Growth Facts with Intellectual Property Products: An Exploration of 31 OECD New National Accounts*

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Abstract

We document a rise of intellectual property products (IPP) captured by up-to-date national accounts in 31 OECD countries. These countries gradually adopt the new system of national accounts (SNA08) that capitalizes IPP—which was previously treated as an intermediate expense in the pre-SNA93 accounting framework. We examine how the capitalization of IPP affects stylzed growth facts and the big ratios (Kaldor, 1957, Jones, 2016). We find that the capitalization of IPP generates (a) a decline of the accounting labor share, (b) an increase in the capital-to-output ratio across time, and (c) an increase in the rate of return to capital across time. The key accounting assumption behind the IPP capitalization implemented by national accounts is that the share of IPP rents that are attributed to capital, χ, is equal to one. That is, national accounts assume that IPP rents are entirely owed to capital. We question this accounting assumption and apply an alternative split of IPP rents between capital and labor based on the cost structure of R&D as in Koh et al. (2018). We find that this alternative split generates a secularly trendless labor share, a constant capital-to-output ratio, and a constant rate of return across time. We discuss the implications of these new measures of IPP capital—conditional on χ—for cross-country income per capita differences using standard development and growth accounting exercises.

Keywords: Growth Facts, Intellectual Property Products, Labor Share, Cross-Country Income Differences
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1 Introduction

In 2009, the United Nation Statistical Commission adopted the new System of National Accounts from 2008 (SNA08) .[1] The most notable update in the new system is the capitalization of (some) intangibles in national accounts which recognizes the growing importance of these assets in the economy (Corrado et al., 2005, McGrattan and Prescott, 2005). Following SNA08, national accounts create a separate investment account labeled intellectual property products (IPP). To be precise, the set of IPP measured by national accounts includes research and development (R&D) and artistic originals, in addition to computer software introduced since SNA 1993. By 2016, most OECD countries have implemented the new system.[2]

We construct a new dataset using the new national accounts for 31 OECD countries that have implemented SNA08. We then use this database to document the secular behavior of economic growth and the big ratios (à la Kaldor (1957) and Jones (2016)) for these countries. We find 1) a decline of the labor share of income, 2) a rise of capital-output ratio, and 3) a rise of the rate of return to capital. We show that the new secular behavior of the big ratios that we document is entirely driven by the reclassification of IPP from expense to capital. In particular we show that treating IPP as expense—as in the pre-SNA93 accounting framework in which only tangible investment (i.e., structures and equipment) is capitalized—implies a relatively trendelss labor share of income, capital-to-output ratio, and rate of return.

The main accounting assumption behind the capitalization of IPP implemented by national accounts following the SNA08 is that all IPP rents are attributed to capital (Koh et al., 2018). That is, the IPP investment on the national product side of the accounts is moved to gross operating surplus (hence, capital income) on the national income side of the accounts. We argue that this accounting assumption guidelines is arbitrary and extreme. Indeed, we show that the assumption that all IPP rents are capital income is crucial in generating the new facts. Once we relax this assumption and use alternative splits of IPP rents based, for example, on the cost structure of R&D (as in Koh et al. (2018)), we go back to the familar trendless secular behavior of the big ratios in the pre-SNA93 accounting framework.

The introduction of IPP as capital in national accounts poses important challenges for measurement that are not present for tangible capital. Indeed, although the introduction IPP as

[1] *European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, and World Bank,* System of National Accounts 2008 (New York: 2009)

[2] Koh et al. (2018) provide a detailed description of accounting assumptions behind the capitalization IPP implemented by the Bureau of Economic analysis (BEA) in the U.S. in 2013. We find that similar procedures are implemented by the national statistics offices of the OECD countries that we study. Three exceptions are Turkey, Chile, and Japan.

investment in national accounts is sensible given the long-run nature of its provided services, it is challenging (if not imposible) to accurately measure IPP and to split the IPP rents across factors of production. First, most IPP is simply unobserved. Even within the context of the IPP items incorporated in national accounts (which are arguably better measured), a large part of their production (such as software or R&D) is conducted in-house without observable transactions for their valuation and pricing. Currently the national accounts measure this own account production based on costs (plus an estimated nonmarket markup). Second, it is not obvious how to preserve the product-income identity in the presence of intangibles. Currently the national accounts equate the rents generated from IPP to IPP invesment expenditure and attribute all these rents to gross operating surpplus (GOS), i.e., to capital income. This distribution of IPP rents is not justified empirically. Many workers directly related to the production of intangibles (e.g., R&D lab managers) are paid a wage below their marginal value product in exchange of future equity in the firm (McGrattan and Prescott, 2010, 2014). We find that more reasonable splits of IPP rents generate a trendless labor share of income, capital-to-output ratio, and rate of return.

The contribution of IPP to cross-country differences income and growth is extremely sensitive to the distribution of IPP rents, even though it does not alter the amount of IPP capital. The mechanism is simple, when IPP rents are allowed to go to labor—as opposed to capital as in the current SNA08, the contribution of IPP to development and growth accounting works more through the labor input and less through capital. This is important because labor (in efficiency units adjusted for schooling) has less variation across time and space than capital. This implies that while the contribution of IPP capital accounts for about a quarter of the total factor productivity dispersion and growth when we use the declining labor share observed in data (i.e., SNA08), this contribution goes down to half once we allocate IPP rents based on the cost structure of R&D activities associated with a trendless labor share.

The paper is structured as follows. In Section 2 we describe the capitalization of IPP in the national accounts. In Section 3 we show the effects of IPP capitalization on economic growth and the big ratios including the labor share of income, the capital-to-output ratio, and the rate of return on capital. We conduct a development accounting exercise in Section 4 and a growth accounting exercise in Section 5. Section 6 concludes.

2 IPP Capitalization in the National Accounts

In 2009, the United Nation Statistical Commission adopted the new System of National Accounts, SNA 2008. The most notable update in the new system is an attempt to better measure the intangible capital in a national economy. In SNA 2008, the intangible capital measured by the national accounts of OECD countries is labeled as intellectual property products (IPP). IPP accounts include include R&D and artistic originals, in addition to computer software introduced since SNA 1993. By 2016, most OECD countries have implemented the new system.[3] Koh et al. (2018) explain in detail this accounting change using the US national income and product accounts.

Since most countries have implemented SNA 2008 very recently, and are still updating data figures, we build a new dataset that combines data from individual national sources with the OECD stats database. We construct capital series by type (i.e. tangible, IPP, and aggregate) using the perpetual inventory method with type specific depreciation rates obtained from the consumption of fixed capital data whenever available. For countries with no information on the consumption of fixed capital (either directly or indirectly from capital stock data), we use estimated depreciation rates corresponding to the level of log GDP per capita.[4] The labor share is also adjusted for self employed income using data for mixed income or number of self employment, whichever provides longer data. The resulting dataset has 907 country-year observations covering 31 OECD countries for various time periods (see our Appendix for details). In documenting the growth facts, we exclude sample with GDP per capita less than 10,000 USD (in 2005), which is near 1940 in US, to focus on economies that are near balanced growth path in the sense of Kaldor (1957) and Jones (2016). This drops 37 out of 907 observations and makes no difference in our results.

Three major differences between our dataset and the Penn World Table (PWT) are noteworthy. First and most importantly, ours has IPP capital separately whereas PWT does not. This separation is essential for our study of the effects of IPP capitalization on growth and the big ratios across time and space. Second, we used longer series of mixed income or self employment data in general compared to PWT in the adjustment of labor share. Third, we used information of time varying depreciation rates for the construction of capital stock while PWT assumes constant depreciation rates for each capital type. These depreciation rates have implications for the measures of the stock of capital and hence growth and development accounting decompositions.

What does the IPP capitalization entails for the national product and income accounts? All OECD countries follow an similar revision as the one conducted by the BEA in the US in 2013 (Koh et al., 2018). Basically, after the revision, expenditures on IPP (X_I) are treated as

[3] A few exceptions are Turkey, Chile, and Japan.

[4] These include Spain, Mexico, and Portugal.

investment. This way, the identity between the national product and national income is,

$$Y = C + X_T + X_I = \underbrace{RK}_{\text{gross operating surplus}} + \underbrace{WL}_{\text{compensation of employees}}. \tag{1}$$

Instead, before the revision, IPP investment was treated as an expense on intermediate inputs. Because the revision has the key accounting assumption that all IPP investment, X_I, is moved to gross operating surplus, GOS, we can summarize the result of the revision in the SNA showing the difference between the current accounting (equation (1)) and the previous accounting:

$$Y_{\text{Pre-Revision}} = C + X_T = \underbrace{(RK - \chi X_I)}_{\text{gross operating surplus}} + \underbrace{(WL - (1-\chi)X_I)}_{\text{compensation of employees}}. \tag{2}$$

where χ refers to the fraction of IPP expenses coming from capital owners, whereas $1 - \chi$ is the fraction of IPP expenses from workers. That is, χ captures the distribution of IPP rents across factors of production. The main accounting assumption behind the IPP capitalization implemented by national statistical offices—following the SNA2008 guidelines—is that $\chi = 1$. McGrattan and Prescott (2010) refer to χX_I and $(1-\chi)X_I$ as expensed and sweat investment, respectively. The current accounting practice under the SNA 2008 adds the entire X_I to the gross operating surplus, which implicitly assumes $\chi = 1$. In reality, χ is not neccessarily one as workers in R&D activities often get paid less than their marginal productivity with a promise of future equity compensation (McGrattan and Prescott, 2010). This potentially relevant for the behavior of the labor share in OECD countries following the result in Koh et al. (2018) for the US. These authors show that setting $\chi = 1$—as opposed to perhaps more reasonable values of χ closer to 0.4-0.6 based on the cost structre of R&D—explains the secular decline of the labor share in the U.S.

For simplicity, our comparison between the current accounting (1) and the pre-revision accounting (2) has focused on the change in the accounting treatment of IPP in the business sector. There is one additional dimension regarding the capitalization of IPP for nonprofit institutions serving households (NPISHs) and the government. For NPISHs and the government, the expenditure on IPP was treated as final consupmtion in the pre-revision accounting. This implies that in the current accounting only the measured depreciation of IPP capital in NPISHs and the government secotr is added to national accounts. Again, all this depreciation coming from NPISHs and the government is assumed to go to GOS on the income side of the accounts (see Koh et al. (2018)).

Table 1: IPP investment at current PPP rates (Billions) in 2011

	IPP inv			IPP inv			IPP inv			IPP inv	
AUS	29.8	(3.4)	ESP	41.3	(3.0)	ISL	0.2	(2.3)	NZL	4.2	(3.3)
AUT	16.2	(5.1)	EST	0.7	(2.6)	ISR	9.8	(4.9)	POL	10.2	(1.4)
BEL	17.1	(4.4)	FIN	10.7	(6.0)	ITA	53.8	(2.9)	PRT	7.6	(3.2)
CAN	44.1	(3.4)	FRA	117.9	(5.7)	KOR	81.5	(6.1)	SVK	2.5	(2.0)
CHE	24.6	(6.3)	GBR	85.3	(4.3)	LUX	1.2	(3.1)	SVN	1.8	(3.7)
CZE	9.8	(3.8)	GRC	4.8	(1.9)	MEX	7.5	(0.4)	SWE	25.9	(7.6)
DEU	121.9	(4.1)	HUN	5.7	(3.0)	NLD	33.0	(5.0)	USA	783.8	(5.7)
DNK	11.7	(6.0)	IRL	11.7	(6.4)	NOR	9.8	(3.7)			

Notes: We write in parenthesis the proportion (%) of IPP investment in value added.

3 The Effects of IPP Capitalization on Growth and the Big Ratios

First discuss the effects of IPP capitalizaiton on output growth and dispersion (Section 3.1). Second, we show that the decline of the accounting labor share observed in OECD countries can be explained by the capitalization of IPP (Secction 3.2). The capitalizaiton of IPP is also behind an increase in the capital-to-output ratio (Section 3.3) and in the rate of return to capital (Section 3.4).

3.1 Effects of IPP Capitalization on Output Growth and Dispersion

Under the new SNA (2008) the production of IPP, x_I, is added to the pre-accounting measures of value added. This procedure has been gradually implemented by OECD countries. Precisely, the accouting change implies an increase in value added in the OECD output by 4% on average in 2011. Table 1 summarizes the effects of the IPP capitalization on value added for all our OECD countries in year 2011. The largest change occurs in the US with a value added that increases by 783.8 billions, the lowest change is by 0.2 billions in Iceland.

The accounting increase in value added due to the capitalization of IPP in percentage terms, γ_y, is captured by this ratio,

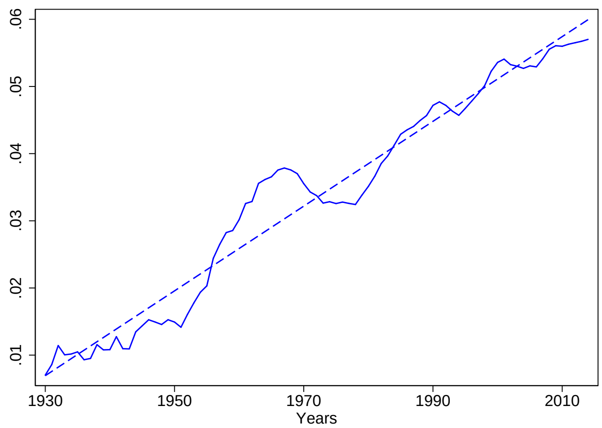
$$\gamma_y = \log \frac{y}{y - x_I}, \tag{3}$$

where y is value added x_I is IPP investment, and the denominator, $y - x_I$, captures value added before the capitalization of IPP. We plot γ_y for the OECD across time (panel (a1), Figure 1) and across space (panel (a2), Figure 1). The increasing importance of IPP investment across time and space is clear. Precisely, we find that γ_y increases from 0.9% in 1930 to 5.8% in 2014 on average in OECD countries. Across space, when a country's GDP per capita is near 8,000 USD (in 2005 PPP), γ_y is 0.7% on average. The γ_y increases to 5.7% on average when the GDP per capita attains near 70,000 USD (in 2005 PPP).

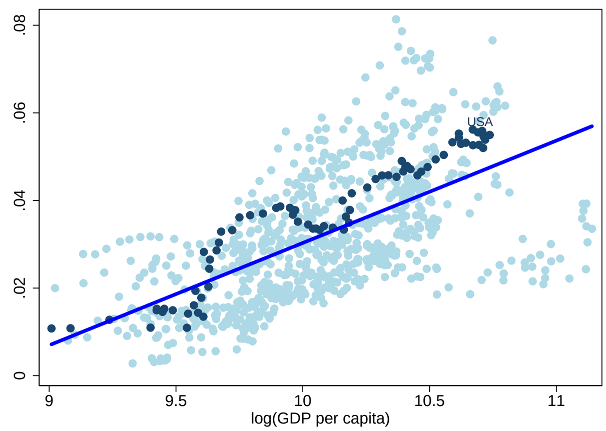
Figure 1: The Effects of IPP Capitalization on Value Added, 31 OECD countries

(a) Percentage Increase in Value Added due to IPP Investment (γ_y)

(a1) Across Time

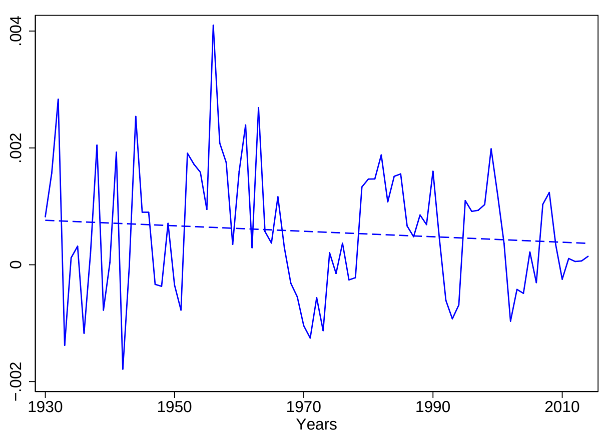


(a2) Across Space

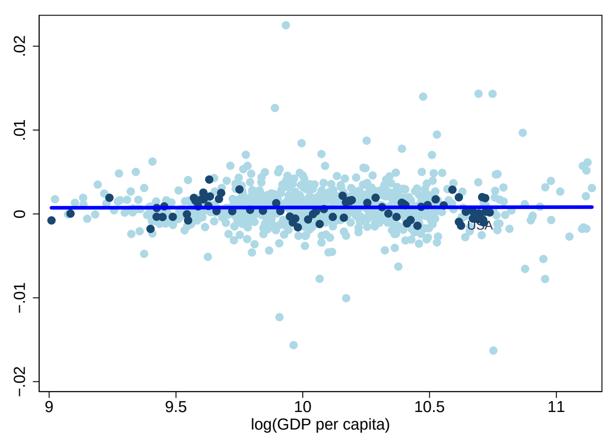


(b) Increase in Value Added Growth due to IPP Investment ($d\gamma_y$)

(b1) Across Time



(b2) Across Space



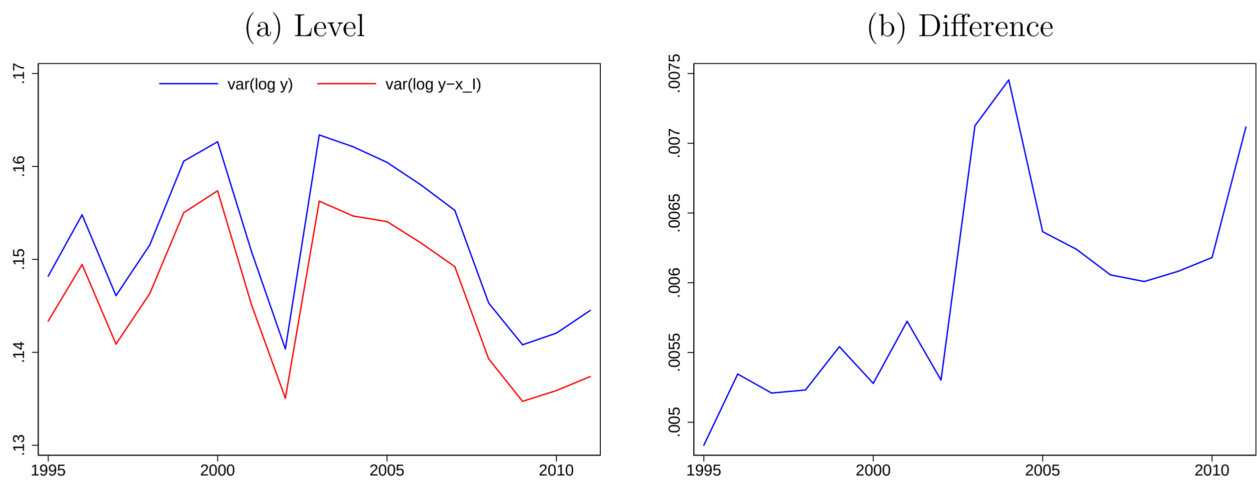
Notes: Where γ_y is constructed as in equation (3). The average time series are based on the estimated time fixed effects using GDP (PPP) as weight.

Naturally, the growth rate of value added also changes with the capitalization of IPP. The OECD value added growth rate currently averages 3.20% from 1950 to 2011, while this figure is 3.13 with the pre-SNA93 that expenses IPP. To be precise, we plot the changes over time for

γ_y $(:= d\gamma_y)$ which is the difference between the growth rate of value added corresponding to the current accounting and the growth rate of the pre-SNA93 accounting value added for the OECD across time (panel (b1), Figure 1) and across space (panel (b2), Figure 1). The difference between the growth rates has no clear trend over time and space, remaining at around 0.07% on average across time and space.

An interesting aspect of the IPP capitalization is that it increases value added proportionally more for countries with larger IPP investment. If countries that have large IPP investments are income-rich countries before the accounting change, then IPP capitalization can increase the dispersion of cross-country incomes. If countries that have large IPP investments are poor countries before the accounting chnage, then IPP capitaliation can decrease the dispersion of cross-country incomes. In Figure 2, we show the difference between cross-country standard deviation of log value added per capita before and after IPP capitalization across time. The cross-country standard deviation of value added per capita increases for all years with the capitalization of IPP (+ .77% on average between 1995 and 2011).

Figure 2: The Effects of IPP Capitalization on Cross-Country Income Variation



3.2 Effects of IPP Capitalization on the Labor Share

The accounting labor share is experiencing a global decline that has attracted lots of attention (Karabarbounis and Neiman, 2014). Figure 3 shows this decline for our updated OECD dataset across time (panel (a)) and space (panel (b)). The accounting labor share is defined as

$$LS = 1 - \frac{GOS}{Y}.$$

where GOS is gross operating surplus and Y is gross domestic income.

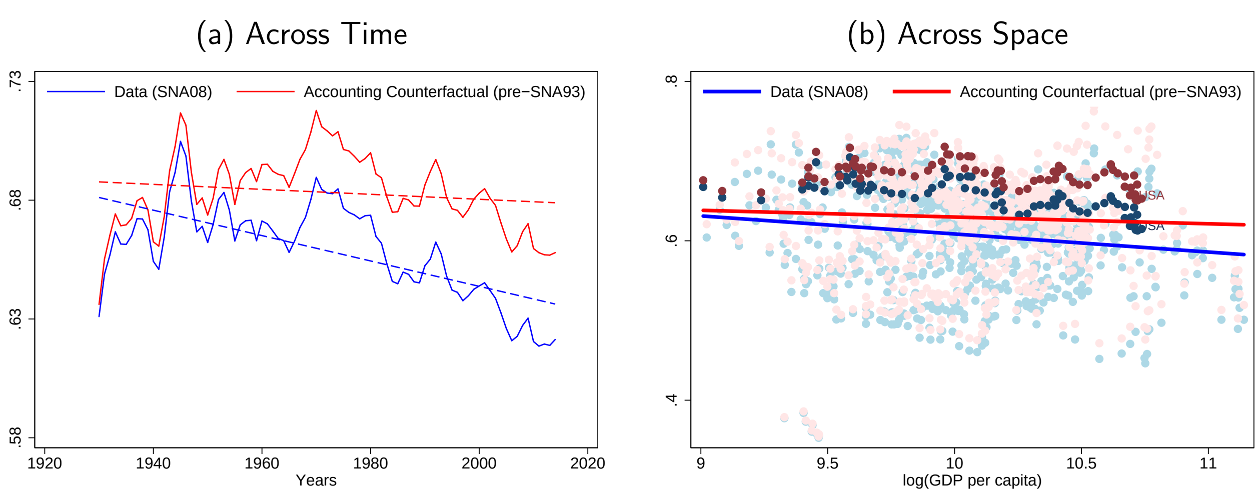
To measure the effects of the capitalization of IPP on the accounting LS, we follow the strategy in Koh et al. (2018) by constructing a counterfactual pre-SNA93 accounting LS in which IPP items are expensed as opposed to capitalized,

$$LS_{Pre-SNA93} = 1 - \frac{GOS - X_I}{Y - X_I},$$

where X_I is investment in IPP. Because $Y > GOS$, IPP capitalization unambiguously reduces labor share. Moreover, the revision can generate a declining trend for the labor share if the IPP investment is growing faster than value added which it does.

Figure 3 depicts accounting LS under the current SNA2008 scenario where IPP is capitalized and the pre-SNA1993 scenario where IPP is expensed. The time path of OECD labor share is obtained by the year fixed effects weighted by the dollor output as time coverages are different by countries[5] Both graphs show that the accounting LS declines in OECD countries across time and space under the current SNA2008, but the trend vanishes when IPP is expensed, i.e., under the pre-SNA2008 scenario. That is, the decline of the accounting LS is fully explained by the capitalization of IPP.

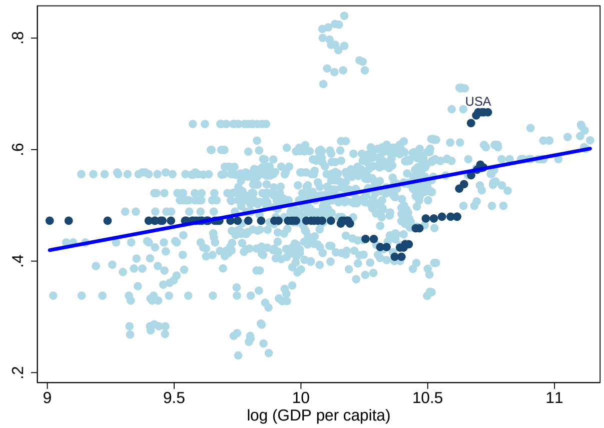
Figure 3: Effects of IPP Capitalization on Labor Share, 31 OECD Countries



The current accouting assumes that the IPP investment from the national product side is entirely attributed to GOS in national income (i.e. $\chi = 1$), see Section 2. This assumes that the

[5]We estimate $LS_{i,t} = c_i + \beta_t t + \varepsilon_{i,t}$ and then plot $\hat{\beta}_t$ where its 1950 value is normalized to the weighted average of 1950 labor share.

Figure 4: Labor Share in R&D Based on Cost Structure, 31 OECD Countries



workers do not fund the R&D activities. However, it is widely happening in the R&D activities that workers get paid less than their contribution (marginal productivity) for a promise of future compensation such as stock options. We argue that this should be understood as evidence of $\chi < 1$. That is, workers also fund R&D investment, and their contribution should be understood as labor income, not capital income.

However, estimating χ is not a trivial matter as it requires a detailed micro-level information on the R&D activities. For now, we use the information based on the cost structure of R&D to examine the value of χ different from one. Specifically, we set $\chi = 1 - LS_{R\&D}$, where $1 - LS_{R\&D}$ is a fraction of capital expenses in total cost of R&D, obtained from OECD statistics database. Figure 4 confirms that $LS_{R\&D}$ is clearly different from 0, and has a slightly increasing trend over the development path (log GDP per capita). For example, for the US it raises from roughly 45% to 65% over the past 20 years.

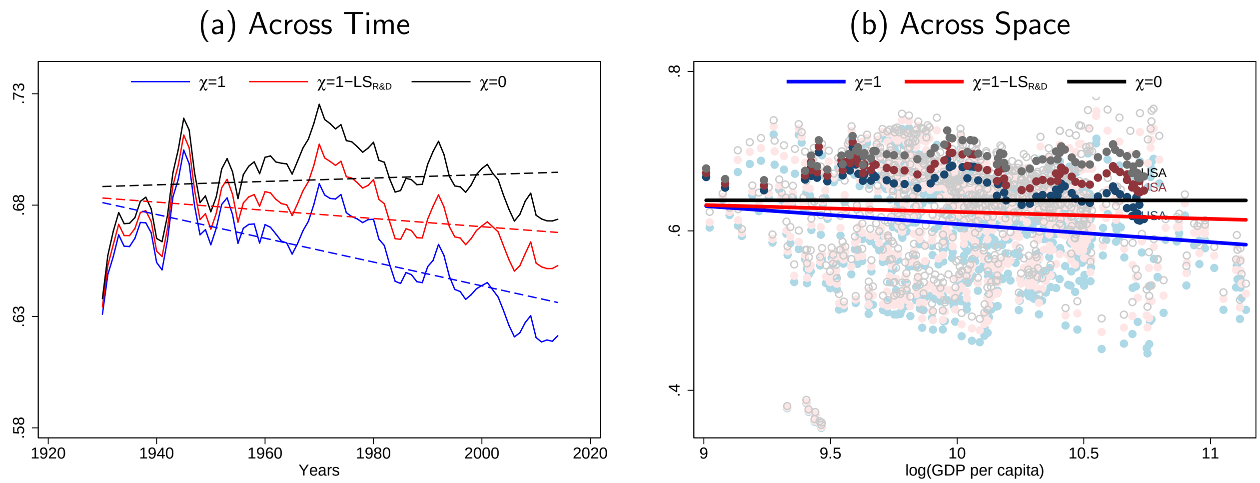
With our proxy for χ based on the cost structure of R&D, we compute an alternative labor share as following.[6]

$$LS_{\chi=1-LS_{R\&D}} = 1 - \frac{GOS - (1-\chi)X_I}{Y}.$$

We find that the role of χ is critical in understanding labor share decline. In particular, the decline of the labor share vanishes when relaxing the assumption that all the rents on IPP

[6]More precisely, we also adjust for the mixed income in computing labor share with any values for χ. That is, the labor share is $LS = [CE + (1-\chi)X_I \times (Y - MI)/Y]/(Y - MI)$ where MI is mixed income (mainly proprietors' income).

Figure 5: Labor Share with alternative distributions of IPP rents, χ's



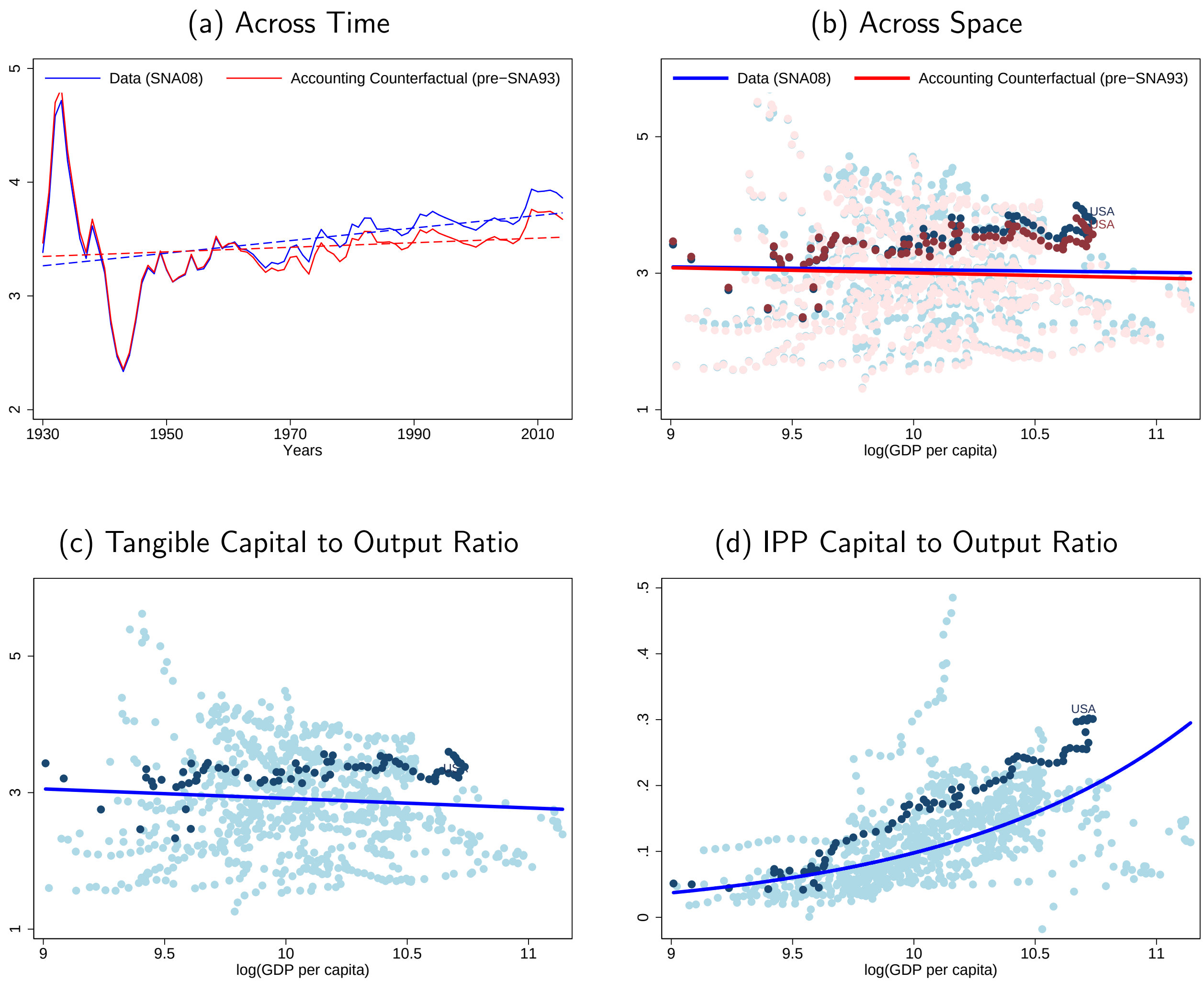
investment go to capital ($\chi = 1$). Using our estimate of χ based on the cost structure of R&D activities, we find that the accounting labor share is trendless across time (panel (a), Figure 5) and space (panel (a), Figure 5). These findings extend to the OECD countries the accounting results in Koh et al. (2018) for the U.S.

3.3 Effects of IPP Capitalization on the Capital-to-Output Ratio

We plot the aggregate capital to output ratio with the current SNA08 and pre-SNA93 where all IPP was expensed. To replicate the pre-SNA93 scenario we compute the capital to output ratio as $\frac{K_T}{Y-X_I}$ where K_T is tangible capital and we remove investment in IPP from output in the denominator. It is clear that the capital to output ratio that incorporates IPP capital grows over time, while the capital to output ratio of the pre-IPP capitalization accounting is relatively trendless and consistent with the Kaldor facts (panel (a), Figure 6). Similarly, the capital to output ratio across space is larger when IPP is capitalized (panel (b), Figure 6). Although in this case we find relatively trendless capital-to-ouptut ratios across space in both scenarios, with and wihout IPP capitalization.

We decompose the sources behind the increase in the aggregate capital to output ratio. We compare the ratio of tangible capital K_T to output Y (panel (c), Figure 6) and the ratio of IPP capital K_I to output Y (panel (d), Figure 6). It is clear that it is the increase in the ratio of IPP capital to output over time that generates the increase in the aggregate capital to output ratio. Instead, the ratio of tangible capital to output decreases over time.

Figure 6: Effects of IPP Capitalization on the Capital to Output Ratio, 31 OECD Countries



But is IPP capital accurately measured? A very important caveat of these findings is that the construction of the series of capital is based on the perpetuary inventory method (consistent with the procedure followed in the fixed asset tables of the national accounts) and this requires measures of unobserved IPP prices and unobserved IPP depreciation rates. National accounts capitalize structures and equipment, as well as IPP, using separate laws of motion for capital to obtain the series for K_T and K_I (see the appendix for the details). Therefore, the construction of the capital stock series implies that we need to use data on IPP prices and IPP depreciation rates which are unobservable and, we argue, subject to questionable assumptions in their construction. Precisely, in the US, the BEA does not provide an accounting measure of IPP depreciation but an economic one (Koh et al., 2018). To estimate R&D depreciation—aimed at capturing obsolescence and competion which are not directly observable—the BEA uses an economic model that maximizes profits over R&D choices with ad-hoc assumptions on the effect of R&D on profits (Li and Hall, 2016). Hence, treating the BEA IPP depreciation as measurement is only logically consistent with theory that complies with the BEA economic model that estimates IPP depreciation. In addition, the estimation of IPP depreciation requires IPP prices that we do not observe because there are no transactions of in-house production of intangibles and because R&D projects are heterogeneous in nature. Because we simply do not observe transactions of in-house production, the estimates of IPP prices for in-house production are hard to measure. A useful approach to estimate intangible capital that is unobservable is introduced in McGrattan and Prescott (2010). Instead, the BEA uses an input cost index as a proxy for the R&D output price change. However, an input cost index does not capture the impact of productivity change on real R&D output. Argumenting that R&D increases aggregate productivity, the BEA uses the economy-wide measure of multifactor productivity (MFP) from the BLS to proxy for unobserved R&D productivity and subtracts the growth rate of MFP from the input cost index (Crawford et al., 2014). Again, this is breeding ground for logical inconsistencies between theory and measurement if theory does not comply with the MFP from the BLS.

3.4 Effects of IPP Capitalization on the Rate of Return

The rate of return under the current system of national accounts is plotted across time and space in Figure 7. We find an increasing pattern for the rate of return in both cases. Instead, using the pre-SNA1993 accounting we go back to the standard Kaldor facts that deliver a rate of return that is relatively constant across time and space, see Figure 7.

Now we turn to an investigation of the quantitative importance of the IPP capital by level and growth accounting exercises in the following sections.

4 Development Accounting with IPP Capital

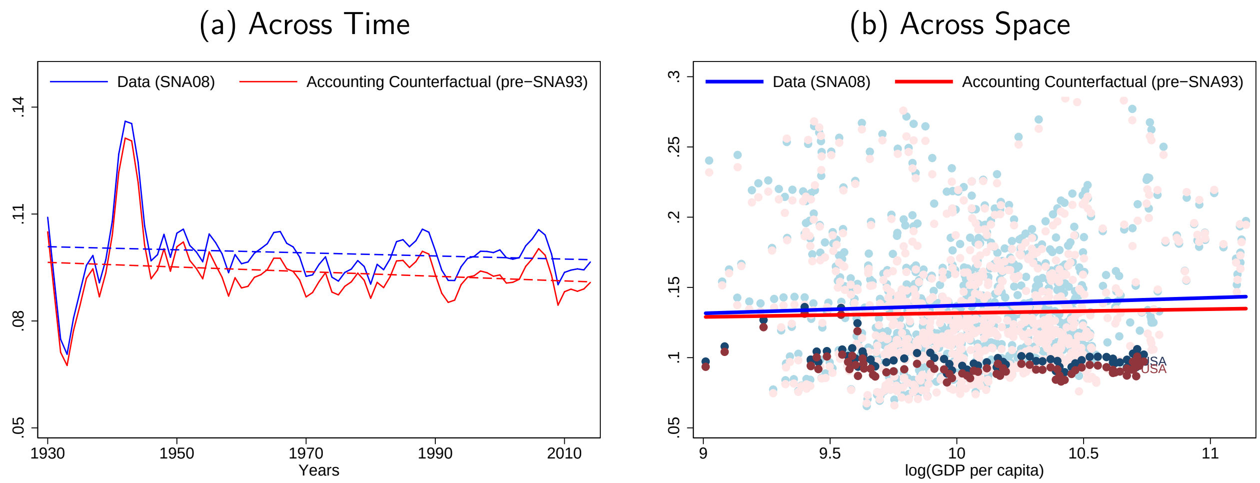
We first focus on the standard production function approach to level (or development) accounting. Second, we look at the product side (i.e., expenditures) of the national product.

4.1 Production Function Approach

We conduct a standard development accounting exercise with the introduction of IPP capital in national accounts. Consider the following constant returns to scale (CRS) production function,

$$y_{j,t} = a_{j,t} k_{I,j,t}^{\theta_{I,j,t}} k_{T,j,t}^{\theta_{T,j,t}} h_{j,t}^{\theta_{h,j,t}} \tag{4}$$

Figure 7: Effects of IPP Capitalization on the Rate of Return to Capital, 31 OECD Countries



where $y_{j,t}$ is output for country j in period t. The factor inputs of production are tangible capital, $k_{T,j,t}$, IPP capital, $k_{I,j,t}$, and labor in efficiency units, $h_{j,t}$. Each of these factors of production contribute to output according to their respective coefficients θ, where $\theta_{I,j,t} + \theta_{T,j,t} + \theta_{h,j,t} = 1$.

We assume competitive markets which together with CRS technology implies that the coefficients θ are the factor shares of income. In terms of measurement, we compute each of these shares as:

$$\theta_{h,j,t} = \frac{wh_{j,t} + (1 - \chi_{j,t})x_{I,j,t}}{y_{j,t}}, \tag{5}$$

$$\theta_{I,j,t} = \frac{\chi_{j,t}x_{I,j,t}}{Y_{k,t}}, \tag{6}$$

$$\theta_{T,j,t} = \frac{y_{j,t} - wh_{j,t} - x_{I,j,t}}{y_{j,t}} = 1 - \theta_{I,j,t} - \theta_{h,j,t}, \tag{7}$$

Again, consistently with the current system of national accounts (SNA, 2008) we use the accounting assumption that $\chi_{j,t} = 1 \; \forall j, t$. We parallelly examine the implications of this assumption by using the cost structure of R&D ($\chi_{j,t} = 1 - LS_{R\&D,j,t}$). Detailed data construction procedure for the level accounting is described in the appendix. Note that if $x_I = 0$, then we are back to the previous accounting (SNA 1993 where IPP capital was not capitalized). If $x_I > 0$ and $\chi = 1$, then we are in the current system of national accounts (SNA, 2008).

The quantitative assessment of the importance of the IPP capital in accounting for the cross-country differences in output, we need measures of IPP capital. National accounts for each

Table 2: Cross-Country Differences in Output per employment: Value Added and the Importance of IPP Measured by National Accounts

(a) With $\chi = 1$ (SNA, 2008)

	1996	1999	2002	2005	2008	2011
Measure (A):						
1. Success	0.42	0.45	0.44	0.48	0.54	0.53
2. Success without IPP	0.32	0.34	0.32	0.36	0.41	0.40
3. Contribution of IPP (L.1 - L.2)	0.10	0.11	0.12	0.12	0.13	0.13
Measure (B):						
4. Success	0.54	0.54	0.53	0.59	0.63	0.61
5. Success without IPP	0.41	0.41	0.38	0.45	0.48	0.45
6. Contribution of IPP (L.4 - L.5)	0.13	0.13	0.15	0.14	0.15	0.16

(b) With $\chi = 1 - LS_{R\&D}$

	1996	1999	2002	2005	2008	2011
Measure (A):						
7. Success	0.37	0.39	0.38	0.42	0.47	0.46
8. Success without IPP	0.33	0.34	0.32	0.37	0.41	0.40
9. Contribution of IPP (L.7 - L.8)	0.04	0.05	0.06	0.05	0.06	0.06
Measure (B):						
10. Success	0.50	0.50	0.48	0.55	0.58	0.56
11. Success without IPP	0.43	0.43	0.41	0.48	0.51	0.49
12. Contribution of IPP (L.10 - L.11)	0.06	0.07	0.07	0.07	0.07	0.07

Notes: Success measure is fraction of variance explained by factor inputs. IPP explanation refers difference between success measure with IPP and without IPP out of output variation unexplained by traditional factors.

country provides these measures constructed using the perpetual inventory method given series for IPP investment, IPP prices and IPP depreciation rates. As we discussed earlier, these series of capital are subject to substantial mismeasurement and are in large part of the result of accounting assumptions behind the series of IPP investment, IPP prices and IPP depreciation rates. For now, we take these series as given.

To see the impact of IPP on the cross-country per capita income differences we write production (4) for each period t in logs as,

$$\log(y_{j,t}) = \log(a_{j,t} + \underbrace{\theta_{I,j,t}\log(k_{I,j,t}) + \underbrace{\theta_{T,j,t}\log(k_{T,j,t}) + \theta_{h,j,t}\log(h_{j,t})}_{\log(q_{-I,j,t})}}_{\log(q_{j,t})}.$$

Table 3: Decomposition of the output variance in 2011

	IPP related			h related		k related
	var(k_I)	cov(k_I, h)	cov(k_I, k)	var(h)	cov(h, k_T)	var(k_T)
$\chi = 1$ (SNA08)	9.5	6.6	35.5	37.3	6.6	233.9
$\chi = 1 - LS_{R\&D}$	2.0	3.1	16.2	40.1	6.9	233.9
Difference	-7.5	-3.5	-19.3	+2.7	+0.2	+0.0

where $q_{j,t} = k_{I,j,t}^{\theta_{I,j,t}} k_{T,j,t}^{\theta_{T,j,t}} h_{j,t}^{\theta_{h,j,t}}$ captures the set of observable factor inputs in the national accounts and $q_{-I,j,t} = k_{T,j,t}^{\theta_{T,j,t}} h_{j,t}^{\theta_{h,j,t}}$ excludes IPP capital. To see the impact of IPP on the cross-country per capita income differences we compare measures of accounting success with and without IPP capital. Our two measures of accounting success follow Caselli (2005). First, we define,

$$\text{Success A} = \frac{\text{var}(\log q_{j,t})}{\text{var}(\log y_{i,t})}$$

$$\text{Success A, without IPP} = \frac{\text{var}(\log q_{-I,j,t})}{\text{var}(\log y_{i,t})}$$

Because total factor productivity potentially comoves with the observable factor inputs we also use the following alternative measure of success:

$$\text{Success B} = \frac{\text{var}(\log q_{j,t}) + \text{cov}(\log q_{j,t}, \log a_{j,t})}{\text{var}(\log y_{i,t})}$$

$$\text{Success B, without IPP} = \frac{\text{var}(\log q_{-I,j,t}) + \text{cov}(\log q_{-I,j,t}, \log a_{j,t})}{\text{var}(\log y_{i,t})}$$

Table 2 shows the results. With IPP capital, the success measure (A) increases by 10% in 1996, from 32 to 42%, and by 13% in 2011, from 40 to 53% (see panel (a) in Table 2). We find a similar increasing pattern of the contribution of IPP capital to cross-country per capita income differences over time using success measure (B). Precisely, we find that IPP capital increases success measure (B) by 13% in 1996, from 41 to 54%, and by 16% in 2011, from 45 to 61%. However, the results change with the value of χ, which can be easily seen from equation (5) to (7). Even though χ does not alter the level of IPP capital, it changes factor shares. Indeed, the additional explanation from the IPP capitalization goes down to less than a hal, when relaxing the extreme assumption that $\chi = 1$ to $\chi_{j,t} = 1 - LS_{R\&D,j,t}$, see panel (b) in Table 2.

Why does the explanation decrease with $\chi < 1$? The reduction in χ essentially lowers the IPP capital share with higher labor share. When the labor's contribution becomes more important, our understanding on cross country income differences gets smaller. This is because the variation in human capital is less useful for the understanding of the cross country income disparities than

Table 4: Additional fraction explained by IPP capital in 2011

	δ_I	$\delta_I = 0$	$\delta_I = \delta_T$
$\chi = 1$ (SNA08)	0.22	0.20	0.23
$\chi = 1 - LS_{R\&D}$	0.10	0.08	0.10

that of capital, at least for the human capital measured by the average years of schooling a la Barro-Lee in the PWT. Yet the precise measurement on human capital has not reached consensus (Schoellman and Hendricks, 2017, and references therein).

Note that the IPP rents going to labor makes workers' compensation higher but not their human capital better. When a country increases IPP investment, its additional contribution works through both labor and capital. The indirect channel working through additional compensation to labor explains less for the increase in output, as long as the level of human capital remains same. Therefore, it would be important to distinguish wage and human capital in the level accounting exercise, which is consistent with the point made in Caselli and Ciccone (2017) or Schoellman and Hendricks (2017).

To see how much the explanation coming from the variation in human capital is small using the Barro-Lee measures of human capital from the PWT, we decompose the variance of output as following:

$$\begin{aligned}
\text{var}(\log y) = & \underbrace{\text{var}(\log a) + 2[\text{cov}(a, \theta_h \log h) + \text{cov}(a, \theta_I \log k_I) + \text{cov}(a, \theta_T \log k_T)]}_{\text{TFP related}} \\
& + \underbrace{\text{var}(\theta_h \log h) + \text{cov}(\theta_h \log h, \theta_I \log k_I) + \text{cov}(\theta_h \log h, \theta_T \log k_T)}_{\text{Human capital related}} \\
& + \underbrace{\text{var}(\theta_I \log k_I) + \text{cov}(\theta_h \log h, \theta_I \log k_I) + \text{cov}(\theta_I \log k_I, \theta_T \log k_T)]}_{\text{IPP capital related}} \\
& + \underbrace{\text{var}(\theta_T \log k_T) + \text{cov}(\theta_h \log h, \theta_T \log k_T) + \text{cov}(\theta_I \log k_I, \theta_T \log k_T)]}_{\text{Tangible capital related}}
\end{aligned}$$

Table 3 shows the decomposition result, which confirms that the larger success from IPP and smaller success from human capital under the current accounting ($\chi = 1$). The magnitude of additional explanation from IPP capital is larger than that of human capital, resulting in larger overall success in the case with $\chi = 1$.

Another parameter to consider a variation is the depreciation of IPP capital (δ_I). In the accounting of IPP capital, the depreciation of IPP capital is higher than that of traditional capital. Different values for the depreciation may also change the level accounting results, as it alters the amount of IPP capital accumulated in the national economy. We examine the sensitivity of the level accounting to various depreciation rates; benchmark depreciation rate ($\delta_I = \hat{\delta}_I$), no depreciation ($\delta_I = 0$), and depreciation rate of traditional capital ($\delta_I = \hat{\delta}_T$). Contrary to the case of χ, changes in δ_I do not affect the results of level accounting much (see table 4).

4.2 Level Accounting from the Product Side of National Accounts

Because the production of IPP is equated to IPP investment in national accounts, an alternative approach to document the role of IPP in explaining cross-country differences in output per capita is conducting the analysis from the product side of the accounts, i.e.,

$$y = c + x_I + x_T + g \tag{8}$$

where c is private consumption, x_I is investment in IPP, x_T is investment in tangible assets, and g is government expenditure.

The level accounting from the product side of the accounts is interesting because it does not rely on measures of IPP capital (which requires measures of IPP prices and depreciation). At the same time it does not require mesaures of the factor share. Because the product side is additive (8), we can directly measure the contribution of its components to the cross-country variation in the level output. For example, to study the role of IPP investment we compute,

$$\frac{\mathsf{var}(x_{I,j,t}) + \mathsf{cov}(x_{I,j,t}, y_{j,t} - x_{I,j,t})}{\mathsf{var}(y_{j,t})}. \tag{9}$$

Note that because we do not take logs the variance of output across countries depends on its average. This is however irrelevant for our analysis as we are interested in the percentual contribution of each of the components in the product side of the accounts (8) to output variation.

A difficulty is that the product components do not add up to the value added (y) when considering the price dispersion across countries. For example, we convert the unit of each product component into USD using the PPP rates that are different across items in the previous subsection. Therefore, we consider two different cases, one with x_I converted by investment PPP rate (as in the previous subsection) and another with x_I converted by GDP PPP rate.

Our results are in Table 5. We find that IPP investment explains about 4.8% of GDP variation on average. When using investment PPP, its explanation increases, but the difference is not significant. Because national accounts equate IPP investment to IPP income, we can

Table 5: Cross-Country Differences in Output per Worker: Contribution of IPP from the Product Side of National Accounts (%)

	1996	1999	2002	2005	2008	2011
Eq (9) (investment PPP)	4.0	4.5	4.7	4.6	5.2	6.4
Eq (9) (GDP PPP)	3.7	4.4	4.8	4.5	4.9	5.6

Notes: We use the decomposition in (9)

use this result from the product side of the national accounts to validate the value of χ on the income side of the accounts. In this direction, we note that our results for the IPP contribution to cross-country income per capita differences is much more similar to the our preferred case with $\chi = 1 - LS_{R\&D}$ (4.3% on average) than the SNA08 assumption of $\chi = 1$ (8.9% on average). This suggests a value close to our choice $\chi = 1 - LS_{R\&D}$ is preferred.

5 Growth Accounting with IPP capital

In this section, we do growth accounting exercise. Many studies have attempted to account for the importance of innovational activities in economic growth. Related, Corrado et al. (2005, 2009) extend the standard growth accounting to incorporate a precisely measured innovation-related capital. The main difference with respect to Corrado et al. (2005, 2009) is that we focus on the implication of income allocation of the R&D activities (i.e. χ) in the growth accounting.

Note that under the assumption of constant return to scale and competitive market, growth accounting exercise is insensitive to exact form of production function. Specifically, given any constant return to scale production function $y = af(k_I, k_T, h)$, we have

$$\frac{dy}{y} = \theta_T \frac{dk_T}{k_T} + \theta_I \frac{dk_I}{k_I} + \theta_h \frac{dh}{h} + \frac{da}{a},$$

where y, k_T, k_I, h, and a are output per employment, traditional capital per employment, IPP capital per employment, average human capital, and total factor productivity, respectively. The θ_f's are the income share of factor input f.

Hence, the TFP growth from year s to year u can be approximated by

$$\log(a_u/a_s) = \log(y_u/y_s) - \bar{\theta}_T \log(k_{T,u}/k_{T,s}) - \bar{\theta}^I \log(k_{I,u}/k_{I,s}) - \bar{\theta}_h \log(h_u/h_s), \qquad (10)$$

where $\bar{\theta}$ is average factor share between s and u, y is GDP per worker, k_T is traditional capital per worker, k_I is IPP capital per worker, and h is average human capital (measured by the

Table 6: IPP explanation for growth $(\Delta \log(k_I)/[\Delta \log(k_I) + \Delta \log(a)])$: OECD average

	δ_I	$\delta_I = 0$	$\delta_I = \delta_T$
$\chi = 1$ (SNA08)	0.25	0.55	0.49
$\chi = 1 - LS_{R\&D}$	0.12	0.26	0.23

years of schooling). Decomposition of growth of output from a specific time period s to u is straightforwad by summing up each of four components. Similar to section 4, we define the additional IPP explanation as $\log(k_{I,u}/k_{I,s})/[\log(k_{I,u}/k_{I,s}) + \log(a_u/a_s)]$ and do the growth accounting exercise with various χ's and δ_I's.

Table 6 shows the summarized results which we present in more detailed in table 7 and 8. On average, IPP capital contributes around 9% of output growth, which is slightly less than one half of the TFP (22%). This means that the additional IPP explanation is 25% under the benchmark χ $(= 1)$ and δ_I. Again, the additional explanation from the IPP capital goes down to 12% with $\chi = 1 - LS_{R\&D} < 1$, which is less than half of the case with $\chi = 1$. The reason is similar to the case with level accounting: average human capital grows less than IPP capital itself.

Of course, the IPP growth increases when the depreciation rate is lower. For example, with no depreciation in IPP capital ($\delta_I = 0$), the IPP's explanation goes up to even higher than that of TFP (IPP explanation of 55%). But the fraction explained by IPP capital again is reduced to a half when relaxing the assumption on the distribution of IPP rent from $\chi = 1$ to $\chi = 1 - LS_{R\&D}$.

Table 7: Growth Accounting with $\chi = 1$

	Growth rates					Percent explained				time	
country	y	h	k	z	tfp	h	k	z	tfp	s	t
AUS	1.51	0.10	0.70	0.14	0.57	6.4	46.2	9.4	38.0	1985	2012
AUT	1.39	0.34	0.41	0.17	0.47	24.3	29.6	12.3	33.8	1977	2014
BEL	0.66	0.24	0.20	0.14	0.09	36.2	30.2	20.6	13.0	1996	2014
CAN	1.14	0.36	0.63	0.11	0.04	31.2	55.7	9.4	3.7	1982	2010
CHE	0.91	0.17	0.00	0.16	0.57	19.1	0.3	17.5	63.2	1995	2013
CZE	2.47	0.25	1.06	0.04	1.12	10.0	42.9	1.8	45.4	1994	2014
DEU	0.57	0.17	0.25	0.08	0.06	30.2	44.7	14.9	10.2	1992	2014
DNK	1.74	0.38	0.64	0.20	0.53	21.6	36.9	11.4	30.2	1967	2013
ESP	0.47	0.39	1.08	0.13	-1.13	83.4	230.8	27.1	-241.3	1996	2011
EST	5.17	0.49	2.45	0.21	2.01	9.4	47.5	4.1	39.0	1996	2013
FIN	1.87	0.46	0.55	0.52	0.34	24.6	29.2	28.0	18.3	1976	2014
FRA	2.29	0.47	0.91	0.15	0.77	20.5	39.5	6.4	33.6	1961	2014
GBR	1.70	0.42	0.76	0.13	0.39	24.8	44.8	7.5	23.0	1981	2014
GRC	0.78	0.36	1.42	0.07	-1.08	46.4	181.3	9.5	-137.2	1996	2013
HUN	1.82	0.47	0.44	0.20	0.71	26.0	24.3	11.0	38.7	1996	2013
IRL	3.48	0.27	1.70	0.45	1.05	7.9	48.9	13.0	30.3	1996	2013
ISL	1.98	0.45	1.11	0.09	0.34	22.4	56.1	4.4	17.1	1998	2011
ISR	1.12	0.44	0.21	0.02	0.45	39.1	18.6	1.8	40.5	1996	2014
ITA	1.18	0.53	0.55	0.07	0.03	45.0	46.9	5.7	2.4	1971	2014
KOR	4.30	0.87	2.57	0.40	0.45	20.2	59.8	9.4	10.5	1970	2013
LUX	0.63	0.56	0.25	0.23	-0.41	89.3	39.9	36.7	-65.8	1997	2012
MEX	0.72	0.25	1.57	0.00	-1.10	35.0	219.0	-0.3	-153.6	2004	2011
NLD	0.69	0.29	0.45	0.15	-0.20	42.0	64.7	22.1	-28.8	1981	2014
NOR	2.46	0.38	0.60	0.17	1.30	15.5	24.4	7.1	53.0	1971	2013
NZL	0.41	0.04	0.91	0.15	-0.68	9.5	219.1	35.6	-164.2	1972	2011
POL	3.24	0.43	1.60	0.07	1.14	13.3	49.3	2.1	35.2	1996	2013
PRT	0.91	0.49	0.96	0.06	-0.60	53.9	105.3	6.7	-65.9	1996	2013
SVK	2.81	0.41	0.41	0.06	1.93	14.7	14.5	2.2	68.6	1996	2013
SVN	2.11	0.29	0.55	0.11	1.14	14.0	26.3	5.4	54.3	1996	2013
SWE	2.14	0.20	0.90	0.09	0.96	9.1	41.8	4.4	44.7	1993	2013
USA	1.63	0.36	0.56	0.13	0.57	22.3	34.5	8.1	35.0	1950	2014
OECD	1.75	0.37	0.85	0.15	0.38	20.9	48.6	8.7	21.8		

Notes: Growth rates are computed by $100 \times (\ln(x_t) - \ln(x_s))/(t - s)$, where t and s refers to final and initial point. OECD refers to average.

Table 8: Growth Accounting with $\chi = 1 - LS_{R\&D}$

	Growth rates					Percent explained				time	
country	y	h	k	z	tfp	h	k	z	tfp	s	t
AUS	1.51	0.10	0.70	0.08	0.63	6.6	46.0	5.4	42.0	1985	2012
AUT	1.39	0.35	0.41	0.08	0.55	25.0	29.5	5.7	39.9	1977	2014
BEL	0.66	0.25	0.20	0.06	0.16	37.6	30.1	8.7	23.7	1996	2014
CAN	1.14	0.37	0.63	0.05	0.10	32.1	55.4	4.2	8.3	1982	2010
CHE	0.91	0.18	0.00	0.07	0.66	20.0	0.3	7.3	72.4	1995	2013
CZE	2.47	0.25	1.06	0.03	1.14	10.3	42.7	1.1	46.0	1994	2014
DEU	0.57	0.18	0.25	0.03	0.10	31.3	44.4	6.0	18.4	1992	2014
DNK	1.74	0.39	0.64	0.07	0.64	22.3	36.6	4.3	36.7	1967	2013
ESP	0.47	0.40	1.08	0.06	-1.06	85.4	229.5	12.0	-226.9	1996	2011
EST	5.17	0.49	2.45	0.14	2.09	9.5	47.4	2.7	40.4	1996	2013
FIN	1.87	0.47	0.54	0.27	0.58	25.2	29.1	14.6	31.2	1976	2014
FRA	2.29	0.49	0.90	0.06	0.84	21.4	39.1	2.7	36.8	1961	2014
GBR	1.70	0.43	0.76	0.07	0.44	25.4	44.6	3.9	26.1	1981	2014
GRC	0.78	0.37	1.41	0.04	-1.04	47.5	180.0	4.8	-132.3	1996	2013
HUN	1.82	0.48	0.44	0.12	0.78	26.4	24.2	6.6	42.8	1996	2013
IRL	3.48	0.29	1.69	0.20	1.30	8.3	48.7	5.7	37.4	1996	2013
ISL	1.98	0.46	1.11	0.03	0.38	23.0	56.1	1.8	19.1	1998	2011
ISR	1.12	0.47	0.21	0.00	0.45	41.5	18.3	0.4	39.8	1996	2014
ITA	1.18	0.54	0.55	0.03	0.06	46.0	46.6	2.5	4.9	1971	2014
KOR	4.30	0.89	2.55	0.23	0.63	20.8	59.3	5.3	14.6	1970	2013
LUX	0.63	0.58	0.25	0.09	-0.29	91.4	39.8	14.7	-45.8	1997	2012
MEX	0.72	0.25	1.57	0.00	-1.10	35.1	218.9	-0.2	-153.8	2004	2011
NLD	0.69	0.30	0.44	0.05	-0.11	43.7	64.2	7.3	-15.3	1981	2014
NOR	2.46	0.39	0.60	0.07	1.40	16.0	24.2	2.8	57.0	1971	2013
NZL	0.41	0.04	0.91	0.07	-0.60	9.7	218.9	17.3	-145.9	1972	2011
POL	3.24	0.44	1.59	0.04	1.17	13.5	49.1	1.3	36.1	1996	2013
PRT	0.91	0.50	0.96	0.03	-0.58	54.8	104.8	3.8	-63.5	1996	2013
SVK	2.81	0.42	0.40	0.04	1.94	14.9	14.4	1.5	69.1	1996	2013
SVN	2.11	0.30	0.55	0.06	1.20	14.3	26.1	2.7	56.8	1996	2013
SWE	2.14	0.21	0.89	0.05	1.00	9.6	41.6	2.3	46.5	1993	2013
USA	1.63	0.38	0.56	0.05	0.65	23.1	34.3	3.1	39.5	1950	2014
OECD	1.75	0.38	0.85	0.07	0.45	21.5	48.4	4.2	26.0		

Notes: Growth rates are computed by $100 \times (\ln(x_t) - \ln(x_s))/(t-s)$, where t and s refers to final and initial point. OECD refers to average.

6 Conclusion

We document a rise of intellectual property products (IPP) captured by up-to-date national accounts in 31 OECD countries. These countries gradually adopt the new system of national accounts (SNA08) that capitalizes IPP—which was previously treated as an intermediate expense in the pre-SNA93 accounting framework. We examine how the capitalization of IPP affects stylzed growth facts and the big ratios (Kaldor, 1957, Jones, 2016). We find that the capitalization of IPP generates (a) a decline of the accounting labor share, (b) an increase in the capital-to-output ratio across time, and (c) an increase in the rate of return to capital across time. The key accounting assumption behind the IPP capitalization implemented by national accounts is that the share of IPP rents that are attributed to capital, χ, is equal to one. That is, national accounts assume that IPP rents are entirely owed to capital. We question this accounting assumption following (Koh et al., 2018). Indeed, we find that an alternative split of IPP rents between capital and labor based on the cost structure of R&D generates a secularly trendless labor share, a constant capital-to-output ratio, and a constant rate of return across time. We discuss the implications of these new measures of IPP capital—conditional on χ—for cross-country income per capita differences using standard development and growth accounting exercises.

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A The Data

A.1 Data sources

We use National Accounts data of countries following SNA 08, which are AUS, AUT, BEL, CAN, CHE, CZE, DEU, DNK, ESP, EST, FRA, FIN, GBR, GRC, HUN, IRL, ISL, ISR, ITA, KOR, LUX, MEX, NLD, NOR, NZL, POL, PRT, SVK, SVN, SWE, and USA. Data are from either OECD statistics or National statistical offices, which gives longer or conceptually more accurate series. The data sources are summarized in table A1 and A2.

Table A1: National sources

Country	Name of Institution	Name of Table
AUS	Australian Bureau of Statistics	Australian System of National Accounts
AUT	Statistics Austria	National Accounts
BEL	NBB statistics	National Accounts
CAN	Statistics Canada	System of macroeconomic accounts
CHE	Swiss Statistics	National Accounts
CZE	Czech Statistical Office	National Accounts
DNK	Statistics Denmark	National accounts and government finances
DEU	Statistisches Bundesamt	National Accounts
ESP	National Statistics Institute	National Accounts
EST	Statistics Estonia	National Accounts
FIN	Statistics Finland	National Accounts
FRA	National Institute of Statistics and Economic Studies	National Accounts
GBR	Office for National Statistics	National Accounts
GRC	Hellenic Statistical Authority	National Accounts
HUN	Hungarian Central Statistical Office	Integrated economic accounts
IRL	Central Statistical Office	National Accounts
ISL	Statistics Iceland	National Accounts
ISR	Bank of Israel	National Accounts
ITA	Italian National Institute of Statistics	National Accounts
KOR	Bank of Korea	National Accounts
LUX	Grand-Duchy of Luxembourg	National Accounts
NLD	Statistics Netherlands	Macroeconomics table
NOR	Statistics Norway	National Accounts
NZL	Statistics New Zealand	National Accounts
POL	Central Statistical Office of Poland	National Accounts
PRT	Statistics Portugal	National Accounts
SVK	Statistical Office of the Slovak Republic	Macroeconomic Statistics
SVN	Statistical Office RS	National Accounts
SWE	Statistics Sweden	National Accounts
USA	Bureau of Economic Analysis	National Income and Product Account
OECD	OECD Statistics	National Accounts

A.2 Investment

We classify type of investments by traditional and IPP. Traditional investment includes dwellings, other buildings and structures, and equipments & weapon systems. We exclude cultivated biological resources from both classification of which shares in total investments is less than 1% on average.

Table A2: Data sources by country

	Variables										
	CE	MI	GVA	SE[5)]	P^c	NI	RI	NK	RK	CFC	D
AUS	NS	NS	NS	–	NS	NS	NS	NS	NS	NS	NS
AUT	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	–
BEL	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	–
CAN	OECD	OECD	OECD	OECD	OECD	OECD	OECD	NS	–	OECD	–
CHE	OECD	OECD	OECD	–	OECD	OECD	OECD	NS	NS	OECD	–
CZE	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	–
DEU	OECD	OECD	OECD	OECD	OECD	OECD	OECD	NS	NS	OECD	–
DNK	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	–
ESP	OECD	OECD	OECD	OECD	OECD	OECD	OECD	–	–	OECD	–
EST	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	–
FRA	OECD	OECD	OECD	–	OECD	OECD	OECD	NS	OECD	OECD	NS
FIN	OECD	NS	OECD	OECD	OECD	OECD	OECD	OECD	OECD	NS	–
GBR	NS	NS	NS	OECD	NS	OECD	OECD	OECD	OECD	OECD	NS
GRC	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	–
HUN	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	–
IRL	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	–
ISL	OECD	–	OECD	–	OECD	OECD	OECD	–	–	OECD	–
ISR	OECD	OECD[4)]	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	–
ITA	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	–
KOR	OECD	OECD[4)]	OECD	OECD	OECD	OECD	OECD	NS	NS	NS	–
LUX	OECD	–	OECD	OECD	OECD	OECD	OECD	OECD	–	–	–
MEX	OECD	OECD	OECD	OECD	OECD	OECD	OECD	–	–	OECD	–
NLD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	–
NOR	OECD	NS	OECD	OECD	OECD	OECD	OECD	OECD	–	NS	–
NZL	OECD	OECD[4)]	OECD	OECD	OECD	OECD	NS	NS	OECD	NS	–
POL	OECD	NS	OECD	OECD	OECD	OECD	OECD	OECD	OECD	NS	–
PRT	OECD	OECD	OECD	–	OECD	OECD	OECD	OECD	OECD	OECD	–
SVK	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	OECD	–
SVN	OECD	OECD	OECD	–	OECD	OECD	OECD	OECD	OECD	OECD	–
SWE	NS	NS	NS	OECD	NS	NS	NS	OECD	OECD	NS	–
USA	NS	NS	NS	–	NS	NS	NS	NS	NS	NS	NS

Notes: 1) CE: compensation of employees, MI: gross mixed income, GVA: gross value added at basic price, SE: total employment / (total employment - # of self employee), P^c: price index of private consumption, NI: nominal investment by type, RI: real investment by type, NK: nominal net capital stock by type, RI: real net capital stock by type, CFC: consumption of fixed capital from income account, D: consumption of fixed capital by type.
2) NS refers to national source.
3) Marked as OECD when OECD series and NS series are same.
4) Gross operational surplus of households sector is used instead of MI for ISR, KOR, and NZL.
5) SE is used (and appeared here) only when it is longer available than mixed income.

Since statistical office does not provide real value of traditional investment, we construct it from subitems – dwellings, other buildings and structures, and equilpments & weapon systems – using Törnqvist index. Specifically, price change of traditional investment (π_t^T) is

$$\pi_t^T = \omega_t^R \pi_t^R + \omega_t^S \pi_t^S + \omega_t^E \pi_t^E,$$

where R, S, E refer to dwellings (R), other buildings and structures (S), and equipments & weapon systems (E), ω refer to two-year moving average of nominal share of each item in total investments, and π's refer to price changes. Then the price index of traditional investment is given by $P_t^T = \prod_{i=0}^{t}(1+\pi_i^T)$, with $\pi_0^T = 0$. Nominal investment is simply sum of subitems ($I_t^T = I_t^R + I_t^S + I_t^E$) and real investment is nominal investment divided by price index ($X_t^T = I_t^T / P_t^T$).

A.3 Depreciation rates

Depreciation rates is defined as consumption of fixed capital divided by capital stock at end of previous year. When both real value of consumption of fixed capital (CFC) and capital stock data are available, we use data (AUS, GBR, and USA) where real value of traditional capital and traditional consumption of fixed capital are constructed using Törnqvist index as above. When only nominal value of CFC is available (FRA), depreciation rate is obtained by

$$\delta_t^i = \frac{NCFC_t^i}{NK_{t-1}^i \times PK_t^i / PK_{t-1}^i},$$

where NCFC is nominal CFC in data, NK is nominal capital in data, and PK is price of capital in data for IPP and Törnqvist index for traditional, and $i \in \{T, IPP\}$.

However, most countries do not provide CFC data by asset type. For these countries, we consider two estimates of CFC from data. Firstly, we can estimate real value of CFC by asset type using

$$R\hat{C}FC_t^i = RK_{t-1}^i + X_t^i - RK_t^i,$$

where RK is real value of capital, X is real value of investments, and $i \in \{T, IPP\}$. It is worth noting that price of capital is different from price of investment in data since all subitems in each category differ in terms of both depreciation rates and price changes. When RK is not available in data (e.g. CAN, ESP, ISL, LUX, MEX, and NOR), however, we use price of investment for price of capital.

Secondly, we can estimate nominal value of CFC by

$$N\hat{C}FC_t^i = NK_{t-1}^i \times \frac{PK_t^i}{PK_{t-1}^i} + I_t^i - NK_t^i,$$

where NK is nominal capital, I is nominal investments, and $i \in \{T, IPP\}$. Note that $N\hat{C}FC / R\hat{C}FC$ is not simply PK since price of investment and capital are different.

The prices of CFC, capital, and investment are all different since composition of subitems are different. In this sense, RCFC should be better measure for true depreciation rates than NCFC. However, we can use more information with NCFC, which is total CFC that can be obtained from income accounts.

Specifically, we can obtain one of NCFC as residual from total CFC of income accounts, for example, $N\hat{C}FC_t^T = CFC_t - N\hat{C}FC_t^{IPP}$.

Note that dep rates are actually stable for countries with CFC data available, but CFC estimated above could fluctuate due to re-valuation and inventory adjustment. Hence, in practice, we plot depreciation rates from both $R\hat{C}FC$ and $N\hat{C}FC$, and then chooses dep rates that are more stable. If they are similar, we went with $RCFC$. The countries with $RCFC$ are AUT, CHE, DEU, FIN, GRC, HUN, ISR, ITA, LUX, NLD, and PRT. Those with $NCFC$ are BEL, CAN, CZE, EST, IRL, KOR, NOR, NZL, POL, SVK, SVN, and SWE.

A.4 Capital

Depending on methods of getting depreciation rates, it is possible that RK in data is not compatible with implied depreciation rates. Importantly, this includes cases where we get depreciation rates from CFC data. This is because in data, capital is adjusted for revaluation and inventories, where gross fixed capital formation does not include them. To make capital series to be compatible with investment data in a standard model sense, we construct real value of capital as following.

$$K_{t+1}^i = (1-\delta_t^i)K_t^i + X_t^i, \tag{A.11}$$

with K_0^i being nominal capital data of base year.

Note that above methods require estimated δ which requires data for capital and investment. In many countries, however, we have longer investment series available than capital series. For these countries (AUT, CAN, CHE, CZE, ESP, EST, FIN, FRA, GBR, ISL, ITA, KOR, LUX, MEX, NLD, POL, PRT, SVK, SVN, and SWE), it could be useful to consider extension of capital series.

With X_t^i given as data, what we need is δ_t^i for those years without capital data. For the depreciation rates, we use fitted value obtained from the following regression.

$$\delta_{j,t}^i = \beta_j + \gamma \log(\text{GDP per capita}_{j,t}) + \varepsilon_{j,t},$$

where j refers each country. To make GDP per capita comparable across countries, we use constant PPP rates obtained from PWT 8.1.[7]

With estimated depreciation rates $\hat{\delta}_{j,t}$ at hands, we can get capital series by computing

$$K_t^i = \frac{K_{t+1}^i - X_t^i}{1-\hat{\delta}_t^i}. \tag{A.12}$$

The problem with this method, however, is that it is very sensitive to even very small error in base year because errors are accumulated across the extension. To be precise, when NK_0 in data is a little bit different from K_0 that could have been obtained if we had data for K_{-10}, estimated $\hat{K}_{-10}$ from NK_0

[7] To be specific, PPP rates (pppr) is obtained from pppr = q_gdp/rgdpo, where q_gdp is real GDP in national currency from NA data of PWT 8.1 and rgdpo is output-side real GDP at chained PPPs. We then multiply 1/pppr to our series of real GDP with SNA 08. We assume $\text{pppr}_t = \text{pppr}_{2011}$ for $t > 2011$.

can be very different from true K_{-10} because the small difference in time 0 is accumulated from $t = 0$ to $t = -10$. To see this more clearly, it is useful to see an example.

Figure A1 compares K from equation (A.11) with $K_0 = K_{1929}$ (call this $K1$, a blue line) and K from equation (A.12) with $K_0 = K_{2005}$ (call this $K2$, a red line). Because of reasons stated above, $K1$ is not exactly same with K_t in data. Since we use exactly same δ_t, $K1$ has to be equal to $K2$ if $K1_{2005} = K_{2005}$. However, $K1$ is a little bit different from K at 2005 and this makes $K2$ a lot different from $K1$ as time goes back.

One way to mitigate this problem is to set a restriction on the initial movement of capital. Since errors are accumulated, magnitude of K_1/K_0 becomes really big (either positive or negative as can be seen in graphs) if there was an error in base period. By restricting K_1/K_0 to be a reasonably small number (e.g. fitted growth rate of capital against log GDP per capita), we can mitigate the exploision problem as can be seen by a black line in figure A1. Precisely, the black line is obtaind by equation (A.11), with

$$K_1^i = \hat{g}_0^i K_0^i, \ K_1^i = (1 - \hat{\delta}_0^i) K_0^i + X_0^i \ \rightarrow \ K_0^i = \frac{X_0^i}{\hat{g}_0^i + \hat{\delta}_0^i}, \tag{A.13}$$

where $\hat{g}_0^i$ and $\hat{\delta}_0^i$ are fitted growth rate and depreciation rate of capital against log GDP per capita. Note that the assumption we use is not a steady state assumption because we use estimated depreciation rates that are fluctuating over time. Rather, our assumption is simply stating that the growth rate of capital from the initial period to next period is set to fitted growth rate. From then on, we use exactly same procedure of making capital series via equation (A.11) using freely moving depreciation rates, $\hat{\delta}_t^j$.

In practice, we plot capital series obtained from equation (A.12) (method 1), and if capital series go up or become negative as time goes back, we use the restriction (A.13) (method 2). As a result, we apply method 2 to traditional capital of NLD, ITA, and PRT, and to IPP capital of AUT, CAN, CZE, EST, FRA, GBR, IRL, ITA, NLD, POL, SVK, SVN and SWE.

We have three countries in our sample with no capital stock available in data (ESP, ISL, and MEX). For these countries, we set initial level of capital as a fitted value from the following regression,

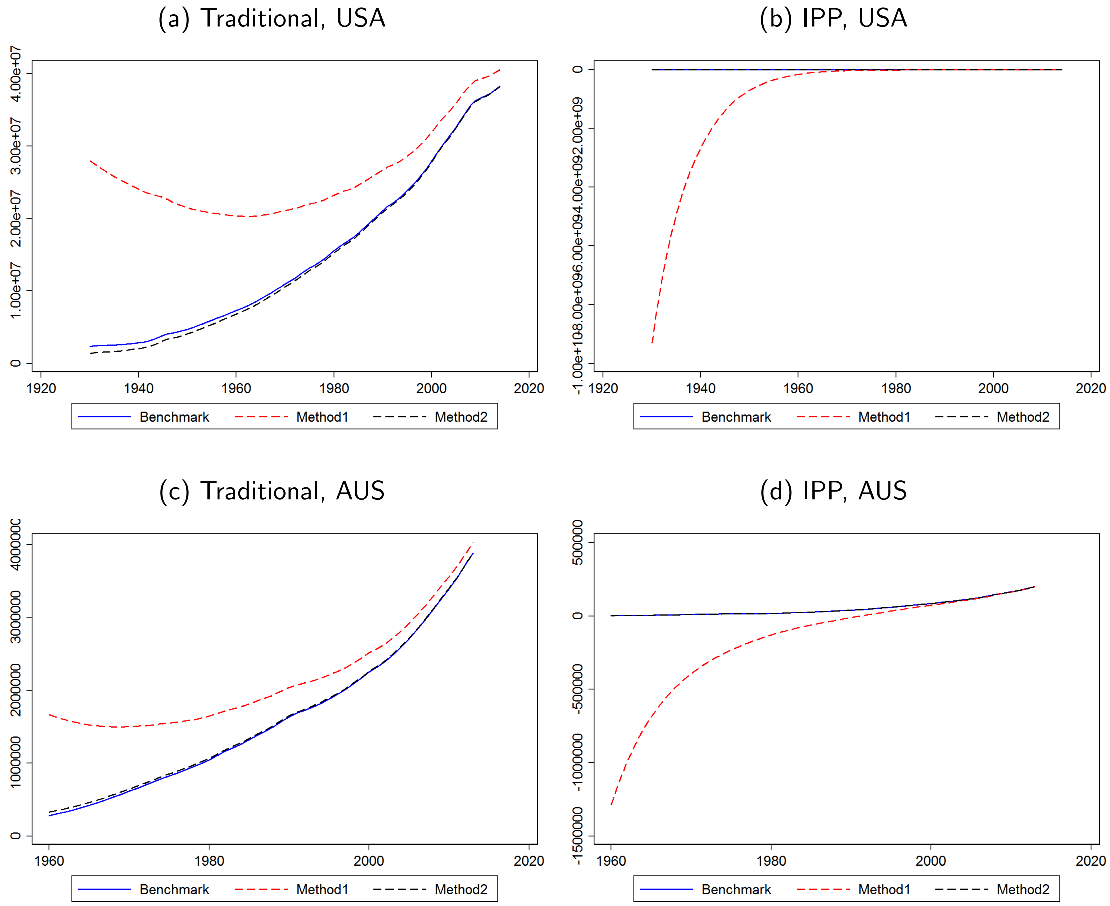
$$\log\left(\frac{K^i}{Y}\right) = \beta + \gamma \log(\text{GDP per capita}_{j,t}) + \varepsilon_{j,t},$$

and then apply equation (A.11). Since Mexico gives decreasing IPP capital near initial period, we apply method 2 (equation (A.13)) for IPP capital of Mexico.

A.5 Labor Share

We adjust for mixed income following Koh, Santaeulàlia-Llopis, and Yu (2015) in constructing our baseline labor share. To begin with, we classify Gross Domestic Income into unambiguous capital income (UCI), unambiguous income (UI), and ambiguous income (AI). Unambiguous capital income (UCI) is the gross operating surplus (GOS) which does not include gross mixed income (GMI) in the National

Figure A1: Extended capital by different methods



Notes: Benchmark: $K' = K(1-\delta) + X$ with K_0 =data, Method 1: $K = (K' - X)/(1-\delta)$ for $t < 2005$, Method 2: $K' = K(1-\delta) + X$ with $K_0 = X_0/(g+\delta)$.

Accounts. Note that both gross operating surplus and gross mixed income includes consumption of fixed capital. Adding compensation of employees (CE) to unambiguous capital income (UCI), we get unambiguous income (UI=UCI+CE). Ambiguous income is income other than UI, which is sum of gross mixed income and tax net of subsidy (AI=GMI+Tax-Sub). We assume gross capital income share in ambiguous income is same as gross capital income share of unambiguous income. Then the total capital income can be obtained by summing up unambiguous capital income and capital income in ambiguous income (KI=UCI+$\theta\times$AI, θ =UCI/UI). Finally, labor share is one minus capital share which is capital income divided by total income (LS=1-KI/GDI).

$$\begin{aligned}
&\text{Unambiguous Capital Income, UCI} = \text{GOS} \\
&\text{Unambiguous Income, UI} = \text{CE} + \text{UCI} \\
&\text{Ambiguous Income, AI} = \text{GMI} + \text{Tax} - \text{Sub} \\
&\text{Capital Income, KI} = \text{UCI} + \text{AI} \times \theta,\ \ \theta = \text{UCI}/\text{UI} \\
&\text{Labor Share, LS} = 1 - \frac{\text{KI}}{\text{UI} + \text{AI}} = 1 - \frac{\text{KI}}{\text{GDI}}
\end{aligned} \tag{A.14}$$

The differences between ours and Koh, Santaeulàlia-Llopis, and Yu (2015) are that we do not adjust for Business Current Transfer Payments in gross operating surplus due to limited data availability (table A3) and that we use gross operating surplus not net operating surplus. However, the Business Current Transfer Payments is only 0.5% of GDI on average and does not affect trend of labor share. The BEA only provides proprietor's income excluding consumption of fixed capital, i.e net mixed income. Hence we have to use net labor share to get accurate labor income of proprietors for US. Net capital income share of unambiguous income is $\tilde{\theta}$=NOS/(CE+NOS) and so total capital income becomes KI=NOS+$\tilde{\theta}\times$NMI+$\theta\times$(Tax-Sub)+DEP, where θ is gross capital share and $\tilde{\theta}$ is net labor share. Labor share is then computed by LS=1-KI/GDI.

To avoid confusion, we call net operating surplus excluding net proprietor's income as net operating surplus (NOS). Note, however, that Net operating surplus in NIPA table includes (net) proprietor's income so that net operating surplus in NIPA table is different from what we call NOS here (see table A3).

In cases where longer series of self employee are available (i.e. AUT, BEL, CAN, CHE, CZE, DEU, DNK, ESP, EST, FIN, GRC, IRL, ISR, ITA, KOR, MEX, NLD, NOR, NZL, POL, PRT, and SVK), we

Table A3: Structure of income account: BEA NIPA and OECD National Accounts

BEA NIPA (USA)	OECD NA
GDI	GDI
Compensation of employ (CE)	Compensation of employ (CE)
Taxes (Tax)	Taxes (Tax)
Subsidies (Sub)	Subsidies (Sub)
Net operating surplus (NOS+NMI)	
Net intersts	
Business current transfer payments	
Proprietor's income (NMI)	Gross operating surplus (GOS)
Rental income	Gross mixed income (GMI)
Corporate profits	
Current surplus of government enterprises	
Consumption of fixed capital (DEP)	

extend labor share in equation (A.14) with self employee adjusted labor share as

$$LS_{t-1} = LS_t \times (LS^{SE}_{t-1}/LS^{SE}_t),$$

where $LS^{SE} = \frac{\text{CE}}{\text{GDI-(Tax-Sub)}} \times \frac{\text{Total employment}}{\text{Total employment - \# of self employees}}$. In words, LS^{SE} is labor share adjusted with assumption that average wage of self employees is same with that of employees. Since average wage of self employees is usually less than that of employees, LS^{SE} is likely to overestimate the level of labor share. However, LS^{SE} gives similar pattern with our baseline labor share and we only reflect changes in labor share to extend our baseline labor share which we believe the best measure for labor share in the economy. The exceptions are LUX and ISL where only LS^{SE} is available (LUX) or neither MI nor SE is available (ISL).

An adjustment of IPP effects on labor share is as following. From the standard representative firm's profit maximizing problem, we have

$$R^i_{t+1} = (1 + r_{t+1})\frac{1}{V^i_t} - (1 - \delta^i_{t+1})\frac{1}{V^i_t},$$

where R is gross return, r is net return, $V^i = P^c/P^i$, and $i \in \{T, IPP\}$. Also, labor share in data can be expressed as

$$LS = 1 - \frac{R^T K^T}{Y} - \frac{R^{IPP} K^{IPP}}{Y},$$

from any constant returns to scale production function.

Assuming common net return for T and IPP (i.e. no arbitrage), these constitute three equations for three unknowns R^T, R^{IPP}, and r. Then the labor share without IPP (LS^T) is obtained by

$$LS^T = 1 - \frac{R^T K^T}{Y - R^{IPP} K^{IPP}}.$$

Note that this adjustment is available only when our capital series are available. Since capital was extended up to a point with investment data available, we have LS^T whenever investment data are available. However, for some countries in our sample, labor share data covers longer periods than investments. To extend LS^T up to a point when LS data starts, we estimate following regression.

$$dif_{j,t} = \beta_j + \gamma \log(\text{GDP per capita}_{j,t}) + \varepsilon_{j,t},$$

where $dif_{j,t} = \frac{LS^T}{LS} - 1 = \frac{R^{IPP} K^{IPP}}{Y}$. Then extended LS^T is computed by

$$\hat{LS}^T_{j,t} = LS_{j,t} \times (1 + \hat{dif}_{j,t}).$$

Further Details on Country-Specific National Accounts

Australia

- All the series are from Australian Bureau of Statistics.
- Data for SNA 93 comes from National Account release at Jun 2009.
- IPP refers to R&D, Mineral and Petroleum exploration, Computer software, and Artistic Originals.

- Artistic Originals start from 1971. We assume Artistic Originals at 1970 to be 0.
- They provide "weapon system" separately. We put weapon system into equipment, following other countries (e.g. ESA 2010).
- Real capital stock is available only for subitems. So we computed real capital stock for structure (non-dwelling + ownership transfer cost), equipment (machinery and equipment + cultivated biological resources), and IPP (weapon system + R&D + mineral + software + artistic), using Törnqvist index.
- Some Facts: Non-dwelling engineering construction boom since late 1990s (throw in some number).
- K_0: 1970

Korea

- Data comes from Bank of Korea.
- SNA 93 data is from National accounts 2005. SNA 08 data is National Accounts 2010.
- Mixed income data starts from 1975. For 1970 to 1975, We assume that $\Delta LS_t^{MI} = \Delta LS_t^{SE}$, where MI refers to Mixed income, SE refers to self-employed adjustment.
- No real value for Structure: Counstruction is divided by Residential, Non-residential, and Others, and so the real value for structure is computed using Törnqvist index.
- No data for software: IPP divided by R&D and others.
- Mixed income is net operational surplus from household sector.
- K_0: 1970

Italy

- Data comes from i.stat.
- I.STAT provides real (2010 base) CFC for subitems. Nominal CFCs are computed using above formula.
- Equipment is computed by combining "Machinery and Equipment and Weapon Systems" and "Cultivated Biological Resources". Real equipment is computed using Törnqvist index.
- SNA 93 is from 2011 release.
- K_0: 1995
- Updates were made at Feb 14. (1) Investment series were extended to 1970 in data. (2) Capital series were extended to 1970 using investment series. In doing so, we match $K_0 = \frac{I_0}{g+\delta}$ with $K_{1995}^{data} = K_{1995}$ with δ for EQP and IPP. Values in 1996 were used for STR and RES. Now K_0 is 1970.
- To smooth CFC's (to match with CFC from income account), we use HP filter (with $\lambda = 20$) for CFC series by type.

New Zealand

- From INFO SHARE.
- No real value before 1988 except for capital stock. Nominal values are available from 1972. Real Capital Stock is available from 1972.
- So price index used in computing CFC is from capital stock, not flow data.
- Weapon system is classified into IPP. For consistency, we computed IPP excluding Weapon systems. Weapon systems are included in Equipment instead.
- CFCs for structures and residential in 2011 is too big compared to total CFCs. Used HP filter series for structures and residential.
- Provides SNA 93 account separately.
- Mixed income is gross operational surplus from household sector.
- Self employed data provided by OECD covers data for 1971, 1976, 1970-81. Inerpolated figures between 1971 and 1985. Used self-employed adjustment labor share as baseline.
- GDP, RGDP, price of consumpion data is from OECD, because New Zealand info share only provides real variables only after 1988.
- K_0: 1972

France

- Capital stock data is available only through EUROSTAT. No detailed data for IPP subitems.
- Computed CFC fluctuates from CFC in income account (see FRA cfc difference.png). HP filter series are used.
- Tried to extend capital stock using flow data. However, generated flow data for IPP and structures become negative when using the depreciation rate of 1996.
- So depreciaion rate is found so that $K_0 = I_0/(\delta + g)$ and $K_t = I_t + (1 - \delta)K_{t-1}$ for $t = 1978, \cdots, 1995$ where $K_{1995} = K_{1995}^{\text{data}}$.
- Instead, use CFC from income account to extend capital stock. Firstly, assume $CFC_t^i = CFC_t * \frac{\hat{CFC_t^i}}{CFC_t}$ for $i = RES, STR, EQP, IPP$, where $\frac{\hat{CFC_t^i}}{CFC_t}$ is extrapolated value from log-linear trend and CFC_t is CFC data from income account. Secondly, CFC_t^i is adjusted so that $\sum_i CFC_t^i = CFC_t$.

- K_0: 1978
- Updates were made at Feb 14. (1) Investment series were extended to 1960. (2) Capital series were extended to 1978 in data. (3) Capital series were extended to 1960 using investment series. In doing so, we use time trend of depreciation rate from 1983 to 1990 for EQP and IPP. Values in 1979 were used for STR and RES. Now K_0 is 1960.

Austria

- Labor Share related data (CE, MI, GVA, etc) come from Statistics Austria. Capital related data (both stock and flow) come from OECD.
- OECD provides capital stock measured by previous price as a real variable. Hence nominal CFC is

$$\text{NCFC} = \text{nominal flow} - (\text{previous price current stock - nominal previous stock}) \times \frac{p_t}{p_{t-1}}$$

- K_0: 1995
- Updates were made at Feb 14. (1) Investment series were extended to 1976 in data. (2) Capital series were extended to 1976 using investment series. In doing so, we use time trend of depreciation rate from 1995 to 2000 for EQP and IPP. Values in 1996 were used for STR and RES. Now K_0 is 1976.

Belgium

- Data from National Bank of Belgium.
- Price index for equipment is constructed using Törnqvist index (combining equipment and cultivated biological resources).
- K_0: 1995

Norway

- Data from Statistics Norway.
- Statistics Norway classifies asset type as (1) IPP, except oil exploration, (2) Building and Construction, (3) Oil exploration, drilling, pipelines for oil and gas, (4) Oil platforms etc., (5) Ships and boats, (6) Other transport equipment, (7) Machinery and equipment, and (8) Cultivated biological resources.
- In the preliminary computation, we classified (1) as IPP, (2) as Structures, from (3) to (8) as Equipment. Maybe, (3) could be IPP but drilling and pipelines are closer to equipment. Also, (4) could be Structures.
- When combining the subitems, Törnqvist index is used.
- No IPP subitems are available.
- K_0: 1970

Finland

- Data from Statistics Finland - PX-Web database.
- Capital is classified into Dwellings (RES), Other buildings and structures (STR), Machinery, equipment and trasport (EQP1), Weapons (EQP2), IPP and RND. There is an item named Costs of ownership transfer but its value is missing.
- EQP is sum of EQP1 and EQP2.
- Other IPP includes software.
- SNA93 account is from OECD.
- K_0: 1978

Sweden

- Data from Statistics Sweden.
- Capital classification: Dwellings (RES), Other buildings and structures (STR), Total machinery and equipment and weapon (EQP1), Cultivated Biological Resrources (EQP2), IPP, RND, Computer programs and database (SFT), and Other IPP.
- EQP = EQP1 + EQP2
- CFC fluctuates a lot. HP filter series are used.
- Flow data from 1980 but stock data from 1993.
- SNA93 account is from OECD.
- Capital stock data are extended using flow data and depreciation rate of 1994 and 1995.
- Software and Other IPPs become negative when using depreciation rate of 1994 and 1995. For software and Other IPPs, δ is found so as to make $K_0 = I_0/(\delta + g)$ and $K_t = I_t + (1-\delta)K_{t-1}$ where $K_{1993} = K_{1993}^{\text{data}}$.
- Instead, use CFC from income account to extend capital stock. Firstly, assume $CFC_t^i = CFC_t * \frac{\hat{CFC_t^i}}{CFC_t}$ for $i = RES, STR, EQP, IPP$, where $\frac{\hat{CFC_t^i}}{CFC_t}$ is extrapolated value from log-linear trend and CFC_t is CFC data from income account. Secondly, CFC_t^i is adjusted so that $\sum_i CFC_t^i = CFC_t$.

- K_0: 1982

Denmark

- Data from Statistics Denmark.
- All the variables except Mixed Income are available from 1966. (Should extend the analysis to 1970 using self-employed adjustment later.)
- SNA93 account is from OECD. It does not include Mixed Income for Denmark. So the MI93 is computed as MI93=OS93*MI08/OS08, where OS is operational surplus.
- Asset types are Dwellings (RES), Buildings other than dwellings (STR1), Other structures and land improvements (STR2), Transport equipment (EQP1), ICT, other machinery and equipment and weapon systems (EQP2), Cultivated biological resources (EQP3), IPP, R&D, Computer software and database, Mineral exploration and evaluation (OIPP1), Entertainment, literacy or artistic originals and other IPPs (OIPP2).
- Real capital for STR, EQP and other IPPs are constructed using Törnqvist index.
- K_0: 1970

Czech Republic

- Data is from Czech Statistical Office, Database of Annual National Accounts.
- Gross Mixed Income is computed by GMI = NMI+ $\text{CFC}_{\text{Household}} \times (\text{NMI}/(\text{NMI}+\text{NetOS}_{\text{Household}}))$.

- Capital types are Dwellings (RES), Other buildings and structures (STR), Machinery and equipment (EQP1), Weapons systems (EQP2), Cultivated biological resources (EQP3), IPP, R$D, Computer software and database (SFT).

- Capital formation for weapon systems (EQP2) is included in EQP1 before 1994.
- Real values for EQP and Other IPP are constructed using Törnqvist index.
- Price of structure is not available from 1990 to 1993, so the price of structure is assumed to be equal to price of dwellings from 1990 to 1993.
- K_0: 1991

United Kingdom

- Data from Office for National Statistics. SNA 93 data are from OECD.
- Capital category: Dwellings (RES), Other buildings and structures (STR1), Costs associated with the transfer (STR2), ICT, other machinery, equipment, and weapons system (EQP1), Transport equipment (EQP2), Cultivated biological resources (EQP3), IPP, R&D, Computer software and database (SFT), Mineral exploration and evaluation (OIPP1), and Entertainment, literary or artistic originals (OIPP2).
- Stock data are available from 1997, and flow data are available from 1987.
- CFC stats are provided by ONS.
- Capital Stock is extended using flow. For STR, EQP, and RES, assumed depreciation rate is constant (at level of 1998) from 1987 to 1997. For IPP, find δ so that initial capital stock is $I_0/(\delta + g)$.
- K_0: 1987

Germany

- Data from OECD.
- Capital category: Dwellings (RES), Other buildings and structures (STR), Machinery and equipment and weapon systems (EQP1), Cultivated biological resources (EQP2), IPP, R&D, and Computer software and database.
- Stock data do not include IPP subitems.
- CFC stats are constructed.
- K_0: 1995

Hungary

- Data from Hungarian Central Statistical Office. SNA 93 data are from OECD.
- Capital category: Dwellings (RES), Other buildings and structures (STR), Machinery and equipment and weapon systems (EQP1), Cultivated biological resources (EQP2), IPP, R&D, and Computer software and database.
- HP filter series are used for CFCs.
- K_0: 1995

Ireland

- No capital stock for SNA08.

Greece

- Data from EUROSTAT and Hellenic Statistical Authority.
- Computed CFC is not smooth, especially near initial period (1995). HP filter series are used.
- Self-employed adjusted LS is used due to lack of data (MI is provided from 2006).

Israel

- Data from OECD. Capital stock is from OECD balance sheet data.
- Flows are available from 1995. Stocks are available from 2001. Stocks are extended via PIM method assuming that depreciation rate for 1995 to 2000 is same with that of 2001.
- Self-employed adj LS is used. (MI is provided after 2000).
- HP filter series are used for CFC.

Netherlands

- Data from Statistics Netherlands. Capital Stock is from OECD national balance sheet.
- Computed CFC is not smooth, especially near great recession. HP filtered series are used.
- Capital category: Dwellings (RES), Buildings other than dwelliings (STR1), Other structures (STR2), Costs of ownership transfer of land (STR3), Transport (EQP1), Computers (EQP2), Telecom (EQP3), Machinery (EQP4), other tangible (EQP5), Cultivated biological resources (EQP6), R&D, Computer and software, and Other IPPs.
- K_0: 1995

Switzerland

- Data from Swiss Statistics. Some of real flow data is from Eurostat. Mixed income is from OECD. SNA 93 data is from OECD.
- IPP is divided by RND and SFT. (IPP=RND+SFT $\rightarrow$ Other IPPs = 0).
- No stock data for RES and STR separately.
- K_0: 1995

Slovenia

- Data from Republic Slovenia Statistical Office and OECD (SNA93).
- Software flow at 1999 seems to be wrong and so made an adjustment using inflation rate computed from Eurostat data (Nominal value: 1.5 while previous price value: 100.3).
- Stock is available from 2000 and hence extends it using PIM method assuming dep rate from 1995 to 2000 is same as 2000.
- K_0: 1995

Canada

- Data from Statistics Canada (CANSIM). SNA 93 data from OECD.
- Stock data is available from 1990 while flow data is available from 1981. Stock is extended using PIM assuming constant depreciation rate from 1981 to 1989.
- Computed CFC is not smooth especially during 2000s. HP filtered series are used.
- Weapon system is included in Equipment.
- No IPP subitems for stock data.
- K_0: 1981

Slovakia

- Data from Statistics SLOV STAT and EUROSTAT
- Stock data available from EUROSTAT.
- Computed CFC fluctuates **a lot**, and level does not match with CFC from income account. Will not use for initial analysis.

Estonia

- Data from Statistics Estonia and OECD (SNA93).
- Computed CFC fluctuates a lot so that used HP-filtered series.
- 2013 stock data is made using PIM.
- K_0: 2000
- Updates were made at Feb 14. (1) Investment series were extended to 1995 in data. (2) Capital was extended to 1995. (3) Depreciation is set to $I_0/(g+\delta)$ for IPP and EQP. For STR and RES, dep in 2001 was assumed for 1995 to 2000.

Poland

- Data from OECD and Eurostat.
- For CFC, used HP-filtered series.
- Capital is extended using PIM (from 1995 to 2005). Depreciation is set to 2006 for RES and STR. Used SS assumption for EQP and IPP.
- K_0: 1995

Countries that stock data unavailable

- Spain, Iceland, Ireland, Luxembourg, Mexico, and Portugal
- Updates: Ireland, Luxembourg, Slovakia, and Portugal were added.
- Usually, depreciation was set to $I_0/(g+\delta)$, or constant.