

## PUBLIC INTANGIBLES: THE PUBLIC SECTOR AND ECONOMIC GROWTH IN THE SNA

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This paper sets out a framework for analyzing the impact of public investments on industry-level productivity and economic growth. The concept of capital in the public sector is broadened from that which is mostly tangible (e.g. physical infrastructure) to that which also includes intangibles and long-lasting societal assets. For the analysis of public investments, we find that in addition to expanding the asset boundary, national accounts also need to: (a) impute a net return to government and other non-market capital—or provide industry-level data by institutional sector of origin, allowing researchers to do so; (b) include all public payments to industry in industry-level gross operating surplus (i.e. all subsidies, production, and product, and the annuity value of investment grants); and (c) provide cross-walks for key components of government expenditure by function of government (e.g. public funds for extramural R&D or worker training) to kind-of-activity classifications used for industries.

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### 1. INTRODUCTION

The analysis of an economy's performance requires information on public investments and their impact on private-sector outcomes. This paper explores the theoretical and empirical underpinnings of public investments and public policies toward those investments by expanding previous work on intangible capital by Corrado *et al.* (2005, 2009, hereafter CHS) to include the public sector. The CHS framework was developed to analyze the contribution of intangible capital to economic growth in the business sector of an economy, and considerations arise in a public context that require extension and modification.

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In this paper, we review and analyze key issues with regard to the boundaries of public intangibles and offer a framework for the analysis of intangibles and public-sector activity consistently across countries. Our ultimate goal is to construct satellite national accounts that capture public investments in intangibles at the level and detail needed for modeling the creation and use of knowledge-based capital in a society. This makes possible the generation of new empirics on the evolution of productivity and living standards, as well as the design of policies supporting economic growth through knowledge investments.

To understand what we think is our contribution in this paper, consider first that Stiglitz *et al.* (2009) counseled policymakers to avoid confusing GDP (production) with societal welfare. We address this concern from the novel perspective of expanding the asset boundary. We identify the real savings that are proportional to the change in aggregate social welfare and thereby account more appropriately for production, real net expenditure, and changes in wealth in a society. Second, we provide a unique perspective on public goods, namely, the *longevity of the proximate services they provide*. In other words, we ask not whether such services yield social benefits (by which, following Samuelson, 1954, they are public goods) but rather whether they *directly* produce long-lived returns and therefore should be treated as investment in national accounts.

A way to see the “proximate services” distinction is that, in our final analysis, public spending on the institutions devoted to public safety, the justice system, and national defense are *not* treated as intangible assets that directly yield a flow of services over time. Such spending is, rather, viewed as building and maintaining the rule of law, and while the rule of law and the institutions that support it may be ultimate determinants of national investment (in that the appropriation of private capital is prevented per Hayek, 1944), spending on them does not *directly* yield a flow of knowledge services in future time periods.

We thus proceed as follows. In Section 2, we review the scope and nature of the “public” activities, where it becomes immediately obvious that we must focus on *kinds* of activities—that is, education or health—irrespective of whether the services at question are publicly or privately supplied. We also review the current treatment of public activity in national accounts and consider adjustments to industry accounting in the SNA that are needed to fully understand the links between public spending and industry productivity performance.

Section 3 then reconsiders the asset boundary for the production of public services. Based on the same logic that was set out and applied to for-profit business activity by CHS, we propose two new broad categories of public investment: (1) investments in information, scientific, and cultural assets; and (2) investments in societal competencies. We reconsider the common understanding of public infrastructure, currently limited to physical or tangible investments in national accounts, and regard “social infrastructure” as an asset type (in the second category) where, for example, human knowledge capital built via a nation’s school system and human health built via its health system could be regarded as societal assets. Section 4 sets out a social welfare framework for studying the contribution of intangible assets to

TABLE 1  
FUNCTIONS OF GOVERNMENT

Function
1. General public services <sup>1</sup>
2. Defense
3. Public order and safety
4. Economic affairs <sup>2</sup>
5. Environmental protection
6. Housing and community amenities
⑦a Health
⑧ Culture and recreation <sup>3</sup>
⑨ Education
10. Social protection <sup>4</sup>

*Notes:* 1. Includes interest payments. 2. Transportation affairs, general economic and labor affairs, agriculture, energy and natural resources. 3. Also includes religion. 4. Disability and retirement income, welfare and social services, unemployment and other transfers to persons. *Source:* OECD (2009a).

productivity growth and level of living in a society and also discusses key issues for measurement. A final section concludes and summarizes.

## 2. THE SCOPE AND NATURE OF PUBLIC ACTIVITIES

The section begins with a review of the kinds of activities performed by governments, including government capital formation, and then discusses in general terms how government payments of various types make their way into national and industry accounts used for productivity analysis.

### 2.1. *The Functions of Government*

The *functions of government*, according to economics textbooks, include maintaining the legal and social framework, providing public goods and services, maintaining competition, redistributing income, correcting for externalities, and stabilizing the economy. This is formalized in national accounting in a system called “classification of the functions of government,” or COFOG.

Table 1 shows a list of the ten COFOG categories used to classify government expenditures. The categories are largely self-explanatory except for the first, general public services. This category includes expenses related to executive and legislative organs, financial and fiscal affairs, external affairs, foreign economic aid, general services, general R&D, and interest payments on debt. The category excludes expenditures specifically related to one of the other functions; for example, R&D related to defense is included in defense, R&D related to health is included in health, and so on.

With the exception of social protection, where expenditures are payments to households, most of the functions in Table 1 involve the provision (or funding) of a service activity. In the case of direct provision of services, the production corresponds to services production in SNA-based industry accounts. For example, the three functions circled—education, health, and culture and recreation—correspond

directly to NACE sections (P, Q, and R, respectively); the function housing and community amenities includes public provision of water and sewerage services (in NACE section E).<sup>1</sup> Therefore, in a country with a public health service (only), the activity reported as NACE industry Q is public production. In a country where health services are supplied by a mix of institutions, the output of NACE industry Q is a mix of private and public production.

Because COFOG data are a breakdown of *government expenditure* according to kinds of services activity, at least in principle, government expenditure by type for most functions can be mapped to corresponding concepts in industry productivity accounts. While such mappings may seem essential for modeling and determining how government expenditures affect changes in productivity and social welfare, the relevant mappings are generally not available because the SNA does not call for an accounting of government payments according to kind of activity (i.e. industry). In principle, these crosswalks could be developed from COFOG data, but many countries do not provide COFOG data in sufficient detail to do so.

Government expenditure includes payments for all government consumption and investment, as well as payments for subsidies, transfers, and interest on public debt. In national accounting, the acquisition (or production) of goods and services by the government for community use is classified as government consumption expenditure because it is spending aimed at satisfying *current collective needs*. Government acquisition (or production on own-account) of goods and services intended to create *future societal benefits*, such as infrastructure or research spending, is government investment (or capital expenditure). The two types of final spending by governments, consumption and investment, are components of GDP.

Transfers and subsidies are excluded from GDP because they are goods and services (payments) supplied without any transformation. Transfer payments may be distinguished according to whether they are current or capital transfers. Current transfers directly affect the level of disposable income for the purpose of influencing household consumption. The extent to which countries rely on such transfers varies widely and accounts for much of the cross-country differences in government expenditure. For example, the expenditure on maintenance of household income averages about 40 percent of GDP in the European Union (EU) in recent years, whereas the comparable figure for the United States (U.S.) (based upon expenditures classified as transfer payments, that is, excluding tax expenditures benefitting households) is less than 25 percent.

Capital transfers, assuming that they are domestically bound, are primarily investment grants—payments to market producers for the acquisition of fixed assets. They differ from subsidies, which are not tied to the purchase of an asset, but which have a similar economic impact in that they both subsidize the return to capital. The objectives and recipients of investment grants vary across countries and time. For instance, funds may be used to offset the difficulty that SMEs have obtaining capital given the risk-averse nature of financial markets, or they

<sup>1</sup>NACE is the European standard classification of productive economic activities. It is derived from ISIC, the United Nations' International Standard Industrial Classification.

may be used for the revitalization of a rural area, or they may be for explicit agricultural, transportation, energy, or housing investment projects.

Under SNA guidelines, gross fixed capital formation (GFCF) by general government *excludes* investment grants and own-financed investment by government enterprises (GEs).<sup>2</sup> The former means that when, say, certain power companies receive public funds in the form of investment grants for expansion of the electric grid, or private universities receive public funds in the form of investment grants to build new science education facilities, the investments are not counted as government gross fixed capital formation in SNA-consistent national accounts. It is not that the investments are not counted; rather, they appear as GFCF by private industry. From an economic point of view, it makes little difference whether public investments are implemented via government creation or purchase of fixed assets or whether they are implemented via grant payments to private organizations (who create or purchase the fixed assets). The decision to invest emanated from a public body in both cases, and from an economic policy point of view, both are public investment.

The SNA does not instruct national accountants to construct measures of public investment even though the ability to distinguish between public and private domestic investment is relevant for fiscal policy analysis—for example, studying “crowding out” or impacts of austerity. Rather the reality is that public institutions can be governed so as to render the SNA’s distinction between government capital formation and investment grants irrelevant. For example, the distinction is rarely relevant in the U.S., whereas it is in many EU Member States. The rate of public investment via investment grants—that is, investment grants as a percentage of GDP—averaged 0.6 percent in the EU from 2010 to 2014 and was 0.8 percent or higher in 11 Member States (Belgium, Germany, Estonia, Greece, France, Italy, Latvia, Hungary, Malta, Slovakia, and the United Kingdom (U.K.)).<sup>3</sup>

General government GFCF in the EU, Japan, and the U.S. (relative to GDP) is shown in Figure 1(a) from 1970 to 2015, along with European Commission forecasts for 2016 to 2019. Total domestic GFCF excluding general government is shown in Figure 1(b); in both figures, rates for the EU15 and the EU accession countries (labeled EU13) are shown separately because data for the EU13 begin in 1995, whereas investment rates for the EU15, Japan, and the U.S. can be examined for nearly 50 years. Two points may be made. First, government investment rates for the three advanced countries or country groups (excluding the EU13) have gradually trended down over time; in the early 1970s, government investment ranged between 4 and 6 percent of GDP, whereas from 2010 on, the range was between 2.75 and 3.5 percent of GDP. Second, although government investment for the EU13 accession states has been on the high side since 2004, government investment for the EU15 appears, on balance, to be rather low relative to the U.S. and Japan.

<sup>2</sup>Government GFCF also excludes changes in public financial ownership of private companies and non-produced assets, but these tend to be rather small compared with investment grants and own-financed investment by GEs.

<sup>3</sup>The figure for the overall EU is a simple average over countries, save Luxembourg.

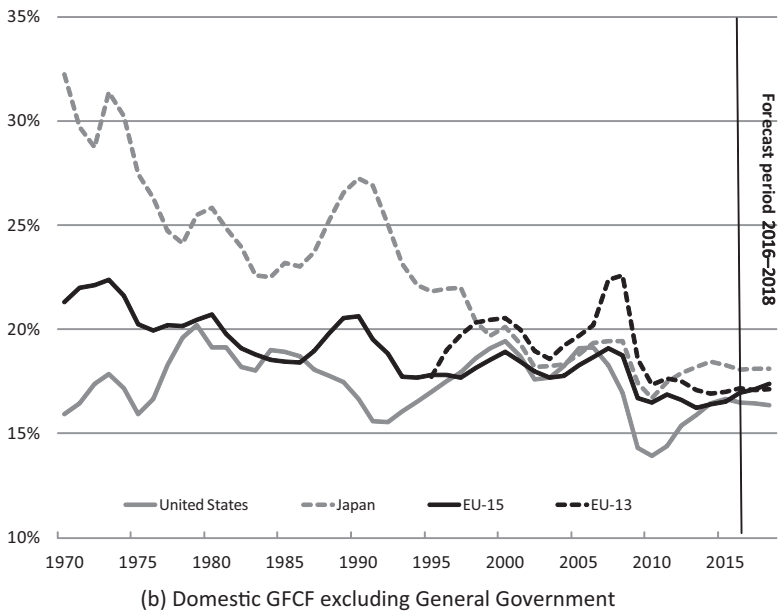
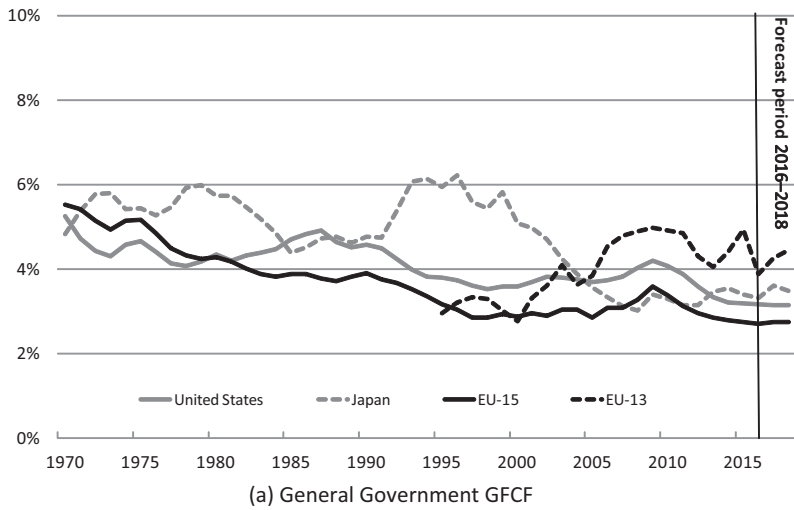


Figure 1. Gross Fixed Capital Formation (domestic), 1970–2018

*Note:* EU15 excludes Luxembourg; EU13 refers to the most recent EU accession countries.

*Source:* AMECO database (annual macro-economic database of the European Commission’s Directorate General for Economic and Financial Affairs) accessed November 15, 2016; available at [http://ec.europa.eu/economy\\_finance/db\\_indicators/ameco/zipped\\_en.htm](http://ec.europa.eu/economy_finance/db_indicators/ameco/zipped_en.htm).

What looks like a relatively low rate of public investment in the EU15 is a product of the SNA’s sectoral investment conventions, however. If statistics on the “true” rate of public investments were readily available, that is, if investment grants were combined with government GFCF, the rate of public investment for the EU15 would lie very close to the rate for (a) the U.S. from at least 1995 on

and (b) Japan from 2013 on, suggesting little difference in public investment spending propensities among these advanced countries in recent years.<sup>4</sup>

In summary, a consequential source of cross-country differences in government investment rates calculated from SNA-based national accounts may be governance structures, not underlying differences in public investment policy. Central government investment grants may be administered by other levels of government (in which case the investment still appears as government GFCF) or grants may be carried out by private industry or public corporations (in which case a sectoral transfer occurs, and the resulting investment is recorded as corporate GFCF). While sector distinctions and asset ownership loom large in the SNA for good reasons, the SNA treatment of public investment grants creates national accounts investment aggregates that are not very useful for comparative policy analysis.

## 2.2. Government in GDP, National Income, and Industry Output

To reconsider the impact of changes in production and asset boundaries for each of the functions of government listed in Table 1, we need to set out the conceptual relationships between the value of total government expenditure on each function and the value of government final spending and government output of the same service. And for each product or service within a function we also need to know (a) government subsidies for private production of the product and (b) grants for investment by private producers to make that product.

### Government Expenditure

Total government expenditure on function  $i$  is denoted  $GExp_i$  and may be further disaggregated according to whether expenditure is for (1) final spending on the service, denoted by  $P_i^G G_i$ , or for (2) non-production payments. The latter fall into two major categories:

- (a) Transfer payments  $Tr_i$ , which are either capital transfers (mainly investment grants) to private producers for the acquisition of fixed assets used in the production of  $i$  ( $TrB_i$ ), or payments to households to support individual consumption of goods and services  $i$  ( $TrH_i$ ). Total transfers ( $Tr_i$ ) are equal to  $TrB_i + TrH_i$ .
- (b) Subsidies, which are either for prices of products associated with  $i$  ( $SbP_i$ ), or for production of output  $i$  ( $SbQ_i$ ) where total subsidies ( $Sb_i$ ) are equal to  $SbP_i + SbQ_i$ .

Thus we have

$$(1) \quad GExp_i = P_i^G G_i + (Tr_i + Sb_i),$$

when interest on public debt and other capital transfers are ignored.

<sup>4</sup>Data on investment grants in the EU are available beginning only in 1995.



### Final Spending

Final spending for each government function  $i$  can be expressed as the sum of final consumption and investment

$$(2) \quad P_i^G G_i = P_i^C C_i^G + P_i^I I_i^G,$$

where investment is given by

$$(3) \quad \begin{aligned} P_i^I I_i^G &= P_i^{IP} IPur_i^G + P_i^{IO} IOwn_i^G \\ &= \sum_a P_a (IPur_a + IOwn_a)_i^G. \end{aligned}$$

Equation (3) shows that total investment  $I_i^G$  consists of market purchases ( $IPur_i^G$ ) and production on own-account ( $IOwn_i^G$ ), where each sub-aggregate reflects summation over asset types  $a$  and  $P_a$  is the acquisition cost (investment price) of the  $a$ th asset type. As with other producing sectors, the government investment price index is a sector-specific, share-weighted combination of these underlying asset prices, a nuance not reflected in the notation used in equation (3).

Government final consumption of  $i$  represents the value of collective consumption services provided to the community (as distinguished from the individual benefits delivered as transfers and subsidies). How is this related to government output of  $i$ , denoted as  $P_i^Q Q_i^G$ ? The standard approach to setting out the relationship between final spending and production, given by Domar (1961), is to define output as that produced for use outside the sector, which is total gross output by assumption in our case, and then to distinguish between (a) output shipped to final demand versus (b) output sold to other producing sectors,  $Sales_i^{G,S \neq G}$  ( $Sales$  by sector  $G$  to sector  $S$ , where  $S \neq G$ ). When production is purely non-market, such sales are of course zero, but it is useful to illustrate the general case. Thus we have

$$(4) \quad P_i^Q Q_i^G = P_i^C C_i^G + P_i^{IO} IOwn_i^G + Sales_i^{G,S \neq G},$$

which after rearranging equation (4) to solve for  $P_i^C C_i^G$  yields

$$(5) \quad P_i^C C_i^G = P_i^Q Q_i^G - P_i^{IO} IOwn_i^G - Sales_i^{G,S \neq G}.$$

Government final consumption of  $i$  then is equal to government gross output of  $i$ , less own-account capital formation by producers of  $i$ , less receipts from sales of  $i$  to other sectors.

Because sales by non-market producers are not typically observed, their output is valued by the sum of costs incurred in production. Nonetheless, output may be written in the usual way (i.e. as if it was based on industry revenue):

$$(6) \quad P_i^Q Q_i^G = \underbrace{P_i^L L_i^G + P_i^K K_i^G}_{\text{Value added}} + \underbrace{P_i^I I_i^G}_{\text{Intermediate inputs}}.$$

Substituting equation (6) into equation (5) yields an expanded expression for final consumption:



$$(7) \quad P_i^C C_i^G = P_i^L L_i^G + P_i^K K_i^G + P_i^{II} II_i^G - P_i^{IO} IOwn_i^G - Sales_i^{G,S \neq G}.$$

We now use equations (7) and (3) to expand equation (1):

$$(8) \quad GExp_i = \underbrace{P_i^L L_i^G + P_i^K K_i^G + P_i^{II} II_i^G - P_i^{IO} IOwn_i^G - Sales_i^{G,S \neq G}}_{P_i^C C_i^G} + \underbrace{P_i^{IP} IPur_i^G + P_i^{IO} IOwn_i^G}_{P_i^I I_i^G} + (Tr_i + Sb_i).$$

Equations (1)–(8) are written in terms of general government production, but as a conceptual matter, they apply to any institutional sector or industry group.

With regard to measurement of output by input costs, consider first the market sector where goods are sold at observable prices. To fix ideas, suppose we have an industry sector producing energy for sale to final consumers and for sale to other producers; that is, sales as in the first and third terms on the right-hand side of equation (4). If, in addition, the sector undertakes own-account investment, that must also be added to obtain a measure of gross output (as done with the second term on the right-hand side of the same equation). Now consider measurement in the non-market sector. There may be some sales outside the sector, in which case we can measure them:  $Sales_i^{G,S \neq G}$ . But if sales are not observed, we have to determine gross output based on the sum factor costs; that is, as the sum of payments for labor, capital, and purchased inputs, as in equation (6).

### Subsidies

The sources-of-growth (SOG) approach that guides the framework for productivity measurement is derived from the national accounting identity that the sum of factor payments equals aggregate production, or GDP, at market prices. In national accounts practice, the identity contains conceptual reconciling items, namely, subsidies and taxes on production and imports. The reconciling items often are ignored when focussing on SOG basics, but they affect the measurement of capital income and also the return to capital when capital rental prices are determined on an *ex post* basis per Jorgenson (1963) and Jorgenson and Griliches (1967).

As previously mentioned, subsidies may be product subsidies  $SbP_i$  or production subsidies  $SbQ_i$ , where we can assume for this discussion that the subscript  $i$  is used to represent market activity at the industry level. Subsidies on products are used to reduce the market price that producers charge customers; for example, agricultural price supports. Production subsidies are payments directed at labor or capital employed in production, or for output produced; for example, a government may provide subsidies for job creation or employer-provided worker training, or they may make payments to encourage energy production or for expanding national defense capacity. Because subsidies are offsets to costs (like revenue), they are augmenters of the return to capital and thus reflected in gross operating surplus,  $GOS$ . Gross operating surplus is the before-tax gross return to

capital in national income accounts, where before-tax means before *business income* taxes; that is, before the net effect of the corporate income tax including all tax credits and expenditure write-offs.

In addition to business income taxes, there are also taxes on production and imports, which consist of: (a) taxes on products and imports,  $TxPI_i$ ; and (b) other taxes on production,  $TxQ_i$ . The former are sales taxes or value added taxes, which are naturally not included in producers' revenue or value of production. The latter are taxes on factors used in production; they include, for example, employer payroll taxes or taxes on motor vehicles or buildings—that is, we have  $TxQ_i = TxQ_i^L + TxQ_i^K$ . In industry production accounts, factor taxes are combined with factor incomes because, from the producers' point of view, both are payments for factor inputs to production.

In the national income identity, subsidies are subtractions from income and taxes on production and imports are additions. Consider now equation (6) and the definitions of labor compensation  $P_i^L L_i$  and capital compensation  $P_i^K K_i$  used in SOG analysis, we have the following:

$$(9) \quad \begin{aligned} P_i^L L_i &= W\&S + OLI + TxQ_i^L, \\ P_i^K K_i &= GOS + TxQ_i^K, \end{aligned}$$

where  $W\&S$  is wages and salaries,  $OLI$  is other labor income (paid benefits), and proprietors' income is ignored. *Aggregate* gross domestic income (which equals GDP at market prices) is then expressed as

$$(10) \quad GDP \equiv GDI = \sum_i (P_i^L L_i + P_i^K K_i) + \sum_i (TxPI_i - Sb_i).$$

The value of each producing industry's primary factor payments in the first summation term of equation (10) forms the basis of industry growth accounting as originally set out in Jorgenson and Griliches (1967).

The SNA counsels that *industry* and *institutional unit* production accounting be formulated in terms of "basic prices," in which GDP at market prices is represented as the sum of industry (or institutional unit) gross value added at basic prices plus taxes on products and imports ( $TxPI$ ) less subsidies on products ( $SbP$ ), that is

$$(11) \quad GDP = \underbrace{\sum_i (P_i^Q Q_i - P_i^H H_i + SbP_i)}_{GVA^{BP}} + \sum_i (TxPI_i - SbP_i),$$

where  $GVA^{BP}$  is gross value added at basic prices. Basic prices are designed to reflect the value of output produced; that is, as in value created and retained by the producer. Product subsidies are added because the subsidy has been used to reduce the market price that producers charge customers, whereas the actual value of production is higher by the amount of subsidy. With regard to production subsidies, when the value of capital compensation is determined residually

from industry GVA at basic prices, equations (10) and (11) imply that  $P_i^{K^{BP}} K_i$  will be less than the full gross return to capital by the value of production subsidies paid to the industry by the government, that is

$$(12) \quad \begin{aligned} P_i^{K^{BP}} K_i &\equiv GVA^{BP} - P_i^L L_i \\ &= P_i^K K_i - SbQ_i. \end{aligned}$$

In the EU15, production subsidies averaged 0.7 percent of GDP from 2006 to 2013, with a fair bit of variation by country; that is, from 2.0 percent in Belgium to 0.1 percent in the U.K. Equation (12) is important to bear in mind given that most NSOs follow the SNA and issue production accounts at basic prices, and that GVA at basic prices is the basis for EUKLEMS growth accounts (O'Mahony and Timmer, 2009).

That said, three further points must be made. First, outside of agriculture, the value of production subsidies typically is small for many advanced economies. Second, there is much room for judgment in what might be considered a production subsidy. National accountants tend to consider only direct payments to industry as production subsidies, whereas such payments are little different from tax expenditures (of which R&D and energy tax credits might be considered examples). Third, data on subsidies to production by industry and tax expenditures are not readily available for many countries. A complete accounting of public expenditures on industry, be they direct payments for production or tax expenditures, is needed to obtain appropriate measures of capital income for industry-based SOG analysis.

### Investment Grants

Investment grants are a capital transfer, as previously discussed. They do not appear directly in equations (10) and (11), although they significantly impact the return to capital and implicit capital rental price  $P_i^K$  for recipient industries. Consider again equation (12). From a production perspective,  $P_i^K K_i$  is the total rental equivalence payment for capital services. Rearranging terms suggests that the total payment consist of two terms:

$$(13) \quad \underbrace{P_i^K K_i}_{\text{Total payment}} = \underbrace{P_i^{K^{BP}} K_i}_{\text{Private payment}} + \underbrace{SbQ_i}_{\text{Public payment}} .$$

An investment grant operates like an investment tax credit. It reduces the acquisition price of a fixed asset and thereby the private industry payment, much as a subsidy does.

To see this, suppose that an investment grant  $TrB_i$  is given to industry  $i$  for the acquisition of a produced capital asset  $a$  in the amount  $(P_a I_a)_i$ . Let  $\psi_a$  be the ratio of the grant to the purchase price:  $\psi_a = \frac{TrB_i}{(P_a I_a)_i}$ . Then the after-tax purchase price of the asset is  $P'_a = (1 - \psi_a)P_a$ . This suggests that, in the absence of all other taxes, industry  $i$ 's capital rental equivalence price for  $a$  is given by

$$(14) \quad \begin{aligned} P_i^{K_a^{BP}} &= (\rho_i + \delta_a) P'_a \\ &= (1 - \psi_a)(\rho_i + \delta_a) P_a \end{aligned}$$

and its capital payment is

$$(15) \quad \begin{aligned} \sum_a P_i^{K_a^{BP}} K_a &= \sum_a (1 - \psi_a)(\rho_i + \delta_a) P_a K_a \\ &= \sum_a (\rho_i + \delta_a) P'_a K_a - \sum_a \psi_a (\rho_i + \delta_a) P_a K_a. \end{aligned}$$

These equations illustrate several points. First, for a very long-lived asset,  $\psi_a$  is also the approximate annuity value of the grant, suggesting a symmetry between investment grants expressed as in equation (14) and tax credits in the Hall and Jorgenson (1963) formula for the tax-adjusted cost of capital. Second, equation (15) shows that if investment grants are an important means of capital financing for an industry ( $\psi_a$  is non-negligible for major assets), then very little capital income might be associated with very large capital stocks. As a practical matter, this simply means that the capital was massively subsidized by public investment grants; the actual *ex post* return net of grants  $\rho_i$  may be low, high, or on a par with the return to private investments. One cannot know without compiling data on  $TrB_i$  for the industry and computing  $\psi_a$  for its relevant assets.

Third, following equation (13), the simple transformation of equation (12), we can express total capital compensation in basic prices in this industry as the sum of two components, shown in the second line of equation (15). The first term represents the *i*th industry's actual rental equivalence payment, and the second is a term that must be subtracted for the payment to equal what national accounts are instructed to do by the SNA—namely, to exclude the government's payment (here, in the form of an investment grant expressed as a per-period subsidy). Most of the points with regard to equation (12) also then apply here, although there is one notable exception, namely, as previously discussed, the relative value of the subsidy-like payment is neither small nor confined to agriculture for many countries.

In summary, the discussion of the last two subsections suggests that: (a) production subsidies are little different in an economic sense from product subsidies and tax expenditures; and (b) investment grants are little different from investment tax credits, or for that matter, subsidies. That production subsidies and the annuity value of investment grants are not included in SNA industry gross value added at basic prices is a notable limitation of the usefulness of system's industry accounts for policy-motivated analyses of investment and productivity.

### 3. THE ASSET BOUNDARY

Before reconsidering the current asset boundary of national accounts, a very important first point to make is that the scope of existing GDP is kept as the production possibilities frontier. In other words, while all market activity and

TABLE 2  
KNOWLEDGE CAPITAL FOR A TOTAL ECONOMY

Market Sector		Non-market Sector	
Computerized information		Information, scientific, and cultural assets	
1	Software	1	Software
2	Databases	②	Databases, including open data
Innovative property			
3	R&D, broadly defined to include all new product development costs*	3	Basic and applied science research, industrial and defense R&D
4	Entertainment & artistic originals	④	Cultural and heritage, including architectural design
5	Design		
6	Mineral exploration	5	Mineral exploration
Economic competencies		Societal competencies	
7	Brands	6	Brands
8	Organizational capital	7	Organizational capital
(8a)	Managerial capital	⑦a)	Professional and managerial capital
(8b)	Purchased organizational services	(7b)	Purchased organizational services
9	Firm-specific human capital (employer-provided training)	8	Function-specific human capital (employer-provided training)
		⑨	Schooling-produced human capital

*Note:* \*New product development costs include expenditures for testing and development of new products (including financial products and other services products) not included in conventional science-based R&D, software, databases, and design.

traditional non-market production by governments and non-profit institutions serving household (NPISH) are regarded as within the production boundary, *non-market production by households is considered beyond it*. Many challenges are nonetheless encountered when reconsidering the definition of public investment germane to the current national accounts production boundary. In this section, rather, we ask two fundamental questions, as follows. What intangible investments are undertaken by government and non-profit producers of social services? Are societal assets produced by these organizations? These are *very* different questions. We begin by appealing to the CHS framework.

### 3.1. CHS-type Assets

Table 2 summarizes the CHS list of intangible assets (on the left) and maps them to the public or non-market sector (on the right). As may be seen, two broad categories of public intangible assets are proposed. One consists of information, scientific, and cultural assets, and the second is societal competencies. Before we discuss what is different across the two columns, let us make a few points about the similarities. First, while the character of some assets is rather different when produced by public institutions—for example, R&D, brands, and mineral exploration—we may still draw a correspondence between these assets across sectors. For example, Jarboe (2009) defines public investments in brand as expenditures for export promotion, tourism promotion, and consumer product and food and drug safety (i.e. investments in product reputation). The correspondence for computer software, purchased investments in organizational capital, and function-specific worker capital (employer-provided training) is even closer.

The circled items 2, 4, and 7a are rather different in a public-sector context; the circled item 9 pertains to the non-market sector only and will be discussed separately (in subsection 3.2 below). Beginning with circled item 2, open data refers to *information assets* in the form of publicly collected data curated and issued for public use. This runs the gamut from patent records to demographic statistics and national accounts to geographic information and local birth/death records. An extensive list of information assets of governments has been compiled for the Measuring European Public Sector Information Resources (MEPSIR) project by (Dekkers *et al.*, 2006, p. 25) and provides a starting point for empirical work. Indeed, after asking the question, “What are public sector intangible assets in the U.K.?” (Blaug and Lekhi, 2009, p. 53) concluded that “perhaps the most important . . . is information assets.” Jarboe (2009) includes government information creation as a high-level category in his estimates of U.S. federal government intangible investments. His category includes spending on statistical agencies, the weather service, federal libraries, non-partisan reporting and accounting offices, and the patent office, suggesting that information assets loom large in the U.S. as well. Indeed, the U.S. Census Bureau’s release of the Topologically Integrated Geographic Encoding and Referencing (TIGER) dataset, in 1991, is commonly thought to have bootstrapped the country’s booming geospatial industry.

*Cultural assets* are public intangible assets the services of which are used in production in cultural domains dominated or influenced by the public and non-market sectors. Cultural domains are kinds of activities, such as cultural and natural heritage, performance and celebration, visual arts and crafts, books and press, and are areas defined by the UNESCO Framework for Cultural Statistics (UNESCO Institute for Statistics, 2009). The capital used in many domains is included in existing estimates of private capital (tangible and intangible), but public investments (or funding) for new asset creation needs to be identified and newly capitalized.<sup>5</sup> Note that cultural assets are notionally grouped with public architectural and engineering design in Table 2 on the grounds that the British Museum’s tessellated glass ceiling or the Louvre Pyramid are as valuable (and as incalculable) as the museums’ contents—although, of course, their correspondence to private counterparts is apparent. Cultural assets also include the value of curative activities not normally capitalized in national accounts (a form of humanities R&D, if you will).

Finally, *organizational investments* on own-account (professional and manager time devoted to organizational innovation) take on a somewhat different character in a public and/or non-profit setting (O’Mahony, 2012; Squicciarini and Le Mouel, 2012). Hospitals, for example, often have professional medical doctors in managerial roles absent the manager moniker, and “lead” doctors may be mandated to spend a fixed fraction of their time instructing team members. Recent studies have considered the scope of investments in own-account organizational

<sup>5</sup>This assumes that national statistical offices have not already done so as part of their efforts to capitalize artistic and entertainment originals. Unfortunately, this is difficult to ascertain, because the published data on investment by asset type for many countries are not sufficiently detailed. Data that are available, however, suggest that the category artistic and entertainment originals contains little or no public investment and that public cultural assets are in practice distinct from artistic and entertainment originals.

capital by public institutions—hospitals in particular. O’Mahony *et al.* (2016) find evidence suggesting that investments in organizational capital in terms of clinical managers in public hospitals in England (NHS Trusts) are associated with better outcomes in terms of mortality, and Hütty and Nagy (2016) find that broad rather than narrow measures of organizational capital are mildly more correlated with cost-weighted output measures for 58 government-owned hospitals in Hungary. The prevalence of training among hospital professionals is a subject for further study.

The SPINTAN project estimated the CHS-type intangibles set out in Table 2 for the non-market sector of 22 EU countries plus China, Brazil, and the U.S. (The non-market sector refers to general government and NPISH activity in industry sectors M72, O, P, Q, and R.) Jarboe’s expanded notion of brands, and expanded versions of cultural and information assets, are only available for a few countries for a few years and were not included in the final database. Estimates for national accounts intangibles (R&D, software, mineral exploration, and artistic and entertainment originals) are available along with the non-national accounts CHS intangibles (design, brands, organization capital, and function-specific human capital) from 1995 to 2013 at [www.spintan.net](http://www.spintan.net).

Figure 2 combines the recently available SPINTAN results with the INTAN-Invest database.<sup>6</sup> The figure compares intangible intensities (intangible investment relative to sector gross value added) for the market and non-market sectors of 15 EU countries and the U.S. The panel at the top shows results for total intangibles, whereas the bottom panel excludes R&D and software.

As may be seen in the top panel, the total intangibles intensity of non-market production varies substantially by country (from 3.5 percent to 15 percent) compared with the intangibles intensity of market production (from 5.5 percent to 13 percent). When investment in R&D and software assets are excluded, however, the cross-country variation in non-market intangible intensities is more muted. The impacts of these estimates on growth and productivity performance and their relevance for fiscal policy is the subject of several SPINTAN project working papers.

### 3.2. *Social Infrastructure*

Most of the spending currently classified as public investment is spending on physical infrastructure (roads, bridges, water supply, sewers, electrical grids, communication systems) where returns to society accrue for many years. While this accords with the usual economic notion of infrastructure as a capital-intensive natural monopoly (Gramlich, 1994), over the past decade or two, a broader notion of a nation’s infrastructure has taken hold, namely, that governments also provide long-lasting “soft” infrastructure via the nature of the services that they produce. While the investments in asset types 1–8 may be both the output of and/

<sup>6</sup>INTAN-Invest is an unfunded collaboration of researchers who periodically update internationally comparable estimates of intangible investment for all sectors of the economy save real estate, education, health and social services, and public administration and defense. The data and documentation are available at [www.intan-invest.net](http://www.intan-invest.net), and further information and analysis is in Corrado *et al.* (2013) and Corrado *et al.* (2016).



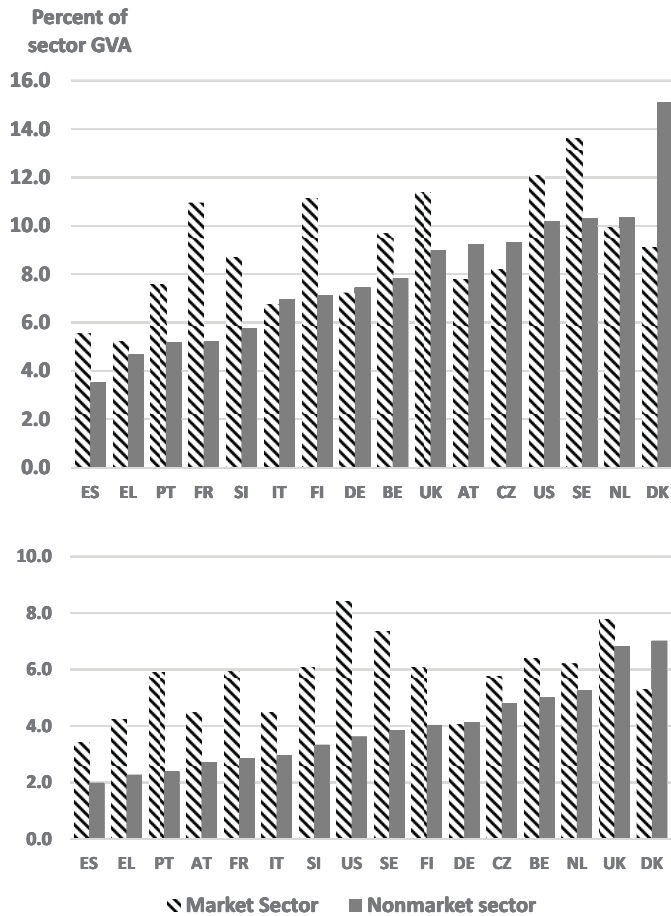


Figure 2. Intangible Investment in Non-market and Market Sectors, 1995–2013 (top panel is all CHS intangibles, bottom panel excludes R&D and software).

Note: CHS = Corrado *et al.* (2005, 2009) intangibles framework.

Sources: The SPINTAN and INTAN-Invest databases.

or inputs to non-market production, certain of the social services produced by governments (per Table 1) may themselves be long-lasting—and thereby reflect asset creation for the society as a whole.

The notion that governments provide “soft” infrastructure via the nature of the services produced has gained recognition based on a body of evidence demonstrating that the economic (i.e. pecuniary) benefits of providing such “social infrastructure” outweigh the costs and result in a net return on investment. From our point of view, the issue is not so simple if significant household production is involved, in which case the activity lies outside the production boundary of our analysis. Besides determining the longevity, proximity, and nature (i.e. private or social) of the pecuniary returns that accrue to non-market production, the location of this production is a key aspect of determining which services should be counted as social infrastructure. Whether returns are private versus social is not

relevant to this determination but, rather, can be key to measurement once a determination is made (i.e. returns to education are captured, at least in part by wages, and this impact may be measured).

Consider now whether the services shown in Table 1 produce long-lived assets or short-lived services (with or without social returns).

## Education

Many studies show that the returns to education accrue to private individuals in the form of higher lifetime wages. The longevity of private returns to education, with or without the detection of excess returns, supports the treatment of the service capacity of an education system as social infrastructure. A fundamental feature of the education process as modeled by Jorgenson and Fraumeni (1989, 1992a, 1992b) is the lengthy gestation period between the application of the educational inputs—mainly the services of teachers and the time of their students—and the emergence of human capital embodied in graduates of educational institutions. From the Jorgenson–Fraumeni (JF) perspective, the household is the ultimate producer; it invests time and money via purchases of teacher services (either at cost for public institutions in national accounts or actual outlays in the case of private services) to build human capital. JF human capital production thus lies outside the production boundary of existing GDP.

Can education output be viewed within a framework where its current production value is an increment to national wealth without extending the production boundary of GDP to include households? In Corrado *et al.* (2016), the production of education services is viewed as the acquisition of *schooling-produced knowledge assets*  $\Delta E$ , whose change in value  $P^{ES}\Delta E$  is included in national saving and wealth. The asset  $E$  is not used in current production while in the building phase. Rather,  $E$  is held in inventory, within the school system, until students graduate and enter the working-age population, after which the value of the societal asset is unchanged (by the school system). Their “inventory” view follows the logic of: (a) Ruggle’s proposed approach to accounting for consumer durables as an asset, while still viewing household production as out of scope for GDP (Ruggles, 1983; see also Moulton, 2001); and (b) the SNA’s approach to the treatment of valuables.

Schooling-produced knowledge assets can thus be related to the JF lifetime-income approach to human capital measurement via an “inventory” accounting approach. Some observers have suggested that the JF “market” component of human capital production be used to replace the existing measures of education services in conventional GDP (e.g. Ervik *et al.*, 2003). The inventory approach is a different adaptation of the JF model for inclusion in conventional accounts, but like other JF-based work (e.g. Christian, 2014), the inventory approach includes values, volumes, and prices as basic elements, and in that capacity embraces human capital within the conventional boundary of the SNA.

Note further that drop-out rates and graduation rates at each level of schooling can be built into the calculation of a lifetime income measure, and via this channel low productivity of a school system diminishes the quantity of schooling-produced knowledge assets  $E$ . Labor market conditions—that is, probabilities

that students will be employed or not upon graduation or leaving the system—can also be factored into the calculation of lifetime income, although this is not usually done in the human capital measurement literature. When knowledge assets produced and held in school systems are considered societal assets, and thereby school systems as social infrastructure, it seems reasonable to ponder how poor labor market conditions might diminish the societal value of resources devoted to schooling (just as low productivity of a school system itself does).

## Health Care

The principles set out and applied to education do not lead to very clear answers when applied to human health. First, there is a vast literature studying the effectiveness (i.e. returns) to various treatments of various diseases. As this literature is disease-based, it cannot be as readily summarized as the literature on returns to education; that is, some spending yields winners (the “war” on cancer) whereas some other does not, or has not to date (i.e. spending on Alzheimer’s).

Second, although the health-care process is typically modeled as the treatment of diseases, the notion that households promote their own wellness through consumption of preventative care (vaccines) and engagement in wellness-enhancing activities (diet, exercise) is an alternative approach. Does this wellness process work the same way as the educational process; that is, as in building human capital? The answer would appear to be yes, but with the exception of O’Mahony and Samek (2016), a broader model in which wellness production plays a key part has not been a feature of the health-care (or human capital) modeling literature.

Note further that the intangible capital literature does not capitalize employer expenditures on wellness even though such expenditures would appear to meet the criteria for investment.<sup>7</sup> Thus while it may be possible to tweak the CHS framework and perhaps marry the O’Mahony and Samek model of health-adjusted lifetime income with the Corrado *et al.* (2016) approach to measuring education as social infrastructure, the feasibility of expanding intangible capital measures to include human wellness stocks remains unknown.<sup>8</sup>

## Defense, Public Safety, and Other Services

Returning to the headings in Table 1, the question of whether or not to count their expenditure as intangible assets rests likewise on whether they directly produce long-lived assets versus short-lived services (with possibly social benefits in either case). For the moment, we shall assume that spending on these government functions produce short-lived services. While it might be possible to think of examples where aspects of such spending is long-lived—for example, defense

<sup>7</sup>For example, in the U.S., where employers shoulder a large portion of health-care costs, a recent RAND review of available studies (Matte *et al.*, 2013) concluded that medical costs in the U.S. are reduced approximately \$3.27 for every dollar spent on workplace wellness programs.

<sup>8</sup>This is not to say that the commonly used framework for productivity analysis does not capture the benefits of human longevity and wellness, albeit if only indirectly, because (a) workforce capacity increases with greater human longevity, and costs of (b) workplace absenteeism and (c) future health care are lower with increased wellness.

spending produces long-lived reputation for a country—we shall henceforth focus exclusively on education as social infrastructure.

#### 4. THE FRAMEWORK FOR ANALYSIS

The scope of capital investment is important because it defines the value of wealth in an economic system. National accountants define an asset as something that is owned by an economic unit from which economic benefits are derived over a period greater than one year. CHS grounded their definition of investment following the optimal growth literature (Weitzmann, 1976, 2003) as spending designed to increase consumption in a future period.

An increase in consumption occurs via expansion of the economy's productive capacity in the CHS framework, consistent with a multi-sector production possibility frontier. The future benefits of investment spending are derived solely from private capital formation in this framework, however, and while an aggregate social welfare function is implicit, analyzing welfare change has not been a focus of the intangibles literature to date. Below, we follow Jorgenson and Landefeld (2006) and take steps to incorporate social welfare in the analysis.

##### 4.1. *Sources and Uses of Economic Growth*

We consider both the sources and *uses* of economic growth and evaluate to what extent they are affected by the inclusion of private and public intangibles in the asset boundary. We begin by looking at real output, inputs, and productivity in the usual way:

$$(16) \quad V(C, I) = A \cdot X(L, K, R),$$

with sources-of-growth analysis written as follows:

$$(17) \quad \bar{w}_C \Delta \ln C + \bar{w}_I \Delta \ln I = \bar{v}_L \Delta \ln L + \bar{v}_K \Delta \ln K + \bar{v}_R \Delta \ln R + \Delta \ln A,$$

where  $V$  is total real output (i.e. real gross value added), and  $\bar{w}$  and  $\bar{v}$  denote Divisia shares of outputs and inputs in current prices, respectively, in gross value added. Total real output is expressed in equation (16) as a production possibilities frontier for consumption ( $C$ ) and investment ( $I$ ), where  $C$  and  $I$  are produced from domestic labor ( $L$ ) and tangible capital ( $K$ ) and knowledge capital ( $R$ ) inputs augmented by multifactor productivity ( $A$ ).  $C$  consists of personal consumption and government consumption, and  $I$  consists of private investment, government investment, and rest-of-world investment. Investment covers both types of capital in the production function; that is, tangible and knowledge capital.

The capitalization of intangible assets has a direct impact on the sources of growth via investment ( $I$ ) and knowledge capital services ( $R$ ) in the above equations. But what are the effects on the uses of economic growth—and on social welfare? To answer this question, we follow Jorgenson and Landefeld (2006, esp. pp. 98–104) and consider that economic growth creates opportunities for future as well as present consumption, summarized in real net expenditures  $Z$ . These

opportunities are generated by the expansion of real national income  $Y$ , comprising real labor and net property income ( $L$  and  $N$ ) augmented by changes in the level of living  $B$ :

$$(18) \quad Z(C, S) = B \cdot Y(L, N),$$

$$(19) \quad \bar{\omega}_C \Delta \ln C + \bar{\omega}_S \Delta \ln S = \bar{v}_L \Delta \ln L + \bar{v}_N \Delta \ln N + \Delta \ln B.$$

Real net expenditures  $Z$  consists of real consumption  $C$  and real saving  $S$ , net of depreciation.  $S$  is comprised of personal, business, and government net saving. The share-weighted growth of real net expenditures as per the left-hand side of equation (19) is the sum of the share-weighted growth of real incomes plus growth in the level of living per the right-hand side. The Divisia shares  $\bar{\omega}$  and  $\bar{v}$  are with respect to net expenditures and national income in current prices; they differ from the gross value added shares used in equation (17).

Real net expenditures is a measure of social welfare in the current period in that it consists of the quantity of current consumption and the quantity of the net increment to future consumption (change in real saving), as suggested by Weitzmann (1976, 2003).<sup>9</sup> Real net expenditures thus represents the annual increment to welfare resulting from each year's production activity. Equation (19) shows that social welfare  $Z$  is affected by the capitalization of intangibles directly via changes to real saving  $S$  and real net property income  $N$ , both of which are components of the economy's income and expenditure account. Real net saving equals real net investment and, ignoring complications due to proprietor profits and differences in relative prices by asset type, real net property income is the real net operating surplus, or real return to capital  $\rho(K+R)$ .

The level of living is not the same as multifactor productivity. The latter is a measure of productive efficiency whereas the level of living implies that, for a given supply of factor services generating labor and property incomes, the economy may produce greater opportunities for present and future consumption (Jorgenson and Landefeld, 2006, p. 88). As a practical matter, because of the close correspondence of the labor contributions to  $A$  versus  $B$  and the fact that the capital services contribution to  $A$  differs from the net property income contribution to  $B$  primarily because capital consumption is excluded from the latter, estimates of  $\Delta \ln B$  will be close to  $\Delta \ln A$  for economies with stable investment shares by asset type. A shift to shorter-lived assets, all else equal, creates a wedge between  $\Delta \ln A$  and  $\Delta \ln B$  (with  $\Delta \ln A > \Delta \ln B$  during the transition period), whereas a shift toward long-lived assets has the opposite impact.

The above framework can be expanded to recognize that benefits from asset ownership accrue not only from capital formation but also from exchanges of "non-produced" assets between business and governments; for example, mineral or spectrum rights granted or sold to producer units by governments. The framework can also be augmented to account for "inventories" of societal assets—the schooling-produced knowledge assets discussed in the previous section.

<sup>9</sup>Christensen and Jorgenson (1973) identified the income and expenditure account with a social welfare function, the conceptual framework for which is provided by the Ramsey (1928) model of intertemporal preferences.

Under the inventory approach, equations (16)–(19) as set out above are essentially unaffected by the capitalization of education as social infrastructure, whereas the composition and character of national wealth, saving, and investment change notably. Real gross investment  $I$ , as before, includes real gross fixed capital formation  $\Delta K + \delta^K K_{-1}$  and  $\Delta R + \delta^R R_{-1}$ , where  $K$  and  $R$  are the net asset stocks used in current production. After recognition of schooling-produced knowledge assets, gross and net investment also include the human knowledge capital produced by a nation's education system  $\Delta E$ .<sup>10</sup> In nominal terms, gross investment, net saving, and the wealth of the society ( $W$ ) are as follows:

$$(20) \quad P^I I = P^{FA}(\Delta K + \delta^K K_{-1} + \Delta R + \delta^R R_{-1}) + P^{ES} \Delta E,$$

$$(21) \quad P^S S = P^{FA}(\Delta K + \Delta R) + P^{ES} \Delta E,$$

$$(22) \quad W = P^{FA}(K + R) + P^{ES} E.$$

where the increment to nominal wealth includes holding-period gains (losses) as well as net saving:

$$(23) \quad \Delta W = P^S S + \Delta P^{FA}(K + R) + \Delta P^{ES} E.$$

$P^{FA}$  denotes the aggregate replacement cost of the stock of fixed assets—that is, an appropriately weighted index of tangible and intangible capital asset prices—and  $P^{ES}$  is the notional equivalent for schooling-produced knowledge assets.<sup>11</sup> Investments in education tend to be a function of the age structure of a society, and thus a relatively stable fraction of GDP in most advanced countries, suggesting that the implications of capitalizing investments in education as social infrastructure for real GDP and productivity change may depend importantly on trends in the implied price index for education services. Notwithstanding, recognition of schooling assets as societal wealth packs an extra punch for net saving and, possibly, real net expenditures (relative to real GDP) due to the fact that in moving from real GDP to real net expenditures, no depreciation charge is taken.

<sup>10</sup>To see why equations (16)–(19) do not fundamentally change under the inventory approach (even though  $I$  does), first write the production function for real education services  $Q_{i,ES}$  in a standard way:

$$Q_{i,ES} = A_{i,ES} \cdot \mathcal{F}^E(K_{i,ES}, R_{i,ES}, L_{i,ES}),$$

where  $K_{ES}$ ,  $R_{ES}$ , and  $L_{ES}$  are the education system's fixed tangible and intangible capital and labor services inputs;  $A_{i,ES}$  is the efficiency with which those inputs are transformed into additional schooling knowledge; and intermediate inputs are ignored. Now note that our discussion of education as social infrastructure implied that the schooling-produced increment to human knowledge stocks,  $\Delta E_i$ , is the real output of the education system,  $Q_{i,ES}$ . Given that  $Q_{i,ES} = \Delta E_i$  and that  $E$  does not depreciate, the above can also be written as follows:

$$E_i = A_{i,ES} \cdot \mathcal{F}^E(K_{i,ES}, R_{i,ES}, L_{i,ES}) + E_{i-1},$$

where  $E_{i-1}$  is the beginning-of-period schooling-produced knowledge stocks held by this year's students.

<sup>11</sup>For further discussion, see Corrado *et al.* (2016).

#### 4.2. Return to Non-market Capital

For market producers, the value of production is based on industry revenues, and the return attributed to capital is obtained as revenues less current expenses. Because non-market producers offer their products at a price that covers only part or none of the costs of production, revenues cannot serve as a measure of the value of production for non-market producers. National accounts therefore use the sum of costs incurred in production to value output. For governments and NPISH, capital costs are measured as the value of economic depreciation (capital consumption), thus ignoring that part of capital compensation reflecting the real net return.

The main reason for the national accounts convention lies in the fact that (a) to include a net return requires imputation, and that (b) any such imputation directly affects GDP and national income, and that (c) there is a broad spectrum of possible imputations. The imputation of a return to public investments is discussed in the OECD capital services manual (OECD, 2009b), where a key point, also made earlier by Moulton (2004, p. 169), is that aiming to create a production account for the government sector—especially one that includes its contribution to total economy multifactor productivity—necessitates estimation of a net return to public capital formation. This was done, for example, in Mas *et al.* (2006), in their study of the contribution of infrastructure capital to economic growth in Spain where such capital is largely held by government entities.<sup>12</sup>

To illustrate the issue from a productivity perspective, let  $i$  be a NACE services industry or NACE section with institutionally mixed producers, in which case  $i$ 's industry gross output  $Q_i$  and value added  $V_i$  is the sum of activity by governments, NPISH, and market-sector producers:

$$(24) \quad P_i^Q Q_i = \sum_S P_i^Q Q_i^S ; \quad P_i^V V_i = \sum_S P_i^V V_i^S ; \quad \Delta \ln V_i = \sum_S \bar{\sigma}_{S,i}^V \Delta \ln V_i^S,$$

$$(25) \quad P_i^V V_i = \sum_S P_i^Q Q_i^S - \sum_S P_i^H H_i^S = \sum_S P_i^L L_i^S + \sum_S P_i^K K_i^S,$$

where  $S$  is an index of sectors within industry  $i$  and  $\bar{\sigma}_{S,i}^V$  is a given sector's Divisia share weight in total industry value added. Now for each  $S$ , let capital payments be determined residually:

$$(26) \quad P_i^{K^S} K_i^S = P_i^V V_i^S - P_i^L L_i^S,$$

in which case industry value added productivity change  $\Delta \ln A_i$  can be expressed in the following equivalent ways:

<sup>12</sup>Imputing a return to government capital is a common move by productivity researchers interested in total economy performance measures; see, for example, the works of Jorgenson and associates conducted for the U.S. (e.g. Jorgenson *et al.*, 2005). The imputation also has been made in the official U.S. total economy multifactor productivity estimates issued by the BLS (Harper *et al.*, 2009). From 2002 to 2006, the adjustment averages 3.9 percent of GDP (calculated using Harper *et al.*, 2009, table 5).



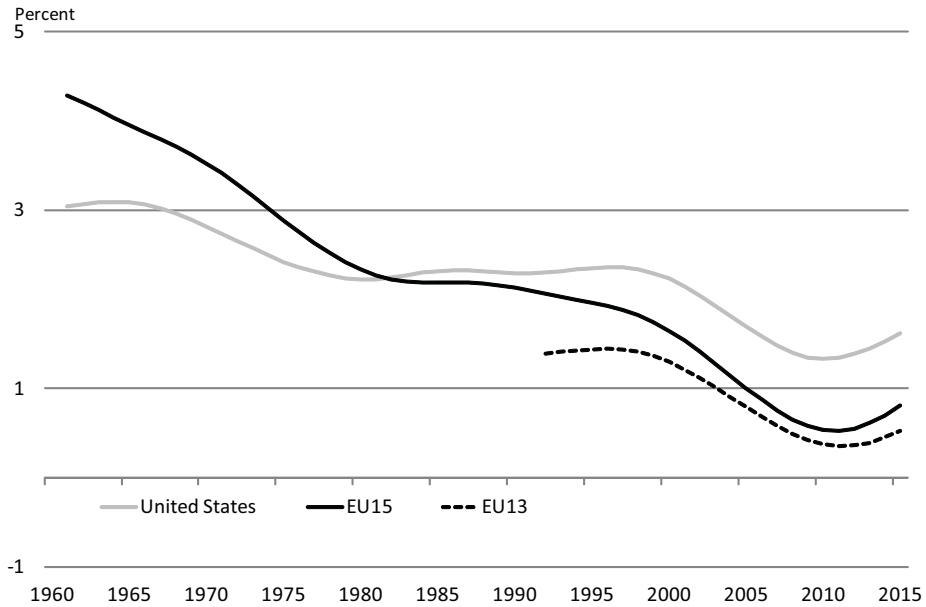


Figure 3. Social Rate of Time Preference, 1961–2015

Note: EU15 excludes Luxembourg; EU13 refers to the most recent EU accession countries.

Sources: Corrado and Jäger (2015), based on total consumption per capita data and forecasts from the AMECO database (see note to Figure 1) and Hodrick and Prescott (1997) filter.

$$\begin{aligned}
 \Delta \ln A_i &= \Delta \ln V_i - \bar{v}_i^L \Delta \ln L_i - \bar{v}_i^K \Delta \ln K_i \\
 (27) \quad &\equiv \sum_S \Delta \bar{\sigma}_{S,i}^V \ln V_i^S - \sum_S \bar{v}_{S,i}^L \Delta \ln L_i^S - \sum_S \bar{v}_{S,i}^K \Delta \ln K_i^S \\
 &\equiv \sum_S \bar{\sigma}_{S,i}^V \Delta \ln A_i^S,
 \end{aligned}$$

where  $\bar{v}_{S,i}^K$  is capital's Divisia share for sector  $S$  in industry  $i$  based on equation (26). Note that the technology for producing  $i$  is assumed to make no material use of intermediate inputs produced elsewhere in industry  $i$ .

Consider now  $\Delta \ln A_i^G$  for the non-market sector portion of total industry  $i$ . Adding a net return to non-market capital adjusts value added and capital compensation equally, and real output and capital contribution quantity change *within the sector* equally too, with the result that estimated  $\Delta \ln A_i^G$  is unaffected by the imputation. But as equation (27) also makes clear, the measured contributions of  $\Delta \ln A_i^G$ ,  $\Delta \ln K_i^G$ , and  $\Delta \ln V_i^G$  to their respective industry  $i$  aggregates *are* affected. All told, both for industries and the total economy, *the contribution of non-market activities will be understated* (as in under-weighted) unless a net return to capital is imputed. A set of accounts that (1) cross-classifies industry-level information by institutional sector based on national accounts data and (2) includes a return to capital compensation in the general government and NPISH subsectors

circumvents this problem and is especially relevant for total economy productivity analysis.<sup>13</sup>

What rate of return should be used? Studies that impute a return to non-market capital to total economy productivity analysis use different approaches to determining the appropriate rate. Most studies do not embrace the social welfare framework of Section 3, however, and that framework naturally suggests an approach based on the Ramsey (1928) equation for the social rate of time preference (SRTP). The case for using the SRTP as the return to public assets is set forth in the OECD capital manual (OECD, 2009b) and Corrado and Jäger (2015). Estimates developed in Corrado and Jäger (2015) using the Ramsey formula are shown in Figure 3. As may be seen, the SRTP for Europe and the U.S. trends downward, on balance, over time. This result is unsurprising, given the relatively slow rates of growth of consumption per capita in these economies after 2005. The SRTP is a good option for national accounts as it is relatively easy to compute, and some governments already use SRTP as a hurdle rate for public projects.

## 5. CONCLUSIONS

This paper has attempted to complete the accounting of intangible investment to cover the public sector. The implementation of the framework of this paper, which centers on the capitalization of public intangible assets as listed on the right-hand side of Table 2, makes possible the generation of new data on the evolution of productivity and living standards, as well as new empirics for the analysis of public policies supporting their growth.

The framework set out in this paper has three key features: First, it covers the total economy in a coherent manner by placing public capital on the same footing as private capital; besides capitalizing the public counterparts to the intangible assets set out in Corrado *et al.* (2005), this requires imputing a real net return to public capital as has long been done by Dale Jorgenson and associates (e.g. (Jorgenson *et al.*, 2005)) and recently implemented in official total economy productivity measures for the U.S. Second, it sets out how public investments in human capital via schooling can be treated as additions to wealth and saving within the current GDP production boundary by following the logic used by Ruggles (1983) and Moulton (2001) to argue that spending on consumer durables is household saving. Third, it includes social welfare in productivity analysis by following Jorgenson and Landefeld (2006) and exploiting information on real net expenditure and real saving in national accounts. As we noted, capitalization of public intangibles may alter the relative trajectories of the level of living as compared with multifactor productivity, and computing trends in both measures presents a more complete picture of economic growth.

<sup>13</sup>Note further that aggregation in such a database can proceed along multiple lines, giving rise to the possibility of computing aggregate productivity from: (1) a “one-step” procedure (aggregating over all assets and worker types to obtain aggregate capital services, aggregate labor services, and aggregate productivity); and (2) a multiple-step procedure, say, from sector-by-industry productivity to industry productivity (or to sector productivity), and then from industry (or sector) productivity to total economy. Following Jorgenson *et al.* (2005), one can interpret differences between the one-step and multiple-step total factor productivity measures as “reallocation” effects; for further discussion, see also Baldwin and Gu (2007), Oulton (2007), OECD (2009a, pp. 150–1), and Jorgenson and Schreyer (2012).

After reviewing the nature of public-sector economic activity and how it is measured in national and industry accounts, the paper points out some basic changes to the SNA that are needed for the analysis of the public sector and economic growth. First, data on industry output and inputs need to be disaggregated according to institutional unit, and a return to non-market capital needs to be imputed. Second, public payments to industry need to be included in industry-level gross operating surplus; and, third, key components of government expenditure by function of government by function of government (e.g. public funds for extramural R&D and worker training) need crosswalks to kind-of-activity classifications used for industries. These needs, plus the fact that not all intangible assets are now capitalized in national accounts, frame the broad outline of the challenges presented by recognizing public intangibles and analyzing the public sector in a growth framework.

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