GETTING INCOME SHARES RIGHT: A PANEL DATA INVESTIGATION FOR OECD COUNTRIES

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A Panel Data Investigation for OECD Countries

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Abstract

In this paper we reassess the conventional measure of the capital share in income by estimating the shares of inputs in income for 23 OECD countries for the period 1960-2003 utilizing panel data techniques. A share of physical capital of over 0.50, and not one-third as commonly accepted, is found to be robust to a variety of specifications of the production function and the econometric models used. Additionally, we find that following the first oil shock the share of physical capital dropped while the share of human capital rose. Consequently, using the conventional shares may have led to overstating the severity of the post-1973 productivity slowdown.

Keywords: OECD, Shares of Inputs, Growth Accounting, TFP, Panel Data

JEL Classification: O47, C23

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Introduction

The remarkable growth records of the East Asian economies has provided fertile ground for analyzing sources of growth and has fueled the tireless debate of whether economic growth is driven by accumulation of resources or productivity gains. Recent studies, notably Collins and Bosworth (1996), Young (1995), and Krugman (1994) conjecture that the "Asian Miracle" was driven mainly by capital accumulation rather than by the adoption of new technologies and rising total factor productivity, as commonly believed.

A pivotal issue in the ongoing debate is the value of the share of physical capital in national income. Most of the studies applying growth accounting have adopted a benchmark of roughly one-third as has been drawn from the national accounts of various industrial countries (Bernanke and Gürkaynak, 2001; Jorgenson and Yip, 2000; Collins and Bosworth, 1996). This conventional share is so deeply rooted that the textbook Solow growth model was deemed inappropriate by Mankiw et al. (1992) since its implied capital share exceeded one-third.

The national accounts are the basis for the official estimates of the share of physical capital as reported in the OECD Productivity Database. According to these estimates, the physical capital share during the period 1985-2003 averaged 0.24 and ranged between 0.16 in the case of Ireland and 0.31 for Australia. Another database that uses national accounts to calculate the shares of inputs in national income for the European Union countries is the total economy database of the Groningen Growth and Development Center (GGDC). Generally speaking, their estimates of the share of capital are higher than those obtained from the OECD productivity database (see Figure 1). According to the GGDC database, the capital share of the OECD members averages 0.31 and ranges between 0.23 (Greece) and 0.36 (Ireland). Despite the fact that both databases are based on national accounts and cover the same periods, their estimates vary greatly. For example, while the OECD productivity database estimates Ireland's share of capital at 0.16, the GGDC database places it at 0.36.

While the above mentioned databases are in line with the conventional wisdom, some studies have shown that the share of physical capital in income is higher than the share that is derived from the national accounts. In general, they showed that the capital share for developing countries is much higher than one-third (Senhadji, 2000, and Abu-Qarn and Abu-Bader, 2007). Romer (1987) argued that due to positive externalities in investment, the weight to be attached to capital accumulation in the growth accounting exercise for developed countries is likely to fall in the range of 0.7-1.0 and that the share is expected to be even larger for developing countries. Lower estimates, though much higher than the conventional measure of the capital share, have been reported by Senhadji (2000). By applying Fully Modified OLS (FMOLS), he found an average share of physical capital of 0.53 for OECD countries. A completely opposing view is expressed by Gollin (2002) who argued that adjusting for income of self-employed entrepreneurs, results in a higher share of labor and thus a lower share of capital than the naïve method in which only the compensation for employees is considered.

In this paper, using panel data techniques we estimate regional shares of inputs for 23 OECD countries instead of relying on the conventional shares.[1] To the best of our knowledge, panel data techniques have not been used to estimate the regional shares of inputs in national income for OECD countries.[2] A sample of OECD countries was chosen because the conventional

[1] Our sample does not include the recent expansions of OECD and Luxemburg due to lack of data. The core members constitute a more homogenous sample that is likely to share similar technologies and parameters of the production function.

[2] Abu-Qarn and Abu-Bader (2007) apply panel data techniques for the Middle East and North Africa region and find that the physical capital share is higher than 0.4.

share of capital is drawn from their national accounts. Additionally, OECD countries are likely to share similar technologies and parameters of the production function.[3] Thus, we examine the appropriateness of the conventional share by estimating a regional share that utilizes both the time and space dimensions of the data. Unlike many earlier studies, we explicitly include human capital as an input in the production function either as embodied in labor or as a stand-alone input.[4] Our measure of human capital, drawn mainly from Collins and Bosworth (1996) and Barro and Lee (2001), is the average years of schooling adjusted to the return on schooling of various education levels. The shares of inputs in income are estimated using various specifications of the production function (with and without human capital, and with and without the assumption of constant returns to scale). Using panel data techniques allows us to address country and time specific effects. Since endogeneity of capital constitutes a major concern, we perform Two-Stage OLS (2SLS) regressions to correct for possible endogeneity. Our regressions are accompanied by tests of redundancy of the fixed effects, the Hausman test for the consistency of random effects, and the Sargan test for the validity of the instrumental variables.

In order to conduct our analysis of the determinants of economic growth of OECD countries, we construct a series of physical capital stocks using the perpetual inventory method (PIM). We then estimate the OECD regional factor shares in national income applying panel data techniques. Finally using the growth accounting exercise we attempt to identify the proximate determinants of economic growth. We use our estimates of productivity to reexamine the magnitude of the widely-documented post-1973 productivity slowdown (see Baily, 1986 and

[3] See Bentolila and Saint-Paul (2003).

[4] Neither does the official OECD productivity database incorporate human capital explicitly in its calculations.

Jorgenson and Yip, 2001) and the rebound of the mid 90's (see Hansen, 2001 and Kahn and Rich, 2004).

The rest of the paper is organized as follows. Section 2 lays out the theoretical foundations of the growth accounting exercise and section 3 addresses the empirical methodologies employed. Section 4 describes the data and its resources. Our results are presented in section 5 and the paper ends with a summary and concluding remarks in section 6.

2. Theoretical Foundations

The purpose of the growth accounting exercise, which was formally introduced by Solow (1957), is to decompose the growth of aggregate output into the contributions of factor accumulation and productivity. This approach does not assume a specific functional form of the production function, but relies solely on the assumption of competitive markets under which the production factors are paid their marginal products. A widely used functional form of the production function is that of Cobb-Douglas:

$$Y(t) = A(t) \cdot \left(K(t)\right)^{\alpha} \left(L(t)\right)^{\beta} \qquad (1)$$

where *Y(t)*, *K(t)*, and *L(t)* represent aggregate output, physical capital stock, and labor force, respectively. The term *A(t)*, often referred to as *Total Factor Productivity* (TFP), is designated to capture a host of factors that affect overall efficiency. These factors include, among others, technology level, quality of labor (human capital), quality of management and governance, strength of institutions, geography and climate, property rights, and cultural factors.

By taking logs on both sides of equation (1), differentiating with respect to time, and assuming that factors are paid their marginal products we can obtain the basic growth accounting equation:

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \alpha \cdot \frac{\dot{K}}{K} + \beta \cdot \frac{\dot{L}}{L} \tag{2}$$

where a dot on the top of a variable denotes its derivative with respect to time, and α and β are the shares in total income of payments to capital and labor, respectively.

Under the assumption of constant returns to scale (CRS), we can express the growth of per worker output as a function of the growth of capital intensity:

$$\frac{\dot{y}}{y} = \frac{\dot{A}}{A} + \alpha \cdot \frac{\dot{k}}{k} \tag{3}$$

where lower case letters stand for the respective per worker term. Equations (2) and (3) attribute the growth rate of output or output per worker to the observable factors of growth of capital and labor and to the unobservable *Solow Residual* which is the portion of output growth left unaccounted for by the growth of inputs.

In the case of labor-augmenting human capital, the production function takes the following form:

$$Y(t) = A(t) \cdot \left(K(t)\right)^{\alpha} \left(L(t)H(t)\right)^{\beta} \tag{4}$$

where *H(t)* is a measure of the human capital stock that is embodied in the labor force, and the expression *L(t)H(t)* denotes a skill-adjusted measure of the labor input. Once again, the growth accounting equation can be expressed in terms of either the growth of output as in equation (5) or in terms of the growth of output per worker (under constant returns to scale) as in equation (6):

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \alpha \frac{\dot{K}}{K} + \beta \left(\frac{\dot{L}}{L} + \frac{\dot{H}}{H} \right) \tag{5}$$

$$\frac{\dot{y}}{y} = \frac{\dot{A}}{A} + \alpha \cdot \frac{\dot{k}}{k} + (1-\alpha)\frac{\dot{H}}{H} \tag{6}$$

Another specification of the production function incorporates human capital as a stand-alone input. Under this specification human capital is not embodied in labor and thus the elasticity of output with respect to human capital differs from that of labor. A Cobb-Douglas production function that captures this assumption is:

$$Y(t) = A(t) \cdot \left(K(t)\right)^{\alpha} \left(L(t)\right)^{\beta} \left(H(t)\right)^{\gamma} \tag{7}$$

The corresponding growth accounting equations for equation (7) (with and without the assumption of constant returns to scale) are:

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \alpha \frac{\dot{K}}{K} + \beta \frac{\dot{L}}{L} + \gamma \frac{\dot{H}}{H} \tag{8}$$

$$\frac{\dot{y}}{y} = \frac{\dot{A}}{A} + \alpha \cdot \frac{\dot{k}}{k} + \gamma \frac{\dot{h}}{h} \tag{9}$$

The assumption of constant returns to scale is widely accepted and has been adopted also by the official OECD productivity database. In our study, we opt not to impose this restriction but rather to test it.

In spite of its ease and readability, growth accounting does not explain how changes in inputs and improvements in total factor productivity are related to economic policies, preferences and technology. The method consistently decomposes the proximate sources of growth but fails to address the fundamental causes of growth. Moreover, although the use of aggregate production function is very common among growth economists, some still cast doubts on the appropriateness of such a notion.[5]

3. Empirical Methodology

[5] Felipe and Fischer (2003) comprehensively outline the arguments against , while Mahadevan (2003) provides some justifications for the use of aggregate production functions.

To perform the growth accounting exercise takes several steps. First, we construct a series of physical capital stock for all the considered countries based on accumulation of past investments, net of depreciation. Second, we estimate the shares of production inputs in national income utilizing panel data techniques (common intercept, one and two-way fixed and random effects, and 2SLS) under several specifications of the production function. Finally, we conclude our analysis by decomposing the growth of output into the contributions of inputs and TFP.

To construct the capital stock series we employ the PIM. A general PIM featuring a geometric pattern of decay can be expressed as:

$$K_t = (1-\delta)^t K(0) + \sum_{i=0}^{t-1} I_{t-i}(1-\delta)^i \tag{10}$$

According to equation (10), the capital stock of year *t* equals the initial capital stock net of depreciation (at an annual rate of δ) plus the sum of the stream of net investments. In order to construct a capital stock series we need an estimate of the initial capital stock, *K(0)*; an estimate of the depreciation rate of capital stocks, δ; and a series of past investments, I_t. Once we obtain an estimate of the initial capital stock, we can use a variation of equation (10) to describe the evolution of capital stock:

$$K_t = I_t + (1-\delta)K_{t-1} \tag{11}$$

In equation (11), the capital stock in a certain year, K_t, equals the capital stock of the previous year, K_{t-1}, net of depreciation, plus the flow of gross investment in the current year, I_t.

Since the capital stock series is constructed from accumulation of investments, it is vital to have a reliable estimate of the initial capital stock. Preferably, such an estimate should be directly obtained from a benchmark study. However, if this is not feasible, a rough estimate can be used. The literature suggests several ways to generate an estimate of the initial capital stock. By far, the most common method is due to Harberger (1978) and is expressed formally as:

$$K_{t-1} = \frac{I_t}{(g+\delta)} \tag{12}$$

where g is the long-run growth rate proxied by the average annual growth rate of the real GDP.

Optimally, depreciation rates data is obtained from surveys on the industry level or from the guidelines to tax schedules. For the aggregate capital stock a rate of 4-6% is usually assumed. Obviously, these rates differ across time and space.

3.1 Estimation of the Shares of Inputs

The shares of inputs in income play a major role in the debate of what drives economic growth. Many methods for evaluating the shares of inputs in income have been proposed, however, none has been found adequate. One way to measure the shares of inputs in income is using the national accounts to find the compensation to labor and capital out of the national income. In this paper we question the appropriateness of using national accounts due to serious difficulties in allocating income of self-employed workers between the returns to capital and labor.

A widely used method for gauging the shares in income is using a priori measures in the order of 0.30-0.40 for the share of capital. Some economists who have broadened the definition of capital to include human capital, externalities and R&D have taken even higher values.[6]

Many economists have evaluated the shares of inputs through direct estimation of a Cobb-Douglas production function in a log-linear form:[7]

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[6] For example, Mankiw et al. (1992) used a share of 2/3 and Barro et al. (1995) use an even higher one (0.75).

$$\ln Y_t = a + \alpha \ln K_t + \beta \ln L_t + \varepsilon_t \qquad a = \ln A \tag{13}$$

This method is often associated with econometric problems of simultaneity, multicollinearity, and heteroskedasticity. Such violations of the assumptions of the ordinary least squares result in dubious estimates. One variation of this method that incorporates the assumption of constant returns to scale is to estimate the intensive form of the production function:[8]

$$Ln(y_t) = a + \alpha Ln(k_t) + \varepsilon_t \tag{14}$$

We advocate applying the direct estimation of the production function to panel data. Such a method is applicable when the countries considered share some economic characteristics and are likely to have similar production functions as is the case for OECD countries. By combining time series and cross-section data we utilize the information embodied in both dimensions. Combining space and time dimensions provides us with a larger sample, thereby increasing degrees of freedom and reducing co-linearity among explanatory variables. Furthermore, the scope of issues that can be addressed using panel data is much broader. Additionally, it is possible to account for country-specific factors through the introduction of dummy variables for each country or through the adoption of panel data techniques that allow for variations among cross-section members (especially the fixed effects technique).

We consider several specifications of the production function in order to estimate the shares of inputs. The first is a production function with physical capital and labor as the only inputs. In this case the estimated regression is:

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[7] Another commonly used function is the CES. See Duffy and Papageorgiou (2000) for the merits of CES as opposed to Cobb-Douglas.

[8] Some researchers estimate the intensive form of the production function in first difference to eliminate possible unit roots in levels. However, this approach does not capture the valuable information embodied in levels, by removing the low frequencies in the data and emphasizing short-term fluctuations.

$$Ln(Y_t^i) = a^i + \alpha Ln(K_t^i) + \beta Ln(L_t^i) + \varepsilon_t^i; \quad i = 1,2,..., N \tag{15}$$

where *i* is a cross-section index. Alternatively, we can estimate the intensive form of the production function under the assumption of constant returns to scale:

$$Ln(y_t^i) = a^i + \alpha Ln(k_t^i) + \varepsilon_t^i \tag{16}$$

The second specification is to incorporate human capital as an input in the production function. We distinguish between two cases: human capital embodied in labor and human capital as a stand-alone input. When human capital is embodied in labor, we consider two specifications; one with and one without the assumption of constant returns to scale (equations 17 and 18):

$$Ln(Y_t^i) = a^i + \alpha Ln(K_t^i) + \beta Ln(L_t^i H_t^i) + \varepsilon_t^i \tag{17}$$

$$Ln(\tilde{y}_t^i) = a^i + \alpha Ln(\tilde{k}_t^i) + \varepsilon_t^i \qquad \tilde{y} = \frac{Y}{LH}; \tilde{k} = \frac{K}{LH} \tag{18}$$

where a ~ on top of a variable denotes that variable in terms of per skill-adjusted units of labor.

Our last specification treats human capital as a distinct input. In this specification, the equations to be estimated are the unrestricted equation (equation 19) and equation (20) in which the production function is characterized by constant returns to scale:

$$Ln(Y_t^i) = a^i + \alpha Ln(K_t^i) + \beta Ln(L_t^i) + \gamma Ln(H_t^i) + \varepsilon_t^i \tag{19}$$

$$Ln(y_t^i) = a^i + \alpha Ln(k_t^i) + \gamma Ln(h_t^i) + \varepsilon_t^i \tag{20}$$

For each of the above specifications we estimate the production function in four different ways. First, we estimate the model under the assumption that all the 23 OECD countries in our sample share the same intercept (a^i) in equations (15)-(20). Second, we estimate the model with cross-sectional fixed effects. Here, every country is assumed to have a different intercept to reflect country-specific characteristics that are constant over time. The fixed effects model is estimated when there is reason to believe that the unobserved effect a^i is correlated with the explanatory variables. Third, we estimate a two-way fixed effects model that incorporates both cross-sectional and time fixed effects. Fourth, we estimate a model with random effects under the assumption of a lack of correlation of the unobserved a^i with each k^i in all time periods.

The choice between fixed and random effects is governed by the results of the Hausman test. This test assesses whether the unobserved effect a^i is correlated with k^i or not. Additionally, we address the likely endogeneity of the explanatory variables by using the Two-Stage Least Squares (2SLS) method where the instruments are the two-period lagged explanatory variables. Last, the Sargan test for over-identifying restrictions is used to assess the validity of the instruments.

4. Data Sources

Our principal data source is the newly released Penn World Tables (PWT) version 6.2 that is available online from the Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania. The data covers the period 1950-2004 for 23 OECD countries. Monetary values are expressed in 2000 international dollars. The period 1950-1959 was used only for estimating the initial capital stock and constructing the capital stock series. Data on labor force was generated from the PWT per worker, per capita, and population series. Human capital data is confined to education and proxied by the average years of schooling adjusted to the return of the various education levels. Our main source of human capital data is Collins and Bosworth (1996) which is supplemented by data from Barro and Lee (2001). All growth rates were calculated by regressing the natural logarithm of the respective variable on a constant and time trend. Doing so, we avoid relying on few observations that are volatile and use all the observations in the relevant period.

5. Results

The first step in the growth accounting exercise is to construct a series of physical capital stock from investment flows using PIM. All our calculations are based on a depreciation rate of 6% . We began with 4 and 5% rates but these rates generated no significant changes to our estimates of inputs shares in income and the *K* growth rates. The average capital-output ratio observed in the series is 2.48 which is in line with previous studies of developed countries.

Tables 1-3 report the estimated shares of inputs in national income over the period 1960-2003 under several specifications of the production function. Table 1 presents our estimates under the assumption of two production inputs: physical capital and labor with and without assuming constant returns to scale. Under all our estimation methods, the share of capital exceeds 0.50. Since the Hausman test implies that the unobserved effects are correlated with the error term, the fixed effects model is preferred. Redundancy tests of the fixed effects indicate that including both cross-sectional and time-fixed effects is justified. To address the likely endogeneity of *K* and *L*, we use their two-period lags as instruments in the 2SLS model. The Sargan test for overidentifying restrictions verifies the validity of our instruments. We find that the shares of physical capital for the two-way fixed effects OLS model and the two-way fixed effects 2SLS model are identically 0.51, while the shares of labor are 0.23 and 0.24, respectively. Contrary to the majority of studies, we reject the constant returns to scale hypothesis at the 1% significance level. Estimating under the assumption of CRS yields a share of 0.53 for capital. Thus, in the absence of human capital we prefer using the 2SLS model.

Incorporating human capital into the production function is done either as embodied in labor or as a stand-alone input. The results of the estimated shares in income when human capital is embodied in labor are presented in Table 2. Surprisingly, the share of physical capital is not altered; it equals 0.51 in the 2SLS model and 0.52 in the two-way fixed effects OLS, whereas the share of skill-adjusted labor equals 0.22 in the 2SLS model. We find no support for CRS since the hypothesis of sum of the coefficients of *K* and *HL* equaling unity is rejected.

Including human capital as a stand-alone production factor does not lead to changes in our estimate of the share of physical capital (Table 3). Once again, we get a share of 0.51. However, we obtain a share of 0.27 for human capital and 0.20 for labor. The hypothesis of CRS cannot be rejected. This leads us to believe that constant returns to scale holds true only when one incorporates human capital as a stand-alone production factor.

To sum up our estimations of the shares of inputs, we find that the value of the share of physical capital is very robust to changes in the specification of the production function. A share of 0.51 is found in all our specifications. Our estimates far exceed the official OECD estimates, the GGDC estimates, and the conventional share used by many researchers. However, our results conform to Romer's (1987) and Senhadji's (2000) results who contended that the "true" share is much higher than previously believed.

We also examined the effect of the first oil shock on the magnitude of the shares of inputs.[9] We split our sample into pre and post 1973 and we find that the share of physical capital went down from 0.62 before 1973 to 0.46 after 1973 while the share of human capital increased from 0.12 to 0.34.[10] No significant change was observed in the share of labor. These findings imply that the oil shock led to structural changes under which more investments were directed towards accumulating human capital. Another factor that can explain the fall of the share of physical capital and the rise of the share of human capital is the steady growth of the weight of

[9] Bentolila and Saint-Paul (2003) challenge the stylized fact of constancy of the input shares in income and provide evidence for a strong relationship between the labor share and the capital-output ratio.

[10] Results are drawn from the two-way fixed effects 2SLS model with a stand-alone human capital.

skilled-labor services in the total output. The share of services in GDP rose from 55% in 1973 to 72% in 2003, and the share of services in total employment rose from 58% in 1980 to 70% in 2002.[11]

Once we estimated the shares of inputs in income we proceed to conduct the growth accounting exercise. The results for the decomposition of output into the contributions of inputs and TFP over the period 1960-2003 for several specifications of the production function are presented in Tables 4-6. Table 4 reports the contributions of inputs and TFP under the assumption of no human capital in the production function. Accumulation of physical capital is found to be the dominant determinant of growth while the role of TFP in the performance of most OECD countries is marginal. The contribution of TFP varies between countries and ranges between 0.16% for Switzerland to 1.69% per annum for Ireland. On average, a mere 0.96% of OECD annual growth of 3.29% is attributed to TFP while accumulation of physical capital accounts for 2.01%.

Incorporating human capital in the production function leads to a lower contribution of TFP for all countries, except for Australia. Our estimates of TFP growth for the two specifications of human capital, both embodied in labor (Table 5) and as a stand-alone factor (Table 6), are practically identical. For the stand-alone specification we find that TFP grew on average by 0.87% per annum which constitutes about 26% of GDP growth of OECD members while physical capital, labor, and human capital accounted for 61%, 6%, and 26%, respectively. Our estimates of TFP are, in general, lower than those obtained by Jorgenson and Yip (2001) as well as the official estimates appearing in the OECD productivity database. When applying the average physical capital shares calculated from the OECD productivity database (Figure 2) we

[11] Based on the online database of World Development Indicators.

find that our estimates of TFP growth over the period 1960-2003 are lower for all countries with the exceptions of Australia, Canada, and New Zealand. While we estimate the average annual OECD TFP growth at 0.86%, using the shares from the OECD database results in an estimate of 1.32%. These results are expected in the light of the significantly higher share of capital that emerges from our estimations.

Now, we reexamine the well-documented slowdown in TFP following the first major oil shock in 1973 and the possible rebound in the mid-90s[12]. Table 7 presents the average GDP and TFP growth during the periods 1960-1973, 1973-1995, and 1995-2003. The TFP figures are based on our estimated shares, and on the reported shares in the OECD productivity database (OPD). Prior to 1973, OECD members experienced high growth rates that ranged from 3% for the UK case to 9.68% for Japan. Of the average 5.88% annual growth in GDP, about 1% is attributed to productivity gains when our shares are used, while the contribution of TFP rises to 2.69% based on OPD. According to our calculations, the gains in productivity varied greatly and ranged from -0.42% for UK to an impressive 1.65% for Canada. The slowdown in economic activity after 1973 was experienced in all the countries in our sample, although to different extents. On average, GDP growth dropped from 5.88% to 2.43% and the variation between the growth rates of the members declined greatly. While the decline in GDP growth was across the board, the decline in TFP was not shared by seven out of the 23 economies, based on our estimates but was experienced by all the countries based on OPD. Overall, OECD experienced a modest decline in productivity from 0.99% to 0.71%. However, when using OPD shares TFP plummeted from 2.69% to 0.86%. The considerable difference between our estimates and the

[12] Jimeno et al. (2006) find that, unlike for the US, labor productivity and TFP for EU countries decelerated since the mid-90s.

OPD-based of TFP, as illustrated in figures 3 and 4, originates from our previous findings in which the post-1973 shares of capital were much lower than those before 1973. Earlier studies that did not account for the decline in the share of physical capital and the rise of the share of human capital are likely to have overestimated the decline in TFP since it attached a higher weight for physical capital in the post-1973 period.[13]

Another issue that we reexamine is the rebound in productivity since the mid-90s. A look at Table 7 and Figures 3 and 4 does not provide us with a clear conclusion regarding a possible rebound of economic activity; seven of the 23 countries continued to experience the post-1973 low GDP growth rates. The picture that emerges from looking at our estimates of TFP after 1995 resembles mixed results, as well. Seven countries, including the US, continued to suffer from low productivity gains. Two countries, Japan and Turkey, even recorded negative TFP growth of -0.55% and -0.69%, respectively. An interesting finding is that contrary to what earlier studies (Nordhaus, 2004) have argued, the US economy did not experience a rise in TFP growth (0.75% after 1995 compared with 0.93 before 1995), although its GDP grew at a faster pace. Despite the fact that some of the European countries experienced a decline in TFP growth after 1995, our study fails to identify the existence of a significant shift to lower productivity as asserted by Jemino-Serrano et al. (2006). When considering the OPD estimates of TFP after 1995, we find that five members (Germany, Italy, Japan, Portugal, and Turkey) experienced a decline in TFP while the rest recorded higher productivity growth relative to the pre-1995 period. Moreover, although TFP growth increased from 1.07% to 1.34% in the US, the magnitude of the change does not justify labeling the post-1995 period a period of rebound.

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[13] The contribution of human capital to growth is minor in all countries. Thus, taking a higher share of physical capital translates to lower TFP.

The outstanding performance of several economies since the mid-90s is worth mentioning. In the lead was Ireland who experienced remarkable growth that was coupled with a sharp rise in overall productivity. Ireland's economy grew since 1995 at a rate of 8.28% while gains in productivity contributed 4.48% per annum. Other fast growing economies include Finland, Greece, Sweden, and Iceland.

5. Summary and Concluding Remarks

In this paper we reassess the conventional measure of the physical capital share in income. Instead of using an arbitrary share of one third or relying on national accounts, we employ panel data techniques to estimate the shares of inputs in national income for 23 OECD countries over the period 1960-2003. Several specifications of the production function and the econometric settings were considered. In almost all of our specifications we found a share of physical capital that exceeds 0.50 which is higher than the national accounts-based estimates. Moreover, we found that following the first major oil shock in 1973, the share of physical capital dropped from about 0.62 to 0.46 while the share of human capital increased from 0.12 to 0.34. These developments may reflect a movement away from physical capital-intensive goods towards human capital-intensive services.

The higher shares of physical capital were generally found to result in lower estimates of TFP growth than is reported in the OECD productivity database. Of the average growth of OECD members during the period 1960-2003 of 3.29%, our calculations indicate a TFP growth of 0.87% while OPD estimates puts it at 1.32%. Additionally, we used our estimates of the shares to reexamine the magnitude of the productivity slowdown following the oil crisis of 1973. The slowdown is evident in GDP growth which dropped from an annual average of 5.88% prior to 1973 to 2.43% during 1973-1995. Our results also show that the decline in TFP was lower than what previous studies have reported. According to our estimates, TFP growth dropped from an annual average of 0.99% prior to the oil crisis to 0.71% after it. Our evidence regarding the apparent rebound in productivity since the mid-90s is mixed. Interestingly, we do not find support for a sharp rise in productivity for the US.

In general, we showed that using the conventional share of capital in the case of OECD countries leads to an understatement of the contribution of accumulating resources alongside an overstatement of the contribution of productivity. Thus, using the conventional share may distort our understanding of the proximate determinants of economic growth, and consequently, mislead policymakers in their quest for sustained growth. As a remedy, we propose utilizing the available data and advanced panel data techniques to estimate the shares of inputs in income for relatively homogenous groups of countries such as OECD. In the future as longer samples become available, the use of time series techniques to estimate country-specific production functions could prove fruitful.

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Table 1 – Shares of Inputs (Without Human Capital), 1960-2003

Method	Elasticity of K	Elasticity of L	$\overline{R}^2$	Redundancy Test[a]	Hausman Test[b]	Sargan Test[c]
		Production Function: $Y = AK^{\alpha}L^{\beta}$				
Pooling	0.64	0.38	0.99			
	(0.00)	(0.00)				
One-way fixed effects	0.67	0.41	0.99	78.07		
	(0.00)	(0.00)		(0.00)		
Two-way fixed effects	0.51	0.23	0.99	43.33		
	(0.00)	(0.00)		(0.00)		
Random effects	0.68	0.36	0.97		9.83	
	(0.00)	(0.00)			(0.01)	
2SLS (two-way fixed effects)	0.51	0.24	0.99			62.8
	(0.00)	(0.00)				(0.00)
		Production Function: $y = Ak^{\alpha}$				
Pooling	0.64	0.36	0.92			
	(0.00)					
One-way fixed effects	0.70	0.30	0.97	86.17		
	(0.00)			(0.00)		
Two-way fixed effects	0.54	0.46	0.98	42.64		
	(0.00)			(0.00)		
Random effects	0.70	0.30	0.91		5.34	
	(0.00)				(0.02)	
2SLS (two-way fixed effects)	0.53	0.47	0.98			13.9
	(0.00)					(0.00)

Notes:

[a] Tests the hypothesis that the estimated fixed effects are jointly significant using F test statistics.

[b] Tests the hypothesis that the random effects are correlated with the explanatory variables. The statistic is distributed $\chi^2(m)$ where *m* is the number of explanatory variables.

[c] Tests the hypothesis that the instrumental variables are uncorrelated with the residuals. The statistic is distributed $\chi^2(m-r)$ where *m-r* is the number of instruments minus the number of endogenous variables.

Table 2 – Shares of Inputs (With Human Capital), 1960-2003

Method	Elasticity of K	Elasticity of LH	$\bar{R}^2$	Redundancy Test[a]	Hausman Test[b]	Sargan Test[c]
		Production Function: $Y = AK^{\alpha}(LH)^{\beta}$				
Pooling	0.57	0.45	0.99			
	(0.00)	(0.00)				
One-way	0.63	0.37	0.99	80.93		
fixed effects	(0.00)	(0.00)		(0.00)		
Two-way	0.52	0.23	0.99	42.38		
fixed effects	(0.00)	(0.00)		(0.00)		
Random effects	0.63	0.39	0.98		5.38	
	(0.00)	(0.00)			(0.07)	
2SLS (two-way	0.51	0.22	0.99			10.90
fixed effects)	(0.00)	(0.00)				(0.00)
		Production Function: $\tilde{y} = A\tilde{k}^{\alpha}$				
Pooling	0.57	0.43	0.90			
	(0.00)					
One-way	0.64	0.36	0.97	89.68		
fixed effects	(0.00)			(0.00)		
Two-way	0.57	0.43	0.97	39.52		
fixed effects	(0.00)			(0.00)		
Random effects	0.63	0.37	0.91		6.10	
	(0.00)				(0.01)	
2SLS (two-way	0.56	0.44	0.97			15.60
fixed effects)	(0.00)					(0.00)

Notes:

[a] Tests the hypothesis that the estimated fixed effects are jointly significant using F test statistics.
[b] Tests the hypothesis that the random effects are correlated with the explanatory variables. The statistic is distributed $\chi^2(m)$ where *m* is the number of explanatory variables.
[c] Tests the hypothesis that the instrumental variables are uncorrelated with the residuals. The statistic is distributed $\chi^2(m-r)$ where *m-r* is the number of instruments minus the number of endogenous variables.

Table 3 – Shares of Inputs (With Human Capital), 1960-2003

Method	Elasticity of K	Elasticity of L	Elasticity of H	$\overline{R}^2$	Redundancy Test[a]	Hausman Test[b]	Sargan Test[c]
			Production Function: $Y = AK^{\alpha}L^{\beta}H^{\gamma}$				
Pooling	0.57	0.45	0.48	0.99			
	(0.00)	(0.00)	(0.00)				
One-way	0.63	0.31	0.56	0.99	82.29		
fixed effects	(0.00)	(0.00)	(0.00)		(0.00)		
Two-way	0.52	0.21	0.29	0.99	42.36		
fixed effects	(0.00)	(0.00)	(0.00)		(0.00)		
Random effects	0.62	0.38	0.46	0.98		13.95	
	(0.00)	(0.00)	(0.00)			(0.00)	
2SLS (two-way	0.51	0.20	0.27	0.99			41.38
fixed effects)	(0.00)	(0.00)	(0.00)				(0.00)
			Production Function: $y = Ak^{\alpha}h^{\gamma}$				
Pooling	0.64	0.38	-0.02	0.93			
	(0.00)		(0.00)				
One-way	0.69	0.32	-0.01	0.98	88.57		
fixed effects	(0.00)		(0.77)		(0.00)		
Two-way	0.52	0.21	0.27	0.98	51.95		
fixed effects	(0.00)		(0.00)		(0.00)		
Random effects	0.69	0.33	-0.02	0.93		4.45	
	(0.00)		(0.07)			(0.10)	
2SLS (two-way	0.51	0.20	0.29	0.98			35.66
fixed effects)	(0.00)		(0.00)				(0.00)

Notes:

[a] Tests the hypothesis that the estimated fixed effects are jointly significant using F test statistics.

[b] Tests the hypothesis that the random effects are correlated with the explanatory variables. The statistic is distributed $\chi^2(m)$ where *m* is the number of explanatory variables.

[c] Tests the hypothesis that the instrumental variables are uncorrelated with the residuals. The statistic is distributed $\chi^2(m-r)$ where *m-r* is the number of instruments minus the number of endogenous variables.

Table 4 – Sources of Growth – Without Human Capital, 1960-2003

Country	Growth of GDP (%)	Contribution of (%)		
		K	L	TFP
Australia	3.50	1.86	0.49	1.15
Austria	3.01	2.04	0.10	0.88
Belgium	2.74	1.58	0.11	1.05
Canada	3.35	2.01	0.54	0.80
Denmark	2.16	1.40	0.20	0.56
Finland	2.74	1.56	0.15	1.03
France	2.95	1.97	0.17	0.80
Germany	2.10	0.66	0.10	1.33
Greece	3.05	2.00	0.23	0.81
Iceland	3.69	1.97	0.49	1.23
Ireland	4.25	2.33	0.23	1.69
Italy	2.87	1.60	0.14	1.14
Japan	4.33	3.43	0.24	0.66
Netherlands	2.74	1.42	0.36	0.96
New Zealand	2.19	1.26	0.45	0.48
Norway	3.52	1.54	0.30	1.68
Portugal	3.89	2.58	0.29	1.01
Spain	3.46	2.41	0.26	0.79
Sweden	2.10	1.17	0.23	0.70
Switzerland	1.92	1.52	0.24	0.16
Turkey	4.36	3.34	0.49	0.52
United Kingdom	2.36	1.58	0.12	0.66
United States	3.25	1.89	0.39	0.97
OECD	**3.29**	**2.01**	**0.32**	**0.96**

Notes:
Contributions are based on the estimated shares of 0.51 for physical capital and 0.24 for labor.

Table 5 – Sources of Growth – Human Capital Embodied in Labor, 1960-2003

Country	Growth of GDP (%)	Contribution of (%)			
		K	L	H	TFP
Australia	3.50	1.86	0.45	0.05	1.13
Austria	3.01	2.04	0.09	0.04	0.85
Belgium	2.74	1.58	0.10	0.07	0.99
Canada	3.35	2.01	0.49	0.11	0.73
Denmark	2.16	1.40	0.18	0.03	0.54
Finland	2.74	1.56	0.14	0.20	0.84
France	2.95	1.97	0.16	0.10	0.72
Germany	2.10	0.66	0.10	0.07	1.27
Greece	3.05	2.00	0.21	0.17	0.67
Iceland	3.69	1.97	0.45	0.12	1.16
Ireland	4.25	2.33	0.21	0.13	1.58
Italy	2.87	1.60	0.13	0.09	1.06
Japan	4.33	3.43	0.22	0.09	0.60
Netherlands	2.74	1.42	0.33	0.15	0.84
New Zealand	2.19	1.26	0.41	0.10	0.41
Norway	3.52	1.54	0.28	0.22	1.49
Portugal	3.89	2.58	0.27	0.17	0.86
Spain	3.46	2.41	0.24	0.16	0.66
Sweden	2.10	1.17	0.21	0.12	0.60
Switzerland	1.92	1.52	0.22	0.11	0.07
Turkey	4.36	3.34	0.45	0.16	0.40
United Kingdom	2.36	1.58	0.11	0.09	0.58
United States	3.25	1.89	0.36	0.14	0.86
OECD	**3.29**	**2.01**	**0.30**	**0.12**	**0.87**

Notes:
Contributions are based on the estimated shares of 0.51 for physical capital and 0.22 for labor and human capital.

Table 6 – Sources of Growth – Stand-alone Human Capital, 1960-2003

Country	Growth of GDP (%)	Contribution of (%)			
		K	L	H	TFP
Australia	3.50	1.86	0.41	0.07	1.16
Austria	3.01	2.04	0.08	0.05	0.85
Belgium	2.74	1.58	0.10	0.09	0.97
Canada	3.35	2.01	0.45	0.15	0.74
Denmark	2.16	1.40	0.17	0.04	0.55
Finland	2.74	1.56	0.12	0.26	0.79
France	2.95	1.97	0.14	0.13	0.70
Germany	2.10	0.66	0.09	0.10	1.25
Greece	3.05	2.00	0.19	0.22	0.63
Iceland	3.69	1.97	0.41	0.15	1.16
Ireland	4.25	2.33	0.19	0.17	1.56
Italy	2.87	1.60	0.12	0.12	1.04
Japan	4.33	3.43	0.20	0.11	0.59
Netherlands	2.74	1.42	0.30	0.20	0.82
New Zealand	2.19	1.26	0.38	0.14	0.42
Norway	3.52	1.54	0.25	0.29	1.44
Portugal	3.89	2.58	0.24	0.23	0.83
Spain	3.46	2.41	0.22	0.21	0.63
Sweden	2.10	1.17	0.19	0.15	0.58
Switzerland	1.92	1.52	0.20	0.14	0.06
Turkey	4.36	3.34	0.41	0.21	0.39
United Kingdom	2.36	1.58	0.10	0.12	0.56
United States	3.25	1.89	0.33	0.19	0.84
OECD	**3.29**	**2.01**	**0.27**	**0.15**	**0.86**

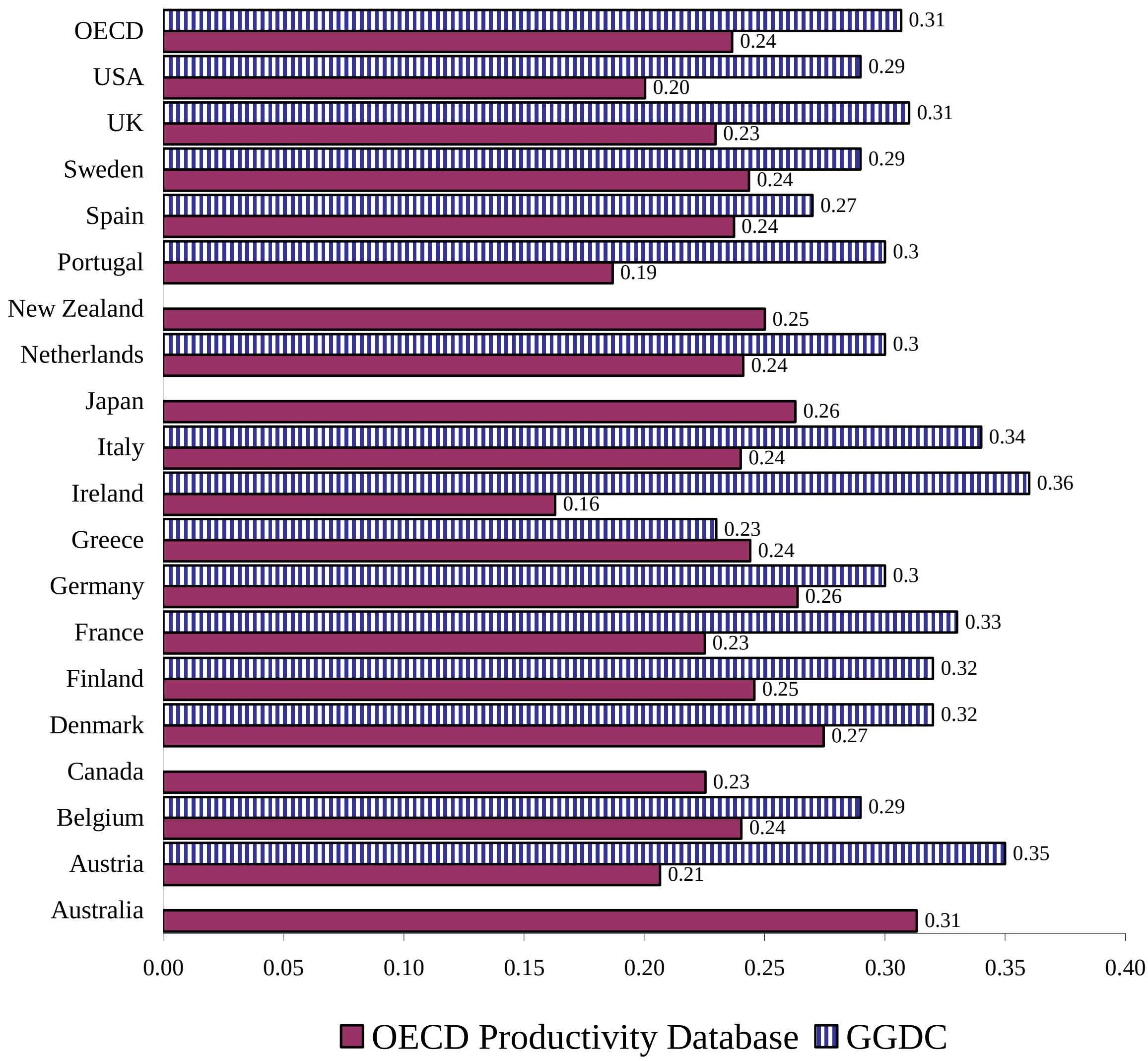
Notes:
Contributions are based on the estimated shares of 0.51 for physical capital, 0.20 for labor and 0.29 for human capital.

Table 7 – GDP and TFP Growth (%)

Period	60-73			73-95			95-03		
Country	GDP Growth	TFP Growth		GDP Growth	TFP Growth		GDP Growth	TFP Growth	
		Ours	OPD*		Ours	OPD*		Ours	OPD*
Australia	5.21	1.33	1.74	3.06	1.16	0.65	3.75	1.36	1.45
Austria	4.83	0.88	3.84	2.41	0.77	1.29	2.27	0.93	1.69
Belgium	4.75	1.46	3.24	2.06	0.77	1.19	2.27	0.81	1.36
Canada	4.98	1.65	1.70	2.69	0.39	0.22	3.87	1.80	2.14
Denmark	4.14	0.15	1.53	1.60	0.65	0.64	2.14	0.57	1.32
Finland	4.44	0.81	2.46	1.91	0.26	0.81	3.81	3.03	3.51
France	5.39	0.84	3.07	2.31	0.67	1.18	2.64	1.11	1.62
Germany	3.76	1.50	2.36	2.16	1.38	1.46	1.54	0.88	1.27
Greece	7.61	1.02	4.99	1.37	0.09	0.05	3.75	2.05	2.38
Iceland	5.09	0.67	1.70	2.89	0.96	0.70	3.89	1.84	2.07
Ireland	4.38	0.69	3.25	3.07	1.09	1.87	8.28	4.48	5.25
Italy	5.05	1.37	3.47	2.35	0.92	1.21	1.71	0.61	1.08
Japan	9.68	0.94	4.93	3.49	0.85	1.48	0.61	-0.55	-0.13
Netherlands	4.95	0.84	2.43	1.98	0.70	0.25	2.72	1.37	1.79
New Zealand	3.47	0.84	0.95	1.47	0.20	-0.40	3.12	1.35	1.49
Norway	4.25	1.32	2.15	3.01	1.25	1.56	2.79	1.38	1.59
Portugal	6.50	1.46	4.81	3.15	0.74	1.40	2.79	0.17	1.31
Spain	6.87	0.86	4.01	2.36	0.40	0.68	3.86	1.51	1.94
Sweden	3.70	0.49	1.53	1.60	0.49	0.48	2.84	1.88	2.20
Switzerland	4.23	0.07	1.73	1.69	0.26	0.21	1.55	0.65	0.87
Turkey	5.55	0.58	2.65	4.08	0.84	1.05	2.15	-0.69	-0.82
UK	3.00	-0.42	1.36	2.12	0.79	1.16	2.97	1.09	1.84
USA	4.32	1.36	2.11	3.01	0.93	1.07	3.25	0.75	1.34
OECD	**5.88**	**0.99**	**2.69**	**2.43**	**0.71**	**0.86**	**2.98**	**1.23**	**1.65**

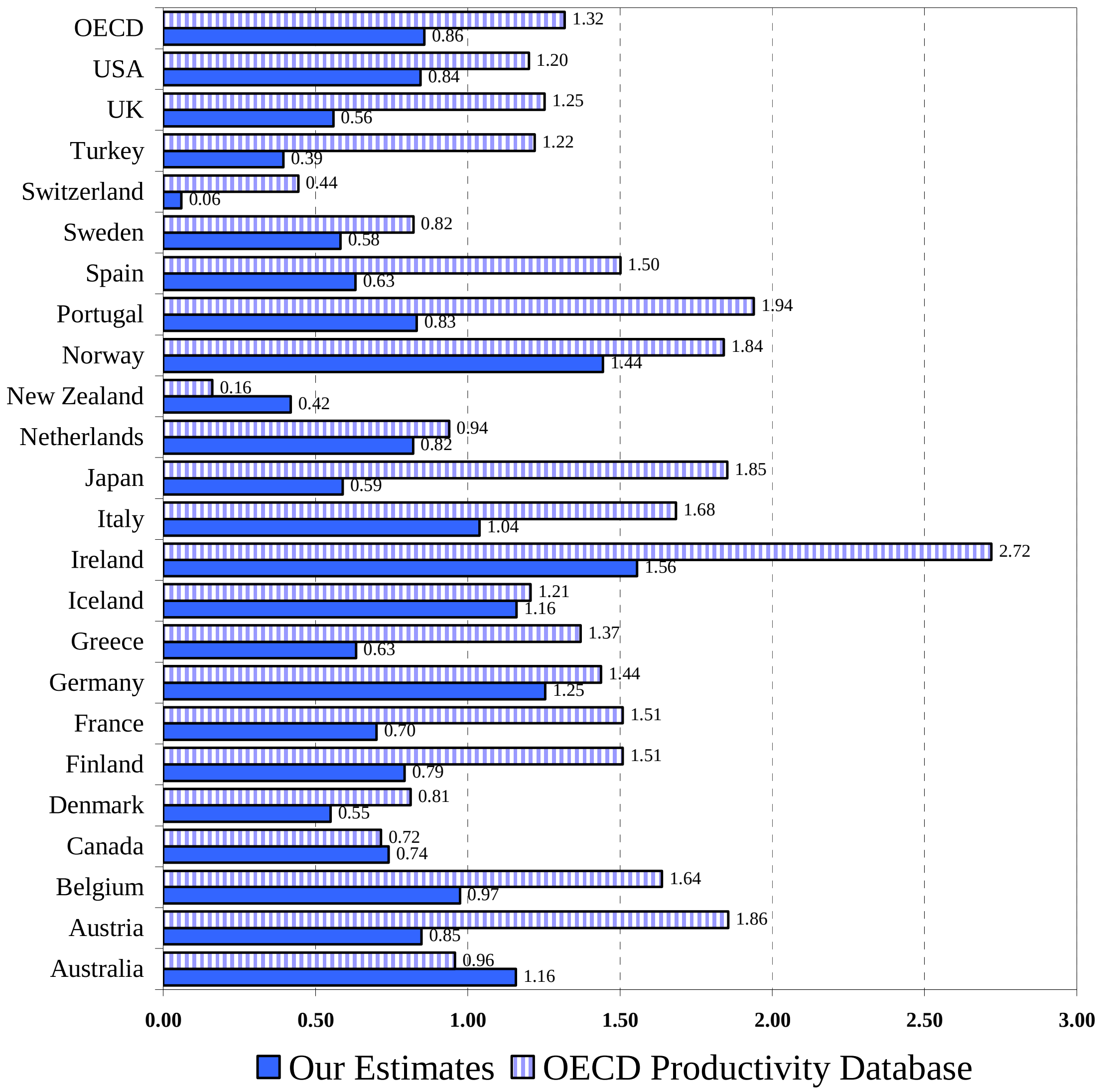
Notes:
* Based on *OECD Productivity Database* average shares.

Figure 1 – Official Average Capital Share (1985-2003) for OECD Countries



Sources: *OECD Productivity Database* (available online at http://www.oecd.org) and the *Total Economy Growth Accounting Database* of the Groningen Growth and Development Centre (GGDC) (available online at http://www.ggdc.net)

Figure 2 – TFP Growth (%), 1960-2003



Source: Our calculations based on: *OECD Productivity Database* (available online at http://www.oecd.org)

Figure 3 – TFP Growth (%), Our Estimates, Various Periods

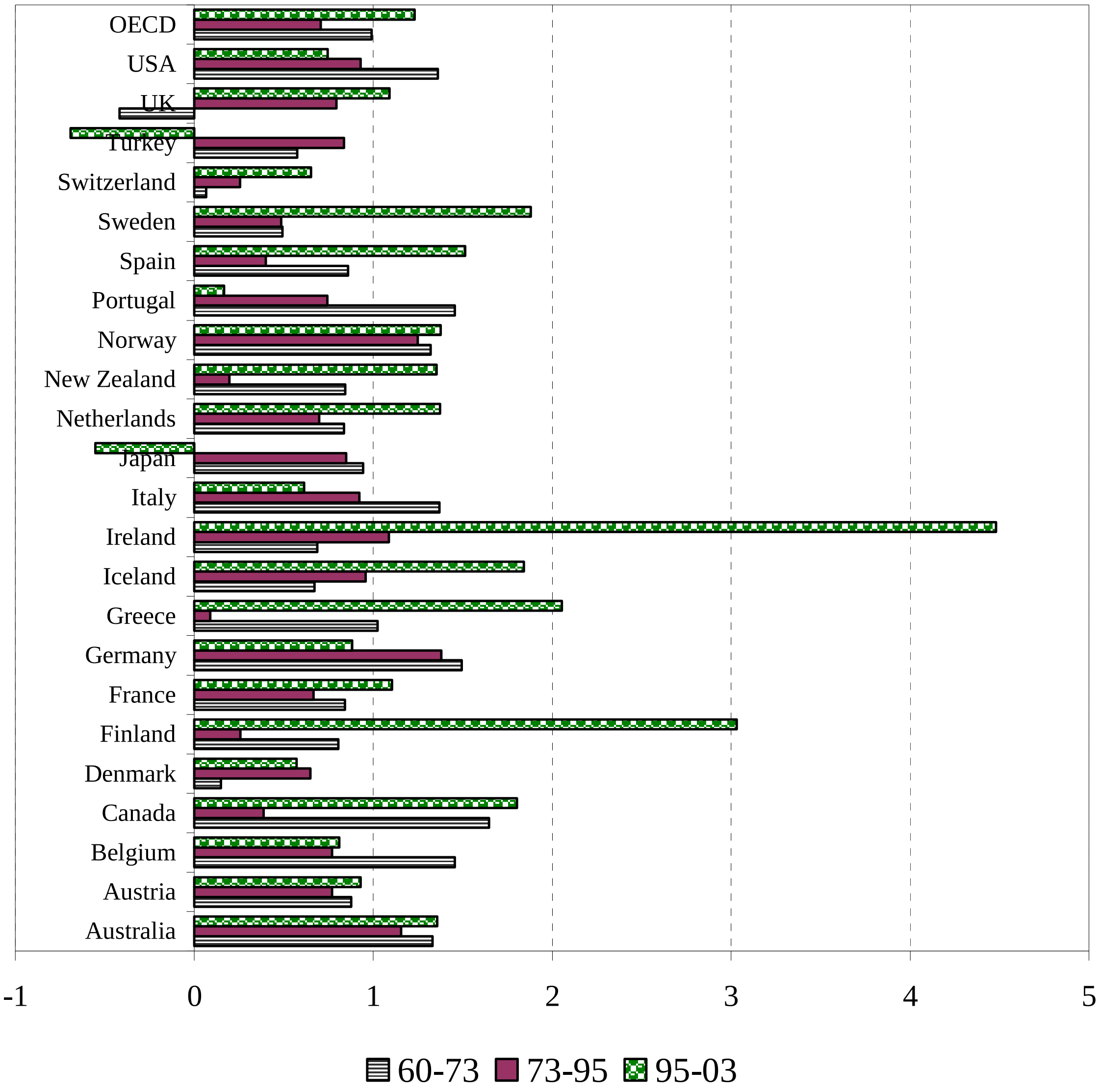
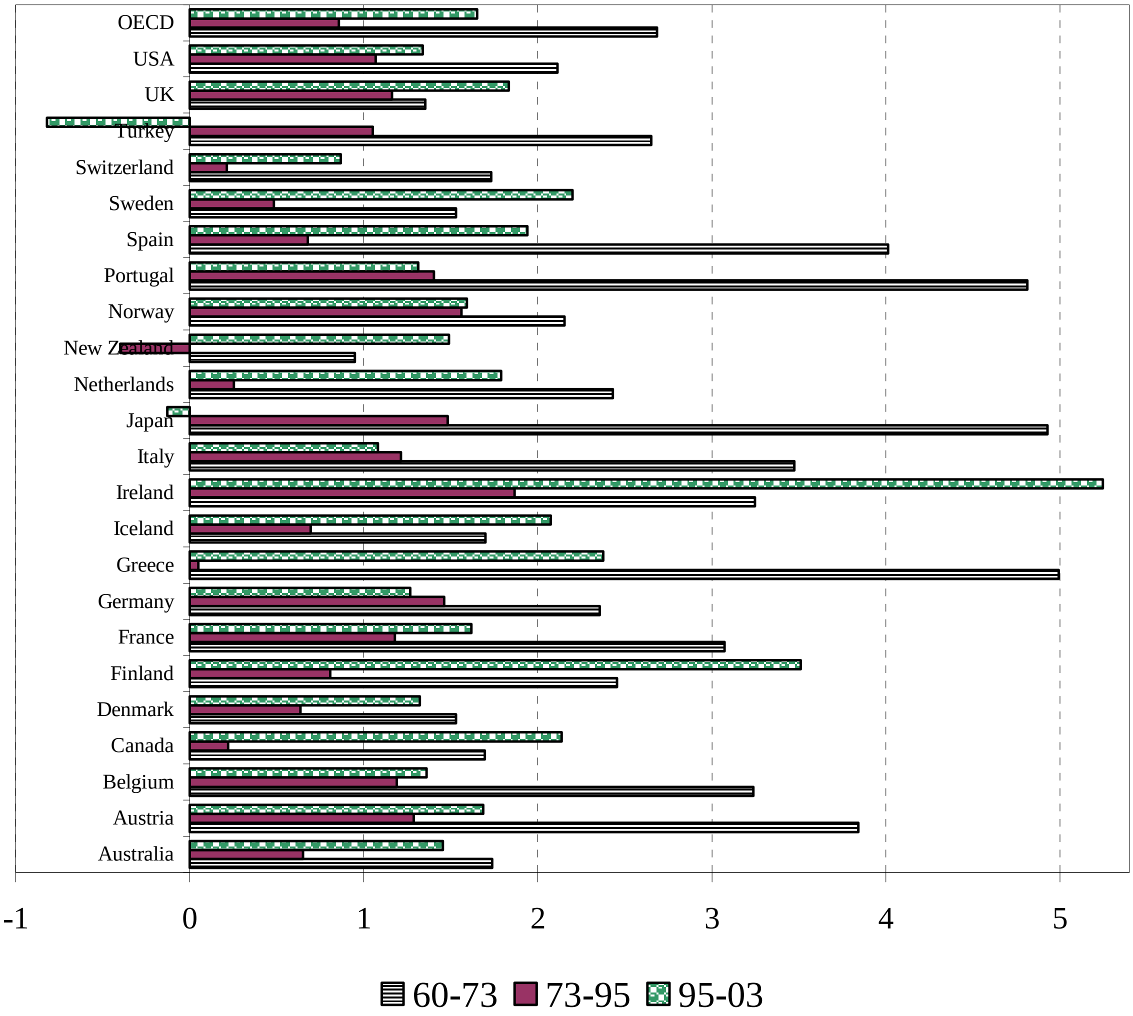


Figure 4 – TFP Growth (%), OECD Productivity Database, Various Periods



Source: our calculations based on: *OECD Productivity Database* (available online at http://www.oecd.org)