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Investment rates and the aggregate production function

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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. The neoclassical growth model predicts that aggregate investment may be influenced by income growth, the capital income share, the relative price of capital, taxes, and other market distortions. 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. These empirical exercises shed light into the shape of the neoclassical production function.

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. Mankiw et al., 1992; Hall and Jones, 1999). There is, however, much more controversy about the influence of some other forces (e.g., Caselli, 2005; 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 computed by a permanent inventory method using aggregate investment data as a primitive element in the analysis.

Therefore, it is of great economic interest to delve into the ultimate reasons underlying world investment patterns. A basic tenet in the economic growth literature is that domestic investment rates are pretty constant across countries (cf. Summers and Heston, 1991; 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. Thus, when adjusting GDP data by a common set of prices, real investment rates are much higher in rich countries. Consequently, rich countries display comparable nominal investment rates that get translated into higher real investment

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rates. This efficiency in capital accumulation is of course considered to be a major source of income disparity across countries.

In spite of the low variability of nominal investment rates across countries, we cannot rule out the possibility that taxes and some other distortions matter for investment: There could be countervailing forces that make countries experience similar nominal investment rates. Indeed, taxes are usually higher in OECD countries, but non-OECD countries may endure further non-pecuniary distortions. Hence, the presumed stability of the share of nominal investment across groups of countries and time periods may conceal some other growth trends. For instance, when decomposing investment data into equipment and structures we find a rather weak correlation between these two sub-aggregates. We also observe substantial variation in the relative price of equipment across countries, but much less variation in the relative price of structures. Therefore, by analyzing investment subcategories and country groups we may be able to unmask some other patterns shaping the stability of the aggregate investment rate.

We address all these empirical issues within a simple version of the neoclassical growth model. The model predicts that aggregate investment may be influenced by income growth, the capital income share, the relative price of capital, taxation, and other market distortions. The behavior of nominal investment rates and relative prices can actually shed light into the form of the neoclassical production function. As we depart from the Cobb–Douglas paradigm, our empirical exercise can capture the influence of external effects on the aggregate production function.

Our results, however, support the Cobb–Douglas assumption for the aggregate production function. First, we find weak evidence of additional external effects coming from human capital, expenditures in R&D, and public investment. Second, the elasticity of substitution between aggregate capital and labor is slightly less than one, and so the Cobb–Douglas production function seems a good approximation. Third, by dividing aggregate investment into equipment and structures we try to unveil complementarities with labor, and the possibility of a nested production function. Again, this is rejected by the data. All this evidence works in favor of a simple Cobb–Douglas production function.

But 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 the nominal investment rate and the capital income share across countries. This is the most puzzling fact against the neoclassical production function. We also show that the observed weak connection between expenditures in equipment and structures cannot just be attached to the variability of the relative prices of equipment and structures.

We later analyze the volatility of the relative prices of equipment and structures. These two prices are weakly correlated, and the relative price of equipment displays much more volatility than the relative price of structures. Hence, aggregation of these two prices into a single index may not be adequate. Early studies (Jones, 1994; DeLong and Summers, 1991; Restuccia and Urrutia, 2001) focus on the influence of relative prices on economic growth and development. Here, we are just concerned with the ultimate determinants of the relative prices of equipment and structures in order to enhance our understanding of the production of these two investment components. Hsieh and Klenow (2007) and Herrendorf and Valentinyi (2012) associate differences in relative prices with variations in sectoral TFPs. This would imply that the volatility of these sectoral TFPs is very large. We allow for other sources of price variability besides TFP. More precisely, we find that the factor income share of services is more pronounced in the production of structures, and the factor income share of goods is more pronounced in the production of equipment. The relative price of structures is not affected by the Balassa–Samuelson effect. This latter effect becomes prominent in the relative price of equipment.

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. The original aggregate model is extended in Section 4 to include two types of capital goods. In Section 5 we test this latter model on various grounds. Section 6 presents a quantitative 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 model delivers 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. In each country there is a representative household supplying capital and labor. To this conventional 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.

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 the 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

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

where 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. Function $A_t(x_t)$ reflects external effects which may come from human capital, R&D, and public capital;