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National accounting in the knowledge and information society

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1 Introduction

1. The competitiveness of firms in post-industrialised economies is increasingly determined by product and process innovations in which intangible capital such as human capital, knowledge obtained from research and development, patenting and brand building plays a crucial role. Another important characteristic of post-industrialised economies is the rise of information and communication technology (ICT). Despite overwhelming evidence about the economy wide adoption of ICT in the nineties, its effect on economic performance, also in relation to knowledge creation, is still not always very well understood. One fundamental part of this puzzle concerns measurement issues. One important precondition for analysing and understanding 'new economy' features is undoubtedly their coherent representation in terms of statistics and indicator frameworks.

2. Policy strategies may aim at enhancing the knowledge and ICT orientation of economies as a way to increase competitiveness, employment and productivity. A good example in this respect is the Lisbon goals formulated in Europe. At the 2000 Lisbon Summit, the European Union formulated the ambition to transform itself in ten years time into "the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion". Within this strategy, full employment and a rise in labour productivity are considered as important intermediate goals in abating social exclusion and sustaining pension provisions in an aging society. However, the scope of Lisbon goals is much broader and includes pillars such as economic reform, innovation and research, environment related issues, employment and social cohesion.

3. One important complication of such a broad policy framework is undoubtedly the interdependencies between the various identified policy fields. The European Commission (2000) stated in the context of the Lisbon strategy that "the indicators selected should not be seen in isolation but rather as different elements of the same picture". In addition to general qualities such as relevance, reliability, international comparability and timeliness, such a system's approach requires the following additional indicator properties.

4. Firstly, selected indicators should be complementary in scope and mutually comparable. Without the possibility of indicator comparability, the internal coherence of such a broad policy framework is seriously distorted. Also, overlap between indicators should be eliminated to the greatest extent. A clear overview of progress made in the various policy fields is disturbed when different indicators are used for measuring (partly) the same phenomena.

5. Van Rooijen-Horsten and De Haan (2004) show how the Lisbon indicators, 'Public expenditure on education', 'R&D expenditure' and 'ICT expenditure', can be embedded in a national accounts framework. They detect several overlaps and conceptual differences between these three indicators. They also illustrate how a national accounts oriented harmonised representation of these indicators provides a consistent picture of the knowledge and information orientation of an economy. In other words, a national accounting based presentation clearly enhances the eloquence of these indicators.

6. Secondly, the indicator framework should facilitate the analysis of interrelationships between indicators. Especially in the context of the new economy, it seems highly relevant to shape indicator

systems in such a way that the impacts of knowledge creation and information technology on for example economic growth and labour productivity can be analysed. The current Structural Indicators are in this respect a rather incoherent list of indicators. They principally omit a conceptual framework. As a result their mutual comparability is hampered by the application of a variety of concepts and definitions. This may seriously hamper the assessment of trade offs between the various policy goals formulated in the Lisbon Strategy.

7. The national accounts potentially play an important role in the structuring and the subsequent analysis of indicators. For mainstream economic policy, the national accounts are the world wide accepted statistical information system for empirical analysis. The national accounts can be regarded as an information pyramid in which a detailed information system underlies the macroeconomic indicators on top such as gross domestic income, net national income, consumption, fixed capital formation. In this way the national accounts co-ordinate the information requirements of different kinds of users. The key macroeconomic aggregates determine together the condensed set of indicators required for short-term reviews. The underlying accounts serve various analytical purposes such as productivity measurement and macroeconomic modelling. Both user types are unified by one set of macroeconomic entities.

8. Quite obviously, the 1993 System of National Accounts (SNA93) does not cover all information requirements of such a multidimensional policy strategy. And it is probably infeasible to construct a comprehensive accounting system covering all dimensions of the Lisbon strategy. However, with respect to the knowledge and information orientation of modern economies, there are a number of improvements imaginable that may reinforce the relevance of national accounts statistics in this context. For example, the System currently does not acknowledge research and experimental development (R&D) as an activity leading to codified knowledge capital. In addition, the System does not define ICT capital as such. Also, the System should provide much guidance to volume and price measurement, especially concerning services, intangible capital and the rapid quality changes in ICT equipment.

9. Finally, national accounts statistics are undoubtedly useful in analysing how knowledge and ICT capital contribute to economic growth and other economic developments. Statistics Netherlands considers productivity analysis on the micro and macro level as one of the new development areas for the near future. However, we doubt whether productivity measures and analytical constructs such as capital services can be considered as straightforward extensions of the national accounts system. As newcomers in this field of work we have the impression that the estimation of capital services are based on models and related assumptions which are beyond the scope of an accounting oriented recording of factual events. Therefore, we do not recommend the introduction of capital services as part of the central framework of the upcoming SNA update (SNA93rev1). Instead we plea for an introduction of capital services in terms of a satellite account in the SNA93rev1.

10. In summary, this paper explores in the light of the upcoming SNA update scheduled for 2008 several changes that may enhance the SNA's relation to indicators that are currently being used to measure the knowledge and information based economy. Strengthening this relationship is expected to increase the analytical strength of both national accounting and indicators measuring the knowledge and information technology orientation of post-industrialised economies.

2 Productivity accounts, capital services and consumption of fixed capital

2.1 Introduction

11. Understanding the determinants of labour productivity improvements is of major importance in any policy that aims at stimulating economic growth. In the long run, productivity growth is the only sustainable source of economic growth, as in many countries future demographic developments may put absolute restrictions to labour supply. In the Lisbon agenda, the member countries of the European Union have explicitly committed themselves to achieve higher productivity growth. Adequate indicators of productivity growth and its sources are therefore necessary.

12. Although by now it almost has the status of a cliché, Solow's (1987) observation that 'you can see computers anywhere except in the productivity statistics' has bugged economists for a long time. Since the 1980s the ICT industry has grown enormously, and other industries have been rapidly increasing their investments in ICT equipment. Despite this, it took a long time for ICT to have any measurable effects on productivity growth. This is both because the effects of ICT on productivity and output growth are hard to measure in the first place, but also because it took some time for ICT to actually have an effect on growth.

13. This section discusses possible changes of the SNA that may support productivity measurement on the meso/macro level. Productivity measures rely on three components: firstly a framework for productivity measurement, secondly input and output indicators usually measured in terms of current money values and thirdly price and volume measures. These three components are subsequently discussed in sections two, three and four of this paper with a specific reference to 'new economy' phenomena.

2.2 Measuring productivity: different approaches

14. The OECD *Productivity Manual* (OECD, 2001a) defines productivity as the ratio of a measure of output and a measure of input. It can be interpreted as a measure of technological change or efficiency, or simply as a residual of economic growth that cannot be explained by an increase in the amount of inputs used in the production process.

15. The best known productivity framework is the growth accounting approach. This is a non-parametric approach, meaning that it uses assumptions and properties of an underlying production function to determine productivity growth. This is opposed to parametric (econometric) approaches, which try to explicitly estimate parameters of a production function that is subsequently applied to determine productivity growth. Econometric approaches are rarely used in statistical practice and are not recommended in the OECD Manual. Therefore it seems logical to not propagate their use in the SNA.

16. The growth accounting framework only accounts: it divides economic growth up into a growth of inputs and a change in technology or productivity growth. It does not explain anything. Nevertheless, it is very useful in that it provides insight in the proximate sources of productivity growth. A variant of the growth accounting approach is the KLEMS framework. This framework divides total output (i.e. not value added) in five components: capital (K), labour (L), energy (E), material inputs (M) and services inputs (S). Any remaining output growth is interpreted as growth in productivity. Because it uses output rather than value added, the KLEMS-approach can also be used on the level of individual firms, where the concept of value added is rather artificial. The index number method of Balk (2003) represents an approach with a primary focus on the micro/meso level.

17. Other approaches like Data Envelopment Approach[1] are specifically used to determine (relative) efficiency at the firm level, and are less used on higher levels of aggregation e.g. industries and the total economy. Until now, most productivity studies at higher levels of aggregation use some kind of growth accounting framework. For a more detailed overview of the different methods of productivity measures introduced in this field we refer to the OECD *Productivity Manual* (OECD, 2001a) and Balk (2003).

2.3 Introducing capital services in the SNA: some critical remarks

18. Since one of the main goals of national accounting is the measurement of economic growth, it seems quite logical to support in the SNA growth accounting as way to measure and analyse the main determinants of economic growth. Following the KLEMS framework, one important step in this direction is the separate identification of labour and capital inputs of production. Labour input is to a large extent, but not entirely, represented by the compensation of employees recorded in the generation of income account. The services derived from assets are usually not statistically observable unless assets are rented.

19. In addition to labour (or human capital), the use of capital is an important factor in economic development. By its nature, capital is a stock delivering productive flows (capital services) during its lifetime. The measurement of capital stock and derived concepts such as depreciation are by now well understood and explained in the OECD (2001a, 2001b) manuals for measuring capital and productivity. The OECD manuals pay attention to the measurement of capital services, and some national statistical offices even regularly publish estimates. Schreyer *et al.*(2003) and Diewert (2003) discuss the measurement of capital services in detail.

20. The explicit representation of capital (and labour) services in the national accounts broadly requires the following adjustments of the generation of income account:

- a split up of the balancing item gross mixed income into a labour and a capital component;
- and subsequently a breakdown of the capital component of gross mixed income plus the gross operating surplus into capital services by type of asset;

[1] See Coelli et al. (1998) for an introduction.

21. Although the representation of capital services in the production account is undoubtedly an important precondition for multi-factor productivity measurement at the meso/macro level, their measurability differs fundamentally from most transactions recorded in the national accounts. This can be argued as follows.

22. If a capital good is rented, then the money value of its service flow is equal to its rent. For example, in case a building or a machine is rented, the user pays a rent to the owner and in turn the owner grants the right to use the capital good to the user. So, abstracting from the possibility of idleness, the payment by the user can be seen as the value of the service derived from the capital good.

23. Most capital goods are not rented but owned by the user. In fact, for many capital goods there is no rental market, or only a very thin one. Therefore another route must be taken for example by presupposing *what the cost of capital would have been when it would have been rented*? The conceptual model for estimating capital services in this way is the user cost model. This model defines the user cost of a capital good as the sum of three components:

- the financial opportunity cost of the capital good, viewed as an asset;
- the depreciation of the capital good, i.e. the loss of value as it ages;
- the capital gain or capital loss.

These user costs are supposed to represent the money value of the services provided by a capital good.

24. The indirect estimation of capital services is based on a model and encompasses an imputation. This is not very surprising. Capital services include depreciation estimates which are equally an imputation in the SNA. However, what is more, the user cost model is only valid under the assumptions of perfect competition and perfect foresight or absence of uncertainty (Nickell, 1978, chapter 2). The OECD capital manual mentions this in several places, e.g. on pages 60, 84, 86 and 88. Only under these assumptions the user of a capital good is indifferent between renting and buying the capital good and between internal finance (profits withheld or shares) and external finance (loans).[2]

25. The absence of well functioning rental markets for many types of capital goods seems related to the existence of imperfect competition and uncertainty about the future. Indeed this is one of the main aspects of the new information economics, pioneered by amongst others Stiglitz and Greenwald. Most likely, the absence of well functioning rental markets indicates that the equivalence between renting and owning does not always hold. As a result, user costs computed on the assumptions that this equivalence holds do not in all cases properly measure the value of capital services. To put it another way: if capital services were actually priced according to the user cost model and economic agents were to act on these price signals, we would probably have another economy and observe other levels of GDP. In this respect it is also significant that in most countries the tax laws do no discriminate between capital services derived from own capital goods and pure profits.

26. If the assumptions of perfect competition and perfect foresight are valid, one can set up a complete system for the simultaneous measurement of capital services and capital consumption (OECD, 2001b, chapter 9; Diewert, 2003). It is then possible and also preferable to compute both

[2] The second equivalence is known as the Modigliani-Miller theorem (Nickell, 1978, chapter 8).

capital services and capital consumption using one consistent framework. When the assumptions do not hold, the user cost model may cease to be a valid valuation measure of capital services.

27. This raises the question of how much the measurement of consumption of fixed capital in the SNA is entwined with the concept of capital services and to what extent consumption of fixed capital is truly a forward-looking measure (SNA93, paragraph 6.183). The SNA93 (paragraph 6.179) firstly defines capital consumption "as the decline, during the course of the accounting period, in the current value of the stock of fixed assets owned and used by a producer as a result of physical deterioration, normal obsolescence or normal accidental damage." The subsequent paragraphs of the SNA translate this definition into the annual change in the net present value of expected future earnings (i.e. rents) from the asset. Again, this equivalence only holds under the assumptions of perfect competition and perfect foresight and may not hold in the real world of imperfect functioning markets.

28. Conceptually, it seems that this relation is not a necessary one. If there would exist a lively market for all sorts of second hand capital goods, the prices observed on these markets would certainly be the preferable source for calculating consumption of fixed capital. Perhaps, in addition to this information, some calculations for normal accidental losses would be required. Only because this price information is usually not available, we are forced to adopt assumptions about the decline in efficiency of assets over time in order to be able to estimate consumption of fixed capital. Although such an assumption is certainly based on expected future events, these imposed expectations replace those of buyers of second hand capital goods. It is clear that the value of an asset is somehow determined by future events. Yet, a future looking measure is only applied in practice as a way to calculate consumption of fixed capital. When looking at the core definition of consumption of fixed capital in the SNA, one may conclude that it does not differ much from the occasionally used business practice of measuring depreciation based on replacement values, so that this concept has a clear relation to microeconomic reality.

29. Of course there is nothing wrong with entertaining a particular, important, model of the economy, analyze its mechanics, and testing it against the data. Nor is it to be doubted that capital goods deliver productive services. Since statistical institutes are already involved in computations for capital consumption, they may also be well equipped for estimating capital services. However, the representation of capital services in the national accounts is more demanding in terms of underlying assumptions compared to the calculation of net instead of gross balancing items. Based on the arguments given below, we argue that capital services should be introduced in the SNA93rev1 as a satellite account and not as an optional item in the generation of income account.

30. Only under the condition of perfect competition and transparent market conditions will gross operating surplus and the capital component of gross mixed income represent the sum of capital services. In reality these conditions will not always be met and there is no reason why gross operating surplus would not contain a positive or negative residual term after subtracting the total sum of capital services. This severely complicates the measurement of capital services since its estimation is often based on the assumption that gross operating surplus represents in total the gross return to capital (OECD, 2001a, paragraph 108).

31. A related argument for relegating capital services to a satellite account is that is not entirely clear how the rate of return to capital should be determined. This problem becomes particularly apparent once it is accepted that a residual term could appear in which case an endogenous rate of

return cannot be straightforwardly compiled. Should an alternative rate of return be based on the long term return on stocks, the return on government or non-government bonds? Should it be a nominal rate or a real rate? As long as there is no clear answer, it seems also from this perspective preferable to introduce capital services in a satellite account.

32. Another obstacle is the determination of capital services of difficult to measure non-produced assets such as environmental assets and goodwill. Without including these assets the generation of income account will not provide an exhaustive representation of capital services. Also, as long as there is no satisfying recording of depletion in the SNA, the representation of capital services of mineral deposits in the generation of income accounts seems to be rather premature.

33. In conclusion, we think that the SNA93rev1 should introduce capital services, however preferably in a satellite accounting setting. This acknowledges that capital services depend on analytical models which are more remote from those models or imputations currently found in the core system.

3 Knowledge and ICT capital

3.1 Introduction

34. In the 1980s investment in ICT accelerated and in the second half of the 1990s ICT investment growth really exploded. This led to excessive expectations regarding the 'new economy' which were tempered once output growth slowed substantially at the beginning of the current decade. For economists this revived the question whether ICT was responsible for the fast economic growth in the United States in the second half of the 1990s. A related question was to what extent ICT can be considered as a new general purpose technology (GPT) with long lasting effects on economic growth, like the steam engine and electricity were in the past?

35. At the turn of the century this gave rise to a heavy debate between proponents of the GPT thesis and sceptics. Robert Gordon (2000, 2002), a renowned expert in the field of productivity research, proved himself a sceptic, arguing that productivity growth in ICT producing industries was indeed impressive, but that the increased use of ICT products in other sectors (capital deepening) had not led to substantial productivity increases.

36. Other authors,[3] however, showed in several detailed growth accounting exercises that both the production and use of ICT did have major contributions to productivity growth. The capital-deepening effect seemed to exist after all. A belief that ICT affected productivity growth in both ICT-producing and ICT applying industries is now widespread. Part of the conventional wisdom is that European countries lag behind the United States for two reasons: investment in ICT was much lower in Europe and the capital deepening effect was smaller as well. Nevertheless, the scope for further productivity performance due to ICT is still present in Europe.

37. Measuring ICT and its effects is useful in its own right for national accountants. That alone provides reason enough for the SNA to explicitly tackle this issue. For politicians understanding the effects of ICT on economic growth is necessary as well if they want to formulate policy measures to stimulate economic growth, as member countries of the European Union have declared in the Lisbon strategy.

38. The competitiveness of industries is not led by ICT alone but is equally determined by their level of knowledge orientation. This section discusses how knowledge and ICT can be statistically described in terms of assets in the SNA sense.

[3] See, for example, Schreyer (2000) and Colecchia and Schreyer (2001)

3.2 Knowledge capital

39. When identifying the knowledge orientation of economies, it is relevant to distinguish human skills, sometimes referred to as tacit knowledge, from codified knowledge such as scientific and artistic originals. Tacit knowledge is the result of human capabilities, education and working experience. Although dissemination of knowledge via education and training may enhance this human embodied knowledge, its level is equally determined by non-exchangeable virtues such as intelligence and imaginative powers. Tacit knowledge is inseparable from human beings and therefore principally not exchangeable. Codified knowledge refers to the output of an artistic or scientific nature, registered by way of written text, images, sound, computer software code etc. Codified knowledge may exist independently from its creator and is therefore principally exchangeable between individuals.

40. Codified and human embodied knowledge are complementary in nature. The creation of codified knowledge highly depends on the availability of human capital. Similarly, the productive use of codified knowledge is only possible in combination with people endowed with the required knowledge skills. The representation of tacit and codified knowledge in the SNA is discussed below.

Human capital

41. Knowledge embodied in persons may have a market value and this value is usually referred to as human capital. Human capital is currently not an asset defined in the SNA. Human capital is inseparable from individuals and for that reason human capital cannot be regarded as freely exchangeable entities. The exclusive rights of use coincide with the individual endowed with human capital.

42. Yet education, is generally acknowledged as a key source of economic growth. This is why most economists will consider education as investment in human capital which reinforces the knowledge endowments of the labour force over longer periods of time. However, the representation of human capital in the SNA as a fixed asset must be considered a revolutionary change of the system which is beyond the scope of the upcoming SNA update.

43. Bos (1996) shows by way of a satellite account a number of consequences of recording education as gross fixed capital formation in human capital. In his approach, all expenditure on education, either by households, government or enterprises, is recorded as capital formation. Formal education, provided by the government or non-profit institutions serving households, is recorded as capital formation by households while company education is considered as fixed capital formation by enterprises. Education expenditure is recorded as work-in-progress when it pertains to people that have not yet entered the labour force. Fixed capital formation takes place at the moment a student finalises her education and enters the labour force. This accumulated value of education expenditure is counterbalanced by a concomitant 'work-in-progress' inventory withdrawal.

44. The recording of education and training expenditure as gross fixed capital formation entails that compensation of employees must now be regarded as a payment of (human) capital services provided by households. In other words, the employee has become an entrepreneur selling the services derived from the exploitation of his human capital. He can decide to increase the quality and value of his labour services by additional investments in education. Also, part of the income generated from

human capital consists of the depreciation of human capital. The value of human capital services includes the full compensation of employees: wages and social contributions paid by employers.

45. One could argue that this way of recording reflects the more flexible and dynamic relationship between employers and employees experienced in more recent years. However, the implications of this recording for the SNA are substantial. For example, value added at the industry level will no longer include the compensation of employees. Instead, a corresponding amount of value added is generated by the household sector in newly introduced production activities, which output mainly consists of human capital services. These newly introduced human capital services industries would generate together more than 50% of GDP at market prices in most countries.

46. GDP itself is also likely to change since work related consumption expenditure such as commuter traffic expenses must now be regarded as intermediate consumption. GDP will also increase because education expenditure by enterprises is no longer part of intermediate consumption but is instead included in gross fixed capital formation. Furthermore, this approach may substantially widen the production boundary. If the process of learning leads to capital formation, it seems almost unavoidable to accumulate in this capital formation also the opportunity costs of time spent on education of those receiving education or training.

47. In other words, the described implications of recording education expenditure as gross fixed capital formation will rigorously change the SNA. Beforehand it has been decided that the upcoming SNA update is not going to lead to fundamental changes of the System and therefore the representation of human capital in the System will not be taken into consideration.

48. In the national accounts the separation of gross fixed capital formation from current expenditure is required to show how fixed assets contribute to production over longer periods of time. Capital services are being approximated to quantify the capital inputs of production. In the case of human capital such an indirect measurement of capital services is not needed. The recording of compensation of employees in the generation of income account provides an almost complete picture of the human capital inputs of production. Only the labour component of mixed income is not separately identified in the System.

49. It may be desirable to add more detail to wages and labour inputs, for example by means of a subdivision by educational attainment or occupation. This may provide a further differentiation between various human capital input categories. For this purpose, the SNA after the upcoming update (i.e. SNA93rev1) may for example make reference to the OECD (1995) Canberra manual and to the sub-categorisation of labour presented in the Human Resources in Science and Technology (HRST) concept found in this manual.

(codified) Knowledge capital

50. Many characteristics of codified knowledge coincide with the SNA definition of fixed assets. In many cases, the creation of codified knowledge is the outcome of a production activity as defined in the SNA. Codified knowledge may be used repeatedly or continuously in processes of production over longer periods of time. Knowledge assets may be subject to exclusive ownership for example by way of legal protection.

51. The SNA93 considers the creation of books, recordings, films and software as the production of intangible fixed assets. One important exception is however the knowledge obtained from R&D. Scientific knowledge is currently not considered a fixed asset in the System. Only patented entities are regarded as non-produced assets in the SNA93.

52. One may argue under what conditions R&D genuinely leads to the creation of an asset in the SNA sense. A majority of Canberra II Group members advocate, as one of the upcoming SNA updates, a generic capitalisation of R&D, including both private and public performed R&D (basic research).[4] One important reason why R&D may lead to the creation of an asset in the SNA sense is that, due to the exclusive access to knowledge obtained by R&D, the owner may exert a certain level of market power. The service of a knowledge asset decays together with the inevitable loss in monopolistic power the owner experiences over time. Quite logically, this loss in market power determines the service life of a knowledge asset. Also, the sharing of this knowledge incurs an opportunity cost since it delimits the monopolistic power of the initial owner. Exclusive ownership of scientific knowledge is not necessarily obtained by way of patenting only but can also be obtained by way of secrecy or by the exclusive access to the complementary tacit knowledge.

53. This opportunity cost is not present in the use of freely accessible knowledge. Knowledge created in the public domain misses any form of ownership. Although governments can be identified as the financer and performer of R&D, it is not necessarily true that they also own this public knowledge. In other words, exclusive ownership maintains to be a decisive precondition for knowledge to be accepted as an asset in the SNA sense. This is why De Haan & Van Rooijen-Horsten (2004) recommend excluding public R&D from capitalisation unless the resulting knowledge is either being patented or explicitly tied to government production. For example R&D carried out for defence purposes will usually not lead to public accessible knowledge and therefore this R&D could be capitalised in a meaningful way.

Other intellectual property

54. The Frascati handbook (OECD, 2002) thoroughly demarcates intramural expenditure on research and experimental development. These Frascati guidelines are equally useful to define in the SNA93rev1 (codified) knowledge capital as a fixed asset. This will certainly be an improvement of the System from the knowledge economy point of view. However one may argue that this narrowly defined fixed asset, i.e. knowledge capital, still represents only part of all intangible capital tied to innovation processes in companies. It should be acknowledged that a range of creative activities (and related expenditure) may lead to the blueprints of new modes of production or products that do not meet the definition of R&D. Yet, these creative processes may add in several ways to the value of companies. In many cases these values are legally protected for example by way of copyrights, brands or trademarks.

55. Innovation related expenditures, other than those on research, are generally difficult to measure. In many cases companies have difficulties to provide reasonable estimates (cf. Statistics

[4] The Canberra II Group is currently preparing SNA revision proposals related to the measurement of non-financial capital.

Netherlands, 2003, p. 104). And their contribution to asset values is perhaps even more difficult to assess. One innovation expenditure category discussed in this context by Van de Ven (2000) is expenditure on advertising. Van de Ven argues that so-called long term marketing expenditures add to the value of assets such as brand names, trademarks and franchise formulas. This expenditure could therefore be regarded as part of gross fixed capital formation. However a major problem related to capitalising marketing expenditure is the uncertainty about the extent to which related expenditure genuinely and exclusively contributes to the value of brand names or trademarks. One expects that brands or trademarks are to some extent produced and to another non-produced. Consequently, the service lives of advertising expenditure are not easily determined.

56. In conclusion, the capitalisation of market R&D is certainly an important improvement. Although, the time is perhaps not yet ripe to include other types of intangible fixed assets, the SNA93rev1 should acknowledge that other creative activities, other than scientific work, may equally contribute to the value of companies and that this should be subject to future development.

3.3 ICT capital

57. The revision of the International Standard Industrial Classification (ISIC rev.4) is due to be completed by 2007. One of the major proposed changes in this revision is the introduction of the Information and Communication section (5) that brings together various elements from the former ISIC such as publishing, motion picture and sound recording activities, broadcasting and telecommunications. Together with the division Manufacture of computers, communication equipment, and electronic components (26), this newly introduced section allows for a sound representation of the ICT industry.

58. With respect to the delineation of ICT investment and capital, Schreyer (2000) distinguishes the following three ICT capital categories: Computer software, Computer hardware and Network equipment. Most if not all of these investment categories are already regarded as gross fixed capital formation in the SNA. However, the classification of assets in the SNA at present does not always allow for the explicit representation of ICT related assets. It seems quite appropriate and useful to identify ICT capital in the main SNA93rev1 classification of assets in a similar way.

Computer software

59. Computer software (including large databases) is separately headed in the asset classification (AN.1122). The SNA93 requires expenditure on computer software, i.e. purchases of copies and costs of in-house developed software, to be recorded as gross fixed capital formation. This requirement represents one of the major changes compared to the former 1968 SNA. In the last couple of years, countries have included estimates for gross fixed capital formation of software in their national accounts, adding directly to GDP. There was evidence though, that the applied estimation methodologies differed substantially between countries. In 2002 a Eurostat-OECD task force finalised their recommendations that must lead to better international comparability of software investment estimates.

60. One outstanding issue is the coverage of databases. The SNA recommends including large databases in gross fixed capital formation although no precise indication is given of the actual size being required. One conceptual issue related to representing databases as a separate category of assets is to what extent they carry a value that differs fundamentally from software in general. Is a database mainly an excess devise to data (i.e. a piece of software) or should the data themselves being considered an intrinsic part of the value of a database? Another conceptual issue is whether only commercial exploitable databases such as client records should be considered an asset or more generally all databases including for example business administrations?

61. From a practical point of view most countries have great difficulties with identifying expenditure on databases. Computer software purchases may include databases which are not always separately identifiable. Also, since the output of own account software is usually estimated on the basis of information on software development staff, one may expect that the output of own account software will cover most of the costs related to own account developed databases. This is why the Canberra II group recently agreed to propose for the SNA93 update to capitalise expenditure on databases together with expenditure on software. For databases a subdivision will be provided for those users that are able to make a sensible split.

Computer hardware

62. ICT hardware may include servers, personal computers, workstations and peripherals. Computer hardware is in the current SNA asset classification headed under "Other machinery and equipment" (AN.11132; 45 office accounting and computing equipment). All but household consumption expenditure on ICT hardware qualifies as gross fixed capital formation in hardware and thus as part of the ICT capital stock. Expenditure on e.g. semiconductors and related components should not be included separately since these components will usually serve as inputs into hardware manufacturing.

63. Nowadays, many types of assets are equipped with microchips and corresponding software like motor cars and all kinds of machinery. ICT capital should mainly address the information and communication infrastructure of an economy and not the automation of regular production systems. Therefore, the application of microelectronic devices in general machinery and equipment should not be considered part of ICT capital.

Network equipment

64. There is at this moment no internationally acknowledged definition of network (or communications) equipment. Attempts have been made to define network equipment based on product classifications (e.g. Radio, audio and communication equipment). However, one may argue that network equipment should represent more generally the complete ICT network infrastructure including for example cable and mobile telecommunication networks. After all, telecommunication equipment does not function without the complementary telecommunication infrastructure.

65. Part of this infrastructure coincides with traditional fixed asset types such as “Other machinery and equipment” (AN.11132) and “Other structures” (AN.11122). One way to identify the ICT utilisation of these assets is by adding further sub categorisations:

- AN.11132; (CPC-47) Audio, video communication equipment;

This sub categorisation based on the Central Product Classification is already present in the SNA93 (p.307).

66. For ICT Infrastructure specifically tied to the Information and Communication industry the following sub categorisation could be made:

- AN.11132; (..) e.g. Transmission equipment;
- AN.11122; (..) e.g. Communication lines; Radio TV towers; Mobile phone networks etc.

Table 1
Gross fixed capital formation of ICT capital in the Netherlands

	1995	1996	1997	1998	1999	2000	2001
	million-€						
Total gross fixed capital formation	63 144	68 030	73 373	78 274	86 361	91 353	95 798
ICT capital	6 685	7 756	9 417	11 193	14 062	14 969	15 342
Computer hardware	2 714	3 156	3 489	3 704	4 180	4 195	4 207
Computer software	2 332	2 729	3 530	4 805	5 512	6 106	6 550
Network equipment	1 639	1 870	2 397	2 684	4 370	4 668	4 585
Audio, video and telecommunication equipment	502	545	656	626	717	760	723
Other machinery and equipment	766	966	1 054	1 752	2 933	2 778	2 757
Other structures	371	359	687	306	720	1 130	1 105
	%-shares in total gross fixed capital formation						
ICT capital	10,6	11,4	12,8	14,3	16,3	16,4	16,0
Computer hardware	4,3	4,6	4,8	4,7	4,8	4,6	4,4
Computer software	3,7	4,0	4,8	6,1	6,4	6,7	6,8
Network equipment	2,6	2,7	3,3	3,4	5,1	5,1	4,8
Audio, video and communication equipment	0,8	0,8	0,9	0,8	0,8	0,8	0,8
Other machinery and equipment	1,2	1,4	1,4	2,2	3,4	3,0	2,9
Other structures	0,6	0,5	0,9	0,4	0,8	1,2	1,2
	%-shares in total gross domestic product at market prices						
ICT capital	2,2	2,5	2,8	3,2	3,8	3,7	3,6

Source: De Haan & Van den Bergen (2004)

67. Table 1 provides an overview of ICT related gross fixed capital formation in the Netherlands. In this table network equipment is being defined as all economy wide gross fixed capital formation in "Radio, video and communication equipment" and gross fixed capital formation of "Other machinery and equipment" and "Other structures" in the telecommunication industry only. A closer look at the company records of companies in the telecommunication branch in the Netherlands indicates that almost all investments in "Other machinery and equipment" and "Other structures" is ICT related. Estimates for the Netherlands indicate that especially ICT capital tied to the Information and Communication industry is substantial, i.e. more than 25% of all ICT related capital in 2001.

68. Its growing importance in most economies deserves that ICT capital should be as represented as a main category in the asset classification of the SNA93rev.1. The demarcation of ICT capital from other asset types can be established along the lines presented here. With respect to network equipment we argue that, in addition to radio, audio and communication equipment, this subheading should more generally include the complete telecommunication infrastructure.

3.4 Double counting of intangible capital

69. A sound delineation of intangible fixed assets in the SNA is being complicated by the fact that intangible capital is frequently being used to produce other intangible capital. This may give rise to double counting problems in macroeconomic entities such as gross fixed capital formation and gross domestic product. A frequently disputed example in this respect is the use of software, literary or artistic originals for the purpose of selling copies. Another example is the use of fixed intangible assets in the creation of new intellectual property. Both examples are briefly discussed below.

Originals and copies

70. Concerning originals and copies, the double counting issue is well documented in the OECD software taskforce report (Ahmad, 2003, A.2.6). One crucial element in the discussion of originals and copies is whether or not the copying of originals truly encompasses a production activity. Another way of putting this is whether intellectual property can be copied at all or being shared only. The current SNA93 (6.143) considers the production of books, recordings, films, software, tapes, disks, etc. as a two-stage process of which the first stage is the production of the original and the second stage the production and use of copies of the original. The output of the first stage is the original itself over which legal or de facto ownership can be established by copyright, patent or secrecy. The value of the original depends on the actual or expected receipts from the sale or use of copies at the second stage. Alternative options discussed in the Canberra II Group are to record the sale of a reproduction as either a partial sale of the original asset or as a rent payment. In both alternatives, which differ from the present SNA93 guidelines, the reproduction of originals is not recorded as production.

71. One may argue that intangible fixed assets are not very different from other assets in a sense that capital goods are more generally used for producing capital goods. As explained in the OECD software taskforce report, for software this analogy is refused by some because the actual costs of reproduction may be negligible. Also a copy may not differ in any way from the original. However,

although the intermediate costs of physical reproduction may be relatively small, other intermediate costs such as marketing, distribution and packaging expenses may be significant. Also from the perspective of the users of copies, there is a rational to capitalise the concomitant payments on licensees and other types of payments when these are expected to be used for more than one year.

Delineation of R&D and software

72. The SNA93 (§6.163) considers by convention all expenditure on R&D as intermediate inputs. However, at the same time the current System recommends that expenditure on R&D should be explicitly recorded as output. "Research and development is not an ancillary activity, and a separate establishment should be distinguished for it, when possible" (SNA93, §6.142). Concerning the delineation between computer software and R&D, the European System of Accounts (ESA95) indicates that "expenditure on R&D does not include the costs of developing software as a principal or secondary activity"(§3.64). In the Frascati Manual, according to which a majority of countries compile R&D statistics, R&D related to software development is principally included.

73. De Haan & Van Rooijen-Horsten (2004) discuss possible overlaps between R&D and software. They argue that it is not very meaningful to separately record R&D output that is fully devoted to the development of a new software original. In this case R&D and software development will generally constitute an inseparable part of the production process with one single identifiable output, being the software code that defines the original.

74. They recommend that all R&D with the specific goal of developing a software original should be identified as software and not as R&D which is in line with the present recording of software according to ESA95. In case the R&D concerns basic or applied research of a more general nature that may be used in several software development projects, it would be meaningful to identify this R&D output (and the resulting knowledge asset) separately from software.

75. Similarly, when the development of software is an inseparable part of an R&D project (not resulting to the development of a software original), this software should not be identified as a separate asset. The costs of this software development should be an integral part of the R&D project. In case software is being developed as a supplementary multi purpose tool, this software should be separately identified as an independent computer software asset in which case the consumption of fixed capital of this software should be part of the production costs of the R&D output.

A plea for net measures

76. Regarding the delineation of software and R&D, the SNA update does not have to lead to major changes. Additional guidance with respect to a sound delineation of the recording of these fixed intangible assets in the System will be sufficient.

77. Another concern is the use of Gross Domestic Product as the leading production indicator in most countries. This gross indicator is inevitably disturbed by double counting and this distortion is further amplified as a result of capitalising software and R&D. The recent debate among national

accountants about double counting issues affirms the confusion that results from putting gross measures to the forefront.

78. As a consequence of expanding the boundary of fixed assets, the use of net indicators should be advocated more strongly for example in the introductory chapter of the SNA93rev1. In this context it is also highly desirable to underline the importance of internationally harmonised estimates for consumption of fixed capital. As argued by Bos (1990, p.6) “both concepts (i.e. capital formation and capital consumption) must be regarded as inseparable twins, because accounting for capital formation without accounting for capital consumption is like making a pudding without eating it”.

4 Price and volume measurement

79. The previous section focused on measuring knowledge and ICT capital in a given period in current prices. However, the calculation of volume changes, which ought to be a key issue in an accounting system like the SNA which is first of all used to measure economic growth, requires constant price measures and thus deflators. In the case of ICT and knowledge capital, we encounter the following two major problems:

- quality changes especially with respect to ICT equipment;
- deflators for intangible asset inputs and services outputs.

4.1 Quality changes for ICT equipment

80. The debate surrounding the quality issue is nearly a century old. In 1915, Wesley Mitchell identified the quality problem in the U.S. wholesale price index (Banzhaf, 2001). Subsequent reviews raised the quality change issue which got a new stimulus with the publication of the advisory report of the so-called Boskin Commission (Boskin et al., 1996). This review focused on the US Consumer Price Index (CPI). Although a CPI is only one out of several price indices frequently calculated by statistical agencies, problems relating to the CPI are relevant for other types of price indices as well. The Boskin Commission estimated that in recent years the US. CPI had an annual upward bias of 1.1 percentage points, half of which was due to new and improved products.

81. Within the scope of this paper quality problems are especially apparent in the case of ICT equipment. According to estimates by Van Ark et al. (2002), the average share of ICT equipment in total equipment capital services in 2000 is close to 30% in twelve European countries,[5] and even exceeds 40% in the US. Deflators that do not adequately adjust for the rapid quality improvements in ICT equipment will serious distort the measurement of real output and productivity. Wyckoff (1995) shows how different ICT deflators in different countries lead to extreme differences in relative levels of productivity. For these reasons alone it is recommendable that the next update of the SNA provides explicit guidelines on how to deal with the rapid quality changes that are so apparent in ICT equipment.

82. An increasingly applied method in this respect is the hedonic price measurement. This method was pioneered by Waugh (1928) and Court (1939) and brought to the foreground of economic analysis by Griliches (1961). The basic idea of the hedonic method is that price changes of heterogeneous goods or services can be analysed by disaggregating them into more elementary units that better measure the nature of the good, namely its characteristics. Lancaster (1971) defines characteristics of goods as “objective properties of things that are relevant to people”. Rather than

[5] Austria, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

goods, characteristics are seen as homogeneous economic variables, which together form heterogeneous goods.

83. Van Mulligen (2003) argues that the hedonic method is potentially most useful for products that witness rapid quality changes, like ICT products. Not surprisingly it is in this area that most of both research and implementation of the hedonic method has concentrated. The hedonic method was first implemented in official price statistics in 1986 in the US in the investment deflator for computer equipment (Cartwright, 1986). Since then, the US Bureau of Economic Analysis (BEA) and the Bureau of Labor Statistics (BLS) have adopted the hedonic method for many price indices. Statistical agencies in other countries have followed suit.

84. Given the wide body of research and experience by several (mainly US) statistical agencies, the hedonic method seems the best method available to deal with rapid quality changes in ICT capital. Although some issues regarding this method still need to be resolved, there exists some *communis opinio* on many issues as well. The current sections on quality adjustment leave a lot of room for interpretation, and it would profit from a more detailed exposition on the hedonic method as a method of quality adjustment. The OECD is preparing an excellent handbook on the hedonic method (Triplett, forthcoming) that can serve as a starting point for detailed recommendations in the SNA on how to measure volume growth of ICT investment and capital stock. If necessary, the relevant chapter in the revised SNA could contain a technical annex based on this manual.

4.2 Price and volume measures for services and intangible capital

85. We now turn to areas where measurement problems are very large: services and knowledge capital. In the knowledge and information economy, one may expect the role of knowledge capital and computer software to be considerable. At the same time, the share of services in total output is rising. In other words measuring economic growth and productivity depend increasingly on measuring the volume changes of services and intangible capital.

86. In contrast to sectors that produce physical output, like agriculture and manufacturing, national accountants have always had difficulties with constructing adequate price and volume measures for services. A major reason for this is that it is often unclear what actually constitutes the volume unit of measurement. Surprisingly, the SNA93 spends precious little attention to measuring price and volume indicators for services and intangible assets.

87. The importance of services is well understood both in economic literature and by statistical agencies. In 1986, several statistical agencies set up the Voorburg Group with the main goal of stimulating research in price and volume measures for services.[6] In addition, Eurostat directed several Task Forces to devise adequate measures of price and volume changes. Each Task Force focused on single product groups. The resulting Task Force Reports were summarised in the *Handbook of price and volume measures in National Accounts* (Eurostat, 2001).

[6] See http://www4.statcan.ca/english/voorburg.

88. For each industry, the Eurostat Handbook listed different price and volume measures. These are grouped along three classifications: A, B and C methods. A methods are ideal quality adjusted methods of deflation, B methods are adequate and C methods will no longer be allowed after a certain period. Eurostat ordered the statistical agencies of all member countries of the European Union to classify their National Accounts deflators, and to replace all labelled as a C-method with better ones.

89. The sad fact is that for such an important area of economic activity, adequate measures of volume growth simply lack. Many efforts have been undertaken, but many of these largely focus on conceptual issues, with only little implications for the practice of volume measurement by statistical agencies. For the next update of the SNA, the best option seems to be to include a set of recommendations regarding price and volume indicators for services and intangible assets that stand a good chance of being possible to implement in daily statistical practice. Eurostat's Handbook and the underlying Task Force Reports provide one useful source for guidelines in the area of price and volume measures for the coming update of the SNA. Together with the hedonic method, such measures could be included in a technical annex to the Price and Volume Measures chapter of the SNA93rev1.

90. Furthermore, the updated SNA should explicitly acknowledge that for a large part of output and capital inputs, we still lack satisfactory methods to measure real volume growth. In this respect, the SNA should urge for the development of methods that can actually be put into practice in statistical measurement. Here lies much scope for further cooperation between academics and national statisticians.

5 Conclusions

91. Not more than 25 years ago, we still entered data and programs into large mainframe computers via punch cards. Nowadays, personal computers, networks, e-mail and internet are a fact of life, both in our personal life and in our professional life. Moreover, innovation driven by ICT-developments and creation of knowledge, embodied as well as disembodied, are considered to be decisive elements in providing post-industrialised economies and companies their competitive edge. When discussing the contents of the SNA93, the importance of changes in the economy from these developments was recognised, and resulted in some major changes from the 1968 SNA. Especially, the extension of the asset boundary to include several kinds of intangible assets should be mentioned here. 10-15 years later, however, one can only conclude that the SNA93 is, in some respects, outdated in relation to the ICT- and knowledge-base of present-day economics. And what else could one expect, given the incredible pace of the relevant changes? It does, however, show the need for rethinking the asset boundary and related issues in the recently started process of updating the SNA93. This need has been recognised and, as a consequence, these issues are now being discussed in the Canberra II Group. Here, we would like to acknowledge the importance of the papers and discussions in this working group for the production of this paper.

92. In this paper, we have discussed a number of issues that, in our opinion, should be taken into account in the upcoming SNA update. First and foremost, we think that the asset boundary should be further extended to include knowledge capital derived from R&D. A major point of discussion in this respect is the inclusion or exclusion of freely accessible knowledge created in the public domain, predominantly by government. In our opinion, this kind of knowledge should not be included, because it does not meet one of the main criteria for the recognition of an asset, i.e. exclusive ownership. Although value may be created for the society as a whole, the knowledge does not have any value in economic life as the "owner" can not exert a certain level of market power and, as a consequence, derive future economic benefits from it.

93. One could argue that an extension of the asset boundary is needed in more areas, e.g. to include intangible assets such as brand names, trademarks and franchise formulas. And undeniably and far from incidentally, these kinds of assets may be the most valuable ones for companies. One only has to think of examples such as Coca Cola, Mercedes, Nike, McDonalds, etc. In our opinion, the updated SNA should at least acknowledge the existence of these intangible assets and its possible relationship with purchased goodwill. Clearly, acknowledging this deficiency is also relevant with respect to an exhaustive accounting of capital services. There are, however, too many problems regarding the process of creation, the itemisation and the measurement to provide clear guidelines. Furthermore, a more fundamental discussion is needed here. Perhaps, at some time in future, we may end up with the recommendation to measure them as a bundle, with a value equal to the difference between the stock market value and the intrinsic value of a corporation. Such a recording would certainly have some equivalence with the recording of purchased goodwill.

94. Knowledge embodied in persons, human capital, can be considered as one of the most important prerequisites for the innovative capability of a society or a corporation. As such, it represents a certain value and could be looked upon as an asset produced by among others investments

in education, although other non-producible features such as personal character and talent contribute to its value as well. The inclusion of human capital into the asset boundary, however, would result in a major and quite fundamental upset of the whole system of national accounts. For example, compensation of employees would have to be recorded as sales of capital services provided by the employees. In our opinion, such a fundamental change in the core system of national accounts would drive the SNA away from the present-day mainstream economic thinking, and, for this reason, it is not to be recommended. An alternative representation of human capital in a satellite accounts may, however, prove to be very powerful for certain areas of economic analysis.

95. ICT capital is already included in the present asset boundary. In our opinion, however, some clarifications are needed. In relation to (software) originals and copies, more guidance is needed on the distinction between the production of the original and the subsequent production of copies. In this respect, we are in favour of the recognition of the so-called "two-stage" approach. Furthermore, there still seems to be some confusion about the contents and definition of large databases, as part of software. In addition, we propose to emphasise the importance of ICT capital in present-day economies by changing the classification of fixed capital formation and fixed assets. In line with Schreyer (2000) we propose to include computer hardware, computer software and network equipment as primary headings in the classifications by type of assets.

96. The definition and measurement of productivity has always been a topic of prime importance in North America and Australia. More recently, it has been put much higher on the European agenda as well, mainly because of economic policy questions in relation to the financial sustainability of an ageing society and the competitiveness of the European economies as compared to the US. Furthermore, the increasing role of ICT and knowledge has given a strong momentum to more fundamental research of productivity and economic growth. For certain types of productivity analysis, the concept of capital services may be very useful. In our opinion, however, this concept should preferably not be introduced in the core system of national accounts. The main reason for our position in this respect is that capital services too much depend on modelling assumptions.

97. The increasing role of ICT and knowledge, the growing share of services in our economies and the call for more and improved data for productivity and growth analysis do make it necessary to give more guidance on the volume measurement of output (and inputs). In our opinion, the updated SNA should pay more attention to these issues. As a minimum, the inclusion of much more guidance on the general principles and preferred methodologies is to be recommended; for technical details, reference could be made to specific handbooks in this area.

98. We would like to end this paper with a strong plea for the use of Net Domestic Product as the leading production indicator. In future, the analytical usefulness of gross measures will be disturbed even more by the above mentioned extensions of the asset boundary and "double counting" issues as a consequence of the preferred "two-stage" recording of originals and copies. In our opinion, the use of net indicators should be advocated more strongly in the updated SNA. We do understand, however, that a strong plea in the SNA alone will not change the general use of gross measures as the primary indicators of economic performance. To change this, national statistical offices and international organisations will have to put much more effort in promoting net measures, e.g. by putting more emphasis on these measures in their publications.

References

Ahmad, N. (2003), Measuring investment in software, OECD (Paris).

Balk, B.M. (2003), The residual: On monitoring and benchmarking firms, industries, and economies with respect to productivity, Journal of Productivity Analysis, vol. 20, pp. 5-47

Banzhaf, H.S. (2001), "Quantifying the Qualitative: Quality-Adjusted Price Indexes in the United States, 1915-61" in J.L. Klein and M.S. Morgan (eds.), The age of economic measurement, History of Political Economy vol. 33, Duke University Press, Durham

Boskin, M.J., E.R. Dulberger, R.J. Gordon, Z. Griliches and D.W. Jorgenson (1996), Toward a more accurate measure of the cost of living, Advisory Commission to study the Consumer Price Index. Interim report to the Senate Finance Committee, December 4

Bos, F. (1990), Net versus gross national income, National Accounts Occasional Paper, NA-38, Statistics Netherlands (Voorburg/Heerlen).

Bos, F. (1996) Human capital and economic growth; a national accounting approach. Paper presented at the 24th General Conference of the International Society of Research in Income and Wealth (Lillehammer, 18-24 August).

Cartwright, D.W. (1986), "Improved Deflation of Purchases of Computers", Survey of Current Business, March, pp. 7-9.

Coelli, T., D.S. Prasada Rao and G.E Battese (1998), An introduction to efficiency and productivity analysis, Kluwer Academic Publishers.

Colecchia, A. And P. Schreyer (2001), "ICT investment and economic growth in the 1990s: Is the United States a unique case? A comparative study of nine OECD countries", OECD STI Working Paper, 2001/17, OECD (Paris).

Court, A.T. (1939), Hedonic Price Indexes with Automotive Examples, The Dynamics of Automobile Demand, The General Motors Corporation , New York, pp. 99-117

De Haan M. & D. van den Bergen (2004) ICT investment in the national accounts of the Netherlands, Paper for the OECD expert meeting on ICT investment, 27 April 2004, OECD (Paris).

De Haan M. & M. van Rooijen-Horsten (2004) Measuring R&D Output and Knowledge Capital Formation in Open Economies, paper Prepared for the 28th General Conference of the International Association for Research in Income and Wealth (Cork, August 22 – 28).

Diewert W.E., 2003, Measuring capital.. NBER Working Paper 9526, National Bureau of Economic Research, Cambridge (Mass.).

European Commission (2000) Communication from the Commission on Structural indicators, COM (2000) 594 final.

Eurostat (2001), Handbook of price and volume measures in National Accounts, Eurostat (Luxembourg).

Gordon, R.J. (2000), "Does the new economy measure up to the great inventions of the past?", Journal of Economic Perspectives, vol. 4, no. 14, pp. 49-74

Gordon, R.J. (2002), Recent productivity puzzles in the context of Zvi Griliches' research, Paper presented to meetings of the American Economic Association, January 5, 2002

Griliches, Z. (1961), "Hedonic Price Indices for Automobiles: An Econometric Analysis of Quality Change", in The Price Statistics of the Federal Government, General Series, no. 73, pp. 137-196, NBER (New York).

Lancaster, K. (1971), Consumer Demand: A New Approach, Columbia University Press (New York).

Nickell S.J., 1978, The investment decisions of firms. Cambridge UP / Nisbet (Cambridge).

OECD (1995) Manual on the measurement of human resources devoted to science and technology; "Canberra manual", OECD (Paris).

OECD (2001a), Productivity Manual, OECD (Paris).

OECD (2001b), Measuring capital, OECD (Paris).

OECD (2002) Frascati Manual 2002, OECD (Paris).

Schreyer, P. (2000) The contribution of information and communication technology to output growth: a study of the G7 countries. OECD STI Working Papers 2000/2, OECD (Paris).

Schreyer P, P.-E. Bignon and J. Dupont (2003), OECD Capital services estmates: methodology and a first set of results. OECD Statistiscs Working Paper 2003/6. OECD (Paris).

Solow, R.M. (1987), "We'd better watch out", New York Times (July 12), Book Review, 36

Statistics Netherlands (2003) Kennis en economie 2002, Statistics Netherlands (Voorburg/Heerlen).

Triplett, J.E. (forthcoming), Handbook on quality adjustment of price indexes for information and communication technology products, draft, OECD (Paris).

Van Ark, B., J. Melka, N. Mulder, M. Timmer and G. Ypma (2002), ICT investment and growth accounts for the European Union, 1980-2000, final reoprt on "ICT and growth accounting" for the DG ECFIN, European Commission (Brussels).

Van de Ven, P. (2000) Intangibles: Invaluable? Should the asset boundary in the 1993 SNA be extended?, paper presented at the 26th General conference of the International Association for Research in Income and Wealth (Krakow, 27 August – 2 September).

Van Mulligen, P.H. (2003), Quality aspects in price indices and international comparisons: Applications of the hedonic method, Statistics Netherlands (Voorburg/Heerlen).

Van Rooijen-Horsten, M. & M. de Haan (2004) Kennisindicatoren verankerd in de nationale rekeningen, Economische Statistische Berichten, no. 89/4432, pp. 204-206.

Waugh, F.V. (1928), "Quality Factors Influencing Vegetable Prices", Journal of Farm Economics, vol. 10 no. 2, pp. 185-196.

Wyckoff, A.W. (1995), "The impact of computer prices on international comparisons of labour productivity", Economics of Innovation and New Technology, vol. 3, pp 277-293.