



Cross-Country Income Differences Revisited: Accounting for the Role of Intangible Capital

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Abstract

This paper develops a new intangible investment database that is consistent and internationally comparable for a set of 60 economies over the period 1995-2011. I find that over time a growing share of total investment consists of intangible assets, rather than investment in tangible assets, like machinery and buildings. Across countries, the level of economic development of a country is positively associated with its investment intensity in intangibles. By including intangible capital as an additional factor of production, this paper finds that we can account for substantially more of the variation in cross-country income levels. Depending on the assumptions regarding the output elasticities of factor inputs, the observed differences in intangible capital can account for up to 16 percentage points of the cross-country income variation.

Keywords: Intangible capital; cross-country income differences; development accounting.

JEL Classification Numbers: E22, O10, O47, O57

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1. Introduction

Living standards, as captured by average income per person, vary dramatically across countries. According to the estimates of the World Development Indicators (World Bank, 2015), the ratio of 90th to 10th percentile in the world income distribution is at an alarming factor of 28 in 2012.¹ What can explain such enormous differences in income per capita across countries?

Based on the Solow growth model economists have been seeking to provide answers around two proximate determinants: differences in *factors of production* and in *efficiency*. This analytical framework is formally known as development accounting. The main idea of this analysis is that by using cross-country data on output and inputs at one single point in time, development accounting quantifies how much of the cross-country variation in income can be accounted for by the observed differences in production factors and how much is left to be explained by the differences in efficiency as measured by total factor productivity (TFP). The latter is a residual, i.e. everything that cannot be accounted for by the observable inputs.² The current consensus is that efficiency plays the largest role in accounting for cross-country income variation, while the observed differences in factor inputs merely account for a small share (Caselli, 2005; Easterly & Levine, 2001; Hall & Jones, 1999; Mutreja, 2014).

The goal of this paper is to extend the existing works on international income differences by accounting for an important factor of production that has been ignored so far – intangible capital. This is likely to be a promising extension, as the emerging research agenda on intangible investment has shown that intangible assets, such as brand equity, scientific research and development (R&D), and organisation capital, have become increasingly the more important forms of investment in the modern economy and they have escaped the statistical net (Corrado & Hulten, 2010). In the System of National Accounts (SNA), investments are broadly defined as the acquisition of fixed assets that is undertaken specifically to enhance future production possibilities. According to the guidelines of SNA 1993 revision, this includes physical assets such as machinery, equipment and buildings as well as a limited set of intangibles, namely software, mineral exploration, and artistic originals, which I will indicate by national accounts (NA) intangibles in the remainder. In SNA 2008, the investment boundary was extended to also cover expenditures on R&D.³ However, this still omits

¹Real GDP per capita is calculated using constant internationally comparable dollars (i.e. adjusted for differences in relative prices–PPPs).

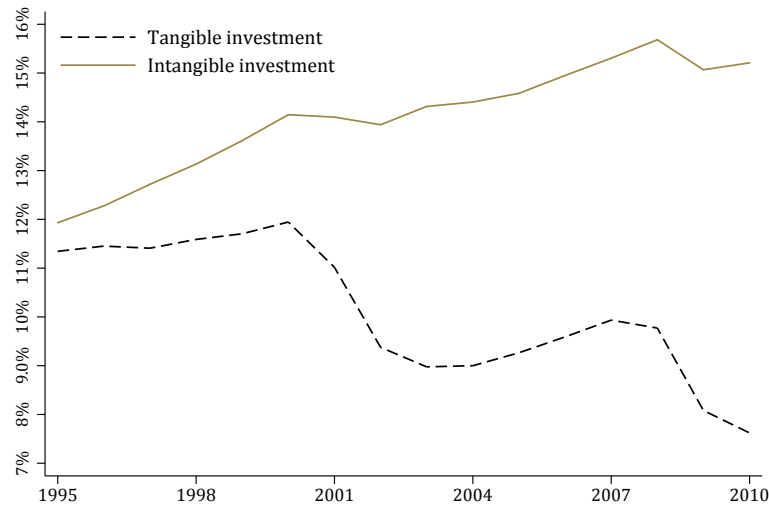
²Abramovitz (1956, p.11) labelled it as “a measure of our ignorance”.

³Since 2013 a small number of countries have started to capitalise R&D spending as investment (e.g. USA, Australia)

other important intangible assets, such as brand equity and organisation capital.

Thanks to the pioneering measurement work of intangible investment by Corrado, Hulten, and Sichel (2005, 2009), evidence is growing stronger that there is a gradual shift in investment composition towards intangible assets. In the US, for example, business intangible investment as a share of GDP had already exceeded the share of traditional investment in tangible assets (e.g. machinery and equipment) by the mid-1990s and has kept on rising over time (see Figure 1). Rather than being an exception, other country-specific studies and the research project commissioned by the OECD (2013) also show that investment in intangibles has been rising in both high-income economies and emerging economies.⁴ In light of this evidence, it is clear that the traditional emphasis on physical capital as the only capital input is missing out on an important part of investments in the modern knowledge-intensive economy. This implies that inputs might account for more of cross-country income differences than generally known so far.

Figure 1: INTANGIBLE INVESTMENT TREND IN THE US (% OF GDP)



Note: Author's calculation based on the INTAN-Invest database

This paper is the first to explicitly account for a country's (business) investment in intangible capital as an additional production factor in accounting for income variation across countries. I first develop a novel database on intangible investment that is consistent and internationally comparable for a set of 60 economies over the period 1995-2011. The dataset, by itself, is a contribution to the rapidly

following the guidelines of SNA 2008. Most countries around the world, however, have not yet switched to SNA 2008. For this reason, R&D is still counted as *new intangibles* instead of *NA intangibles* in this paper.

⁴Other country-specific studies include Australia (Barnes, 2009), Brazil (Dutz, Kannebley, Scarpelli, & Sharma, 2012), China (Hulten & Hao, 2008), South Korea (Chun, Fukao, Hisa, & Miyagawa, 2012), and Japan (Fukao, Miyagawa, Mukai, Shinoda, & Tonogi, 2009).

growing literature on intangible investment as this is the first database providing internationally comparable data on intangibles for such a wide range of countries, including not only the advanced economies, but also major emerging economies like China and Brazil as well as much less developed countries, such as Honduras and Vietnam. This dataset offers two important insights. First, there is a strong positive association between the level of economic development of a country and its investment intensity in intangibles, reaffirming the important role of intangible capital in modern economic growth. Second, the share of investment in intangible assets as a percentage of (intangibles-adjusted) GDP has been increasing steadily over time, while the share of traditional investment in physical assets is highly volatile and had declined somewhat during the period of observation.

Starting with the basic development accounting framework that features physical and human capital akin to Caselli (2005), I find that the observed differences in the traditional factors of production account for approximately 23 percent of the cross-country income variation in 2011. This result holds true whether the analysis is based on the total economy or the market economy which excludes public sectors such as Public Administration and Defence. Therefore, for the set of 60 economies that I cover efficiency is still the main factor accounting for international income differences, conforming to the findings of the existing literature (e.g. Caselli, 2005; Easterly & Levine, 2001; Mutreja, 2014). In the augmented development accounting analysis where intangible capital is included as an additional factor of production, I show that the variance accounted for by the observed differences in inputs increases significantly and systematically across a wide range of specifications. Depending on the assumptions regarding the output elasticity of intangible capital, the observed differences in factor inputs can account for up to 40 percent of the income variation, an improvement of 16 percentage points compared to the conventional analysis that ignores intangible capital. Even under a more conservative specification, I still find that including intangible capital leads to an increase of nearly 5 percentage points of income variation.

Before proceeding, it is helpful to place these results in a broader context. The emphasis on the comparability of the intangible investment series across a set of 60 economies has required rather restrictive assumptions that apply to all countries and measuring intangible investment in a less comprehensive fashion. For instance, I have only focused on three major intangible assets that can be well covered using standardised international databases, which leaves out intangible investment in, for example, firm-specific human capital. This means that the estimates constructed in this study do not reflect the full extent of intangible investment. Superior in this regard are the outcomes

of the INTAN-Invest project (Corrado, Haskel, Jona-Lasinio, & Iommi, 2012) and other country-specific studies that mainly rely on national accounts and national survey data to measure intangible investment.⁵ However, since such studies have not achieved the level of country coverage necessary for an informative development accounting exercise, I have developed my estimates specifically for this purpose.

A key finding of this paper is that intangible capital is important in accounting for cross-country income variation at a single point in time. This echoes with the macro-level studies that find intangible capital to be important for a country's growth over time (e.g. Corrado et al., 2009; Dutz et al., 2012; Fukao et al., 2009). In both cases, the role of efficiency, measured by TFP, is diminished once intangible capital is accounted for.

Since my analysis is an accounting exercise, it can shed no light on whether investing more in intangible assets would lead to higher income or if causality runs the other way. However, there are prior firm-level studies that analyse the role of intangible capital in determining firm productivity and performance. For instance, using a large panel of company accounts data, organisation capital is found to lead to higher firm productivity (Chen & Inklaar, 2016; Tronconi & Vittucci Marzetti, 2011) and larger stock market returns (Eisfeldt & Papanikolaou, 2013), and it is also complementary to the exploitation of the productivity potentials of information technologies (Bloom, Sadun, & Van Reenen, 2012; Brynjolfsson & Hitt, 2000, 2003). At the firm level, there thus seems to be a causal relationship between investment in intangibles and productivity. One of the main insights from my analysis is that high-income countries tend to invest more in intangibles than lower-income countries, which raises the question why firms in lower-income countries are not investing more. So far, the evidence on this is scarce, though Bloom, Eifert, Mahajan, McKenzie, and Roberts (2013) find that the adoption in Indian manufacturing firms of modern management practices – a form of investment in organisation capital – is hampered by informational barriers. While it is a useful piece of evidence, this is a question that awaits further research.

The rest of the paper is organised as follows. Section 2 describes the general measurement procedure of intangible investment and how capitalising expenditures on intangible assets changes the conventional gross domestic product (GDP) concept. A brief discussion on the key features of the intangible investment data is presented in the second part of Section 2. Section 3 outlines the basic

⁵See footnote 4 for the list of country-specific studies.

and the augmented development accounting framework and elaborates on the data that I use for analysis. Results, obtained across various specifications, and robustness checks are discussed in Section 4. Section 5 concludes and discusses the main limitations of the paper.

2. Measuring intangible inputs and output

In this section, I describe the general approach used to measure intangible investment and show how capitalising such investment requires a change in the measurement of GDP. Then, I discuss the list of intangible assets measured in this study as well as the key features of the data that I construct and use for the subsequent development accounting analysis. It is important to note that this section only provides a general overview of the measurement procedure. For a more extensive and detailed discussion on the data construction of intangibles, please refer to Appendix A.

2.1. General measurement approach

Before discussing how to measure intangible investment, a natural question to ask a priori is: why do we need to reclassify expenditures on intangibles and capitalise them as investment? The argument is presented more formally in Corrado et al. (2005) based on inter-temporal capital theory, but the simple answer is: “*any* use of resources that reduce current consumption and production in order to increase it in the future” should be capitalised as investment. Expenditures on tangible assets, such as office buildings, machinery, vehicles, and equipment certainly satisfy this criterion, but so does much spending on brand equity, R&D, and organisational structures.⁶ Expenditures on these assets, collectively termed new intangibles in this paper, contribute to (rather than detract from) the value of individual companies and growth of the economy.

While few would disagree with the potentially long-lasting benefits of intangible capital and their role as productive inputs, little is known about the size of intangible investment at the level of the economy.⁷ The measurement of intangibles is particularly difficult as they are often created for internal use within the firm and suffer from a lack of observable market transaction data for valuation. To circumvent this measurement issue, researchers turned to use the cost approach as an

⁶R&D projects, for instance, can take more than a decade to generate revenue and require large co-investments in marketing.

⁷Various proxy measures, such as business surveys, are used in firm-level studies (e.g. Black & Lynch, 2005; Lev & Radhakrishnan, 2005). But none of these proposed approaches yield the kind of comprehensive measure needed for national accounting or source-of-growth analysis.

alternative. The underlying assumption of the cost approach is that firms are willing to invest in intangible assets until the discounted present value of the expected income stream equals the cost of producing the marginal asset (Jorgenson, 1963).

A key problem of this cost approach, however, is that it is not known with precision how much or what portion of intangible spending has long-lasting impact (i.e. longer than one year) and can be and should be treated as investment. In this paper, I follow the work of Corrado et al. (2005) which suggests a wide range depending on the specific asset. For own-account organisation capital, 20 percent of managers' wage are counted as conducive to organisational development; for advertising, the literature suggests that about 60 percent of advertising expenditures have long-lasting benefit. While for R&D all expenses are treated as investment following SNA 2008.

To cumulate intangible investment flows (N) into capital stocks, one can use the usual perpetual inventory method (PIM) which accumulates past capital formation and subtracts the value of assets due to obsolescence. Physical capital is generally subject to value loss because they tend to be used up in production mainly due to wear and tear. Intangible capital, on the other hand, does not physically deteriorate due to its intangibility. It is more subject to the rise of superior knowledge that supplants the existing ones and thereby making the current intangible or knowledge stock obsolete.

By including some expenditures as investment, one also needs to adjust the GDP concept. More specifically, a country's nominal GDP as measured traditionally (Y) will be expanded accordingly as follows:

$$GDP' \equiv Y + N = \overbrace{C + I + N}^{\text{Expenditure side (GDP)}} = \overbrace{L + K + R}^{\text{income side (GDP)}} \quad (1)$$

$\underbrace{\hspace{1.5cm}}_{\text{added}} \qquad \qquad \qquad \underbrace{\hspace{1.5cm}}_{\text{added}}$

where N is the flow of new intangible investment added on to the expenditure side and R is the income from the flow of services provided by the intangible capital stock. In other words, intangible capital is now both a productive input (R) and a part of intangibles-augmented output (N). This new concept of GDP, denoted by GDP' , is larger in magnitude than conventionally defined.

2.2. List of intangibles measured and overview of the data

I assemble internationally comparable data to estimate intangible investment for a set of 60 economies over the period 1995-2011 (see Appendix Table A1 for the full list of economies covered).

I capture the following three intangible assets in this study: brand equity, R&D, and organisation capital. Brand equity can be seen as the value premium that a firm can capitalise on from a product or service with a recognisable name as compared to its generic equivalent. Following Corrado and Hao (2014), I measure brand equity as the sum of expenditures on advertising and market research. R&D refers to the innovative activities leading mainly to the development of a new or improved product and it is measured by business expenditures on R&D. Organisation capital can be thought of management know-how and the information a firm about its assets and how these can be used in production (Prescott & Visscher, 1980). Following the broad literature, organisation capital is measured as a fraction of manager’s wage compensation. Table 1 provides a general overview of the list of intangibles covered, how they are measured, and the sources of the data used. Readers should refer to Appendix for more detailed discussions on the measurement issues.

Table 1: LIST OF INTANGIBLE ASSETS MEASURED AND DATA SOURCES

Asset Type	Measured by	δ	Data source*
Brand equity	Spending on advertising and market research	60%	WARC & ESOMAR
Scientific R&D	Business expenditures on R&D	20%	UNESCO & Eurostat
Organisation capital	Wage compensation of managers	40%	ILO, PWT8.1, BLS

δ : Asset-specific depreciation taken from Corrado et al. (2009)

* ILO: International Labour Organisation; PWT: The Penn World Table version 8.1; BLS: Bureau of Labour Statistics; WARC: World Advertising Research Centre; ESOMAR: European Society for Opinion and Marketing Research; UNESCO-UIS: UNESCO Institute for Statistics; Eurostat: Statistical Office of the European Communities.

It is important to emphasise that these do not include all intangibles investments in the economy. As noted earlier, investment in national accounts intangibles are already capitalised and included in investment and GDP statistics following the SNA 1993. There is hence no need for additional estimation.⁸ Corrado et al. (2005) include three other intangibles, namely architectural and engineering designs, firm-specific human capital, and new financial products, but these are relatively minor. According to the estimates of the INTAN-Invest project, a pioneering database providing country-level intangible investment data for a sample of 29 countries, the sum of these three assets account for nearly 75 percent of the total intangible investment not covered in SNA 1993 statistics. Thus, in terms of their shares in total intangible investment these three assets can be considered as the most important ones to capture.

⁸To have a full-fledged analysis on how the addition of total intangible capital affects the development accounting analysis, it would be ideal to isolate those national accounts intangible investments from total tangible investment (I) and reclassify them as intangibles. This is however not possible due to data constraints.

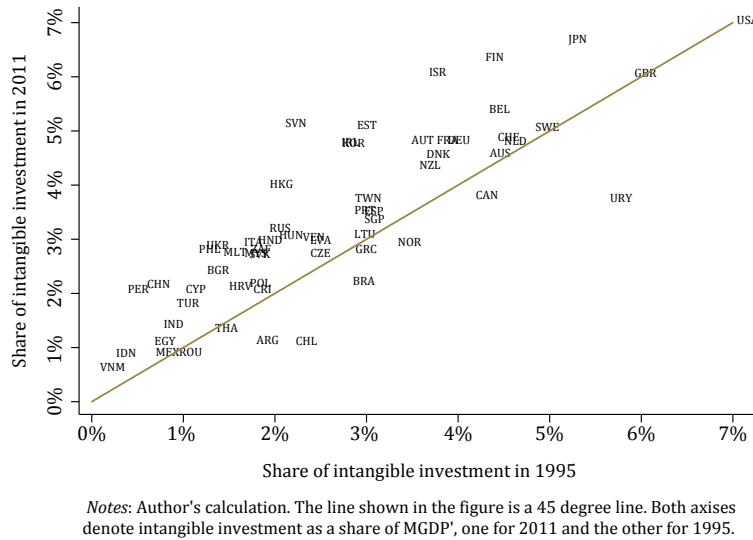
Like many other studies on intangibles, I focus on market sector investment in intangible assets and omit public intangible investment due to measurement difficulties.⁹ Hence, a country's market GDP (MGDP) after adjusting for business investment in intangible assets is calculated as follows:

$$MGDP'_{c,t} \equiv mY_{c,t} + N_{c,t}^{BE} + N_{c,t}^{RD} + N_{c,t}^{OC} \quad (2)$$

where m denotes the share of market economy; Y denotes GDP calculations based on SNA 1993 revision, and intangible investments are represented by the letter N indexed by the asset-specific superscripts – BE, RD, and OC.

The intangibles data constructed in this paper offers several important insights. The first is that, there has been a steady increase in the share of investment in intangibles between 1995 and 2011 for most of the countries covered in my sample (see Figures 2 and 3). Whereas, the same is not true about the share of traditional investment in physical assets, which had declined somewhat over time. These two contrasting investment trends or patterns seem to suggest that the modern economy is currently undergoing structural changes with investment composition shifting gradually towards intangible assets.

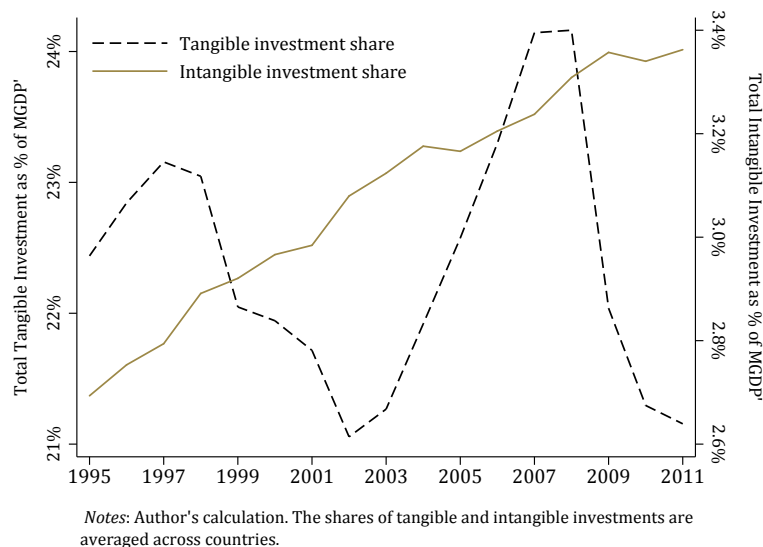
Figure 2: INTANGIBLE INVESTMENT AS A SHARE OF MGDP' IN 1995 AND 2011



In addition, it is also interesting to note the difference in volatility of investment in tangible and intangible assets. Figure 3 shows that investment in intangible assets as a share of MGDP' seems to

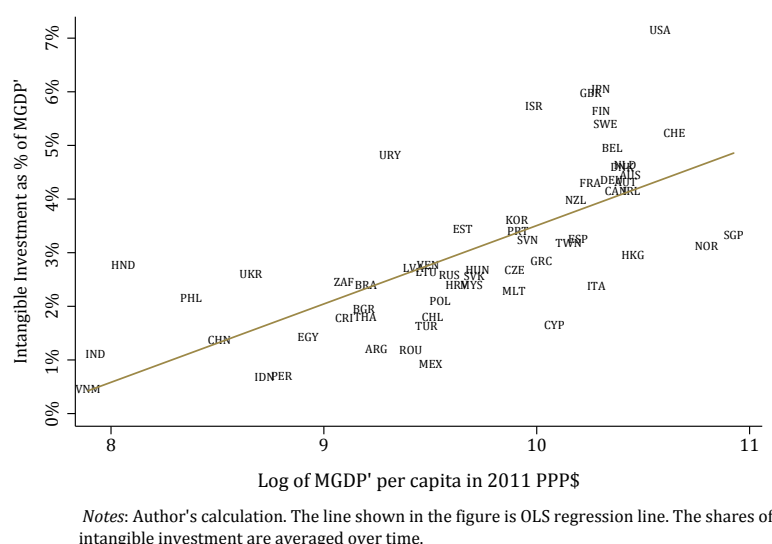
⁹The distinction between market and nonmarket (public) sector is the same as defined in EU KLEM (O'Mahony & Timmer, 2009). According to NACE classification, sectors A-K plus sectors O and P consist of market sector. See Appendix B for more detailed discussions.

Figure 3: CROSS-COUNTRY AVERAGE INVESTMENT TREND OF INTANGIBLES AND TANGIBLES



be much more stable and resilient to economic downturns, while traditional investment in tangible assets appears to be highly volatile and sensitive to external shocks. This is reflected by the sharp decline in tangible investment share observed in 1997, 2001, and 2008. In chronological order, these three years are, respectively, associated with the Asian financial crisis, the dot-com bubble burst, and the global financial crisis.

Figure 4: INTANGIBLE INVESTMENT AND LEVEL OF ECONOMIC DEVELOPMENT



Third, the world's leading investor in intangible capital is the US, which has an average intangible investment share of over 7 percent of MGDPP'. Vietnam, on the other hand, has the smallest share (i.e. slightly over 0.5% of MGDPP'). The positive slope of the fitted line shown in Figure 4 suggests

that there is a strong positive correlation between the level of economic development of a country and its investment intensity in intangible assets, which is above 0.67. This, of course, could mean that rich countries tend to invest more in intangible assets or that, intangible assets tend to make these investing countries richer.

3. Development accounting and data analysis

In this section, I revisit the basic development accounting technique and set the stage for the extension of the basic model, which already features physical capital and human capital as factor inputs, to further include intangible capital. Then, I elaborate on the data that I use for the development accounting analysis and briefly discuss how the key variables of interest are constructed.

3.1. Development accounting framework

The point of departure for our empirical analysis is the benchmark Hall and Jones (1999)'s production function:

$$Y = A \cdot K^\alpha (Lh)^\gamma \quad (3)$$

where Y is a country's GDP, K is the aggregate physical capital stock and Lh is employment adjusted for labour quality (i.e. number of workers L multiplied by their average human capital h). The superscripts α and γ are the output elasticities of capital and labour,¹⁰ and A denotes the state of technology with which production factors are combined to produce output. Assuming that the production function features the property of constant returns to scale (i.e. $\gamma = 1 - \alpha$) and normalise the function by the number of employees, equation (3) can be rewritten as follows:

$$y = A \cdot k^\alpha h^{1-\alpha} \quad (4)$$

where y is the output per worker, k is the capital-labour ratio for physical assets (i.e. K/L). Equation (4) basically asks how much of the variation in output per worker y can be attributed to variation observed in physical capital k and human capital h , each weighted by their output elasticities, and how much is left to be accounted for by differences in technology A or total factor productivity (TFP).

¹⁰In growth or development accounting the output elasticity of factor inputs is equal to its income share if inputs earn their marginal product and firms maximise profits. I will speak of output elasticities, instead of income shares, throughout the paper.

Akin to Caselli (2005), I define $y_{KH} \equiv k^\alpha h^{1-\alpha}$ as the so-called factor-only model and for ease of exposition rewrite equation (4) accordingly as:

$$y = A \cdot y_{KH} \quad (5)$$

where both y and y_{KH} are observable. In the tradition of variance decomposition, this equation can be further transformed as follows:

$$\text{var}[\log(y)] = \text{var}[\log(A)] + \text{var}[\log(y_{KH})] + 2\text{cov}[\log(A), \log(y_{KH})] \quad (6)$$

The explanatory power of observed input differences is then defined as:

$$\text{VAF} = \frac{\text{var}[\log(y_{KH})]}{\text{var}[\log(y)]} \quad (7)$$

where VAF denotes the fraction of income variances accounted for by the observed differences in factor inputs. The higher the value of VAF, the more the variance can be accounted for by the observable inputs. In the work of Caselli (2005), this ratio or fraction is alternatively labelled as the success rate: how successful are observable factor inputs in accounting for cross-country income differences?

I extend the basic framework to further include intangible capital (R) as an additional production factor and denote its output elasticity by a constant parameter β . Then, the augmented production function in per worker terms becomes:

$$y' = A \cdot y_{KRH} = A \cdot k^\alpha r^\beta (h)^{1-\alpha-\beta} \quad (8)$$

where $y_{KRH} \equiv k^\alpha r^\beta h^{1-\alpha-\beta}$ denotes the *augmented* factor-only model; the superscripts α and β represent the output elasticities for tangibles and intangibles; and y' is the market GDP adjusted to include intangible capital constructed per equation (1). Again, following Caselli (2005) the decomposition of the variation in GDP per worker is now given by:

$$\text{VAF}' = \frac{\text{var}[\log(y_{KRH})]}{\text{var}[\log(y')]} \quad (9)$$

The prime interest is essentially the difference between VAF and VAF'. If intangible capital is important in accounting for international income differences, one would expect the value of the latter to exceed the former. In fact, the larger the difference between the two ratios, the larger the role of intangible capital in accounting for income variation.

3.2. Basic data

The basic data I use are obtained from various sources. Countries' (nominal) GDP and total investment in tangible assets,¹¹ and number of workers are primarily extracted from the United Nations National Accounts (UN NA) database, human capital (h) comes from the standard database of Barro and Lee (2013), and total investment in intangibles (N) is constructed in this study. Since both GDP and investment are denominated in local currency unit (LCU) and are expressed in nominal terms, I first estimate real GDP per worker ($RGDPWOK_{c,t}$) and real value of tangible investment ($I_{c,t}$) in international comparable dollars as follows:

$$y_{c,t} \equiv RGDPWOK_{c,t} = GDP_{c,t} / P_{c,t} / ppp_{c,2011} / emp_{c,t} \quad (10)$$

$$I_{c,t} = GFCF_{c,t} / P_{c,t}^I / ppp_{c,2011} \quad (11)$$

where the subscripts c and t denote country and year, respectively; P is the GDP price deflator with 2011 as base and ppp is the GDP PPP divided by the exchange rate in 2011 and is taken from the World Development Indicators (World Bank, 2015). Physical capital stock K is calculated using the perpetual inventory method:¹²

$$K_{c,t} = I_{c,t} + (1 - \delta_K) \cdot K_{c,t-1} \quad (12)$$

where I is the real investment in traditional tangible assets deflated by the investment price deflator (P^I) and δ_K is the rate of depreciation for physical capital K , which is set equal to 0.06 following the broad literature (e.g. Caselli, 2005).¹³ For the initial capital stock calculation (K_0), I follow the standard approach proposed by Harberger (1978) by assuming the steady-state relationship from the Solow growth model:

$$K_0 = I_0 / (g + \delta_K) \quad (13)$$

¹¹Investment is measured by gross fixed capital formation (GFCF). Since Taiwan is not covered in the UN NA database, I alternatively extract its (nominal) GDP and total gross fixed capital formation (I) from the PWT 8.1 database.

¹²It would be ideal to measure capital services rather than capital stocks as a capital input measure, as a capital services measure would capture the larger return of shorter-lived assets. However, the data requirements are much more demanding for estimating capital services than for capital stock and there is no readily available data to measure capital services. For instance, one would need additional information on the user cost of capital to calculate capital services. The user cost of capital requires the rate of return on capital and the rate of asset-specific inflation. The former is generally hard to measure with precision (e.g. Inklaar, 2010) and data on the asset-specific capital gains are not available for many countries. Due to these practical constraints, total capital stock (both tangible and intangible) based on perpetual inventory method is used as a measure of capital input, rather than the preferred services measure. Note, the existing studies on international income differences generally relied on a stock measure as well for capital input (e.g. Caselli, 2005; Mutreje, 2014), so the results obtained in this paper by adding intangibles as an additional capital input can be directly compared to previous studies.

¹³The investment price deflator for tangible assets P^I is calculated as GFCF at current national prices divided by GFCF at constant national prices. Both data series are retrieved from the UN NA database.

The initial capital stock K_0 for an asset is related to investment in the initial year I_0 , the (steady-state) growth rate of investment g and the rate of depreciation δ . Unlike intangible investment data that is only available for 17 years (i.e. 1995-2011), tangible investment I is, for many countries, available since 1960.¹⁴ Therefore, to make the best use of the existing data, tangible capital stock K is constructed for a much longer time series than intangible capital stock, which I turn to discuss in the next subsection.¹⁵ The (physical) capital-labour ratio is calculated as:

$$k_{c,t} = K_{c,t} / emp_{c,t}^{PWT} \quad (14)$$

As for human capital h , I rely on the recently updated data on educational attainment for population aged 25 and over from Barro and Lee (2013)¹⁶. Following the broad literature, I measure human capital h of country c at time t as a function of average years of schooling (s) as follows:

$$h = e^{\phi(s)} \quad (15)$$

The function $\phi(s)$ from equation (15) takes the following form as in earlier studies (e.g. Caselli, 2005; Inklaar & Timmer, 2013). The rationale for this form is that early years of schooling is believed to have a higher rate of return than later years. This assumption is also empirically supported by the cross-country Mincerian wage regressions (Mincer, 1974). To be precise, $\phi(s)$ is piece-wise linear with rates of return based on Psacharopoulos (1994):

$$\phi(s) = \begin{cases} 0.134 \cdot s & \text{if } s \leq 4 \\ 0.134 \cdot 4 + 0.101 \cdot (s - 4) & \text{if } 4 < s \leq 8 \\ 0.134 \cdot 4 + 0.101 \cdot 4 + 0.068 \cdot (s - 8) & \text{if } s > 8 \end{cases} \quad (16)$$

Unlike the basic data discussed in the previous section where y and k are calculated both for the total economy and for the market economy,¹⁷ data on intangibles is solely constructed for the market sector. The real value of market investment in intangibles n , expressed in international comparable

¹⁴To be precise, 1960 (29 countries), 1965 (2 countries), 1966 (1 country), 1968 (1 country), 1970 (18 countries), 1980 (1 country), 1989 (2 countries), 1990 (6 countries).

¹⁵With a rate of depreciation of 6%, a much longer time series is also needed to calculate tangible capital stock, especially for the initial capital stock. To note, there are nine East European countries that do not have a reasonably long time series of tangible investment (i.e. dating back to 1970), I will drop them in the subsequent development accounting analysis for robustness check. For countries that have a negative average growth rate, I reset it to 4%, which is the mean geometric growth rate observed for the other countries.

¹⁶The educational attainment data provided by Barro and Lee (2013) is available every five years, going back to 1950 and most recently up to 2010. For 2011, I assume that 2010 average years of schooling prevail.

¹⁷Due to lack of data, human capital h is only calculated for the total economy and is assumed to be the same for the market economy.

dollars, is computed as follows:

$$n_{j,c,t} = N_{j,c,t} / P_{j,c,t}^N / ppp_{c,2011} \quad (17)$$

where N denotes nominal intangible investment flows; P^N is the asset-specific price deflator for intangibles and is imputed based on the US data (see Section 3.3 for more detailed discussions on intangible price deflator); ppp is the GDP PPP divided by the exchange rate in 2011 taken from WDI. Intangible capital R is then calculated using PIM:

$$R_{j,c,t} = (1 - \delta_j^R) \cdot R_{j,c,t-1} + n_{j,c,t} \quad (18)$$

where δ^R is the country-time-invariant depreciation rate for asset j from Table 1. The initial capital stock is computed based on the steady-state assumption:

$$R_{j,0} = n_{j,0} / (g_j + \delta_j^R) \quad (19)$$

where $n_{j,0}$ is the real value of intangible investment in 1995, and g is the average growth rate of the intangible investment series between 1995 and 2011. Given the relatively high rates of depreciation assumed for intangible capital, a time span of 17 years is long enough for the initial capital stock to have only little impact on the development accounting analysis as the true value of the initial stock will be depreciated by 2011, the year I use for cross-country analysis.¹⁸ Intangible capital-labour ratio is computed as follows:

$$r_{c,t} = (R_{c,t}^{BE} + R_{c,t}^{OC} + R_{c,t}^{RD}) / (s^M \cdot emp_{c,t}^{PWT}) \quad (20)$$

where s^M denotes the share of employment in the market sector (see Appendix B2 for a more detailed discussion).

To have a general overview of the data, a brief summary of some descriptive statistics is provided in Table 2. As can be seen, Vietnam is the poorest country in the sample with the least amount of physical and intangible capital, while Singapore has the highest income per worker. The US has the highest level of both intangible capital and human capital. Figure 5 correlates tangible capital per worker with intangible capital per worker, both of which are normalised relative to the US values. As can be seen, these two capital-labour ratios are highly correlated (correlation coefficient

¹⁸Even for asset with the lowest rate of depreciation (e.g. $R^{RD} = 20\%$), the initial capital stock would wear out almost completely after 17 years: $(1 - 0.2)^{17} = 0.02$. This still holds true if the depreciation rate is just 15%: $(1 - 0.15)^{17} = 0.06$. Thus, a time span of 17 years is already long enough to measure intangible capital stock with precision.

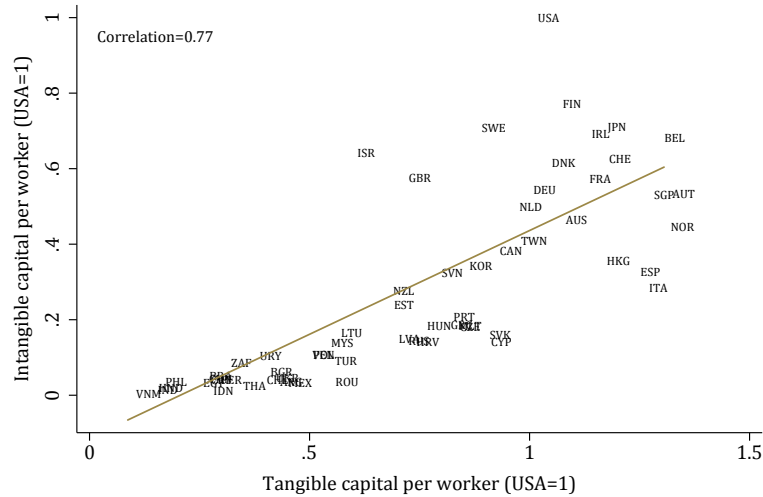
is approximately 0.77). This suggests that countries with higher tangible capital per worker tend to have more intangible capital per worker as well.

Table 2: DESCRIPTIVE STATISTICS OF THE BASIC DATA FOR 2011 (MARKET ECONOMY)

	Description	Min.	Mean	Max.	S.D.
y'	real market output per worker	7666 (VNM)	65747	139955 (SGP)	334305
k	physical capital per worker	15485 (VNM)	126681	233007 (NOR)	63191
r	intangible capital per worker	77 (VNM)	7429	26839 (USA)	6731
h	human capital per worker	1.97 (IND)	3.00	3.70 (USA)	0.435

Note: All numbers presented in the table are based on the market-sector of the economy for a set of 60 economies.

Figure 5: CORRELATION BETWEEN TANGIBLE AND INTANGIBLE CAPITAL PER WORKER



Notes: Author's calculation. The line shown in the figure is OLS regression line.

3.3. Intangible investment price deflator

Currently, there is very limited knowledge on the appropriate price measures of intangible investment as these assets tend to be internally generated and lack observable market data for valuation. The existing studies have primarily relied on the non-farm business output price deflator as a proxy for the price of intangibles and applied this deflator uniformly to all intangible assets (Corrado et al., 2012, 2009). It could be argued however that rather than using the uniform business output price deflator, more appropriate asset-specific deflators would be the price indices of the industries

that produce (in part) intangible assets, such as management consulting industry for organisation capital, advertising and marketing research industry for brand equity, and R&D services industry for R&D.

Since price deflators for intangible-producing industries are not widely available for the other economies, I use the US, where the data are available, as the benchmark country and impute the asset- and country-specific intangible price deflators as follows:

$$R_{j,t,US}^N = P_{j,t,US}^N / P_{t,US}^I \quad (21)$$

where R^N denotes the relative intangible price deflator of the US, $P_{j,t,US}^N$ is the price deflator of the asset-specific intangible-producing industry obtained from US Bureau of Economic Analysis, and $P_{t,US}^I$ is the tangible investment price deflator provided by the UN NA data. Assuming that the relative price between intangible and tangible investments are constant across countries, I derive intangible investment price for the other economies as follows:

$$P_{j,c,t}^N = P_{c,t}^I \times R_{j,t,US}^N \quad (22)$$

It is important to emphasise that the price of intangibles calculated per equation (22) is only a crude proxy and a practical choice needs to be made. Robustness to the choice of intangible price deflator, rate of depreciation of intangible capital stock, and other assumptions made during the data construction process will be examined in the next section.

4. Empirical Results

In this section, I discuss the main empirical findings, first with results of the basic development accounting analysis which only features physical and human capital, followed by the analysis augmented to include intangible capital as an additional factor of production. By varying the output elasticities of factor inputs, I compare and contrast the findings across various specifications and discuss the robustness of the main result.

4.1. Basic development accounting analysis

With data on y , k and h , and setting the output elasticity of physical capital α equal to 1/3 as suggested by the broader literature, the variance of the basic factor-only model for year 2011, $var[\log(y_{KH})]$, is 0.088 and the observed actual output variance, $var[\log(y)]$ is 0.387 (see the first row

of Table 3). This result suggests that, for a sample of 60 economies, only about 23 percent of the income variances can be accounted for by the observed differences in factor inputs. This fraction remains largely unchanged if I drop those nine former Soviet Union countries that do not have a sufficiently long tangible investment series going back to 1970.¹⁹

Table 3: VARIANCE ACCOUNTED FOR: BASIC MODEL FOR 2011

	Coverage	$\text{var}[\log(y)]$	$\text{var}[\log(y_{KH})]$	VAF
Own data	Total Economy (60)	0.387	0.088	22.7%
Own data (excl. former USSR)	Total Economy (51)	0.432	0.101	23.4%
Data from PWT 8.1	Total Economy (60)	0.452	0.109	24.1%
Own data	Market Economy (60)	0.432	0.101	23.3%

Note: Market economy indicates that the analysis is based on market- GDP, -investment, and -employment. The share of variance accounted for in the last column is calculated based on values to the seventh decimal point. For brevity, variance values to the third decimal point are shown in the table.

To check whether this result is plausible, I compute the VAF of the basic factor-only model by solely using the PWT8.1 data constructed by Feenstra, Inklaar, and Timmer (2015) for 2011 (see Table 4 for the variables used). The counterfactual variance using PWT8.1 data, $\text{var}[\log(y_{KH})]$ takes the value 0.109 and the observed variance of $\text{var}[\log(y)]$ is 0.452, resulting in a fraction of 24 percent of the income variances accounted for by factor inputs. This rate is very similar to the prior finding. If I narrow the focus down to the market sector of the economy (i.e. y is the market output per worker, k is the capital stock accumulated by the market sector, and L is the market share of employment), the variance accounted for remains nearly identical (about 23%). So regardless of the coverage of the economy (i.e. market or total), in the basic factor-only model the differences of the observed factor inputs can account for no more than 25 percent of cross-country income differences and the rest is attributable to the differences in efficiency measured by TFP.

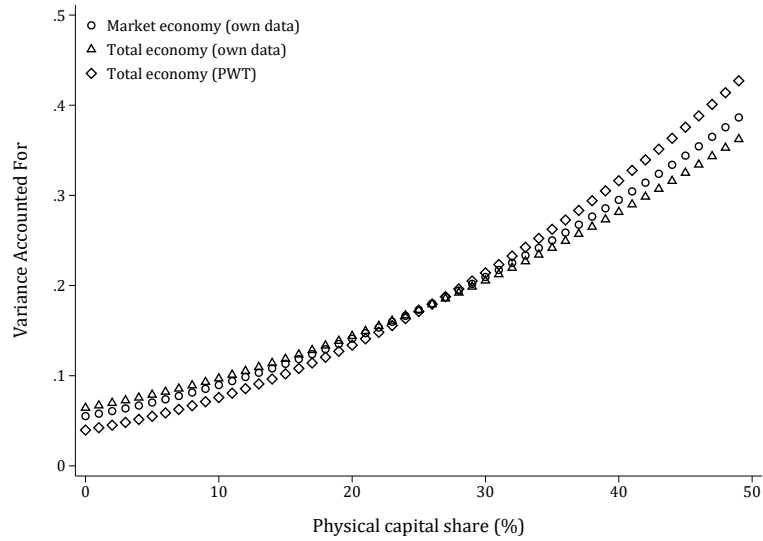
A caveat to bear in mind is that these results rest on the restrictive assumption that the output elasticity of physical capital is time-invariant and constant at 1/3. According to various recent studies (Inklaar & Timmer, 2013; Karabarbounis & Neiman, 2014; Rodriguez & Jayadev, 2010), there is robust evidence that the labour share of income has been declining over time around the

¹⁹The rationale for this sensitivity check is that for those countries that have a short investment series, the initial capital stock (calculated based on the steady-state assumption) has a non-trivial impact on the development accounting analysis because about 14 percent (i.e. 1980-2011, $(1 - 0.06)^{32}$) to over 25 percent (i.e. 1990-2011, $(1 - 0.06)^{22}$) of the initial capital stock is still in use in 2011. Only for countries with a reasonably long investment series (i.e. time span of 42 years or more), would the true value of the initial capital stock be (nearly) depreciated away by 2011.

Table 4: ALTERNATIVE DATA FROM PWT 8.1

	Variables names	Data	Description
y	real output per worker	rgdpe	Expenditure-side real GDP at chained PPPs (in 2005 US\$)
k	capital-labor ratio	ck	Capital stock at current PPPs (in 2005 US\$)
L	number of workers	emp	Number of persons engaged (in millions)
h	human capital	hc	Human capital index, based on years of schooling

world. Under the assumption of constant returns to scale, this means that the income share of capital is increasing and income shares are typically used to approximate output elasticities. As a consequence, using $1/3$ as the output elasticity for capital is a simplification which may not reflect the reality. Figure 6 plots the change of VAF as a function of the output elasticity of capital α . This analysis illustrates that as long as the output elasticity of capital is less than 50 percent (i.e. $\alpha \leq 0.5$), most of the variation in income is still accounted for by TFP. It is also reassuring that the variance accounted for remains fairly similar across different data sources and coverage of the economy.

Figure 6: VAF BY VARYING OUTPUT ELASTICITY OF PHYSICAL CAPITAL

4.2. Augmented development accounting analysis

To examine how much of the income variation can be accounted for by intangible capital, I now turn to examine the augmented factor-only model. The first challenge is to pin down the output elasticity of intangible capital β and the resulting changes of output elasticities brought to labour

γ and physical capital α .²⁰ In a growth accounting framework, Corrado et al. (2009) find that after capitalising intangible investment in the US, the total capital share of income (i.e. $s_K + s_R$) rises to 40 percent, of which about 62.5 percent accrues to physical capital and 37.5 percent accrues to intangible capital (i.e. $\alpha'=0.25$ and $\beta=0.15$), and the labour share of income drops to 60 percent.²¹ I take these shares as the baseline but also as the upper-bound specification for the development accounting analysis. Given that the US invests most intensively in intangibles assets, it is unlikely for the other economies to have an income share of intangible capital to be higher than the share of the US.

Table 5: VARIANCE ACCOUNTED FOR: AUGMENTED MODEL FOR 2011 (MARKET ECONOMY)

	Output elasticities	$\text{var}[\log(y')]$	$\text{var}[\log(y_{KRH})]$	VAF'	Δ
Lower-bound	$\alpha = .33 \ \& \ \beta = .05$	0.445	0.124	27.9%	+5%-points
Mid-range	$\alpha = .33 \ \& \ \beta = .10$	0.445	0.166	37.2%	+14%-points
Upper-bound (Baseline)	$\alpha = .25 \ \& \ \beta = .15$	0.445	0.177	39.8%	+16%-points

Δ : denotes the difference in the variance accounted for by the augmented model as compared to the basic model (i.e. $\text{VAF}' - \text{VAF}$) in percentage points.

As shown in Table 5, the counterfactual variance, $\text{var}[\log(y_{KRH})]$ under the upper-bound specification, takes the value 0.177 and the market output variance $\text{var}[\log(y')]$ becomes 0.445. This leads to a significant improvement in the variance accounted for from 23 percent under the basic development accounting analysis to nearly 40 percent. Even if I calibrate the model to a more conservative specification with the output elasticity of physical capital unchanged (i.e. $\alpha=1/3$ as previously used) and the output elasticity of intangibles accounting for merely 5 percent (i.e. $\beta=0.05$), the VAF' ratio still has a sizable increase of about 5 percentage points as compared to the basic model that ignores intangible capital.

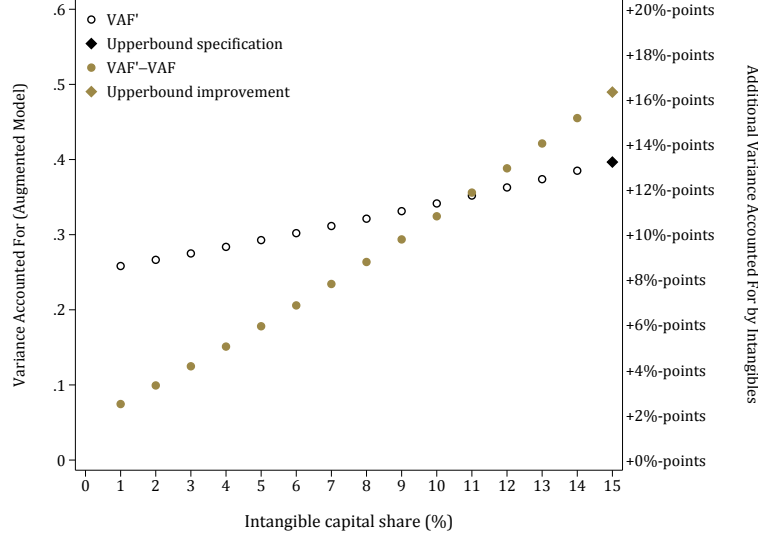
It is clear that the exact value of VAF' is sensitive to the choice of the output elasticities. This sensitivity prevents the paper from drawing firm conclusions about the exact improvement of the additional variance accounted for by intangibles. The qualitative evidence, however, is clear: intangible capital systematically improves the explanatory power of observed input differences in accounting for income variation. As shown in Figure 7 where I keep the output elasticity of labour

²⁰After capitalising intangible investment, labours share of income changes from $s_L = (P^L L)/(P^L L + P^K K)$ to $s_L = (P^L L)/(P^L L + P^K K + P^R R)$

²¹Similar pattern-changes, but in much larger magnitude, also emerged in studies that rely on econometric estimation. For a sample of EU countries, Roth and Thum (2013) find the following output elasticities for these factor inputs: $\alpha'=0.30$, $\beta=0.25$, and $\gamma'=0.45$.

fixed at 60 percent (i.e. $\gamma=0.6$) and only vary the output elasticities between two capital inputs,²² the variance accounted for is increasing steadily as I increase the share of intangible capital (and thus decrease the share of tangible capital).

Figure 7: CHANGES IN VAF BY VARYING OUTPUT ELASTICITIES OF CAPITAL INPUTS



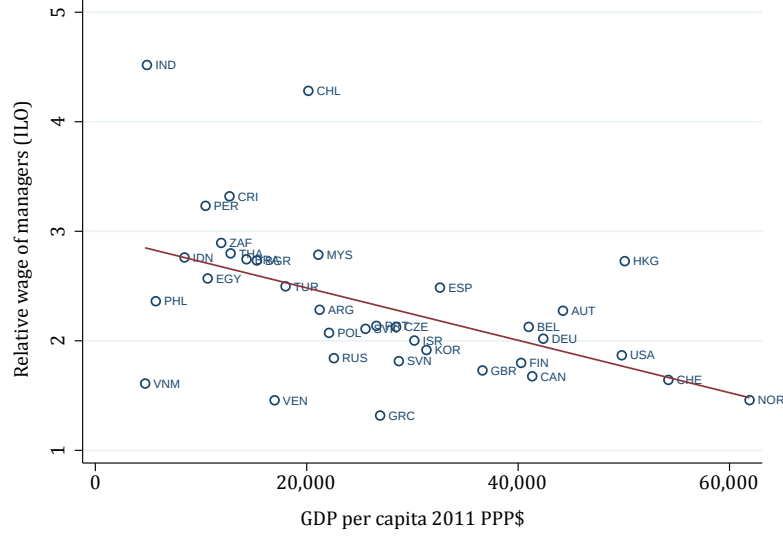
4.3. Robustness of the main result

Despite the fact that the quantitative implication is sensitive to the choice of the output elasticities of factor inputs, the main result is that including intangible capital systematically improves the explanatory power of observed input differences in accounting for income variation across countries. In this subsection, I test the robustness of this main result using various alternatives. The baseline is the upper-bound result from Table 5 (i.e. output elasticity of intangibles at 15 percent). I discuss how this baseline result changes when I make alternative choices in various stages of the data construction process.

First, investment in organisation capital is measured by the wage compensation of the managers, but data on wage compensation by occupation is not widely available outside the US. My main results are based on the assumption that the relative wage of managers to an average worker is the same for all the other countries as in the US. Based on the scant earnings data provided by the International Labour Organisation, a fairly strong negative relationship can be observed between a

²²This can be seen as the most conservative specification, as labour share has been declining over time as argued previously in the text. Thus, using 60 percent for the labour share (after adjusting for intangible capital which would also decrease labour share, see footnote 18) should be the maximum possible. Since the variation of human capital is less than the other capital inputs, changing the labour share to any value less than 60 percent would only increase VAF by factor inputs. In other words, the improvement shown in Figure 7 is on the conservative side.

Figure 8: RELATIVE WAGE DIFFERENTIALS AND THE LEVEL OF ECONOMIC DEVELOPMENT



country's level of investment and its wage differentials (see Figure 8). Thus, using the US relative wage would mean that I am likely to underestimate the actual level of investment in organisation capital for most of the other economies covered in my sample, as countries at a lower level of development tend to have a larger wage differential than the benchmark economy – the US. In light of this evidence, I provide an alternative measure of investment in organisation capital that allows for the relative wage of managers to an average worker to differ by country (i.e. R_c).²³ As shown in the first row of Table 6, applying this alternative measure of organisation capital has little impact on the main result.

Second, due to data constraints, the intangible investment data of some countries have mainly relied on imputations. For instance, business investment in R&D for Brazil is approximated based on the data from Mexico (see the Appendix for greater detail). In the second and third rows of Table 6, I show that the main result remains unchanged to alternative country samples. It is not sensitive to dropping Spain and Greece, two countries with anomalously large amount of investment in organisation capital, or dropping Brazil, Egypt, Honduras, and Venezuela, countries with investment in R&D imputed.

²³The alternative wage differential R_c is based on the limited earnings data by sex and occupation from the ILOSTAT database. I use the ISCO 2008 classification and retrieve the wage data for two occupational categories: Managers and Total for 2009, 2010 and 2011, the only three years that have the wage data available. In total, 35 countries are covered by ILO. Since there is little variation over time, I take an average of the ratio ($Managers/Total$) and held it constant for all years. Hence, the alternative measure of organisation capital assumes a country-variant but year-invariant wage rate for managers. For the rest of the 24 countries that have no earnings data by occupation, I simply use the wage differential from a similar country that has a comparable level of GDP per capita and are geographically located close to one another. The wage data for the US is extracted from the Occupational Employment Statistics database provided by the US Bureau of Labour Statistics.

In row (4) of Table 6, I show that the main result is also robust to using lower rates of depreciation as the rates assumed by Corrado et al. (2009) might have been too high. Take R&D and organisation capital for example, other studies have suggested to use a rate of 15 percent to depreciate both capital stocks (Eisfeldt & Papanikolaou, 2013; Hall, 2007). For brand equity, I lower the depreciation rate to 50 percent following the empirical evidence surveyed in Bagwell (2007). In addition, the main result is not affected if the average growth rate of intangible investment, g , per equation (19) is calculated based on early years of observation (i.e. 1995-1999), since investment in intangibles were much lower in the 1990s than later on.

Last but not least, if other price proxies were used to deflate intangible investments, for instance the tangible investment price deflator, the GDP price deflator, or the non-farm business output price deflator, the resulting intangible capital stock correlate very highly (correlation above 0.98) and the main result of the analysis also remains largely unchanged (see the last three rows of Table 6).

Table 6: ROBUSTNESS ANALYSIS OF THE MAIN RESULT

	$\text{var}[\log(y')]$	$\text{var}[\log(y_{\text{KRH}})]$	VAF'	Δ
Baseline result from Table 5	0.445	0.177	39.8%	+16%-points
(1) Alternative OC	0.443	0.171	38.6%	+15%-points
(2) Dropping GRC&ESP	0.456	0.181	39.7%	+16%-points
(3) Dropping sample	0.403	0.160	41.1%	+18%-points
(4) Alternative δ_j	0.445	0.177	39.8%	+16%-points
(5) Alternative K_0 & R_0	0.445	0.173	38.9%	+15%-points
(6) Alternative price P^{BS}	0.445	0.172	38.6%	+15%-points
(7) Alternative price P^{GDP}	0.445	0.173	38.9%	+15%-points
(8) Alternative price P^I	0.456	0.261	57.2%	+32%-points

Note: 'Alternative OC' denotes alternative measures of investment in organisation capital. 'Dropping sample' means Brazil, Egypt, Honduras, and Venezuela are dropped from analysis. Alternative prices in (6) -(7), denote intangible price deflator proxied by non-farm business output price deflator (P^{BS}), the GDP price deflator (P^{GDP}), and the tangible investment price deflator (P^I).

Δ : denotes the difference in the explanatory power of the augmented model as compared to the basic model (i.e. VAF'-VAF) in percentage points.

5. Concluding Remarks

Why do some countries produce so much more output per worker than others? I revisit this question by accounting for the role of intangible capital, a form of investment that has become increasingly more important in the fast-changing modern economy. Based on various data sources, I first develop a new intangible investment database that is consistent and internationally comparable for a sample of 60 countries and over a time span of 1995-2011. I find a high positive correlation between a country's level of GDP per capita and its investments in intangibles. In a development accounting framework, I show that the fraction of cross-country income variation accounted for by the observed differences in factor inputs increases substantially after taking intangible capital into account. In my baseline result, observed input differences can account for approximately 40 percent of income differences, which is notably higher than the 23 percent if only differences in physical and human capital are accounted for.

Furthermore, the potential of intangible capital to account for international income differences is likely to be greater than what the results in the paper suggest, as the set of intangible assets I cover is only a subset of the full list of intangibles identified by Corrado et al. (2005).

Although the evidence this paper finds are encouraging, it is important to note the limitations as well. First, there are still many unresolved yet highly important issues surrounding the measurement of intangible capital. For instance, I have not adequately addressed the issue of appropriate price deflators for the asset-specific intangible investments. Assumptions made in this regard may have non-trivially affected the quantitative results. Second, the standard 'one-size-fits-all' output elasticities of inputs (e.g. $1/3$ or $1/4$ for physical capital) are simplifications which may not reflect the reality. As noted by Inklaar and Timmer (2013), the explanatory power of variation in observed inputs could be larger if output elasticities of inputs are country- and year-specific. This limitation, however, does not discredit the contribution of this study to the literature as the results are comparable to earlier studies that have also assumed a common output elasticity of factor inputs (e.g. Caselli, 2005; Mutreja, 2014). Third, the analysis is based on capital stocks rather than capital services, which would have been a more appropriate measure for capital input since shorter-lived assets should have a larger return in production as it would be indicated by its user cost. But while these are limitations, my analysis is still a useful step forward. By focusing attention on low levels of investment in intangible assets in lower-income countries, this paper suggests a research agenda

for trying to uncover the determinants of this low investment and thus a promising new direction for understanding international income differences.

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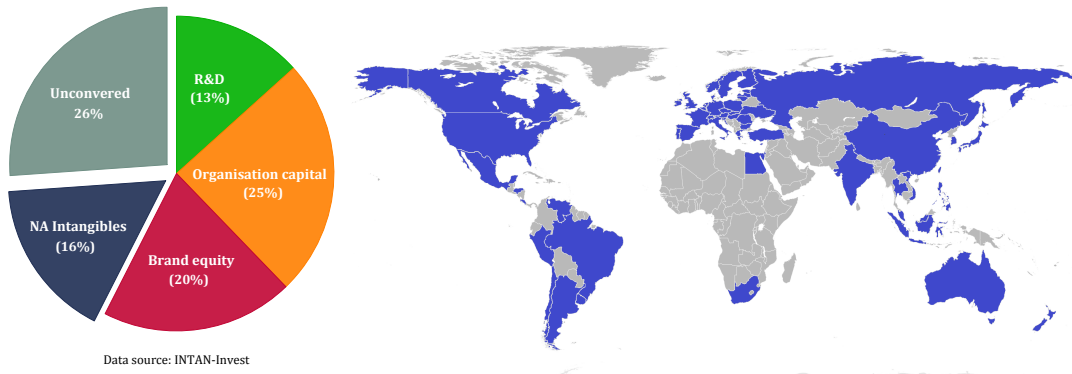
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A. Appendix – Data Construction

In this note, I describe in detail the data sources and estimation methods used to produce the global series of intangible investment for 60 economies and for the period 1995-2011 (see Table A1 for the full list of economies covered). Given data constraint, the focus is placed on the construction of three major types of intangible assets that are not yet fully incorporated in the System of National Accounts (SNA): (1) scientific research and development (R&D), (2) own-account organisation capital, and (3) brand equity. According to the estimates of INTAN-Invest, a pioneering database that provides country-level intangible investment data for 27 EU countries plus Norway and the US, these three assets taken together account for nearly 60 percent of all the intangibles identified by Corrado et al. (2005, 2009).²⁴ Therefore, the estimates presented in this study should provide a fair representation of the cross-country investment patterns in intangible assets. Moreover, the set of economies covered account for over 91 percent of the world gross domestic product (GDP),²⁵ which means that (nearly) all of the worlds total investment in intangible capital should be captured in this study.

Figure A1: ASSETS COVERAGE AND COUNTRY COVERAGE



To avoid the difficulty of measuring intangible investment in public sectors (i.e. Education, Health, and Public Administration), the research scope is restricted to merely cover the market sector of the economy.²⁶ Hence, about 80%-85% of aggregate economic activity is captured (see Appendix B for more detailed discussions on the distinction between market and nonmarket sectors).

²⁴The other six intangible assets are: computerised database, mineral exploration, artistic originals, new financial products, architectural and engineering designs, and firm-specific human capital.

²⁵This is according to the GDP estimates in 2005 from the Penn World Table version 8.1

²⁶Since the pioneering work of Corrado et al. (2005, 2009), there is a general consensus on the measurement for private business spending on intangibles. While public intangibles are rife with both conceptual and operationalisation problems. A new research project named SPINTAN has recently been launched and it deals with public investment in intangibles specifically. This project, however, is still in its early phase and we are still far from reaching any consensus regarding the asset types to be measured as public intangibles as well as a sound metric for valuation.

Table A1: LIST OF ECONOMIES COVERED

Country	ISO	Country	ISO	Country	ISO	Country	ISO
Argentina	ARG	Estonia	EST	Latvia	LVA	Slovak Rep.	SVK
Australia	AUS	Finland	FIN	Lithuania	LTU	Slovenia	SVN
Austria	AUT	France	FRA	Malaysia	MYS	South Africa	ZAF
Belgium	BEL	Germany	DEU	Malta	MLT	Spain	ESP
Brazil*	BRA	Greece	GRC	Mexico	MEX	Sweden	SWE
Bulgaria	BGR	Honduras*	HND	Netherlands	NLD	Switzerland	CHE
Canada	CAN	Hong Kong	HKG	N. Zealand	NZL	Taiwan*	TWN
Chile	CHL	Hungary	HUN	Norway	NOR	Thailand	THA
China	CHN	India	IND	Peru	PER	Turkey	TUR
Costa Rica	CRI	Indonesia	IDN	Philippines	PHL	Ukraine	UKR
Croatia	HRV	Ireland	IRL	Poland	POL	U.K.	GBR
Cyprus	CYP	Israel	ISR	Portugal	PRT	U.S.A.	USA
Czech Rep.	CZE	Italy	ITA	Romania	ROU	Uruguay	URY
Denmark	DNK	Japan	JPN	Russia	RUS	Venezuela*	VEN
Egypt*	EGY	Korea	KOR	Singapore	SGP	Vietnam	VNM*

Note: Countries marked with an asterisk indicate that for one of the three intangible assets estimated, one or more external data sources are used (e.g. business investment in R&D for Taiwan is derived from OECD). Estimates for other countries, on the other hand, are consistently based on the same data provider (e.g. data on business investment in R&D is solely taken from the UNESCO Institute for Statistics).

A1. Research and development

For the estimation of cross-country investment in (scientific) R&D, I primarily rely on the data provided by the UNESCO Institute for Statistics. To be specific, I obtain annual gross expenditures on R&D performed by Business Enterprises (BERD) for 56 countries and for the period 1996-2011.²⁷ For values that are missing from UNESCO, I first extrapolate them using the growth of the actual BERD values from the other data sources, such as OECD, Eurostat, and/or a country's own Statistical Office. Then, I linearly interpolate the data that are missing between two observed data points based on the logged variables (i.e. assuming a constant annual growth rate). The interpolation takes the following general form:

$$y^X = y_0^X + (y_1^X - y_0^X) \times \left(\frac{t - t_0}{t_1 - t_0} \right) \quad (\text{A1})$$

where y_0 and y_1 denote two data points observed at year t_0 and t_1 ; y is the missing value needs to be interpolated at year t where $t_0 < t < t_1$, and X denotes the specific type of an asset, which in this case is R&D.

²⁷For Taiwan, the BERD data is alternatively extracted from the OECD database. As shown later in the paper, there is a perfect match of the BERD data between UNESCO and OECD. Thus, even though BERD data for Taiwan is extracted from OECD, it is counted as taken from UNESCO.

A1.1. Countries with missing BERD

There are four countries (i.e. Brazil, Egypt, Honduras, and Venezuela) that warrant extra attention as none of them, to the best of my knowledge, provide any information on business investment in R&D.²⁸ As a result, I apply a rough proxy by using the share of BERD in GERD (i.e. $\frac{BERD}{GERD}$) from a ‘similar’ country to back out their business expenditures on R&D. Two countries are defined to be similar if they have identical or very similar intellectual property rights (IPR) protection scores and are geographically located close to one another. The assumption I make here is that the higher the level of IPR protection in a country, the larger the share of business investment in R&D. Despite being simplistic, this assumption is not without any plausibility. As shown in Figure A2 where the strength of a country’s IPR protection is significantly associated with the private share of R&D (Pearson’s correlation coefficient is also highly significant at .01 percent).²⁹ The exact matching procedure for these four countries is shown in Table A2.³⁰

Figure A2: RELATIONSHIP BETWEEN IPR PROTECTION AND BUSINESS SHARE OF R&D

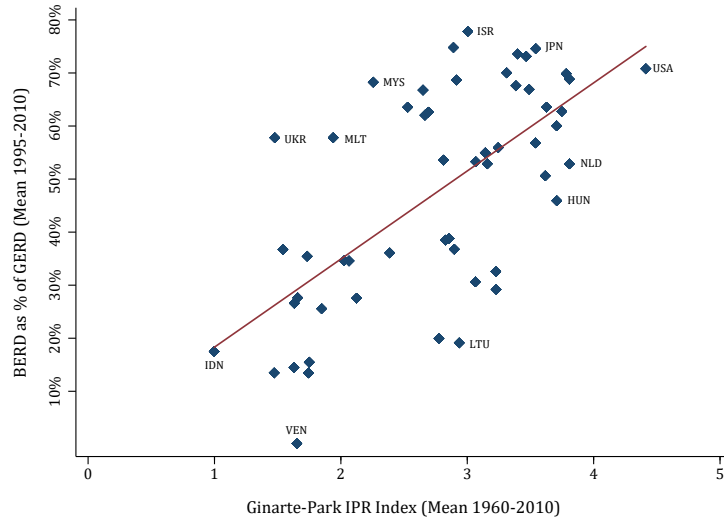


Table A2: MATCHING THE SHARE OF BERD

Countries	Matched with	IPR Scores
Brazil	Mexico	5.5 - 5.2
Egypt	Kenya	4.6 - 4.6
Honduras	Argentina	4.5 - 5.5
Venezuela	Paraguay	3.2 - 4.1

Note: IPR scores are obtained from Intellectual Property Rights Index 2014.

²⁸For Venezuela, there is even no data on GERD from the UNESCO Institute for Statistics. I alternatively extract the GERD data for Venezuela from the ECLAC database.

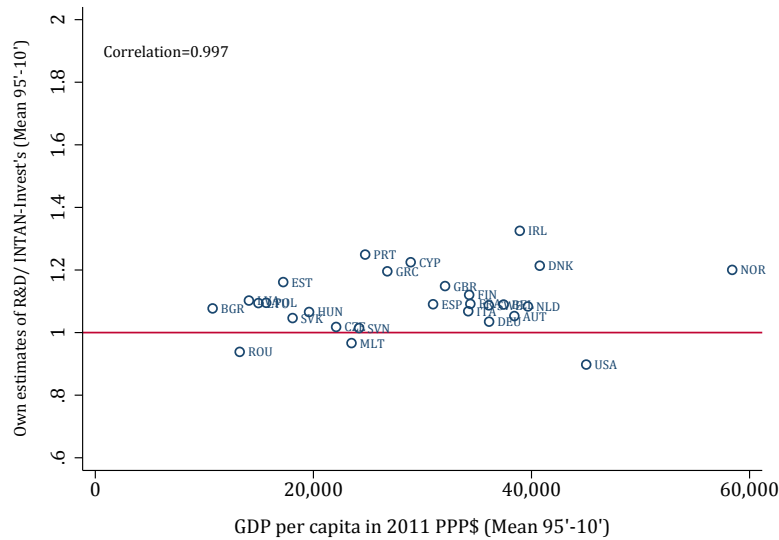
²⁹The IPR index is only available quinquennially from 1960 to 2010. Thus, the years of observation used to plot Figure A2 are discrete: 1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995, 2000, 2005, and 2010.

³⁰For robustness check, I also consider dropping those four countries in the development accounting analysis and results remain robust.

A1.2. Reliability check by comparing with OECD and INTAN-Invest

To examine how well the R&D numbers derived from the UNESCO Institute for Statistics line up with the other existing estimates, I compare them with two other prominent sources of data: (1) R&D investment by sector of performance provided by the OECD for a set of 34 countries and a time span of 1995-2011; and (2) estimates on business R&D investment reported by the INTAN-Invest database for 29 countries and over the period 1995-2010. With a (near) perfect correlation, comparisons with both data series assured the validity and reliability of my estimates of business investment in R&D. In fact, the investment figures of BERD are identical between UNESCO and OECD. As can be seen in Figure A3, however, there is a somewhat wider range of dispersion when I compare my estimates with INTAN-Invest's. The estimates are generally larger than that of INTAN-Invest by about 10 percent. The largest discrepancy is observed in Cyprus for year 2004 where my estimates are close to twice as large. One of the reasons to explain the discrepancy is the difference in the methodology. In INTAN-Invest project, R&D expenditures of the computer sector (K72) and the financial intermediation sector (J) are excluded from calculation in order to avoid double-counting with the other intangible investments in software and new financial products. Due to the lack of data, however, I am not able to exclude R&D investment of these two sectors and correct for the potential double-counting bias noted by the INTAN-Invest project.³¹

Figure A3: OWN MEASURE OF BUSINESS INVESTMENT IN R&D VERSUS INTAN-INVEST



³¹ As a robustness check, I tried to subtract the share of R&D investment of these two sectors from final estimation. According to the national accounts data provided by Eurostat, the sum of these two sectors is about seven percent (based on a cross-country average of 27 EU countries). As a crude measure, I downsized business investment in R&D by seven percent for all countries and years. This has little impact on the development accounting analysis.

A2. Organisation capital

Organisation capital or organisational structure is arguably the largest component of intangible assets and the hardest to measure. According to the estimates compiled by INTAN-Invest (see Figure A1), this asset alone accounts for 25 percent of all intangibles. Rather than inventing or improving technologies like investment in scientific R&D, organisation capital is associated with innovation in methods, management practices, and business models. In the literature, organisation capital has two components: *own-account* and *purchased*. Due to the lack of data, I restrict the focus on the own-account component only and further assume, à la Corrado et al. (2005, 2009), that own-account organisation capital can be represented by the value of managers' time spend on improving the effectiveness of business organisations and/or devising more efficient business models. Though it is a rather arbitrary number, I follow the broad literature by assuming that 20 percent of managers' time/wage is spent on enhancing organisational structures and this fraction holds true for all the 60 economies covered in the paper. Therefore, in order to measure a country's investment in own-account organisation capital, I would need data on the total amount of managers employed in the economy and their corresponding annual wage. Investment in (own-account) organisation capital is then calculated as follows:

$$I_{c,t}^{OC} = \left(20\% \times W_{c,t}^{Managers}\right) \cdot EMP_{c,t}^{Managers} \quad (A2)$$

A2.1. Data for managers

To retrieve data on employment by occupation, I rely on the International Labour Organisation (ILO) which, to the best of our knowledge, provides the most comprehensive information on labor statistics both in terms of time and country coverage. I obtain three datasets from ILO and as will be explained later, they are used complementarily during the employment data construction process. The first and the most important data, which I name it the benchmark data, is the number of employees by occupation using the International Standard Classification of Occupation (ISCO-88) from the ILOSTAT database. As described by ILO, this is a new database extending the previous data collection effort (i.e. LABORSTA) to more recent years (i.e. from 2008 onwards). From ILOSTAT I obtain employment data for all 60 economies covered in the sample and for the entire time period of 1995-2011.³²

³²Other employment classifications are provided by ILO as well, but the 1988 version is used because it provides the most complete employment data by occupation.

A detailed look into this data shows that about 33 percent of the employment data on managers are missing. To fill the gaps that are observed between two data points, I again apply the linear interpolation technique per equation (A1). The other possibility to recover some of the missing data is to check whether the old labor statistics database (i.e. LABORSTA) may cover any information that is missing in the benchmark data (i.e. ILOSTAT). Consistent with the earlier ISCO-88 classification, I retrieve managers' employment data from LABORSTA for 59 countries and for the period 1999-2008. After matching the two databases, I find that there are 77 observations having managers' employment statistics in the former but not in the latter database. Even though employment numbers from ILOSTAT and LABORSTA are very similar or even identical most of the time, there are cases where these two data series differ by more than double.³³ To ensure consistency and comparability of the numbers by merging two databases, I extrapolate the benchmark data using the growth of LABORSTA numbers.³⁴ In other words:

$$EMP_{c,t-1}^{NEW} = EMP_{c,t}^{NEW} \times \left(\frac{EMP_{c,t-1}^{OLD}}{EMP_{c,t}^{OLD}} \right) \quad (A3)$$

where the superscripts *NEW* and *OLD* refer to the benchmark (i.e. ILOSTAT) and LABORSTA databases. Since some of the employment data in early years (i.e. before 2000) are only available with an older version of the occupational classification (i.e. ISCO-68), I further extrapolate the missing values of early years using the growth of ISCO-68 numbers per equation (A3). A brief summary of the employment data construction process is shown in Table A3. As can be seen in this table, extrapolation only takes place after linear interpolation is performed first.

Table A3: CONSTRUCTION OF THE EMPLOYMENT DATA

Order of integration	Source	Methods	Missing(%)
1.1	ILOSTAT ISCO-88 (BM)*	<i>Non</i>	32.84%
1.2	ILOSTAT ISCO-88 (BM)	<i>Interpolation</i>	29.90%
2.1	LABORSTA ISCO-88	<i>Interpolation</i>	
2.2	LABORSTA ISCO-88	<i>Extrapolate using its growth</i>	21.08%
3.1	ILOSTAT ISCO-68	<i>Interpolation</i>	
3.2	ILOSTAT ISCO-68	<i>Extrapolate using its growth</i>	16.27%

Note: Linear interpolation, based on logged variables, is applied to all three databases to fill the gaps observed between two data points

*BM: Benchmark data

³³For Indonesia in year 2007, managers employment level is reported in both LABORSTA and ILOSTAT but the former reports a total of 4,720,675 managers are employed in that year while ILOSTAT reports less than half of that (i.e. 2,160,000).

³⁴For countries that have no data in ILOSTAT but do in LABORSTA, I simply copy the employment figures directly from LABORSTA. These countries include: Cuba, Honduras, Japan, Venezuela, and Zambia.

One important issue to note about the employment data is that ILO only provides employment classification at the most aggregate level. Thus, it is not possible to separate managerial workers from legislators and senior officials under ISCO-88 classification or from administrative workers under ISCO-68 classification (see Table A4 for a detailed outline of occupational classification). As a consequence, the estimates of own-account investment in organisation capital may well be larger than the conventional measure that focuses on workers with managerial titles only. This departure from the convention, however, is in line with the recent work of OECD (i.e. Squicciarini & Le Mouel, 2012) which calls for the inclusion of other non-managerial workers in measuring organisation capital. This is because those non-managerial titled workers may well be engaged in tasks that contribute to organisational development.

Table A4: INTERNATIONAL STANDARD CLASSIFICATION OF OCCUPATIONS (ISCO-88 vs. -68)

ISCO-88	Profession group	ISCO-68	Profession group
0	Armed forces	0/1	Professional, technical and related workers
1	Legislators, senior officials and managers	2	Administrative and managerial workers
2	Professionals	3	Clerical and related workers
3	Technicians and associate professionals	4	Sales workers
4	Clerks	5	Service workers
5	Services workers and shop and market sales workers	6	Agriculture, animal husbandry and forestry workers, fishermen, hunters
6	Skilled agricultural and fishery workers	7/8/9	Production and related workers, transport equipment operators and labors
7	Craft and related trades workers	AF	Armed forces
8	Plant and machine operators and assemblers	X	Not elsewhere specified
9	Elementary occupations		
X	Not classifiable occupation		

Note: The profession group denoted in **bold** letters are the occupations considered to contribute to the development of organisational structures. ISCO-68 is only used to complement the benchmark employment figures reported by ISCO-88.

Data source: International Labour Organisation, ILOSTAT and LABORSTA databases.

A2.2. Wage data

It would be ideal to have the wage data on employment by occupation from the same data provider – ILO. This, however, was not possible due to the extremely scant data ILO provides on income by occupation. The income data is reported for a limited sample of 35 countries and for no more than three years of observation (i.e. 2009, 2010 and 2011). As a result, the wage data has to be externally imputed and I do so in two steps using two data sources: the Penn World Table version 8.1

(PWT) database and the Occupational Employment Statistics (OES) provided by the U.S. Bureau of Labour Statistics. First, I extract the data on annual income for management occupations from OES and denote it by $W_{BLS}^{Managers}$.³⁵ Then, I calculate the wage rate of an average worker for all 60 economies using data from PWT 8.1 as follows:

$$W_{c,t}^{Mean} = \left(\frac{labshare \times cgdpo \times pl_gdpo}{emp} \right)_{c,t} \times xr_{c,t} \quad (A4)$$

where *labshare* indicates the share of labour compensation in GDP at current national prices; *cgdpo* is the output-side GDP calculated at current PPPs (denominated in 2005 USD); *pl_gdpo* denotes the price level of GDP; *emp* is the total number of persons engaged in production; and *xr* is the market exchange rate needed to convert currency unit back to national currencies. Combing these two wages, I can derive a year-variant wage differential (or relative wage) between the managers and an average worker for the US as follows:

$$R_t^{US} = \left(W_{BLS}^{Managers} / W_{PWT}^{Mean} \right)_t^{US} \quad (A5)$$

The evolvement of this relative wage R is plotted in Figure A4. Because of the change of the use of Standard Occupational Classification from five-digit to six-digit in 1999, it was only possible to retrieve consistent US wage data for years between 1999 and 2011.³⁶ To complete the estimation for the whole period, the relative wage is held constant to the last value available. Assuming that the wage differential between managers and average workers is the same in other countries as in the US (i.e. R constant across countries), it is then possible to back out the wage rate of managers for all the other economies:

$$W_{c,t}^{Managers} = R_t^{US} \times W_{c,t}^{Mean} \quad (A6)$$

which in turn enables one to estimate the annual investment flows in own-account organisation capital per equation (A2).

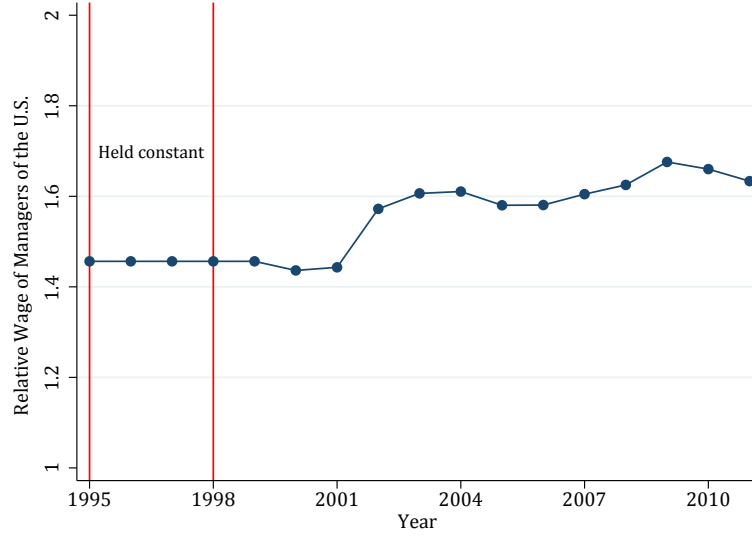
A2.3. Reliability check by comparing with INTAN-Invest

To check how well my estimates, using equation (A2), align with the existing measure, I compare the estimates with INTAN-Invest (see Figure A5). It is worth noting that it is not the goal of this paper

³⁵This is the annual wage of managers averaged across all different types. It is coded as 11-0000 according to the Standard Occupational Classification 2010

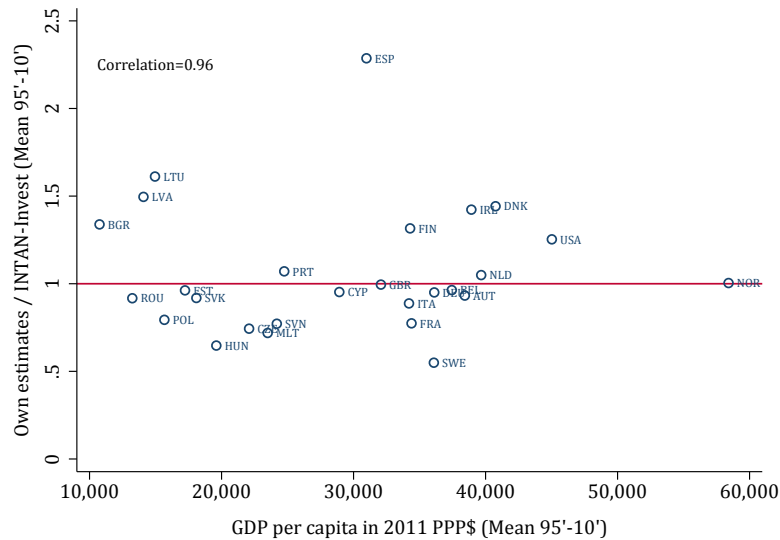
³⁶No clear guideline on the matching between the five-digit SOC and the six-digit SOC are provided.

Figure A4: RELATIVE MANAGERS WAGE OF THE US



to have a perfect match between these two investment series as there are both methodological and data differences. Investment in organisation capital provided by INTAN-Invest has two components: in-house produced and externally purchased. As previously noted, this paper merely focuses on the estimation of the former and omits the latter. Since most of organisation capital are in-house produced (Squicciarini & Le Mouel, 2012), the estimates constructed should be in the same ballpark as INTAN-Invest's, despite of the differences in coverage.

Figure A5: OWN MEASURE OF INVESTMENT IN OC VERSUS INTAN-INVEST

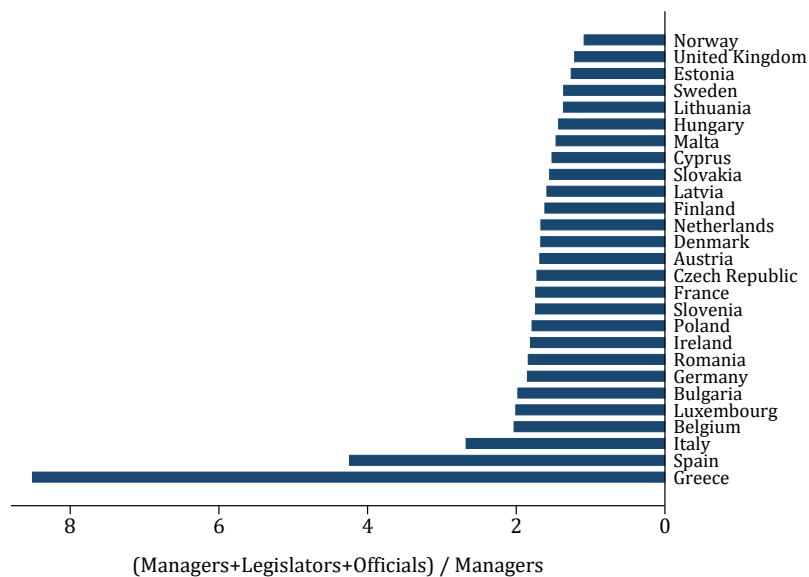


With a correlation of 0.96, the plausibility of the own measure of investment in organisation capital is warranted. In addition to this high correlation, the estimates also fairly closely resemble those

of INTAN-Invest. The mean and the median of the ratio of my estimates to INATN-Invest's are at 0.99 and 1.29. If Greece and Spain are excluded, two countries that I elaborate on later, the similarity between the two investment series improves significantly. The mean and the median of the ratios become 0.962 and 0.998. This suggests that the difference between my estimates and INTAN-Invest's for a sample of 27 countries (i.e. after excluding GRC and ESP) is, on average, less than 0.1 percent.

Greece and Spain are two notable outliers whose investment in own-account organisation capital are significantly larger than the estimates suggested by INTAN-Invest. A careful look into the data shows that the cause of this large discrepancy is primarily due to the difference in the coverage of the number of managers, which is a potential source of discrepancy one would anticipate ex ante. The fact that Greece and Spain are affected most is because the difference between strictly defined and broadly defined managers is anomalously large for them. As shown in Figure 4.A6, the sum of managers, legislators and senior government officials is generally less than twice the amount of corporate managers. For Greece and Spain, however, this difference is more than 8 and 4 times, respectively. This seems to suggest that unlike other EU countries, there is a disproportionately large amount of government managers employed in Greece and Spain than corporate managers. The failure to exclude them caused significant (upward) bias for the estimates of these two countries. As discussed in the main text, findings are not affected if these two countries were left out from the development accounting analysis.

Figure A6: LEGISLATORS, SENIOR OFFICIALS, MANAGERS VERSUS MANAGERS



A3. Brand equity

As the most valuable assets many companies possess (e.g. think of Facebook or Uber, their names probably worth much more than their property and machinery), brand equity is another major type of intangible I measure in this study. The idea of brand equity was born in the US in the 1980s when companies began to realise that patiently building up brands is more enduring to boost sales than other means, as it allows them to hold on to customers, win new ones and provide launching pads for new products. Most brands are closely associated with advertising and marketing activities, which are the most common ways of building up a brand. Thus, I follow the convention by decomposing brand equity into these two components. Closely in line with the recent work of Corrado and Hao (2014), I reproduce the global perspective on brand investments using two international databases: World Advertising Research Center (WARC) and European Society for Opinion and Marketing Research (ESOMAR). The former is a privately owned company that publishes the official advertising expenditure figures for 84 countries and for years dating back to the 1980s; the latter issues marketing research spending data for about 80 countries and for some of them the data is available since 1988.

As noted in Corrado and Hao (2014), these two data sources are likely to underestimate the actual amount of expenditures. For advertising, WARC does not include direct mailing and production costs. This, according to their calculation based on the Coen media-structured advertising database, is a significant omission. If one adds direct mail advertising to WARC's estimates for the US, the overall advertising spending figure of the US would increase by 32 percent. In the case of the UK, the magnitude of such a downward bias is about 7 percent, according to WARC's own calculation.

As for the market research spending figures provided by ESOMAR, it is likely to be overly conservative as well, since it only focuses on traditional market research activities while newer activities associated with the internet are not yet included in their (official) estimation. An external independent research, commissioned by ESOMAR, extends the conventional marketing research activities to include seven more newer ones and found that the expanded set of marketing activities led to spending figures that were 60 to 70 percent larger in the US and the UK, and 20 percent larger in Argentina.³⁷ This finding points to the fact that the marketing industry is undergoing structural

³⁷According to the Market Research Handbook (2007), the traditional marketing research activities are: (1) market measurement, (2) media audience research, (3) stakeholder measurement, (4) market modeling, (5) new product/service development, (6) usage and attitude studies, (7) advertising/brand tracking, (8) advertising pre-testing, (9) opinion research/polling, (10) qualitative/focus groups, (11) business-to-business studies, (12) other omnibus/shared costs survey, and (13) others. The additional activities added by the external research commissioned by ESOMAR

changes and the current focus on traditional marketing activities is simply insufficient to capture the actual level of spending in market research activities. Despite of the known risk of having a downward bias, I still choose to rely on these two data sources for its comprehensive data availability.

A3.1. Estimation method for investment in brand equity

It is well-documented in the existing literature on advertising longevity that only major campaign type of advertising spending is likely to generate long-lasting benefits to the development of a brand. Therefore, not all advertising spending can be counted as investment. I follow Corrado et al. (2005, 2009) and Corrado and Hao (2014) by applying a capitalisation factor (d) of 60 percent.³⁸ This capitalisation factor is also found to be in line with the UK intangible asset survey (Awano & Franklin, 2010).

In two country-specific studies on the UK and Sweden, Marrano, Haskel, and Wallis (2009) and Edquist (2011) used figures from the supply-use tables on business purchases of advertising and market research to measure investment in brand equity. These studies find that advertising media expenditures understates the actual total consumption of advertising services and they reckon that the underestimation is about 39 percent. In light of their suggestion and to remain consistent with Corrado and Hao (2014), I also scale up the advertising media spending figure by multiplying the so-called MHW-Edquist adjustment factor (i.e. $\gamma_{adv} = 1.39$) to measure long-lived investment in advertising. In addition, market research spending provided by ESOMAR only captures the *purchased* component, while the *in-house* production of marketing is omitted. In the case of the U.S., the own-account component based on compensation of marketing managers is about equal in size to the purchased market research activities (Corrado & Hao, 2014). This aligns with the prior assumption used in Corrado et al. (2009) of doubling market research spending to account for own-account component. In sum, investment in brand equity is estimated as:

$$I_{c,t}^{BE} = \underbrace{(d \cdot \gamma_{adv} \cdot E_{c,t}^{adv})}_{\text{Investment in advertising}} + \underbrace{(\gamma_{mkt} \cdot E_{c,t}^{mkt})}_{\text{Investment in market research}} \quad (\text{A7})$$

where γ denotes the adjustment factor (i.e. 1.39 for advertising and 2 for market research), E is the expenditure data obtained from WARC and ESOMAR, and d is the capitalisation factor of

include: (1) marketing reports and research, (3) media monitoring, (3) sample and panel provides, (4) web traffic measurement, (5) social media communities, (6) survey software, and (7) information technology and telecom measurement research.

³⁸Effects that last more than one year, a distinction used widely by national accountants in separating current production costs from expenditures that expand future productive capacity.

60 percent to capture long-lived advertising. To note, I implicitly assume that in-house marketing spending equals out-house spending in all countries.

A3.2. Comparison with the existing estimates

Since both estimation method and data sources are identical to what is used in Corrado and Hao (2014), my estimates in principal should coincide with theirs. Due to the fact that their global series on brand investment estimates are not yet publicly available, a direct one-to-one estimate comparison cannot be made. As an alternative, I performed a somewhat crude comparison by replicating their plot on the relationship between brand investment and level of economic development across a set of 17 countries and they resemble quite well.³⁹ As an additional check, I further compare my investment in brand equity with the estimates from INTAN-Invest. On average, the estimates are somewhat (i.e. 20%) smaller than the numbers suggested by INTAN-Invest, but it is reassuring that these two series have a very high correlation of 0.92.

A4. Dealing with missing values

Like any other data construction works, one of the major difficulties encountered in this project is that not all countries have the data available for all the years that I aim to cover. The data missing patterns also differ significantly across countries and asset types. For intangible asset R&D, some countries only have one year of observation available (e.g. Vietnam), while a smaller set of data-rich countries (e.g. the UK and the US) only has one year of observation missing. In order to complete the investment series for each intangible asset, I apply: (1) linear interpolation technique based on the logged variables, per equation (A1), to fill in the values that are missing between two data points; and (2) backward and forward extrapolations using the average growth of each investment/GDP series observed in the first (last) five years:

$$I_{c,t-1}^X = \left(\frac{S_{c,t}^x}{1+r} \right) \times NGDP_{c,t-1} \quad I_{c,t+1}^X = S_{c,t}^x \cdot (1+r) \times NGDP_{c,t-1} \quad (\text{A8})$$

where the superscript X denotes the intangible asset under concern (i.e. R&D, organisation capital, and brand equity); S denotes the first/last observable share of intangible asset X in GDP, and r represents the average growth rate of this share observed for the first/last five years (i.e. $\sum_{t=1}^5 S/5$). Table A5 provides an overview of the data missing patterns. As can be seen, about 22%–32% of the

³⁹For conciseness, these plots are omitted in the paper but are available upon request.

investment series are not estimated based on the real data, but are imputed. It could be argued that given high rates of depreciation assumed for organisation capital (40%) and brand equity (60%), it is not needed to have series for them going back to 1995 if the development accounting analysis is based on 2011. Focusing on more recent years (e.g. 2003–2011 for organisation capital), however, does not help much to reduce the amount of imputations.⁴⁰ As a result, I choose to have equally long series for those three intangible assets.

Table A5: SHARE OF MISSING OBSERVATIONS BY ASSET-TYPE

Missing (%)	R&D	O.C.	Brand Equity
Originally	21.96%	32.84%	24.71%
After interpolation	16.08%	29.90%	20.88%
After extrapolation	0%	0%	0%
N (60 × 17)	1020	1020	1020

⁴⁰For investment in organisation capital, the reduction in imputation is merely two percent less (30.75%).

B. Appendix – Market versus Nonmarket Sectors

In this section, I discuss the distinction between the market sector and the nonmarket sector for *output*, *employment*, and *investment*. Similar to the definition used in the EU KLEMS project (O’Mahony & Timmer, 2009), I regard NACE industries Revision 1: Public Administration and Defense (L), Education (M), and Health and Social Work (N) as nonmarket sectors and the remaining ones (A through K, plus O) make up the share of the market economy.⁴¹

B1. Market output versus nonmarket output

The nonmarket output share for country c at year t is calculated as follows:

$$Share_{c,t}^{NM} = \frac{(L_{c,t}^{VA} + M_{c,t}^{VA} + N_{c,t}^{VA})}{GVA_{c,t}} \quad (B1)$$

where L , M , and N denote value added of the nonmarket industries; and GVA denotes total value added of the entire economy. Since there is no one single database providing a consistent sectoral breakdown of output for all 60 economies, I complementarily calculate the nonmarket share using various data sources (see Table B1).

Table B1: DATA SOURCE AND VARIABLES USED FOR OUTPUT

Data Source	Countries	Variables used
WIOD (SEA)	39	VA of industry L, M, N, and total industries
GGDC (10-Sector database)	7	VA of Government services, and total industries
ECLAC	5	VA of Pub.Admin, Edu., Health, and total industries
OECD Stat.	4	VA of B1GVO.Q and B1GVA (ISIC Rev.4)
National Statistics office	3	VA of industry L, M, N, and total industries
UN National Accounts	2	VA of Other activities (ISIC J.P)

Note: United Nations National Accounts data is used in conjunction with GGDC’s 10-sector database for calculating the nonmarket output share of Hong Kong and Singapore.

There are, however, two economies (i.e. Hong Kong and Singapore) require some further explanation as neither of them provide detailed data on public output. As an alternative, I back out their output of the nonmarket sectors using two other data sources: the 10 sector database compiled by the

⁴¹In EUKLEMS, real estate activities (K70) is also part of the non-market economy due to measurement difficulties (see O’Mahony & Timmer, 2009). I, however, did not follow EUKLEMS to exclude K70 from the market economy because for nearly one-third of the countries I cover, their GDP data are not detailed enough to isolate real estate activities. To keep the definition of market economy consistent across countries, real estate activities (K70) are therefore part of the market economy.

Groningen Growth and Development Centre (GGDC) and the United Nations National Accounts (UN NA) data. The former provides output data for industry J and K (Finance, insurance, real estate and business activities) and industry O and P (Community, social and personal services); while the latter provides output data at a more aggregate level for industries J through P (denoted as ‘Other activities’ in the UN NA data). Given these, output share produced by industry L, M, and N can be recovered as:

$$Share_{c,t}^{NM} = \frac{(J_P_{c,t}^{UNNA} - J_K_{c,t}^{GGDC} - O_P_{c,t}^{GGDC})}{GVA_{c,t}^{GGDC}}; \quad c \in (HKG, SGP) \quad (B2)$$

Out of 1020 observations (60 countries 17 years), there are four countries with a total number of only 17 missing values. To complete the series of the share of nonmarket output, I resort to using the UNNA data and extrapolate (backward and forward) as follows:

$$\underbrace{LMN_{t\pm 1} = LMN_t \times \left(\frac{J_P_{t\pm 1}^{UNNA}}{J_P_t^{UNNA}} \right)}_{\text{extrapolate nonmarket output}}; \quad \underbrace{GVA_{t\pm 1} = GVA_t \times \left(\frac{GVA_{t\pm 1}^{UNNA}}{GVA_t^{UNNA}} \right)}_{\text{extrapolate total value added}} \quad (B3)$$

The share of the nonmarket output could be as low as 4 percent in Singapore to as high as nearly 25 percent in Denmark.

B2. Market employment versus nonmarket employment

The primary source of data I use for employment is the labor statistics provided by the International Labour Organisation (ILO). In particular, I obtain employment measured by the number of employees (i.e. paid-employment and self-employment) detailed at 1-digit sectoral level using ISIC Rev.3 classification for an unbalanced panel of 57 countries. The employment share of the nonmarket sector is calculated as:

$$EMP_Share_{c,t}^{NM} = \frac{(L_{c,t}^{EMP} + M_{c,t}^{EMP} + N_{c,t}^{EMP})}{TOT_EMP_{c,t}} \quad (B4)$$

where L^{EMP} , M^{EMP} , and N^{EMP} denote the number of employees working in nonmarket sectors; and TOT_EMP denotes the total employment of the economy.

Out of the 969 observations that I retrieve from ILO (57 countries 17 years), over 28 percent of the values are missing. I first apply linear interpolation per equation (A1) to fill the gaps that are observed between two data points (13 values are interpolated) and then extrapolate the

remaining missing values complementarily using various external data sources (see Table B2). The extrapolation takes the following general form:

$$EMP_Share_{t\pm 1}^{ISIC\ Rev.3} = EMP_Share_t^{ISIC\ Rev.3} \times \left(\frac{EMP_Share_{t\pm 1}^{Data}}{EMP_Share_t^{Data}} \right) \quad (B5)$$

where *Data* indicates data origins (e.g. ISIC Rev.2, WIOD, GGDC). After extrapolation, the amount of missing data went down from 28% to about 8% and I hold the share constant to the last value available to complete the series of nonmarket employment share for this set of 57 countries.

Table B2: DATA SOURCES AND VARIABLES USED FOR EMPLOYMENT

Data origins	Used for	Variables used
ILO (ISIC Rev.3)	BM data	Employment by 1-digit sector level (ISIC Rev.3, 1990)
ILO (ISIC Rev.2)	Extrapolation & BM	Employment by 1-digit sector level (ISIC Rev.2, 1968)
WIOD (SEA)	Extrapolation	Number of employees by industry (EMPE)
GGDC (10-Sector database)	Extrapolation	Total persons engaged by industry (EMP)

Note: There are three economies have their nonmarket employment figures proxied based on the employment data of ILO ISIC Rev.2 (i.e. Hong Kong, Honduras, and Venezuela).

As for the other three economies (i.e. Hong Kong, Honduras, and Venezuela) that do not provide any employment information on industry L, M, or N, I try to proxy it using more aggregated sectoral employment data classified by ISIC Rev.2. From ILO, there is employment information available for sector *Community, Social and Personal Services*, which corresponds to the sum of industries of L through Q in ISIC Rev.3. Based on a set of 23 countries, it is found that the employment level of industries L through Q is on average about 1.5 times more than the employment of industry L, M, plus N. Using this ratio as a rough indication, the employment share of nonmarket sectors for Hong Kong, Honduras, and Venezuela is measured as follows:

$$EMP_Share_{c,t}^{NM} = \frac{(L-Q_{c,t}^{Rev.2}/1.5)}{TOT_EMP_{c,t}^{Rev.2}} \quad (B6)$$

The employment share of nonmarket sectors could be as low as 5 percent in Vietnam to as high as over 30 percent in Scandinavian countries.

B3. Market investment versus nonmarket investment

As for the distinction between investment in market sectors and nonmarket ones, I rely on Social Economic Accounts data of the World Input and Output database (Timmer, Erumban, Los, Stehrer, & de Vries, 2014) which provides detailed sectoral breakdown of gross fixed capital formation (GFCF). For a set of 39 economies covered in the sample, the investment share of nonmarket sectors is calculated as follows:

$$GFCF_Share_{c,t}^{NM} = \frac{L_{c,t}^{GFCF} + M_{c,t}^{GFCF} + N_{c,t}^{GFCF}}{TOT_GFCF_{c,t}} \quad (B7)$$

where L^{GFCF} , M^{GFCF} , and N^{GFCF} denote GFCF of nonmarket sectors; and TOT_GFCF denotes the total investment flows of the economy. The investment share of the nonmarket sector for those 39 economies ranges from slightly over 5 percent in Russia to about 23 percent in Taiwan. As there are no other data available to breakdown GFCF by sectors, I use an average share of those 39 economies for the remaining ones that are not covered by WIOD (i.e. 12 percent).⁴²

⁴²The sectoral GFCF data provided by WIOD often do not cover the last 2 or 3 years (i.e. 2010 and 2011). I keep the last observable share constant to complete the data series.