185	-0.4505
				(0.9629)	(0.1259)		(-6.0084)	(-5.9308)
TAXGS				-0.4159	-0.4375		0.0156	-0.1819
				(-6.0509)	(-6.3223)		(0.2007)	(-2.2436)
s_e						0.5315	0.5209	
						(9.7787)	(8.8947)	
R^2	0.2960	0.3378	0.2635	0.3245	0.3071	0.5240	0.5509	0.4632

t-statistics in parentheses.

Table 2b: Equipment and structures investment rates at domestic prices. Non-OECD

Explanatory variables	Dependent variable s_e/s_s	s_e/s_s	s_e	s_e	s_s	s_s
q_e/q_s	0.2973					
	(5.2743)					
q_e		0.5380	0.0259	0.0246	-0.0224	-0.0167
		(5.4776)	(4.0283)	(3.8452)	(-2.7830)	(-2.0283)
q_s		-0.1948	-0.0145	-0.0143	0.0164	0.0088
		(-2.9728)	(-3.5427)	(-3.4777)	(3.0633)	(1.6632)
Y_{gr}			0.2750	0.2787	0.2585	0.3307
			(6.7736)	(6.8604)	(4.9025)	(6.3033)
ECOF			0.0595	0.0615	-0.0045	0.0287
			(4.5896)	(4.7586)	(-0.2581)	(1.7210)
s_s			0.0755			
			(1.5960)			
s_e					0.4391	
					(4.9678)	
R^2	0.2399	0.2583	0.3903	0.3856	0.2916	0.2391

t-statistics in parentheses.

Table 3: Relative prices of equipment and structures

Explanatory variables	Dependent variable q_e	q_e	q_e	q_s
	OECD	Non OECD	OECD	OECD
q_s	0.3205	0.0337		
	(8.2166)	(0.9566)		
Y			-0.2520	0.2219
			(-3.7314)	(3.3686)
HUM			-0.8727	0.8184
			(-1.9123)	(1.8383)
R&D			-13.8565	-12.9154
			(-6.1004)	(-5.8290)
PUB			0.0435	-0.2177
			(0.2212)	(-1.1336)
ECOF			0.1097	-0.4185
			(0.6857)	(-2.6821)
TAXGS			0.0649	1.6615
			(0.1012)	(2.6554)
R^2	0.5103	0.2325	0.6251	0.4658

t-statistics in parentheses.