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Measuring Irish Capital

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Abstract

Irish National Income and Expenditure Accounts do not contain information on capital stocks or capital services estimation. Estimates of the national capital stock and the depreciation of its fixed assets are basic macroeconomic aggregates and are integral components for many modelling exercises. This paper will present a detailed asset-level analysis of the stocks and depreciation of Irish fixed assets and the capital formation flows used to derive them. It will apply an improved perpetual inventory methodology for calculating depreciation based on best practice employed for the US National Income and Product Accounts (NIPA). The paper shows how the three basic capital variables – the net capital stock, consumption of fixed capital and capital services – are linked through a standard equation for the value of an asset. The paper then presents estimates of the volume of capital services for the Irish economy as well as by asset type. The volume index of capital services (VICS) weights together the growth in the net stock of assets using shares that reflect the relative productivity of the different assets that make up the capital stock i.e. without controlling for the share of housing in the capital stock total factor productivity will be overestimated for growth accounting purposes.

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Measuring Irish Capital

1. Introduction

Estimates of the national capital stock and the associated series of capital consumption are basic macroeconomic aggregates and are integral components for many modelling exercises such as calculating potential GDP and the related measures of Gross Domestic Income and Net Domestic Product[1]. Estimates of capital stocks are needed to calculate of the contribution of capital services to the growth of output in growth accounting exercises and for the calculation of total factor productivity (TFP), (Jorgenson and Griliches, 1967).

The link between productivity growth and investment has received considerable attention with particular reference to large investments in housing or assets related to the new economy. While discussion and analysis continues, there has been a parallel debate about the measurement of capital. For any given type of asset, there is a flow of productive services from the cumulative stock of past investments. Capital service estimates follow neatly from depreciation and net stock volume measures but the Irish National Income and Expenditure Accounts (NIE) do not currently contain information on capital stocks. This paper has two aims. First it presents a detailed analysis of the stocks and depreciation of Irish fixed assets and the capital formation flows used to derive them. It will apply an improved methodology for calculating depreciation based on best practice employed for the US National Income and Product Accounts (NIPA) (BEA, 2003). Second, using these measures for capital input, a measure of capital services flow is computed according to a methodology recommended by the OECD for cross-country comparisons (OECD, 2001).

There are several ways to measure the value of the gross capital stock (Hulten, 1991; Jorgenson, 1991). One econometric approach hinges on the fact that capital stock is a basic argument of the production function and can be estimated indirectly; jointly with the production function itself (Hernandez and Mauleon, 2005). By far the most common approach is a model-based approach known as the perpetual inventory method (PIM), pioneered by Goldsmith (1951). A basic PIM approach involves accumulating past capital formation and deducting the value of assets that have reached the end of their productive lives. A third approach can use exact surveys to report the historic or acquisition values of all assets still in use, by charting the dates at which they were installed or constructed. A "balance of fixed assets" method lies between the PIM and survey methods and keeps a current quantity record of the different vintages of assets in the capital stock. Correctly applied, this method can be seen as the ideal version of the PIM, particularly as actual information on asset vintages is recorded and does not have to be assumed as in the conventional case.[2] For Ireland, we attempt to replicate this third method by applying a model-based perpetual

[1] Net domestic product measures the level of consumption that can be maintained while leaving capital assets intact.
[2] This approach was commonly applied in centrally planned economies where enterprises were required to keep a running inventory of their fixed capital assets, tracking outflows as well as inflows. The central statistical agency could then obtain a total capital stock figure with a simple summation.

inventory methodology to construct a balance sheet of capital stocks adopting non-Irish surveys of depreciation and service life parameters by detailed asset type.

The quantities and efficiency of assets held are priced according to detailed price indices. This type of capital stock valuation depends on a detailed data breakdown by asset type according to the amount of gross fixed capital formation undertaken in previous years that has usefully survived to the current period. The asset-type investment cost deflators of the Irish National Accounts are used in our analysis.

Our panel of data runs from 1980 to 2004, with most detailed information by asset type and sector running from 1998 onwards. Starting values for cumulated stocks from Henry (1989) are available for some asset types but several problems arise. There is left-censoring where the capital formation data is not sufficiently long to cover the longest lifespan of any asset in the stock e.g. 90 years approx. The accumulated or 'initial' capital before 1980 would be grossly underestimated if only investments post 1980 were included. Moreover, some assets became prominent after 1980 and starting values are necessary specifically for asset types not provided by Henry (1989). We apply a steady-state growth approach to estimate starting values where these problems arise.

The next section explains the model methodology. Specifically, it discusses the valuation principles and definitions of gross and net fixed stocks, consumption of capital and the theoretical basis of the measurement of capital stocks and flows. Section 3 describes the measurement issues and the basic data requirements for implementing the PIM. We will apply detailed asset-life parameters to Irish gross fixed capital formation across the specified asset types imported from the evidence collected by the US Bureau of Economic Analysis. Sections 4 and 5 present the calculation results for capital stocks and capital service flows and a final section concludes.

2. Perpetual Inventory Method and depreciation concepts

The traditional simple application of the perpetual inventory method involves the accumulation of investment series but does not prevent its results being enriched with additional information. An estimate of the gross capital stock is made by applying a depreciation function to capture the productive efficiency and age-price profile of the assets. A realistic retirement pattern for assets is constructed using an asset mortality function. The estimations based on the PIM distinguish between two measurements of capital stock: gross and net.

Following Berndt (1991, pp. 227-29), let $I_{i(t-j)}$ be the net real investment of asset type *i* by a household, firm or government in time *t* - *j*; and K_{jt} be the amount of all investment surviving to time *t*, then

$$K_{jt} \equiv e_{jt} I_{t-j} \qquad (1)$$

where e_{jt} is the survival rate (depending on when the investment took place i.e. asset vintage *j*) or also called the efficiency rate for all investment to time period t. The aggregate capital stock at the end of the period *t* is the sum over all assets of equation (1) and is denoted K_t

$$K_t \equiv \sum_{j=0}^{L} K_{ijt} = \sum_{j=0}^{L} e_{jt} I_{t-j} \qquad (2)$$

where *i* is an individual asset and *L* is the assumed number of years for which it will be productive.

The survival rate e_{jt}, representing the life pattern of the specific asset raises the first important empirical issue. The survival rates have also been called relative efficiencies in the literature on this topic. The survival rate of new investment can be normalised at unity such that that relative efficiency is assumed to be non-decreasing i.e. assets starts life at full efficiency $e_0 = 1$ and $e_t - e_{t-1} \geq 0 \ \ (t = 0,\ 1,\ 2...)$. We also assume that relative efficiency eventually approaches zero, $\lim e_t = 0$ as $t \rightarrow \infty$.

There are at least four age-efficiency profiles referred to in the literature. A constant age-efficiency with no decline in efficiency until the asset is retired (a "one-hoss shay" pattern) assumes that the same amount of service is provided during each time period, such that

$$e_t = \begin{cases} 1, & t = 0,\ 1,\ 2,\ ...,L-1 \\ 0, & otherwise \end{cases}$$

where *L* is the lifetime after which the asset expires or is scrapped.

Second, the age-efficiency decline may be determined as a constant amount each year (linear or straight line pattern) over the lifetime of the asset, then

$$e_t = \begin{cases} 1 - \dfrac{t}{L}, & t = 0,\ 1,\ 2,\ ...,L-1 \\ 0, & otherwise \end{cases}$$

Third, age-efficiency can be deemed to be falling hyperbolically (slowly at first and at an increasing rate towards the end of the asset's life) but at a constant exponential rate each year, say $\partial\%$. This implies that depreciation will follow a geometric decline.

$$e = (1 - \partial)^t, \quad t = 0,\ 1,\ 2,\ ...,L$$

With a geometric pattern, the rate of depreciation ∂ depends only on the declining-balance rate and the asset's service life *L*. When the expected lifetime expression is substituted into Equation (2), the aggregate stock at time period *t*, base is

$$K_t = \sum_{j=o}^{L} K_{t-j} + \sum_{j=0}^{L} (1-\partial)^j I_{t-j} \tag{3}$$

In practice, we cannot go back to the date at which investment first took place as this would involve an infinite number of past investment flows. Equation (3) must be replaced by the following expression:

$$K_t = (1-\partial)^t K_1 + \sum_{i=0}^{t-1} (1-\partial)^j I_{t-j} \tag{4}$$

where K_1 is an initial or starting value for the gross capital stock.

By extension, the capital stock obtained at the end of any period is the opening capital stock for the following period. The stock of capital in each sector is then equal to a efficiency-corrected sum of all past capital formation flows. Equation (4) is the detailed formulation of the perpetual inventory method taking vintage and asset life into account and one which is used in our calculations below.

The treatment of scrappage value must also be decided i.e. the net value of an asset (scrappage minus demolition costs) when asset life expires. In line with Hulten and Wykoff (1981), it is assumed in our analysis below that the net value of an asset retired from service is on average zero such that the asset-specific depreciation estimates reflect both efficiency declines and retirements.

Ideally, information on usage of assets would be available so that the present value of expected capital service flows for existing assets can be updated over the remaining service life of an asset. However in the absence of such information, the assumed *age-price profile* has to estimate the change in the market value of an asset (of a particular age) from one accounting period to the next (assuming the price level is stable). The OECD (2001) showed how the age-price profile in turn depends on assuming a plausible *age-efficiency* profile, as discussed above, where there is a direct correspondence between efficiency patterns and the depreciation method applied. The geometric depreciation method was shown to have the highest coincidence of value and efficiency declines over time.

Standard Efficiency Units

Different vintages of capital assets are accounted for according to the simple extension of the geometric calculation

$$d_j = \partial.(1-\partial)^{j-1} \tag{5}$$

where *j* is the age of the asset. All gross fixed capital formation is assumed to be "as new" so that the vintage composition of the capital stock is determined according to the first year the investment was undertaken. The efficiency value is adjusted according to the composite vintage in Equation (4), which is centred on the constant geometric depreciation rate ∂ appropriate to the asset in question. The total capital stock represents the efficiency-adjusted volume of all productive assets available in an economy and is considered to be the volume of capital available for the productive process at time *t* when it may be used in the economic system. The principle is that the economic productivity of goods that remain in the net stock should be held constant.

Caveats: weaknesses of the PIM

There are two main weaknesses identified with the use of PIM model: one is deficiencies due to data inputs and another is the weakness in the assumptions underlying the methodology.

No Irish information exists regarding transactions in used assets. This causes potentially distorting effects on a number of levels. First, where no information exists on the disposals of assets, the capital acquisition figures have to be used to represent the net additions to the capital stock. This is particularly the case for the government sector where very limited capital information exists. Second, the price differential between new and second-hand fixed assets are generally excluded from the construction of price indices. These are only accounted for in so far as gross fixed capital formation data has been assembled for National Accounts purposes. We can only attempt to overcome some of the data weaknesses by employing the most detailed gross fixed capital formation figures at the asset level rather than at the whole economy level.

Third, according to the Bureau of Economic Analysis (BEA), capital consumption in the US National Income and Product Accounts (NIPAs) is the outlay required to keep the 'capital stock intact'. This notion, while quite intuitive, has generated a surprising amount of controversy in the literature on capital measurement. At the risk of oversimplifying the debate, the issue is whether any positive change in an asset value should be included as a net deduction from the consumption of fixed capital. The 1993 System of National Accounts (SNA)[3] recommends the construction of a revaluation account – separate from the measurement of capital consumption allowances – that records the gain or loss in value that "... accrue[s] purely as a result of holding assets over time without transforming them in any way" (Section 12.67). These competing interpretations of what it means to hold capital intact date back at least to the debate between Hayek (1941), Pigou (1941), and Hicks (1942). Economists have yet to settle this issue.

This paper does not attempt to make any estimates of net appreciation or after-purchase revaluation. This debate could be significant in the Irish case where investment in dwellings makes a major contribution to the Irish capital stock. The PIM convention is to deflate an asset series according to an investment (cost) price deflator and not a market index such as the house price index. The investment price deflator is driven by the materials and wages cost of building and construction and does not represent the land cost element of the housing stock. In this way, the 'replaced investment cost' of the dwellings capital stock does not represent the significant appreciation in house price-driven wealth witnessed over the period.

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[3] The SNA are a comprehensive set of macroeconomic accounts prepared jointly by the World Bank, the International Monetary Fund, the OECD, the Commission of the European Communities, and the United Nations.

3. Data, Measurement and Valuation Method

Data

The basic ingredient for the application of the perpetual inventory method is the gross fixed capital formation information provided by the Irish NIE accounts (CSO, 2005). Details of capital assets in industry are available on a quarterly basis by detailed asset type since 1998 (CSO, 2004). The annual Public Capital Programme gives some details on annual public expenditure on capital, which was used to account for government investment in machinery and equipment (Department of Finance, 2005).

Table 1: Asset types by sector for the study period 1980 to 2004 inclusive

i: **Asset types**	***s: Sectors***	***t: Years***
New Dwellings	Households	1980
Home improvements	Industry (incl. Agriculture)	
Roads	Government (Local and Central)	
Building and Construction		….
Transport equipment		
Agricultural machinery		
Other machinery and equipment		….
Software		
Exploration		
Artistic Originals		2004

Our estimation exercise is comparable to that performed by Jacob, Sharma and Grabowski (1997) where our aim is to obtain estimates by asset type rather than by industrial activity as per Table 1. The current price data for each year are assembled for the period 1970 – 2004. The CSO National Accounts' represent the control totals for GFCF by the total economy fixed capital (NIE Table 15). Together with sectoral data (NIE Table 16), household consumption (NIE Table 13) and Government Gross Physical Capital Formation (NIE Table 25), the following sector and asset subdivisions are made:

Table 2: Decomposition of Gross Fixed Capital Formation (NIE Table 15) by Asset Type

	Households	Firms	Government	Total
Dwellings: Purchases	v (DoE)		(DoE) } (NIE 25)[a]	} NIE Table 15
Home Improvnts	v (DoE)		v (DoE) } (NIE 25)[a]	
Roads			v (NIE25)	NIE Table 15
Other Building & Const[b]		v (CIP: 2/3)	v (PCP: 1/3)	NIE Table 15
Consumer Durables	v (NIE13)			NIE Table 13
Transport equipment	v (NIE13)	v (Resid)	v (NIE25)[c]	NIE Table 15
Agricultural machinery		v (NIE15)		NIE Table 15
Other machinery & equip		v (CIP&Resid)	v (NIE25)[c]	NIE Table 15
Software		v (Resid)	v (1996 share)[d]	NIE Table 15
Exploration		v (CIP)[e]	v (Resid)	NIE Table 15
Artistic Originals		v (NIE15)		NIE Table 15

Notes:

a. Details on the breakdown of investment in dwellings by purchases and home improvements only became available from 1995 onwards. A combined series for both government and private investment in dwellings is also available.

b. Despite compiling detailed information from the various years' Public Capital Programme and investment by firms in structures (from the Census of Industrial Production), the combined figure did not equal the total given by NIE Table 15. The ratio of government to industry investment in building and construction was on average two-thirds industry, one-third government. In line with Henry (1989) and Vaughan (1980), it was necessary to 'scale up' the results to match the CSO annual control totals. The two-to-one ratio is maintained.
c. Capital formation by government in vehicles and machinery & equipment is combined in NIE Table 25. After consulting the Government PCPs it was necessary to impose the restriction that government investment in both asset types did not exceed the value shown in NIE25. In most cases, the capital formation figure had to be scaled up to reach the desired control total.
d. From 1996 onwards, an internal CSO estimate of government investment in software was given as €13.7m in 1996 [Personal Communication: Mark Davis, CSO February 2006]. The series for government software investment was extended forward using the 1996 share of total investment in software. The following depreciation treatment of software investment was treated identically for firms and government in our analysis despite this arbitrary allocation of total software investment across sectors.
e. From 1996 onwards, it was assumed that industry investment in exploration was conducted fully by industries classified as NACE 10-14 (Mining and Quarrying). The CSO data series Capital Flows in Industry (available from 1996 onwards) is the industry data employed here. It is assumed that all remaining capital formation represents that conducted by Government (State and Semi-State bodies).

Starting Values

A benchmark figure for the year just prior to the year when our investment series begins is needed. The issue of starting values is a contentious one and we are not alone in having to look for a compromise solution where starting values are not available. For instance, Hofman (1992) constructs manufacturing capital stock estimates for several Latin American countries and Ball *et al* (1993) had to artificially construct values under the assumption that capital stock was zero in the year 1940 and that gross investments grew linearly from that date to its observed current level.

Starting values for some categories of Irish assets are available from Henry (1989) but as historical information, particularly for capital stock held by the government sector, is not available at a detailed asset-type level, we opt for a "steady-state growth approach" on accumulated investment (Fuente and Domenech, 2002, p.47) Neoclassical growth theory suggests that investment and capital grow at the same rate in the steady state. The growth rate of the capital stock can be expressed as

$$g_t^K = \frac{K_{t+1} - K_t}{K_t} = -\partial + \frac{I_t}{K_t}.$$

Thus the end value capital stock for the period (t =1970-1979) can be calculated as investment in the period divided by the sum of the depreciation rate and the growth rate of the capital stock over the period:

$$K_t = \frac{I_t}{\partial + g_t^K}$$

The figures for the 1970s are not shown in the tables as this "start-up period" allows the starting values to become less significant as effects of new investment grow larger. The question arises as to why this method was not employed for all starting values. The oil shocks of the 1970s destabilised the economy and rendered some forms of capital stock redundant. This raises some specific concerns with the use of the steady-state assumption about this period. A number of deficiencies were found with the available Henry starting values. Transport equipment (and its agricultural component in particular) appear to have been substantially overvalued by Henry (1980). Other machinery and equipment were significantly understated by Henry compared with the steady state growth method such that the Henry starting value had to be scaled by a factor of two, in line with the methodology of Vaughan (1980). The opening value for roads on the other hand was found to be very plausible and very close to the value that would be derived under the steady-state calculation. The components of the housing stock, on the other hand, were not particularly detailed in the Henry estimated capital stocks but proved much more sensitive to the choice of the deflator than opening value assumed.

Measurement

There are at least three reasons why the perfect economic environment does not exist with regard to capital assets. An economic downturn could lead to voluntary and compulsory liquidations and premature scrappage of assets. A second phenomenon that undermines the reliability of PIM is rapid technological change. Being unpredictable, technological change leads to scrapping of fixed assets earlier than would otherwise have been expected when an investment was undertaken. Third, depreciation allowances have been used by government as a tool to encourage capital investment. Investment schemes often allow assets to be written off for tax purposes by firms in a preferential manner, often while still in use and long before their useful lives are over. These phenomena cannot be tackled directly but our cursory application of an asset life distribution, in a statistical sense, is intended to lessen the effects of these indirect economic effects.

Using a pioneering approach developed by Hall (1971), many studies have reported that depreciation is best captured by a geometric rate; "while depreciation is almost certainly not geometric, the geometric form fits a reasonable approximation" (Hall, 1971).[4] This assumption implies that the rate of depreciation may be treated as an exogenous variable, independent of economic forces (Nelson and Caputo, 1997). The dissenters cited the 1970 energy shocks as major events, which increased the rate of obsolescence and systematically changed the age-price profile. Fraumeni (1997) suggests that a non-geometric depreciation rate should be used for computer equipment with most of the rest of the BEA series using the geometric rate.[5]

[4] Some assets which have retired from useful life and will never be replaced and thus will not have data available from the second-hand market – a censoring problem. Hulten and Wykoff (1981) suggest multiplying market data by the probability of survival to correct for this form of bias. Another misrepresentation occurs when poorer quality assets ('lemons') are over-represented in the market data relative to their share of the aggregate stock (Akerlof, 1970). Another form of bias is that heavily-used assets will need to be replaced more often than the replacement of the same asset used less intensively. Therefore market data need to scale for usage patterns.

[5] She also suggests that a straight-line depreciation method is appropriate for missiles and nuclear fuel rods, but unfortunately the Irish requirement for depreciation of these assets does not allow us to apply this particular schedule!

Depreciation Rates

Most empirical studies of economic depreciation have relied on US data for used assets, where retirement, efficiency and service-life profiles of detailed asset types are provided by the US Commerce Department's Bureau of Economic Analysis (BEA) for U.S. NIPA purposes. Evidence on economic depreciation is notoriously hard to obtain and the BEA rely on cross-sectional studies of used asset prices, notably those of Charles Hulten and Frank Wykoff (1981). These estimates have not been adjusted for quality (wealth and economic depreciation are not differentiated).

Table 3 Applicable BEA rates of depreciation by asset type *j* and sector *s*

Rate of Depreciation	**Sector**		
Asset Type	*Households*	*Industry*	*Government*
Dwellings	0.0114	-	0.0114
Private home improvements (alterations and additions)	0.0227	-	0.0227
Roads	-	-	0.0202
Non-Dwelling construction	-	0.0314	0.0182
Consumer Durables	0.1375	-	-
Transport equipment	0.1650	0.2500	0.0990
Agricultural Machinery	-	0.1179	-
Other Machinery and Equipment	-	0.1650	0.1179
Software	-	0.5500	0.5500
Exploration	-	0.0413	0.0237
Artistic Originals		0.0152	

Source: Herman and Katz (2003)

Asset lives

A lack of knowledge about asset lives is one of the principal problems in the application of the perpetual inventory method. Statistical agencies have always found it reasonably easy to collect figures for capital expenditure from industry but problems arise when obtaining accurate and current information on the life span of different classes of asset. A simple PIM approach could assume fixed life spans for assets within the ideal situation of a totally stable economy, limited technological change and accurate initial lifespans for assets. This easy-to-implement 'simultaneous exit' approach was assumed by Henry (1989). However, industrial equipment is an example with considerable variability regarding asset life. With heavy usage of machinery and equipment, it may need to be modernised often.

Our study imports the average lives used in the following estimations: Henry (1989); Bureau of Economic Analysis (BEA) of the U.S.A.; OECD (2001); Mas *et al* (2000) and Munnell (1990) in his estimation of public capital in the US. Future work could account for the maximum lives permitted for taxation purposes in Irish company tax, but many countries derive these from their estimations of average lives. There are notable differences in average lives among the above-mentioned sources. There seems to be agreement on the reduction of life expectancy since the oil shocks of the 1970s due to faster obsolescence. This process has been intensely observed in the case of computer-centred technology in the machinery and equipment asset category but neither is it non-negligible in the building and construction categories. Table 4 summarises the average years of life used in this estimation of capital stock for the Irish economy

Table 4: Asset lives used in this study

Asset Type		Years	Ref:
Dwellings		80	Henry
Government New Houses		60	OECD
Local Authority home improvements		40	OECD
Private New Dwellings		80	OECD
Private home improvements		40	OECD
Roads		45	OECD
			(Henry indefinite!)
Non-Dwelling construction		57.5	Henry
Building and Construction: Industry		65	Henry
	: Government	50	Mas
Transport equipment		20	BEA
	Households	15	OECD
	Industry	20	OECD
	Government	25	BEA
Other Machinery and Equipment		10	BEA
	Industry	10	BEA
	Government	20	BEA
Agricultural Machinery		15	Henry
Software		5	ONS
	Industry	5	ONS
	Government	5	ONS
Exploration		40	BEA
	Industry	40	BEA
	Government	40	BEA
Artistic Originals		20	Own

Note: average age of the gross capital stock will be produced as a by-product of the model. Average age is the age of past year's gross fixed capital formation weighted by their proportions of the gross stock, assuming a midyear purchase.

An upward revision to the service life of a particular asset increases the share of that asset in the total stock and compounds the effect of an incorrect starting value. The effect of errors in the average service lives used in the PIM can be gauged through sensitivity analyses by running the PIM model with alternative estimates of service lives. A first place to start would be to run with alternative estimates of service lives used by the different statistical agencies. For instance, the UK Office for National Statistics (UK ONS) has depreciation rates for housing corresponding to an asset life of approximately 100 years, as expected from typical leasehold contracts common in the UK. A separate review of the PIM was conducted for the UK ONS by the National Institute for Economic and Social Research (NIESR) in 1993 which made several recommendations about the life-lengths of computers and numerically-controlled machinery with robotic parts. Following from this study, the UK ONS adopted a life-length of 5 years for computers that is likewise applied to software in our study.

Using shorter service lives reduces the level of the stocks. Increasing all service lives by 50 per cent increases the net stock levels by up to 40 per cent in our case. A sensitivity study conducted by Statistics Canada of minor changes of +/- 10 per cent of their assumed service lives suggested that stock levels may have error margins of

+/-8 per cent. Further, an upward revision to a faster (slower) growing component of the stock will raise (lower) the growth rate of the capital stock as a whole.

Investment deflators

Price indices are required for the measurement of capital stocks as these convert all expenditure and costs of capital goods that occur in different periods to a similar monetary unit so that they can be aggregated to ascertain a time independent level of the capital stock. In PIM this is achieved by deflating current price gross capital formation flows to constant prices before determining retirements and depreciation. We use the investment price indices used in the NIE accounts (2003=100).

The limitations of the existing formula, in particular that it is subject to 'substitution bias' or a 'quality bias' over time, is generally understood. Hwang (1996) is critical of a single price function as it does not represent the rate of economic depreciation and inflation which are separate processes. Further computers, for instance, are subject to fast technological improvements that are difficult to capture and are generally ignored with no attempt made to capture quality change (Whelan, 2002). Our application of PIM uses a long run constant price time series of investment data classified in as much detail as possible. These limitations will be addressed by future work that introduces chain-linked indices, which are generally not subject to such biases.

Valuation method

The valuation of the stock of capital assets defines an economy's wealth in its broadest sense. The capital stock excludes financial wealth owned by households, firms and government but includes the stock of consumer durable goods and is thus regarded as the stock of tangible assets.[6] We estimate the capital stock in 2003 prices using equation (4) per detailed asset type adjusted for vintage. Data limitations will mean that assets will remain within the sector that purchased them.

Equation (5) does not preclude the possibility that an asset survives longer than its expected lifetime or average life. One of the shortcomings of the PIM is that it introduces a relatively high degree of uncertainty if the retirement or scrapping pattern of capital assets by user sector has not been determined. There are several options for mortality functions as shown in Table 1.

Table 5: Official retirement functions used in PIM calculations[7]

Country	Mortality Function
Australia	Bell-shaped
Germany	Bell-shaped. Left skewed gamma distribution
Japan	Simultaneous exit
United Kingdom	Delayed linear retirements spread ±20% of assumed average service lives.
United States	Bell-shaped. Retirements spread over ±55% of assumed average service lives.

[6] Some studies have attempted to expand the definition of the capital stock to include human capital and land.

[7] Taken from OECD (1991) Statistics Directorate

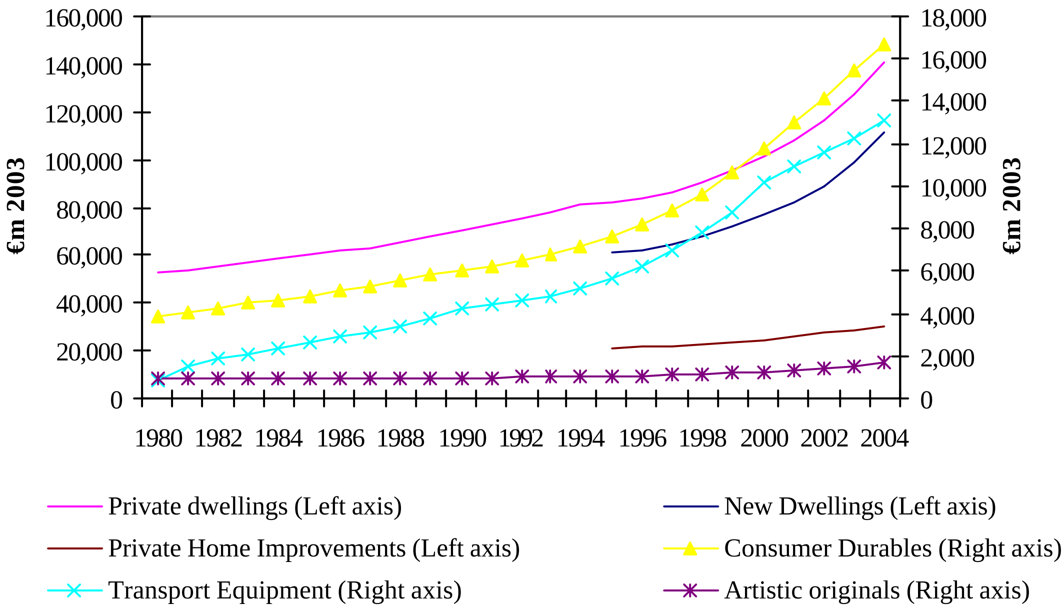
There are good arguments for using either a truncated normal distribution for service lives or a left-skewed gamma distribution; not least because the strongest proponent of the former (the US Bureau of Labour and the Bureau of Economic Analysis) and the latter (the German Statistics Office) both conducted large-scale studies and determined their respective method best fitted their economic conditions. In Ireland's case we have no empirical data on scrapping patterns.

For our analysis, in line with the UK Office of National Statistics, a simplified mortality function is applied where a delayed linear retirement of +20% of the assumed average service life of the asset is assumed. Premature scrapping is not modelled as the gross fixed capital formation data flow is, in most cases, net of capital disposal.

4. Capital Stock Estimates

Tables of estimated stock series by detailed asset type across each of the three main asset holders of households, firms and government for the years 1980 – 2004 are shown in the appendix. The following three graphs show the development in the detailed asset net capital stocks for each of the sectors.

Figure 1a: Net Capital Stocks held by Households 1980-2004 (€m, 2003 prices)



As shown in Figure 1a, the change of pace in housing investment is obvious from 1998 onwards with new dwellings more important than the stock of home improvements. It is important to distinguish these two types of investment as they have different rates of depreciation and the asset life length for home improvements is considerably shorter than the investment in new dwellings. The figures show a significant increase in the rate of investment in transport equipment from 1996 onwards with the highest ever year-on-year growth for 2000 perhaps reflecting the

'00' number plate phenomenon. The stock of consumer durables has increased steadily with general economic growth with a notable acceleration in spending on durables since the mid 1990s.

The most significant pattern arising from our estimation of stocks held by the industrial sector (Figure 1b) relates to the significant reduction in transport equipment held between 1990 and 1998. The starting value for this series was the Henry (1989) scaled by a factor of three according to the methodology recommended by Vaughan (1980). In nominal terms, the Census of Industrial Production reports that net acquisitions of plant and vehicles remained steady from 1990 to 1994 (total transport equipment investment fell in real terms during this period) but this was not enough to maintain the consumption of capital derived from these assets as shown by the depreciation calculations for this sector.

Figure 1b: Net Capital Stocks held by Firms 1980-2004

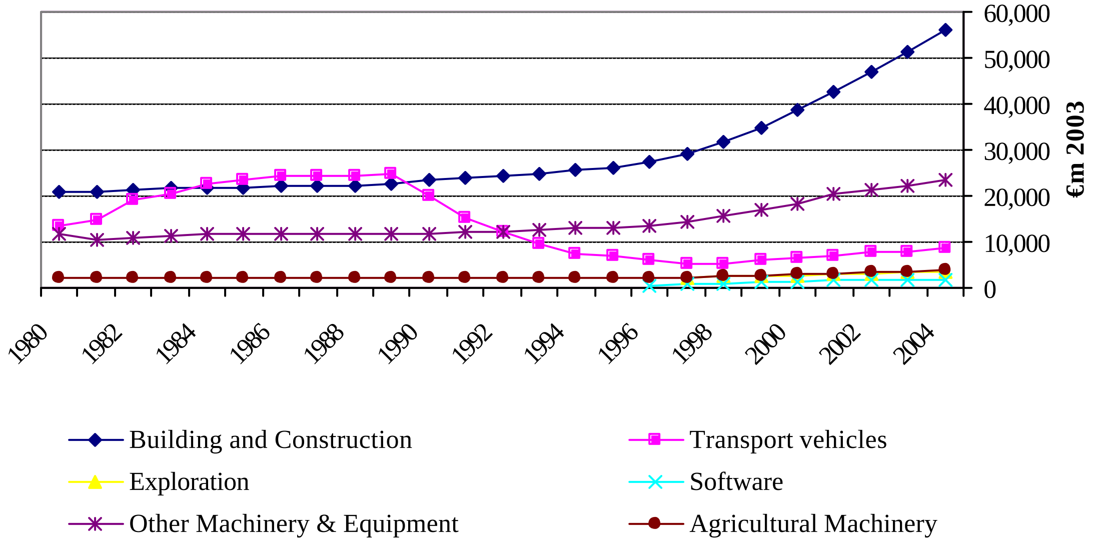
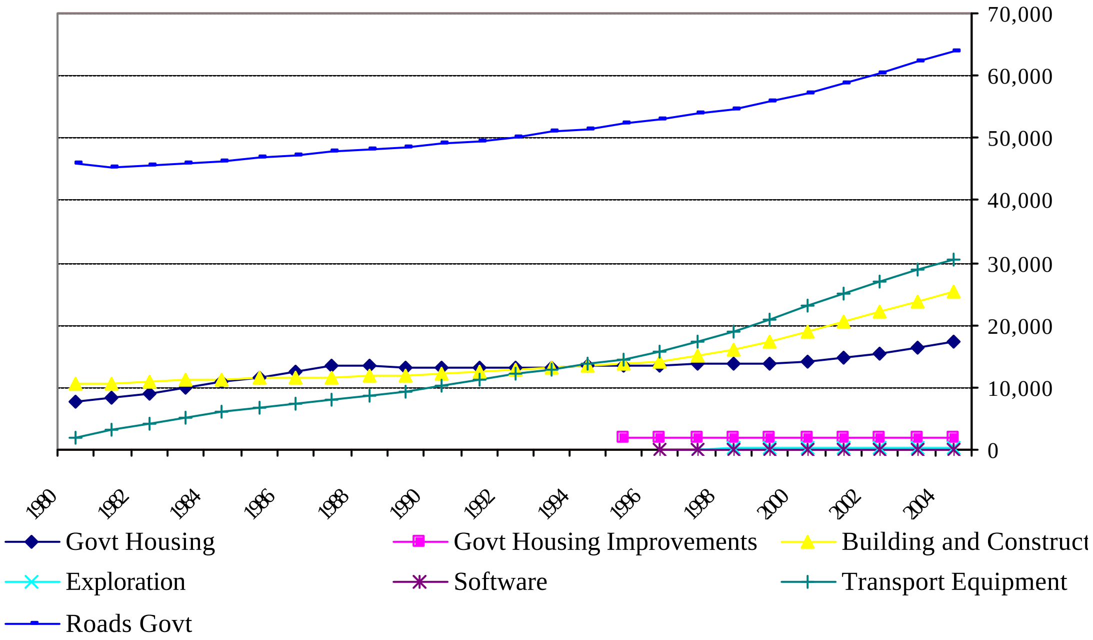


Figure 1c shows that the capital stock of roads (owned wholly by the public sector) has increased over the period. A higher depreciation rate than the BEA rate of 0.0202 for roads may be more appropriate for Irish geographical and topological conditions. Also evident from Figure 1c are the effects of public investment in infrastructure arising from substantial EU Structural Co-Funding, particularly in public transport equipment and building and construction.

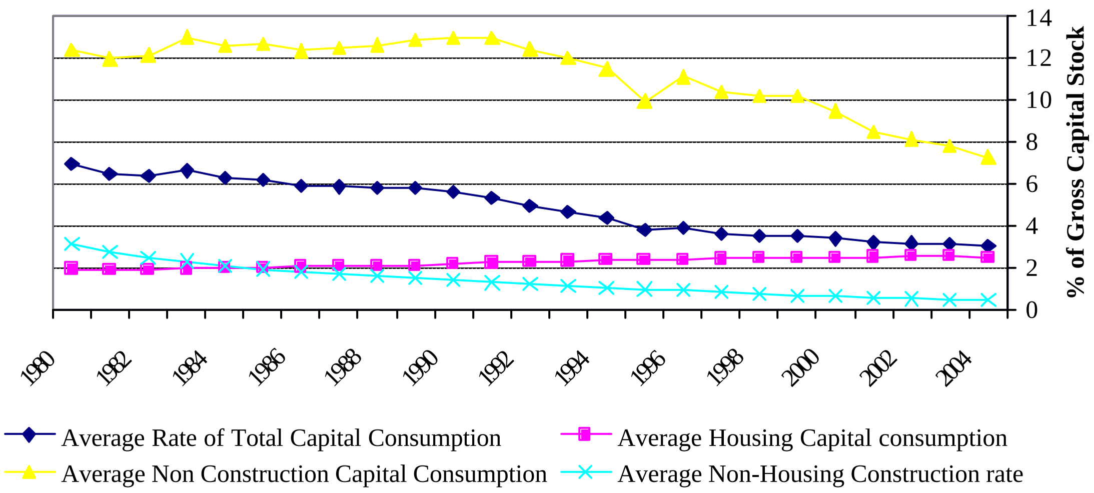
Figure 1c: Net Capital Stocks held by Government 1980-2004 (€m, 2003 prices)



The annual consumption of fixed capital is defined as the calculated depreciation on the gross capital stock plus the depreciation amount on a share of the new capital formation flow. Capital consumption measure is such that the productive efficiency of the asset base is held stable (as per vintage and the assumed age-efficiency profile). The method relies on a strict consistency between the age-efficiency profiles and consumption of fixed capital. Prices usually decline quite rapidly in the early years of an asset's life and as such capital services estimates are sensitive to the choice of deflator particularly in fast evolving high-technology asset stocks. Nonetheless, we find that the productive efficiency of software can also be captured by a geometric declining balance depreciation. For this reason, assumptions about age-efficiency functions and choices of rates of (rental) return are very significant and, in themselves, are least sensitive to the geometric assumption. The net stock of assets is thus measured in 'standard efficiency units' approximating the marginal productivity of the different types of assets.

While we have imported appropriate depreciation rates and asset service-lives from international sources, Figure 2 shows the average capital consumption rate dependent on the composition and vintage of our asset mix. These time-varying average depreciation rates can be used for macromodelling purposes. For total capital stock, the depreciation rate has declined rapidly between 1980 and 1995 but the rate of decline has levelled off in the last 10 years and stands at close to 3 per cent at present. This corresponds to an average lifetime of the capital stock of around 32.5 years, which is quite high compared with international estimates due to the high proportion of long-life housing in the current Irish capital stock. As expected, depreciation rates for housing assets are lower than for non-housing assets because of the higher average lifetime of construction assets. An interesting pattern emerges within the construction asset type. Housing depreciation rates are relatively stable over the period at a rate of between 2 and 3 per cent. On the other hand, the recent boom in the construction sector is reflected by the capital stock which is increasing at a much faster rate than the consumption of non-housing construction capital which leads to a consistent decline in the average rate of depreciation within this sector. At present, the depreciation rate is relatively close to zero at 0.42 per cent but can be expected to asymptote towards zero if the rate of construction investment continues to the end of the decade and beyond.

Figure 2: Average capital consumption rates for Total, Housing and Non-Housing Capital Stocks



For non-construction, the depreciation rates are depreciation rates are significantly higher. They are broadly constant for Transport and other Machinery, Software and Equipment and other assets such as exploration, until the mid 1990s at around 12 per cent. This corresponds with an average lifetime of less than 12 years, reflecting to a large extent the fact that software depreciates more quickly than other assets.

Figure 2 also suggests that the average rate of depreciation for housing has increased gradually from 1.85 per cent in 1980 to 2.43 per cent for 2004. This is as precise an estimate as possible as it accounts for the difference between new dwelling construction and the considerable recent investment in home improvements, which has a higher depreciation rate and a shorter asset life.

Since detailed Irish survey data about the age-efficiency and age-price profiles of fixed assets do not exist, the perpetual inventory method applied above is limited to estimating the capital stock at constant not current prices. By accounting for investment 'vintages', we account for the age profile of capital services and produce stocks measured in standard efficiency units. The net results give our best estimate of the result of combining average asset service lives, some leeway on asset mortality and retirement, a detailed age-efficiency profile and the corresponding age-price profile.

The valuation of the capital stock in an economy is the main component of an economy's wealth whereby price variations in assets represent a significant wealth effect for their owners (not captured here as capital formation deflators not asset price indices are used). Using simple net or gross capital stock presents the problem that neither reflects the productive efficiency of the capital. In calculating the net or gross capital stock, each asset in the stock is weighted by its market value. This implies that two assets of the same market value (having controlled for vintage) are assumed to make an equal contribution to production. The next section will refine the aggregation of capital flows so that the weights used are not market values but the marginal capital productivity of each asset type.

5. Capital services estimation

For many macroeconomic purposes, such as the study of *productivity* or the assessment of capacity utilization, we need measures of the level and growth rate of the productive services that the capital stock is capable of providing. Aggregate supply calculations depend crucially on the volume of productive services provided by the capital stock (Oulton, 2001). Capital stock estimates derived above are measures of *wealth* estimated in "standard efficiency units" i.e. as a weighted sum of past investments by asset type with weights given by the relative efficiencies of capital goods at different ages, defined by when the investment took place.[8] However, economic theory suggests that the wealth concept of capital is not appropriate for a production function or for a measure of capacity utilization. For capital services estimation, it must be recognized that an asset with a shorter life-length must generate its contribution to production at a faster rate than an asset with a longer life to recoup the initial investment. This section derives a concept of aggregate capital that is known as the volume index of capital services (VICS), which answers the theoretical need for an aggregate and asset-detailed measure of capital services.

Jorgenson (1963) and Griliches and Jorgenson (1967) in their seminal growth accounting study were the first to develop aggregate capital service measures to take the heterogeneity of assets into account. They defined the flow of quantities of capital services individually for each type of asset, and then applied asset-specific user costs as weights to aggregate across services from the different types of assets. Rental rates are prices for capital services. Under competitive markets and equilibrium conditions, these prices reflect the marginal productivity of the different assets. Marginal productivity weights thus provide a means to effectively account for the contribution of different types of investments to output but cannot be used until details of net capital stock by asset type are available. The more disaggregated the asset detail of the capital stock, the more precise capital services measurement can be. The flow of capital services for each asset type is assumed to be proportional to its stock at a point in time.

The main difference between the VICS and wealth measures of capital is the way in which different types of assets are aggregated together. In the VICS, each item of capital is weighted by its rental price which measures the value of an asset's capital

[8] An important implicit assumption made was that the services by assets of different vintages are perfect substitutes for each other.

service or more precisely the flow of rentals that it is expected to earn during its lifetime. By contrast, in wealth measures of the capital stock each item is weighted by the asset price (i.e. the price at which it could be sold to another user) (Oulton, 2001). For two assets of the same original value but with different service lives, the shorter-lived asset will have a higher rental value because it will depreciate more rapidly. The owner must recoup the initial outlay on the short-lived asset over a shorter period than in the case of the longer-lived asset. The practical implication of this is that assets with high rental prices will have a higher weight in the VICS measure compared with a wealth measure of capital. Likewise, if the stock of low rental rate assets (such as housing) was growing more rapidly than the gross or net stock, the VICS measure will report lower growth rates than the gross or net stock.

In equilibrium, an investor is indifferent between two alternatives: earning a nominal rate of return, *r*, on a different investment (*q*) or buying a unit of capital, collecting a rental *p* and then selling the depreciated asset $(1-\partial).q$ in the next period. In the absence of taxation the equilibrium condition therefore is (Jorgenson and Stiroh, 2000 p. 192):

$$(1+u_t).p_{i,(t-1)} = r_{it} + (1-\partial_i).p_{it} \qquad (6)$$

where u_t is the user cost (discount rate), r_{it} the asset-specific rental fee and p_i the acquisition price of investment good *i*. For simplicity it is assumed that the rentals are received at the end of the year. The marginal benefit from holding an asset is the real implicit rental return r_{it}, while the marginal cost is the user cost of capital u_t. Rearranging the familiar cost-of-capital equation, we make use of the fact that there is a relationship between the (usually unobserved) rental price and the corresponding (observed) asset price. ∂_{it} is the relevant depreciation rate per asset, *p* is the price index of a new investment good, and the last term is the change in the price of an asset from periods *t-1* to *t* (the nominal holding gain):

$$r_{it} = p_{i,(t-1)}u_t + \partial_i.p_{i,(t-1)} - [p_{it} - p_{i,(t-1)}] \qquad (7)$$

Equation 7 shows that the asset-specific rental fee is determined by the nominal rate of return, the rate of depreciation and the asset-specific capital gain.[9] In the case of computers, the price of new computers is falling; so holding them incurs a capital loss, which increases the rental price (Whelan, 2000). By contrast, The asset revaluation term is taken from the investment price indices and the rate of depreciation is the rate used in the construction of the capital stock estimates. The sum of rental payments for all assets is equal to the total capital compensation or capital services flow.

A single volume index of capital services (VICS) for the whole economy can be compiled in a number of steps. The first step is to estimate the user cost of capital u_t, which is used to represent the discount rate or opportunity cost of undertaking

[9] By rearranging Equation 7 the rate of depreciation, due to the geometric form assumed, is the proportional difference between the price of a new asset and the price of an asset that is one period old).

investment at a point in time. The user cost of capital is derived from the standard equation relating the value of all assets to the discounted flow of rentals expected over an asset's lifetime (Equation 6).

Because rents generated by an asset are received over several years, they have to be discounted in calculating the value of an asset at a point in time. The rental rate expected in future periods are discounted using a user cost of capital rate, which can be approximated in either of two ways. With the opportunity cost or *ex-ante* method some external rate of return is used, e.g. the Central Bank base interest rate. The second approach is the residual or *ex-post* method. This method estimates an internal rate of return as a residual given the value of capital compensation from the national accounts, depreciation and the capital gains. The National Accounts information is taken from the production and generation of income table (NIE Table 1).[10] The method obtains net operating surplus from the production table (value added at factor cost) of their national accounts by deducting compensation of employees from net value added. The attractive property of the *ex-post* approach is that it ensures complete consistency between income and production accounts but it requires that the underlying production function exhibit constant returns to scale, that markets are competitive and that the expected rate of return equals the realised (*ex-post*) rate of return.

Capital income (NVA^K) is defined as net value added less compensation of employees and since we know the rate of depreciation the rate of return is

$$u_t = \frac{NVA^K}{[p_t d_t - (p_t - p_{t-1})]K_{t-1}} \qquad (8)$$

where K is the real stock and pK is the nominal wealth stock i.e. the market value of the capital stock. d_t is the average annual capital consumption (total depreciation) for all assets). In other words, the numerator in Equation 8 is the portion of net value added to remunerate capital and the denominator is the current net capital stock. The calculation above derives a single nominal rate of return for the entire economy based on the simple sum of capital stocks and thus assumes that the rate of return is the same for all assets in an industry.[11] Figure 3 plots the development between 1980 and 2004 of u_t together with operating surplus to remunerate capital in the economy. It is obvious that the capital income rate drives the user cost of capital.

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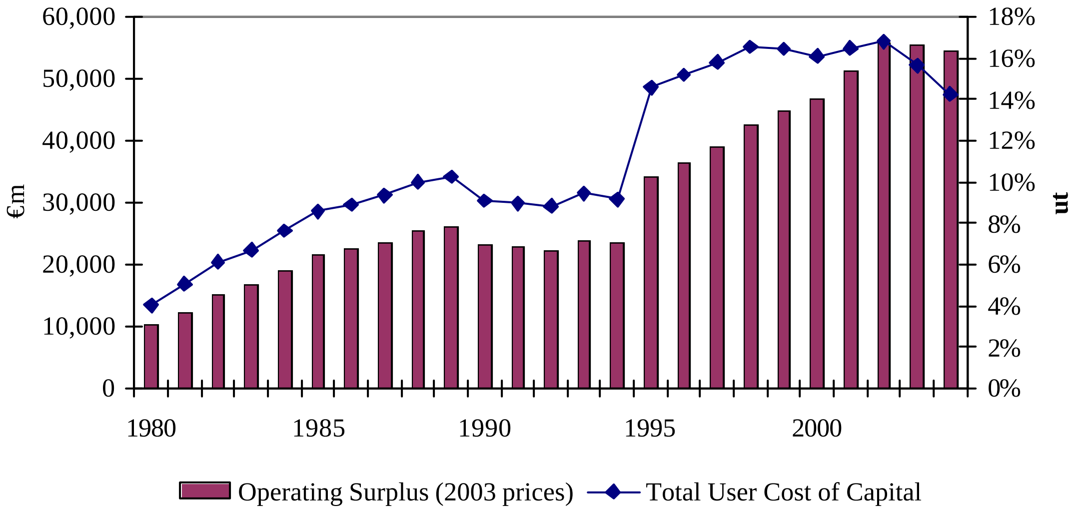
[10] In the two of the few published capital services calculations, the US BLS and the Australian ABS use the *ex-post* approach.

[11] The *ex post* approach using the actual operating surplus data for Ireland could be criticised on the grounds of the transfer-pricing problem. A large part of the surplus could be tax driven and may not represent the return on capital employed in Ireland. One way of dealing with this could be to use the operating surplus net of total profit repatriations but this proved too extreme, as it excluded all the return on the substantial real capital stock held by multinationals. Honohan (1992) attempted to overcome this problem by establishing 'true' operating surplus using foreign data on rates of return in the relevant industries. This correction might be justified if the sectoral coverage in this paper were broader than the three sectors of households, industry and government.

Figure 3: Ex-post User Cost of Capital (u_t) and Operating Surplus (NVA-Labour Cost)



Two caveats with this method of calculating the ex-post user cost of capital should be noted. One arises because net value added includes mixed income as well as operating surplus and compensation of employees. Mixed income includes the labour income attributable to the self-employed. This element could be artificially controlled for if it could be assumed that the self-employed receive similar rates of compensation as those earned by employees in similar jobs or by assuming that non-incorporated businesses (e.g. sole traders) earn similar rates of return on their investments as those earned by companies in similar activities. Such an adjustment is not made here on the basis that it can be assumed that most self-employed individuals reinvest a substantial portion of their earnings back into their businesses.

The second step in deriving the capital services measure is to calculate the individual rental rates of return (Equation 7) for every asset for every year, using u_t shown above in Figure 2. In an ideal situation, taxes should be included to account for differences in tax treatment of the different asset types and different sectors (i.e. the different fiscal and legal treatment of household, firms and government) (see Jorgenson and Yun, 1991). However, this refinement would require data on capital tax allowances by asset, legal entity and time which is beyond the scope of this study.

Marginal productivities of Irish capital assets

The choice of aggregation weights is crucial because prices and quantities of different types of capital goods evolve at very different rates. This is, for example, the case when there is relatively rapid quality change of one type asset compared to others. Aggregation of assets by way of flow of investment (purchase prices) will generate a serious bias in the capital input measures because purchase prices will inadequately approximate the marginal productivity of assets[12] that constitute the appropriate weights for aggregation of capital services.

Table 6: Average 5-year Rental Rates of Capital (r_{it}) – Gross Rate of Return by asset type

	1980-1985	1986-1990	1991-1995	1996-2000	2001-2004	Whole period
Dwellings (total)	0.005	0.028	0.032	0.043	0.088	0.036
Government New Houses	0.003	0.025	0.029	0.039	0.080	0.032
Govt Improvements	0.006	0.029	0.033	0.045	0.091	0.037
Private household New	0.003	0.025	0.029	0.039	0.080	0.032
Private households improvements	0.006	0.029	0.033	0.045	0.091	0.037
Roads=Govt	0.008	0.040	0.057	0.088	0.130	0.060
Building & Construction (total)	0.010	0.035	0.061	0.086	0.154	0.063
Industry	0.010	0.035	0.061	0.086	0.154	0.063
Government	0.005	0.029	0.053	0.076	0.141	0.056
Consumer Durables	0.097	0.196	0.220	0.285	0.303	0.212
Transport Equipment (total)	0.091	0.173	0.215	0.295	0.311	0.208
Machinery & Equipment (total)	0.121	0.210	0.216	0.314	0.369	0.236
Industry	0.114	0.202	0.206	0.304	0.358	0.227
Government	0.121	0.210	0.216	0.314	0.369	0.236
Agricultural Machinery	0.078	0.169	0.164	0.261	0.314	0.188
Software (total)	0.161	0.317	0.384	0.478	0.630	0.375
Exploration (total)	0.003	0.048	0.057	0.086	0.124	0.059
Industry (Mining & Quarrying)	0.009	0.057	0.067	0.098	0.141	0.069
Government	0.003	0.048	0.057	0.086	0.124	0.059
Artistic originals (total)	-0.007	0.062	0.077	0.144	0.174	0.083

Rental rates, calculated according to equation 7, are designed to measure the marginal productivity of assets. Rental rates as calculated in Table 6 are net of the effect of quality and price changes (nominal capital gains and losses). Rapid negative price changes or large rates of depreciation will imply large rental rate costs. The rental rate is the gross rate of return that an asset must yield per year. Under an assumption of product maximisation and market competitiveness, these rental rates approximate the elasticity of output to the volume of capital services inputting into the production process.

Negative rental rates for capital can appear when the investment deflators (capturing the nominal price gain) that have shown large increases due to inflation, while the

[12] For firms to maximise profits, the services produced by an asset are its marginal revenue product (marginal productivity) times the stock of the asset. Suppose that firms can rent in each type of capital by paying a rental price per period. Optimisation behaviour implies that the rental price must be equated with the marginal productivity of the asset.

user cost remained low. These deflators are based on investment costs are for the large part driven by wage trends that are, in turn, reflective of general price inflation.

The results in Table 6 show that rental rates for capital assets have been increasing over time with some assets increasing faster than others. The rental rate for structures still remains below that required for short-lived assets such as equipment and software. There has been a doubling of the rental rate for dwellings between every 5 year interval. Negative rental rates do not feature during the recent and ongoing property price boom as the derived user cost of capital is sufficiently large enough to cover the nominal price gains. However, the expectation that a property price boom will cease at some point leads to some uncertainty over the realisation of these capital gains and may lead to negative rental rates in the future.

Volume Index of capital services (VICS)

The capital services estimate will be a superior capital measure (over capital stocks) for growth accounting exercises because the aggregate measure of capital has weighted contributions according to the volume share and contribution of different capital types to the total capital effort. The volume of capital services is calculated by an index aggregating the growth in the stock of individual asset (volumes) using appropriate marginal productivity (rental rate) weights. In this way, the growth of the VICS is a weighted average of the growth rates in the stocks but in this case the weights are the shares of the value of total capital services. The value of the services provided by the stock of a particular asset is the rental price (Table 6) times the net stock (Appendix Table 2).

The short life-length of particular assets such as software (5 years) and machinery and equipment (15 years) mean that these assets play a greater role in aggregate services than longer life assets such as dwellings. Nonetheless, dwellings currently make up the largest share of all investment when weighted in value terms. An aggregation based on rental rate weights will give more weight to assets with relatively large productivity as opposed to a wealth aggregation based on purchase values, p_{it}. Table 6 shows that the rental rate or marginal productivity of dwellings is on average 3.6 per cent over the 25 year period compared with a marginal productivity of 37.5 per cent for software over the same period. Artistic originals and exploration were found to have the lowest financial share of net new investment (less than one percent on average between 1980 and 2004) but yet they return marginal productivity rates of 6 and 8 per cent respectively.

Our interest is in outlining an aggregate volume index of capital services derived from detailed asset type capital stocks.[13] The Tornqvist volume index of aggregate capital services is:

[13] Production theory dictates that the calculation of these indices should be carried out with a superlative index number which is a discrete-time approximation of the continuous Divisia index (Diewert, 1978). A Divisia index is a weighted sum of the growth rates of the various components. The growth rates are defined as the difference in natural logarithms of successive observations of the components. Tornqvist Index numbers are measures of relative change which are usually based on ratios. Log-change index numbers, like Tornqvist, are based on the natural logarithms of those ratios. The Tornqvist index was developed in the 1930s at the Bank of Finland, according to Triplett (1996).

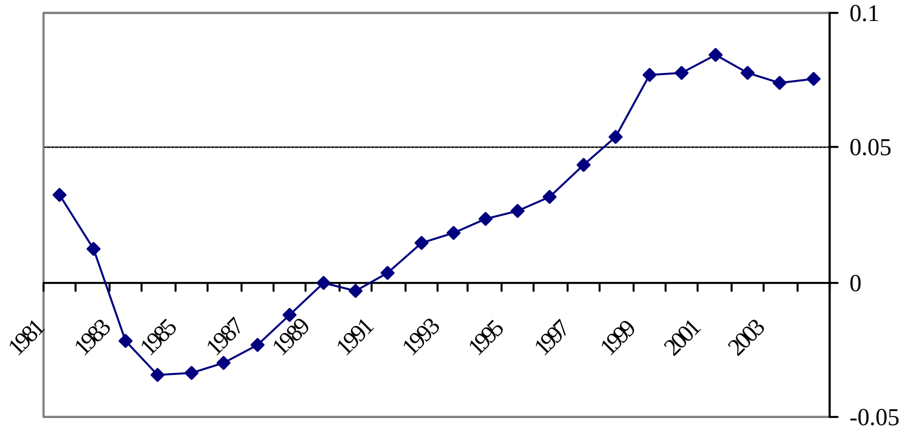
$$c_{it} = \frac{K_{it}}{K_{i(t-1)}} = \prod_j \left(\frac{K_{ijt}}{K_{ij(t-1)}} \right)^{v_{ijt}}$$

The weights *v* are (*i* is asset type and *t* is year):

$$v_{it} = \left(\frac{r_{it}K_{it}}{\sum_i r_{it}K_{it}} + \frac{r_{i(t-1)}K_{i(t-1)}}{\sum_i r_{i(t-1)}K_{i(t-1)}} \right) / 2$$

Using this index, we can evaluate the contribution of capital to the production process in terms of the services that capital assets provide to their owners rather than in terms of the value of the assets themselves, as suggested by Jorgenson and Griliches (1967). A linear aggregation would assume that the capital services yielded by each vintage of a homogenous type of capital would be perfectly substitutable; with this aggregation substitution can take place across assets of equal efficiency not value.

Figure 4: Year on Year growth in the volume index of capital services (VICS)



The early 1980s shows a decline in the flow of capital services to aggregate production, possibly as a repercussion of the second oil crisis. This period shows that the shock to investment in capital recovered slowly but remained below the net replacement level (?VICS< ∂) until the mid 1990s. Since 1991, the growth rate has been rising with acceleration during the 'Celtic tiger' era. The 'dot com' bust may explain the decline in the capital services contribution in 2002 and 2003. This is high by UK standards where average growth in capital services there, moved cyclically around a three per cent level (Vaze, 2003). The recent Irish decline in the index of capital services has occurred despite a significantly higher acceleration in the value of gross fixed capital formation in Ireland. This measure reflects that housing investment is not the most productive form of investment in terms of its contribution to economic growth. The composition of the capital stock away from machinery and equipment towards ICT observed in the 1990s motivates the modelling of the productive capital stock. However the price deflator for software has been falling in very recent years and Figure 3 may be reflecting an overvaluation of the software stock (obsolescence) in the years following 2000.

Figure 5: Comparison of Volume of Capital Services across Sectors

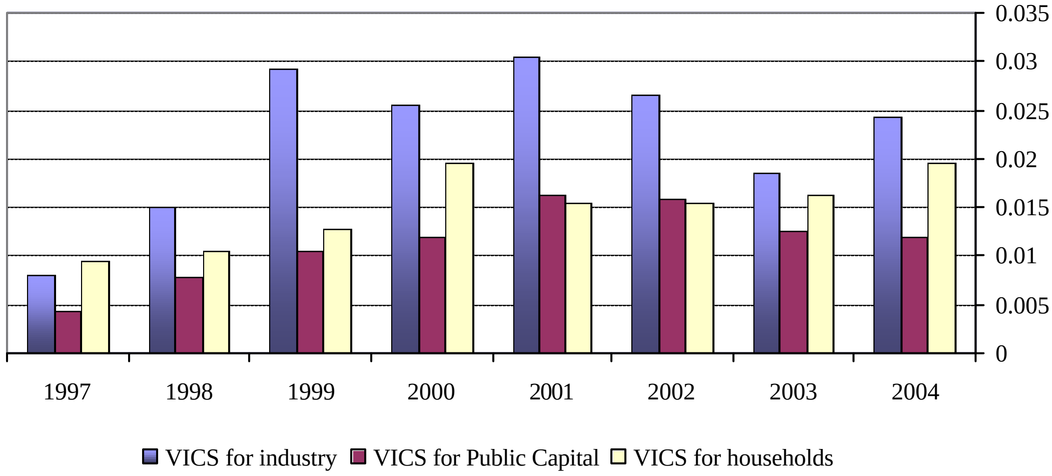


Figure 5 shows how the sectors differ in recent years. Industry has the highest levels of capital service flow as machinery and equipment, software accrue mainly to this sector. These are the asset types with the highest rental rates. Households feature through the considerable expansion in the stock of new private dwellings and home improvements while investment in consumer durables has also boosted the net capital stock since 2000. The vast bulk of the public capital is taken up with roads and building and construction which are long-lived structures and correspondingly have low rental rates reducing their weight in capital services terms.

Comparing the wealth measure with the VICS

As discussed above, both measures are weighted averages of asset stock growth rates and only differ in their weights. The wealth measure has the share in total wealth as its weight and hence depends on asset prices while the VICS measure depends on rental rates indicating the marginal productivity of capital in output. The ratio of the rental price to the asset price differs between asset types: the ratio is lower for assets with long service lives (driven by low rates of depreciation) and increasing capital gains. The VICS gives less weight than the wealth measure to assets with lower-than-average rental price/asset price ratios.

Table 7: Comparison of rental price and asset price weights

Average rental weights (shares in total Capital rents), per cent					
New Dwellings	-0.7%	1.5%	1.5%	1.3%	1.9%
Home improvements	-4.2%	7.3%	8.7%	7.6%	12.9%
Roads	10.8%	8.6%	13.0%	14.5%	13.5%
Building and Construction	8.1%	7.7%	16.3%	19.8%	26.7%
Consumer Durables	3.6%	5.3%	7.1%	8.6%	7.8%
Transport Equipment	3.3%	10.6%	20.6%	29.7%	27.0%
Other machinery and Equip	52.5%	28.9%	22.6%	25.5%	21.0%
Agricultural Machinery	0.4%	1.2%	1.0%	1.4%	1.1%

Software	0.4%	0.6%	1.2%	1.7%	2.0%
Exploration	-0.3%	0.5%	0.5%	0.7%	0.7%
Artistic Originals	-0.5%	0.3%	0.3%	0.5%	0.4%
Average asset weights (shares in nominal value of aggregate net capital stocks), per cent					
New Dwellings	13.2%	15.5%	17.3%	15.4%	15.8%
Home improvements	n.a	n.a	4.9%	4.7%	4.3%
Roads	18.5%	19.6%	20.3%	21.1%	17.8%
Building and Construction	15.5%	21.6%	23.9%	29.4%	29.6%
Consumer Durables	1.8%	2.5%	2.7%	3.7%	4.3%
Transport Equipment	3.8%	6.5%	8.1%	12.4%	14.4%
Other machinery and Equip	24.1%	10.0%	8.9%	10.1%	9.5%
Agricultural Machinery	0.6%	0.5%	0.5%	0.7%	0.6%
Software	0.1%	0.2%	0.3%	0.4%	0.5%
Exploration	0.9%	0.8%	0.8%	1.0%	1.0%
Artistic Originals	0.4%	0.4%	0.4%	0.4%	0.4%

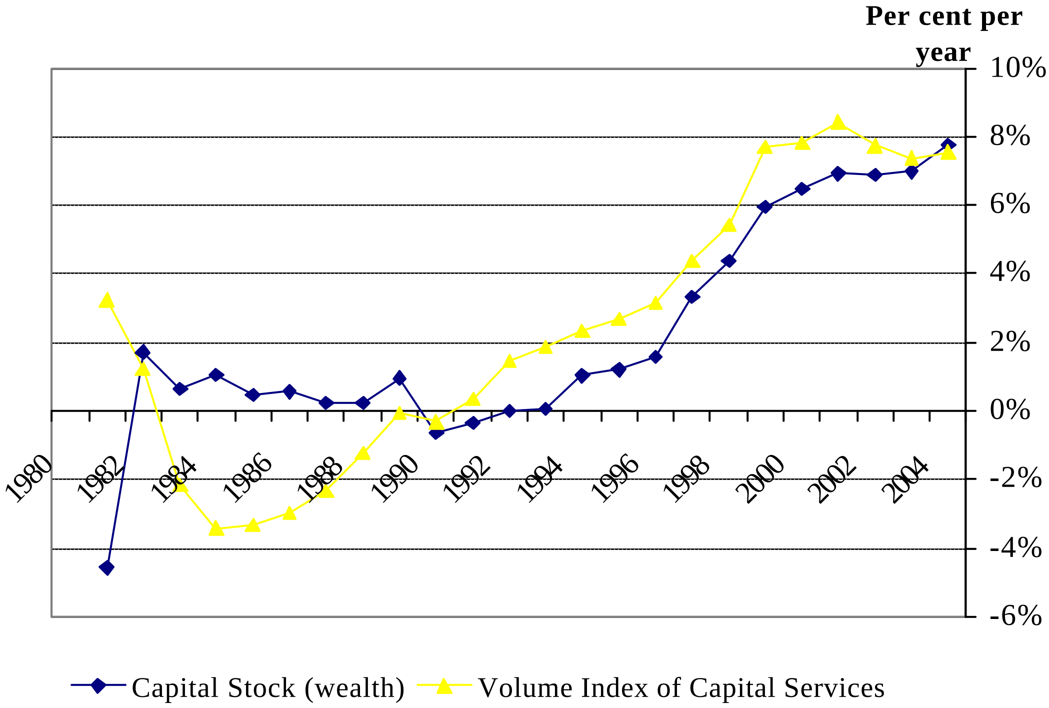
Table 7 compares the rental price weights with the asset price weights. As expected these are very different. For example, the machinery and equipment rental price weight is almost twice that of its asset price weight. In this way we would expect the VICS to give different results from a wealth measure of the capital stock. Likewise there are vast differences between the weights for new dwellings in recent years and given the share of housing in the current capital stock, this is the most significant justification for using a capital measure based on productivity rather than investment value. This is borne out by Table 8, which compares the growth rates of the two measures as well as other summary measures derived in our analysis.

Table 8: Growth of Capital Stocks and Capital Productivity

	1981-1985	1986-1990	1991-1995	1996-2000	2001-2004
Growth of Net Capital Stock (volume)	-0.001	0.003	-0.015	0.043	0.071
Av. Capital Consumption rate	0.065	0.058	0.046	0.036	0.031
Rate of Return (ex post)	0.064	0.095	0.102	0.160	0.158
Av. Rental Rate for Capital	0.047	0.120	0.144	0.204	0.257
Volume Index of Capital Services	-0.009	-0.014	0.017	0.057	0.078

In constant prices terms, the growth of the net capital stock did not keep pace with the rate of capital consumption until the mid 1990s. It was then that the vintage of the components of the capital stock was sufficiently modernised such that the average capital consumption rate fell (the rate of depreciation is constant for each asset but depends on service life!). At the same time, output of the economy was growing in real terms and capital investments were required to recoup increasing returns to cover the opportunity cost of having resources tied up in this way. The volume index of capital services captures these economic processes by weighting the individual components of the capital stock by their marginal productivity or potential contribution to output after controlling for differences in efficiency across assets, time and vintage. An index of capital service is computed for each asset type, by sector, between 1980 and 2004.

Figure 6: Growth rates of VICS and wealth compared (all asset types)



6. Conclusions

The valuation of the stock of capital assets defines an economy's wealth in its broadest sense. In this paper, we applied an accepted stock valuation methodology used by the BEA on US National Income Product Accounts. The simplest method possible, commonly invoked to calculate capital consumption, is to assume that assets in the national capital stock depreciate at a geometric rate that is stable over time. However, by calculating capital consumption using asset-specific depreciation rates and accounting for service lives and vintage of the individual asset stocks, a more accurate estimate of the aggregate capital stock is possible.

A starting value for each capital series was required, which were in the most part drawn from Henry (1989). Having converted this estimate to fixed base (2003) prices, it was then used to construct the remainder of the series as described. This exercise was completed for the whole economy and by the three main owners of capital: households, firms and government. The question of wastage is not relevant as these starting values are already cumulative PIM estimates.

The paper then implemented an integrated approach to derive a volume index of capital services as part of the same process that generates estimates of gross and net capital stocks and the consumption of fixed capital. For each asset a long time-series of investment was used to derive stocks and these were weighted together using shares based on rentals modelled for each asset. A general observation is that the average life-length of all assets has shortened over time due to a shift to short-lived assets, which also prove to be the most productive in generating output. At present, only three countries – the United States, Canada and Australia – publish capital service measures as part of their official programme of statistics but measures of this kind have been calculated by researchers in several other countries.

There is growing interest in the productive potential of detailed capital types, in the productive potential of the new economy and in calculating the productivity benefits of globalisation (Oulton, 2001; Whelan, 2002). The volume index of capital services uses rental price rather than asset price weights, so it gives more weight to assets with a high rental price/asset price ratio i.e. to assets with short service lives and high rates of depreciation. Our findings show that despite the significant boom in building and construction investment, highly productive assets have also been growing sufficiently rapidly to ensure an overall increase in Irish capital services. In the years between 1990 and 2003, the VICS tended to grow more rapidly than a wealth measure of capital stocks based on exactly the same data and depreciation assumptions. The flow of capital services provides an efficient measure for capturing capital's contribution in each case. A consistent dataset is produced based on assumptions that are transparent if heroic given the lack of very detailed Irish data.

Since the VICS is the appropriate concept for productivity analysis, the present estimates have implications for growth accounting exercises.[14] The capital measure used must control for the share of housing in the capital stock or it will over-estimate total factor productivity. A multifactor productivity argument exists which states that labour is more productive with an increasing capital efficiency of the aggregate capital stock. The higher rate of capital services for a given capital stock supports the 'new economy' explanation for accelerated economic growth patterns of recent years. Together with a measure of labour services, further research based on multifactor productivity measures[15] for growth accounting could recognise that the investment in relatively inefficient capital services from housing capital does not maximize an economy's growth in the long term.

The implications for capacity utilisation measurement are a little harder to draw out. Since capital services and capital stocks were growing at similar rates until relatively recently, it might seem that Irish estimation of capacity utilisation would not be affected by the choice of capital measure. However if capital services measure for the 1980s was revisited or if the pattern for 2004 was to continue when the wealth-based measure once again overtook the measure of capital services, capacity utilisation could be growing faster than previously thought. Capital and capacity utilisation play numerous roles in macroeconomic modelling. So teasing out the implications of these new estimates will require further careful analysis beyond the scope of this paper.

[14] Traditional growth accounting studies estimate Total Factor Productivity (*TFP*) by assuming a constant capital lifetime. The resulting TFP estimates are thus biased unless reliable estimates of capital services controlling for changes in capital service efficiency are available at the macroeconomic level.

[15] MFP is often expressed as the geometric average of labour and capital productivity,

References

Ball, V.E., J.C. Bureau, J-P Butault and H. P. Witzke (1993) "The stock of capital in European Community agriculture", *European Review of Agricultural Economics*, Vol. 20, pp. 437-50

Berndt, E. (1991) *The Practice of Econometrics, Classic and Contemporary*. Reading: Addison-Wesley.

Bureau of Economic Analysis (BEA), (2003) *Fixed Assets and Consumer Durable Goods in the United States, 1925-97*, US Department of Commerce

CSO (2005) *National Income and Expenditure*, Central Statistics Office, Stationery Office, Dublin

Diewert, E. D. (2001) "Measuring the Price and Quantity of Capital Services under Alternative Assumptions"; *Department of Economics Working Paper* No 01-24, University of British Columbia.

Diewert, E.D. (1978) "Superlative Index Numbers and Consistency in Aggregation", *Econometrica* vol. 46, pp.883-900

Hall, R.E. (1971) "The Measurement of Quality Changes from Vintage Price Data", in *Price Indexes and Quality Change*, edited by Zvi Griliches, pp. 240-271 Harvard University Press

Hayes, D. and G. Young (1994) "Improving the Estimates of Capital Stock", *National Institute Economic Review*, NIESR London, February 1994

Henry, E.W., (1989) *The Capital Stock of Ireland, 1950-1984*, General Research Series Paper No. 145. Dublin: Economic and Social Research Institute

Fraumeni, B.M. (1997) "The Measurement of Depreciation in the U.S. National Income and Product Accounts", *Survey of Current Business*, July 1997 pp. 7-23

Fuente, A. de la and R. Domenech, (2002) "Human Capital in Growth Regressions: How Much Difference does Data Quality Make? An Update and Further Results", *CEPR Discussion Paper* No. 3587 (London: Centre for Economic Research)

Goldsmith, R. (1951) "A Perpetual Inventory of National Wealth", *NBER Studies in Income and Wealth* Vol.14, No. 1143

Hayek, F.A. (1941) *Pure Theory of Capital*

Hernandez J.A. and I. Mauleon (2005) "Econometric estimation of a variable rate of depreciation of the capital stock" *Empirical Economics* Vol. 30(3), October 2005, pp. 575-596

Hofman, A.A. (1992) "Capital accumulation in Latin America a six country comparison for 1950-89", *Review of Income and Wealth* Vol. 38, pp. 365-402

Honohan, P. (1992) "Intersectoral Financial Flows in Ireland", General Research Series No. 158, Economic and Social Research Institute

Hulten, C. (1992) "Growth Accounting when Technical Change is Embodied Capital", *American Economic Review* Vol. 82, No. 4, pp. 565-82

Hulten, C. and F. Wykoff (1981) "The Estimation of Economic Depreciation Using Vintage Asset Prices", *Journal of Econometrics* Vol. 15, April 1981, pp. 367-396

Hicks, J.R. (1942) "Maintaining Capital Intact", *Economica*

Jacob, V., S.C. Sharma and R. Grabowski (1997) "Capital stock estimates for major sectors and disaggregated manufacturing in selected OECD countries", *Applied Economics*, Vol. 29, pp 563-579

Jorgenson, D.W. (1996) "Empirical Studies of Depreciation", *Economic Inquiry* 24 (January), pp. 24-42

Jorgenson, D.E. and K. Stiroh (2000) "Raising the Speed Limit: U.S. Economic Growth in the Information Age", *Brookings Papers on Economic Activity* 1, pp. 125-211

Jorgenson, D.W. and Z. Griliches (1967), "The Explanation of Productivity Change", *Review of Economic Studies*, Vol. 34, pp. 249-83

Mas, M., F. Perez and E. Uriel (2000) "Estimation of the Stock of Capital in Spain" *The Review of Income and Wealth*, March 2000

Nelson, R.A. and M.R. Caputo (1997) "Price Changes, Maintenance and the Rate of Depreciation", *The Review of Economics and Statistics*, Vol. 79(3), (August), pp. 422-430

OECD (1999) *Capital Stocks Statistics Manual* OECD (the Canberra Group)

OECD, (2001) "Measuring Capital" *OECD Manual Measurement of Capital Stocks, Consumption of Fixed Capital and Capital Services*, OECD Paris

Oulton, N. (2001) "Measuring capital services in the United Kingdom", *Quarterly Bulletin Bank of England* Autumn 2001

Pigou, A.C. (1941) *Employment and Equilibrium*

Triplett, J.E. (1996) "Depreciation in Production Analysis and in Income and Wealth Accounts: Resolution of an Old Debate", *Economic Inquiry* Vol. 34, pp. 93-115

Vaze, P. (2003) "Estimates of the volume of Capital Services", *Economic Trends 600*, November 2003 pp. 58-66, Office of National Statistics

Vaughan, R.N. (1980) “Measures of the Capital Stock of in the Irish Manufacturing Sector, 1945-1973”, *General Research Series*, Paper No. 103 Dublin: The Economic and Social Research Institute

Whelan, K. (2002) “Computers, Obsolescence and Productivity” *Review of Economics and Statistics*, Vol. 84(3), August 2002, pp. 445-461

Table A1: Gross Fixed Capital Stocks at End of Year, 1980-2004 (€m 2003 prices)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Dwellings	**59939.5**	**63,047**	**64,701**	**66,237**	**67,742**	**69,004**	**70,266**	**71,341**	**71,893**	**72,739**	**74,127**	**75,365**	**76,827**
Government New Houses Govt Improvements	7576.1	8298.6	9141.3	9972.4	10884.4	11809.9	12786.5	13568.5	13487.6	13373.6	13371.4	13382.4	13382.6
Private household New Private households improvements	52358.5	54618.5	56468.8	58259.7	59991.3	61520.4	63050.8	64641.9	66614.6	68946.8	71709.4	74436.8	77458.0
Roads=Govt	**45774.5**	**46,083**	**46,436**	**46,846**	**47,206**	**47,665**	**48,127**	**48,511**	**48,857**	**49,300**	**49,805**	**50,332**	**50,920**
Building & Construction	**32175.0**	**35444.9**	**38837.0**	**41165.9**	**43259.3**	**44977.6**	**46541.4**	**47889.8**	**49510.4**	**51272.2**	**53768.3**	**56311.2**	**58565.6**
Industry	21447.9	21719.9	22103.7	22296.9	22465.1	22578.3	22698.2	22786.8	23020.7	23334.1	23981.1	24657.1	25253.4
Government	10723.9	10934.1	11196.2	11360.8	11518.8	11640.5	11757.9	11854.1	12002.0	12160.8	12486.1	12827.5	13121.7
Consumer Durables	**4447.2**	**4682.6**	**4891.9**	**5108.0**	**5246.3**	**5491.3**	**5735.8**	**5953.3**	**6270.7**	**6576.0**	**6821.8**	**7079.6**	**7302.7**
Transport Equipment	**16235.2**	**14643.7**	**15502.0**	**16327.8**	**17219.9**	**18066.2**	**19024.5**	**19931.6**	**21051.7**	**22553.8**	**24267.5**	**25559.5**	**26699.4**
Households	832.6	1670.8	2178.7	2484.6	2755.6	3059.1	3328.4	3600.7	3877.1	4296.4	4846.5	5098.4	5305.1
Industry + Ag	13383.5	18254.4	23425.0	26672.1	28137.4	29142.4	29636.3	29970.7	29842.6	30974.3	25375.5	20260.1	15649.3
Government	2019.1	3231.7	4493.1	5410.0	6246.4	6966.9	7637.4	8092.5	8783.4	9520.3	10392.0	11383.3	12276.7
Other Machinery & Equipment	**95415.5**	**81923.7**	**70782.9**	**61456.7**	**53537.4**	**46722.4**	**40979.6**	**36327.2**	**32259.8**	**28949.2**	**26373.2**	**24079.0**	**23916.8**
Industry	11864.3	12149.3	12662.1	13045.7	13348.4	13493.5	13435.1	13353.8	13415.1	13281.6	13264.0	13402.6	13600.7
Government	83551.2	73712.4	65033.9	57399.5	50667.4	44719.5	39476.1	34847.3	30768.9	27179.4	24009.4	21227.6	18780.2
Agricultural Machinery	**1793.2**	**1,781**	**1,746**	**1,704**	**1,665**	**1,644**	**1,612**	**1,570**	**1,553**	**1,558**	**1,541**	**1,511**	**1,490**
Software	**124.2**	**162.2**	**216.2**	**265.3**	**311.5**	**358.8**	**391.9**	**429.7**	**467.8**	**512.2**	**564.6**	**616.7**	**668.6**
Industry													
Government													
Exploration	**2384.1**	**2371.5**	**2341.3**	**2318.4**	**2300.4**	**2279.7**	**2261.5**	**2233.7**	**2209.9**	**2188.5**	**2168.7**	**2150.0**	**2133.4**
Industry (Mining & Quarrying)													
Government													
Artistic originals	**916.2**	**942**	**969**	**982**	**992**	**1,002**	**1,007**	**1,004**	**1,003**	**1,005**	**1,013**	**1,041**	**1,053**
Total Gross Stocks	**259196.6**	**260612.7**	**263303.1**	**264124.3**	**263736.0**	**263371.6**	**262942.0**	**262418.9**	**262174.0**	**264207.6**	**261349.2**	**259406.5**	**258394.8**

Table A1: Continued

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Dwellings	**77,712**	**79,606**	**82,177**	**85,701**	**90,102**	**94,686**	**100,046**	**105,924**	**112,159**	**118,627**	**126,448**	**135,608**
Government New Houses	13457.7	13696.5	11845.0	11918.1	11995.5	12115.9	12280.8	12546.3	13080.3	13816.4	14720.9	15548.9
Govt Improvements			1851.5	1845.1	1839.8	1836.3	1838.5	1852.3	1877.9	1908.1	1949.4	2002.4
Private household New	79877.6	83200.7	61524.61783	63027.0	65247.8	68365.5	72517.7	77596.7	83312.1	90167.1	99862.6	112382.8
Private households improvements			21676.1	22044.2	22623.2	23234.9	24151.9	25294.2	26800.0	28106.8	29250.4	30676.1
Roads=Govt	**51,664**	**52,273**	**52,956**	**53,665**	**54,475**	**55,406**	**56,552**	**57,766**	**59,314**	**61,086**	**62,860**	**64,613**
Building & Construction	**60384.6**	**62342.2**	**64784.1**	**68019.0**	**72185.2**	**77077.3**	**82580.6**	**88335.1**	**94143.5**	**100086.2**	**105385.9**	**110682.7**
Industry	25677.7	26239.3	27022.2	28261.9	30122.5	32614.9	35839.4	39746.7	43897.9	48251.4	52742.4	57747.4
Government	13351.0	13608.8	13969.6	14512.1	15309.2	16341.8	17638.7	19184.3	20885.3	22627.1	24182.3	25746.0
Consumer Durables	**7611.9**	**7967.2**	**8456.8**	**9121.7**	**9853.1**	**10677.3**	**11813.0**	**13039.5**	**14357.9**	**15656.8**	**17078.2**	**18454.2**
Transport Equipment	**27833.4**	**29278.6**	**31133.3**	**33029.8**	**35276.1**	**37964.3**	**41929.5**	**45950.4**	**49700.5**	**53831.5**	**57366.3**	**61754.2**
Households	5503.6	5861.5	6313.7	7000.6	7774.1	8690.5	9769.7	11295.5	12227.5	13003.8	13745.3	14649.8
Industry + Ag	12209.3	9717.1	8140.7	7291.2	6545.8	6235.3	7114.5	7590.4	8120.5	9006.6	9175.2	9831.3
Government	12944.8	13732.5	14675.4	15877.2	17379.1	19115.0	21047.1	23054.4	25068.8	27115.8	28935.5	30739.8
Other Machinery & Equipment	23990.5	24091.6	24319.2	25050.3	26166.2	28301.0	30239.7	32249.4	33709.2	34669.6	36131.4	37065.2
Industry	13848.5	14242.9	14606.0	15048.4	15904.1	17215.5	19097.0	20570.3	22732.3	23996.7	24910.8	26274.2
Government	16613.6	14713.0	13036.8	11558.0	10265.0	9126.4	8159.5	7323.6	6594.4	6581.2	6522.3	6476.8
Agricultural Machinery	**1,472**	**1,515**	**1,598**	**1,712**	**1,808**	**1,921**	**1,986**	**2,033**	**2,084**	**2,143**	**2,199**	**2,278**
Software	755.7	815.4	888.3	1010.1	1112.2	1228.7	1435.2	1631.7	1882.7	2053.6	2130.1	2183.4
Industry				926.3	1060.8	1180.2	1384.0	1571.2	1812.5	1966.8	2032.0	2077.1
Government				83.8	51.4	48.4	51.2	60.6	70.2	86.8	98.2	106.3
Exploration	2118.5	2106.0	2096.8	2152.7	2433.3	2652.5	2858.0	3005.1	3239.5	3456.9	3741.1	3884.9
Industry (Mining & Quarrying)					2408.3	2453.5	2632.0	2829.7	3062.7	3211.8	3425.7	3401.7
Government					25.0	199.1	226.0	175.4	176.7	245.1	315.4	483.2
Artistic originals	1,066	1,090	1,116	1,139	1,174	1,203	1,229	1,292	1,371	1,431	1,522	1,700
Total Gross Stocks	258171.9	260779.1	261773.3	267184.6	275862.2	287981.0	305327.4	324823.3	346846.3	370409.3	395528.9	425189.1

Table A2: Net Fixed Capital Stocks at End of Year, 1980-2004 (€m 2003 prices)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Dwellings	**59939.5**	**61,881**	**63,482**	**64,965**	**66,418**	**67,631**	**68,844**	**69,876**	**70,391**	**71,234**	**72,516**	**73,698**	**75,105**
Government New Houses Govt Improvements	7576.1	8208.5	9043.0	9865.3	10768.1	11683.9	12650.1	13421.6	13330.9	13218.3	13212.2	13223.8	13224.0
Private household New Private households improvements	52358.5	53416.3	55214.9	56961.4	58654.1	60145.4	61640.9	63199.1	65138.3	67465.3	70147.9	72820.3	75782.5
Roads=Govt	**45774.5**	**45,177**	**45,546**	**45,971**	**46,346**	**46,821**	**47,295**	**47,693**	**48,052**	**48,505**	**49,014**	**49,559**	**50,159**
Building & Construction	**31164.7**	**34466.3**	**37889.1**	**40218.0**	**42370.0**	**44116.3**	**45707.1**	**47081.7**	**48727.7**	**50514.1**	**53034.0**	**55599.9**	**57876.6**
Industry	20774.4	21055.7	21434.0	21610.7	21791.4	21912.3	22040.8	22137.7	22320.3	22630.5	23270.3	23931.9	24508.8
Government	10528.8	10739.5	10998.6	11159.1	11316.9	11439.0	11557.1	11654.0	11787.8	11944.6	12267.4	12604.4	12892.7
Consumer Durables	**3835.7**	**4097.0**	**4282.0**	**4478.0**	**4601.1**	**4828.0**	**5048.5**	**5244.5**	**5535.2**	**5809.2**	**6029.1**	**6263.7**	**6465.2**
Transport Equipment	**16235.2**	**11733.5**	**11750.2**	**11046.8**	**12115.6**	**12533.7**	**13213.1**	**14222.7**	**15072.0**	**16589.1**	**18204.1**	**19816.6**	**21679.4**
Households	832.6	1485.9	1885.3	2053.6	2350.0	2621.3	2934.2	3122.8	3354.5	3797.5	4262.2	4459.0	4656.5
Industry	13383.5	14833.0	19147.8	20293.8	22602.2	23305.2	24177.3	24280.4	24135.4	24760.2	19860.1	15405.5	11984.7
Government	2019.1	3050.8	4328.7	5242.8	6106.4	6837.1	7372.2	7981.9	8680.6	9318.1	10301.9	11298.0	12117.2
Other Machinery & Equipment	**95415.5**	**68592.1**	**59315.1**	**51553.5**	**44957.0**	**39275.5**	**34499.2**	**30647.9**	**27258.7**	**24522.7**	**22407.9**	**22235.5**	**22164.6**
Industry	11864.3	10421.8	10888.4	11242.5	11534.9	11698.3	11674.2	11616.5	11707.3	11606.9	11600.8	11984.7	12213.5
Government	83551.2	65022.5	57365.9	50631.7	44694.1	39447.5	34822.8	30739.5	27141.8	23976.0	21179.0	18725.2	16567.2
Agricultural Machinery	**1581.8**	**1,584**	**1,550**	**1,511**	**1,477**	**1,461**	**1,433**	**1,395**	**1,383**	**1,392**	**1,375**	**1,347**	**1,329**
Software	**55.9**	**102.2**	**146.8**	**189.5**	**244.8**	**275.3**	**308.7**	**347.0**	**383.8**	**427.1**	**477.0**	**523.6**	**606.7**
Industry													
Government													
Exploration	**2327.6**	**2315.8**	**2286.7**	**2264.6**	**2247.5**	**2227.7**	**2210.3**	**2183.5**	**2160.5**	**2139.9**	**2120.9**	**2103.0**	**2087.2**
Industry (Mining & Quarrying)													
Government													
Artistic originals	**902.3**	**925.3**	**946.2**	**954.5**	**961.0**	**966.7**	**967.8**	**959.4**	**956.8**	**955.3**	**959.8**	**985.0**	**994.2**
Net Fixed Assets	**257366.3**	**242434.5**	**245064.1**	**244429.9**	**245696.3**	**245669.8**	**246133.7**	**245975.6**	**246068.0**	**247945.8**	**246077.1**	**245234.4**	**245588.8**

Table A2: Continued

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Dwellings	**75,930**	**77,747**	**80,255**	**83,666**	**87,940**	**92,386**	**97,594**	**103,307**	**109,369**	**115,645**	**123,244**	**132,319**
Government New Houses	13299.0	13538.4	11710.0	11781.8	11855.2	11974.8	12133.8	12396.0	12926.1	13656.1	14552.1	15373.4
Govt Improvements			1809.5	1803.2	1797.0	1793.7	1794.4	1807.7	1832.8	1862.2	1902.6	1955.6
Private household New	78139.9	81455.9	60823.2	62309.5	64486.8	67579.8	71643.8	76654.5	82294.6	89071.3	98684.1	111150.1
Private households improvements			21184.0	21546.5	22098.5	22697.8	23560.9	24671.1	26141.3	27408.6	28514.8	29936.1
Roads=Govt	**50,916**	**51,530**	**52,220**	**52,936**	**53,785**	**54,724**	**55,876**	**57,095**	**58,646**	**60,420**	**62,201**	**63,951**
Building & Construction	**59717.3**	**61695.9**	**64158.1**	**67412.6**	**71597.8**	**76508.4**	**82029.6**	**87801.4**	**93626.6**	**99585.4**	**104900.8**	**110212.9**
Industry	24914.6	25461.6	26230.4	27450.3	29280.8	31726.7	34886.2	38708.2	42753.1	46987.2	51349.6	56227.2
Government	13116.5	13369.8	13726.4	14263.4	15052.6	16073.3	17354.0	18879.1	20555.0	22268.2	23792.7	25328.0
Consumer Durables	**6820.6**	**7151.5**	**7608.4**	**8221.7**	**8887.3**	**9638.8**	**10676.3**	**11782.2**	**12972.9**	**14141.6**	**15426.7**	**16664.4**
Transport Equipment	**23513.8**	**25453.6**	**27742.1**	**29945.5**	**32416.5**	**35260.6**	**39295.4**	**43238.6**	**46831.3**	**50849.3**	**55630.1**	**60012.8**
Households	4817.0	5156.2	5643.3	6226.9	6942.6	7782.2	8765.7	10177.1	10953.3	11601.5	12269.3	13104.1
Industry	9378.9	7506.5	6825.2	5916.1	5411.4	5278.6	6252.2	6652.0	7093.0	7940.1	8011.2	8636.1
Government	12866.3	13656.3	14603.1	15804.1	17306.8	19043.2	20973.5	22975.9	24984.2	27021.3	28831.8	30631.2
Other Machinery & Equipment	**22300.7**	**22445.9**	**22703.2**	**23410.4**	**24600.4**	**26396.6**	**27768.3**	**29864.7**	**31125.7**	**31985.5**	**33304.0**	**34167.1**
Industry	12474.2	12872.4	13231.6	13625.3	14525.7	15505.2	16859.7	18385.6	20354.3	21517.2	22284.2	23577.9
Government	14655.8	12979.6	11501.5	10196.7	9060.3	8050.8	7191.1	6460.0	6379.2	6372.1	6321.0	6280.2
Agricultural Machinery	**1,315**	**1,361**	**1,468**	**1,576**	**1,664**	**1,770**	**1,828**	**1,870**	**1,919**	**1,977**	**2,030**	**2,104**
Software	**656.4**	**712.7**	**780.9**	**894.9**	**976.8**	**1080.8**	**1272.5**	**1431.7**	**1651.5**	**1786.8**	**1843.7**	**1910.3**
Industry				816.6	861.6	984.5	1210.4	1391.3	1605.9	1734.4	1800.4	1846.5
Government				37.7	35.0	34.9	36.5	43.6	49.4	63.4	74.8	83.0
Exploration	**2072.9**	**2061.2**	**2052.7**	**2108.7**	**2387.5**	**2605.6**	**2809.9**	**2956.5**	**3189.5**	**3405.9**	**3688.5**	**3831.7**
Industry (Mining & Quarrying)					2350.8	2395.0	2567.9	2760.0	2988.3	3133.5	3342.4	3319.2
Government					24.1	192.3	220.2	171.8	172.5	238.4	307.0	469.6
Artistic originals	**1006.9**	**1027.7**	**1049.0**	**1072.2**	**1104.7**	**1127.6**	**1184.8**	**1247.5**	**1325.4**	**1384.3**	**1474.8**	**1651.6**
Net Fixed Assets	**246449.1**	**249840.6**	**229474.0**	**233942.9**	**242534.4**	**253882.3**	**269660.0**	**287649.4**	**307971.8**	**329527.6**	**352753.1**	**380397.6**