Factor Incomes in Global Value Chains: The Role of Intangibles

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Abstract

Today's production processes are fragmented across countries and industries. Intangibles play an important role, but their measurement is elusive. In contrast to tangible inputs, their use is not bound by geographical location. We propose an empirical framework to measure factor incomes in production that spans countries. We define intangible capital income residually as the difference between the value of a final product and the costs of all tangible factor inputs (capital and labour) in any stage of production. We bring this to the data using the WIOD and additional national account statistics on capital stocks.

Our main finding is that the share of intangibles in the value of final goods has increased, in particular in the run up to the financial crisis in 2008. Its share is generally (much) higher than the tangible capital income share. This is found at the aggregate as well as for more detailed manufacturing product groups. Nevertheless, there is clear heterogeneity in the pace of the increase. For some non-durable products the intangible share increased only slightly over the whole period 2000-14. In contrast the share increased rapidly in durable goods (machinery and equipment products). We find suggestive evidence that this variation is linked to variation in the speed of international production fragmentation. We discuss measurement problems and stress the explorative nature of the exercise.

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1. Introduction

The long-run decline in the income share of labour since the 1980s is one of the most debated macro-economic topics in recent years. Various studies have documented that the trend is widely shared across industries and countries. While it has been particularly strong in the US, it has also been observed for other advanced countries, and perhaps surprisingly, also for many emerging and poor countries So far, these trends have been analysed mainly in isolation, searching for common causes such as technological advancements and globalization in single country models, or in panel regressions with countries (and industries) as separate observations. (Elsby, Hobijn and Şahin, 2013; Karabarbounis and Neiman, 2014; Rognlie 2015; Barkai 2016; Dao et al., 2017).

The aim of this paper is to show that a approach which explicitly takes account of inter-country production linkages contributes to a better understanding of factor income distributions. Due to cross-border fragmentation of production, factor income shares are related across various stage of production that take place in distinct locations. Factory-free goods producers like Apple provide an iconic example: they sell and organise the production of manufacturing goods without being engaged in the actual fabrication process (Fontagné and Harrison, 2017). More generally, goods are typically produced and distributed in intricate networks with multiple stages of production and extensive shipping of intermediate goods and services. We refer to this as *global value chain* (GVC) production. In this paper we introduce a novel empirical framework to measure the income shares of labour, tangible assets and intangibles assets in GVCs.

GVCs can be represented by a production function that can be thought of as the vertical integration of all stages of production. Canonical production functions describe single-stage production where value added is generated by domestic capital and labor, $VA(K_1, L_1)$. But when production is fragmented into various stages that are carried out in multiple locations we can write the production function as $VA(K_1, L_1, \ldots, K_N, L_N)$ with factor inputs from N countries. Intangible assets, such as brand names and production technology, play a crucial role in GVCs, but their measurement is elusive. A major issue is that their use is not bound by a location, in contrast to tangible assets (such as machinery) and labour that by nature have a presence at a particular geographical location. Moreover, due to their non-rival nature intangibles can be shared across plants and countries. This implies that income to intangibles can be accounted for in GDP of various countries.[1] Even in the absence of purposeful profit shifting, increasing cross-border ownership and sharing of intangibles is undermining the very notion of location-bound assets and country-level earnings. As an alternative, we suggest to observe intangible income through identification in a GVC rather than in individual countries. Put simply, we calculate residual profits in the chain as the sales of a good minus the costs of tangible inputs (labour and tangible capital) needed in production. We will refer to this residual as income payments for intangible assets in GVCs. This will provide for the first time a comparison of their relative importance in production.

To this end we will built upon the GVC approach to factor income measurement as outlined in Los et al. (2015).[2] This approach starts from the production function of a final product, $F(K_1, L_1, II)$. For simplicity, suppose the intermediates are imported and produced abroad according to $II(K_2, L_2)$. By simple substitution one can derive the reduced functional form $F(K_1, L_1, K_2, L_2)$. Information on the factor content of imports is crucial to implement this approach. This is derived this from so-called world input-output tables. Previous work in this tradition, reported on in Timmer et al. (2014), focused on trends in factor income in GVCs of manufacturing goods. The production processes of goods have been fragmenting across borders with major impetuses from the NAFTA agreement in the early 1990s, and China's accession to the WTO in 2001. It was found that the share of labour income in final output of GVCs was declining over the period 1995-2007. Surprisingly, this was the case not only in those stages carried out in advanced countries, but also in stages carried out in less advanced regions. The former was expected, given that offshored stages are typically labor-intensive, but the latter finding was not. It highlighted the increased importance of capital in production, as its income share increased in virtually all GVCs.

[1] Through profit shifting, including transfer pricing and other tax strategies, transnational companies can allocate the largest share of their profits to subsidiaries (Dischinger et al., 2014). Guvenen et al., (2017) find the US multinationals have increasingly shifted income from intellectual property rights to foreign jurisdictions with lower taxes, leading to an understatement of the U.S. labour share decline.

[2] The GVC approach to factor income measurement has a much longer history going back at least to Gereffi (1994), see Kaplinsky (2000) for an overview. Studies in that tradition are typically more qualitative and analyse how interactions in these increasingly complex systems are governed and coordinated.

In this paper we update and expand the analysis of Timmer et al. (2014) by splitting off the payment for use of tangible assets in GVCs, such that a residual remains. We rely on additional information from the national accounts on industry-level investment in tangible assets in a wide set of countries. We build capital stocks using the perpetual inventory method and impute the income payments by multiplying with a standard Jorgenson-Griliches type of rental rate. We use an ex-ante rate of return such that there is a wedge between value added and measured factor input costs.[3] By subtracting from final output *FO* the sum of measured factor payments to labor *WL* and to tangibles *RK* (in all stages across *N* countries) a residual remains. We will refer to this residual as payments for intangible assets in GVCs:

$$\text{Income to intangibles in GVC} = FO - \Sigma_N W_N L_N - \Sigma_N R_N K_N .$$

Is our interpretation of the residual as income for intangibles justified? Karabarbounis and Neiman (2018) refer to the residual income as 'factorless income' and argue that it can be alternatively interpreted as economic profits, arising from firms' pricing power; as a wedge between imputed rental rates for assets and the rate that firms perceive when making the investment; or as income that accrues to unmeasured forms of capital. They argue that, in a single country setting, it is likely a combination of the three. In our GVC setting, we interpret our residual more specifically as payment for intangible capital. To fix ideas, we think of the global market for manufacturing goods in the following way. Final goods are supplied by large firms that organise production in vertically integrated processes spanning borders. The market structure for final goods is monopolistic competition: each firm supplies a differentiated good and is able to charge a price higher than average costs. In our view, firms derive their monopoly power from investment in firm-specific assets.[4] These include patents, trademarks, brands, (customer) databases but also organisational capacity to manage production and supplier networks. We refer to these collectively as intangible assets. Conceptually, they differ from other factor inputs because, by and large, companies cannot

[3] See Barkai (2017) and Karabarbounis and Neiman (2018) for similar calculations but at the country and industry level (thus single stage). In a recent study Clausen and Hirth (2016) derive a firm-level excess rate of return by dividing (value added minus labour cost) by the book value of tangible assets. They show for a set of U.S. firms that this residual measure serves as an additional factor to explain firm stock value.

[4] Mark ups might of course also be the result of a natural monopoly of government regulation. This situation is less likely to occur for manufacturing goods that are heavily traded worldwide.

freely order or hire them in markets. Viewed this way, intangible capital is the firm-specific "yeast" that creates value from labour and purchased assets (see also Prescott and Visscher, 1980 and Cummins, 2005, for similar views).[5] We would like to stress though that the measurement of the residual income in GVCs is model free and does not depend on this particular interpretation. And although this is our preferred interpretation, alternative interpretations of our findings are possible.

We illustrate our empirical approach in Figure 1. We distinguish between the distribution stage of the product to the consumer, the final production stage and other (upstream) stages of production. Other stages of production involve the production of intermediates to be used in the final stage, or in any earlier stage of production.[6] The sum of value added across the final and other production stages makes up the value of the product at basic (ex factory) prices. We add the value added in the distribution stage plus (net) taxes payed by the final consumer to arrive at the value of a final product at purchasers' prices (see first pillar in Figure 1). Subsequently we decompose the value of a final product (as paid for by the consumer) into income payments to tangible and intangible production factors in a second step (last pillar in Figure 1). In the final step we will sum income to each factor across stages. This is important as income to intangibles (as recorded in national statistics) can be accounted for in various stages. For example, compare a situation in which Apple charges the iPod assembler for its intellectual property with a situation in which it does not. The basic price of the iPod (ex-factory) would be higher in the former case and the return to the intangibles consequently lower in the distribution stage. But the return to intangibles would be higher in one of the earlier stages of production as it would involve a payment for use of Apple´s

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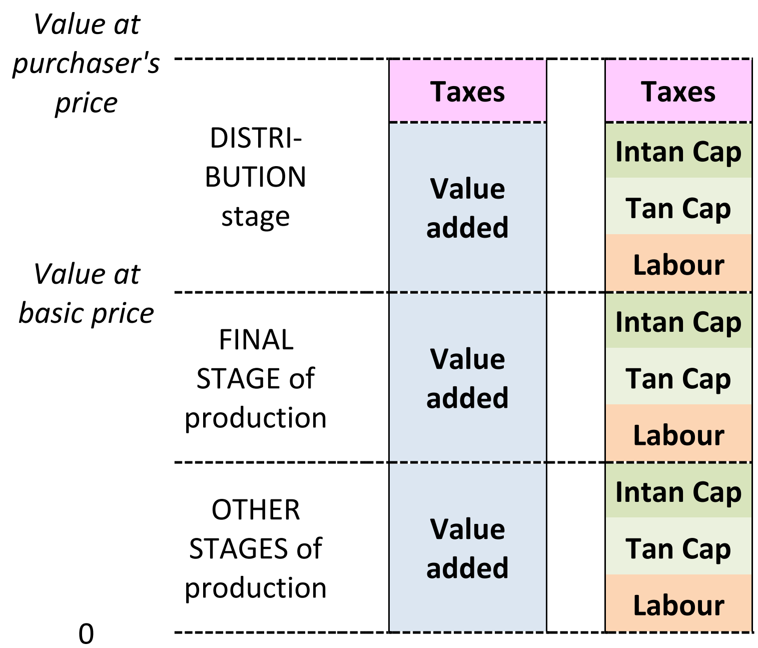
[5] Ideally, we would like to be able to distinguish between in-house produced ("own account") assets and market mediated ("purchased") assets in the data. Unfortunately, (published) national accounts statistics do not provide this information. We will use the terms (in)tangibles instead as empirically most of the tangibles will be purchased, while most of the intangibles are likely produced by the firm itself and are not covered in national account statistics (this is further discussed in section 4).

[6] The fragmentation of production processes can take many forms, sometimes characterized as "snakes" and "spiders" (Baldwin and Venables, 2013). Snakes involve a sequence in which intermediate goods are sent from country A to B, and incorporated into intermediate goods sent from B to C, and so on until they reach the final stage of production. Spiders involve multiple parts coming together from a number of destinations to a single location for assembly of a new component or final product. Most production processes are complex mixtures of the two. To stick with commonly used terms, we refer to all fragmented production processes as "chains", despite the "snake"-like connotation of this term. The validity of our measures are not depending on a particular configuration of stages.

intangibles. It will thus lead to a shift in the location of the profit in a particular stage, but not affect the income to intangibles in the overall GVC. We focus on factor incomes in the overall GVC such that our measure is not sensitive to this shifts.

Figure 1 Decomposition of factor incomes in global value chains



It should be noted that, given the residual approach, we limit ourselves to measuring the overall income to all intangibles in the chain. In seminal work Corrado et al. (2005) aim at deriving investment and stock estimates for intangibles that are not covered in the national account statistics. This requires data on intangibles investments (and stocks) as well as additional data on their depreciation rates and asset prices. Compared to this ongoing research effort (see e.g. Corrado et al., 2009; Corrado et al., 2013) we are thus taking one step back. But at the same time we extend the analysis in another direction by studying the role of intangibles in production chains that extend across industries and countries. At this stage we remain agnostic about the division of income across different types of intangibles, which could be attempted in follow-up research.

We confront various measurement challenges. Most importantly, GVCs are not observable and need to be inferred from information on the linkages between the various stages of production. We use information from so-called global input-output tables that contain (value) data on intermediate products that flow across industries as well as across countries. We built upon the GVC decomposition approach introduced by Los et al. (2015). This allows for a decomposition of the ex-factory value of a product into the value added in each stage of production. This is combined with information on factor incomes in each stage as discussed above. Throughout the paper we will study the GVCs of final manufacturing goods. It is important to note that these GVCs do not coincide with all activities in the manufacturing sector. They also include value-added outside the manufacturing sector (such as business services, transport, and communication and finance) and value-added in raw materials production. These indirect contributions will be explicitly accounted for by the modelling of input-output linkages across sectors. On average, they make up about 40 to 50% of the overall value added in GVCs of goods (Timmer et al., 2013).

We study developments in GVC factor incomes for goods over the period 2000-14 (the begin and end points of the data in the WIOD 2016 release). Our main finding is that the share of intangibles in the value of final goods has increased, in particular in the run up to the financial crisis in 2008. Its share is generally (much) higher than the tangible capital income share. This is found at the aggregate as well as for more detailed manufacturing product groups. Nevertheless, there is clear heterogeneity in the pace of the increase. For some non-durable products the intangible share increased only slightly. In contrast the share increased rapidly in durable goods (machinery and equipment products). We find suggestive evidence that this variation is linked to variation in the speed of international production fragmentation.

The rest of the paper is organised as follows. In section 2 we outline our GVC accounting methodology. Data sources are discussed in section 3. Section 4 provides main results on trends in factor incomes in GVCS over the period 2000 to 2014. Section 5 provides concluding remarks. We stress that this study is explorative and mainly aimed at setting out a new framework. It puts high demand on the data and our results should thus be seen as indicative only.

2. Accounting for factor incomes in global value chains: method

In this section we outline our empirical method to slice up incomes in global value chains (GVCs). The basic aim is to decompose the value of a final good into a stream of factor income earnings worldwide. By modelling the global economy as an input-output model in the tradition of Leontief, we can use his famous insight that maps consumption of products to value added in industries.[7] We first outline our basic accounting framework. Next, we outline how we trace value added in production stages of the GVC. This follows the approach outlined in our previous work (Los et al., 2015). In section 2.3 we discuss our measurement of value added in the distribution stage, which has been ignored in macro GVC studies so far. All our measures are based on statistics collected within the framework of the System of National Accounts (SNA) and typically refer to gross measures (inclusive of depreciation) unless otherwise noted (see section 4 for more discussion).

2.1 Basic accounting framework

In our empirical approach we focus on three sets of activities in a global value chain (see also Figure 1). These are activities in:

- the distribution of the final product from factory to consumer (*D*). This includes transportation, warehousing and retailing activities.
- the final stage of factory production (*F*). This can be thought of as a low-value added activity such as assembly, packaging or testing, but might also involve high value-added activities.
- all other stages of production (*O*). This might include the manufacturing of components to be used in the final stage, but also business services or more upstream activities in e.g. raw material production.

These three activity sets (*D*, *F* and *O*) are mutually exclusive and together cover all activities that contribute to the value of the final product. More formally, let *P* be the consumer (purchaser's) price of a good, *Y* the quantity consumed and *VA* value added then we can state the following accounting identity:

[7] This approach of mapping final demand to value added is also used in related settings by Johnson and Noguera (2012), Valentinyi and Herrendorf (2008), and Herrendorf, Rogerson and Valentinyi (2013).

(1) $$PY \equiv VA_F + VA_O + VA_D.$$

In each activity factor inputs are being used and we will distinguish between labour (L), tangible capital (K) and intangible capital (R) inputs. Using this notation, we can write the production function of the final good as:

(2) $$Y = f(\underbrace{R_F, K_F, L_F}_{\text{FINAL STAGE}};\quad \underbrace{R_O, K_O, L_O}_{\text{OTHER STAGES}};\quad \underbrace{R_D, K_D, L_D}_{\text{DISTRIBUTION}})$$

The corresponding cost equation is given by multiplying the factor quantities with their respective prices:

(3) $$PY = \underbrace{\textstyle\sum_{x \in F,O,D}(P_x^R\, R_x)}_{\text{INTAN CAPITAL}} + \underbrace{\textstyle\sum_{x \in F,O,D}(P_x^K\, K_x)}_{\text{TAN CAPITAL}} + \underbrace{\textstyle\sum_{x \in F,O,D}(W_x L_x)}_{\text{LABOUR}}$$

with W the wage rate and P the rental price for capital that may differ across tangible and intangible assets. It may also differ across stages, since the asset-mix is likely to vary over these. This is our basic decomposition of the output value of a final product into three elements: the income to intangible capital, to tangible capital and to labour. We will report on the shares in income for tangibles:

(4) $$S^K = \frac{\sum_{x \in F,O,D}(P_x^K\, K_x)}{PY}$$

and similarly for labour and intangibles.

2.2 Factor incomes in production stages (Los et al., 2015)

Stages in GVCs are not observable and need to be inferred from information on the linkages between the various stages of production. We use information from so-called global input-output tables that contain (value) data on intermediate products that flow across industries as well as across countries. An example is the delivery of inputs from the steel industry in China to the automobile industry in Japan. This information is taken from the 2016 release of the world input-output database (WIOD, see Timmer et al. 2015). GVCs for products are defined by the country-industry where the final stage of production is taking place, e.g. cars finalised in the German vehicle manufacturing industry.

More formally, our decomposition method builds upon the approach outlined in Los, Timmer and de Vries (2015). It relies on a multi-country extension of the method outlined by Leontief (1936). Leontief started from the fundamental input-output identity which states that all products produced must be either consumed or used as intermediate input in production. This is written as $\mathbf{q}=\mathbf{Aq}+\mathbf{c}$, in which $\mathbf{q}$ denotes a vector of industry-level gross outputs, $\mathbf{c}$ is a vector with final consumption levels for the outputs of each of the industries. Both vectors contain SN elements, in which S stands for the number of countries and N for the number of industries in each country. $\mathbf{A}$ denotes the SNxSN matrix with intermediate input coefficients. These coefficients describe how much intermediates are needed to produce a unit of output of a given product, split between the countries from which these intermediates can be sourced. Hence, it is a representation of the world production structure. $\mathbf{Aq}$ then gives the total amounts of each of the SN intermediates used in the global economy. The identity can be rewritten as $\mathbf{q}=(\mathbf{I}-\mathbf{A})^{-1}\mathbf{c}$, in which $\mathbf{I}$ represents an identity matrix. The SNxSN matrix $(\mathbf{I}-\mathbf{A})^{-1}$ is famously known as the Leontief inverse. It gives the gross output values of all products that are generated in all stages of the production process of one unit of a specific final product.

To see this, let $\mathbf{z}$ be an SN column vector of which the first element represents the global consumption of iPods produced in China, and all other elements are zero. Then $\mathbf{Az}$ is the vector of intermediate inputs, both Chinese and foreign, needed to assemble the iPods in China, such as the hard-disk drive, battery and processors. But these intermediates need to be produced as well and $\mathbf{A}^2\mathbf{z}$ indicates the intermediate inputs directly needed to produce $\mathbf{Az}$. This continues until the mining and drilling of basic materials such as metal ore, sand and oil required to start the production process. Summing up across all stages, one derives the gross output levels for all SN country-industries generated in the production of iPods by $(\mathbf{I}-\mathbf{A})^{-1}\mathbf{z}$, since the summation over all rounds converges to $(\mathbf{I}-\mathbf{A})^{-1}\mathbf{z}$ under empirically mild conditions.[8]

[8] See Miller and Blair (2009) for a good starting point on input-output analysis.

To find the value added by a particular factor, for example labour, we additionally need labour input per unit of gross output represented in an SNxSN diagonal matrix **H**. The elements in this matrix are country- and industry-specific: one element contains the labour costs per dollar of output in the Chinese electronics industry, for example. To find the costs of all labour that is directly and indirectly involved in the production of a particular final good, we multiply **H** by the total gross output value in all stages of production given above such that

(5) $$\mathbf{L}=\mathbf{H}(\mathbf{I}-\mathbf{A})^{-1}\mathbf{z}.$$

A typical element in the SN vector **L** indicates the costs of labour employed in country i and industry j in the production of the final good. A similar procedure can be followed to find similar vectors for the costs of tangible and intangible capital choosing suitable requirement matrices. Following the logic of Leontief's insight, the sum over value added by all factors in all countries that are directly and indirectly involved in the production of this good will equal the output value of that product at basic prices. Thus we have measures for the variables $P_x^R\, R_x$, $P_x^K\, K_x$ and $W_x L_x$ for x ∈ {F,O} in decomposition equation (3).

2.3 Extension: factor incomes in the distribution stage

The Leontief method can be applied to decompose value added in various stages of production. It remains silent on the value added in distribution of the final product to the consumer however. This is due to the nature of the data used: the distribution sector is represented in input-output tables as a so-called margin industry. This means that the final products bought by the distribution sectors (to be resold) are not treated as intermediate inputs. The gross output of the distribution sector is measured in the SNA in terms of the margin (value of goods sold minus the purchase value of those goods) and not sales. This precludes the treatment of the distribution sector in a Leontief type of decomposition. In this section we outline a novel approach to nevertheless analyse the distribution stage alongside the production stages. Key is information on margins rates derived from differences in valuation of final goods at basic prices and at purchaser's prices.

A basic distinction in the System of National Accounts is between a value at basic prices and at purchaser's prices. The basic price can be considered as the price received by the producer of the good. The purchaser's price is the price paid by the final consumer. It consists of the basic price plus trade and transport margins in the handling of the product and any (net) product taxes. We use this price concept to measure final output (represented by P in the formula's above). Accordingly, we define the value added in the distribution stage by a margin rate (*m*) derived from the ratio of the basic and purchaser's price (adjusted for net product taxes) such that:

(6) $$VA_D \equiv m(PY(1-\tau))$$

with τ the net tax rate on products. We use the factor shares in the industries responsible for distribution (wholesale and retailing) to derive the shares in value added, and finally derive measures for $P_D^R\ R_D$, $P_D^K\ K_D$ and $W_D L_D$ in decomposition equation (3) .

3. Data sources

For our empirical analysis we use three types of extensive data sources: world input-output tables (including supply and use tables), information on distribution margins and data on factor costs of industries. The input-output tables and data on labour compensation and value added are derived from the World Input-Output Database (WIOD), 2016 release and have been extensively described in Timmer et al. (2015). Important to note here is that the WIOD contains data on 56 industries (of which 19 are manufacturing), in 43 countries and a rest of the world region such that all value added in GVCs is accounted for. Gross output, value added and labour compensation are provided at the industry level. These can be used to derive the share of labour in value added at the industry level. In this section we provide more information on two new pieces of empirical information that are needed additionally: the cost shares of tangible capital and data on distribution margins.

3.1 Imputing the income payments to tangible capital asset

We measure intangible income through a "residual claimant" approach and define it for any given industry *i* as:

(7) $$B \equiv VA_i - r_i^K K_i - w_i L_i.$$

Gross value added (*VA*) and labour compensation (*wL*) can be derived from national accounts statistics (with appropriate adjustment for the income of self-employed) and this information is taken from the WIOD (see data appendix in Chen et al. 2017). We measure K as tangible capital stock and the rental price r^Kusing the Jorgenson-Griliches user-cost approach as the sum of the depreciation rate plus a real rate of return:

(8) $$r_i^K = \delta_i^K + \rho_i^K$$

with ρ_i^K the real rate of return. We choose an ex-ante rate of return for tangible capital such that a residual remains in (7). The real rate of return is set to 4 per cent for all tangible assets. This is a standard rate used in many studies. Alternatively, we could base it on a more sophisticated approach, see e.g. Corrado et al. (2005) or Barkai (2017). Barkai (2017, Fig 1) shows that for the U.S. debt costs (set to the yield on Moody's Aaa bond portfolio) declined from about 7% in 2000 to 5% in 2014. Expected capital inflation (calculated as a three-year moving average of realized capital inflation) oscillated around 2%. This suggests a small, but steady, decline in the real rate of return from 5% to 3% over our period. Sensitivity analysis using these rates instead (not reported) show that this will have no significant impact on our results.

We base our estimates on national accounts statistics such that our definition of tangible capital follows the System of National Accounts (SNA) convention. Tangible asset types include: buildings, machinery, transport equipment, information technology assets, communication technology assets, and other tangible assets. Asset depreciation rates are based on the year- and industry-specific geometric depreciation rates for Spain (obtained from the EU KLEMS database December 2016 revision), which are calculated using each assets' nominal capital stock as weights. Geometric depreciation rates for detailed asset types *j* are taken and aggregated such that the rate is industry specific (see data appendix in Chen et al. 2017 for details): $\delta_i^{KT}\, KT_i = \sum_j \delta_j^{KT}\, KT_{ij}$.

These rates take into account the differences in the composition of capital assets both across countries, industries as well as over time.

Country-industry tangible asset stock estimates over time are derived from EU KLEMS (O'Mahony and Timmer, 2009). We have capital stock data by asset type for Australia, Japan and the United States and twelve major European countries (Austria, Czech Republic, Denmark, Finland, France, Germany, Italy, the Netherlands, Slovenia, Spain, Sweden and the United Kingdom). It should be noted the recent version of the system of national accounts (SNA 08) also covers investments in some types of intangibles, namely intellectual property products (R&D, computer software and databases, mineral exploration and entertainment and artistic originals.) We do *not* include these assets in our set of tangible assets. Yet, for the other countries we typically have stocks by industry only, but not by asset type. Thus we are not are not able to split off the intangibles in case. In practice though, most of these countries do not collect data according to SNA08 rules such that this is not a major problem in practice. For countries reporting under SNA1993 it will include an imputation for software at most. We carefully distinguish between various data environments across countries, see data appendix in Chen et al. (2017) for elaborate discussion on a country-by-country basis.

A final issue that needs to be discussed is the measurement of gross value added. In our framework, this should be measured without any imputations for output of intangibles. For countries that still publish national accounts according to SNA68 or SNA93 these imputations will be nil or only small (in the latter case it includes an imputation for own-account software at best). For countries publishing on SNA08 basis, expenditures on intellectual property products (IPP) are "capitalised" rather than "expensed" in the value added data. Value added will thus be overestimated in some country-industries.[9] Fortunately, we can provide a back-of-the-envelope estimate of this overestimation by using information on IPP stocks. Typically, the imputation for value added in the NAS is cost-based. Therefore we calculated cost for IPP in the same way as we did for tangible

[9] A comparison of pre- and post-2008 SNA numbers suggest that at the aggregate GDP level these imputations were relatively minor, ranging from 2 to 4% of GDP, see http://www.oecd.org/std/na/new-standards-for-compiling-national-accounts-SNA2008-OECDSB20.pdf. More detailed industry information on this is urgently needed.

capital: based on IPP depreciation rates plus a real rate of return of 4 percent. We find that in manufacturing GVCs, IPP cost was 2.4% of gross value added in 2000, staying rather constant over the period (between 2.2 and 2.7%).[10] To set this in perspective: we find that intangible income is more than 27% of value added in 2000 increasing to more than 30% in 2014 (see next section). This shows that our main results are very robust to this data issue.

3.2 Margins and value added in distribution

Ideally, we need to have information on the margins for each final manufacturing product. Unfortunately, this is not available because of the sparseness of data on the magnitude of distribution margins for detailed product flows, either by supply (import or domestically produced) or use (intermediate use, domestic final use or exported). In particular, as final goods are traded internationally, we cannot trace the margins paid by final consumers around the world for a particular product. Instead we proxy the margin by using country specific domestic margins. As an example, to measure the value added in the distribution stage in the GVC of a car finalised in Germany, we need information on the total margins paid by all consumers (domestic and foreign) of these cars. We use information on the margins paid by German consumers of cars instead. This includes margins on cars finalised in Germany as well as cars finalised abroad (and imported). We thus assume that these margins (and tax) rates are the same. This approximation holds when a product finalised in a country is mostly consumed domestically, or when margins for this product are the same across countries.

Margins are calculated from information on final expenditures at purchaser's and basic prices as given in national supply and use tables. This data can also be found in the WIOD (under the heading of national SUTs for most countries). For China, Japan and the U.S. only data at producer prices is given in WIOD however. We complemented this with data from detailed retail and wholesale sector censuses. We adjust for (net) taxes (τ) on the products as these are paid for by the consumer to the government and do not constitute payment for factor inputs in any stage of production.

[10] See Koh et al. (2017) for more information on treatment of IPP by the U.S. BEA.

It is useful to note that by also taking account of distribution margins, we are much more likely to capture all value added contributions in the production of goods, even in the case of factory-less goods producers (FGPs). In the current U.S. statistical system FGPs are likely to be classified in wholesaling, and their output is recorded as a wholesale margin, rather than as manufacturing sales. See also contributions in Fontagné and Harrison (2017) on this topic.[11]

4. Empirical findings

Our new approach to the measurement of intangible incomes allows us to provide novel insights. For the first time, we will be able to study the evolution of the income payment to intangibles in the production of manufacturing goods and compare this with the income payments to tangibles and labour. To reiterate: we decompose the value of all manufacturing goods finalised in whatever country in the world.

4.1 Factor income shares in GVCs

In Table 1 we show the income incomes to labour, tangible and intangible capital as derived in equation (4). The most important finding is the large share of income payments to intangibles relative to tangible capital. In 2000, 27.8 per cent of the final output was income for intangibles, against only 15.8 per cent for tangibles. This gap remains large also in the years after.[12] This gap is robust to possible measurement errors in depreciation rates and (real) rates of return. To see this, remember that the rental rate to tangible capital is a sum of the real rate of return and the depreciation rate (equation 8). The real rate of return was set to be 4 per cent. The average depreciation rate for tangible assets is around 8 per cent. Thus suppose that the real rate of return was 5 per cent instead. This would increase the estimated income share of tangibles by

[11] Bernard and Fort (2013) suggest that reclassifying the FGPs to the manufacturing sector would increase reported manufacturing output in 2007 by about 5 percent in a conservative estimate and by a maximum of 17 percent using a more liberal set of assumptions.

[12] We think that most of these intangible assets are outside the asset boundary covered in the System of National Account (SNA 2008). Intangibles covered by the SNA 2008 are called intellectual property products (IPP). As discussed in section 3.1, IPP income was estimated as less than 3 per cent of gross value added which suggest that there are many intangibles that are not covered by national accounts statistics. See Corrado et al. (2009, 2013) for estimates of intangible stocks beyond IPP such as organisation capital.

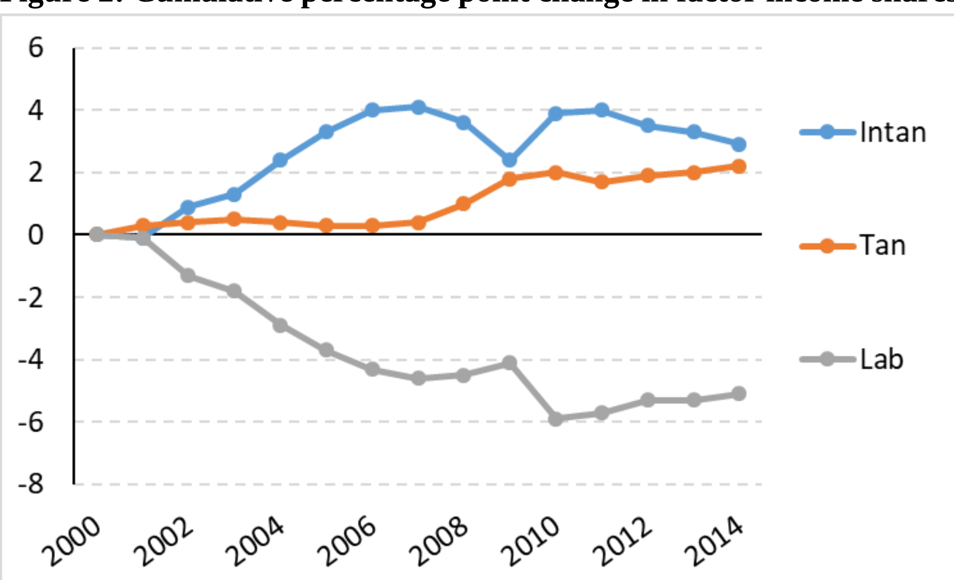
((5+8)/(4+8)) x 15.8 ≈ 17.1, and the intangible share (the residual) would decline correspondingly by (17.1 -15.8 =) 1.3 percentage point. A major gap between the two shares will remain for any plausible set of rates of return and depreciation rates.

Table 1 Factor income shares in GVCs of manufacturing goods (%-share).

	Labour (1)	Tangible capital (2)	Intangible capital (3)
2000	56.4	15.8	27.8
2001	56.2	16.1	27.7
2002	55.1	16.2	28.7
2003	54.6	16.3	29.1
2004	53.5	16.3	30.2
2005	52.7	16.2	31.2
2006	52.1	16.1	31.8
2007	51.8	16.3	31.9
2008	51.8	16.8	31.4
2009	52.2	17.6	30.2
2010	50.5	17.8	31.7
2011	50.6	17.6	31.8
2012	51.0	17.7	31.3
2013	51.1	17.8	31.1
2014	51.2	18.1	30.7

Notes: Share of factor income in % in the worldwide output of final manufacturing products valued at purchaser's prices (before product tax). (1) Labour includes all costs of employing labour, including self-employed income. (2) Tangible capital includes gross returns to tangible assets as defined in the SNA08 based on a 4% real rate of return and geometric depreciation rates. (3) Returns to intangible capital is calculated as a residual (final output minus labour and tangible capital income). Own calculations based on the WIOD, 2016, extended with data on capital compensation and stocks as described in this paper.

Figure 2: Cumulative percentage point change in factor income shares (2000 base)



Note: see Table 1.

A second finding is that the period up to 2007 was a special period. Figure 2 charts the cumulative changes in factor income shares with the year 2000 as base. We find a strongly increasing capital share, and a concomitantly declining trend in the share of labour during this period. This resonates well with the findings in our previous research (Timmer et al., 2014).[13] Interesting, and a novel finding in this paper, is that the increasing share of capital is mainly due to increasing incomes to intangibles. The income share of tangible capital grew only slowly, to 16.3 per cent in 2007. In the same period, the share of intangibles jumped from 27.8 to 31.9 per cent. These trends did not continue however after the 2008 crisis. The share for labour income stabilised at about 51 per cent, while the share of intangible hovered around 31 per cent. These findings suggest that the period in the run up to the 2008 crisis was a special period in the global economy. It supports the view that during this period global manufacturing firms benefitted from increased opportunities for offshoring of labour-intensive activities to low-wage locations. The income accruing to labour declines due to wage cost savings in the GVC.[14] If the production requirements (and prices) for tangible capital remain unaltered, the share of intangibles must go up by virtue of its definition as a residual. In addition, the growth in purchasing power in the global economy (e.g. growing consumer demand in China) might have benefitted international firms that were able to capitalise on existing intangibles such as brand names and distribution systems at little marginal costs.

4.2 Product heterogeneity

Is this aggregate trend driven by similar developments at a more detailed level, or a composition effect? In Table 2 and Figure 3 we provide an overview of the change in intangible income shares for more detailed manufacturing product groups. The trend is shared but there is clear heterogeneity in the pace of the increase. For some products (such as pharmaceuticals, furniture, textiles and food) the intangible share barely increased over the whole period 2000-14. An initial increase up to 2008 was almost nullified in the period after. In contrast the share increased rapidly in machinery and equipment products. This includes computer, optical, other electrical as well as

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[13] The 2014 study did not include distribution activities but only production stages, that is, it decomposed output at basic prices. Our extension to output at purchaser's prices did not appear to have a major impact on factor income shares however.

[14] This is true only under the assumption that factor substitution possibilities between labour and capital are limited. See Reijnders et al. (2016) for an econometric analysis of factor substitution and technical change in global value chains. They find wage elasticities to be well below one.

non-electrical machinery). Intangible income shares increased strongly until the crisis in 2008, followed by a slight decline afterwards.

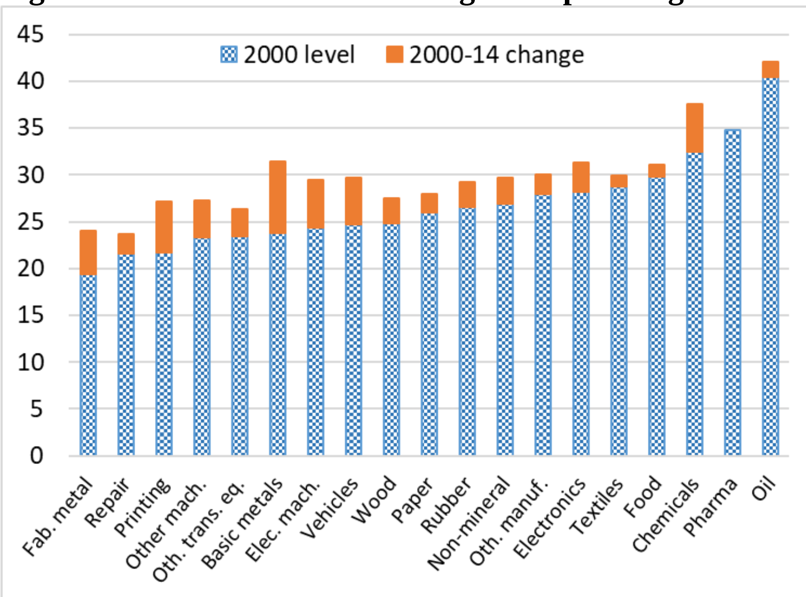
Table 2 Income shares for intangible capital in global value chains (% of final output).

Final product group name	ISIC rev. 4 code	2000	2007	2014	Change 2000-07	Change 2007-14	Change 2000-14
Elec. machinery	27	24.3	31.6	29.5	7.3	-2.1	5.1
Chemicals	20	32.4	36.5	37.5	4.1	1.0	5.1
Vehicles	29	24.8	29.9	29.7	5.1	-0.2	5.0
Metal products	25	19.3	25.6	24.0	6.3	-1.6	4.7
Non-elec. mach.	28	23.3	30.1	27.2	6.8	-2.8	4.0
Electronics	26	28.2	33.8	31.3	5.6	-2.4	3.2
Other transport eq.	30	23.4	29.4	26.3	6.0	-3.1	2.9
Furn. and other	31t32	28.0	30.5	30.1	2.5	-0.4	2.1
Oil products	19	40.5	47.0	42.1	6.5	-4.9	1.6
Food	10t12	29.8	31.1	31.0	1.3	-0.1	1.2
Textiles	13t15	28.7	31.1	29.9	2.4	-1.2	1.2
Pharmaceuticals	21	34.8	37.7	34.7	3.0	-3.1	-0.1
All products		27.8	31.9	30.7	4.1	-1.2	2.9

Notes: Share of intangibles in the final output value of manufacturing products (%). Product groups ranked by change over 2000-14.

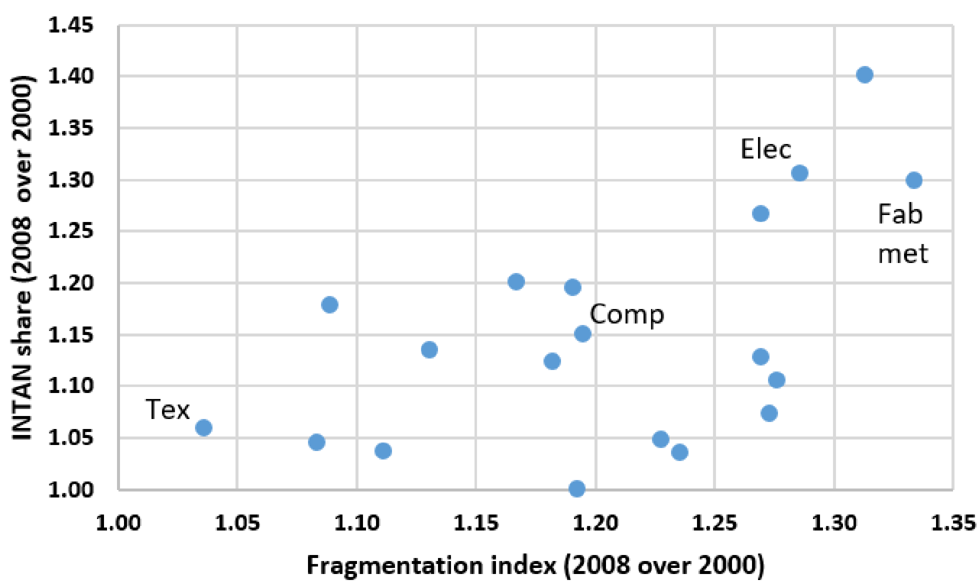
Arguably, this is related to the rapid international fragmentation of the production processes of these goods, speeded up by the opening up to China and its joining the WTO in 2001. In contrast, production of textiles and furniture was already quite fragmented before this period. Other products are arguably less susceptible to international fragmentation trends, such as food and pharma. To test this hypothesis more formally, we combine our estimates of intangible income shares with information on international fragmentation of production processes. Timmer et al. (2016) provide a new measure that tracks all imports that are made along the production chain and argue that this is a good indicator for international production fragmentation. In Figure 4 we plot the change in this indicator for our 19 manufacturing product groups against the change in the share of intangible income in those GVCs from Table 2. Timmer et al. (2016) find that over the period 2000-08, GVCs for electrical machinery (elec), electronics and computers (comp) and fabricated metal products (metal) fragmented the most. We find here that there is a clear positive correlation with the change in the share of intangible income in those GVCs. The overall correlation coefficient is 0.52, which fits our conjecture.

Figure 3: Income shares for intangible capital in global value chains



Note: see Table 2, sorted by share in 2000.

Figure 4 Intangible income and production fragmentation



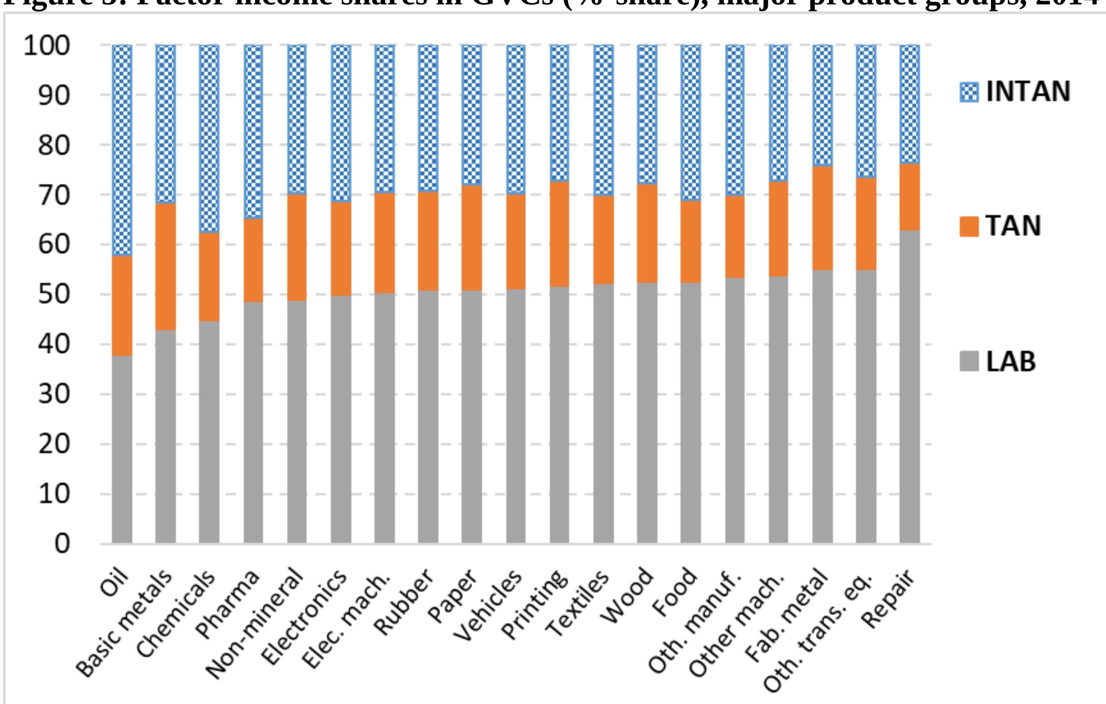
Notes: Fragmentation index from Timmer et al. (2016) based on all imports made along the production chain (2008 as ratio of 2000 level). Intan share level in 2008 as ratio of level in 2000. Observations for nineteen manufacturing product groups. Observations for textiles (tex), electrical machinery (elec) electronics and computers (comp) and fabricated metal products (metal) are indicated.

Table 3 Factor income shares in GVCs (%-share), major product groups, 2014

Final product group name	ISIC rev. 4 code	Labour share	Tangible capital share	Intangible capital share	Ratio of intan to tan
Petroleum products	19	37.9	20.0	42.1	2.1
Chemical products	20	44.9	17.5	37.5	2.1
Pharmaceuticals	21	48.8	16.5	34.7	2.1
Food products	10t12	52.6	16.4	31.0	1.9
Furniture and other	31t32	53.7	16.3	30.1	1.8
Textiles and apparel	13t15	52.4	17.7	29.9	1.7
Electronic products	26	50.0	18.6	31.3	1.7
Motor vehicles	29	51.3	19.0	29.7	1.6
Electrical equipment	27	50.6	20.0	29.5	1.5
Non-elec. machinery	28	53.9	18.8	27.2	1.4
Other transport equipment	30	55.2	18.5	26.3	1.4
Fabricated metal products	25	55.2	20.8	24.0	1.2
All manufacturing products		51.2	18.1	30.7	1.7

Notes: See Table 1. Twelve major manufacturing product groups (where importance is defined by final output value), ranked by ratio of intangible to tangible income share.

Figure 5: Factor income shares in GVCs (%-share), major product groups, 2014



Note: see Table 3, sorted by labour income share.

Finally, we can ask which product GVCs are the most intensive in the use of intangibles? In Table 3 and Figure 5 we provide an overview of the factor income shares in 2014 for more detailed main manufacturing product groups. The intangible income share is more than double the tangible share for pharmaceuticals, chemical products and oil refining products (see last column). It is also relatively high for food products and furniture and other manufacturing products. The ratio between intangible and tangible incomes is lowest, but still well above one, for motor vehicles, other transport equipment, electrical equipment and non-electrical machinery. It is even above one for metal industries that are characterised by heavy reliance on tangible assets.

5. Concluding remarks

In this paper we provide a novel attempt to derive the incomes to intangibles in global production networks. We rely on a residual claimant approach where we derive the incomes to intangibles by subtracting the costs for tangible factors (capital and labour) from the value of the final product. Importantly, these factor costs are identified in all stages of production including delivery to the final consumer. Our main finding is that the share of intangibles in the value of final goods has increased, in particular in the run up to the financial crisis in 2008. Its share is generally (much) higher than the tangible capital income share. This is found at the aggregate as well as for more detailed manufacturing product groups. Nevertheless, there is clear heterogeneity in the pace of the increase. For some non-durable products the intangible share increased only slightly over the whole period 2000-14. In contrast the share increased rapidly in durable goods (machinery and equipment products). We find suggestive evidence that this variation is linked to variation in the speed of international production fragmentation. Fragmentation showed a clear positive correlation with the change in the share of intangible incomes.

Although our accounting model to measure intangible returns is relatively straightforward, it is clear that the validity of the findings relies heavily on the quality of the database used. Data can, and needs, to be improved in many dimensions. For example, the WIOD is a prototype database developed mainly to provide a proof-of-concept, and it is up to the statistical community to bring international input-output tables into the realm of official statistics.[15] From the perspective of measuring intangibles' returns, one of the biggest challenge is in the concept and measurement of trade in services (Houseman and Mandel, 2015). Fortunately, there are important developments in the international statistical community. Recently, the UNUCE published its *Guide to Measuring Global Production* (De Haan et al, 2014). Building on this are new initiatives, most notably the initiative towards a *System of Extended International and Global Accounts (SEIGA)*. In the short run this would involve mixing existing establishment and enterprise data (in extended supply and use tables) as well as expanding survey information on value-added chains and firm characteristics. In the longer term this would entail common business registers across countries, increased data reconciliation and linking and new data collections on value-chains beyond counterparty transactions (Landefeld, 2015). A deeper understanding of the workings of global value chains is needed before our measurement systems will adequately capture the importance of intangibles in today's economy.

[15] The development work done by the OECD is certainly a step in the right direction, see http://oe.cd/tiva for more information. For example, one currently has to rely on the assumption that all firms in a country-industry have a similar production structure, because firm-level data matching national input-output tables are largely lacking. If different types of firms, in particular exporters and non-exporters have different production technologies and input sourcing structures (i.e., exporters import larger shares of inputs), more detailed data might reveal an (unknown) bias in the results presented here.

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APPENDIX The residual income in GVCs as intangible income: a simple model

In this section we will outline some simple accounting equations that suggest a clear interpretation of the residual income in GVCs. The key imputed variable in our approach is the residual measured as final output minus tangible input costs. We will show how this residual can be interpreted as net income payment to intangible assets, using the capital accounting approach.

To fix ideas, we use the example of a multinational firm that sells goods, but does not produce them. This firm imports a good, say shoes, and sells them (at a premium) under its brand name. The firm only employs marketing staff. We model the production function of this firm as $Y(L, S)$, with Y sales, L number of workers and S number of shoes.[16] Let P denote prices, with superscripts indicating the output or input to which it refers. Gross profit of the firm in this stage, π^R, is then given by:

(A1) $$\pi^R = P^Y Y - P^{LR} L^R - P^S S$$

It is obvious, but important, to see that this residual profit of the firm depends crucially on the price it is paying for the shoes. Profits can be shifted across locations making the geographical attribution of income to intangibles arbitrary.[17] Put otherwise, by observing the profit in the selling stage only, we are likely to mismeasure the returns to intangibles. The solution is to consider the profits in the two stages together. To see this, we need to model the fabrication stage of shoes. Assume shoes are fabricated with labor (L^F) and tangible capital (K), say machines. We can then write:

(A2) $$\pi^F = P^S S - P^{LF} L^F - P^K K \, ,$$

[16] We only use the time subscript in cases where its omission might generate confusion. Otherwise it will be suppressed for expositional simplicity.

[17] This is due to so-called transfer pricing. For tax reasons the firm might not be fully free to do so, and bound by cost-pricing rules. In practice profit shifting is abundant, involving complex IP arrangements. Note also that this practice is not restricted to affiliated firms only, see Neubig and Wunsch-Vincent (2017).

where π^F is the residual profit measure after subtracting cost of tangible inputs from gross output in the fabrication stage. The particular division of the profits in the selling and fabrication stages will depend on the price of the shoes which might be an endogenous variable to be set by the firm for accounting purposes. However, the overall profit in the chain, B = $(\pi^R + \pi^F)$ is independent of this choice. It equals sales minus cost of tangible inputs in the integrated production process:

(A3) $B = P^Y Y - (P^{LR} L^R + P^{LF} L^F) - P^K K$.

In order to bring this measure to the data we need to use the GVC approach to trace the labour *L* and tangible capital *K* involved in both stages. P^K is the user cost of *K*. According to neo-classical theory, the user cost of capital consist of four elements: depreciation, capital taxes (net of subsidies), (expected) capital gains and a (net) rate of return (Jorgenson and Lin, 1991). For simplicity of exposition we abstain from (net) tax and capital gain considerations here. Then, user costs for tangibles are given by:

(A4) $P^K = (\bar{\rho} + \delta^K)\, P^{IK}$,

with δ^K the depreciation rate, P^{IK} the price of tangible investment and $\bar{\rho}$ an ex-ante real rate of return.

How to interpret the residual *B*? In order to link it to intangible capital, we use the capitalization approach. Intangibles are created with a view of generating profits over a longer time period and hence should be considered as a capital input. In this approach the firm is using a new input, namely the intangible capital stock *R* (say "brand name"). This stock is generated by the usual accumulation of investments:

(A5) $R_{t+1} = (1 - \delta^R) R_t + I_t^R$,

where δ^R its depreciation rate and *I* investment. We assume that the firm is producing this asset using its own workers (for own account in the jargon of the System of National Accounts, SNA). In that case, nominal output of the firm is given by $P^Y Y + P^{IR} I^R$: it includes the value of the intangible assets created. Input costs go up by the use of the intangible capital stock in each period, $P^R R$, with P^R its user cost. The user cost is given by:

(A6) $P^R = (\rho^R + \delta^R)\, P^{IR}$,

where $\rho^R$is the (net) rate of return to intangible capital. This rate is notional, pinned down by the assumption that the sum of all factor incomes, now including the intangibles, exhaust gross value added. Put otherwise, the user cost of intangibles is determined using an *ex-post* endogenous rate of return. Thus

(A7) $P^Y Y + P^{IR} I^R = (P^{LR} L^R + P^{LF} L^F) + P^K K \quad + P^R R.$

Using the definition of B in (A3), we then have:

(A8) $B = P^R R - P^{IR} I^R.$

None of the right0hand side variables are observable in the data. In practice many alternative combinations of P^R, R, P^{IR} and I^R are possible that satisfy the accounting restrictions set by observable data. To simplify, let us consider two extreme cases. First, suppose a start-up firm produced the intangible, but is not using it, that is, it is not selling yet. In that case B will be equal to $-\mathrm{P^{IR} I^R}$. Alternatively, when the firm stops to produce its intangible, but continues selling, it can be said to "exhaust" its brand name. In that case B will be equal to $\mathrm{P^R R}$. An intermediate situation is when the firm is in a steady-state such that in each period depreciation is equal to new investment:

(A9) $\delta^R P^R R = P^{IR} I^R.$

Substituting (A9) in (A8), and using (A6) we find:

(A10) $B = \rho^R P^I R.$

In this case B is a measure of the net income to intangible assets.

A number of characteristics of B need to be noted. First, the rate of return on intangibles, ρ^R, is an *ex post* rate. It is calculated to exhaust value added minus tangible costs, such that there is no residual profit left. This ex post rate contains a 'normal' rate of return to capital, $\bar{\rho}$, which is the opportunity cost of the invested capital. This is similar to tangible capital assets. Any returns above this can be referred to as 'supra-normal' such that B can be split into normal returns and supra-normal returns: $B = (\rho^R - \bar{\rho})P^I R + \bar{\rho}\, P^I R$. There are many reasons why the rate of return to intangibles can be different from the rate of return to tangible capital. Beyond the standard business risk, it may include additional compensation for its unusual risk-profile (Hansen, 2005).

Second, for simplicity we abstained from tax and capital gain considerations in the discussion above. Also in our empirical work reported on in the main text we will not be able to measure these. This is not to say that they are unimportant, but simply unknown and further work is needed in this direction.

Third, equation (A10) shows that intangible income measured by B can increase because of an increase in its rate of return ρ^R, or because an increase in the stock $P^I R$. Without quantifying the stock, we are not able to distinguish between the two. More generally, the firm might not be in a "steady state", driving a wedge between depreciation and new investment. This wedge will also be absorbed in B. However without further information on δ^R, R, P^I and I we will not be able to know this.