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THE CONTEMPORARY STANDARDS OF NATIONAL ACCOUNTS – APPLICABILITY AND LIMITATIONS IN ECONOMIC GROWTH AND PRODUCTIVITY STUDIES

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ABSTRACT

The purpose of this article is to survey the contemporary standards of modern national accounts, and to assess their applicability in tracing differences in economic growth across countries. In order to perform a growth accounting study one requires good quality and mutually comparable information about the three main macroeconomic indicators: i) production output, ii) capital input and iii) labour input. Thus, the author outlines the sources and reasons behind the creation of such statistics as well as the national accounts standards they comply with. Each of the above indicators is discussed in respect of these standards, limitations in applying and availability in international databases. The study also provides insights into the current stage of development of the System of National Accounts and how different measurement standards can augment inference on economic growth.

ABSTRAKT

Celem niniejszej pracy jest analiza współczesnych standardów dla rachunków księgowych budżetów państw oraz ich ocena pod kątem przydatności w pomiarze różnic we wzroście gospodarczym pomiędzy krajami. Badania typu *growth accounting* wymagają wysokiej jakości, porównywalnych między sobą informacji o trzech głównych wskaźnikach makroekonomicznych: i) wartości produkcji, ii) nakładu kapitału rzeczowego oraz iii) nakładu pracy. Dlatego też, autor niniejszej pracy zarysowuje źródła i przyczyny stojące za powstaniem takich danych oraz przedstawia standardy, którym podlegają. Każdy z wyżej wymienionych wskaźników omawiany jest po kątem tych standardów, ograniczeń w jego zastosowaniu oraz dostępności w międzynarodowych bazach danych. Artykuł zarysowuje również obecny poziom rozwoju *System of National Accounts* oraz pokazuje, jak różne standardy pomiaru mogą wpływać na wnioskowanie o wzroście gospodarczym.

KEYWORDS

macroeconomic data, system of national accounts, measurement standards, growth accounting

1. INTRODUCTION

Evaluating countries' productive capacities becomes a crucial element in today's globalized world. Benchmarking economies allows us to evaluate their industrial potential, stage of development and rate of economic growth. Growth accounting in particular has become a preferred framework for such research [Chen *et al.* 2010]. Though it does not, by itself, explain the underlying causes of each factor's contribution to the production output it can serve as a powerful policy review tool when complemented by historical and case study analyses [Schreyer 2004]. Such a comprehensive approach brings the essence of quantitative and qualitative research together, and allows us to fully understand the reasons of growth, innovation and productivity change. In doing so, growth accounting methods bring a fair share of knowledge that comes from the source of economic growth observation – meaning the data. Since every quantitative analysis of economic growth is dependent on the data accuracy and cross-country comparability, their methodologies and proper usage become an ongoing concern. It poses a considerable research challenge in the early stages of virtually every growth accounting study.

Because crunching the numbers can be so time consuming and complex, many economists spend little time considering the pedigree of the pre-crunched data. Compiling countries' productivity statistics is not only complex but also involves as much politics as science. What is more, once such data are made available throughout a set of countries, their comparability and across-nation applicability is still questionable. This issue was raised decades ago by international organizations[1] in the post-war era. Back then, such data were crucial to form the bases of policy recommendations and guidelines to efficiently allocate scarce resources needed to rebuild Europe after two world wars [Ward 2004].

At first, due to the world's division between American and Soviet spheres of influence, the earliest versions of international systems of accounts ("western" System of National Accounts and "eastern" Material Product System) were not entirely applicable or even comparable [Ward 2004]. However much changed after the USSR collapse and for some time now, we have been witnessing a gradual convergence towards mutual comparability of main macroeconomic indicators, that is, the production output and capital and labour inputs. The purpose of this article is to survey the contemporary state of knowledge about these international standards, discuss the outstanding issues, outline databases suitable for use in growth accounting studies and show the implications of using different measurements.

Section 2 of this work outlines principles of growth accounting where macroeconomic indicators are used to trace sources of economic growth. Section 3 focu-

[1] The League of Nations, precursor to the UN and OEEC later to be renamed as OECD .

ses on standards for macroeconomic accounts and their origins. These concepts set the methodological framework for compiling the main national statistics on which we focus in section 4. Section 5 provides insights into tools and methods necessary for bringing special-temporal observations to comparability. Finally, section 6 demonstrates what implications measurement standards may have on economic growth inference and section 7 concludes with a discussion.

2. PRINCIPLES OF GROWTH ACCOUNTING

Growth accounting procedures are largely based on macroeconomic production theory and their purpose is to trace each factor's contribution to economic growth. The underlying assumption is that a change in macroeconomic output, given as:

$$Y_{ti} = f(K_{ti}, L_{ti}; B_t) \cdot EF_{ti} \tag{1}$$

where Y_{ti} is the macroeconomic production output, K_{ti} is capital input and L_{ti} denotes labour input, is the result of a change in the i) quantity of inputs and ii) the way they are used in production. The latter is broadly referred to as the change in productivity and there are two ways to consider it. First, when the production technology is progressing (or regressing) it augments parameters (B_t) of the function that describes it. This way, more (or less) product can be made given the same quantity of inputs. Second, productivity may shift as the result of change in a country's technical efficiency (EF_{ti}). This may be due to a number of factors, like i) changes in work culture over years, ii) governmental policies, or the recently discussed iii) malicious practices of worldwide financial institutions. In short, the mainstream growth accounting framework can be summarised as[2]:

$$OC_{t+1,i} = IC_{t+1,i}xTC_{t+1,i}xEC_{t+1,i} \tag{2}$$

where *IC* is input change, *TC* is technical change, *EC* is efficiency change, *i* is country index and $t+1$ denotes a change from t to $t+1$ period. Suffice to say that increase in any of the three factors results in economic growth.

There have been several methodologies suggested to implement the growth accounting framework. In recent years, stochastic frontier analysis (SFA), independently developed by Aigner, Lovell, Schmidt [1977] and Meeusen and Van den Broeck [1977], seems to have become a preferred parametric approach (see,

[2] There have been many conceptual frameworks in this field. Very few, however, stood the test of time. One alternative idea recently mentioned in the literature, and introduced by Caselli and Coleman [2006], assumes that each country has its own unique technology and the aim of growth accounting is to trace differences among these different technologies. Considering the ongoing globalisation, however, this idea has already earned some critique.

e.g., Fried, Lovell and Schmidt [2008] for a lengthy list of applications in macroeconomics). A typical SFA model is denoted as:

$$Y_{ti} = f(K_{ti}, L_{ti}; B_t) \cdot \exp(v_{ti} - u_{ti}) \tag{3}$$

where $f(\cdot)$ is the production frontier[3], B_t is a vector of technology parameters (in period t), v_{ti} reflects stochastic nature of the frontier (symmetric disturbance) and "$-u_{ti}$" is the inefficiency term of country i in period t. Inefficiency is measured as the distance between the observed output and the world production frontier[4]. Having this, we can compute country i's efficiency as:

$$EF_{ti} = \frac{\exp(y_{ti})}{\exp(f(k_{ti}, l_{ti}; B_t) + v_{ti})} = \exp(-u_{ti}) \tag{4}$$

where lower case letters (y, k, l) indicate natural logs of upper case letters (Y, K, L).

The above model can be easily re-arranged to accommodate growth accounting framework. Given any two corresponding periods t and $t + 1$, if we consider world frontiers as well as country i's inputs and inefficiencies, the expected increase in the log of its macro-output is [Koop, Osiewalski and Steel 1999]:

$$\frac{1}{2}(x_{t+1,i} + x_{ti})'(\beta_{t+1} - \beta_t) + \frac{1}{2}(\beta_{t+1} + \beta_t)'(x_{t+1,i} - x_{ti}) + (u_{ti} - u_{t+1,i}) \tag{5}$$

where the first component captures technical progress (or regress), the second reflects input change and the third accounts for shifts in efficiency over time. Thus, if we define these components as input change: $IC_{t+1,i} = \exp(\frac{1}{2}(\beta_{t+1} + \beta_t)'(x_{t+1,i} - x_{ti}))$; technical change: $TC_{t+1,i} = \exp(\frac{1}{2}(x_{t+1,t} + x_{ti})'(\beta_{t+1} - \beta_t))$ and efficiency change: $EC_{t+1,i} = \exp(u_{ti} - u_{t+1,i})$,, we can rewrite (5) as:

$$OC_{t+1,i} = IC_{t+1,i} x TC_{t+1,i} x EC_{t+1,i}$$

which is exactly the same formula as in (2) that we want to analyze.

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3 The function here is assumed to be linear with respect to natural logs of Y, K and L

4 Meaning: the potentially obtainable output given inputs under the current level of technology. Also, here I assume that there is a common frontier for all investigated countries. See Makiela [2009] for a discussion.

3. SOURCES OF MODERN NATIONAL ACCOUNTS

Quite obviously, countries' economic and financial structures vary significantly. Therefore, when compiling datasets for a growth accounting study, it is important to use data that maintain comparability. Issues on calculating either a given country's output or the level of its capital stock are still left fairly open, so when analyzing growth one should remember that research conclusions also depend on calculation methodologies used in a given dataset. The data should be collected from databases that provide international comparability instead of directly from National Statistical Offices (NSOs hereafter). Slowly but steadily over the last 50 years, economists and statisticians have been unifying the national accounts methodology. Their efforts have been much appreciated and it is no accident that the two major creators of modern national accounts have been both awarded Nobel prizes for Economics – Simon Kuznets (USA) in 1971 and Richard Stone (UK) in 1984.

The System of National Accounts (SNA hereafter) had its origin in the policy monitoring and evaluation tools used during the rebuilding of postwar Europe. The SNA can be traced back to 1947 when, at its first meeting, the United Nations Statistical Commission (UNSC), chaired by Richard Stone, expressed the need to develop international statistical standards that would enable policy monitoring. This was especially crucial for the postwar Western Europe as, in order for the Marshal Plan to succeed, scarce resources had to be properly managed and efficiently allocated.

The first SNA was introduced in 1953 and adopted mainly by western economies. Though consisting of only six main tables, it enabled the basic policy reviews of the postwar reconstruction efforts [Bos 2008]. Several revisions to the 1953 version were issued (in 1960 and 1964), but it wasn't until 1968 when the first milestone achievement in unifying national accounts was made. The 1968 SNA comprised a set of balance sheets, input-output tables and, due to interindustry sectoring, allowed policymakers and researchers to conduct more extensive macroeconomic analyses. Moreover, efforts have been made for 1968 SNA to be compatible with the Material Product System (MPS), a methodology which had been concurrently developed by the USSR and its satellite economies[5].

The new standard, however, was not adopted as widely as its creators had anticipated. The Western economies did not have the slightest problem converting to it, as it directly responded to their policy and planning evaluation needs. Because the 1968 SNA was tailor-made for the West, NSOs and analysts encountered difficulties adopting it for non-Western economies. Furthermore, advancing complexity of financial and economic systems as well as technological progress quickly made it clear that SNA needs further development.

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[5] Countries like Cuba and North Korea still produce accounts in line with MPS methodology

The spread of intangible instruments such as intellectual property, electronic transfers and financial services were the main reasons of the 1993 revision. 1993 SNA was released jointly under the auspices of the United Nation (UN), the Organization for Economic Co-operation and Development (OECD), the European Commission (EC), International Monetary Fund (IMF) and the World Bank (WB). It was the most comprehensive issue of SNA compiled to date, revising the national accounts framework and bringing them up-to-date. Based on internationally agreed classifications, concepts and definitions, macroeconomic data could be gathered and presented in a format that is suitable for international comparative analysis. The 2008 revision of the System of National Accounts addressed issues left open in previous updates and provided advances in methodologies like the concept of *capital services* and *labour services*.

As far as international standards are concerned there is one more that should be mentioned. In 1995 the European Commission introduced the European System of National Accounts (ESA95) which was consistent with 1993 and 2008 SNA releases but provided strict guidelines to some issues that were deliberately left open in SNA. These, however, were necessary because national accounts in the EU are used by the European Commission to distribute development funds, calculate Members' contributions to the EU budget and, more recently, to monitor the sustainability of Members' public finances. Since ESA95 is part of the European Union legislation system, the international comparability of national accounts is a legal requirement for all Member States and for EU candidates. The SNA standard is designed to be flexible in order to be applicable for countries with different economic systems and at various stages of economic development. ESA95 is therefore more effective than SNA in ensuring international comparability. However, unlike SNA, not every country can adhere to its standards. Currently ESA is undergoing a five year revision plan, which is scheduled to conclude in 2012 [Gueye 2007].

4. MAIN PRODUCTIVITY INDICATORS IN SNA

Gross Domestic Product

The most frequently used macroeconomic production output indicator in the System of National Accounts is Gross Domestic Product (GDP). This single figure combines the production of all the companies, government bodies and non-profit institutions in a given country during a certain period. GDP is usually calculated annually, but in some countries also quarterly or even monthly. When aggregated from the microeconomic to the macroeconomic level, it follows three essential rules of SNA [OECD 2003]: i) avoid double counting, ii) relate to aggregates that are economically significant (i.e., which value is independent of non-economic factors) and iii) create indicators that are measurable in practice.

Apart from GDP, SNA defines one more output indicator – the Net Domestic Product, called NDP in short. It is used to assess the genuine level of newly created wealth during a given production period. Thus, subtraction from GDP must be made to account for the costs of using up capital assets. In 2008 SNA and ESA95 this is done through a figure called "consumption of fixed capital". When this consumption is deducted, the result is Net Value Added, and the NDP is equal to all net values added summed across industries: NDP = Σ Net Values Added. Although less widely used than GDP, NDP in theory is a better measure of the wealth produced as it deducts the costs of machinery wear-off and other capital assets used-up in the production process. However, economists tend to prefer GDP for two reasons. First, methods and techniques for calculating consumption of fixed capital are rather complex and tend to differ between countries, making NDP comparability uncertain. Second of all, when ranking countries or analyzing their growth, the differences between GDP and NDP are small and do not change the conclusions.

When considering GDP (or NDP) as a production output, we should bear in minds that it does not account for i) home produced durables, ii) volunteer work, iii) wealth earned before, and most notably iv) makes no account of the "grey area" which may vary significantly across countries as well as in time. So, in principle GDP (or NDP) should be regarded more as a proxy rather than a good measure of countries' production output (or welfare). It reflects output with no regard to its inputs that are used or even depleted in production. In some countries people may be working longer hours to maintain a comparable life standard, while in others they may be running down country's natural resources for the same purpose. Furthermore, the fact that GDP does not reflect various kinds of economic activity, such as home production, may make a difference when GDPs of two nations are compared. If the first one is caring for its young and elder "for free" at home, while the other does it through market-based services, the latter will register higher GDP level. This does not mean, however, that the latter is actually better off [Gylfason 1999].

GDP can be calculated using *income*, *expenditure* or *output* approach (see, e.g., Chamberlin and Yeuh [2006]), but all the methods arrive at the same value only in theory. In practice the resulting estimates differ, since they are subjects to errors and omissions during aggregation process. The most significant discrepancy is between GDP acquired through *output* approach also known as *value added* approach. GDP should be obtained when intermediate consumption for total economy is deducted from its Gross Output. In practice, however, the Gross Value Added (GVA) calculated in this way does not equal Gross Domestic Product. To arrive at GDP level one needs to add the income from taxed goods and services, and deduct subsidies for them. From the output perspective, however, GDP is supposed to be a proxy for the total production output in a given economy. Hence, some countries, like the United States of America, define GDP from *output* approach as GVA leaving discrepancies between the three methods behind. Also, differences between GVA and GDP are small and the most important thing is to use the same indicator for the whole dataset.

Being the most recognized macroeconomic output indicator, GDP is published by all significant international statistical institutions. United Nations Statistics Division and the World Bank provide the most comprehensive datasets of Gross Domestic Product. The statistics are gathered either directly from NSOs or, more often, through other international organizations such as OECD or Eurostat. Although they contain most numerous GDP dataset, variety of sources may make international comparability questionable.

IMF and OECD also provide estimates for GDP in IMF's *World Economic Outlook* and OECD's *Economic Outlook* databases. The two databases are called similarly not by a coincidence. By using the same data sources they usually provide the same estimates. However, when choosing between the two databases one should know that IMF's online database sometimes publishes rounded estimates directly from OECD's datasets[6].

Capital input

Measuring capital input at the national level and assuring its international comparability is an ongoing problem for several reasons [OECD 2001]. Firstly, not all NSOs regularly publish data on physical capital stocks, which are the indicators needed to assess the level of capital input in an economy. Even if such data are made available their international comparability is vague. Secondly, there are several types of capital stock measures and each has its analytical applicability [Schreyer and Webb 2006]. Thirdly, we cannot measure capital stock directly. Most estimates mentioned by SNA are estimated by NSOs using available data according to local methodologies, although there is an increasing convergence towards international standards. This is mainly due to OECD's active involvement in recent years. The organization has issued numerous papers and handbooks on how to produce unified capital stock estimates.

Another reason for problems with obtaining capital stock estimates may be due to large data requirements. A given NSO needs to have at least data on i) all assets (by type), ii) investment volumes (by type of asset), iii) price deflators (by type of asset), iv) industry by asset-type investment matrices and v) a benchmark level of capital stock for no less than one year [OECD 2001]. Moreover, some types of capital measures, like *capital services*, require additional information like average service life (by asset) and depreciation rate of each asset type.

The first attempt to produce unified capital stock estimates for international comparisons was made at the *Center for International Comparisons* at the Univer-

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[6] Purchasing Power Parity estimates would be one such an example

sity of Pennsylvania (CICUP). Alan Heston, Robert Summers and Bettina Aten, developed a database called *Penn World Tables*. Version 5.6 contains *Physical Capital Stock per worker* estimates. Unfortunately they are based on an older version of SNA from 1968. The 1993 issue of SNA, however, dealt with several new concepts like i) how to allocate software and other intangible assets to investment (see Ahmad [2003] or Lequiller, Ahmad, Varjonen, Cave and Ahn [2003] for details), or ii) how to use quality-adjusted prices to deflate investment in information and communication technologies (ICT) assets. The new way of constructing national accounts changed significantly the way we now measure capital and proved the former capital estimates to be inconsistent [Schreyer 2007]. So far, the *Center for International Comparisons* has not published an update of their capital stock estimates.

OECD on the other hand, has been very active over the past years in developing new standards and ensuring capital stock comparability across its members. According to OECD, there are two main concepts of capital stock [Schreyer 2003]. The first type of capital stock is defined as a services provider in production. Hence, productivity of each asset is taken into consideration and the concept of *capital services* is introduced (see, e.g., OECD [2003], SNA [2008] or Timmer, O'Mahony and van Ark [2007] for details regarding methodology). In this case, not only the quantity of capital goods involved but also their physical characteristics play a role in assessing the total *capital services* level. Statisticians estimate it by weighting different types of stocks by their relative productivity. Unfortunately *capital services* hadn't been recognized by SNA until its 2008 edition, and thus only a few countries regularly publish data on their *productive stocks*. For now there are only three international databases that provide estimates on *capital services* at an international level. That is OECD's *Productivity database*, EU *KLEMS* project and *The Conference Board Total Economy Database* (only growth rates).

The second concept of capital stock measurement traces its role as an indicator of wealth. The *net* stock, also known as the *wealth* stock, represents the market value of all (fixed) capital goods. It is usually acquired from the *gross* capital stock by accounting for the decline in assets' value before they retire. The purpose here is to track capital's role as a sum of assets with their market values [OECD 2003]. This indicator, however, should be treated with caution in growth accounting or productivity studies, as the actual asset market value may not always reflect its productive potential. Thus, while *net* capital stock is more informative in terms of price value of the capital stock (wealth), *gross* capital stock or, if available, *productive stocks* are preferred measures of the capital's productive potential [OECD 2003].

Both concepts have their disadvantages. On the one hand, it is logical to assume that different types of fixed assets will have different productivity capabilities. Countries with the same capital stock (capital wealth) may produce different output volumes only based on differences in their capital structure. On the other hand, though *capital services* in theory provide much more exact productivity estimates of a given country's capital stock, they are always delivered in the form of a percentage change to the base year (e.g., 1995=100% in EU *KLEMS* database) and they cannot be used straightforward in a cross-country productivity analysis. One way to solve this issue would be first to define a given country's *capital services* for the benchmark year at the *gross* (or *net*) capital stock level. That way we take into consideration initial differences in capital input volumes between analysed countries. Then, *capital services* for remaining years can be easily calculated by adding the percentage change for the year of interest to the benchmark year estimate. Although intuitively this is the right course of action to acquire *capital services* at market prices that allow for a cross-sectional comparison, I have not encountered any study or growth accounting handbook that would provide justification to it.

Currently, there are six working repositories of internationally comparable capital stock estimates: four at OECD, one at EU KLEMS database (*capital input* files) and one at the Conference Board (*Total Economy Database*). OECD's *Economic Outlook* and *Productivity Database* contain annual aggregates, the latter measuring them in *productive stocks* (*capital services*). OECD's *Structural Analysis* (STAN) and *Annual National Accounts* (ANA) on the other hand provide asset breakdown by industry. Eurostat's *National Accounts Team* is also planning to launch a web-based searchable database for its resources on capital stock. The launch date, however, is yet unknown.

Labour input

Usually, labour input in a given country is measured by the *average number of people employed* in a given year. According to many, however, this is not a good way of measuring economy's labour input, since it i) does not account for differences in work patterns across countries and ii) does not reflect the quality of labour (i.e., the level of human capital; see Gylfason [1999]).

In some countries the average number of hours worked per week by an employee may significantly differ from others, for example, as a result of discrepancies in the number of free days (holidays etc.). Moreover, the *average number of people employed* takes under consideration only those employed in enterprises and therefore leaving behind i) *self-employed workers* and ii) *family workers* [OECD 2009]. In order to account for such discrepancies in work patterns among countries and consider non-employed people who, nonetheless, are engaged in some productive activities, more detailed labour indicators are provided in 2008 SNA. By joint estimation of hours worked by employees and the two work groups mentioned above, NSOs can calculate the *total number of hours worked by persons engaged* in productive activities in the economy. This, however, is a complex figure and at least for now not many NSOs have the potential to produce it regularly.

The only datasets providing such indicators suitable for international comparisons are the ones available at the EU and OECD's databases.

Furthermore, contemporary standards also provide an internationally agreed on framework for considering the level of labour quality broadly referred to as human capital. By distinguishing between different types of labour in terms of gender, age and education attainment, NSOs can calculate a standardized measure of *labour services* (see SNA [2008], Van Ark, O'Mahony and Ypma [2007] or Timmer, O'Mahony and van Ark [2007] for details on methodology). Like *capital services* to *gross/net* capital stock, in theory *labour services* is a better estimate than the *total hours worked by persons engaged* because it grasps differences in labour quality, not only its quantity. Unfortunately also alike *capital services*, this figure is usually given as a percentage change to the base year, and due to its recent introduction into SNA only a handful of countries make such statistics available.

There are many repositories of labour statistics nowadays. Widely recommended and acknowledged statistics are available at OECD (*Employment database,* and for *labour services* OECD's *Productivity database*), European Commission (Eurostat's database, and for *labour services* EU *KLEMS* project) and the Conference Board (*Total Economy Database*).

5. BRINGING NATIONAL ACCOUNTS TO COMPARISON

When analyzing differences in economic growth across countries we should remember that apart from internal economic phenomenon like inflation, the data need to account for differences in currency values across countries and differences in their purchasing powers. Today, economists distinguish between the international market value of a given currency and its purchasing power. The first one, foreign exchange rate (*forex* rate), specifies how much one currency is worth in terms of the other. Price levels on the domestic markets are not taken into account and the exchange value is solely dependent on the currency attractiveness, which can be subjected to high volatility or speculation.

Shortcomings of this method have led to the creation of indices that base on the concept of "the law of one price", first introduced by Gustav Cassel (1921). According to Cassel exchange rate between two countries needs to be adjusted by their currencies' purchasing powers on their domestic markets so that a purchase in one currency would be equivalent to the other. Thus, Purchasing Power Parity (PPP) indices are a crucial element of data preparation for growth accounting studies as they bring the unifying element. The most acknowledged PPP indices convert countries currencies to a so-called "international dollar". They are compiled jointly by Eurostat and OECD and can be viewed in many databases, IMF and UNstats including. The methodology is based on "the basket of goods" concept, which is a complex and time-consuming study [Eurostat-OECD 2006].

Using PPP in a cross-section analysis is rather straightforward. However, when dealing with spatial and temporal observations we have two options to consider. One way is to use the *current international prices* base and apply benchmark PPPs from every year allowing the price structure to vary over time. Within the same year volumes are measured by the same price structure and are directly comparable. Comparison over time, however, carries effects of i) a relative change in volume and ii) changes in relative prices between countries [Schreyer and Koechlin 2002]. Moreover, benchmark PPP indices take time to compile and are usually made available after few years pass.

Another way is to set a base year and then extrapolate PPPs for the required period. This is done by applying countries' relative inflation rates to the chosen base year. Volumes measured in this way are at *constant international prices*. The underlying assumption of such measurement practise is that price structure is constant within the analyzed period. However, over time the relative price structure does change. By ignoring this, we may acquire a biased picture of economic development.

Which of the two methods should be used is dependent on the time scope of a particular analysis. The former one is advised for studies involving long periods of time (usually a decade or more; see, e.g., Schreyer and Koechlin [2002] for a disscusion) while the latter for short.

6. MEASUREMENT STANDARDS AND THEIR IMPLICATIONS FOR GROWTH ACCOUNTING

In order to show what impact different measurement standards have on inference about economic growth let us consider two data sets: *A* and *B*. Both datasets contain information about sixteen countries over the period of eleven years (1995–2005). Both have the same output measure (Gross Value Added) and capital input measure (real fixed capital stock). The difference is only in the way labour input is defined. The first growth accounting estimation is conducted using dataset *A* which contains labour input defined as *total hours worked by persons engaged* (in millions in a given year). As mentioned in the previous section, using this indicator allows us to account for differences in countries' work structure, and to consider all people engaged in a productive activity (like self employed or family workers). Next, we take dataset *B* which uses *total number of employees* (in thousands in a given year), a more common but less precise labour input indicator. Then we run the growth accounting procedure again. All data come from the same database, EU KLEMS project, and can be accessed via its website. Purchasing Power Parities were obtained from OECD-Eurostat statistics and applied as described in section 5. Growth accounting is employed using the decomposition methodology first introduced by Koop, Osiewalski and Steel [1999], briefly outlined in section 2. The estimation procedure is based on Bayesian approach to SFA (*Bayesian Frontier*), and follows Koop, Osiewalski and Steel [1999, 2000a, 2000b]. Since the full posterior distribution is too complex to derive marginal distributions analytically we solve the problem numerically using Gibbs sampler. The results are based on first 500 000 burnt draws and 120 000 retained to compute the characteristics of the posterior marginal distributions. Throughout the study we use posterior means as point estimates and posterior standard deviation as dispersion measures. The list of countries used for this comparison is similar to Makiela [2009], which provides a more in-depth analysis of their growth characteristics (based on dataset *A*). The purpose of this exercise, however, is merely to demonstrate what implications may the above mentioned measurement standards have on inference.

Tables from 1 to 3 and Figures 1 & 2 summarise the main results of such comparative analysis. Using different labour input indicators has a profound implication on economic growth inference. Economic regularity conditions imposed on the translog function based on dataset *A* have been significantly violated when dataset *B* was used (see Table 1 and Figure 1, 2). Though *Returns to Scale* (RTS) estimates in the two datasets are fairly close to each other[7], estimated elasticities of capital and labour (grand averages) have shifted from a near 1:1 ratio to over 1:7 in favour of labour (in dataset *B*). This change is especially noticeable in Figure 1. All countries in dataset *B* are shifted relatively more to the right-bottom corner on the isoquant map, indicating generally much higher elasticities of labour than capital. Countries most influenced by such change are Denmark, Austria, Germany and Netherlands.

Furthermore, as reported in Table 2 structural decomposition using dataset *A* (which bases on a more detailed indicator of labour) shows an average decline of technical efficiency. Estimates based on dataset *B*, on the other hand, show efficiency growth over time[8]. Considering this as well as other discrepancies in decomposition results between the estimates from both samples, we can conclude that their posterior means are significantly away from each other.

As far as technical efficiency scores are concerned, Spearman's rank correlation coefficient between the two datasets is 0.7118. Sweden has lost its supremacy as the efficiency leader (Table 3). When dataset *B* is used in the analysis, Sweden's score falls below Italy's and is just slightly over Finland's, which jumped from 10th to 3rd third place. What is more, Germany has dropped 8 places, from 6th according to dataset *A* to 14th place in dataset *B*. Considering the underlying definitions of the two labour input indicators, such shifts may inform us of diffe-

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[7] Most importantly *RTS* order in the two datasets has largely remained the same. Spearman's rank correlation is 0.965, with USA and Japan as countries with the highest posterior means of average *Returns to Scale* in the analysed period.

[8] This being said, I should point out that inference about efficiency change based on both datasets is very uncertain (high posterior standard deviations in respect to posterior means).

rences in work patterns among the countries. Work culture in countries such as Germany or Sweden may be less labour intensive, meaning that though many people are employed, they work relatively few hours per day in comparison to countries such as Italy or Finland.

7. CONCLUDING REMARKS

As indicated in section 6, empirical analysis of economic growth is conditioned upon the underlying data and their methodologies. Issues regarding data comparability over time, across countries, and even between different databases are an ongoing concern for statisticians and policymakers all over the world. Given the presented material, it is safe to say that today we have the means of producing unified, standardised macro-accounts, which present nations' economies in detail and are suitable for international comparisons. Unfortunately, as usual the practice is far from the theory. Developing countries often do not have the means and resources to adopt these standards, unless forced and subsidised by international institutions. Even some members of OECD or EU, organizations so active in bringing standardisation to national accounts, neglect their responsibilities in supplying the necessary statistics. For example Poland, since its accession to the EU, has not delivered a full dataset of fixed capital stock estimates to Eurostat[9]. The country, however, is not the only one and the previously mentioned international databases are missing data for many countries, which should be providing those statistics. Thus, in practice it is often impossible to obtain data for a predefined set of countries.

Currently we are not so much falling behind with setting the new accounting rules as much as with actually applying them in practice. As the world changes fast, new technologies constantly augment the way we think and make our livings. It is logical to assume that, due to the current pace of change, it will always be difficult to develop and apply standards that address our contemporary needs and account for all that is "new" in the economy. But today, even though we have increased the pace of SNA revision, we are still often missing the actual tools (meaning data) for international research and policymaking that this standard was supposed to deliver. Moreover, due to recent increase in SNA's complexity this problem is bound to become worse.

It seems that international organizations such as UN, OECD or EU should re-think their policy priorities regarding national accounts. More stress should be put on the "production" and "delivery" issues rather than SNA's "design" itself. This is because even the best and most up-to-date standard will fail, if its appli-

[9] 29.07.2010 I obtained a spreadsheet from Eurostat. It contains all the data on (fixed) *gross/net* capital stock that EU members had provided Eurostat up to that date (contact person: Paul Allison). It does not contain data on capital stock for Poland after 2004.

cation across countries is neglected. Unfortunately, so far the pace with which modern national accounts are being implemented worldwide is falling sharply behind the rising quality of their standards, and there seems to be no particular interest in changing the situation.

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APPENDIX I. TABLES AND FIGURES

Table 1

Comparison of capital and labour elasticities estimates based on datasets *A* and *B*, 1995–2005 averages

Countries	Results based on dataset *A*			Results based on dataset *B*		
	el_K *D(el_K)*	el_L *D(el_L)*	RTS *D(RTS)*	el_K *D(el_K)*	el_L *D(el_L)*	RTS *D(RTS)*
Australia	0.3862 *0.0495*	0.5963 *0.0482*	0.9825 *0.0133*	0.0634 *0.1223*	0.8773 *0.1329*	0.9407 *0.0496*
Austria	0.2984 *0.0658*	0.6476 *0.0766*	0.9460 *0.0310*	-0.0129 *0.1557*	0.9185 *0.1849*	0.9056 *0.0669*
Czech Republic	0.5456 *0.0581*	0.4262 *0.0598*	0.9718 *0.0175*	0.1724 *0.1028*	0.7508 *0.1249*	0.9233 *0.0481*
Denmark	0.0238 *0.1415*	0.8927 *0.1653*	0.9166 *0.0606*	-0.1888 *0.2089*	1.0777 *0.2441*	0.8889 *0.0864*
Finland	0.4108 *0.0671*	0.5207 *0.0800*	0.9315 *0.0312*	0.1133 *0.1375*	0.7797 *0.1719*	0.8931 *0.0614*
Germany	0.2133 *0.1072*	0.8070 *0.0974*	1.0203 *0.0201*	-0.0021 *0.1483*	0.9946 *0.1360*	0.9925 *0.0430*
Italy	0.4200 *0.0734*	0.5990 *0.0777*	1.0190 *0.0094*	0.0249 *0.1296*	0.9429 *0.1252*	0.9679 *0.0445*
Japan	0.3465 *0.1212*	0.7059 *0.1253*	1.0524 *0.0182*	0.0094 *0.1521*	0.9995 *0.1367*	1.0089 *0.0396*
Korea	0.6468 *0.1113*	0.3894 *0.1311*	1.0362 *0.0283*	0.0715 *0.1166*	0.8902 *0.1151*	0.9617 *0.0429*
Netherlands	0.2513 *0.0714*	0.7116 *0.0732*	0.9629 *0.0284*	-0.0292 *0.1336*	0.9051 *0.1473*	0.9343 *0.0543*
Poland	0.5506 *0.0698*	0.4556 *0.0773*	1.0062 *0.0136*	0.1441 *0.0973*	0.8093 *0.1026*	0.9533 *0.0396*
Portugal	0.7446 *0.1040*	0.2325 *0.1053*	0.9770 *0.0284*	0.3808 *0.0725*	0.5491 *0.0874*	0.9299 *0.0350*
Slovenia	0.7832 *0.1406*	0.1330 *0.1411*	0.9162 *0.0435*	0.4360 *0.1335*	0.4352 *0.1622*	0.8712 *0.0573*
Sweden	0.5197 *0.0569*	0.4373 *0.0598*	0.9570 *0.0211*	0.2812 *0.0822*	0.6449 *0.1013*	0.9261 *0.0393*
United Kingdom	0.5080 *0.0846*	0.5186 *0.0961*	1.0266 *0.0151*	0.2173 *0.0838*	0.7717 *0.0763*	0.9890 *0.0233*
United States	0.3506 *0.1515*	0.7317 *0.1640*	1.0823 *0.0300*	0.0650 *0.1612*	0.9803 *0.1474*	1.0452 *0.0323*
Average	**0.4375** ***0.0921***	**0.5503** ***0.0986***	**0.9878** ***0.0256***	**0.1128** ***0.1274***	**0.8329** ***0.1373***	**0.9457** ***0.0477***

Note. "el_" labels denote posterior means of countries' average elasticities in the analysed period (1995–2005); RTS stands for Returns to Scale; *D(•)* are the corresponding posterior standard deviations where *K* stands for capital and *L* for labour, written in italic; source: author's calculations

Table 2

Comparison of growth decomposition results based on datasets *A* and *B*, 1995–2005 average growth rates

	Empirical GVA growth rate	Results based on dataset *A*					Results based on dataset *B*				
		Average technical growth	Average efficiency growth	Average input growth	Average productivity growth	Average output growth	Average technical growth	Average efficiency growth	Average input growth	Average productivity growth	Average output growth
Australia	5.7204	2.5009 *0.3261*	-0.0028 *0.4202*	3.3080 *0.1759*	2.4968 *0.2104*	5.8871 *0.1219*	1.3932 *0.2641*	0.2676 *0.2809*	4.1537 *0.0802*	1.6638 *0.1144*	5.8865 *0.0871*
Austria	3.9720	3.0096 *0.6035*	-0.7458 *0.6170*	1.7748 *0.0947*	2.2377 *0.1501*	4.0521 *0.1198*	2.1074 *0.3312*	0.2346 *0.3051*	1.6585 *0.0890*	2.3460 *0.1203*	4.0433 *0.0832*
Czech Republic	4.3918	1.9212 *0.2544*	0.6584 *0.2442*	1.8506 *0.1998*	2.5918 *0.2337*	4.4900 *0.1208*	1.9665 *0.2337*	1.4177 *0.2337*	1.0423 *0.0863*	3.4116 *0.1226*	4.4894 *0.0856*
Denmark	3.9079	6.0013 *3.0638*	-2.6315 *2.8729*	0.8366 *0.0981*	3.1239 *0.1556*	3.9865 *0.1211*	1.8159 *1.0832*	1.0401 *1.0222*	1.0908 *0.1782*	2.8641 *0.1996*	3.9857 *0.0854*
Finland	5.0423	2.2120 *0.4849*	0.6022 *0.5044*	2.2816 *0.1314*	2.8253 *0.1774*	5.1712 *0.1202*	2.7594 *0.2706*	-0.2481 *0.2811*	2.6099 *0.0687*	2.5037 *0.1071*	5.1790 *0.0846*
Germany	3.1007	3.7708 *0.8565*	-1.3109 *0.9590*	0.7323 *0.4264*	2.4031 *0.4497*	3.1512 *0.1159*	0.1404 *0.3931*	-0.2443 *0.4258*	3.2589 *0.2502*	-0.1056 *0.2553*	3.1492 *0.0843*
Italy	2.9829	2.2477 *0.2648*	-1.0578 *0.3027*	1.8557 *0.1460*	1.1655 *0.1766*	3.0426 *0.1138*	0.7334 *0.3023*	-0.2903 *0.3029*	2.5789 *0.0710*	0.4401 *0.1054*	3.0303 *0.0814*
Japan	3.1907	2.7018 *0.4141*	-0.3922 *0.5568*	0.9268 *0.6867*	2.2990 *0.7041*	3.2424 *0.1206*	0.0975 *0.4175*	-0.6793 *0.4320*	4.0520 *0.3456*	-0.7774 *0.3394*	3.2420 *0.0848*
Korea	5.6243	1.8677 *0.9452*	-0.6458 *1.1707*	4.5337 *0.4837*	1.1997 *0.4818*	5.7855 *0.1232*	0.9379 *0.2721*	0.2551 *0.3014*	4.5368 *0.1552*	1.1947 *0.1719*	5.7855 *0.0866*
Netherlands	5.1154	3.4260 *0.7159*	-0.1894 *0.8000*	1.9581 *0.1556*	3.2245 *0.1932*	5.2456 *0.1156*	1.4671 *0.2653*	0.5493 *0.2793*	3.1610 *0.0712*	2.0238 *0.1095*	5.2487 *0.0864*
Poland	5.8949	1.8974 *0.3612*	3.3341 *0.3763*	0.7391 *0.1321*	5.2936 *0.1850*	6.0717 *0.1234*	1.2623 *0.2746*	3.9951 *0.2974*	0.7263 *0.0655*	5.3071 *0.1102*	6.0719 *0.0866*
Portugal	4.5645	2.0038 *0.9225*	-3.0411 *0.9565*	5.8451 *0.4989*	-1.1059 *0.4794*	4.6723 *0.1221*	1.5845 *0.4549*	-1.6977 *0.4007*	4.8195 *0.2561*	-0.1416 *0.2570*	4.6705 *0.0853*
Slovenia	6.1409	1.7946 *1.1235*	-1.0311 *1.3375*	5.5677 *0.8552*	0.7331 *0.8311*	6.3346 *0.1210*	2.9740 *0.8530*	1.2246 *1.0075*	2.0202 *0.4294*	4.2273 *0.4481*	6.3310 *0.0866*
Sweden	4.2960	1.9206 *0.2386*	-0.0853 *0.1491*	2.5295 *0.2040*	1.8335 *0.2231*	4.4090 *0.1009*	1.8664 *0.2702*	-0.1323 *0.2307*	2.6221 *0.1167*	1.7310 *0.1410*	4.3984 *0.0825*
United Kingdom	5.0926	1.9800 *0.3250*	0.4242 *0.4027*	2.7456 *0.2447*	2.4116 *0.2688*	5.2228 *0.1120*	0.6625 *0.4394*	0.6410 *0.4449*	3.8674 *0.1401*	1.3059 *0.1596*	5.2236 *0.0849*
United States	5.2450	2.4414 *0.7813*	0.0682 *0.4211*	2.8077 *0.6686*	2.5096 *0.6745*	5.3833 *0.1131*	0.3216 *0.5393*	-0.1000 *0.4516*	5.8363 *0.4203*	-0.4230 *0.4034*	5.3870 *0.0849*
Average	**4.6427**	**2.6061** ***0.7301***	**-0.3779** ***0.7557***	**2.5183** ***0.3251***	**2.2027** ***0.3497***	**4.7592** ***0.1178***	**1.3806** ***0.4165***	**0.3896** ***0.4186***	**3.0021** ***0.1765***	**1.7232** ***0.1978***	**4.7576** ***0.0850***

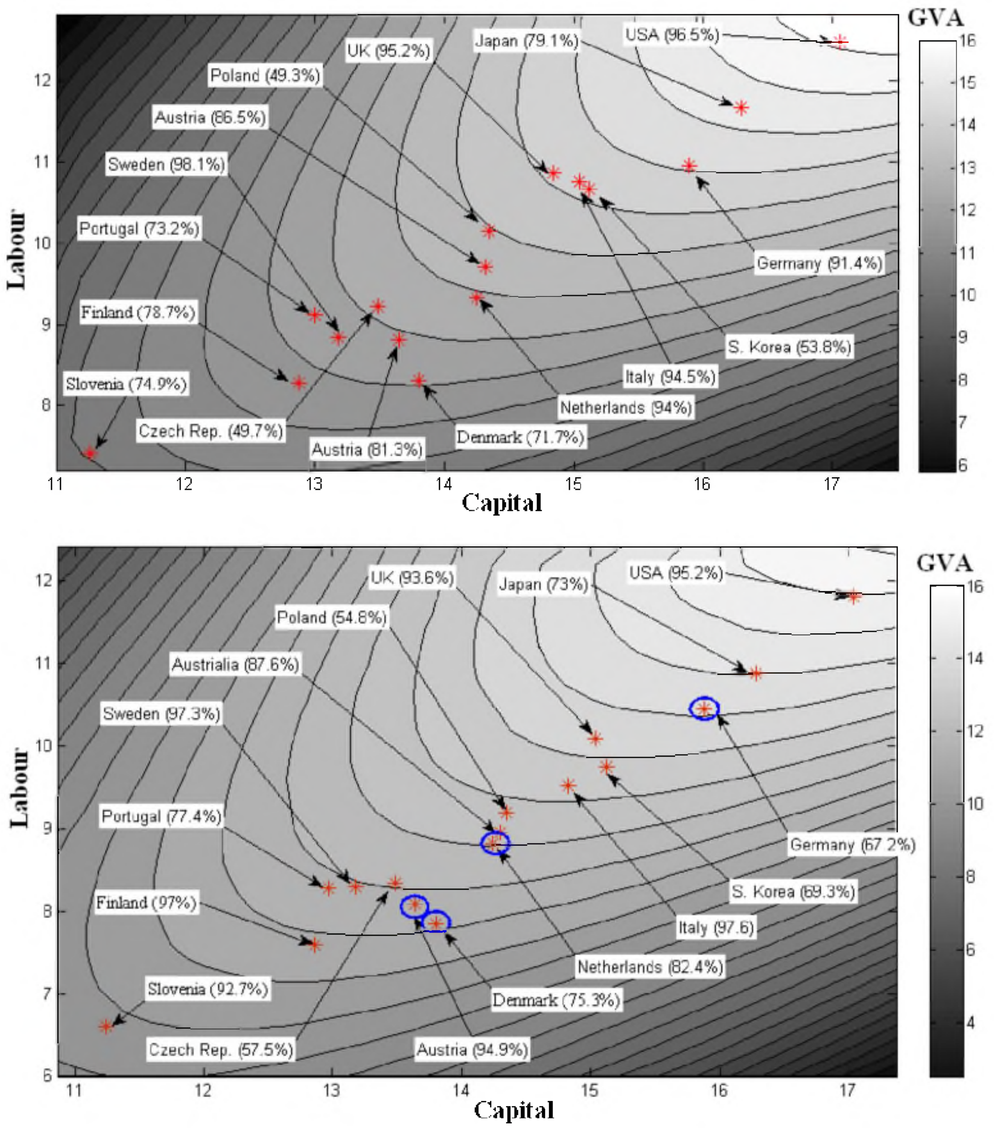
Note. Point estimates are posterior means of countries' average growth rates; posterior standard deviations are in italic; source: author's calculations.

Table 3

Estimation results for average technical efficiencies, datasets *A* and *B*

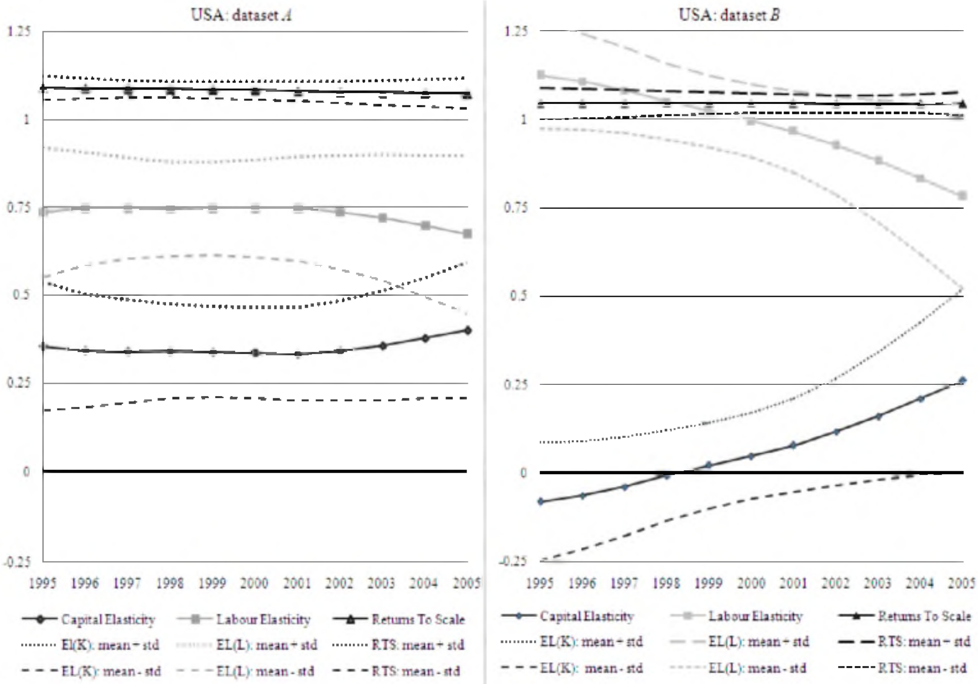
Countries	dataset *A*			dataset *B*		
	rank	AEF	*D(AEF)*	rank	AEF	*D(AEF)*
Sweden	1	0.9817	*0.0088*	2	0.9733	*0.0107*
United States	2	0.9657	*0.0245*	4	0.9524	*0.0260*
United Kingdom	3	0.9527	*0.0195*	6	0.9361	*0.0207*
Italy	4	0.9453	*0.0152*	1	0.9760	*0.0110*
Netherlands	5	0.9408	*0.0275*	9	0.8240	*0.0106*
Germany	6	0.9140	*0.0425*	14	0.6723	*0.0117*
Australia	7	0.8652	*0.0167*	8	0.8765	*0.0112*
Austria	8	0.8135	*0.0217*	5	0.9491	*0.0142*
Japan	9	0.7909	*0.0201*	12	0.7304	*0.0144*
Finland	10	0.7875	*0.0283*	3	0.9705	*0.0152*
Slovenia	11	0.7490	*0.0559*	7	0.9275	*0.0431*
Portugal	12	0.7323	*0.0317*	10	0.7738	*0.0145*
Denmark	13	0.7172	*0.0648*	11	0.7573	*0.0290*
Korea	14	0.5379	*0.0258*	13	0.6930	*0.0093*
Czech Rep	15	0.4967	*0.0073*	15	0.5752	*0.0064*
Poland	16	0.4936	*0.0099*	16	0.5480	*0.0073*
Average	–	**0.7927**	***0.0263***	–	**0.8210**	***0.0160***

Note. AEF's are posterior means of countries' average efficiency scores in the analysed period; *D(•)*'s denote posterior standard deviations, written in italic; source: author's calculations.



Note. Axes are in natural logs. Countries with negative elasticities are circled; percentages in brackets are based on estimated posterior average efficiencies in the analysed period; countries are placed on the maps according to their productive frontier and average inputs in 1995–2005; source: author's calculations

Figure 1. Isoquant maps for datasets *A* and *B*, 1995–2005 averages



Note. Economic regularity conditions not met (at means) in dataset *B* between 1995 and 1998; source: author's calculations

Figure 2. Example of violated economic regularity conditions, USA, 1995–1998