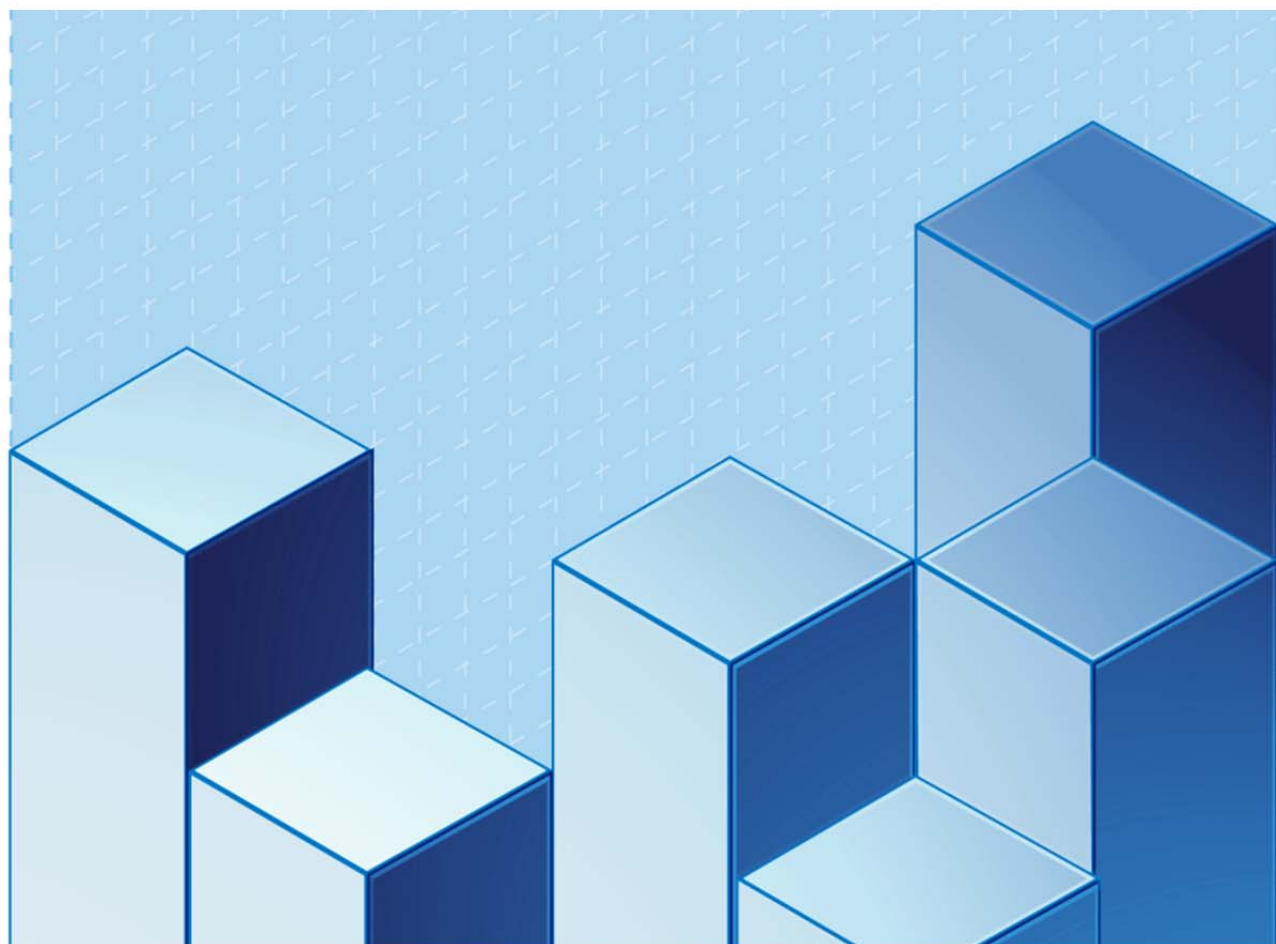


# **PUBLIC INTANGIBLES: THE PUBLIC SECTOR AND ECONOMIC GROWTH IN THE SNA**

Carol Corrado  
Jonathan Haskel  
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# **PUBLIC INTANGIBLES: THE PUBLIC SECTOR AND ECONOMIC GROWTH IN THE SNA<sup>\*</sup>**

Carol Corrado<sup>†</sup>  
Jonathan Haskel<sup>‡</sup>  
Cecilia Jona-Lasinio<sup>§</sup>

## **Abstract**

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This paper sets out a framework for the analysis of public investments, tangible and intangible, at the level of detail needed for the economic analysis of impacts of public policies influencing economic growth. To do this, we broaden the concept of capital in the public sector from that which is mostly tangible (e.g. physical infrastructure) to that which also includes intangibles and long-lasting societal assets. We also need to overcome some significant measurement challenges, such as the accounting treatment of returns to public capital and the assignment of public capital and relevant expenditures, including tax expenditures, to industries. All told, for the analysis of public investments, we find that national accounts need to (a) impute a net return to government capital, (b) disaggregate industries by institutional sector of origin, (c) use industry capital compensation measured to include all public payments, and (d) where relevant, build crosswalks for components of government expenditure by function of government to industries.

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

Carol Corrado, Jonathan Haskel, and Cecilia Jona-Lasinio

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 towards those investments by widening previous work on intangible capital, e.g., by Corrado, Hulten, and Sichel (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 market (or business) sector, and thus considerations that arise in a public context require extension and modification.

In this paper we review and analyze key issues with regard to the boundaries of public intangibles and offer an accounting 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 analyzing policies affecting the creation and effective 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 public intangible investments.

To understand what we think is our contribution in this paper, consider first that Stiglitz, Sen, and Fitoussi (2009) counseled policymakers to avoid confusing GDP (production) with societal welfare. We address this concern from the novel perspective of an expanded asset boundary. We identify the real savings that is proportional to the change in aggregate social welfare and thereby account more appropriately for production, real net expenditure, and 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. In the final analysis, as shall shortly be seen, we do *not* treat public spending on institutions, public safety, and national defense that build and maintain the rule of law as investment that proximately yields a flow of services over time. Rather these aspects of civil society are an ultimate determinant of national investment, tangible or intangible, in the sense of Hayek (1944): the rule of law and the institutions that support it prevent the appropriation of capital.

We thus proceed as follows. First, we review the scope and nature of the “public” activities, where it becomes immediately obvious that we must focus on *kinds* of activities, i.e., education or health, irrespective of whether the services at question are publically or privately supplied. Next, we reconsider the asset boundary appropriate for modeling the production of public services. Based on the same logic that was set out and applied to for-profit business activities by CHS, we first propose two new broad categories of public investment: (1) investments in information, scientific, and cultural assets, and (2) investments in organizational competencies. Then, we reconsider the common understanding of public infrastructure, currently limited to physical or tangible investments in national accounts, and propose a third new category of public investment, (3) social infrastructure. To develop the need for this category, in which, for example, human knowledge capital and human health could be regarded as societal assets, we review the complexities and theoretical rationale. We then present an accounting treatment of education services as changes in societal capital, a treatment that borrows from the human capital framework developed by Jorgenson and Fraumeni (1989, 1992a,b).

The final section of the paper discusses issues related to the impact of capitalizing public intangible capital and studying its contribution to productivity growth and level of living in a society. We also discuss the mixed and special nature of certain government functions (health, education, cultural activities), note that a rate of return that must be assigned to capture services flows from public capital, and consider adjustments to industry accounting in the SNA that are needed to fully understand the links between public spending and industry productivity performance. A final section concludes and summarizes.

## 1 Scope and Nature of Public Activities

We begin with a brief review of the kinds of activities performed by governments, including government capital formation, and discuss how government payments of various types make their way into industry accounts used for productivity analysis.

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 1 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

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
7.	Health
8.	Culture and recreation <sup>3</sup>
9.	Education
10.	Social protection <sup>4</sup>

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.

economic aid, general services, general R&D, and interest payments on debt. The category excludes, however, expenditures 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.

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 (a component of 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 industry.

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

<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.

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 societal 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. 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. 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 EU28 and EU15 whereas the comparable U.S. figure (based upon expenditures classified as transfer payments, i.e., excluding tax expenditures) 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. 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 guidelines, gross fixed capital formation (GFCF) by general government *excludes* investment grants and own-financed investment by government enterprises (GEs).<sup>2</sup> This means that when, say, certain power companies receive public funds in the form of investment grants for expansion of the electric grid, or certain universities receive public funds to build new science education facilities, the investment is not counted as general government gross fixed capital formation in SNA-consistent national accounts. From an economic point of view, it makes little difference whether public investments are implemented via purchases of fixed assets from private organizations or whether they are implemented via grant payments (for the purchase or creation of

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<sup>2</sup>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 and own-financed GE investment.

fixed assets) to private organizations. The decision to invest emanated from a public body in both cases, and from an economic point of view both are public investment.

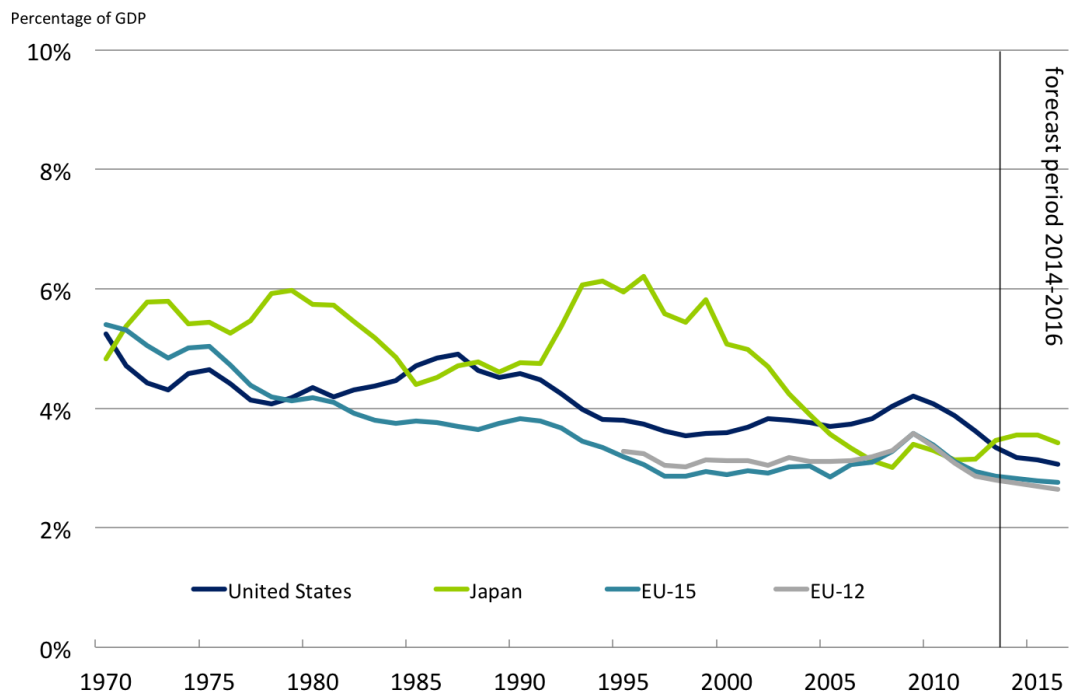
The SNA does not instruct national accountants to construct measures of public investment even though the ability to distinguish between public and private domestic investment is relevant for fiscal policy analysis, e.g., studying impacts of austerity. Of course, public institutions in some countries may govern so as to render the distinction between public capital formation and investment grants irrelevant. For example, in the United States the distinction is rarely appropriate, whereas in many European countries the distinction is very relevant. Unfortunately, the data needed to ascertain the size and direction of investment grants in European countries is obscure. As of the writing of this paper, the recently posted SNA2008-compliant COFOG data on the Eurostat website did not contain sufficient information on series D92 (general government investment grants) to ascertain an EU aggregate. The data available for some countries, however, e.g., Italy, Spain, and the UK, suggest investment grants run in the neighborhood of 1 percent of GDP (in these countries).

The rate of general government GFCF (i.e., GFCF relative to GDP) for the European Union, Japan, and the United States is shown in figure 1(a). As many be seen, this rate is running 3 or more percent currently, with the EU on the low side. If the figure could be redrawn to include investment grants, the EU rates could be similar to the United States suggesting that what looks like a relatively low rate of “public” investment in the EU is a product of the SNA’s sectoral conventions for national accounts.<sup>3</sup> And if figure 1(a) could be redrawn to show the “true” rate of public investment, a corresponding correction to figure 1(b) could be made to show the “true” rate of private investment.<sup>4</sup> This picture of investment should not remain imaginary forever.

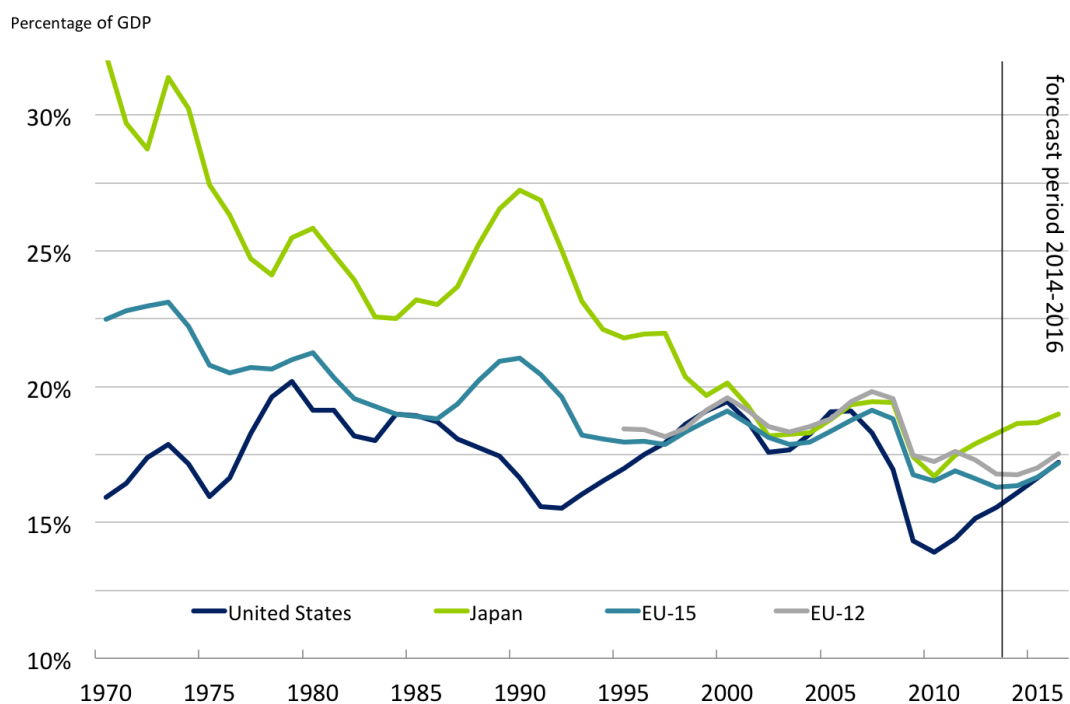
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<sup>3</sup>As previously noted, among advanced countries, the source of cross country differences in investment rates is governance structures, i.e., central government investment grants may be administered by other levels of government (in which case the transfer nets out in general government, and the investment appears as government GFCF) or by private industry or public corporations (in which case a sectoral transfer occurs, and the investment is recorded as corporate 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 generally not available although detailed COFOG data likely permit inferences.

<sup>4</sup>Of course, owing to the relatively larger size of nongovernment GFCF, removing public investment grants from it is likely to have a small impact compared with the impact of adding investment grants to the rate of government GFCF, which is likely to increase the rate by as much as one-third.



(a) General Government.



(b) Excluding General Government

Figure 1: Gross Fixed Capital Formation (domestic), 1970–2016

Source: AMECO database, accessed April 2015, and EUKLEMS.

## 2 Asset Boundary

As we proceed to expand the existing national accounts framework for analyzing intangible capital, a very important first point to make is that we continue to regard the current scope of GDP as the production possibilities frontier. In other words, while all market activity and traditional nonmarket production by governments and nonprofit institutions are regarded as within our production boundary, nonmarket production by households is considered beyond it.

Many challenges are nonetheless encountered when reconsidering the definition of public investment germane to the current scope of GDP. In this section we ask two fundamental questions, What intangible investments are undertaken by government and nonprofit producers? What societal assets are produced by these organizations? These are *very* different questions. We begin by appealing to the CHS framework.

### 2.1 CHS-type Assets

Table 2 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.

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. An extensive list of information assets of governments has been compiled for the MEPSIR (Measuring European Public Sector Information Resources) project and provides a starting point for empirical work. Indeed, 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

Table 2: Knowledge Capital for 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	Organizational 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.

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, nonpartisan reporting and accounting offices, and the patent office, which suggests information assets loom large in the United States as well. The U.S. Census Bureau's release of its TIGER (Topologically Integrated Geographic Encoding and Referencing) dataset—in 1991—is commonly thought to have bootstrapped the country's booming geospatial industry.

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 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, 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

<sup>5</sup>Note this assumes 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 investment by asset type data for many countries is not sufficiently detailed. The 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.

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).

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 nonprofit 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. The prevalence of managerial time and training time among hospital professionals is a subject for further study.

In ongoing work known as the SPINTAN project, researchers are assembling CHS-type intangibles according to the scheme set out in table 2.<sup>6</sup> Estimates using Jarboe’s expanded notion of brands, or for cultural and information assets beyond what exists in national accounts are not yet available. Put differently, total economy estimates for the national accounts intangibles R&D, software, mineral exploration, and artistic and entertainment originals plus the non-national accounts CHS intangibles design, brands, organization capital, and training are available for a wide range of European countries and the United States.

SPINTAN’s results are on an industry basis, and its preliminary results are combined with the INTAN-Invest database and shown in figure 2.<sup>7</sup> The figure plots intangible investment relative to sector gross value added (or intangibles intensity) for two groups of industries within 11 economies (Spain, Austria, France, Germany, Netherlands, Sweden, Belgium, Italy, Finland, United States, and United Kingdom). One group of industries, labeled “nonmarket,” consists of the R&D services; education services; human health and social services; arts, entertainment and recreation services; and public administration and defense industries. The other group is an aggregate of all other industries (save real estate) and is labeled “market.”

As may be seen, the intangibles intensity of the “nonmarket” group of industries—industries supplying R&D and social services—in the four countries to the right on figure 2 (Italy, Finland, United States, and United Kingdom) is greater than the intangibles intensity of the “market” group of industries in these countries. And whereas the intangibles intensity of “market” sector industries in four other European countries (France, Netherlands, Sweden, and Belgium) is very similar to the

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<sup>6</sup>Smart Public INTANgibles is a project funded by the European Commission FP-7 grant agreement 612774.

<sup>7</sup>INTAN-Invest is an unfunded collaboration of researchers who have periodically updated and improved 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. See Corrado, Haskel, Jona-Lasinio, and Iommi (2013) and other information available at [www.intan-invest.net](http://www.intan-invest.net).

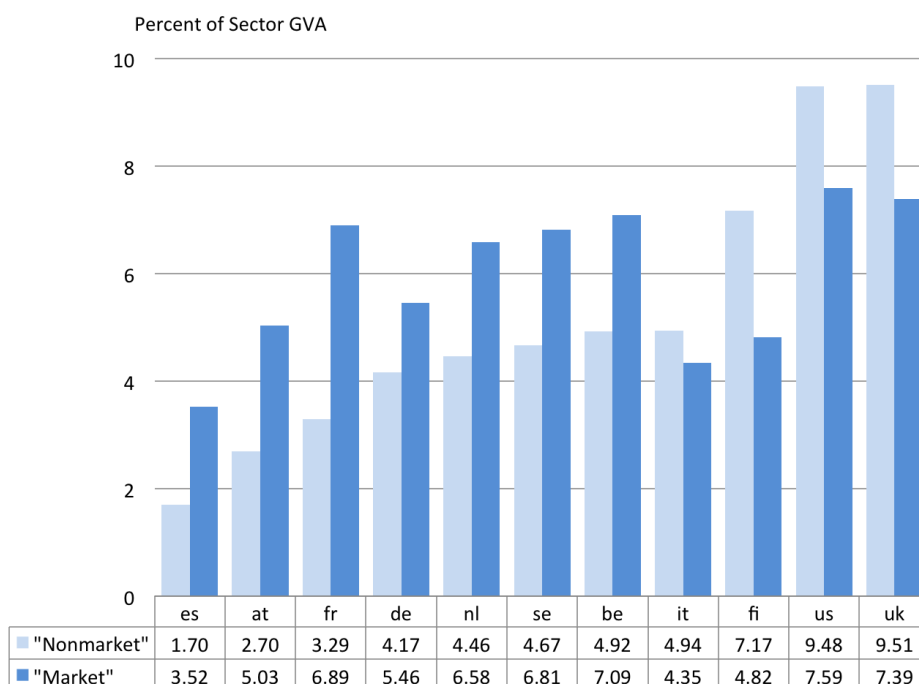


Figure 2: Intangible Investment in “Nonmarket” and “Market” Industries, 2001–2010.

Source: Preliminary results from a forthcoming (March 2016) update to the INTAN-Invest database ([www.intan-invest.net](http://www.intan-invest.net)) and the forthcoming (December 2016) dissemination of the SPINTAN database ([www.spintan.net](http://www.spintan.net))

United States and United Kingdom for the period shown, the intangibles intensity of the “nonmarket” sectors of these four countries is much lower.

In general, the variation in intangible investment across countries is very interesting, and SPINTAN is addressing composition effects, impacts on growth, and robustness to measurement assumptions in an effort to improve its preliminary estimates. Quantifying the CHS-type assets shown in table 2 does not cover all societal assets produced by governments and nonprofit institutions, however, and we now turn to discussing what is often meant by a public intangible asset, namely, social infrastructure.

## 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 result in a net return on investment. From our 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.<sup>8</sup> 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.

The human capital production process as modeled by Jorgenson and Fraumeni is out of scope for GDP as traditionally defined. 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, e.g., a school system’s expenditures on teacher training would be considered investment in the framework of table 2 because the spending presumably increases the effectiveness of the system

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<sup>8</sup>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.

to deliver educational services.<sup>9</sup> Is it possible to view the service capacity of an education system as social infrastructure by carefully delineating the *intersection* of its economic activity with the JF model of human capital formation? We believe so and revisit this topic in section 3 below.

**Health Care.** Consider now the consumption and production of health care services. 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. 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 a broader model in which household production plays a key part has not been set out in the literature to our knowledge. Nonetheless, as with educational institutions, it is important to consider organizational capital and its effectiveness in promoting efficiency and productivity of health care institutions.

Note further 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.<sup>10</sup>

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 overall economic activity benefits as (a) workforce capacity increases with greater human longevity,

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<sup>9</sup>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.

<sup>10</sup>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. And writing in the January-February 2011 *Harvard Business Review*, William C. Weldon, Chairman and CEO of Johnson & Johnson, stated “For every dollar we invest in our workers’ health, we see a return of more than \$4 in reduced health care costs, lower absenteeism, and improved productivity.” The source for this information and quote is the U.S. Centers for Disease Control website, [http://www.cdc.gov/policy/resources/Investingin\\_ReducesEmployerCosts.pdf](http://www.cdc.gov/policy/resources/Investingin_ReducesEmployerCosts.pdf) .

and both (b) workplace absenteeism and (c) future health care system costs are lower with increased wellness. The commonly used framework for productivity analysis should capture these benefits of human wellness, albeit if only indirectly.

### 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 (??), 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:

$$(1) \quad V(C, I) = A \cdot X(L, K, R)$$

with sources-of-growth analysis written as:

$$(2) \quad \bar{w}_C \Delta \ln C + \bar{w}_I \Delta \ln I = \bar{v}_L \Delta \ln L + \bar{v}_K \Delta \ln K + \bar{v}_R \Delta \ln R + \Delta \ln A$$

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 (1) 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, i.e., 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. 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  $B$ :

$$(3) \quad Z(C, S) = B \cdot Y(L, N)$$

$$(4) \quad \bar{\omega}_C \Delta \ln C + \bar{\omega}_S \Delta \ln S = \bar{\nu}_L \Delta \ln L + \bar{\nu}_N \Delta \ln N + \Delta \ln B .$$

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 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 Weitzmann (1976, 2003).<sup>11</sup> Real net expenditures thus represents the annual increment to welfare resulting from each year's production activity. Equation (4) 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, real net property income is the real net operating surplus, or real return to capital  $\rho(K + R)$ .<sup>12</sup>

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

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<sup>11</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.

<sup>12</sup>For exposition purposes, we write total capital as a simple sum which holds true only if both types of capital have the same asset price.

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 towards 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 “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 capital within households. It follows the logic of Ruggles’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  $\Delta E$  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  $Q_{ES} = E^{Grads} + \Delta E^{InSchool}$ .<sup>13</sup> 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

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

which implies

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

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<sup>13</sup>Note the similarity of this syntax to “production = sales+inventory change.”

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 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 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.<sup>14</sup> The JF model is not reviewed in any detail here but it is important to note that

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<sup>14</sup>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

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 produced by schooling may be computed as follows:

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

where  $\rho$  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 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). 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

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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

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

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  $E$ .

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  $\Delta E$  into the currently estimated value of household, NPISH, and general government consumption of education services.<sup>15</sup>

Of course, to obtain the appropriate  $\Delta E$  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.

**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  $\Delta K + \delta^K K_{-1}$  and  $\Delta R + \delta^R R_{-1}$  where  $K$  and  $R$  denote the stock of productive tangible and intangible fixed assets used in current production.  $P^{FA}$  denotes the replacement cost of the stock of fixed assets, which we assume for simplicity is the same for tangible and intangible capital.

After recognition of schooling-produced knowledge assets,  $I$  also includes the net acquisition of knowledge capital held within the education system  $\Delta E$ , 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:

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

$$(9) \quad P^S S = P^{FA}(\Delta K + \Delta R) + P^{ES} \Delta E$$

$$(10) \quad W = P^{FA}(K + R) + P^{ES} E$$

where note:

$$(11) \quad \Delta W = P^S S + \Delta P^{FA}(K + R) + \Delta P^{ES} E .$$

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

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<sup>15</sup>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 its 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.

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.

### 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.<sup>16</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:

$$(12) \quad P_i^Q Q_i = \sum_S P_i^Q Q_i^S ; \quad P_i^V V_i = \sum_S P_i^V V_i^S ; \quad \Delta \ln V_i = \sum_S \bar{\omega}_{S,i}^V \Delta \ln V_i^S$$

$$(13) \quad P_i^V V_i = \sum_S P_i^Q Q_i^S - \sum_S P_i^{II} II_i^S = \sum_S P_i^L L_i^S + \sum_S P_i^K K_i^S$$

<sup>16</sup>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.

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

$$(14) \quad P_i^{KS} K_i^S = P_i^V V_i^S - P_i^L L_i^S ,$$

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

$$(15) \quad \begin{aligned} \Delta \ln A_i &= \Delta \ln V_i - \bar{v}_i^L \Delta \ln L_i - \bar{v}_i^K \Delta \ln K_i \\ &\equiv \sum_S \Delta \bar{\omega}_{S,i}^V \ln V_i^S - \sum_S \bar{v}_{S,i}^L \Delta \ln L_i^S - \sum_S \bar{v}_{S,i}^K \Delta \ln K_i^S \\ &\equiv \sum_S \bar{\omega}_{S,i}^V \Delta \ln A_i^S \end{aligned}$$

where  $\bar{v}_{S,i}^K$  is capital's Divisia share for sector  $S$  in industry  $i$  based on (14). Note we assume that the technology for producing  $i$  makes no material use of intermediate inputs produced elsewhere in industry  $i$ .

Consider now  $\Delta \ln A_i^G$  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  $\Delta \ln A_i^G$  is unaffected by the imputation. But as equation (15) 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 nonmarket 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.

What rate of return should be used? Studies that impute a return to nonmarket 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, or SRTP. The case for using the SRTP as the return to public assets is set forth in the OECD capital manual. Estimates using the Ramsey formula are developed in Corrado and Jäger (2015) and shown in figure 3. As may be seen, the SRTP for Europe and the United States trends downward over time and stands at rather low rates currently. This result is unsurprising, given the slower rates of growth of consumption in these economies in recent years. The SRTP is a good option

for national accounts as it is relatively easy to compute and many governments already use the SRTP as a hurdle rate for public projects.

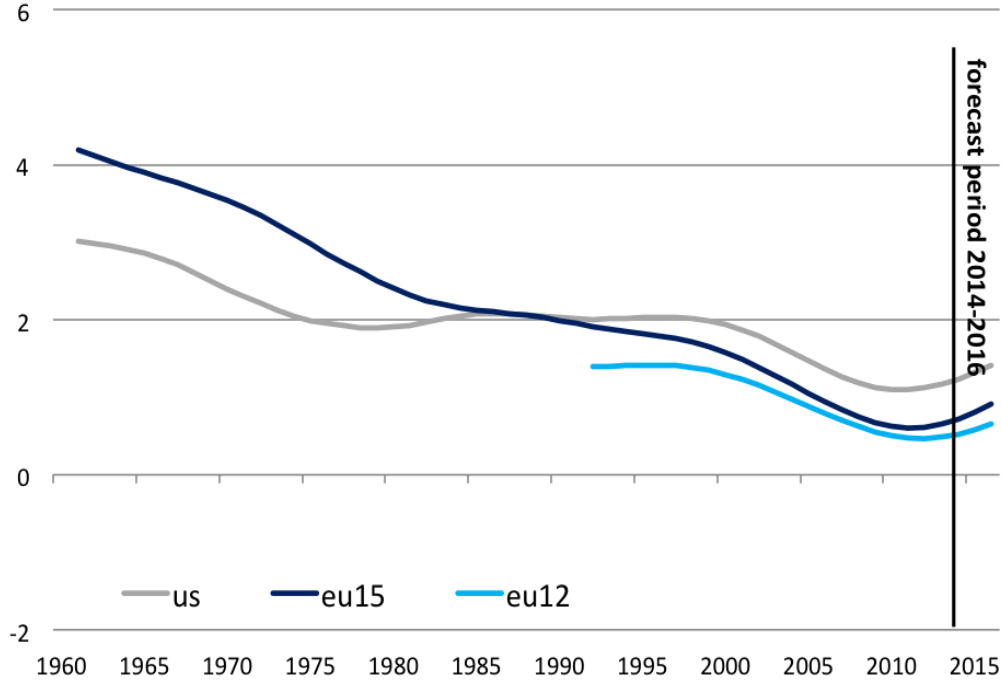


Figure 3: SRTP based on HP-filtered Growth of Total Consumption per capita, 1961–2016

Source: Corrado and Jäger (2015). Consumption forecasts are from AMECO, accessed April 2015.

## 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 1, 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  $i$

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

$$(16) \quad GExp_i = P_i^G G_i + (Tr_i + Sb_i) .$$

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

$$(17) \quad P_i^G G_i = P_i^C C_i^G + P_i^I I_i^G$$

where investment is given by

$$(18) \quad \begin{aligned} P_i^I I_i^G &= P_i^{IP} IPur_i^G + P_i^{IO} IOwn_i^G \\ &= \sum_a P_a (IPur_a + IOwn_a)_i^G . \end{aligned}$$

Equation (18) 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.

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

$$(19) \quad P_i^Q Q_i^G = P_i^C C_i^G + P_i^{IO} IOwn_i^G + Sales_i^{G,S \neq G}$$

which yields

$$(20) \quad P_i^C C_i^G = P_i^Q Q_i^G - P_i^{IO} IOwn_i^G - Sales_i^{G,S \neq G}$$

after rearranging (19) 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):

$$(21) \quad P_i^Q Q_i^G = \underbrace{P_i^L L_i + P_i^K K_i}_{ValueAdded} + \underbrace{P_i^{II} II_i}_{Intrmd.Inputs} .$$

Substituting (21) into (20) yields an expanded expression for final consumption,

$$(22) \quad P_i^C C_i^G = P_i^L L_i^G + P_i^K K_i^G + P_i^{II} II_i^G - P_i^{IO} IOwn_i^G - Sales_i^{G,S \neq G} .$$

Now use (22) and (18) to expand equation (16),

$$(23) \quad GExp_i = \underbrace{P_i^L L_i^G + P_i^K K_i^G + P_i^{II} II_i^G - P_i^{IO} IOwn_i^G - Sales_i^{G,S \neq G}}_{P_i^C C_i^G} + \underbrace{P_i^{IP} IPur_i^G + P_i^{IO} IOwn_i^G}_{P_i^I I_i^G} + (Tr_i + Sb_i) .$$

Equations (16)–(23) 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 (19). 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 (21) (i.e., labor, capital, and purchased inputs).

**Subsidies.** Equation (2), the sources-of-growth (SOG) equation that guides the framework for SPIN-TAN 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, subsidies 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 (21) 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:

$$(24) \quad \begin{aligned} P_i^L L_i &= W\&S + OLI + TxQ_i^L \\ P_i^K K_i &= GOS + TxQ_i^K \end{aligned}$$

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

$$(25) \quad GDP \equiv GDI = \sum_i (P_i^L L_i + P_i^K K_i) + \sum_i (TxPI_i - Sb_i) .$$

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.,

$$(26) \quad GDP = \underbrace{\sum_i (P_i^Q Q_i - P_i^{II} II_i + SbP_i)}_{GVA^{BP}} + \sum_i (TxPI_i - SbP_i)$$

where  $GVA^{BP}$  is gross value added at basic prices. Basic prices are designed to reflect the value of output produced, 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 (25) and (26) imply

$$(27) \quad \begin{aligned} P_i^{K^{BP}} K_i &\equiv GVA^{BP} - P_i^L L_i \\ &= P_i^K K_i - SbQ_i \end{aligned}$$

In words, when the value of capital compensation is determined residually from industry GVA at basic prices,  $P_i^{K^{BP}} K_i$  will be less than the full gross return to capital by the value of production subsidies paid to the industry by the government. 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 (27) 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.

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 may not be so 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 they direct payments or tax expenditures.

**Investment grants.** Investment grants are a capital transfer. They do not appear directly in equations (25) and (26) although they significantly impact the return to capital and implicit capital rental price  $P_i^K$  for recipient industries. Consider again equation (27). 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:

$$(28) \quad P_i^K K_i = \underbrace{P_i^{K^{BP}} K_i}_{\text{Private payment}_i} + \underbrace{SbQ_i}_{\text{Public payment}_i} .$$

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  $\psi_a$  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

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

and its capital payment is

$$(30) \quad \begin{aligned} \sum_a P_i^{K_a^{BP}} K_a &= \sum_a (1 - \psi_a)(\rho_i + \delta_a)P_a K_a . \\ &= \sum_a (\rho_i + \delta_a)P'_a K_a - \sum_a \psi_a P_a K_a . \end{aligned}$$

These equations illustrate several points. First, for a very long-lived asset,  $\psi_a$  also is the approximate annuity value of the grant, thus the symmetry of investment grants expressed as in (29) with tax credits in the Hall-Jorgenson formula for the tax-adjusted cost of capital. Second, equation (30) shows that if investment grants are an important means of capital financing for an industry ( $\psi_a$  is nonnegligible 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  $\rho_i$  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  $\psi_a$  for its assets).

Third, following equation (28), the simple transformation of (27), we can express total capital services in this industry as the sum of two components. The first is shown in equation (30), which represents the  $i$ th 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 (27) also then apply here although there is one notable exception, namely, as previously discussed, the relative value of the subsidy-like payment is not all that small for many European countries.

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 SNA industry gross value added at basic prices is a notable limitation of the usefulness of system's industry accounts for investment and productivity analysis.

## 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. We pointed out that, insofar as possible, data on industry output and inputs need to be disaggregated according to institutional unit, payments from government to industry need to be appropriately accounted for, and a return to public capital needs to be imputed. These needs, plus the fact that we must capitalize intangible assets not 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.

The framework we set out 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; this requires imputing a real net return to public capital as has long been done in the work of Jorgenson & associates (e.g., Jorgenson, Ho, and Stiroh, 2005) and recently implemented in official total economy productivity measures for the United States. 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 and by incorporating elements of the Jorgenson-Fraumeni (1989; 1992a;

1992b) lifetime-income approach to measuring human capital. 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.

Finally, 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 do not wish to overstate what fiscal policy can deliver on any score, we do wish to better understand the strength and location of its intangible investment lever.

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