Public Intangibles: The Public Sector and Economic Growth in the SNA

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Abstract

In this paper we present the theoretical framework for analysis of public and non-profit sectors as developed under the SPINTAN (FP-7) project. A specific measurement goal of the project is the construction of satellite accounts that capture public investments, tangible and intangible, at the level of detail needed for the economic analysis of impacts of public policies influencing economic growth.

Many of the challenges faced by the SPINTAN project are rooted in conceptual or empirical national accounting issues that SNA2008 (or its practice) does not fully clarify (or fully satisfy). The paper is organized around these challenges. We find as *desirata* the ability to construct a database that (a) imputes a net return to government capital, (b) disaggregates industries of interest by institutional sector, (c) includes data on external funding of R&D performed by private enterprises, (d) uses industry capital compensation measured to include all public payments, and (e) contains a crosswalk for each component of government expenditure for each function of government to an industry of interest.

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Analysis of an economy's performance requires data on public investment and estimates of how these investments impact private sector outcomes. The SPINTAN project aims at discovering the theoretical and empirical underpinnings of public intangible investments and public policies towards those investments. It widens work carried out in previous FP7 projects by including the nonmarket sector in the Corrado, Hulten, and Sichel (2005, 2009, hereafter CHS) framework for analyzing the contribution of intangible capital to economic growth.[1] The CHS framework was developed for application to the market (or business) sector, and thus considerations that arise in a public context require extension and modification.

The primary purpose of this paper is to review and analyse key issues with regard to the boundaries of public intangibles and to offer a general accounting framework that facilitates the estimation and analysis of public sector activity consistently across countries. Our goal is to be able to construct satellite accounts that capture public investments in intangibles at the level and detail needed for economic analysis of a wide set of public policies. Insofar as possible, we do this using a national accounts approach and national accounts data. In this regard, the imminent forthcoming capitalization of R&D in the national accounts of European countries presents an opportunity for discussion and illumination of many of the principles involved.

revise This paper has four major sections. In the first, we review the scope, goal, and other preliminaries, including terminology. In the second, we set out two broad categories of assets we propose to measure (1) information, scientific, and cultural assets and (2) societal competencies. We also include a list of components for each major category. Then we lay out our basic approach for analyzing public investments and public capital, from which the measurement needs are obtained. We present an accounting treatment of education services as changes in societal capital, discuss the importance of the mixed and special nature of certain government functions (health, education, cultural activities), note how a rate of return that must be assigned to capture services flows from public capital, and present adjustments to national accounts when new public assets are recognized. A final section concludes and summarizes.

[1] COINVEST, EUKLEMS, INDICSER, INNODRIVE, and WIOD.

1 Scope, Goals, and Challenges

Before we review theoretical elements, it must be said that SPINTAN's conceptual framework for the measurement of public intangibles is formulated with the analysis of certain topics in mind. These topics are: health and education, culture and the arts, science and the economy, and information and the economy (i.e., not the environment, not mass transport, etc.). Even so, because the impact of public investment in a particular asset type, scientific R&D, say, depends on other public investments (e.g., education), other types of private investment (physical, human, and intangible), as well as framework conditions (e.g., intellectual property policies), the subject matter we are dealing with is wide-ranging.

As we proceed to expand the existing intangibles framework, broadly speaking we continue to treat the current scope of GDP as our production possibilities frontier. In other words, while we consider nonmarket production by public and nonprofit institutions, *nonmarket production by households is excluded.* Many challenges are nonetheless encountered when estimating the value of public investments germane to this scope and our topics. Restricting the scope of nonmarket production does not, for example, circumvent the need to impute a rate of return to public capital formation for coherency of total economy productivity analysis. Nor does it help with certain measurement and research challenges, such as how to account for cultural assets, many of which are not, strictly speaking, intangible assets but whose intrinsic value to citizens is incalculable and therefore often described as "intangible."

Indeed defining what we mean by public investment (an issue we will discuss in a moment) presents challenges. Finally, the limitations of the currently available data on *real* public outputs (e.g., public safety, education, health care) constrain our ability to reliably estimate the impact of public investments on the wider economy. An understanding of how real output measurement methods differ across the EU and other countries needs to be a component of the comparative productivity analysis of public intangibles, e.g., as provided for health care spending by Schreyer and Mas (2013).

1.1 Preliminaries and Main Aggregates

The SPINTAN measurement goal at its most practical level is to complete the coverage of intangible investment by industry, making possible analysis of productivity for the total economy based on a complete accounting of intangible capital *inputs.* Most existing estimates of intangible assets, e.g., INTAN-Invest,[2] cover a *subset of industries* in the economy that productivity researchers refer to as the "market" sector (e.g., Timmer, O'Mahony, Inklaar, and van Ark, 2010). SPINTAN will thus estimate the intangible capital of "nonmarket" industries.

"Nonmarket" industries consist of the following NACE Rev. 2 sections: (1) public administration and defence; (2) education; and (3) human health and social work activities.[3] To this list we add (4) scientific research and development and (5) arts, entertainment and recreation because these industries contain significant nonmarket production in many countries (e.g., federally-run research laboratories and public parks, libraries, and museums); see table 1 below.

Table 1: **SPINTAN Industries of Interest**

NACE SECTION	INDUSTRY TITLE	NACE NUMBER
MB	Scientific research and development	72
O	Public administration and defence; compulsory social security	84
P	Education	85
QA	Human health activities	86
QB	Residential care and social work activities	87-88
R	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities	90-91
	Gambling and betting activities; sports activities and amusement and recreation activities	92-93

NOTE—NACE Rev. 2.

The use of "market" vs. "nonmarket" as descriptors for groupings of industries is not precise because an industry can reflect activity carried out by a mix of producers, as is evident with NACE Section R and the larger section of which NACE Section MB is a part.[4] Furthermore, in some countries certain NACE industries not listed in table 1 have significant government or nonmarket production, e.g., transportation and utilities. And of course, certain other industries not listed, e.g., those that receive government funds for the conduct of R&D, are indeed of interest, but such industries tend to have little nonmarket production other than own-produced intangible assets for which available estimates (either national accounts or INTAN-Invest) have already accounted.

[2]INTAN-Invest is an unfunded research collaboration that maintains and extends work done under COINVEST and INNODRIVE. Until very recently, INTAN-Invest estimates were available for the aggregate market sector only, but now estimates according to 8 disaggregate industry sectors for 23 EU member states are freely available at www.INTAN-Invest.net. See Corrado, Haskel, Jona-Lasinio, and Iommi (2013, 2014) for further details, and also Niebel, OMahony, and Saam (2013) for related work conducted under INDICSER.

[3]The usual grouping of nonmarket industries also includes real estate, which is not discussed in this paper.

[4]Appendix table A1 (page 41) shows the full intermediate structure of NACE Rev. 2.

National accountants classify economic activity according to *institutional sectors*, not industries. Figure 1 illustrates the relationship between national account sectors and the nonmarket/market conceptual distinction in a simplified way. The national accounts *nonmarket* sector is found above the horizontal line in figure 1 and consists of general government (GG) and nonprofit institutions serving households (NPISH). The *public* sector is found to the left of the vertical line in figure 1 and consists of general governments and state-owned (or government) enterprises (SOEs, or GEs). Investment activities of the general government and nonprofit institutions (NPI, mainly NPISH) are the focus of SPINTAN.

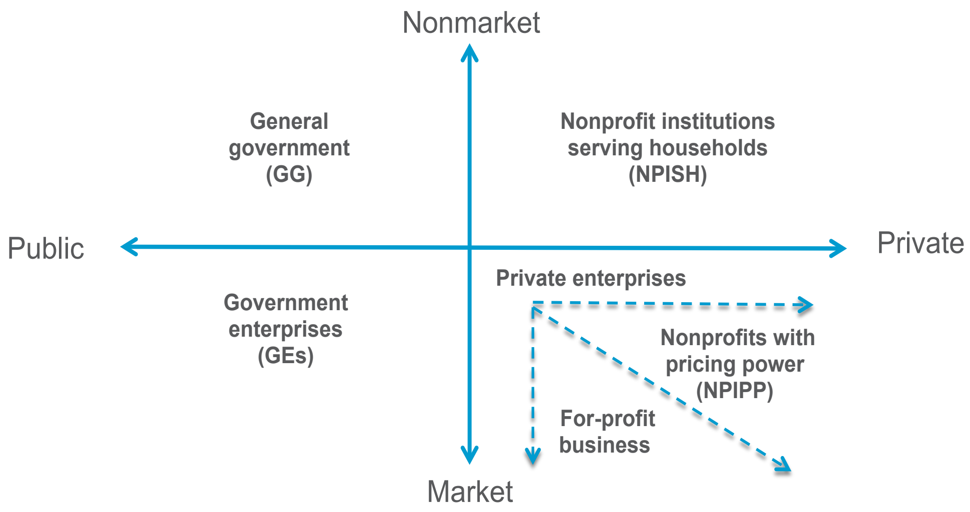

Figure 1: Enterprise types in the SNA: Groups according to control (private, public) and ability to charge economically significant prices (market, nonmarket)

It is important to recognize that many nonprofit institutions are considered market producers according to the System of National Accounts (SNA) because they are able to charge "economically significant" prices.[5] In other words, such institutions are not NPISH but rather are NPIPP (nonprofit institutions with pricing power) where NPI=NPISH+NPIPP. Educational institutions, for example, can be public or private, and among the latter, while most are nonprofit institutions, some are classified as market producers, i.e., they are in the NPIPP segment of the lower right quadrant of figure 1. The arts and entertainment industry is equally diverse

[5]The SNA instructs that producers be classified as businesses if they are able to charge economically significant prices, e.g., schools, colleges, universities, hospitals constituted as nonprofit institutions are to be classified as market producers when they charge fees that are based on their production costs and that are sufficiently high to have a significant influence on the demand for their services (European Commission et al., 2009; para 4.88). In practice, for European countries, the European System of National and Regional Accounts (ESA) implement this as a quantitative criterion, considering economically insignificant prices to be those that cover less than half the cost of production.

in terms of its institutional composition, as is health and social services in many countries. All told, all but one of the industries that we work with (NACE 84, public administration and defence) consists of a mix of institutions: business (whether for-profit or nonprofit), nonprofit institutions serving households, and general government.[6]

The distinction between institutional sector and industry is very important because the information provided by the available data is quite different. Data by institutional sector are available for the whole sequence of national accounts (thus providing a comprehensive description of the economic activity of a country) but only with a rather aggregated set of information on production activity (e.g., only data on total output and total intermediate costs, and usually with no further information on the products that are produced and purchased). The detailed description of the production process is provided by supply and use tables that typically are available only by industry, and from which production accounts for productivity analysis by industry may be derived. Before we elaborate further on the consequences of these distinctions for policy analysis, let us review the main aggregates in each area to fix ideas regarding magnitudes involved.

Gross value added in general government as a percent of GDP in the European Union and the United States from 2008 to 2013 is shown in figure 2. As may be seen, general government for the EU28 as well as the EU15 averages 13.4 percent of GDP, with individual countries such as Sweden, Finland, and France in the 16–18 percent range, and the United Kingdom and Germany much lower at about 10–12 percent. Gross value added in "nonmarket" industries is shown in figure 3; the sum of these activities—which of course covers market and private NPISH as well as nonmarket government or government-run institutional units—averages 18.3 percent of total GDP in the EU28 (18.7 percent for the EU15) and 22.1 percent in the United States. All told, therefore, we will be estimating intangible capital for roughly 1/5 of these economies. Perhaps surprisingly, but estimate that the U.S education sector is about 1 percentage point larger than that in the EU (in value added terms), the U.S. health and social services sector about 2 percentage points larger, and the U.S. R&D and Arts, Entertainment, and Recreation services industries a combined 3/4 percentage point larger.

Note further that, while internationally comparable figures for industries blended by institutional sector are available for Europe on the Eurostat website, official industry data for the

[6] Note that we do not concern ourselves with certain NPIs, such as religious organizations, or membership organizations serving business. The two-digit structure of the classification of purposes of nonprofit institutions serving individuals (COPNI) is shown as Appendix table A2 (page 42), in which it can be seen we cover three of the nine one-digit categories.

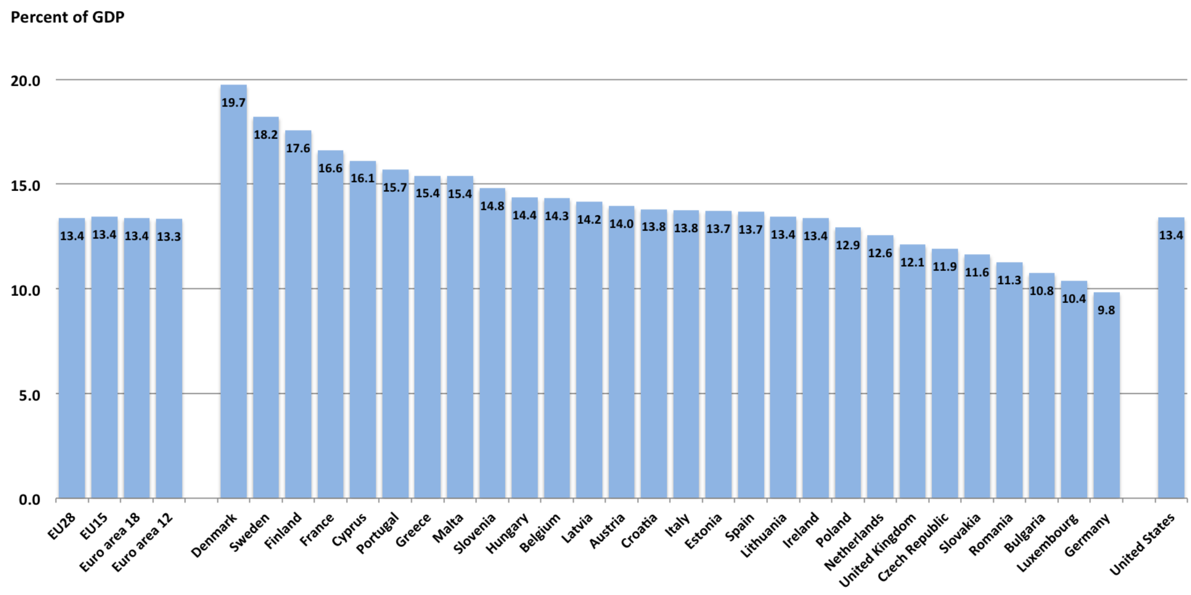

Figure 2: Gross Value Added in General Government, EU28 and United States, 2008 to 2013. Source: Eurostat for EU; EU28, Euro area 18, Estonia, and Poland are for 2010 to 2013 only. U.S. statistics are on an ESA/SNA basis as estimated by the authors; U.S. official GVA for general government is 1.4 percentage points lower.

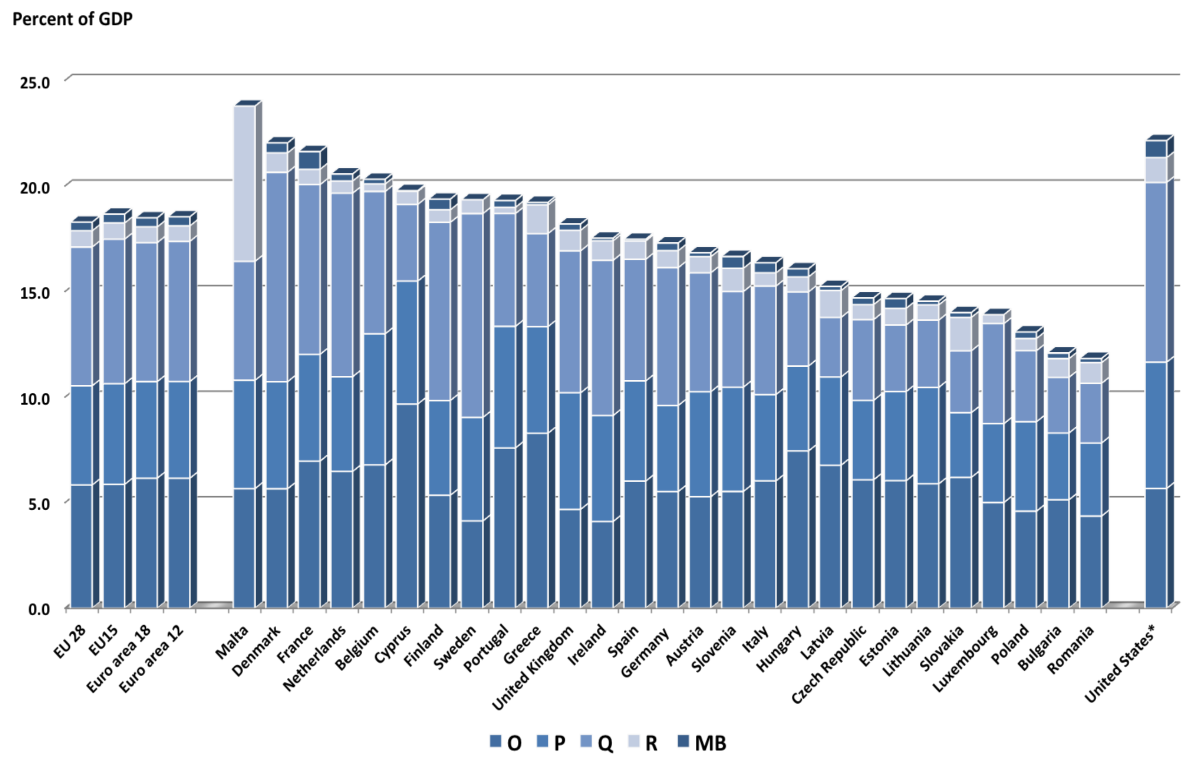

Figure 3: Gross Value Added in "Nonmarket" Industries, EU28 and United States, 2008 to 2013. Source: Eurostat for EU, authors' calculations for the United States. See table 1 (page 5) for definition of industry sectors in legend.

United States (also Canada, to the best of our understanding) do not necessarily follow this convention. In Canada and the United States, the general government and government enterprises sectors are recorded as separate industries in industry and input-output accounts, with the result that the available industry data pertains to private enterprises, i.e., they cover activity to the right of the vertical line in figure 2.[7] The U.S. figures plotted in figure 3 are thus estimates in which data classified by functions of government have been blended with the available data on private industry value added to create data comparable to that reported for Europe.

As just seen, value added in sectors MB plus O–R is greater than in general government—and that value added in sector O alone (Public Administration, Defense, and Compulsory Social Security) is much less than general government. What is the difference between general government and sector O? Is sector O what's left over after stripping out education and health? Frequently that is all that is done to adjust North American industry data to European conventions, but technically other industries also require adjustment. We now turn to a more thorough discussion of data on government activity.

1.2 Measurement of Government Activity

Functions of Government. The functions of government, according to economics textbooks, include maintaining 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 2 below shows a list of the ten COFOG categories used to classify government expenditures. The categories are largely self-explanatory except 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, however, expenditures on such items specifically related to one of the other functions, e.g., R&D related to defense is included in defense, R&D related to health is included in health, etc.

[7] In other words, U.S. public schools and universities, Veterans Administration Hospitals and the like are *not* included in the U.S. education and health industry; the U.S. postal system is *not* in the transportation sector, etc., whereas such organizations would be spread across industries based on homogeneity of production process if European conventions were followed.

Table 2: **Functions of Government**

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

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.

Looking at the list of items in table 2, the three functions circled, health, education, and culture and recreation correspond rather directly to three of the SPINTAN topics. They also correspond to certain of our industries (see again table 1, page 5). R&D, as just noted, is an activity that tends to be sprinkled across several COFOGs, but all told each activity in table 2 involves the provision (or funding) of a service activity. COFOG data then are a breakdown of government expenditure according to service type, and as such, COFOG data may be mapped to NACE industries as well as to income and final demand. Such mappings are essential for modeling and determining how government expenditures are linked to industry activity recorded as blended data.

Government Expenditure. Government expenditure includes payments for all government consumption and investment, as well as for payments for subsidies, transfers, and interest on public debt. In national accounting the acquisition (or production) of goods and services for community use by the government is classified as final 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 benefits, such as infrastructure or research spending, is government investment (or capital expenditure). These 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. As a consequence, when one hears statements such as “government spending is 50 percent of GDP in the EU”—a generally accurate metric (see figure 4)—it must be borne in mind that a significant portion of government expenditure is not final spending that is included in GDP (or value added as we have already seen), and thus private final spending is *not* the remainder. A framework for SPINTAN requires a more refined view on how to think about the contribution of public spending to production, income generation, and consumption.

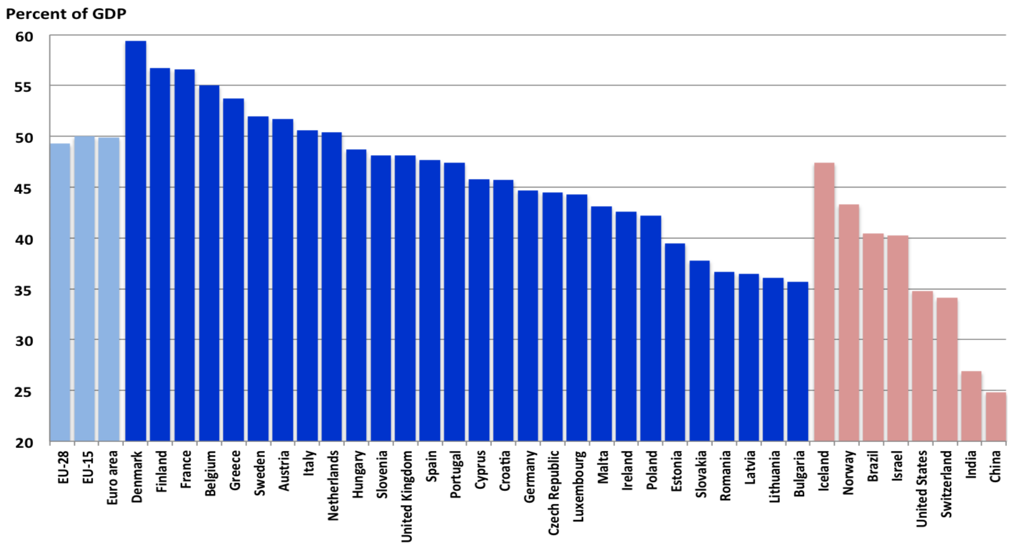

Figure 4: Government Expenditure, EU-27 and Selected Countries, 2012: Percent of GDP. Source: Eurostat, U.S. BEA, IMF

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 consumption. Indeed the bulk of the EU’s government expenditure—nearly 40 percent of GDP (2002–2012 average)—is for maintenance of household income whereas the comparable U.S. figure is less than 25 percent.

Capital transfers, assuming for the moment these are domestically bound, primarily are investment grants, which are 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, a matter discussed more extensively in section 4 below. 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 may be used for the revitalization of a rural area, or they may be for explicit agricultural, transportation, energy, or housing investment projects.

From a conceptual point of view, one might think that investment financed from the budgets of public entities is public investment. But under SNA/ESA guidelines, gross fixed capital formation (GFCF) by general government *excludes* investment grants and all investment by GSEs; see again figure 1. This means that when, say, GSE-run power companies receive public funds for expansion of the electric grid, or certain universities receive public funds to build new science education facilities, the investment *may* not appear as government gross fixed capital formation in national accounts. In this sense, general government GFCF potentially excludes a significant portion of publicly-financed investment.[8]

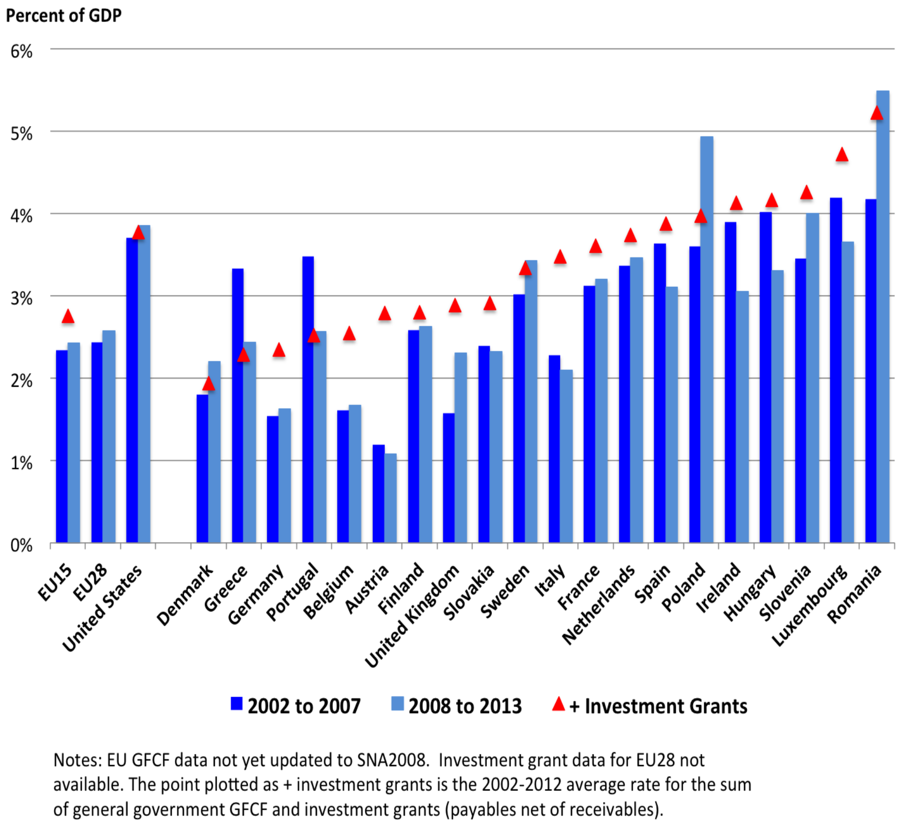

Figure 5: Government Investment in the European Union and United States, 2002–2012: Percent of GDP. Sources: Eurostat, U.S. BEA (SNA table)

The rate of government investment (i.e., investment relative to GDP) in the European Union and United States is shown in figure 5. The red triangles include investment grants and the blue bars show gross fixed capital formation. All told, for most of the countries plotted, the public investment rate (i.e., including investment grants) ranges from 2 to 4 percent of GDP, i.e., public investment is very small relative to total public expenditure.

A very important first point to make regarding this figure is that, as of this writing, data for

[8]Government GFCF also excludes changes in public financial ownership of private companies and nonproduced assets, but these tend to be rather small compared with investment grants.

the European Union do not yet reflect R&D capitalization whereas data for the United States do. After updating the EU data to reflect R&D capitalization, EU government investment rates will move closer to the rate for the United States. Another point regarding figure 5 is that including investment grants raises the rate for the EU15 aggregate by .4 percentage points, whereas the U.S. rate is unchanged.

The most striking feature of figure 5 is the variation in relative importance of investment grants across EU countries; they range from small negatives or nil for some to 1+ percentage points for others (Austria, Italy, and UK). One source of these differences is simply governance structures, i.e., central government investment grants may be administered by other levels of government (in which case the transfer nets out in general government, and the investment appears as government GFCF) or by private industry (in which case a sectoral transfer occurs, and the investment is recorded as private GFCF). These are matters that loom large in national accounting but are of little consequence when assessing the size and direction of a country's rate of public investment. Moreover, information on the industry distribution of investment grants is not readily available, and thus we do not yet know if they loom large in the capital expenditure of FOGs in our topic areas.

A final point is that the likely substantial impact of R&D capitalization on the rate of public investment underscores the relevance of SPINTAN's work to identify and estimate non-R&D public intangibles. R&D capitalization added more than 1 percentage point to the U.S. government investment rate, thereby presenting a very different picture of the relative size of government investment in the overall economy. Will this also be the case for non-R&D public intangibles after SPINTAN? In the next two sections we lay the conceptual groundwork for the analysis we pursue to answer that question.

2 Asset Boundary

What intangible investments are undertaken by government and nonprofit producers? What societal assets are produced by these organizations? These are *very* different questions. We start with the first, which is answered by appealing to CHS.

2.1 CHS-type Assets

Table 3 summarizes the CHS list of intangibles assets (on the left) and maps them to the public or nonmarket 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's different across the two columns, let us make a few points about the similarities. First, while the character of some assets are rather different when produced by public institutions, e.g., R&D, brands, and mineral exploration, one 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 of course far closer.

Table 3: **Knowledge Capital in a Total Economy**

Market Sector		**Nonmarket Sector**	
Computerized Information		Information, Scientific, and Cultural Assets	
1	Software	1	Software
2	Databases	(2)	Open data
Innovative Property			
3	R&D, broadly defined to include all NPD costs	3	R&D, basic and applied science
4	Entertainment & artistic originals	(4)	Cultural and heritage, including arch. & eng. design
5	Design		
6	Mineral exploration	5	Mineral exploration
Economic Competencies		Societal Competencies	
7	Brands	6	Brands
8	Organizational capital (a) Manager capital (b) Purchased organizational services	(7)	Organizational capital (a) Professional and manager capital (b) Purchased organizational services
9	Firm-specific human capital (employer-provided training)	8	Function-specific human capital (employer-provided training)

NOTE—NPD=New Product Development, including testing and spending for new financial products and other services development not included in software or conventional science-based R&D.

The circled items are rather different in a public sector context. Open data refers to information assets in the form of publicly collected data issued and curated for public use. This runs the gamut from patent records to demographic statistics and national accounts to geographic information and local birth/death records.[9] After asking the question, What are public sector intangible assets in the United Kingdom? 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. The category includes spending on statistical agencies, the weather service, federal libraries, nonpartisan reporting and accounting offices, and the patent office, which suggests information assets loom large in the United States as well. Indeed, it has long been held that the U.S. Census Bureau's release of its TIGER (Topologically Integrated Geographic Encoding and Referencing) dataset—in 1991—bootstrapped the country's booming geospatial industry.

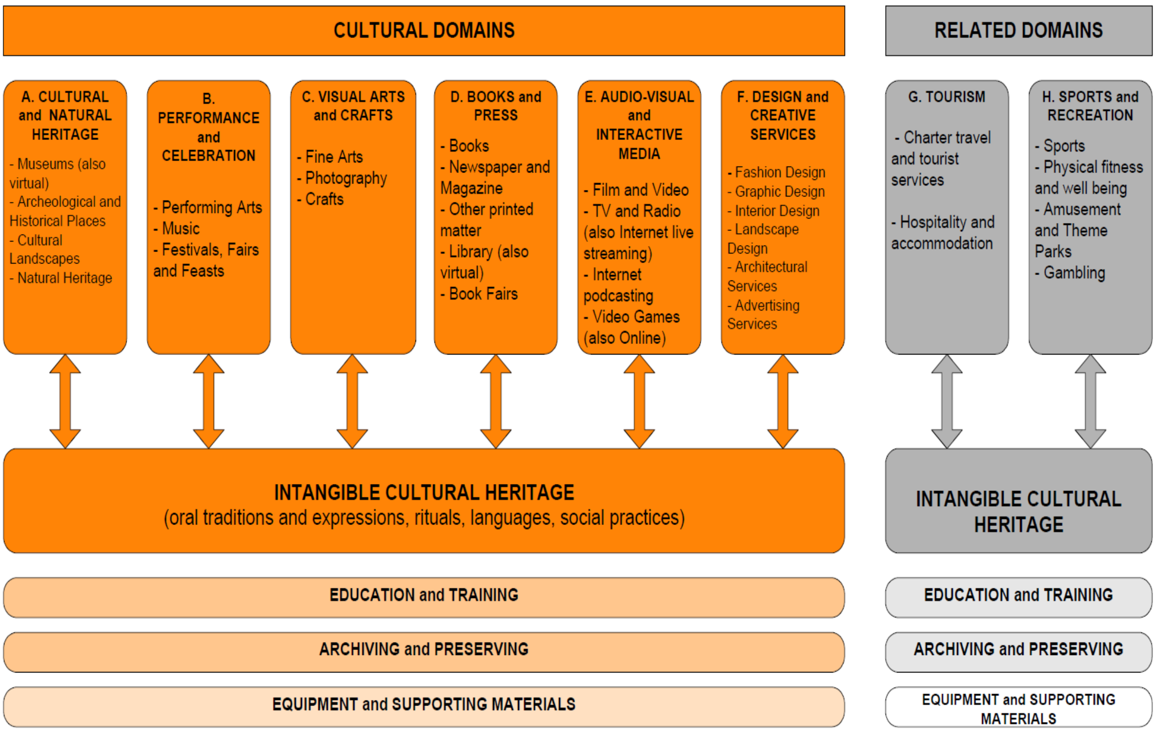

Figure 6: UNESCO Framework for Statistics on Cultural Domains

Cultural assets are public intangible assets whose services are used in production in cultural domains dominated or influenced by the public and nonmarket sectors; cultural domains as defined by the UNESCO Framework for Cultural Statistics are shown in figure 6. 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 (especially in domains A, B, and C) needs to identified and newly capitalized.[10] Note that cultural assets are notionally grouped

[9]Appendix table A3, page 43, reports an extensive list compiled for the MEPSIR (Measuring European Public Sector Information Resources) project.

[10]Note this assumes national statistical offices have not already done so as part of their efforts to capitalize

with public architectural and engineering design, 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 would include the value of curative activities not normally capitalized in national accounts (a form of humanities R&D, if you will). An in-depth analysis and review of sources and methods used to estimate information assets and cultural assets in SPINTAN is forthcoming (**?**).

Finally, organizational investments on own-account (professional and manager time devoted to organizational innovation) take on a somewhat different character in a public setting (O'Mahony, 2012; Squicciarini and Le Mouel, 2012). This topic is also the subject of forthcoming SPINTAN background paper.

2.2 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, many years. This accords with the Oxford dictionary definition of infrastructure: the basic physical and organizational structures needed for the operation of a society or enterprise. Hospitals, educational institutions, public libraries, police stations and firehouses also are infrastructure according to this definition, but the reasons for thinking this have less, indeed very little, to do with the longevity and complexity of the physical equipment and structures involved in producing the underlying service. Rather than the usual economic notion of infrastructure as a capital-intensive natural monopoly (as in Gramlich, 1994), what is typically meant are the societal benefits—the spillovers, or externalities—that result from citizens "consuming" the service.

Over the past decade or so, the notion that governments also provide "soft" infrastructure via the nature of the services themselves has gained recognition based on a body of evidence that the economic benefits of providing such "social infrastructure" outweigh the costs and

artistic and entertainment originals. Unfortunately, this is difficult to ascertain because the published investment by asset type data for most European countries include a category called "other intangible assets" that (a) is defined as mineral exploration + artistic and entertainment originals, (b) is usually very small in magnitude, and (c) implies little or no public investment. An exception to (c) is mineral exploration in Norway. An exception to (a) and (b) is the United States where these assets are separately shown yet (c) holds true. It appears then that public cultural assets are in practice distinct from artistic and entertainment originals and investments in them need to be capitalized as public intangibles.

result in a net return on investment. From a SPINTAN measurement point of view, the issue is not so simple, mainly due to the fact that household production is outside the boundary of economic activity that we consider. Another matter is distinguishing between private and social benefits, or externalities. The existence of social benefits may have implications for policy, but their presence or absence says nothing about whether a service produces long-lasting returns or where the production of the capital (if indeed capital is being built) takes place. Consider now the topics of education and health, starting with education.

Education. Studies show convincingly that returns to education accrue to private individuals in the form of higher wages. There are no paybacks to producers of education services (taken as a whole, except perhaps very indirectly); nor do returns apparently accrue to society in the form of an extra kick to economy-wide productivity (i.e., a spillover) after accounting for the skill composition of the workforce.[11] With regard to the education process, its fundamental feature 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 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.

This human capital production process is out of scope for GDP. Inside that boundary, however, are investments that improve the capacity of the educational system to deliver improved teacher services without a commensurate increase in cost. For example, expenditures on teacher training would be considered investment in SPINTAN because benefits include increased effectiveness of the system to deliver educational services (not simply increased returns to individual teachers via higher wages).[12] All told, our analysis primarily focuses on the investments

[11] Corrado, Haskel, and Jona-Lasinio (2014) and Corrado and Jäger (2014) examine this topic in light of a literature that tends to not find excess returns to education at macro or industry levels. Both studies use a cross-country econometric approach, Corrado et al. (2014) at the "market sector" level for 10 EU countries from 1998 to 2007, and Corrado and Jäger (2014) at the NACE 2 industry-level (market sector industries only) for 8 EU countries from 2002 to 2011, and both studies detect evidence of productivity spillovers to increases in labor composition, i.e., workforce skill upgrades. This topic merits further investigation under SPINTAN.

[12] Yes, that teacher training is investment whereas the education of a teacher is not is akin to the much derided practice in national accounts that motor vehicles purchased by private enterprises or governments constitute capital formation whereas purchases by households do not. Indeed the reasoning is exactly the same: that services from household-owned vehicles are inputs to out-of-scope household production and thus not capital investment included in GDP.

needed to promote the organizational effectiveness of educational institutions, from classroom deployment of modern communication technology to research productivity.[13]

We believe, however, that it is possible to view the service capacity an education system as social infrastructure by carefully delineating the *intersection* of its economic activity with the JF model of human capital formation. The topic is thus revisited in section 3 below.

Health Care. Consider now the consumption and production of health care services. The same principles set out for education apply, but they don't lead to very clear answers. First, there is a vast literature studying the effectiveness (i.e., returns) to various treatments of various diseases. Unfortunately, this literature cannot be summarized as easily as the literature on the returns to education.

Second, the health care process is often modeled as the treatment of diseases, although the notion that households promote their own wellness through consumption of preventative care (vaccines) and engagement in wellness-enhancing activities (diet, exercise) is another approach. Does this wellness process work the same way as the educational process, i.e., as in building human capital? The answer would appear to be yes, but what is less than clear is whether a broader model in which household production plays a key part is more appropriate. What we can say, however, is that, as with with educational institutions, SPINTAN will study organizational capital (and of course ICT capital) and its effectiveness in promoting efficiency and productivity of health care institutions.[14]

Setting aside the location of production and whether health care spending is curative or preventative, let us simply assume that such spending creates benefits in the future and ask, To whom do these benefits accrue? Beyond the person or persons that benefit directly, the commonly held view is that society itself benefits because (a) future health care system costs are lowered, (b) workplace absenteeism is lowered, and (c) workforce capacity increases with greater human longevity. In this sense the commonly used framework for productivity analysis

[13]It is of course too early in experimenting with open online courses (MOOC) to determine the social benefits of very radical approaches to utilizing technology for reorganizing and "opening" educational services to the public at large.

[14]Note that the intangible capital literature does not capitalize employer expenditures on wellness. Such expenditures would appear to meet the criteria for investment even if production of human health is placed in the household sector. Although we are unaware of broad-based statistics on such spending, in the United States, where employers shoulder a large portion of health care costs, there appears to be a growing recognition that preventing disease and maintaining good health pay significant dividends to business. A recent RAND review of available studies (Mattke, S. et al. 2013) concluded that medical costs in the United States are reduced approximately $3.27 for every dollar spent on workplace wellness programs.

captures these benefits of human wellness, as the schematic in figure 7 shows. The schematic shows output-based links on the left and household income-based links on the right, thereby also illustrating the connections between the burgeoning literature on measuring societal well-being (e.g., OECD Secretariat, 2014) in which human health (esp., longevity) plays an important role.

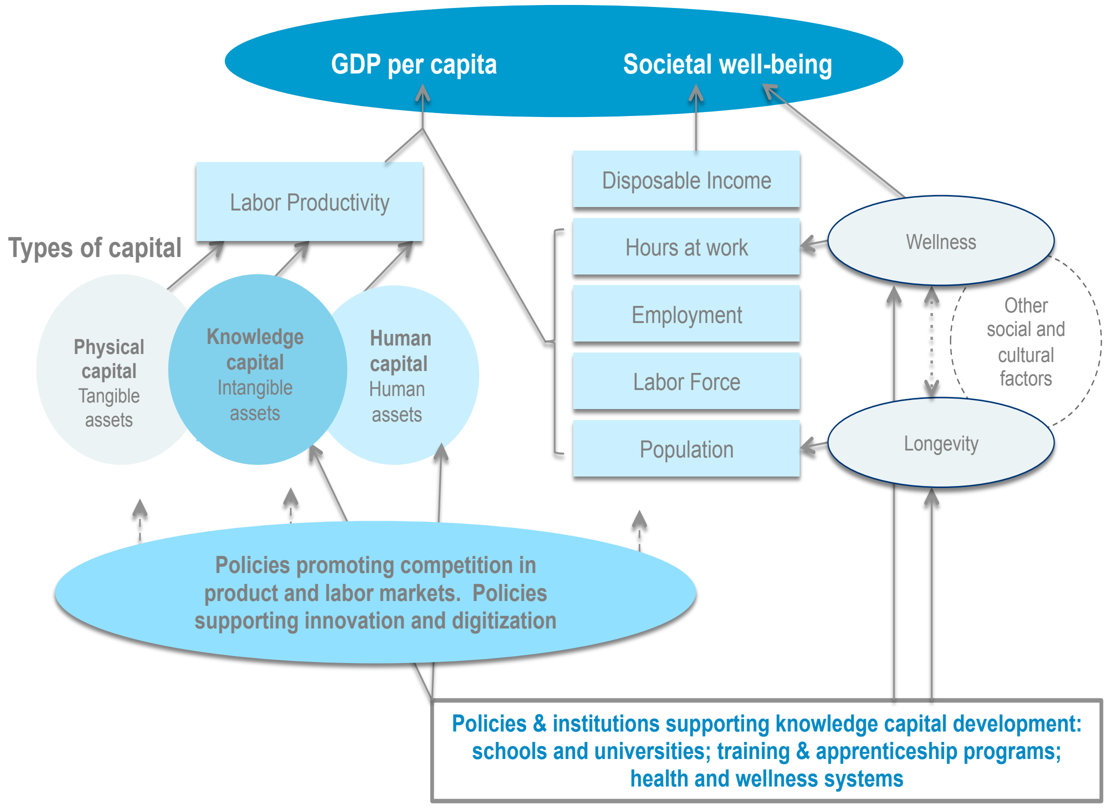

Figure 7: Links from Policies to Capital, GDP per capita, and Societal Well-being

3 Framework for Analysis

The scope of capital investment, or the asset boundary, 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 of time greater than one year. CHS grounded their definition of investment following the optimal growth literature (Weitzmann, 1976, 2003), namely, as spending designed to increase consumption in a future period.

An increase in consumption occurs via an expansion of the economy's productive capacity, and thus a production possibility frontier was explicit in the CHS framework. Indeed in the CHS framework the future benefits of investment spending were derived solely from private productive capital formation. A social welfare function also was implicit but analyzing welfare has not been a focus in the intangibles literature to date. Below we follow Jorgenson and Landefeld (2006) and take steps to incorporate social welfare in the analysis.

3.1 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:

$$V(C,I) = A \cdot X(L,K) \tag{1}$$

with sources-of-growth analysis written as:

$$\overline{w}_C \Delta lnC + \overline{w}_I \Delta lnI = \overline{v}_L \Delta lnL + \overline{v}_K \Delta lnK + \Delta lnA \tag{2}$$

where V is total real output (i.e., real gross value added), and $\overline{w}$ and $\overline{v}$ denote Divisia shares of outputs and inputs in current prices, respectively, in gross value added. Total real output is expressed in (1) as a production possibilities frontier for consumption (C) and investment (I), where C and I are produced from domestic labor (L) and capital (K) 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.

The capitalization of intangible assets produces a direct impact on the sources of growth via investment (I) and capital services (K) 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. pages 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:

$$Z(C,S) = B \cdot Y(L,N) \tag{3}$$

$$\overline{\omega}_C \Delta lnC + \overline{\omega}_S \Delta lnS = \overline{\nu}_L \Delta lnL + \overline{\nu}_N \Delta lnN + \Delta lnB \ . \tag{4}$$

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 LHS of equation (4) is the sum of the share-weighted growth of real incomes plus growth in the level of living, per the RHS of equation (4).

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 Weitzman.[15] Equation (4) shows that social welfare Z is affected by the capitalization of intangibles directly via changes to real saving S and net property income N, both of which are components of the economy's income and expenditure account.

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-Landefeld, page 88). As a practical matter, because of the close correspondence of the labor contributions to A vs 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 ΔlnB will be close to ΔlnA for economies with stable investment shares by asset type. A shift to shorter-lived assets, all else equal, creates a wedge between ΔlnA and ΔlnB (with $\Delta lnA > \Delta lnB$ during the transition period), whereas a shift towards long-lived assets has the opposite impact.

The above framework can be readily expanded to recognize that benefits from asset ownership accrue not only from capital formation but also from exchanges of "nonproduced" assets between business and governments, e.g., mineral or spectrum rights granted or sold to producer units by governments. The framework can also be adjusted to account for "inventories" of societal assets—such as schooling-produced knowledge assets—as we now discuss.

3.2 Schooling-Produced Knowledge Assets

This section sketches out a way to think of education services as producing a societal asset (i.e., a valuable) as opposed to regarding education services as an input to the production of human

[15] Note that aggregate real net expenditure/social welfare is not built from (or decomposed into) average individual social welfare and its distribution as in Jorgenson (1990) and Jorgenson and Slesnick (2014) although doing so would be a logical next step.

capital within households. It follows the logic of Ruggle's approach to accounting for consumer durables (Ruggles, 1983; see also Moulton, 2001) and the SNA's approach to the treatment of valuables.

Schooling as social infrastructure capital. The basic idea is that society's consumption of education services is in fact the acquisition of schooling knowledge assets ΔE whose change in value $P^{ES}\Delta E$ should be included in saving and wealth even though it is not used in current production (or consumed). Rather *the assets are held in inventory, within the school system*, until students graduate and enter the working age population, at which point the assets are withdrawn from the stock. In this view, the real output of an education system Q_{ES} is the knowledge stock of this year's graduates plus the increment to knowledge held by students still within the system, or $Q_{ES} = E^{Grads} + \Delta E^{InSchool}$.[16] This in turn implies $Q_{ES} \equiv \Delta E$ because at any point in time last year's graduates have been withdrawn from the stock (and entrants at the lowest level are assumed to have a zero stock).

The production function $\mathcal{F}^E$ for education services is then given by

$$Q_{t,ES} = \mathcal{F}^E(K_{t,ES}, L_{t,ES}) \tag{5}$$

which implies

$$E_t = \mathcal{F}^E(K_{t,ES}, L_{t,ES}) + E_{t-1} \tag{6}$$

where E_{t-1} is the beginning-of-period knowledge stocks held by this year's students, and education services production is the schooling-produced increment to those stocks. There is no depreciation of schooling-produced knowledge stocks while students are in enrolled in school. K_{ES} and L_{ES} are the education system's fixed capital and labor services inputs; intermediate inputs have been ignored.

These simple accounting relationships are directly related to the JF lifetime-income approach to human capital measurement. 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, Holmoy, and Haegeland, 2003). Our "inventory" approach is a somewhat different adaptation of the JF model for inclusion in conventional accounts, but like the JF work and as discussed in Christian (2014), our approach includes values, volumes, and

[16] Note the similarly of this syntax to "production = sales+inventory change."

prices as basic elements, and in that capacity embraces human capital within the conventional boundary of the SNA.

Our concept of schooling-produced knowledge assets E and human capital as modeled in the labor literature is as follows: Mincer's seminal contribution (Mincer, 1974) mapped the theory of investments in human capital to the empirical literature on the returns to schooling. According to Mincer's model, at the end of each period of schooling, individuals (a) have a level of human capital consistent with that level of schooling, and (b) choose the optimal level of schooling (i.e., years in school) up to the point that the opportunity cost of one more year of schooling equals foregone earnings. This implies an individual's return to schooling must be commensurate with these foregone earnings. In Mincer's canonical wage equation, in which individual j's wage is a return to human capital, there are two key terms, one a return to schooling and the other a return to work experience, suggesting $HC_j = E_j + LX_j$ where HC_j is individual j's total human capital and LX_j is the portion acquired through work, i.e., labor market, experience.

From the point of view of the schooling system, this suggests schooling-produced knowledge assets can be defined as the present discounted value of expected wages of graduates upon entry to the labor market, i.e., when the return to experience is virtually nil. Note that one still needs to account for returns to student time spent in school if schooling extends beyond a compulsory term, in which case the valuation basis becomes the labor market entry wage adjusted for the opportunity cost of time spent in school.[17] The JF model is not reviewed in any detail here but it is important to note that the model distinguishes across levels of schooling j at a point in time, and in its simplest form as applied to our context, given expected labor market entry wages w_j, opportunity cost c_j, and school enrollments S_j, the real value of knowledge assets

[17] A simple way to think of this valuation basis is as follows: suppose workers in the economy are either graduates or non-graduates, i.e., the latter have some schooling but earn a lower nominal wage, i.e., $W_{ng} < W_g$. Let there be N_g newly minted graduate workers whose compensation has two components, (1) a return to the value created by the education system $P^{ES}N_g$, and (2) a return for the opportunity cost of time spent in school, the value of the foregone labor market experience due to time spent in school, $P^{OC}N_g$, where the value of $P^{OC}N_g$ depends on the graduate/nongraduate wage differential and the number of years from the end of compulsory education until graduation. Because this value is recovered over a lifetime of working, the per period nominal opportunity cost charge $C_g = rP^{OC}$, where r is a private rate of return, is rather smaller. (The simple expression $C_g = rP^{OC}$ treats the lifetime of work as infinite, and as a practical matter discounting over 40 years (or fewer) at rates below 10 percent yields a value for C_g that can be materially smaller than P^{OC}/r.) Thus we can express the compensation of new graduates as

$$\text{(1-n)} \qquad \begin{aligned} W_g N_g &= r(P^{ES} + P^{OC})N_g \qquad \text{or} \\ NetW_g N_g &= (W_g - C_g)N_g \\ &= rP^{ES}N_g \end{aligned}$$

where $NetW_g N_g$ is the nominal net earnings of new graduates from the school system and P^{ES} is the asset price of schooling-built knowledge assets E.

produced by schooling may be computed as follows:

$$E = \sum_j \frac{S_j(w_j - c_j)}{(1+\rho)^{y_j}} \tag{7}$$

where ρ is a social discount rate and y_j is years to graduation of students enrolled in level j. Although not immediately apparent from (7), drop-out rates and graduation rates at each level of schooling are built into components of the measure, and low productivity of a school system diminishes the quantity of schooling-produced knowledge assets.

Besides relative wage rates, labor market conditions are not factored into the above set up, i.e., probabilities that students will be employed or not upon graduation or leaving the system are not factored into the calculation of E. When we take the step to consider knowledge assets produced and held in school systems as societal assets, and thereby schools 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). We leave the analysis of this topic for later study, however.

Current Account, Capital Account, and Price Index. When schooling is treated as social infrastructure, consumption is decreased by the cost of the net acquisition of knowledge gained during the year due to schooling and net saving is increased accordingly. The value of these magnitudes is the currently estimated value for the consumption of education services in national accounts. As previously noted, there is no depreciation-like charge to partially compensate for the decrement to consumption because there is no economic depreciation of the asset produced by schooling (it is not being used in current production). The counterpart in the capital account is an increase in investment equal to the net acquisition—which is equal to the decrement in consumption so there are no effects on nominal GDP.

Net acquisition in the case of marketed goods is simply purchases less disposals, as in accounting for inventory change. This is why the counterpart in the case of schooling is the full cost of education services because, if the number of students in a school system decreases (due to high net graduation rates, or for that matter, high drop-out rates), then costs are lower and "disposals" are accounted for accordingly. The quality of the outcomes of the educational system (graduates versus drop-outs) needs to be reflected in the price index P^{ES} used to obtain the quantity index for schooling knowledge asset production. The appropriate P^{ES} can be obtained by dividing ΔE into the currently estimated value of household, NPISH, and general government consumption of education services.[18]

Of course, to obtain the appropriate ΔE we would need JF-style human accounts as in Christian (2014), who provides time series for the United States from 1998 to 2009, and Lui (2014), who provides estimates for selected years for 18 OECD countries (8 of which are SPINTAN countries).

Wealth of the Society. Equations (1)–(4) as set out in the previous section are unaffected by the capitalization of social infrastructure but the composition of key components change. Real gross investment I includes, as before, real gross fixed capital formation $\Delta K + \delta K_{-1}$ where K denotes the stock of productive fixed assets (as in fixed assets used in current production, tangible and intangible). P^{FA} denotes the replacement cost of the stock.

After recognition of schooling-produced knowledge assets, I also includes the net acquisition of knowledge capital held within the education system ΔE, which is equivalent to the real gross output of the education system. In nominal terms, gross investment, net saving, and wealth of the society are as follows:

$$P^I I = P^{FA}(\Delta K + \delta K_{-1}) + P^{ES}\Delta E \tag{8}$$

$$P^S S = P^{FA}\Delta K + P^{ES}\Delta E \tag{9}$$

$$W = P^{FA}K + P^{ES}E \ . \tag{10}$$

Investments in education tend to be a function of the age structure of a society, and 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 will largely depend 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, that is) due to the fact that in moving from GDP to real net expenditures, no depreciation charge is taken.

[18] The knowledge assets of graduates exiting the country needs to be excluded in this calculation if the probabilistic full resource cost of the annual education of foreign students is charged to them (i.e., their charges reflect the costs of their education discounted by the probability they enter the domestic labor force). In this way P^{ES} retains it interpretation as the domestic price of schooling-produced domestic knowledge assets because the cost incurred in producing a foreign graduate is fully offset in revenues, which are subtractions from nonmarket production values estimated on the basis of production costs. Nonmarket production valuation is discussed in section 4 below.

3.3 Return to Nonmarket 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 nonmarket 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 nonmarket 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, 2009), 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, Pérez, and Uriel (2006) in their study of the contribution of infrastructure capital to economic growth in Spain where such capital is largely held by government entities.[19]

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 and value added is the sum of activity by governments, NPISH, and market sector producers:

$$P_i^Q Q_i = \sum_S P_i^Q Q_i^S \;\; ; \quad P_i^V V_i = \sum_S P_i^V V_i^S \;\; ; \;\; \Delta lnV_i = \sum_S \overline{\omega}_{S,i}^V \Delta lnV_i^S \tag{11}$$

$$P_i^V V_i = \sum_S P_i^Q Q_i^S - \sum_S P_i^{II} II_i^S = \sum_S P_i^L L_i^S + \sum_S P_i^K K_i^S \tag{12}$$

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

[19]Imputing a return to government capital is a common move by productivity researchers interested in total economy performance measures, e.g., as in the many works of Jorgenson and associates conducted for the United States. More recently, the imputation also is made for official U.S. total economy multifactor productivity estimates issued by the BLS (Harper et al., 2009). From 2002–2006, the adjustment averages 3.9 percent of GDP (calculated using table 5 of Harper et al., 2009).

Besides Mas et al. (2006), we are unaware of European productivity studies that have imputed a net return to capital used in nonmarket production.

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

in which case industry value added productivity change ΔlnA_i can be expressed in the following equivalent ways:

(14) $$\begin{aligned}\Delta lnA_i &= \Delta lnV_i - \overline{\nu}_i^L \Delta lnL_i - \overline{\nu}_i^K \Delta lnK_i \\ &= \sum_S \Delta \overline{\omega}_{S,i}^V lnV_i^S - \sum_S \overline{\nu}_{S,i}^L \Delta lnL_i^S - \sum_S \overline{\nu}_{S,i}^K \Delta lnK_i^S \\ &= \sum_S \overline{\omega}_{S,i}^V \Delta lnA_i^S\end{aligned}$$

where $\overline{\nu}_{S,i}^K$ is capital's Divisia share for sector S in industry i based on (13). Note we assume that the technology for producing i makes no material use of intermediate inputs produced elsewhere in industry i.

Consider now ΔlnA_i^G for the nonmarket sector portion of total industry i. Adding a net return to nonmarket 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 ΔlnA_i^G is unaffected. But as equation (14) also makes clear, the measured contributions of ΔlnA_i^G, ΔlnK_i^G, and ΔlnV_i^G to their respective industry i aggregates *are* affected. All told, both for industries and the total economy, *the contribution of nonmarket activities will be understated* (as in under-weighted) unless a net return to capital is imputed.

A dataset that (1) cross-classifies industry-level information by institutional sector based on national accounts data, (2) imputes a return to capital compensation in the general government and NPISH subsectors, and (3) recomputes relevant economic aggregates circumvents the above-described problems and is the *desiratum* for SPINTAN. A forthcoming SPINTAN background paper explores the relevant alternatives for imputing a rate of return to government capital (**?**).

Note 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 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, Ho, and Stiroh (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 (2009, pages 150-151); and Jorgenson and Schreyer (2012).

4 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 (FOG) listed in table 2, we need to set out the conceptual relationships between the value of total government expenditure on each FOG service i and the value of government final spending and government output of the same service. We also need to know the relationship between government subsidies for private production of, or government grants for investment by private producers of, a given type of product or service associated with FOG i

4.1 Components of Government Expenditure

Let us first disaggregate total expenditure on FOG i, denoted $GExp_i$, according to whether expenditure is for (1) final spending $P_i^G G_i$ on the service or for (2) nonproduction payments, where the latter fall into two major categories:

(a) Transfer payments, 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 for consumption of goods and services i (TrH_i) where $Tr_i = TrB_i + TrH_i$.

(b) Subsidies, either for prices of products associated with i (SbP_i), or for production of output i (SbQ_i) where total subsidies $Sb_i = SbP_i + SbQ_i$.

Thus we have

$$GExp_i = P_i^G G_i + (Tr_i + Sb_i) \ . \qquad (15)$$

Interest on public debt and other capital transfers are ignored.

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

$$P_i^G G_i = P_i^C C_i^G + P_i^I I_i^G \qquad (16)$$

where investment is given by

$$\begin{aligned} P_i^I I_i^G &= P_i^{IP} IPur_i^G + P_i^{IO} IOwn_i^G \\ &= \sum_a P_a (IPur_a + IOwn_a)_i^G \ . \end{aligned} \qquad (17)$$

Equation (17) 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 ath 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.

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 begin with output 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 $S \neq G$). Thus we have

$$P_i^Q Q_i^G = P_i^C C_i^G + P_i^{IO} IOwn_i^G + Sales_i^{G,S \neq G} \tag{18}$$

which yields

$$P_i^C C_i^G = P_i^Q Q_i^G - P_i^{IO} IOwn_i^G - Sales_i^{G,S \neq G} \tag{19}$$

after rearranging (18) to solve for $P_i^C C_i^G$. Government final consumption of i then is equal to government gross output of i, less the value of own-produced capital formation, less receipts from sales to other sectors.

Because we typically don't observe sales by nonmarket producers, we value their output by the sum of costs incurred in production, which we write in the usual way (i.e., as if it was based on industry revenue):

$$P_i^Q Q_i^G = \underbrace{P_i^L L_i + P_i^K K_i}_{ValueAdded} \quad + \quad \underbrace{P_i^{II} II_i}_{Intrmd.Inputs} \quad . \tag{20}$$

Substituting (20) into (19) yields an expanded expression for final consumption,

$$P_i^C C_i^G = P_i^L L_i^G + P_i^K K_i^G + P_i^{II} II_i^G - P_i^{IO} IOwn_i^G - Sales_i^{G,S \neq G} \quad . \tag{21}$$

Now use (21) and (17) to expand equation (15),

$$(22) \qquad GExp_i = \underbrace{P_i^L L_i^G + P_i^K K_i^G + P_i^{II} II_i^G - P_i^{IO} IOwn_i^G - Sales_i^{G,S\notin G}}_{P_i^C C_i^G}$$
$$+ \underbrace{P_i^{IP} IPur_i^G + P_i^{IO} IOwn_i^G}_{P_i^I I_i^G} + (Tr_i + Sb_i) \ .$$

Equations (15)–(22) are written in terms of general government production, but as a conceptual matter, they apply to any institutional sector or industry group.

In terms of measurement, consider first the market sector where goods are sold at observable prices. To fix ideas, consider an economy producing energy for sale to final consumers and for sale to other producers. Thus the total observed sales of energy equals $P^C C$ + sales outside the sector, i.e., sales as in the first and third terms on the right of equation (18). If, in addition, the sector undertakes own account investment that is added to obtain $P_i^Q Q_i$. Consider next 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 measure output based on the sum factor costs as in equation (20) (i.e., labor, capital, and purchased inputs).

Subsidies. Equation (2), the sources-of-growth (SOG) equation that guides the framework for SPINTAN 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 are rather material when thinking about reclassifying a government subsidy as payment for a public asset. This is because they affect the measurement of capital income and gross return to capital, and thus the identification of capital services prices for SOG/productivity analysis as per Jorgenson (1963) and Jorgenson and Griliches (1967).

As previously mentioned, subsides may be product subsidies SbP_i or production subsidies SbQ_i where the subscript i now represents activity at the industry level. Subsidies on products are used to reduce the market price that producers charge customers, e.g., agricultural price supports. Production subsidies are payments directed at labor or capital employed in production, or for output produced, e.g., 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 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 (i.e, before the net effect of the corporate income tax, investment tax credits, and other producer tax expenditures).

In addition to business income taxes there are also taxes on production and imports, which consists 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, e.g., employer payroll taxes or taxes on motor vehicles or buildings, i.e., we have $TxQ_i = TxQ_i^L + TxQ_i^K$. In industry production accounts, factor taxes are combined with labor and capital 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. Looking back at equation (20) and thinking about how to define labor compensation $P_i^L L_i$ and capital compensation $P_i^K K_i$ for SOG analysis, we have:

(23)
$$P_i^L L_i = W\&S + OLI + TxQ_i^L$$
$$P_i^K K_i = GOS + TxQ_i^K$$

where $W\&S$ is wages and salaries and OLI is other labor income (paid benefits) and mixed income is ignored. Gross domestic income (which equals GDP) can then be expressed as

(24)
$$GDP \equiv GDI = \sum_i (P_i^L L_i + P_i^K K_i) + \sum_i (TxPI_i - Sb_i) \ .$$

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), i.e.,

$$GDP = \underbrace{\sum_i (P_i^Q Q_i - P_i^{II} II_i + SbP_i)}_{GVA^{BP}} + \sum_i (TxPI_i - SbP_i) \tag{25}$$

where GVA^{BP} is gross value added at basic prices. Basic prices are designed to reflect the value of output produced, i.e., 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, equations (24) and (25) imply

$$\begin{aligned} P_i^{K^{BP}} K_i &\equiv GVA^{BP} - P_i^L L_i \\ &= P_i^K K_i - SbQ_i \end{aligned} \tag{26}$$

In words, when the value of capital compensation is determined residually from industry GVA at basic prices, $P^{K^{BP}} K_i$ will be less than the full gross return to capital by the value of production subsidies paid to the industry by the government. In the EU15, production subsidies averaged .7 percent of GDP from 2006 to 2013, with a fair bit of variation by country, i.e., from 2.0 percent in Belgium to .1 percent in the United Kingdom. Equation (26) 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.[20]

That said, three further points must be made. First, the value of production subsidies is rather small for many market-oriented economies. Second, and on the other hand, there is much room for judgment in what may be considered a production subsidy. National accountants tend to consider only direct payments to industry as production subsidies, whereas such expenditures are little different from tax expenditures (of which the R&D and energy tax credits might be considered examples). Third, comparable data on subsidies to production by industry and country are not readily available. Nonetheless, in order to have an accurate picture of gross capital income—and thus accurate weighting of the contributions of labor and capital for SOG analysis—it is necessary to have a complete accounting of public expenditures on subsidies, be

[20]Indeed, one might argue that production subsidies are in fact little different from product subsidies in that both subsidize the return to capital. This position would lead one to question the utility of production accounts in basic prices but this is not our point. Rather we are trying to sort through how public expenditures appear in the data used for productivity analysis so that we may assess the data that need to be gathered for SPINTAN's planned analysis of the impacts of public expenditures on productivity and economic growth.

they direct payments or tax expenditures. While this is a tall order (for possibly a small gain), logic compels it a *desideratum* for SPINTAN.

Investment grants. Investment grants are a capital transfer. They do not appear directly in equations (24) and (25) although they significantly impact the return to capital and implicit capital rental price P_i^K for recipient industries. Consider again equation (26). From a production perspective, $P_i^K K_i$ is the total rental equivalence payment for capital services. Rearranging terms suggests the total payment consist of two terms:

$$P_i^K K_i = \underbrace{P_i^{K^{BP}} K_i}_{Private\,payment_i} + \underbrace{SbQ_i}_{Public\,payment_i} \quad . \tag{27}$$

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 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 ψ_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

$$\begin{aligned} P_i^{K_a^{BP}} &= (\rho_i + \delta_a)P'_a \\ &= (1 - \psi_a)(\rho_i + \delta_a)P_a \end{aligned} \tag{28}$$

and its capital payment is

$$\begin{aligned} \sum_a P_i^{K_a^{BP}} K_a &= \sum_a (1 - \psi_a)(\rho_i + \delta_a)P_a K_a \ . \\ &= \sum_a (\rho_i + \delta_a)P'_a K_a - \sum_a \psi_a P_a K_a \ . \end{aligned} \tag{29}$$

These equations illustrate several points. First, for a very long-lived asset, ψ_a also is the approximate annuity value of the grant, thus the symmetry of investment grants expressed as in (28) with tax credits in the Hall-Jorgenson formula for the tax-adjusted cost of capital. Second, equation (29) shows that if investment grants are an important means of capital financing for an industry (ψ_a is nonneglible for major assets), then very little capital income might be associated very large capital stocks. As a practical matter, this simply means the capital was massively subsidized by public investment grants; the implied ex post return net of grants ρ_i may be low, high, or on par with the return to private investments. One cannot know without compiling data on TrB_i for the industry (more precisely, computing ψ_a for its assets).

Third, following equation (27), the simple transformation of (26), we can express total capital services in this industry as the sum of two components. The first is shown in equation (29), which represents the ith industry's payment, and the second is the term subtracted from the RHS of the equation, the government's payment in which the investment grant is expressed as a per period subsidy. Most of the points with regard to equation (26) also then apply here although there is one notable exception, namely, that the relative value of the subsidy-like payment likely is not all that small for many countries (see again figure 5, page 12).

In summary, the discussion of the last two subsections suggests (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 the SNA concept of industry gross value added at basic prices, whereas product subsidies (along with the tax expenditures and investment tax credits implicit in capital compensation) are, is a limitation that needs to be overcome in SPINTAN if such subsidies and grants loom large in our industries of interest/topic areas. It may be that they do not (e.g., if such expenditures mainly are for public utilities and public transportation) but we cannot know without gathering the relevant data.

4.2 R&D Gross Output and Performer vs. Funder

The main aggregate used for international comparisons of R&D is gross domestic expenditure on R&D (GERD). This consists of the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, and university and government laboratories of a country. It includes R&D funded from abroad but excludes domestic funds for R&D performed outside the domestic economy, i.e., it is a *performance* based metric. Another widely used aggregate is business expenditure on R&D (BERD), where expenditures again are current and capital, and the performance metric (vs. the funder metric) usually holds center stage.

Once R&D is capitalized in national accounts, alternative measures and concepts can be featured. First, R&D gross output measures will be available. As we have seen when comparing government expenditure vs. government gross output, gross output removes capital expenditures and adds capital costs (or capital payments), thereby yielding a output-based metric. Indeed, an output metric might be preferred to a gross expenditure metric in the ever-popular R&D league tables because gross expenditure is biased toward countries that are expanding their R&D facilities from a base of low asset stocks, i.e., it is not a measure of the conduct of R&D. With R&D capitalization in national accounts, output measures (whether value added or gross output) become an alternative source for comparative analyses of the conduct of R&D across countries.

Second, for many (but not all) countries the capitalization of R&D in national accounts will feature series on a funder basis, not a performer basis. Because science policy analysis and the productivity literature (including the literature that focusses on intangible capital) has traditionally used the R&D performer series in analysis and empirical work, estimated trends and relationships may no longer hold when applied to the new national accounts funder-based R&D series.

The performer vs. funder distinction in R&D measures requires additional data no matter what basis is used in national accounts, however. The *desideratum* for SPINTAN is to have, for each country, a database of public R&D funding by industry consistent with the new national accounts aggregates (and we will also need to know whether public R&D spending is on a performer or funder basis for each country). This will enable a consistent analysis of the links between public funding, private funding, and private vs. public performance (e.g., updating the analysis of Guellec and Van Pottelsberghe De La Potterie, 2003), as well as the generation of alternative productivity baselines as suggested in Corrado, Haskel, Jona-Lasinio, and Iommi (2012, pages 26-7).

Appendix table A4 collects the data desideratum for SPINTAN that arose in the first four sections of the paper.

5 Conclusion

In summary we aim to complete the accounting of intangible investment in a manner that is, broadly speaking, within the current scope of GDP. This will make possible the generation of new empirics on the evolution of productivity and living standards, as well as data for the analysis of public policies supporting their growth.

This paper reviewed the nature of public sector economic activity, how it is measured in national and industry accounts, and how that would change if public intangible assets are capitalized. The analysis concluded that it is necessary to identify the sector's footprints in both sets of data (i.e., national and industry accounts). Moreover, the readily available data on industry output and inputs (whether at basic prices or with capital compensation that captures the full gross return to capital) do not consistently disaggregate according to institutional unit. This implies that the standard way of assessing the contribution of a given type of economic activity or factor of production—its share of output or income—is rather a large challenge for SPINTAN as this disaggregation will need to be estimated. An understanding of how real output measurement methods for nonmarket sectors differ across the national statistical offices of the countries analyzed in SPINTAN is also needed.

The next thing we stressed was that detecting social benefits (or spillovers) of government spending policies via growth accounting or econometric analysis requires a database with even more detail than commonly found in industry accounts. Namely, a mapping of each component of government expenditure by FOG (especially subsidies and transfers) to a relevant industry or industries in production accounts is required. All these needs, plus the fact that we need to be able to capitalize assets not now capitalized in national accounts, frame the broad outline of the satellite accounts that need to be in place for SPINTAN's planned analysis of public intangibles. The particular data and information needs for estimating public intangibles are in a forthcoming SPINTAN background paper.

The overarching framework we set out for SPINTAN's growth and productivity analysis has three key features: First, the framework covers the total economy in a coherent manner by placing public capital on the same footing as private capital; this requires imputing a real net return to public capital as has long been done in the work of Jorgenson & associates and recently implemented in official total economy productivity measures for the United States. Second, we sketched out a way in which public investments in human capital via schooling can be treated as additions to wealth and saving within the current GDP production boundary; the approach follows the logic used by Ruggles and Moulton to argue that spending on consumer durables is household saving and incorporates elements of the Jorgenson-Fraumeni lifetime-income approach to measuring human capital. Finally, we took some steps to include social welfare into the analysis by following Jorgenson and Landefeld and exploiting information on real net expenditure and real saving in national accounts. As we noted at several points in the main text, capitalization of public intangibles may alter the relative trajectories of the level of living as compared with multifactor productivity, and it will be necessary to compute trends in both measures to obtain a complete picture of economic growth.

As has been said many times in many places, fiscal policy can be an instrument for growth policy: through its impacts on national saving via the structural budget deficit, through its incentive effects on work, saving and investment via tax rates and tax structure, and through its public investments in intangible (social, economic, scientific) and tangible (physical) infrastructure. While we should not overstate what fiscal policy can deliver on the intangible investment score, we aim in this project to better understand the strength and location of these levers.

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Appendix

Table A1: **NACE 2 Intermediate Structure**

The table below presents the "intermediate SNA/ISIC aggregation A*38":

	A*38 code	ISIC Rev. 4/ NACE Rev. 2	Divisions
1	A	Agriculture, forestry and fishing	01 to 03
2	B	Mining and quarrying	05 to 09
3	CA	Manufacture of food products, beverages and tobacco products	10 to 12
4	CB	Manufacture of textiles, apparel, leather and related products	13 to 15
5	CC	Manufacture of wood and paper products, and printing	16 to 18
6	CD	Manufacture of coke, and refined petroleum products	19
7	CE	Manufacture of chemicals and chemical products	20
8	CF	Manufacture of pharmaceuticals, medicinal chemical and botanical products	21
9	CG	Manufacture of rubber and plastics products, and other non-metallic mineral products	22 + 23
10	CH	Manufacture of basic metals and fabricated metal products, except machinery and equipment	24 + 25
11	CI	Manufacture of computer, electronic and optical products	26
12	CJ	Manufacture of electrical equipment	27
13	CK	Manufacture of machinery and equipment n.e.c.	28
14	CL	Manufacture of transport equipment	29 + 30
15	CM	Other manufacturing, and repair and installation of machinery and equipment	31 to 33
16	D	Electricity, gas, steam and air-conditioning supply	35
17	E	Water supply, sewerage, waste management and remediation	36 to 39
18	F	Construction	41 to 43
19	G	Wholesale and retail trade, repair of motor vehicles and motorcycles	45 to 47
20	H	Transportation and storage	49 to 53
21	I	Accommodation and food service activities	55 + 56
22	JA	Publishing, audiovisual and broadcasting activities	58 to 60
23	JB	Telecommunications	61
24	JC	IT and other information services	62 +63
25	K	Financial and insurance activities	64 to 66
26	L	Real estate activities*	68
27	MA	Legal, accounting, management, architecture, engineering, technical testing and analysis activities	69 to 71
28	MB	Scientific research and development	72
29	MC	Other professional, scientific and technical activities	73 to 75
30	N	Administrative and support service activities	77 to 82
31	O	Public administration and defence, compulsory social security	84
32	P	Education	85
33	QA	Human health services	86
34	QB	Residential care and social work activities	87 + 88
35	R	Arts, entertainment and recreation	90 to 93
36	S	Other services	94 to 96
37	T**	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	97 + 98*
38	U**	Activities of extra-territorial organisations and bodies	99*

* including imputed rents of owner-occupied dwellings

** All of U and part of T (division 98) are outside the SNA production boundary, and will be empty for SNA data reporting, but are included for completeness.

Table A2: **Classification of the Purposes of Nonprofit Institutions**

- 01 - Housing
  - 01.0 - Housing
- 02 - Health
  - 02.1 - Medical products, appliances and equipment
  - 02.2 - Outpatient services
  - 02.3 - Hospital services
  - 02.4 - Public health services
  - 02.5 - R&D Health
  - 02.6 - Other health services
- 03 - Recreation and culture
  - 03.1 - Recreational and sporting services
  - 03.2 - Cultural services
- 04 - Education
  - 04.1 - Pre-primary and primary education
  - 04.2 - Secondary education
  - 04.3 - Post-secondary non-tertiary education
  - 04.4 - Tertiary education
  - 04.5 - Education not definable by level
  - 04.6 - R&D Education
  - 04.7 - Other educational services
- 05 - Social protection
  - 05.1 - Social protection services
  - 05.2 - R&D Social protection
- 06 - Religion
  - 06.0 - Religion
- 07 - Political parties, labour and professional organizations
  - 07.1 - Services of political parties
  - 07.2 - Services of labour organizations
  - 07.3 - Services of professional organizations
- 08 - Environmental protection
  - 08.1 - Environmental protection services
  - 08.2 - R&D Environmental protection
- 09 - Services n.e.c.
  - 09.1 - Services n.e.c.
  - 09.2 - R&D Services n.e.c.

Source: United Nations Website, `http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=6&Lg=1`, accessed July 30, 2014.

Table A3: **MEPSIR Information Types and Sub-types**

		Type or Sub-type
1		**Business information**
	1.1	Chamber of Commerce information
	1.2	Official business registers
	1.3	Patent & trademark information
	1.4	Public tender databases
2		**Geographic information**
	2.1	Address information
	2.2	Aerial photos
	2.3	Buildings
	2.4	Cadastral information
	2.5	Geodetic networks
	2.6	Geology
	2.7	Hydrographical data
	2.8	Topographic information
3		**Legal information**
	3.1	Decisions of international and foreign courts
	3.2	Decisions of national courts
	3.3	National legislation
	3.4	Treaties
4		**Meteorological information**
	4.1	Climatological data (including models)
	4.2	Weather forecasts
5		**Social data**
	5.1	Economic statistics
	5.2	Employment statistics
	5.3	Health statistics
	5.4	Population statistics
	5.5	Public administration statistics
	5.6	Social statistics
6		**Transport information**
	6.1	Information on traffic congestion
	6.2	Information on work on roads
	6.3	Public transport information
	6.4	Vehicle registration

Source—Dekkers, Polman, te Velde, and de Vries (2006).

Table A4: **SPINTAN Data *Desideratum***

1.	Nonmarket output measurement methods in SPINTAN topic areas by country
2.	Industry detail for NACE 72, and possibly 90–91 vs 92–93 in Section R
3.	Mapping of FOGs to NACE industries
	3.1 Final consumption
	3.2 Final investment
	3.3 Investment grants
	3.4 Subsidies
4.	Capital compensation by industry including subsidies and relevant transfers
5.	Disaggregation of industry data by institutional sector in our topic areas
	5.1 Value added and major components
	5.2 Employment and investment by asset type
6.	Estimates of E and P^{ES} from JF-style human capital accounts
7.	Estimates of the real net return to nonmarket capital
8.	Public R&D spending by industry
9.	Ownership of R&D output funded by the public sector, criteria by SPINTAN country

Source—This paper.