

# Twenty Ways to Aggregate Capital

## Does it really Matter for a Study of Economic Growth?

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### Abstract

With the increasing importance of investment in Information Technology, methods for measuring the contribution of capital to growth have assumed center-stage again in growth accounting literature. The importance of using growth of capital services rather than capital stocks has long been advocated, and has become mainstream practice. However, the choice for a particular rate of return in the derivation of capital service prices is not straightforward and has barely been researched.

Using four alternative rental price models – based on both external and internal rates of return models—this paper quantifies differences in capital service and the resultant productivity growth rates under different model assumptions. These differences are examined on two grounds: firstly, the differences when different rental price models are used; and secondly, the differences when allowances are made for the effect of taxes and subsidies in the calculation of rate of return and rental prices.

We have carried out empirical analysis for four European Union countries, in 26 industries, across 6 asset types from 1982 to 2001. The results show that the inclusion of taxes in the rental price formulation has little impact in most industries. Hence, from the empirical point of view, given the dataset, the use of pretax rental prices may not produce significantly different results in most industries. On the other hand, some differences are observed between growth rates generated by external rate of return models versus internal rate of return models. The observed differences, however, are quite meager. Hence, considering the fact that the internal models assure a complete consistency of national income and production accounts, one may prefer the internal rate of return models in calculating capital input rates in a productivity analysis. Nevertheless, the necessity of such conclusion depends on the researcher's discretion on evaluating how “different” is “different”.

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*I am thankful to Bart van Ark, Marcel Timmer and Robert Inklaar for their comments on this paper. I also received useful comments from Gerard Kuper.*

## I. Introduction

Capital is undeniably a major source of growth; it has made an important contribution to differences in growth rates between countries and times (Denison, 1980). With the increasing importance of investment in Information and Communication Technology (ICT), methods for measuring the contribution of capital to aggregate growth have reassumed centre-stage in growth accounting literature. Many recent studies have shown that ICT-capital has contributed significantly to productivity growth (Jorgenson, 2001; van Ark et al., 2002) though the extent of contribution varies across countries. Dividing the total capital into ICT capital and non-ICT capital, studies have attempted to delineate the contribution of these two different components to total growth using the growth accounting framework.<sup>1</sup> One major issue in the quantification of capital's contribution to growth using this framework is related with the measurement of capital input. Though the concept is well defined in theory, empirical measurement has been a longstanding subject of debate.<sup>2</sup> Nevertheless, it has long been advocated and has become mainstream practice that the capital services from an asset, rather than the capital stock, is appropriate for production and productivity analysis. Jorgenson (2001) has argued that the difference between growth in capital services and capital stock represents the improvement in capital quality.<sup>3</sup> The introduction of ICT into a production process is expected to improve the quality of capital significantly, which might enhance labour productivity. The observed improvement in labour productivity in ICT using sectors (van Ark et al., 2002) may be considered to indicate such quality changes, and therefore signifies the importance of reliably estimating capital service flows.

The challenge in measuring capital input for growth accounting is associated with the implicit nature of capital services; the quantity of capital services is not usually directly observable (Harper et al., 1989). Therefore, the empirical researcher has to rely on

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<sup>1</sup> Growth accounting allows the decomposition of total growth into the contribution of the growth of inputs and to a residual factor. This residual is considered to be a depiction of total factor productivity (TFP) and is often called *Solow residual*, as the theoretical premise of this framework is largely derived from Solow (1957).

<sup>2</sup> See the literature on the well-known Cambridge controversy (for example, Harcourt, 1972 and Harcourt and Laing, 1971 and the papers therein).

<sup>3</sup> The premise of this view is that the difference between growth of capital services and capital stock represents the substitution toward assets with higher marginal products. For instance, a shift toward ICT capital increases the quality of capital, as these equipments have relatively high marginal products.

theoretical yardsticks to approximate the capital services. Following the theoretical arguments of Jorgenson (1963), Hall and Jorgenson (1967), and Jorgenson and Grilliches (1967) capital services are usually derived using the estimated capital stock for the individual assets and the relevant user cost or rental price of capital, assuming that flows are in proportion to the stock of assets. However, there are different ways of measuring rental price of capital and thereby of obtaining capital service growth rates. And the selection of any particular measure will significantly influence the calculated growth rates and contributions. The study by Harper et al. (1989) utilizes five alternative rental price models to evaluate the capital aggregation for US manufacturing industries over the 1948-81 period. Their results show significant differences between different models. After examining different performance measures, though empathetic to the approaches based on income identity, they draw no strong conclusions on the matter.

The aim of this paper, in line with Harper et al. (1989), is to understand whether the use of different rental price models in capital service aggregation produce significantly different productivity growth rates in the EU countries. This is important in the context of the recent surge in growth accounting literature that examines the contribution of ICT capital. While Harper et al. (1989) limits their study to the US only, we compare our results across 26 industry groups in four EU countries, over the 1982-2001 period. Also an attempt is made to empirically understand the impact of including tax in the cost of capital equation on the growth rates of capital and thereby productivity. It has been argued that tax plays a major role in altering investment behavior (Hall and Jorgenson, 1967), and therefore, taxation has to be incorporated in the measurement of capital service prices. However, most studies in the context of the EU have considered pretax rental prices in order to arrive at capital service growth rates. Thus this study examines the sensitivity of final growth estimates for capital services and total factor productivity, with respect to different measures of capital service aggregation.

The paper is organized into seven sections. In Section 2 we present a brief discussion on the analytical literature concerning growth accounting and capital aggregation. In Section 3 we discuss rental price formulation in brief, and in Section 4 we discuss different rates of return models used in deriving rental prices. Section 5 briefly discusses the data used

in the study. Empirical results are discussed in Section 6, and finally Section 7 concludes the paper.

## II. Growth Accounting and Capital Aggregation<sup>4</sup>

Growth accounting framework assumes total growth as a sum of weighted input growth and productivity. Assuming a competitive market and constant returns to scale, one may write the aggregate production function, with value-added as output (Q) and labor (L) and capital (K) as inputs, as

$$Q_t = A_t f_t(L_t, K_t) \quad (1)$$

where the subscript t stands for time t, and A denotes the technical progress or the TFP. Then assuming a translog approximation, the growth accounting equation may be written as,

$$\Delta \ln Q_t = a_{(t, t-1)} \Delta \ln L_t + (1 - a_{(t, t-1)}) \Delta \ln K_t + \ln \Delta A_t \quad (2)$$

where  $a_{(t, t-1)}$  is the share of labor in value-added averaged over the two time periods, t and t-1, and  $\Delta$  represents the change over previous year. Equation (2) clearly shows that output growth is measured as a weighted sum of growth of labor and capital flows, where the weights are the share of each input in the value added. Similarly, growth in aggregate inputs may be calculated as the cost share weighted sum of growth of inputs (Jorgenson et al., 1987). In the case of labor such weights may be derived from the wage rates. The absence of an observable service price, however, makes it difficult to directly measure aggregate capital growth rates.

Capital stock consists of different types of heterogeneous assets, associated with specific capital service flows, making it essential that some kind of aggregation exists in order to employ equation (2). Assuming a strict proportionality between capital services and capital stocks at the level of individual assets, Jorgenson (1963) and Jorgenson and Grilliches (1967) have developed aggregate capital service measures that take into account the heterogeneity of assets. In accordance with their aggregation procedure, the growth rate of aggregate capital may be measured as

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<sup>4</sup> See OECD (2001 a and b)-both capital and productivity manuals- for detailed discussion on both these issues. Also see Hulten (2000) for detailed discussion on issues regarding productivity measurement.

$$\Delta \ln K_t = \sum_{i=1}^n \alpha_{i(t,t-1)} \Delta \ln K_{it} \quad (3)$$

where  $\alpha_{i(t,t-1)} = (\alpha_{it} + \alpha_{it-1}) / 2$  and  $\alpha_{it} = P_{it} K_{it} / \sum_{i=1}^n P_{it} K_{it}$

where  $n$  is the total number of assets,  $P_{it}$  is the rental price of  $i^{\text{th}}$  capital asset in year  $t$ ,  $K_{it}$  is the capital stock of  $i^{\text{th}}$  asset in year  $t$ , and  $\alpha_{it}$  is the rental price share for  $i^{\text{th}}$  asset in year  $t$ . It is evident from (3) that the two important components of capital service measure are capital stock and the service prices (rental price) of capital.<sup>5</sup> Hence, though the relevant measure of capital input in the productivity analysis is the flow of capital services, it is essential to have consistent measures of capital stock in productivity analyses in order to practically estimate capital service flows. The usual practice of measuring capital stock is based on a perpetual inventory method, i.e.

$$K_{it} = (1 - \delta_i) K_{it-1} + I_{it} \quad (4)$$

where  $\delta_i$  is the rate of depreciation for the  $i^{\text{th}}$  capital asset.  $K_{it}$  is the beginning of year constant capital stock, and  $I_{it}$  is the constant investment in asset  $i$  installed in the beginning of period  $t$ . Thus using (3) and (4) the change in aggregate capital service flow may be measured as a weighted sum of the changes in the  $n$  asset specific capital stocks, where the weights are the relative cost shares.<sup>6</sup> The remaining task, therefore, is to construct appropriate measures of capital service prices ( $P_{it}$ ) - rental prices or user cost of capital-, in order to derive the relative cost shares.

### III. Rental Prices: Concept and Measurement

As in the case of the wage rate for labor, the rental price for capital represents the unit cost of using a capital good for a specified period of time (Jorgenson and Yun, 1991). Services from capital goods are delivered to their owner, with no recorded market

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<sup>5</sup> The economic rationale of using the rental prices to calculate a reliable service growth is that the investor expects to get more services in short time from an asset whose price is relatively high (or service life is relatively small).

<sup>6</sup> Note that the growth rate of capital may also be calculated using aggregate capital stock. That is  $\ln(K_t/K_{t-1})$  where  $K_t = \sum K_{it}$  and represents the stock growth. However, such growth rate may differ significantly from the calculated share weighted growth rate using (2), as the latter may exhibit quality improvement in capital services.

transaction, over the course of several years. This absence of a complete market for capital services and their durability makes it virtually impossible to figure the appropriate service price from market transactions (Harper, Berndt and Wood, 1989). A challenge in measuring capital input for growth accounting analysis is therefore associated with this implicit nature of capital services. One requires imputing the implicit rent that the owners of capital pay themselves, and therefore, it is often called *user cost of capital*. This makes researchers depend on theoretical benchmarks to derive an appropriate formula for rental prices.

We will examine a few formulas of rental prices that have appeared in the literature in detail, to help us understand the treatment of these variables in their formulations.

Hall and Jorgenson (1967) formulates the rental price equation as

$$P = qr + q\delta - \dot{q} \quad (5)$$

where P is the rental price, q is the asset price ( $\dot{q}$  denotes the change in asset prices), r is the discount rate (rate of return) and  $\delta$  is the depreciation rate. However, there exists different ways of calculating (5) empirically, depending on how one treats the different components (r,  $\delta$  and  $\dot{q}$ ) of this formula.<sup>7</sup> For instance, the last component, i.e. the capital gains may, *inter alia*, be incorporated in two ways. In the first case, which is generally known as Neo-classical I, capital gains are perfectly anticipated. With the subscript t representing time period, (5) may be re-written as (see Appendix 1 for derivation),

$$P_t = r_t q_{t-1} + \delta q_t - \dot{q}_t \quad (6)$$

where  $\dot{q}_t = (q_t - q_{t-1})$ , i.e. the capital gain is perfectly anticipated, represented by the difference between current year and previous year prices (see, Christensen and

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<sup>7</sup> For example, while in Diewert's formulation capital gain is the difference between current and future prices, in Jorgenson's formulations it is the difference between current and last year prices (See Harper et al., 1989).

Jorgenson, 1969 and Jorgenson and Yun, 1991). And in the second case, the Neoclassical II;

$$P_t = r_t q_{t-1} + \delta q_t \quad (7)$$

where capital gain is assumed to be zero. Jorgenson and Siebert (1968) have observed that the Neoclassical I models are relatively preferable to Neoclassical II models.

The general formulation of rental price, thus, comprises the nominal interest cost (or opportunity cost) plus the nominal cost of depreciation (the loss in the value of the asset as it ages) minus the nominal gain from holding the asset for each accounting period. A positive capital gain reduces the user cost of holding the asset, and therefore is subtracted, while a negative gain (or a loss) increases the user cost and therefore must be added, hence it has a negative sign.

### *III.1 The role of Taxes*

The above derivation of rental prices, based on the assumed correspondence between asset prices and service prices<sup>8</sup> abstracts from any type of taxes. It is important to note here that the asset price-service price correspondence depends on the tax structure for property income generated by the asset. This is because taxes are assumed to play a major role in altering investment behavior, the premise being that entrepreneurs in pursuit of gain will be more attracted to purchasing capital goods if prices are low (Hall and Jorgenson, 1967). Therefore, the derivation of rental prices of capital, which assumes strong correspondence with asset prices, should account for the impact of taxes. In this regard, the effect of tax policy on cost of capital has been subjected to empirical scrutiny (see, for instance, Hall and Jorgenson, 1967).<sup>9</sup> Furthermore, some believe that the gap between economic depreciation and capital consumption allowances for tax purposes may be a reason for capital stagnation (Auerbach and Jorgenson, 1980). Therefore, it is

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<sup>8</sup> See Christensen and Jorgenson (1969) for a detailed discussion on asset/service price correspondence. Also see Appendix 1.

<sup>9</sup> Hall and Jorgenson (1967) conclude that tax policy highly influences levels and timing of investment expenditures. They also note the crucial role of tax policy in changing the composition of investment; liberalization of depreciation rules has caused a shift away from equipment structures in the US, while the investment tax credit and depreciation guidelines have caused a shift towards equipment.

important to incorporate taxation and the depreciation allowances for tax purposes in rental price equation, as they will definitely impact the user cost of capital and thereby capital services. In line with Hall and Jorgenson (1967) and Harper et al. (1989), incorporating tax factors into the formula, we may re write equation (7) for  $i^{\text{th}}$  asset as<sup>10</sup>

$$P_{it} = T_{it} \left[ r_t q_{it-1} + \delta_{it} q_{it} - \dot{q}_{it} \right] + b_{it} \quad (8)$$

where  $\dot{q}_{it} = (q_{it} - q_{it-1})$ , and with Neo-classical 2 assumptions,

$$P_{it} = T_{it} \left[ r_t q_{it-1} + \delta_{it} q_{it} \right] + b_{it} \quad (9)$$

where the subscript  $i$  stands for asset,  $b_{it}$  is the rate of taxes on production, and  $T_{it}$  is the effective rate of taxation on capital income in asset  $i$  in period  $t$ .  $T_{it}$  is calculated as<sup>11</sup>

$$T_{it} = \frac{1 - u_t z_{it} - k_{it}}{1 - u_t} \quad (10)$$

where  $u_t$  is the statutory corporate income tax in year  $t$ ;  $z_{it}$  is the present value of depreciation deduction for tax purpose on a unit investment on asset  $i$  over life time of investment;  $k_{it}$  is the effective rate of investment tax credit.<sup>12</sup>

The expressions (8) and (9) reflects the shadow price of capital (Jorgenson, 1963). These equations vividly show that it accounts for the rate of return, depreciation, (capital gain) and taxation. As we mentioned earlier, the measurement of these components may be accomplished in different ways. The first component in (5), i.e. the rate of return, represents the opportunity cost of holding an asset. It may be considered either as a

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<sup>10</sup> See Jorgenson and Sullivan (1981) for a detailed discussion on the derivation of the tax incorporated rental price formula.

<sup>11</sup> Further discussions on effective tax rate measurement may be found in Bradford and Fullerton (1981) and Fullerton (1999)

<sup>12</sup> Investment tax credit is a credit against tax liabilities in proportion to investment expenditure (Jorgenson and Yun 1991) aimed to encourage investment. It is equivalent to subsidies or investment grants aimed to offset tax liability.

nominal rate of interest payment, if a loan was taken to acquire the asset or as the opportunity cost of employing capital elsewhere than in production. The issues associated with measurement of this component will be discussed further in the next section of the paper. Measurement of the second component, i.e. the depreciation, is a well-discussed issue in economics (see Hulten and Wykoff, 1981 and other papers in Hulten, 1981). Depreciation measures the loss of the market value of a capital asset over time. It may vary over time and depend on vintage (Shreyer 2003). However, considering the computational simplicity, the general practice in empirical literature is to assume a geometric depreciation rate. The last term in (5) measures capital gain or losses, or revaluation of an asset - the change in value that corresponds to a rise or fall in the price of that asset, independent of the effects of ageing. It compares the price of new capital assets in two periods, hence is independent of ageing. Despite its crucial role in the rental price specification, the way capital gain is incorporated in the measurement of rental prices is still a matter of dispute. As equation (8) clearly shows one way of incorporating this variable into the measurement of rental prices is to assume a perfectly anticipated capital gain. Another way is to drop out this term from the user cost equation, as in the case of (9). The third possibility is to employ a smoothed capital gain series, in order to reduce the volatility of user cost terms.

#### **IV. Measuring Rates of Return**

The rate of return may be considered as the annual rate of return on an investment, expressed as a percentage of total amount invested, or as the opportunity cost of holding a capital good rather than a financial asset. It may therefore be measured either as an external rate of return or an internal rate of return. The external uses the opportunity, or ex-ante, approach, with some exogenous value for the rate of return, like interest rates on government bonds. The internal is the residual, or ex-post approach, with which one may calculate the internal rate of return as a residual, given the value of capital compensation, depreciation and capital gains.<sup>13</sup>

From the productivity measurement point of view the internal approach is considered to be preferable as it ensures complete consistency between income and production

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<sup>13</sup> See OECD (2001) for a discussion of these alternatives.

accounts. This approach, advocated by Hall and Jorgenson (1967), estimates the internal rate of return with the help of an accounting identity. Defining  $M_t$  as the total rent received from the various assets in each time period  $t$  (or the property income in time  $t$ ), i.e.

$$M_t = \sum_{i=1}^n p_{it} K_{it} = p_{Kt} K_t = V_t - W_t \quad (11)$$

where  $p_{it}$  is the price of each asset in time  $t$ ,  $K_{it}$  is the capital stock in each asset,  $V$  is the value added, and  $W$  is the labor compensation. The total capital income or property compensation is thus calculated as value added minus labor compensation, assuming a competitive market and constant returns to scale.<sup>14</sup> Equation (11) implies that the sum of rental payments for all assets is equal to total property compensation. It consists of pretax profits, capital consumption allowances, net interest, transfer payments, business subsidies, indirect taxes and the portion of proprietors' income attributable to capital. Therefore, while calculating the rates of return we need to adjust capital compensation for corporate taxes and indirect taxes and the internal rate of return may be measured as a residual after adjusting for measures of capital stock, depreciation, capital gain and taxes. Nevertheless, the measurement of internal rate of return could be accomplished through different approaches, depending on the assumptions regarding capital gain. We discuss three such methods that will be used in our empirical analysis. Note that in all the models we assume that the nominal rate of return is the same for all assets in an industry.

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<sup>14</sup> Note that the sum of labor and capital compensation is identically equal to gross value added at factor cost under all the typical neo classical assumptions concerning a production function, (Berndt and Hesse, 1986).

#### IV.1 Internal Nominal Rate of return (INR)

The internal nominal rate of return (INR) developed by Christensen and Jorgenson (1969), incorporating tax, may be defined as

$$INR_t = \left[ M_t - \sum_{i=1}^n \left[ \delta_{it} T_{it} q_{it} K_{it} - T_{it} \dot{q}_{it} K_{it} + b_{it} K_{it} \right] \right] / \sum_{i=1}^n q_{it-1} T_{it} K_{it} \quad (12)$$

An important point is that in (12) the expected capital gain is represented by realized capital gain or perfectly anticipated capital gain (that is  $\dot{q}_{it} = [q_{it} - q_{it-1}]$ ) and thus it follows the Neoclassical 1 model.

#### IV.2 Internal Own Rate of Return (IOR)

Excluding the capital gain term from internal nominal rate of return equation (12), we have

$$IOR_t = \left[ M_t - \sum_{i=1}^n \left[ \delta_{it} T_{it} q_{it} K_{it} + b_{it} K_{it} \right] \right] / \sum_{i=1}^n q_{it-1} T_{it} K_{it} \quad (13)$$

The above specification seems to belong to the Neo-classical II, where the capital gain expectations are myopic. However, Harper, Berndt and Wood (1989) have shown that if average capital gains instead of asset-specific capital gains are employed in (12), they produce the same results as that of (13) and therefore (13) accommodates certain amount of capital gain.<sup>15</sup> Therefore, this model may be considered to incorporate capital gain somewhat.

In summary, the nominal rate of return is defined as the return to capital divided by the value of assets, where the return to capital is property compensation before taxes, less corporate taxes and depreciation plus asset revaluation or capital gain; the own rate of return is the return to capital, (excluding capital gain), divided by the value of assets. Hence, the INR reflects returns resulting from earnings on assets and gains accruing

<sup>15</sup> See Harper et al. (1989, p 350) for the derivation of this relationship.

through capital gain, while the IOR reflects only earnings on assets (Fraumeni and Jorgenson, 1980) and the average capital gain (Harper et al., 1989).

#### *IV.3 Internal Nominal Rate of Return using Smoothed Capital Gain (INRS)*

Apart from the above two assumptions regarding capital gain, another possibility is to use smoothed capital gain series. This is useful if price changes are highly volatile. The use of smoothed series reduces volatility of user cost terms (Shreyer, 2003). In accordance with Harper et al. (1989), we propose using a smoothed capital gain series by employing a three-year moving average. These figures are then substituted for the perfectly anticipated capital gain term in (12).

#### *IV.4 Constant External Rate of Return (CER)*

The above-discussed approaches are theoretically consistent under the assumptions of constant returns to scale, competitive markets and the expected rate of return equal to the ex-post, realized rate of return. However, a practical problem arises when capital income in national accounts (gross operating surplus) becomes negative.<sup>16</sup> In such cases, the measured rental prices using internal rate of return may also become negative, which is theoretically inconsistent.<sup>17</sup> One way of eliminating such negative rental prices is to employ an external rate of return. Following Harper, Berndt and Wood we take a constant rate at 3.5 per cent, which is the difference between nominal discount rate and inflation rates in the US as calculated by Fraumeni and Jorgenson (1980) (see Harper et al. 1989). Thus we substitute internal own rate of return in rental price formula (13) with a 3.5. Note that the 3.5 rate of return is assumed to be a real rate of return (net of capital gains).

We measure rates of return using the above four formulations, i.e. the internal nominal rate of return (with capital gains – Neo-classical I), the internal own rate of return (with seemingly no capital gains – Neo-classical II), internal nominal rate of return with smoothed capital gains, and constant external rate of return. These are calculated with and without including tax variable in the formula. Then we derive the rental prices using equations (8) and (9), substituting  $r$  by relevant rates of return measures. Thus finally we

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<sup>16</sup> In cases where there are high amount of net subsidies, or losses, value added may become less than labour compensation resulting in negative property compensation.

<sup>17</sup> Negative user costs of capital can also arise even if the rate of return is positive, when there are large capital gains in the user cost formula

will have 8 different measures of rental prices, and the corresponding capital service and productivity growth rates.

## V. Discussion of Data

The data used in this study are based primarily on Inklaar, O’Mahony and Timmer (2003).<sup>18</sup> The study was carried out for four EU countries for the period 1982-2001. The countries are the Netherlands, France, Germany and the UK.<sup>19</sup> Though the study by Inklaar et al. covers the period 1979-2001, our analysis only covers the period 1982-2001, as the tax data used in this study have only been available since 1982. The study was conducted for 26 industry groups.

The empirical implementation in this paper consists of productivity measurement using growth accounting framework (equation 2). Hence the major variables that enter into our analysis are inputs (labor and capital) and output. The output is measured by *Value added*. The current price gross value added obtained from national accounts statistics is deflated using value added deflators with base 1995. *Labor* input is measured by total hours worked. This is obtained by multiplying man-hours per employee with total number of employees. In order to calculate TFPG using (2) we also required having share of labor and capital in value added. The *labor share* is calculated as Labor compensation divided by value added, both in current prices. And the *capital compensation* is derived as value added minus labor compensation.

Table 1 Types of assets considered

	Asset
1	Non IT machinery
2	Non Residential structure
3	Transport Equipment
4	IT Equipment
5	Communication Equipment
6	Software

*Capital stock* is estimated using a perpetual inventory method for six types of assets using equation (4). The assets considered for this purpose are listed in Table 1.<sup>20</sup> The capital service growth rates are then derived using equation (3) applying alternative rental prices

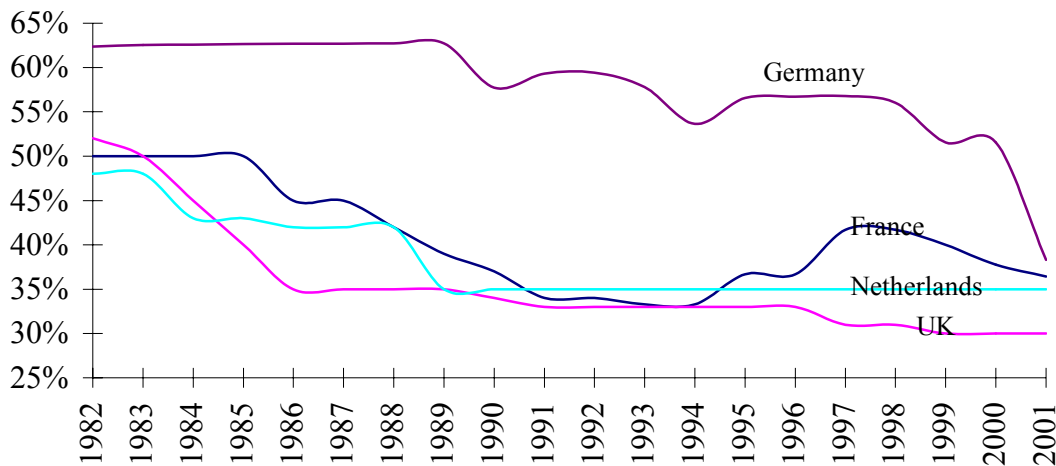
<sup>18</sup> For a detailed discussion on the data see chapter 7 of Inklaar, O’Mahony and Timmer (2003).

<sup>19</sup> Note that in the case of the UK the end year is 2000.

<sup>20</sup> Following Inklaar et al we have excluded residential buildings from our capital stock estimation.

calculated using different rates of return formulas discussed in the previous section. For which we needed to have data on depreciation and asset prices. A geometric rate of depreciation is assumed. The rates are based on Fraumeni (1997) and Jorgenson and Stiroh (2000) and are industry-specific.<sup>21</sup> Investment price deflators with base year 1995 are used to represent asset prices.

Figure 1: Statutory corporate tax rates



Apart from the input, output and price variables, we also need tax variables in our study, for which we rely on a different source. As noted by Jorgenson and Yun (1991), appropriate tax rate to analyze the impact of tax incentives for investment is corporate income tax. Following Harper et al. (1989) we use the effective marginal rate of corporate tax, since our interest is in calculating the rental price. The marginal rate of effective taxation mirrors the incentive to invest. We derived the marginal rate of taxation applying equation (10), using the data provided by Institute of Fiscal Studies (IFS), available from <http://www.ifs.org.uk/corptax/internationaltaxdata.zip>. A detailed description of the sources, definition and construction of these data is provided in Devereux, Griffith and Klemm (2002), and Devereux, and Griffith (2003). Devereux, Griffith and Klemm (2002), provide statutory tax rates on corporate income and the present discounted value of depreciation allowances. Time series data is available for 16 countries of European Union and the G7 for 1982-2001 period, of which we use the rates

<sup>21</sup> See Inklaar et al (2003) for more discussion.

for the countries Netherlands, France, UK and the Germany. These figures (see Graph 1) show a declining tendency in statutory tax rates particularly in recent years. The depreciation allowances are provided for two types of assets, i.e. the plant & machinery and industrial buildings. We have calculated the effective tax rate ( $T_{it}$ ) using these two rates, in such a way that the rate for industrial buildings has been applied for non residential structures in our investment data, and the depreciation allowances for plant and machinery are used in all other assets including software that comes under the category of machinery. In the case of plant & machinery, we used the depreciation allowances calculated using country specific inflation rates. Since such rates are not available for industrial buildings, we used the rates with common inflation rates.

The value added figures in our data consists of operating surplus, compensation to employees, and the taxes on production. Therefore, as we mentioned earlier, while we derive capital compensation as value added minus labor compensation, we also need to subtract taxes while deriving return. The calculation of indirect taxes ( $\sum_{i=1}^n [b_{it} K_{it}]$ ) is made directly from National Accounts of selected countries. The data on taxes on production<sup>22</sup> was gathered from the Source OECD National Accounts Database under components of value added. These values are divided by calculated aggregate capital stock in order to arrive at the tax rate ( $b_{it}$ ). However, these rates are not derived for individual assets. Instead, for deriving individual tax payments (in rate of return equations), a common rate is applied to individual capital stock estimates. Note that in our empirical calculations, we have also measured rates of return and rental prices without including this measure of indirect tax, as this data includes taxes not only on capital but also on employees' compensation. However, since the results are found to remain the same, they are not reported.

## VI. Empirical Results

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<sup>22</sup> These data consist of taxes payable on goods and services when they are produced, delivered, sold, transferred or otherwise disposed of by their producers plus taxes and duties on imports that become payable when goods enter economic territory by crossing frontiers or when services are delivered to resident units by non-resident units. They also include other taxes on production, consisting mainly of taxes on the ownership or use of land, building or other assets used in production, or on the labor employed or on compensation paid to employees.

We have measured the rates of return and rental prices using the four model assumptions, with and without including corporate taxes. Thus we have 8 different measures of rental prices, rates of returns and the corresponding capital service and productivity growth rates. We will first look at the nature of the measured rates of returns and rental prices. As we have mentioned earlier, in situations where capital compensation becomes negative, or there are high capital gains, it is possible to have negative rate of returns and rental prices. Such negative rental prices are theoretically inconsistent, as the theoretical assumption underlying the derivation of growth accounting framework requires input service prices to be positive. One way of empirically eliminating such negative values is to assume a minimum positive value arbitrarily.<sup>23</sup> However, since our aim is to understand the sensitivity of growth rates to different measures, we have not opted to make such an empirical assumption. In addition, since we are interested in understanding which model paints a better picture for growth accounting purpose, it is essential to know which models produce more sensible results. Therefore, it is important and interesting to look at the number of negative values produced by different models.

Table 2: Percentage of negative values in Rates of Return

Model	NLD	FRA	UK	GER
INR	4.4	1.5	5.1	10.8
IOR	9.6	3.5	10.3	15.4
INRS	4.4	1.3	3.2	9.6
INR tax	7.3	3.3	5.8	22.7
IOR tax	12.1	6.1	12.7	33.4
INRS tax	6.3	2.9	3.8	21.3

Table 2 provides the percentage of negative values that appeared for each models of rates of returns. For all the countries except the UK, we had observations for 26 industries in 20 years, while for the UK it was only for 19 years, the last year 2001 was not available. The Table shows that the largest number of negative values appeared in the internal own rate of return models, irrespective of the country we consider. This is true with both tax and non-tax models, though the models with tax have registered in general more number

<sup>23</sup> Barbara Fraumani commented that the problem of negative rate of return may be handled by aggregating industry groups of similar characteristics. However, while we looked at the pattern of negative appearances we found that they are in industries not of near characteristics.

of negative values. The least number of negative values are in the moving average model followed by the internal nominal rate of return model. Among countries, Germany has witnessed more numbers of negative values, followed by the UK and the Netherlands. We also look at the negative values that appeared in the rental prices.

Table 3: Percentage of negative values in Rental prices

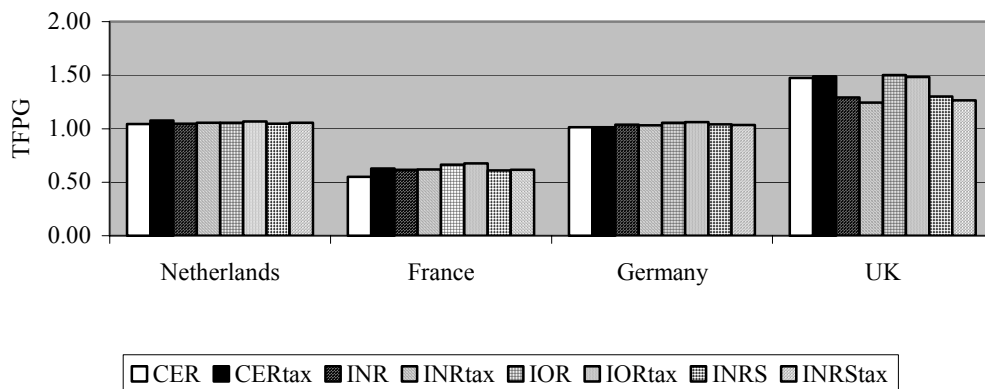
Model	NLD	FRA	UK	GER
INR	0.45	0.29	1.28	1.38
IOR	0.19	0.16	0.23	1.21
CER	0.00	0.00	0.00	0.00
INRS	0.26	0.29	0.30	1.38
INR tax	0.54	0.29	1.68	2.79
IOR tax	0.38	0.25	0.27	3.01
CER tax	0.00	0.00	0.00	0.35
INRS tax	0.35	0.29	0.44	2.92

Though the percentage of negative values that appeared in rates of returns are relatively high, the same is not true of rental prices, which has shown only very few negative observations in most models. Table 3 shows that the largest numbers of negative values appeared in INR and INRtax models compared to two other internal rate of return models. The IOR model has produced the least number. This might be due to the incorporation of capital gain component in the internal nominal rate of return models. In the presence of large capital gains, it is possible to obtain negative rental prices in these models. Surprisingly, in the case of constant rates of return models, Germany has shown a positive number of negative values in tax incorporated model. This is seen in the industry mining and quarrying, during the years 1996-2001, and may be attributed to the high subsidies given to this industry during this period. If we look at the taxes on production in this industry during this period, it is amazingly high as (-) 103 per cent of value added in 1996. These taxes have shown a declining trend in later years, though they trickled down only to (-) 66 per cent in 2001. As a percentage of capital stock, taxes have been as high as 30 percent in 1996 and 25 percent in 2001. In general Germany has witnessed the largest number of negative rental prices.

We have calculated the rental price weighted capital service growth rates using (3) for all 26 industry groups in each country separately, over the period 1982-2001 using alternative rental prices. The resulting capital service growth rates are given in appendix tables 2.1 to 2.4. It can be seen that the capital growth rates produced by different models tend to differ, though not very significantly. While the difference is more prominent between internal and external models, it is trivial between internal models, in general. This is true in most industries in all the countries. More importantly the inclusion of tax in the calculation of rates of return and rental price makes the story not very different. It caused very little difference in the calculated growth rates. The picture will be more vivid while we examine the productivity growth rates estimated using these capital service growth rates, which is our major concern. Hence, we do not intend to elaborate further discussion on capital growth rate differences (the growth rates of capital services are given in Appendix tables 2.1 to 2.4).

The capital service growth rates obtained using alternative rental price models are plugged into equation (2) in order to calculate the productivity growth. A comparison of the TFPG obtained from different models will help us understand how sensitive the measured economic growth is to these different capital aggregation procedures. The calculated TFPG figures for the total economy are plotted in Figure 2.<sup>24</sup>

**Figure 2: Total Factor Productivity Growth in Total Economy, 1983-2001**



<sup>24</sup> The total economy TFPG's are derived as a weighted average of individual industry TFPG, where the weights are the industry value added share in total value added.

It is seen from the figure that while the tax variable makes little differences to the estimated productivity growth rates, there are differences between different models. Apart from the obvious differences between internal and external models, the inclusion of capital gain term in internal models does make notable changes at least in some countries. The largest divergence is seen in the case of the UK. IOR model has generally shown a tendency to produce higher productivity growth compared to the INR models, where the capital gain term is being incorporated. Hence, it shows the significance of incorporating capital gain term in the model.

Table 4: Differences in TFPG: The Impact of Tax, Total Economy

	CER	INR	IOR	INRS
Netherlands	-0.033	-0.009	-0.011	-0.009
Germany	-0.001	0.007	-0.008	0.005
France	-0.078	-0.006	-0.013	-0.005
UK	-0.014	0.048	0.016	0.036

Note: Differences are calculated as TFPG calculated using capital aggregation without giving allowance for tax minus TFPG giving allowance for corporate taxes.

Table 4 and 5 shows the difference between TFP growth rates produced by different models, and the impact of incorporating tax into the calculation. It is clear from Table 4 that the tax variable has shown generally very meager effect on growth differences. The differences are quite marginal in general say less than 0.05 point. To compare alternative models (Table 5), it can be seen that the largest differences are between external and internal models. Within internal models, IOR is found to differ notably from INR and INR moving average models. In all these cases, in all the countries except in the UK, the differences are quite negligible; say again less than 0.05 point. However, in the UK, the difference is found to be much higher, especially between internal and external models. In the UK, the IOR models are generally close to the external models, while it differs from the INR models.

Table 5: Differences in TFPG: Alternative Rental Price Models, Total Economy

	CER-INR	CER-IOR	CER-INRS	INR-IOR	INRS -INR	INRS -IOR
Netherlands	0.021	0.010	0.020	-0.012	0.001	-0.011
Germany	-0.017	-0.048	-0.020	-0.032	0.003	-0.028
France	0.007	-0.049	0.013	-0.057	-0.005	-0.062
UK	0.245	0.004	0.224	-0.241	0.021	-0.220

Table 6: Differences in Average TFPG: The impact of tax

Industry	Netherlands				France			
	CER	INRS	INR	IOR	CER	INRS	INR	IOR
Agriculture, Forestry and Fishing	0.050	-0.005	-0.005	-0.004	-0.024	-0.014	-0.014	-0.015
Mining and Quarrying	0.002	0.005	0.006	0.006	-0.018	0.008	0.007	0.002
Food, Drink & Tobacco	-0.028	-0.005	-0.004	-0.007	-0.039	-0.009	-0.009	-0.016
Textiles, Leather, Footwear & Clothing	-0.022	0.005	0.005	0.002	-0.049	-0.012	-0.012	-0.015
Wood & Products of Wood and Cork	-0.023	0.003	0.003	0.001	-0.026	-0.002	-0.002	-0.005
Pulp, Paper & Pducts; Printing & Publishing	-0.041	-0.002	-0.002	-0.005	-0.065	-0.019	-0.020	-0.026
Mineral Oil Refining, Coke & Nuclear Fuel	-0.004	0.026	0.010	0.015	-0.040	0.007	0.008	0.003
Chemicals	-0.041	-0.018	-0.017	-0.019	-0.083	-0.021	-0.021	-0.029
Rubber & Plastics	-0.013	0.006	0.007	0.005	-0.133	-0.044	-0.044	-0.048
Non-Metallic Mineral Products	-0.049	-0.017	-0.016	-0.019	-0.073	-0.018	-0.018	-0.022
Basic Metals & Fabricated Metal Products	-0.047	-0.007	-0.005	-0.010	-0.035	-0.005	-0.005	-0.011
Mechanical Engineering	-0.033	-0.001	-0.001	-0.005	-0.067	-0.016	-0.016	-0.020
Electrical&Electronic Eqpt; Instruments	-0.033	0.031	0.031	0.029	-0.039	-0.011	-0.011	-0.016
Transport Equipment	-0.015	0.083	0.060	0.069	-0.062	-0.004	-0.004	-0.014
Furniture, Miscellaneous Mfg; recycling	-0.011	0.003	0.003	0.003	-0.010	0.010	0.009	0.008
Electricity, Gas and Water Supply	-0.066	0.011	0.010	0.004	-0.035	0.042	0.038	0.016
Construction	0.002	0.004	0.005	0.003	0.008	0.002	0.002	0.001
Repairs and wholesale trade	-0.058	-0.010	-0.010	-0.011	-0.059	0.002	0.001	-0.007
Retail trade	-0.042	0.000	0.000	-0.001	-0.098	-0.029	-0.029	-0.030
Hotels & Catering	-0.057	-0.005	-0.005	-0.006	-0.064	-0.011	-0.012	-0.017
Transport	0.021	-0.003	-0.003	0.003	0.007	0.019	0.017	0.008
Communications	-0.036	0.007	0.008	0.004	-0.034	0.012	0.012	-0.003
Financial Intermediation	-0.042	0.022	0.020	0.019	-0.321	-0.010	-0.012	-0.034
Real Estate Activities& Business Services	-0.103	-0.121	-0.116	-0.120	-0.202	-0.045	-0.045	-0.056
Other Services	-0.036	0.021	0.021	0.013	-0.107	0.009	0.008	-0.005
Non-Market Services	-0.011	0.012	0.012	0.010	-0.033	0.013	0.013	0.008

Note: Differences are calculated as TFPG calculated using capital aggregation without giving allowance for tax minus TFPG giving allowance for corporate taxes.

This aggregate picture, however, need not necessarily reflect the cross industry story. The results may change significantly across industries. We have presented the difference between TFPG produced by different models for 26 industry groups in Tables 6 to 11. The growth rates are provided in Appendix tables 3.1 to 3.4.

Table 7: Differences in Average TFPG: The impact of tax

Industry	UK				Germany			
	CER	INRS	INR	IOR	CER	INRS	INR	IOR
Agriculture, Forestry and Fishing	0.031	0.021	0.023	0.017	-0.014	-0.211	-0.211	-0.224
Mining and Quarrying	0.221	0.153	0.156	0.132	0.386	0.022	0.021	0.007
Food, Drink & Tobacco	-0.010	0.017	0.017	0.004	0.002	0.003	0.005	-0.009
Textiles, Leather, Footwear & Clothing	-0.003	0.018	0.020	0.006	0.003	-0.036	-0.034	-0.038
Wood & Products of Wood and Cork	0.003	0.015	0.015	0.002	0.002	0.004	0.007	-0.005
Pulp, Paper & Pducts; Printing & Publishing	-0.011	0.014	0.007	0.008	-0.003	0.066	0.067	0.053
Mineral Oil Refining, Coke & Nuclear Fuel	0.026	0.033	0.033	0.013	0.014	-0.012	-0.005	0.023
Chemicals	-0.006	0.035	0.032	0.013	0.000	0.070	0.072	0.060
Rubber & Plastics	-0.009	0.017	0.017	0.004	0.000	0.027	0.029	0.021
Non-Metallic Mineral Products	-0.042	-0.031	-0.031	-0.034	0.004	-0.023	-0.021	-0.034
Basic Metals & Fabricated Metal Products	-0.006	0.016	0.016	0.005	0.001	-0.011	-0.010	-0.015
Mechanical Engineering	-0.006	0.033	0.033	0.013	0.001	0.016	0.017	0.014
Electrical&Electronic Eqpt; Instruments	-0.015	0.019	0.020	0.002	-0.001	0.030	0.031	0.022
Transport Equipment	-0.008	0.024	0.024	0.011	0.000	0.069	0.069	0.064
Furniture, Miscellaneous Mfg; recycling	-0.015	-0.004	-0.002	-0.010	-0.001	0.035	0.036	0.027
Electricity, Gas and Water Supply	0.019	0.054	0.046	0.030	-0.009	-0.133	-0.129	-0.162
Construction	0.003	0.007	0.008	0.005	0.003	-0.022	-0.020	-0.029
Repairs and wholesale trade	-0.038	-0.010	-0.009	-0.023	0.002	-0.009	-0.008	-0.024
Retail trade	0.012	0.043	0.045	0.018	0.000	0.036	0.037	0.026
Hotels & Catering	0.004	0.002	0.003	-0.001	0.000	-0.081	-0.079	-0.086
Transport	0.025	0.030	0.034	0.012	-0.001	-0.143	-0.141	-0.221
Communications	-0.018	0.115	0.128	0.028	0.002	0.239	0.244	0.224
Financial Intermediation	-0.112	0.034	0.060	-0.017	-0.031	0.139	0.141	0.117
Real Estate Activities& Business Services	-0.082	0.059	0.176	0.049	-0.005	-0.011	-0.008	-0.022
Other Services	-0.031	0.075	0.078	0.045	0.002	0.016	0.016	0.015
Non-Market Services	-0.010	0.025	0.024	0.013	-0.001	-0.037	-0.035	-0.048

Note: Differences are calculated as TFPG calculated using capital aggregation without giving allowance for tax minus TFPG giving allowance for corporate taxes.

Regarding the impact of tax, we see no considerable differences in growth rates in most industries in most countries (Tables 6 and 7). In the Netherlands, we see a difference of more than 0.1 point only in the real estate sector. This is true with all the models. While in France the industries rubber and plastics, financial intermediation, real estate and other services have shown a difference only in external model, UK have produced differences in mining and quarrying (in all models), communication (in INR and INRS) and financial intermediation (in external) and real estate in INR model. Germany has shown a difference of more than 0.1 point in agriculture, electricity, gas & water supply, transport and financial services in internal models, and mining in external model.

Thus if we read these observations along with the very minor differences observed at the aggregate level, we may conclude that despite its theoretical importance, from an empirical point of view the incorporation of tax makes no significant changes on the final growth rates of productivity. The impact of incorporating tax variable in the model is important in some industries, while it is trivial in most others in most countries. And at the aggregate level it is quite small. Nevertheless, as is visible from the table, the impact varies considerably across countries. In general the differences in all countries and in all models are observed to be relatively higher in service sector industries. However, the extent of visible differences is generally quite marginal. In most cases the divergence is less than 0.05 point with a few possible exceptions. Thus it seems that the tax variable has only a marginal effect, though it varies significantly across industries, on capital growth rates (aggregated using rental price shares) and the resulting productivity growth rates in all the countries considered.

Table 8: Differences in Average TFPG: Alternative Rental prices, Netherlands

Industry	CER-INRS	CER-INR	CER-IOR	INRS-INR	INRS-IOR	INR-IOR
Agriculture, Forestry and Fishing	0.128	0.126	0.133	-0.002	0.005	0.008
Mining and Quarrying	-0.034	-0.033	-0.033	0.001	0.001	0.001
Food, Drink & Tobacco	-0.070	-0.067	-0.085	0.002	-0.015	-0.018
Textiles, Leather, Footwear & Clothing	-0.011	-0.011	-0.029	0.001	-0.018	-0.018
Wood & Products of Wood and Cork	-0.026	-0.028	-0.042	-0.002	-0.016	-0.014
Pulp, Paper & Pducts; Printing & Publishing	-0.102	-0.101	-0.122	0.002	-0.019	-0.021
Mineral Oil Refining, Coke & Nuclear Fuel	0.126	0.045	0.062	-0.081	-0.064	0.017
Chemicals	-0.109	-0.105	-0.116	0.004	-0.007	-0.011
Rubber & Plastics	0.022	0.024	0.009	0.001	-0.013	-0.014
Non-Metallic Mineral Products	-0.113	-0.110	-0.124	0.003	-0.011	-0.014
Basic Metals & Fabricated Metal Products	-0.066	-0.058	-0.083	0.008	-0.017	-0.025
Mechanical Engineering	-0.098	-0.096	-0.123	0.001	-0.025	-0.027
Electrical&Electronic Eqpt; Instruments	0.063	0.062	0.056	-0.001	-0.008	-0.007
Transport Equipment	0.492	0.331	0.397	-0.161	-0.095	0.066
Furniture, Miscellaneous Mfg; recycling	-0.017	-0.017	-0.022	-0.001	-0.006	-0.005
Electricity, Gas and Water Supply	0.046	0.040	-0.005	-0.005	-0.051	-0.046
Construction	-0.050	-0.049	-0.059	0.001	-0.009	-0.010
Repairs and wholesale trade	-0.193	-0.194	-0.200	-0.001	-0.007	-0.006
Retail trade	-0.088	-0.089	-0.096	0.000	-0.007	-0.007
Hotels & Catering	-0.104	-0.104	-0.116	0.000	-0.012	-0.012
Transport	-0.041	-0.046	-0.015	-0.005	0.026	0.031
Communications	-0.117	-0.113	-0.129	0.005	-0.011	-0.016
Financial Intermediation	-0.136	-0.142	-0.152	-0.006	-0.016	-0.010
Real Estate Activities& Business Services	0.558	0.600	0.578	0.042	0.019	-0.022
Other Services	0.115	0.116	0.055	0.002	-0.059	-0.061
Non-Market Services	0.048	0.047	0.033	-0.001	-0.015	-0.014

Table 9: Differences in Average TFPG: Alternative Rental prices, France

Industry	CER-INRS	CER-INR	CER-IOR	INRS-INR	INRS-IOR	INR-IOR
Agriculture, Forestry and Fishing	-0.053	-0.052	-0.063	0.001	-0.010	-0.011
Mining and Quarrying	0.063	0.057	0.019	-0.006	-0.044	-0.038
Food, Drink & Tobacco	-0.003	-0.006	-0.048	-0.003	-0.045	-0.042
Textiles, Leather, Footwear & Clothing	-0.023	-0.025	-0.043	-0.002	-0.020	-0.017
Wood & Products of Wood and Cork	-0.012	-0.015	-0.039	-0.002	-0.027	-0.024
Pulp, Paper & Pducts; Printing & Publishing	-0.027	-0.030	-0.067	-0.003	-0.040	-0.037
Mineral Oil Refining, Coke & Nuclear Fuel	0.012	0.014	-0.027	0.002	-0.039	-0.041
Chemicals	-0.045	-0.047	-0.100	-0.002	-0.055	-0.053
Rubber & Plastics	-0.112	-0.113	-0.142	-0.001	-0.030	-0.029
Non-Metallic Mineral Products	-0.042	-0.045	-0.078	-0.004	-0.036	-0.032
Basic Metals & Fabricated Metal Products	0.011	0.009	-0.030	-0.002	-0.041	-0.040
Mechanical Engineering	-0.051	-0.052	-0.073	-0.001	-0.022	-0.021
Electrical&Electronic Eqpt; Instruments	-0.028	-0.027	-0.058	0.001	-0.030	-0.031
Transport Equipment	0.037	0.033	-0.031	-0.004	-0.068	-0.063
Furniture, Miscellaneous Mfg; recycling	-0.021	-0.023	-0.035	-0.002	-0.014	-0.012
Electricity, Gas and Water Supply	0.230	0.192	0.003	-0.039	-0.227	-0.189
Construction	0.015	0.014	0.003	-0.001	-0.012	-0.011
Repairs and wholesale trade	-0.019	-0.021	-0.055	-0.002	-0.036	-0.034
Retail trade	-0.035	-0.036	-0.075	0.000	-0.039	-0.039
Hotels & Catering	-0.048	-0.050	-0.093	-0.002	-0.045	-0.043
Transport	0.077	0.069	-0.010	-0.009	-0.088	-0.079
Communications	0.090	0.079	-0.047	-0.012	-0.137	-0.126
Financial Intermediation	-0.047	-0.068	-0.242	-0.022	-0.195	-0.173
Real Estate Activities& Business Services	-0.071	-0.074	-0.140	-0.003	-0.068	-0.066
Other Services	0.086	0.073	-0.027	-0.013	-0.113	-0.100
Non-Market Services	0.085	0.081	0.041	-0.004	-0.043	-0.040

Now, if we look at the differences between TFPG produced by alternative rental price models, it may be seen from the Tables 8 to 11 that the picture is somewhat different. We see a difference of more than 0.1 point in more number of industries in some countries. The difference is more between TFPG generated by internal and external models, while it is generally low between internal models. For instance, in the Netherlands, industries, agriculture, forestry & fishing, pulp, paper & paper products, chemicals, non-metallic minerals, transport equipment, repair services, hotels & caterings, communication, mineral oil refining, other services, mechanical engineering financial services, and real estate have shown difference of at least 0.1 point between internal and external models. Also the industries transport equipment and real estate services have shown a difference of around 0.5 point. Within internal models, only transport equipment has shown a difference of more than 0.1 point.

Table 10: Differences in Average TFPG: Alternative Rental prices, UK

Industry	CER-INRS	CER-INR	CER-IOR	INRS-INR	INRS-IOR	INR-IOR
Agriculture, Forestry and Fishing	0.155	0.174	0.104	0.019	-0.051	-0.069
Mining and Quarrying	0.442	0.453	0.288	0.011	-0.155	-0.166
Food, Drink & Tobacco	0.042	0.033	-0.064	-0.009	-0.106	-0.097
Textiles, Leather, Footwear & Clothing	0.085	0.087	-0.024	0.002	-0.109	-0.111
Wood & Products of Wood and Cork	0.098	0.093	-0.013	-0.004	-0.111	-0.106
Pulp, Paper & Pducts; Printing & Publishing	-0.086	-0.138	-0.149	-0.052	-0.063	-0.011
Mineral Oil Refining, Coke & Nuclear Fuel	0.118	0.114	-0.005	-0.004	-0.124	-0.119
Chemicals	0.109	0.090	-0.068	-0.019	-0.177	-0.157
Rubber & Plastics	0.062	0.055	-0.055	-0.007	-0.117	-0.110
Non-Metallic Mineral Products	-0.309	-0.307	-0.343	0.002	-0.034	-0.037
Basic Metals & Fabricated Metal Products	0.065	0.062	-0.030	-0.003	-0.094	-0.091
Mechanical Engineering	0.104	0.104	-0.075	-0.001	-0.180	-0.179
Electrical&Electronic Eqpt; Instruments	-0.040	-0.044	-0.195	-0.004	-0.155	-0.151
Transport Equipment	0.153	0.146	0.042	-0.007	-0.111	-0.104
Furniture, Miscellaneous Mfg; recycling	-0.109	-0.104	-0.161	0.005	-0.053	-0.058
Electricity, Gas and Water Supply	0.197	0.151	-0.014	-0.046	-0.210	-0.164
Construction	0.025	0.030	0.012	0.006	-0.012	-0.018
Repairs and wholesale trade	-0.293	-0.293	-0.413	0.001	-0.120	-0.121
Retail trade	0.215	0.225	-0.005	0.010	-0.220	-0.230
Hotels & Catering	0.045	0.051	0.018	0.006	-0.027	-0.033
Transport	0.142	0.180	0.003	0.038	-0.140	-0.177
Communications	0.802	0.885	0.003	0.082	-0.799	-0.881
Financial Intermediation	0.002	0.214	-0.447	0.211	-0.449	-0.660
Real Estate Activities& Business Services	1.104	1.188	0.555	0.084	-0.548	-0.633
Other Services	0.556	0.569	0.322	0.013	-0.234	-0.247
Non-Market Services	0.155	0.151	0.061	-0.004	-0.094	-0.090

Similar is the case with Germany also where the difference between internal and external models are found to be noteworthy in sectors of agriculture, fishing and forestry, mining & quarrying, mineral oil refinery, electricity, gas & water supply, hotels and catering, financial services, and transport services, while within internal models differences were found only in transport services. In France, industries rubber, chemicals, electricity, gas & water supply, financial intermediation, and real estate have shown similar differences between internal and external models. Industries electricity, communication, financial intermediation and other services have produced a difference of 0.1 point or more between two internal models. UK has shown a similar occurrence in more number of industries. Differences are observed between all the models in industries agriculture,

paper, non metallic minerals, electricity, and gas & water supply. Between internal and external models, industries mining & quarrying, mineral oil refinery, chemicals, mechanical engineering, electricity, gas & water supply, transport equipment, repair services, retail trade, transport services, communication financial services, real estate and other services; and within the internal models, the industries textiles and wood have shown a difference of 0.1 point or more.

Table 11: Differences in Average TFPG: Alternative Rental prices, Germany

Industry	CER-INRS	CER-INR	CER-IOR	INRS-INR	INRS-IOR	INR-IOR
Agriculture, Forestry and Fishing	-0.346	-0.344	-0.370	0.001	-0.025	-0.026
Mining and Quarrying	-0.334	-0.336	-0.368	-0.002	-0.034	-0.032
Food, Drink & Tobacco	0.017	0.023	-0.009	0.006	-0.026	-0.032
Textiles, Leather, Footwear & Clothing	-0.020	-0.014	-0.022	0.006	-0.002	-0.009
Wood & Products of Wood and Cork	0.023	0.030	0.003	0.007	-0.020	-0.027
Pulp, Paper & Pducts; Printing & Publishing	0.011	0.013	-0.017	0.002	-0.029	-0.030
Mineral Oil Refining, Coke & Nuclear Fuel	0.091	0.105	0.171	0.014	0.080	0.065
Chemicals	0.011	0.015	-0.009	0.003	-0.021	-0.024
Rubber & Plastics	0.001	0.004	-0.013	0.003	-0.014	-0.017
Non-Metallic Mineral Products	0.004	0.009	-0.018	0.005	-0.022	-0.027
Basic Metals & Fabricated Metal Products	-0.004	-0.001	-0.011	0.003	-0.007	-0.010
Mechanical Engineering	-0.001	0.001	-0.007	0.002	-0.006	-0.007
Electrical&Electronic Eqpt; Instruments	0.034	0.036	0.016	0.002	-0.018	-0.021
Transport Equipment	0.045	0.045	0.035	0.000	-0.010	-0.010
Furniture, Miscellaneous Mfg; recycling	0.019	0.022	0.002	0.003	-0.017	-0.020
Electricity, Gas and Water Supply	-0.065	-0.057	-0.127	0.008	-0.061	-0.069
Construction	0.039	0.042	0.023	0.003	-0.015	-0.019
Repairs and wholesale trade	0.028	0.030	-0.003	0.002	-0.031	-0.033
Retail trade	0.006	0.009	-0.020	0.004	-0.025	-0.029
Hotels & Catering	-0.137	-0.132	-0.146	0.004	-0.010	-0.014
Transport	-0.210	-0.204	-0.376	0.006	-0.166	-0.172
Communications	0.066	0.076	0.032	0.011	-0.034	-0.044
Financial Intermediation	-0.164	-0.161	-0.215	0.004	-0.051	-0.054
Real Estate Activities& Business Services	0.057	0.063	0.033	0.006	-0.024	-0.030
Other Services	-0.004	-0.004	-0.006	0.000	-0.002	-0.002
Non-Market Services	-0.035	-0.030	-0.057	0.004	-0.022	-0.026

Thus, while the difference in TFPG produced between pre-tax and post tax (rate of return and rental price) models are quite trivial, there exists more difference between the TFPG produced by four different rental price models. The divergence is more between constant rates of return models and internal rates of return models, while it is relatively less between different internal models. This pattern holds across countries. The number of

industries registering differences is found to be high in the case of UK. Despite the lower quantitative magnitudes, we note that the discrepancies between these measures may not be taken trivial. This is because, many researchers evaluate productivity differences at marginal scale (see for a recent example Gittleman, Raa and Wolff, 2004). The question of how important these observed marginal differences are left to the empirical researcher. If one is interested in attributing significant importance for very minor point differences in productivity growth, these differences are important. On the other hand, if one is interested in general trend, and if one believes that economic data never gives exact point estimates, rather they are abstracts of reality, it is trivial to debate on these differences.

## **VII. To Sum Up**

In this paper we attempted to understand the effect of alternative rental prices in capital aggregation on the measured growth rates of capital input and thereby total factor productivity. The measurement of capital is a disputable issue, at least at the empirical level. In order to arrive at some generally accepted measure of capital service growth, one requires reliable estimates of capital service prices or rental prices. The theoretical literature on rental prices has defined the concept well, though its measurement is still an empirical issue, as the researcher is left with many formulae. This paper has used four alternative rental price models, measured using internal nominal rate of return, internal nominal rate of return with smoothed capital gain, internal own rate of return and an external constant rate of return, in calculating capital service growth rates. Moreover, we attempted to understand the effect of incorporating taxes into the model, on the growth rates of capital input. The calculated capital service growth rates are used to calculate the total factor productivity growth using the growth accounting framework, in order to understand how sensitive the estimated TFPG's are to the use of different rental price models in capital aggregation.

We have observed that the inclusion of corporate tax in the rental price calculation influences the measured growth rates of capital services and productivity only in very few industries. The observed differences between growth rates produced by two types of models are quite negligible in most cases. Therefore, from an empirical point of view, it may not be possible to make a strong argument that the potential peril in using pretax

rental prices in aggregating capital services for growth accounting analysis is very high, given this dataset.

Nevertheless, there are marginal differences in growth rates produced by alternative rental price models in most industries, though the magnitude of divergence may be debated. The growth rates generated by internal rate of return models and external rate of return models are found to differ relatively more. It may be noted that the internal models are more theoretically consistent from the growth accounting point of view, as they provide complete consistency with national income and production accounting. This is because these measures are derived from capital income (see equations 11, 12 and 13), in such a way that capital income estimates are equated with payment to specific assets. In the productivity measurement, consequently, these measures leave the aggregate capital shares unaffected, while the aggregate growth rates calculated using shares may differ, owing to the differences in asset specific rental value shares. Such conditions and the observed difference between external and more relevant internal measures may favor using the internal rates of return models in calculating capital service growth rates for productivity measurement. However, between the three internal rates of return models also we observed differences in the resultant productivity growth rates, though they were marginal in terms of quantitative magnitudes. The observed differences between different measures, however, may not be ignored because the productivity differences across countries are, sometimes, evaluated on a marginal scale. We have also observed that the lowest number of negative rental prices is produced by the internal own rate of return model (with tax) in almost all countries considered. The same is true even if we consider models without tax. Nevertheless the difference between least and most is quite small and indeed, in most cases the produced negative values are quite small say less than 3 percent of total observations.

It is, therefore, quite difficult to conclude that one model is better than the other, from an empirical viewpoint. If one attributes high importance to marginal differences, considering the empirical fact that the IOR models has across countries produced the least number of negative values, as these models accommodate in some way the capital gain component (Harper et al., 1989), and assures a complete consistency between national income accounts, one may argue that the internal own rate of return model is preferable,

given this data set. Hence the answer to the question ‘whether the use of alternative ways of capital aggregation matters for a study on economic growth’ posed in our title may be ‘yes’. Which way one chooses to aggregate capital does play a role in studies of economic growth, particularly while analyzing the contribution of capital to growth, provided the researcher is so concerned about the marginal differences in growth rates.

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## Appendix 1

### Derivation of rental price from the assumed correspondence between rental price and acquisition price

Following the perpetual inventory approach, capital stock can be measured as a weighted sum of past investments, i.e.

$$K_t = \sum_{\tau=0}^{\infty} (1 - \delta)^\tau I_{t-\tau} \quad (1)$$

where the weights are given by relative efficiencies  $(1-\delta)^\tau$  assuming a geometric rate of depreciation. The price counter part of this capital stock equation is the acquisition price of investment goods. In neoclassical theory of optimal capital accumulation, the acquisition price of investment goods is the sum of future rental prices of capital services, weighted by the relative efficiencies of capital goods in each future period (Jorgenson and Yun 1991). Hence, the rental price can be calculated from this basic relationship between the price of a new capital good and the discounted value of all the future services derived from this capital good (Hall and Jorgenson, 1967). The rental prices of capital goods of different ages are proportional to the rental prices of a new capital good. The constants of proportionality are the relative efficiencies  $(1-\delta)^\tau$ . Thus, the acquisition price of investment goods  $q_t$  is expressed as the sum of future rental prices of capital service  $P_t$ , weighted by the relative efficiencies of capital goods in each future period, i.e.,

$$q_t = \sum_{\tau=0}^{\infty} (1 - \delta)^\tau \prod_{s=1}^{\tau+1} \frac{1}{1 + r_{s+t}} P_{t+\tau+1} \quad (2)$$

where  $r_{s+t}$  is the rate of return in period  $s+t$ . Note that  $t$  represents the time of acquisition, and  $s$  denotes the time at which the capital services are supplied. The future rental prices are discounted in order to express prices for different time periods in terms of present values at time  $t$ . This expression can be compared with the corresponding expression PIM giving capital stock as a weighted sum of past investments.

Equation (1) can be expanded as

$$q_t = \frac{P_{t+1}}{1 + r_{t+1}} + \frac{(1 - \delta)P_{t+2}}{(1 + r_{t+1})(1 + r_{t+2})} + \frac{(1 - \delta)^2 P_{t+3}}{(1 + r_{t+1})(1 + r_{t+2})(1 + r_{t+3})} \\ + \frac{(1 - \delta)^3 P_{t+4}}{(1 + r_{t+1})(1 + r_{t+2})(1 + r_{t+3})(1 + r_{t+4})} + \dots \quad (3)$$

Then

$$q_t - q_{t-1} = -\frac{P_t}{1+r_t} + \left[ 1 - \frac{(1-\delta)}{(1+r_t)} \right] \left( \frac{P_{t+1}}{1+r_{t+1}} + \frac{(1-\delta)P_{t+2}}{(1+r_{t+1})(1+r_{t+2})} + \frac{(1-\delta)^2 P_{t+3}}{(1+r_{t+1})(1+r_{t+2})(1+r_{t+3})} + \dots \right) \quad (4)$$

The last term in (4) is  $q_t$ , hence replacing it with (2), (4) becomes

$$q_t - q_{t-1} = -\frac{1}{1+r_t} P_t + \frac{r_t + \delta}{1+r_t} \sum_{\tau=0}^{\infty} (1-\delta)^\tau \prod_{s=1}^{\tau+1} \frac{1}{1+r_{s+t}} P_{t+\tau+1} \quad (5)$$

From (5), the rental price of capital service can be derived as;

$$P_t = q_{t-1} r_t + \delta q_t - (q_t - q_{t-1})$$

## Appendix 2

Appendix Table 2.1: Average Growth rates in Capital Services, Netherlands, 1982-2001

Industry	CER	CER tax	INR	INRtax	IOR	IORtax	INRS	INRStax
Agriculture, Forestry and Fishing	1.83	1.91	2.05	2.04	2.06	2.06	2.05	2.05
Mining and Quarrying	1.77	1.77	1.73	1.74	1.74	1.74	1.73	1.74
Food, Drink & Tobacco	1.52	1.46	1.33	1.33	1.30	1.28	1.33	1.32
Textiles, Leather, Footwear & Clothing	-0.75	-0.82	-0.86	-0.83	-0.92	-0.91	-0.86	-0.84
Wood & Products of Wood and Cork	1.39	1.29	1.21	1.23	1.16	1.17	1.21	1.23
Pulp, Paper & Pducts; Printing & Publishing	3.53	3.41	3.12	3.12	3.07	3.06	3.12	3.11
Mineral Oil Refining, Coke & Nuclear Fuel	2.92	2.90	2.98	3.01	3.01	3.05	3.09	3.14
Chemicals	2.46	2.39	2.23	2.20	2.22	2.18	2.23	2.20
Rubber & Plastics	2.18	2.14	2.21	2.24	2.18	2.20	2.21	2.24
Non-Metallic Mineral Products	2.32	2.21	2.01	1.97	1.98	1.94	2.00	1.96
Basic Metals & Fabricated Metal Products	1.98	1.84	1.69	1.68	1.63	1.60	1.67	1.65
Mechanical Engineering	2.80	2.66	2.32	2.33	2.23	2.23	2.31	2.32
Electrical&Electronic Eqpt; Instruments	2.74	2.60	2.95	3.14	2.91	3.09	2.94	3.13
Transport Equipment	2.27	2.10	6.06	6.90	6.60	7.49	7.77	8.88
Furniture, Miscellaneous Mfg; recycling	1.20	1.13	1.00	1.02	0.97	0.99	1.00	1.02
Electricity, Gas and Water Supply	1.86	1.76	1.80	1.82	1.74	1.75	1.81	1.82
Construction	2.97	2.98	2.73	2.76	2.69	2.71	2.73	2.75
Repairs and wholesale trade	3.12	2.98	2.52	2.49	2.50	2.48	2.52	2.49
Retail trade	2.93	2.81	2.56	2.56	2.54	2.54	2.56	2.56
Hotels & Catering	2.76	2.63	2.40	2.38	2.37	2.36	2.40	2.39
Transport	2.39	2.45	2.33	2.32	2.40	2.40	2.34	2.34
Communications	6.92	6.86	6.64	6.66	6.61	6.62	6.63	6.65
Financial Intermediation	7.94	7.85	7.45	7.50	7.43	7.48	7.46	7.51
Real Estate Activities& Business Services	5.08	4.64	7.77	7.32	7.72	7.25	7.59	7.11
Other Services	6.54	6.29	6.89	7.03	6.58	6.66	6.86	7.00
Non-Market Services	2.23	2.18	2.34	2.39	2.28	2.33	2.34	2.40

Appendix Table 2.2: Average Growth rates in Capital Services, France, 1982-2001

Industry	CER	CER tax	INR	INRtax	IOR	IORtax	INRS	INRStax
Agriculture, Forestry and Fishing	2.61	2.58	2.52	2.50	2.51	2.48	2.52	2.50
Mining and Quarrying	-0.68	-0.74	-0.52	-0.48	-0.67	-0.66	-0.49	-0.45
Food, Drink & Tobacco	3.39	3.29	3.30	3.27	3.21	3.16	3.30	3.28
Textiles, Leather, Footwear & Clothing	2.37	2.16	2.14	2.10	2.08	2.01	2.15	2.10
Wood & Products of Wood and Cork	3.75	3.64	3.65	3.64	3.55	3.52	3.65	3.64
Pulp, Paper & Pducts; Printing & Publishing	5.60	5.38	5.35	5.29	5.25	5.17	5.36	5.30
Mineral Oil Refining, Coke & Nuclear Fuel	0.76	0.67	0.72	0.73	0.64	0.65	0.72	0.74
Chemicals	4.13	3.94	3.89	3.84	3.79	3.72	3.90	3.85
Rubber & Plastics	5.91	5.53	5.34	5.21	5.26	5.13	5.34	5.22
Non-Metallic Mineral Products	2.69	2.50	2.42	2.36	2.33	2.25	2.43	2.37
Basic Metals & Fabricated Metal Products	2.43	2.32	2.38	2.36	2.26	2.22	2.38	2.36
Mechanical Engineering	3.40	3.18	3.06	3.01	3.01	2.94	3.07	3.01
Electrical&Electronic Eqpt; Instruments	4.31	4.19	4.14	4.11	4.06	4.01	4.14	4.10
Transport Equipment	3.92	3.70	4.04	4.05	3.75	3.71	4.04	4.05
Furniture, Miscellaneous Mfg; recycling	1.99	1.97	1.89	1.91	1.86	1.88	1.89	1.92
Electricity, Gas and Water Supply	2.43	2.37	2.62	2.68	2.35	2.38	2.68	2.75
Construction	1.48	1.51	1.57	1.58	1.53	1.53	1.58	1.58
Repairs and wholesale trade	4.34	4.09	4.02	4.03	3.91	3.88	4.02	4.03
Retail trade	4.34	4.00	4.01	3.91	3.87	3.77	4.01	3.91
Hotels & Catering	5.94	5.72	5.59	5.55	5.46	5.40	5.59	5.55
Transport	3.37	3.40	3.56	3.61	3.33	3.36	3.58	3.63
Communications	2.78	2.71	2.85	2.87	2.62	2.61	2.87	2.90
Financial Intermediation	4.75	3.98	3.83	3.80	3.47	3.39	3.87	3.85
Real Estate Activities& Business Services	7.41	6.87	6.79	6.67	6.64	6.49	6.80	6.68
Other Services	4.54	4.24	4.42	4.45	4.18	4.16	4.46	4.49
Non-Market Services	3.58	3.39	3.80	3.87	3.59	3.64	3.81	3.89

Appendix Table 2.3: Average Growth rates in Capital Services, UK, 1982-2000

Industry	CER	CER tax	INR	INRtax	IOR	IORtax	INRS	INRSStax
Agriculture, Forestry and Fishing	0.20	0.25	0.51	0.55	0.40	0.43	0.48	0.52
Mining and Quarrying	0.20	0.49	0.88	1.09	0.68	0.85	0.87	1.06
Food, Drink & Tobacco	1.84	1.81	1.86	1.91	1.59	1.60	1.88	1.94
Textiles, Leather, Footwear & Clothing	-0.74	-0.75	-0.45	-0.37	-0.88	-0.85	-0.45	-0.37
Wood & Products of Wood and Cork	-1.37	-1.35	-1.07	-1.02	-1.39	-1.38	-1.07	-1.02
Pulp, Paper & Products; Printing & Publishing	4.11	4.06	3.47	3.49	3.43	3.46	3.65	3.69
Mineral Oil Refining, Coke & Nuclear Fuel	-1.41	-1.34	-1.18	-1.11	-1.39	-1.36	-1.14	-1.07
Chemicals	1.99	1.97	2.13	2.22	1.76	1.80	2.18	2.27
Rubber & Plastics	2.96	2.93	3.08	3.15	2.69	2.71	3.11	3.18
Non-Metallic Mineral Products	5.29	5.16	4.35	4.26	4.23	4.13	4.35	4.27
Basic Metals & Fabricated Metal Products	-0.46	-0.48	-0.24	-0.16	-0.62	-0.59	-0.22	-0.13
Mechanical Engineering	0.22	0.20	0.49	0.62	-0.12	-0.07	0.49	0.62
Electrical & Electronic Eqpt; Instruments	5.44	5.39	5.16	5.22	4.75	4.76	5.18	5.23
Transport Equipment	3.55	3.49	4.51	4.68	3.93	4.02	4.56	4.74
Furniture, Miscellaneous Mfg; recycling	5.20	5.14	4.78	4.77	4.61	4.57	4.77	4.75
Electricity, Gas and Water Supply	1.63	1.66	1.82	1.89	1.59	1.64	1.88	1.96
Construction	1.51	1.53	1.65	1.69	1.59	1.62	1.63	1.67
Repairs and wholesale trade	6.98	6.87	5.99	5.96	5.67	5.60	5.99	5.96
Retail trade	5.68	5.72	6.25	6.38	5.64	5.70	6.22	6.35
Hotels & Catering	5.24	5.26	5.43	5.44	5.34	5.33	5.41	5.42
Transport	1.95	2.04	2.58	2.70	2.00	2.04	2.43	2.53
Communications	8.12	8.06	10.28	10.67	7.98	8.07	10.06	10.41
Financial Intermediation	8.20	7.85	8.26	8.44	6.64	6.61	7.74	7.84
Real Estate Activities & Business Services	10.50	10.22	13.43	13.93	12.13	12.29	13.45	13.59
Other Services	4.51	4.34	7.06	7.46	6.06	6.30	7.05	7.43
Non-Market Services	4.23	4.11	5.65	5.94	4.84	5.00	5.63	5.91

Appendix Table 2.4: Average Growth rates in Capital Services, Germany, 1982-2001

Industry	CER	CER tax	INR	INRtax	IOR	IORtax	INRS	INRS tax
Agriculture, Forestry and Fishing	1.01	0.93	-0.66	-2.79	-0.85	-3.16	-0.66	-2.77
Mining and Quarrying	-1.83	1.92	-1.62	-1.56	-1.81	-1.90	-1.60	-1.52
Food, Drink & Tobacco	2.14	2.14	2.19	2.20	2.15	2.12	2.19	2.19
Textiles, Leather, Footwear & Clothing	0.01	0.02	0.10	-0.04	0.08	-0.07	0.08	-0.06
Wood & Products of Wood and Cork	2.30	2.31	2.39	2.42	2.33	2.32	2.37	2.40
Pulp, Paper & Products; Printing & Publishing	3.92	3.91	3.77	3.95	3.73	3.86	3.77	3.94
Mineral Oil Refining, Coke & Nuclear Fuel	1.34	1.35	2.43	3.25	2.42	3.23	2.36	3.14
Chemicals	3.11	3.11	2.92	3.13	2.89	3.06	2.92	3.12
Rubber & Plastics	4.53	4.53	4.45	4.55	4.42	4.49	4.45	4.54
Non-Metallic Mineral Products	1.97	1.98	2.07	2.01	2.03	1.93	2.07	2.00
Basic Metals & Fabricated Metal Products	1.38	1.38	1.42	1.37	1.40	1.33	1.41	1.36
Mechanical Engineering	2.51	2.52	2.41	2.49	2.40	2.45	2.41	2.48
Electrical & Electronic Eqpt; Instruments	2.82	2.81	2.85	3.02	2.79	2.90	2.84	3.00
Transport Equipment	4.39	4.39	4.42	4.78	4.39	4.74	4.42	4.79
Furniture, Miscellaneous Mfg; recycling	2.00	1.99	1.94	2.08	1.90	2.00	1.94	2.07
Electricity, Gas and Water Supply	2.93	2.91	3.03	2.79	2.97	2.68	3.02	2.78
Construction	0.44	0.45	0.72	0.63	0.67	0.55	0.71	0.61
Repairs and wholesale trade	2.41	2.42	2.57	2.53	2.50	2.40	2.56	2.52
Retail trade	5.75	5.75	5.59	5.78	5.51	5.65	5.58	5.76
Hotels & Catering	2.27	2.28	1.30	0.00	1.18	-0.23	1.26	-0.07
Transport	2.21	2.20	1.69	0.84	1.27	0.05	1.66	0.78
Communications	5.74	5.74	5.42	5.90	5.37	5.81	5.41	5.88
Financial Intermediation	4.75	4.67	3.96	4.30	3.88	4.16	3.95	4.29
Real Estate Activities & Business Services	7.21	7.20	7.31	7.30	7.28	7.25	7.31	7.29
Other Services	4.53	4.54	4.50	4.53	4.50	4.53	4.50	4.53
Non-Market Services	2.99	2.99	3.03	2.81	2.93	2.63	3.01	2.78

### Appendix 3

Appendix Table 3.1: Average TFPG Netherlands, 1982-2001

Industry	CER	CER tax	INR	INRtax	IOR	IORtax	INRS	INRStax
Agriculture, Forestry and Fishing	1.80	1.75	1.68	1.68	1.67	1.68	1.68	1.68
Mining and Quarrying	-0.67	-0.67	-0.63	-0.64	-0.63	-0.64	-0.63	-0.64
Food, Drink & Tobacco	1.96	1.99	2.05	2.05	2.07	2.07	2.05	2.06
Textiles, Leather, Footwear & Clothing	3.47	3.49	3.51	3.50	3.52	3.52	3.51	3.50
Wood & Products of Wood and Cork	3.17	3.20	3.23	3.22	3.24	3.24	3.23	3.22
Pulp, Paper & Pducts; Printing & Publishing	2.24	2.28	2.38	2.38	2.40	2.40	2.38	2.38
Mineral Oil Refining, Coke & Nuclear Fuel	-2.76	-2.75	-2.79	-2.80	-2.80	-2.81	-2.85	-2.88
Chemicals	2.36	2.40	2.49	2.51	2.50	2.52	2.50	2.51
Rubber & Plastics	3.63	3.65	3.63	3.62	3.64	3.64	3.63	3.62
Non-Metallic Mineral Products	2.07	2.12	2.21	2.23	2.22	2.24	2.21	2.23
Basic Metals & Fabricated Metal Products	1.79	1.84	1.89	1.89	1.91	1.92	1.90	1.90
Mechanical Engineering	3.05	3.08	3.18	3.18	3.20	3.20	3.18	3.18
Electrical&Electronic Eqpt; Instruments	3.08	3.11	3.08	3.05	3.08	3.05	3.08	3.05
Transport Equipment	4.17	4.19	3.92	3.86	3.86	3.79	3.78	3.70
Furniture, Miscellaneous Mfg; recycling	2.58	2.59	2.62	2.61	2.62	2.62	2.61	2.61
Electricity, Gas and Water Supply	0.48	0.54	0.51	0.50	0.55	0.55	0.51	0.50
Construction	0.50	0.50	0.55	0.55	0.56	0.56	0.55	0.55
Repairs and wholesale trade	2.04	2.10	2.28	2.30	2.29	2.30	2.28	2.29
Retail trade	1.56	1.60	1.69	1.69	1.70	1.70	1.69	1.69
Hotels & Catering	-0.53	-0.47	-0.37	-0.37	-0.36	-0.36	-0.37	-0.37
Transport	1.48	1.46	1.50	1.50	1.47	1.47	1.49	1.50
Communications	1.93	1.96	2.08	2.08	2.10	2.09	2.09	2.08
Financial Intermediation	-1.40	-1.36	-1.20	-1.22	-1.19	-1.21	-1.20	-1.22
Real Estate Activities& Business Services	0.34	0.45	-0.27	-0.15	-0.25	-0.13	-0.23	-0.11
Other Services	0.66	0.70	0.60	0.58	0.65	0.64	0.60	0.58
Non-Market Services	0.55	0.56	0.52	0.51	0.54	0.53	0.52	0.51
Total Economy	1.04	1.08	1.05	1.06	1.06	1.07	1.05	1.06

Note: the differences reported in the text may not tally exactly, as the growth rates reported here are rounded to two decimal points.

Appendix Table 3.2: Average TFPG France, 1982-2001

Industry	CER	CER tax	INR	INRtax	IOR	IORtax	INRS	INRStax
Agriculture, Forestry and Fishing	1.83	1.86	1.89	1.91	1.90	1.92	1.90	1.91
Mining and Quarrying	4.44	4.46	4.41	4.40	4.44	4.44	4.41	4.40
Food, Drink & Tobacco	-0.45	-0.41	-0.41	-0.40	-0.38	-0.36	-0.41	-0.41
Textiles, Leather, Footwear & Clothing	0.71	0.75	0.77	0.78	0.78	0.80	0.77	0.78
Wood & Products of Wood and Cork	2.12	2.14	2.16	2.16	2.18	2.18	2.15	2.16
Pulp, Paper & Products; Printing & Publishing	-0.24	-0.18	-0.17	-0.15	-0.14	-0.11	-0.17	-0.15
Mineral Oil Refining, Coke & Nuclear Fuel	-3.90	-3.86	-3.86	-3.87	-3.83	-3.83	-3.86	-3.87
Chemicals	3.82	3.90	3.93	3.95	3.98	4.01	3.93	3.95
Rubber & Plastics	1.82	1.95	2.02	2.06	2.04	2.09	2.02	2.06
Non-Metallic Mineral Products	1.95	2.03	2.05	2.07	2.08	2.10	2.05	2.07
Basic Metals & Fabricated Metal Products	0.05	0.08	0.07	0.07	0.10	0.11	0.07	0.07
Mechanical Engineering	1.38	1.45	1.48	1.50	1.50	1.52	1.48	1.50
Electrical & Electronic Eqpt; Instruments	3.51	3.55	3.57	3.58	3.59	3.61	3.57	3.58
Transport Equipment	3.12	3.18	3.14	3.15	3.20	3.21	3.14	3.14
Furniture, Miscellaneous Mfg; recycling	0.72	0.73	0.76	0.75	0.77	0.76	0.76	0.75
Electricity, Gas and Water Supply	2.56	2.59	2.44	2.40	2.61	2.59	2.40	2.36
Construction	0.47	0.47	0.45	0.45	0.46	0.46	0.45	0.45
Repairs and wholesale trade	1.67	1.73	1.75	1.75	1.78	1.78	1.75	1.75
Retail trade	1.40	1.49	1.50	1.53	1.54	1.57	1.50	1.53
Hotels & Catering	-2.93	-2.86	-2.83	-2.81	-2.79	-2.77	-2.83	-2.82
Transport	1.07	1.07	1.01	1.00	1.08	1.08	1.01	0.99
Communications	4.62	4.65	4.59	4.57	4.70	4.70	4.57	4.56
Financial Intermediation	-0.61	-0.29	-0.23	-0.22	-0.08	-0.05	-0.25	-0.24
Real Estate Activities & Business Services	-1.45	-1.25	-1.22	-1.17	-1.16	-1.11	-1.22	-1.18
Other Services	-2.40	-2.29	-2.36	-2.36	-2.27	-2.26	-2.37	-2.38
Non-Market Services	0.69	0.72	0.65	0.64	0.69	0.68	0.65	0.64
Total Economy	0.55	0.63	0.61	0.62	0.66	0.68	0.61	0.61

Note: the differences reported in the text may not tally exactly, as the growth rates reported here are rounded to two decimal points.

Appendix Table 3.3: Average TFPG, UK, 1982-2000

Industry	CER	CER tax	INR	INRtax	IOR	IORtax	INRS	INRStax
Agriculture, Forestry and Fishing	1.47	1.44	1.29	1.26	1.35	1.33	1.30	1.28
Mining and Quarrying	2.95	2.73	2.43	2.27	2.57	2.44	2.44	2.28
Food, Drink & Tobacco	1.05	1.06	1.05	1.03	1.13	1.13	1.04	1.02
Textiles, Leather, Footwear & Clothing	2.15	2.15	2.08	2.07	2.18	2.18	2.09	2.07
Wood & Products of Wood and Cork	0.58	0.58	0.50	0.48	0.59	0.59	0.49	0.48
Pulp, Paper & Products; Printing & Publishing	1.43	1.44	1.58	1.58	1.60	1.59	1.54	1.52
Mineral Oil Refining, Coke & Nuclear Fuel	1.80	1.77	1.69	1.66	1.79	1.78	1.69	1.65
Chemicals	4.66	4.67	4.61	4.58	4.75	4.74	4.59	4.56
Rubber & Plastics	1.88	1.89	1.85	1.83	1.95	1.94	1.84	1.83
Non-Metallic Mineral Products	0.65	0.69	0.97	1.00	1.00	1.04	0.97	1.00
Basic Metals & Fabricated Metal Products	2.18	2.19	2.14	2.13	2.22	2.22	2.14	2.12
Mechanical Engineering	1.08	1.08	1.01	0.98	1.17	1.16	1.01	0.98
Electrical & Electronic Eqpt; Instruments	6.92	6.93	7.00	6.98	7.13	7.13	6.99	6.97
Transport Equipment	3.86	3.87	3.75	3.73	3.84	3.83	3.74	3.72
Furniture, Miscellaneous Mfg; recycling	-0.29	-0.27	-0.17	-0.17	-0.12	-0.11	-0.17	-0.17
Electricity, Gas and Water Supply	3.09	3.08	2.97	2.92	3.12	3.09	2.93	2.88
Construction	1.89	1.88	1.86	1.85	1.88	1.87	1.86	1.86
Repairs and wholesale trade	2.25	2.29	2.58	2.58	2.68	2.71	2.58	2.59
Retail trade	0.81	0.80	0.62	0.58	0.82	0.81	0.63	0.59
Hotels & Catering	-1.60	-1.60	-1.65	-1.66	-1.62	-1.62	-1.65	-1.65
Transport	4.19	4.17	4.02	3.99	4.18	4.17	4.06	4.03
Communications	4.24	4.26	3.50	3.38	4.29	4.26	3.57	3.46
Financial Intermediation	-0.37	-0.25	-0.41	-0.47	0.18	0.19	-0.22	-0.26
Real Estate Activities & Business Services	-0.78	-0.69	-1.71	-1.88	-1.20	-1.25	-1.74	-1.80
Other Services	1.90	1.93	1.44	1.36	1.66	1.61	1.45	1.38
Non-Market Services	-0.20	-0.19	-0.31	-0.34	-0.23	-0.25	-0.32	-0.34
Total Economy	1.47	1.49	1.29	1.24	1.50	1.48	1.30	1.26

Note: the differences reported in the text may not tally exactly, as the growth rates reported here are rounded to two decimal points.

Appendix Table 3.4: Average TFPG, Germany, 1982-2001

Industry	CER	CER tax	INR	INRtax	IOR	IORtax	INRS	INRStax
Agriculture, Forestry and Fishing	4.15	4.16	4.30	4.51	4.31	4.53	4.30	4.51
Mining and Quarrying	0.96	0.58	0.93	0.91	0.95	0.94	0.93	0.91
Food, Drink & Tobacco	0.72	0.72	0.70	0.70	0.72	0.73	0.70	0.70
Textiles, Leather, Footwear & Clothing	1.55	1.55	1.53	1.57	1.54	1.57	1.54	1.57
Wood & Products of Wood and Cork	1.79	1.79	1.76	1.76	1.78	1.78	1.77	1.76
Pulp, Paper & Pducts; Printing & Publishing	0.54	0.54	0.60	0.53	0.62	0.56	0.60	0.53
Mineral Oil Refining, Coke & Nuclear Fuel	0.51	0.50	0.39	0.39	0.35	0.33	0.39	0.41
Chemicals	2.63	2.63	2.68	2.61	2.70	2.64	2.69	2.62
Rubber & Plastics	1.05	1.05	1.07	1.05	1.08	1.06	1.08	1.05
Non-Metallic Mineral Products	1.63	1.62	1.59	1.61	1.61	1.64	1.59	1.62
Basic Metals & Fabricated Metal Products	1.79	1.79	1.78	1.79	1.78	1.80	1.78	1.79
Mechanical Engineering	1.10	1.09	1.11	1.09	1.11	1.10	1.11	1.09
Electrical&Electronic Eqpt; Instruments	2.74	2.74	2.74	2.71	2.75	2.73	2.74	2.71
Transport Equipment	-0.12	-0.12	-0.09	-0.16	-0.09	-0.15	-0.09	-0.16
Furniture, Miscellaneous Mfg; recycling	-0.15	-0.15	-0.14	-0.17	-0.12	-0.15	-0.13	-0.17
Electricity, Gas and Water Supply	1.61	1.62	1.55	1.67	1.58	1.74	1.55	1.68
Construction	0.13	0.12	0.06	0.08	0.07	0.10	0.06	0.08
Repairs and wholesale trade	1.90	1.90	1.86	1.87	1.88	1.90	1.86	1.87
Retail trade	1.19	1.19	1.22	1.18	1.24	1.21	1.22	1.19
Hotels & Catering	-2.19	-2.19	-2.14	-2.06	-2.13	-2.04	-2.13	-2.05
Transport	3.42	3.42	3.48	3.62	3.58	3.80	3.49	3.63
Communications	4.92	4.92	5.09	4.84	5.11	4.89	5.09	4.86
Financial Intermediation	1.27	1.30	1.60	1.46	1.64	1.52	1.61	1.47
Real Estate Activities& Business Services	-0.59	-0.59	-0.66	-0.65	-0.64	-0.62	-0.65	-0.64
Other Services	-0.53	-0.53	-0.51	-0.53	-0.51	-0.52	-0.51	-0.53
Non-Market Services	0.61	0.61	0.61	0.64	0.62	0.67	0.61	0.64
Total Economy	1.01	1.01	1.04	1.03	1.05	1.06	1.04	1.03

Note: the differences reported in the text may not tally exactly, as the growth rates reported here are rounded to two decimal points.