Measuring the Returns to Intangibles: a Global Value Chain Approach.

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Abstract

Considerable progress has been made in tracing expenditures on intangibles in the macro-economy. But much less is known about their returns. In this paper we outline a new strategy to estimate returns to intangibles in the context of globalised production networks. We view intangibles as inputs that allow a firm to generate surplus value from tangible factor inputs. This is in contrast to the standard treatment of intangible capital as yet another factor of production which can be separately valued. We propose an instrumental definition of the returns to intangibles as the residual value after subtracting the costs of labour and tangible capital. Given international fragmentation of production processes, this residual can only be measured when all stages of production (including distribution) are considered. To this end, we rely on the global value chain (GVC) approach introduced by Timmer et al. (2014). This approach allows for a decomposition of the value of a product into value added at each stage of production. We extend this approach by splitting value added into returns to labour, tangible and intangible capital. We focus on final manufacturing products for the period 1995-2007 using the world input-output database (WIOD) and additional data derived from national accounts statistics. Our main finding is that the share of intangibles in the value of final products has increased from 2000 onwards. This is found for all manufacturing product groups. We also find that for buyer-driven GVCs (like food, textiles and furniture) returns to intangibles are increasingly realized in the distribution stage, that is, in delivery of the final product to the consumer. In contrast, in producer-driven GVCs (like machinery, automotive and electronics) the returns are shifting to activities before the final production stage.

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1. Introduction

The seminal contribution of Corrado et al. (2005) has led to increasing availability of macroeconomic data on intangible investments. Worldwide investment expenditures are shifting from tangible (like machinery, equipment and constructions) to intangible assets like R&D, databases, brands and organizational expertise. According to Corrado and Hulten (2014), intangible investment expenditures in the US have steadily risen from roughly 9% of GDP in 1977 to 14% in 2014. In contrast the share of tangible investment is declining and amounted to only 10% in 2014. Similar patterns are observed in Europe and in Japan as shown by Corrado et al. (2012) and Fukao et al. (2009). Basically, these trends indicate an increasing share of intangibles in firms' expenses. Yet, what are the returns on these intangible investments at the macro-level?

The standard approach to answer this question is to treat intangible capital as being much like any other (quasi-fixed) factor of production which can be priced. In that perspective, firms buy intangibles as they would buy machinery, replacing it when it is worn-out. The costs of intangible assets simply reflect the discounted expected returns over their lifetime.[1] But as argued by Cummins (2005), intangibles are different from other factors because, by and large, companies cannot freely order or hire intangibles. Rather, returns to intangible capital typically result from the distinctive way companies combine the tangible factors of production.[2] Viewed this way, intangible capital is the "yeast" that creates value from labor and tangible assets. This perspective naturally suggests an empirical model in which returns to intangible capital are defined in terms of supra normal profits. Put otherwise, the returns to intangibles are the difference between the cost of tangible factor inputs and the value of output. In this paper we will for the first

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[1] This underlies the well-known valuation approach by Hall (2001) and Hulten and Hao (2008). The value of intangibles is derived as the difference between the stock market valuation of a firm and its book-value of tangible assets.

[2] This perspective also resembles how organization capital, a major component of intangibles, is defined in Prescott and Visscher (1980). In their paper, organization capital is seen as the information a firm has about its assets and how these can be best combined in production.

time derive such a residual measure of the returns to intangibles at the macro-economic level.[3]

In a simple world where products are produced (and sold) by single plants returns to intangibles could be easily measured by subtracting tangible factor costs from sales of the plant. But actual production processes are complex and have become increasingly fragmented across industries and countries. Typically, production of goods is organized in world-wide production networks. We refer to this as global value chain production. Importantly, in such settings the returns to intangibles cannot be identified from national (industry) statistics. The (supra)normal profits could be realized and recorded in the industry finalizing the good, and/or in the industries that deliver intermediate inputs, or in the distribution of the good to the consumers. This implies that returns to intangibles can only be identified when considering costs and profits along all stages of the value chains, including delivery of the product to the final consumer. We therefore measure returns to intangibles as a residual by subtracting the input costs in any stage from the value of a final product. As such, our approach can be considered as the macro-economic equivalent of the seminal product case studies in Dedrick at al. (2010).

Dedrick at al. (2010) devised a new residual accounting approach to estimate the returns to intangibles of lead firms in the global production of electronics. The global value chain (GVC) of a product is defined as all activities in its conception, production and delivery to the final consumer. Based on professional industry sources, they decomposed the retail price of a product into earnings for the various participants in the chain. We dwell on their case study of Apple's iPod to illustrate some of the concepts involved when studying GVCs.[4] The production process of the iPod is exemplary for the global

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[3] As we base our estimates on national accounts statistics, our definition of tangible capital follows the System of National Accounts (SNA) convention. Our data is compiled using SNA 1993 data so tangible investment includes software expenditures. It excludes R&D expenditures that were only accounted for in the national accounts statistics with the introduction of the new 2008 SNA framework.

[4] Dedrick at al. (2010) provide similar decompositions for some other high-end electronic products such as notebooks, see also Ali-Yrkkö et al. (2011) for a study of mobile phones. Kaplan and Kaplinsky (1999) is a seminal contribution on South African peaches. The GVC perspective

fragmentation of production processes with intricate regional production networks feeding into each other. The *retail price* of the 30GB Video iPod at the time of study was US$ 299. It was assembled in China from several hundreds of components and parts sourced from around the world. The Chinese *ex-factory price* of the iPod was estimated on the basis of so-called "teardown" reports. These provide technical information on the parts and components used in the assembled product (such as the hard-disk drive, display and memory) as well as their market prices. All in all, the intermediate inputs were estimated to cost 140$. The cost of assembly was estimated to be no more than 4$. Half of the remaining profit was estimated to be captured by local distribution and retailing services in the country where the iPod was sold (75$). The remaining balance of $80 (=299-140-4-75) was assumed to accrue as income to Apple, the lead firm in the chain (see Dedrick at al., 2010, Table 2). This can be considered as compensation for Apple's provision of software and designs, market knowledge, intellectual property, system integration and cost management skills as well as a high-value brand name.

To apply this residual accounting approach at the macro-economic level, we confront various measurement challenges. Most prominently, GVCs are not observable and need to be inferred from information on the linkages between the various stages of production. The macro-economic counterpart to the teardown reports used by Dedrick at al. (2010) is information from so-called global input-output tables that contain (value) data on intermediate products that flow across industries as well as across countries. So for example, the delivery of inputs from the steel industry in China to the automobile industry in Japan. This information is taken from the world input-output database (WIOD, see Timmer et al. 2015). GVCs are identified by the country-industry were the final stage of production is taking place. Note that we take final products as our units of observation, and not industries as is typically done in macro-studies.

The next challenge is to identify the returns to factor inputs. We built upon the global value chain decomposition approach introduced by Los et al. (2015). This allows

has a much longer history going back at least to Gereffi (1994), see Kaplinsky (2000) for an overview. Studies in that tradition are more qualitative and analyse how interactions in these increasingly complex systems are governed and coordinated.

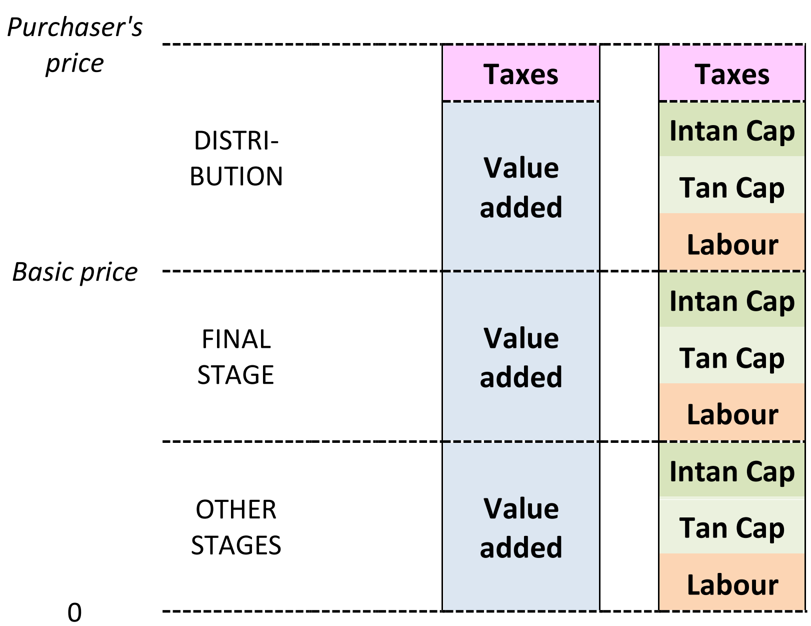
for a decomposition of the ex-factory value of a product into the value added in each stage of production. In previous work we showed that the share of capital in the production value (at ex-factory price) of final manufacturing goods was increasing rapidly. We hypothesized that this was due to the increasing importance of intangibles (Timmer et al., 2014). In this paper we will for the first time test this hypothesis by extending the GVC accounting approach in two directions. First, we add information on tangible capital earnings at the country-industry level. We then measure returns to intangibles as a residual by subtracting the costs for tangible capital and for labour from value added. Second, we add information on the value added in the distribution stage from factory to final consumer. For products that are produced with a major retailer as the lead firm in the GVC (e.g. Nike) most of the intangibles' returns are realised in this stage.

We illustrate our approach in Figure 1. The GVC of a product is divided into three stages: distribution of final product from the factory to the consumer, the final production stage and other stages of production. The final stage can be thought of as a low-value added activity such as assembly or packaging (as in the case of the iPod), but might also involve high value-added activities such as customization of products or producing and adding an engine to a car (as in the case of some luxury cars). Other stages of production involve the production of intermediates used in the final stage, or in any earlier stage of production.[5] The value of a final product (at purchasers' prices) is made up of the value added in each stage (and includes net taxes payed by the final consumer). The value added in the production stages make up the value at basic (ex factory) prices. Macro-economic statistics are used to derive the share of labour in value added for all country-industries. We impute the returns to tangible assets and residually derive the value added

[5] 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 approach is not depending on a particular configuration of stages.

by intangibles. As a result we can decompose the purchaser's value of a final product into value added by tangible and intangible production factors used in any stage of the GVC. An alternative view on this decomposition is from an income perspective (in the spirit of the early work on GVCs). It shows how the expenditures of consumers are distributed among the owners of factor inputs that are involved in the GVC of the product.

Figure 1 Global value chain decomposition



This new approach allows us to provide novel insights in two dimensions. For the first time, we will be able to study the evolution of the returns to intangibles in the production of manufacturing goods and compare this with the returns to tangibles and labour. We will show that the share of intangibles in the value of final manufacturing products is increasing since the early 2000s. This trend is found for all twelve product groups that we study. It also allows us to study in what stage of production the intangible profits are realized. We find that for buyer-driven GVCs (like food, textiles and furniture) returns to intangibles are increasingly realized in the distribution stage, that is, in delivery of the final product to the consumer.[6] In contrast, in producer-driven GVCs (like machinery,

[6] We elaborate on the differences between buyer-driven and producer-driven GVCs below.

automotive and electronics) the returns are shifting to activities before the final production stage.

As argued above, our macro-economic approach to the measurement of intangibles is inspired by the product case approach introduced by Dedrick at al. (2010). It is instructive to dwell on some important conceptual differences, apart from the level of aggregation at which the studies are carried out (individual detailed product cases versus broad product groups). We share the conceptualization of intangibles as assets that allow firms to generate profits and hence the need for a residual approach in which the returns to intangibles are derived as retail value minus costs of tangible capital and labor. Going beyond Dedrick at al. (2010) we consider returns to intangibles in any stage of production.[7] Consideration of all stages in the GVC is paramount in the measurement of returns to intangibles. For example, when a company like Dell is selling PCs manufactured in China through its own retailing channels in the US the profit is likely to be recorded in the distribution sector.[8] Alternatively, when the car body of a Porsche is completed in the Czech Republic and finalized in Germany by adding the engine, then profits are likely to be recorded in German car industry (the last production stage). But in other cases profits might even be recorded deeper down the production chain, for example when Windows software is used as an input in PC assembly by a non-brand manufacturer. Much depends on the configuration of the GVC and in particular the

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[7] They estimate that about 35$ out of the 140$ worth of intermediate inputs used in assembling the iPod is captured as profits by firms in charge of manufacturing the ten highest-value components. The remaining 106$ is covering the costs of basic materials and for labor involved in the production of the components. These are not broken down any further but may of course include returns to intangibles as well.

[8] This will ultimately depend on the classification of the so-called factory-less goods producers (FGPs) in industry statistics. These are firms that are manufacturer-like in that they perform many of the tasks and activities in the GVCs of final goods themselves, except for the physical production process. In the current U.S. statistical system they are often classified in wholesaling, and their output is recorded as a wholesale margin, rather than as manufacturing sales. 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. See also contributions in Fontagné and Harrison (2017).

position of the firms that control the intangibles and secure profits through creating high entry barriers into these activities (Shin et al., 2012).

A few final remarks are in order. First, we provide estimates of intangibles' earnings, but not of the underlying asset stocks. Other studies provide stock estimates through using information from stock market valuation (a future earnings approach as in Hall, 2001)[9] or through investment expenditures (a cost based approach as in Corrado et al. 2005 and Corrado et al. 2013). Instead we derive a measure of current earnings of intangibles based on our residual value added approach.[10] Asset stocks cannot be derived from this without further information on depreciation rates and prices of intangibles.

Second, we do not estimate the distribution of intangible earnings over *countries*. As is well-known the (geographical) distribution of profits along the global value chain does not necessarily correspond with the distribution of value added or intangible assets. 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). More generally, 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 earnings.

Third, our residual measure of intangibles' earnings is affected by many factors that are not directly related to the productivity of intangible assets. Most prominently it will be sensitive to overall business cycle variation. We will therefore mainly focus on long-term trends in earnings profiles. Related, one might point to differences in competitive environments driving variation in mark ups over time and across products. We assume that competitive advantages are the result of intangible investment (in e.g.

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[9] If the equity market reveals the intrinsic value of the firm, then subtracting the value of the firm's tangible assets from its market value reveals the value of the firm's intangible assets. This approach to measuring intangibles relies heavily on the assumption of strongly efficient markets with full information on expected earnings. A variant is provided by Cummins (2005) using analysts' profit forecasts instead.

[10] In a recent study Clausen and Hirth (2016) also take a residual value added approach. They derive a firm-level rate of return by dividing value added (minus labor 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 value.

brands) and not the result of a natural monopoly. As such we want to include them in our intangible returns measure.

Fourth, we interpret the residual value as stemming from intangibles such as patents, trademarks, brands, (customer) databases or efficient organization of production and supplier networks. But given the residual approach we have to remain silent on the precise source and limit ourselves to measuring the overall returns to intangibles in the chain. But we will identify in what stage of production the intangible profits are realized, and show that it differs across products.

Fifth, throughout the paper we will focus on earnings in the production of final manufacturing goods. We denote these goods by the term “manufactures”. It is important to note that GVCs of manufactures do not coincide with all activities in the manufacturing sector. GVCs of manufactures 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 through the modelling of input-output linkages across sectors. On average, they make up about 40 to 50% of the overall value added (Timmer et al., 2013). Importantly, value added in earlier stages of production can contain sizeable intangible earnings as reflected in payments for outsourced R&D, database development, advertising, as well as other business services.

Finally, we would like to stress that this study is explorative. Our ambition to trace macro-economic patterns in the returns to intangibles puts high demand on the data and the validity of the findings relies heavily on the quality of the data used. Put otherwise, it depends crucially on the capabilities of our current statistical systems to keep track of globalised production networks and associated income flows. Much progress has been made in the past decade, but many gaps in our understanding remain (UNECE 2015; Landefeld 2015).

The rest of the paper is organized as follows. In Section 2 we outline our GVC methodology. In section 3 we discuss data sources. Section 4 presents the main results and section 5 concludes.

2. A Global Value Chain (GVC) approach to the measurement of intangible returns

In this section we outline our method to slice up global value chains (GVCs). The basic aim of this empirical analysis is to decompose the value of a final good into a stream of factor earnings around the world. By modelling the world 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. We first outline our basic accounting framework in section 2.1. In section 2.2 we outline how we trace value added in production stages of the GVC. This follows the approach outlined in our previous work (Los, Timmer and de Vries, 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.

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:

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

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

(2)
$$Y = f(\underbrace{KI_F, KT_F, L_F}_{\text{FINAL STAGE}} ;\ \underbrace{KI_O, KT_O, L_O}_{\text{OTHER STAGES}} ;\ \underbrace{KI_D, KT_D, L_D}_{\text{DISTRIBUTION}})$$

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

(3)
$$\begin{aligned} PY = {} & (r_F^{KI} KI_F + r_F^{KT}\ KT_F + w_F L_F) && \text{FINAL STAGE} \\ & + (r_O^{KI} KI_O + r_O^{KT}\ KT_O + w_O L_O) && \text{OTHER STAGES} \\ & + (r_D^{KI} KI_D + r_D^{KT} KT_D + w_D L_D) && \text{DISTRIBUTION} \end{aligned}$$

with *w* the wage rate and *r* 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.

Equation (3) shows how one can decompose the output value of a product into the returns for factor inputs in various stages of production. Based on this we derive two measures that play a central role in our empirical analysis. Rearranging (3) we arrive at:

(4)
$$PY = \underbrace{\textstyle\sum_{x \in F,O,D} (r_x^{KI}\ KI_x)}_{\text{INTAN CAPITAL}} + \underbrace{\textstyle\sum_{x \in F,O,D} (r_x^{KT}\ KT_x)}_{\text{TAN CAPITAL}} + \underbrace{\textstyle\sum_{x \in F,O,D} (w_x L_x)}_{\text{LABOR}}$$

This is our basic decomposition of the output value of a final product into three elements: the returns to intangible capital, the returns to tangible capital and the returns to labor. We will report on the share of intangibles:

(5)
$$SHARE\ (KI) = \frac{\sum_{x \in F,O,D} (r_x^{KI}\ KI_x)}{PY}$$

and similarly for the other factor inputs.

In a second decomposition, we will focus on the location of intangible returns in the three sets of activities. For intangibles in the final stage:

(6)

$$SHARE\ (KI, F) = \frac{r_F^{KI} KI_F}{\sum_{x \in F,O,D} (r_x^{KI}\ KI_x)}$$

and similarly for the other stages.

2.2 Accounting for value added in production stages

Our decomposition method for the value added in the production stages of GVCs is grounded in 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 *SN*x*SN* 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 *SN*x*SN* 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.[11]

To find the value added by factors we additionally need factor inputs per unit of gross output represented in an *SN*x*SN* diagonal matrix **V**. An element in this matrix indicates the value added generated by a particular production factor as a share of gross output. These are factor-, country- and industry-specific: one element contains the value added by labor per dollar of output in the Chinese electronics industry, for example. To find the value added by all factors that are directly and indirectly involved in the production of a particular final good, we multiply **V** by the total gross output value in all stages of production given above such that

$$\text{(7)} \qquad \mathbf{k}=\mathbf{V}(\mathbf{I}-\mathbf{B})^{-1}\mathbf{z}.$$

A typical element in the *SN* vector **k** indicates the value added in the production of the final good by each production factor employed in country *i* and industry *j*. 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. By repeating this procedure for all final goods and production factors, we have completed our decomposition of final output into the value added by various production factors around the world.

2.3 Value added 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 are not treated as intermediate inputs. The production function of the distribution sector is hence in terms of the margin (value

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

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 analyze 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 in our decomposition (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:

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

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 of labor and capital in value added.

2.4 An illustrative example

We provide an illustrative example of the value decomposition of cars that are finalized in Germany in Table 1. It shows for 1995 and 2007 the distribution of value added across the three stages and across the three factor inputs. We find that the value added is concentrated in production, in particular in the non-final stages. The majority of value added is captured by labor but this is declining. German car producers took increasing advantage of the opportunities to offshore to lower labor costs locations, in particular in Eastern Europe. Concomitantly, the income share of capital in the GVC increased over this period. Interestingly, this was predominantly due to the increasing returns to intangibles. This trend is representative for many manufacturing GVCs as shown in section 4.

Table 1 Decomposition of value of a German car (at purchaser's prices).

			1995	2007	Change
(1)		Net taxes	5.0	3.6	-1.3
	(2)+(3)+(4)	***Distribution***	***15.7***	***10.9***	***-4.8***
(2)		Intangible capital	2.1	1.5	-0.6
(3)		Tangible capital	0.2	0.5	0.2
(4)		Labor	13.3	8.9	-4.4
	(5)+(6)+(7)	***Final stage***	***31.9***	***28.5***	***-3.4***
(5)		Intangible capital	2.2	4.2	2.1
(6)		Tangible capital	4.6	3.8	-0.8
(7)		Labor	25.2	20.4	-4.7
	(8)+(9)+(10)	***Other stages***	***47.5***	***57.0***	***9.5***
(8)		Intangible capital	10.0	15.3	5.3
(9)		Tangible capital	6.2	8.5	2.3
(10)		Labor	31.2	33.2	2.0
	sum of (1) to (10)	***Total value***	***100.0***	***100.0***	***100.0***
(2)+(5)+(8)		Intangible capital	14.3	21.1	6.7
(3)+(6)+(9)		Tangible capital	11.0	12.8	1.7
(4)+(7)+(10)		Labor	69.7	62.5	-7.1

Notes: Decomposition of final output of the transport equipment manufacturing industry in Germany (ISIC rev. 3 industries 34 and 35) valued at purchaser's prices. Numbers may not sum due to rounding. Own calculation based on WIOD, November 2013 release.

3. Data sources

For our empirical analysis we use three types of data sources: world input-output tables, distribution margins and factor incomes in value added. The input-output tables and data on labor compensation and value added are derived from the World Input-Output Database (WIOD) and have been extensively described in Timmer et al. (2015).[12] In an Appendix we provide a summary of the main characteristics of this database such that the reader of this study can appreciate its particular strengths and weaknesses. Important to note here is that the WIOD contains data on 35 industries (of which 14 are

[12] We use data from the 2013 release of the WIOD as this includes data on capital stocks. The new 2016 release of WIOD does not contain stock data.

manufacturing), in 40 countries and a rest of the world region such that all value added in GVCs is accounted for. Macro-economic statistics on 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: the share of intangible capital in value added and data on margins.

3.1 Returns to capital

In WIOD overall capital compensation is derived as gross value added minus labor compensation. This is the gross operating surplus (in national accounting terms), including profits and depreciation allowances. For this paper we split it into returns to tangible and intangible assets. Returns to intangibles are not separately observed and we measure them through a “residual claimant” approach. We define for any given industry *i* the returns to intangibles as

$$(9) \qquad r_i^{KI} KI_i \equiv VA_i - r_i^{KT}\, KT_i - w_i L_i.$$

Gross value added (*VA*) and labor compensation (*wL*) can be derived from national accounts statistics (with appropriate adjustment for the income of self-employed). We measure KT as tangible capital stock and r^{KT} as the depreciation rate for detailed asset types j such that $r_i^{KT}\, KT_i = \sum_j \delta_j^{KT}\, KT_{ij}$. Note that we do not include a (real) rate of return in the rental cost of tangible capital, implicitly attributing all profits in an industry to the deployment of intangibles.

We base our estimates on national accounts statistics such that our definition of tangible capital follows the System of National Accounts (SNA) convention. Our data is compiled from SNA 1993 statistics and contains stocks of eight asset types: buildings, machinery, transport equipment, information technology assets, communication technology assets, software and other assets. Note that software is included in tangibles, but R&D stocks are not included as they are only accounted for in the national accounts statistics with the introduction of the new 2008 SNA framework. Asset depreciation rates are based on Fraumeni (1997) and aggregated as outlines in O’Mahony and Timmer

(2009). Depreciation rates are asset-specific, but not country- (or time-) specific. At the industry level the depreciation rate will vary though and reflect changes in the asset composition of the capital stock over time. In particular it will go up with the increasing use of fast depreciating ICT assets.

Country-industry 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). For the other countries we do not have the asset distribution and assume $r_i^{KT}\ KT_i = \delta_i^{KT}\ KT_i$, see Data appendix for more information.

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 finalized 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 finalized in Germany as well as cars finalized abroad (and imported). This approximation holds when a product finalized 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). We adjust for (net) taxes (τ) on the product as these are paid for by the consumer to the government and do not constitute payment for factor inputs in any stage of production.

4. Empirical findings on the role of intangibles in GVCs

In this section we present two types of results. First we present evidence on the increasing importance of intangibles in the GVCs of manufacturing goods. Next we show how the returns to intangibles are shifting away from being realized in the final stage of production. Throughout the section we will make a distinction between two types of GVCs following the basic distinction between buyer- and producer-driven GVCs (Gereffi, 1999).[13] GVCs are governed by so-called lead firm that decide on specifications and have a large share of control. The lead firm in a buyer-driven chain is typically a large retail chain or a branded merchandiser and often has little or no goods production capacity. The lead firm in a producer-driven chain is a manufacturer that derives bargaining power from superior technological and production know-how.[14] We find that for buyer-driven GVCs (like food, textiles and furniture) returns to intangibles are increasingly realized in the distribution stage. In contrast, in producer-driven GVCs (like machinery, automotive and electronics) the returns are shifting to activities before the final production stage.

4.1 Increasing importance of intangibles

In Table 2 we show the returns to labor, tangible and intangible capital as shares in the total value of final manufacturing products, as derived in equation (5). This covers all products finalized in any country in the world and the total value thus represents the total worldwide expenditure on manufacturing goods (excluding net product taxes). We find increasing capital shares over the period 1995-2007, and a steadily declining trend in the returns to labor. This resonates with the findings in our previous research (Timmer et al., 2014) which did not consider distribution activities though. Interestingly, the increasing share of capital is mainly due to increasing returns to intangibles. The share of tangible

[13] See Gereffi and Fernandez-Stark (2011) for a primer on GVC analysis.

[14] Most GVCs are governed in complex ways and combine elements of both governance modes. Governance modes are not necessarily product-group specific. An electronic gadget can be produced in a chain driven by a buyer, e.g. in the case of a generic not-branded product, or in a producer driven chain, e.g. in the case of a high-end branded product. Nevertheless we will show that there are significant and substantial differences in the level of intangible returns across product groups.

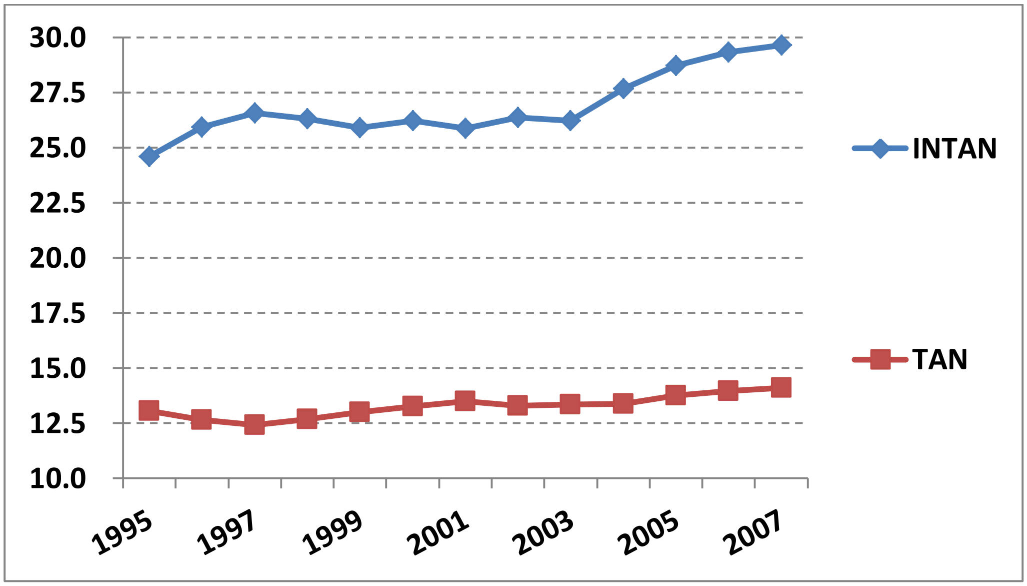
capital grows slowly, from 13.1 % in 1995 to 14.1 % in 2007. In the same period, the share of intangibles jumped from 24.6% to 29.6% (see Figure 2). A simple interpretation of these findings would be that during this period global manufacturing firms benefitted from increased opportunities for offshoring of labor-intensive activities to low-wage locations. When competition is high, final output prices will fall due to the wage cost savings and the share accruing to labor would decline (if factor substitution possibilities are limited). If the production requirements (and prices) for tangible capital remained unaltered, the share of intangibles must go up by virtue of its definition as a residual.

Table 2 Value added by production factors (as %-share in total value of manufacturing products).

	Intangible capital	Tangible capital	Labor
1995	24.6	13.1	62.3
1996	25.9	12.7	61.4
1997	26.6	12.4	61.0
1998	26.3	12.7	61.0
1999	25.9	13.0	61.1
2000	26.2	13.2	60.5
2001	25.9	13.5	60.6
2002	26.4	13.3	60.3
2003	26.2	13.4	60.4
2004	27.7	13.4	59.0
2005	28.7	13.7	57.5
2006	29.3	13.9	56.7
2007	29.6	14.1	56.3

Notes: Percentage shares in the worldwide output of final manufacturing products valued at purchaser's prices (before product tax). Source: Own calculations based on the WIOD, 2013 release as described in Timmer et al. (2015).

Figure 2 Value added by intangible capital (INTAN) and tangible capital (TAN) (as %-share in total value of manufacturing products).



Notes: Share of value added by intangible capital (INTAN) and tangible capital (TAN) in the worldwide value of final manufacturing products (%). The remainder of the output value is added by labor (not shown). Source: See Table 2.

Which product GVCs are the most intensive in the use of intangibles? Table 3 shows that within each product group the share of intangibles in value added has risen. Over the period from 1995 to 2007 the share increased by mere 0.4 percentage-points for paper and printed products to 14.7% for refined oil. Figure 3 shows the annual trends for seven major product GVCs, subdivided into buyer- and producer-driven GVCs.[15] There is clearly a shared upward trend (with year-to-year fluctuations), in particular since the early 2000s. But idiosyncratic patterns can be discerned. The importance of intangibles increased most for machinery (+6.0 %-points), furniture (5.4) transport equipment (5.2) and electronics (4.5). In electronics the share even declined, with a severe drop after 2000 followed by a quick recovery. We do not find clear differences between buyer- and producer-driven chains, neither in trends over time, nor in levels. All groups had intangible shares between 26 and 33 percent in 2007. But as shown below, these returns are realized in different stages of the GVC.

[15] This division is motivated by the qualitative literature on GVCs, and empirically validated by significant differences in the stage in which the intangible returns are realised, namely in the distribution stage for buyer-led GVCs and in the production stages in the producer-led GVCs (see section 4.1).

Table 3 Value added by intangible capital (as %-share in total value).

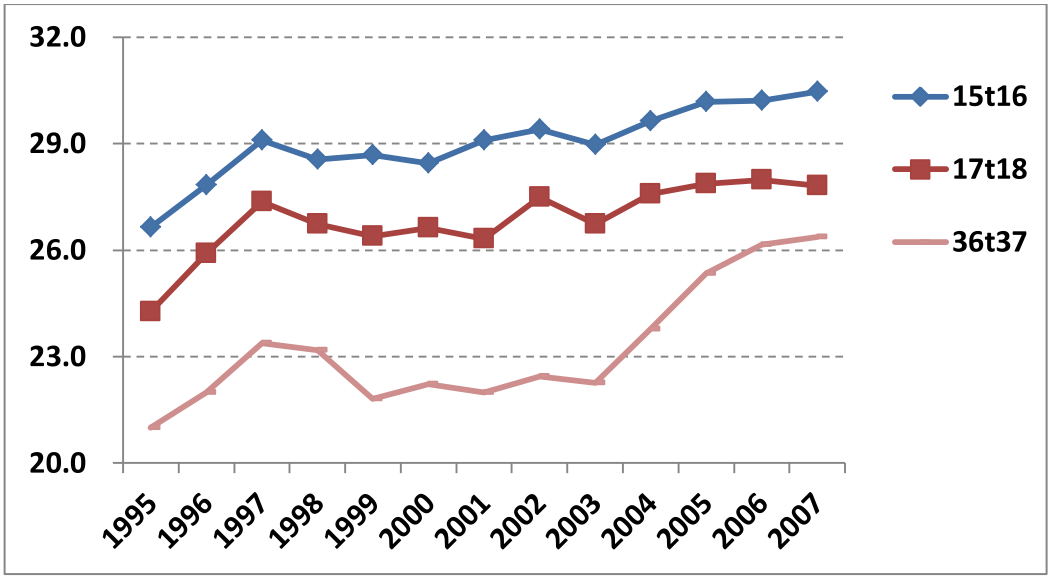
Final product group name	ISIC rev. 3 code of final industry	1995	2007	change 1995 to 2007 (%-points)
Food, beverages and tobacco	15t16	26.6	30.5	3.8
Textiles and textile products	17t18	24.3	27.8	3.6
Leather products and footwear	19	23.9	26.9	2.9
Wood and products of wood and cork	20	23.6	25.3	1.7
Pulp, paper, paper , printing and publishing	21t22	24.1	24.5	0.4
Coke, refined petroleum and nuclear fuel	23	33.0	47.8	14.7
Chemicals and chemical products	24	29.0	32.6	3.6
Rubber and plastics	25	25.0	27.7	2.7
Other non-metallic mineral	26	27.7	32.0	4.3
Basic metals and fabricated metal	27t28	24.2	31.1	7.0
Machinery, not elsewhere classified	29	21.3	27.3	6.0
Electrical and optical equipment	30t33	23.8	28.3	4.5
Transport equipment	34t35	21.9	27.1	5.2
Furniture, toys and other manufacturing.	36t37	21.0	26.4	5.4
All manufacturing products		24.6	29.6	5.0

Notes: Share of intangibles in the final output value of manufacturing products (%).

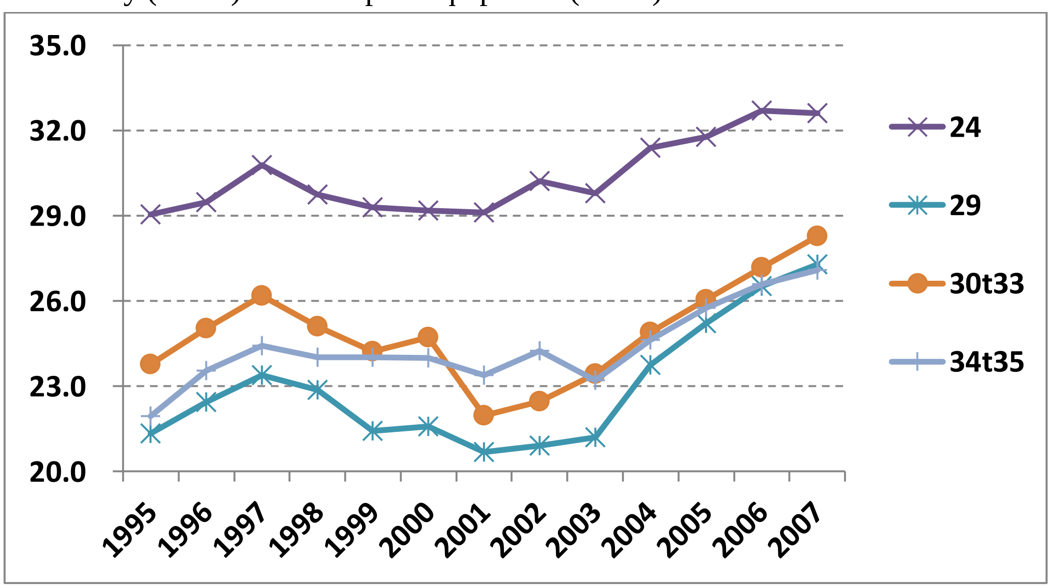
Which final products are most important in terms of intangible returns? Table 4 and Figure 4 provide additional information on the distribution of intangible returns over 14 manufacturing product groups. We provide the share of each group in the overall returns to intangibles for all groups. This is determined by the share of a group in overall consumption of manufacturing goods and the share of intangibles in its GVCs. Three product groups appear to be together responsible for more than half of the intangible returns: Food products (final output from ISIC rev.3 industry 15t16) making up 26.5% of total intangible returns in 2007, Electrical machinery and electronics (30t33, 11.8%) and Transport equipment (34t35, 14.3%). Other important product GVCs are Wearing apparel, Refined oil, Chemicals (including pharmaceuticals), Non-electrical Machinery and Furniture. As consumption expenditure patterns change only slowly, these shares do not vary much over time. Most notable is the increasing share of Refined oil, almost doubling its share. This is likely to be related to the rapid increase in fuel prices in the mid-2000s.

Figure 3 Value added by intangible capital (as %-share of total value) in each manufacturing product group.

(a) Buyer-driven GVCs: food (15t16), wearing apparel (17t18) and furniture, toys and other manufacturing products (36t37)



(b) Producer-driven GVCs: chemicals (24), non-electrical machinery (29), electrical machinery (30t33) and transport equipment (34t35)



Notes: Share of value added by intangible capital in the final output value of manufacturing product groups (in %). Source: Appendix Table 2.

Table 4 Value added by intangible capital (%-share of product group in all manufacturing products).

Final product group name	Final industry code	1995	2007	change 1995 to 2007
Food, beverages and tobacco	15t16	29.2	26.5	-2.7
Textiles and textile products	17t18	8.5	7.0	-1.5
Leather products and footwear	19	1.6	1.4	-0.2
Wood and products of wood and cork	20	0.7	0.4	-0.3
Pulp, paper, paper , printing and publishing	21t22	3.4	2.7	-0.7
Coke, refined petroleum and nuclear fuel	23	4.6	8.3	3.7
Chemicals and chemical products	24	7.0	7.3	0.3
Rubber and plastics	25	1.6	1.3	-0.3
Other non-metallic mineral	26	1.0	0.8	-0.2
Basic metals and fabricated metal	27t28	3.3	3.2	-0.1
Machinery, not elsewhere classified	29	9.3	9.6	0.3
Electrical and optical equipment	30t33	11.6	11.8	0.2
Transport equipment	34t35	12.9	14.3	1.4
Furniture, toys and other manufacturing.	36t37	5.3	5.4	0.1
All manufacturing products		100.0	100.0	

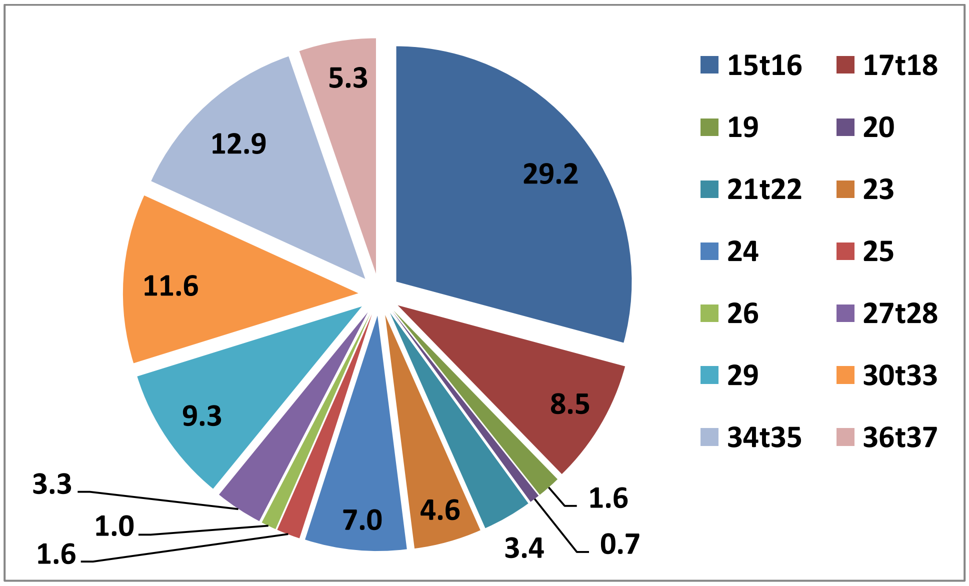
Notes: Value added by intangible capital in any stage of GVC of product groups. Expressed as share in total value added by intangible capital in the worldwide final output value of manufacturing products (%). Source: Appendix Table 4.

4.2 Decreasing importance of intangibles in final stage

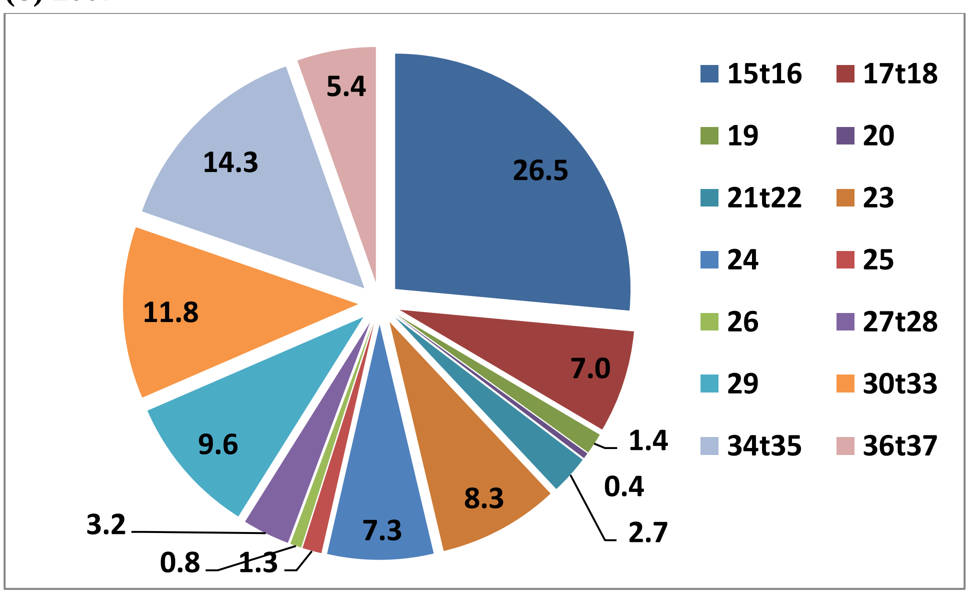
In this section we report on findings related to the stage in which returns to intangibles are realized. Using the ratio given in equation (6), we will show the shares in the distribution stage, the final stage of production and in other stages of production. Results for all manufacturing GVCs together are given in Table 5 and Figure 5. More than half of the intangible returns are realized in the non-final stages of production (51.4% in 2007). The final production stage and distribution are each responsible for about a quarter (23.8% and 24.8% in 2007). This signifies the importance of intangibles in upstream activities for manufacturing GVCs which include the production of parts, components and materials but also a wide variety of business services as well as agriculture and mining activities. Over time there is a clear shift away of intangible returns in the final production stage (- 4.5 %-points), mainly to the pre-final stages (+ 3.7 %-points) and the remainder to distribution (+0.8 %-points). This shift mainly occurred since 2000.

Figure 4 Value added by intangible capital (%-share of product group in all manufacturing products).

(a) 1995



(b) 2007



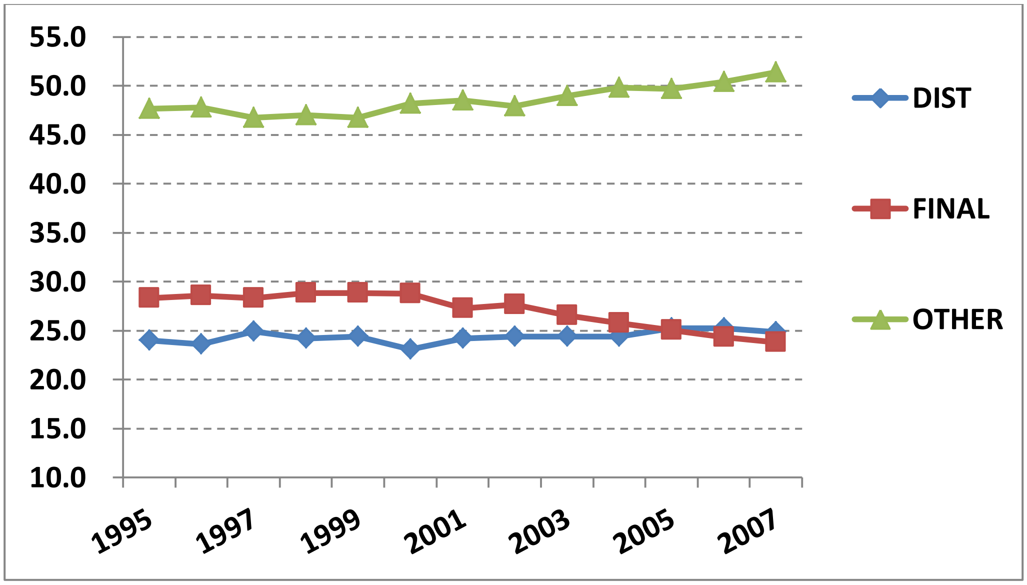
Notes: Value added by intangible capital in any stage of GVC of product groups. Expressed as share in total value added by intangible capital in the worldwide final output value of manufacturing products (%).The product groups are: Food 15t16; Wearing apparel 17t18; Footwear 19; Wood 20; Paper 21t22; Oil 23; Chemicals, 24; Rubber 25; Non-mineral 26; Steel 27t28; Machinery 29; Electrical 30t33; Transport 34t35; Furniture, toys and other 36t37. Source: Appendix Table 4.

Table 5 Share of stages in value added by intangible capital (in %).

	Distribution	Final production stage	Other production stages
1995	24.0	28.3	47.7
1996	23.6	28.5	47.8
1997	24.9	28.3	46.8
1998	24.2	28.8	47.0
1999	24.4	28.9	46.8
2000	23.1	28.7	48.2
2001	24.2	27.3	48.5
2002	24.4	27.6	47.9
2003	24.4	26.6	49.0
2004	24.4	25.8	49.8
2005	25.2	25.1	49.7
2006	25.3	24.3	50.4
2007	24.8	23.8	51.4

Notes: Value by intangible capital can be added in the final or other production stages, or in distribution to the final consumer. Expressed as share in total value added by intangible capital in the worldwide final output value of manufacturing products (%). Source: Own calculations based on the WIOD, 2013 release as described in Timmer et al. (2015).

Figure 5 Share of stages in value added by intangible capital (in %).



Notes: Value by intangible capital can be added in the final production stage (FINAL), in other production stages (OTHER) or in distribution to the final consumer (DIST). Expressed as share in total value added by intangible capital in the worldwide final output value of manufacturing products (%). Source: see Table 5.

The shift in intangible earnings away from the final production stage is shared across most manufacturing product groups, except for machinery and furniture (Table 6). Interestingly, we find sizeable differences in the direction of this shift. In buyer-driven chains, the share of intangibles in the distribution stage increased the most, while in producer-driven chains the share increased most in other production stages (Figures 6 and 7). For example, in Food GVCs the distribution share increased by 3.3 %-points while the share in other production stages by a mere 0.5%. Similar patterns are found for Wearing apparel (+6.1 versus +2.4) and Furniture (+1.9 versus -2.5). In contrast, for Chemical products the share in distribution declines (-0.1) while strongly increasing in the other production stages (+7.0). This is also found in the GVCs of Machinery (-2.4 versus + 2.4) and Transport equipment (-0.6 versus +2.6). The exception is Electronics where shares increase equally strong in both stages (+4.1 versus +4.1%).

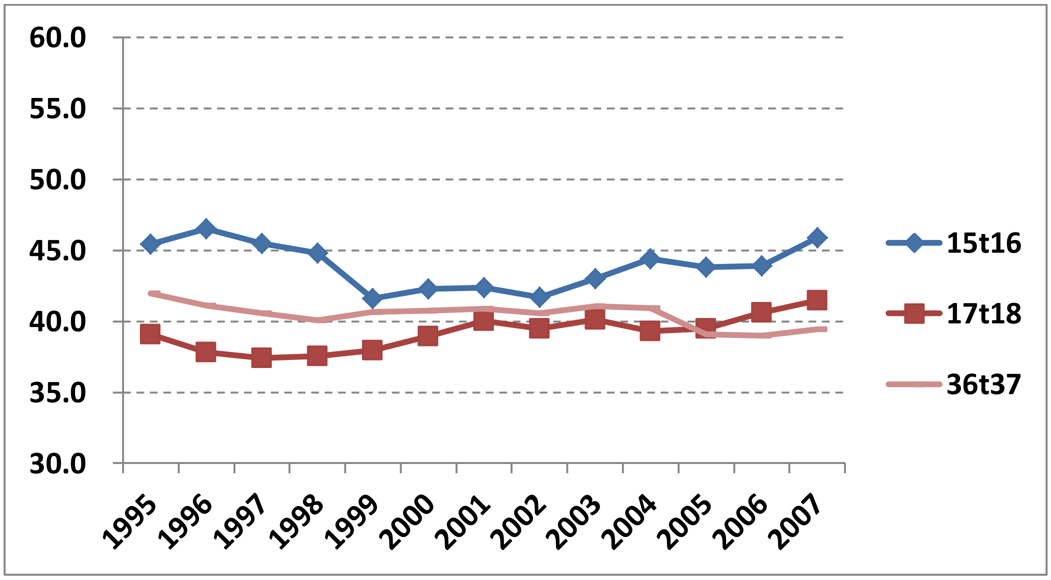
Table 6 Share of stages in total value added by intangible capital (in %), manufacturing product group.

	Distribution			**Final production stage**			**Other production stages**		
Code of final industry	1995	2007	change 1995 to 2007	1995	2007	change 1995 to 2007	1995	2007	change 1995 to 2007
15t16	24.4	27.6	3.3	30.2	26.4	-3.7	45.4	45.9	0.5
17t18	36.9	43.0	6.1	24.0	15.5	-8.5	39.1	41.5	2.4
19	34.7	41.1	6.4	18.4	13.8	-4.6	46.9	45.1	-1.8
20	9.7	19.3	9.6	31.5	23.5	-7.9	58.8	57.1	-1.7
21t22	15.7	21.3	5.7	37.5	29.6	-7.9	46.8	49.0	2.2
23	20.6	12.2	-8.3	31.4	23.5	-7.9	48.0	64.3	16.3
24	21.5	21.4	-0.1	38.2	31.3	-6.9	40.3	47.3	7.0
25	21.5	21.2	-0.3	23.6	18.4	-5.2	54.9	60.4	5.5
26	23.1	24.6	1.4	34.3	29.3	-5.1	42.5	46.2	3.6
27t28	16.1	14.8	-1.2	32.8	28.2	-4.6	51.1	57.0	5.8
29	22.7	20.3	-2.4	23.9	23.9	0.0	53.3	55.8	2.4
30t33	18.1	22.2	4.1	31.3	23.1	-8.2	50.6	54.6	4.1
34t35	20.8	20.2	-0.6	22.8	20.8	-2.0	56.4	59.0	2.6
36t37	40.0	41.9	1.9	18.1	18.7	0.6	42.0	39.4	-2.5
All	24.0	24.8	0.8	28.3	23.8	-4.5	47.7	51.4	3.7

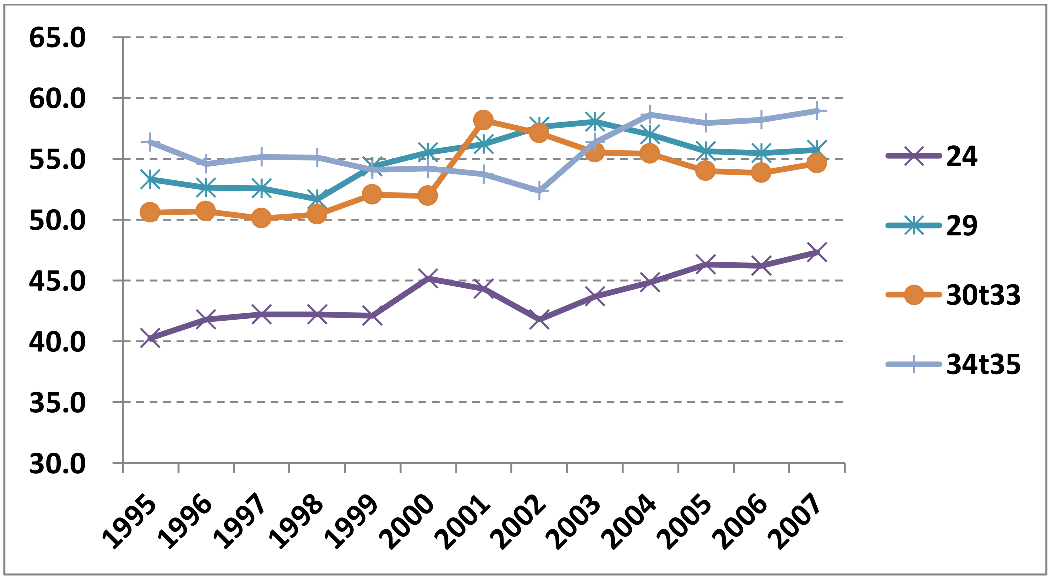
Notes: Value added by intangible capital in each stage of GVC, as share in total value added by intangibles. Source: Appendix Table 2.

Figure 6 Value added by intangible capital in non-final production stages.

(a) Buyer-driven GVCs: food (15t16), wearing apparel (17t18) and furniture, toys and other manufacturing products (36t37)



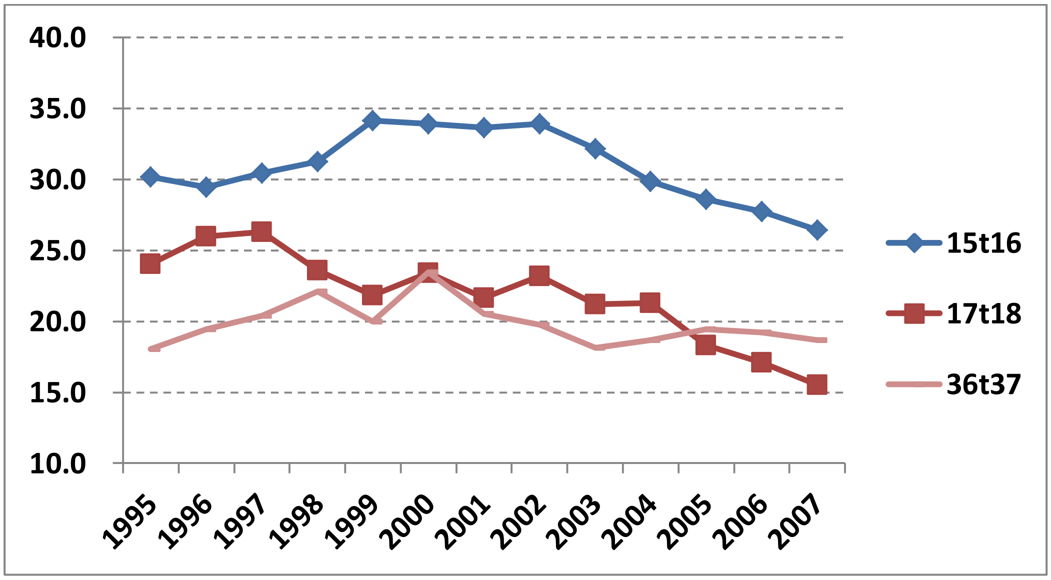
(b) Producer-driven GVCs: chemicals (24), non-electrical machinery (29), electrical machinery (30t33) and transport equipment (34t35)



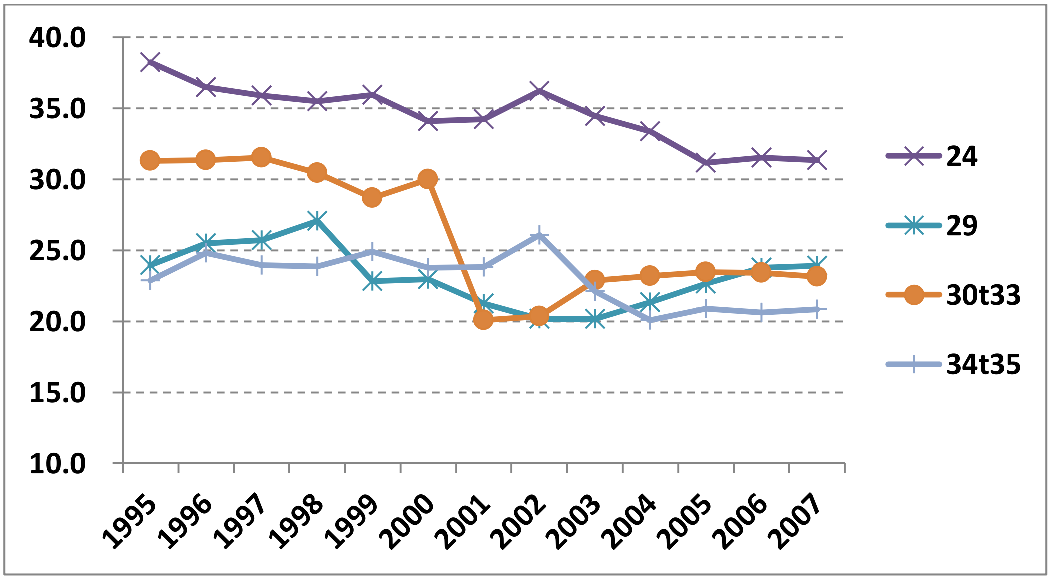
Notes: Value by intangible capital in the other (non-final) production stages. Expressed as share in total value added by intangible capital in the worldwide final output value of manufacturing products (%). Source: Appendix Table 3.

Figure 7 Value added by intangible capital in final stage.

(a) Buyer-driven GVCs: food (15t16), wearing apparel (17t18) and furniture, toys and other manufacturing products (36t37)



(b) Producer-driven GVCs: chemicals (24), non-electrical machinery (29), electrical machinery (30t33) and transport equipment (34t35)



Notes: Value by intangible capital in the final production stage. Expressed as share in total value added by intangible capital in the worldwide final output value of manufacturing products (%). Source: Appendix Table 3.

The patterns found in the data appear to be strong. In interpreting the results, one should be mindful however of the measurement problems posed by transfer pricing practices. International transaction flows, in particular between related parties, might be recorded at transfer prices that bear little relationship with the underlying value. In an analysis of all stages in a GVC (as reported on in section 4.1) this was not a problem (in principle) as transfer pricing would mainly result in shifting reported profits from one stage in the chain to another. However it might affect the attribution of returns to a specific stage and this should be kept in mind when interpreting the results on the breakdown in stages.[16] Another complicating issue is in the industrial classification of lead firms in GVCs, some of which are so-called factory-free goods producers, like Dell. If classified as manufacturers, the intangible returns are likely to show up in the production stages, while if classified as wholesalers these will be recorded in the distribution stage. Shifts over time in profit reporting practices and/or classification of firms by statistical agencies might thus affect the trends reported here.

5. Concluding remarks

While we have increasingly better grip on measuring investment flows, there is no accepted standard for appraising the worth of intangible assets and their returns. In this paper we provide a novel attempt to derive the returns to intangibles at the macro-economy level. We rely on a residual claimant approach where we derive the returns to intangibles by simply 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.

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[16] For example, compare a situation in which Apple charges the iPod assembler for the intellectual property used 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 intangibles. It will thus lead to a shift in the location of the profit in a particular stage, but not affect the overall profits to intangibles in the GVC.

Our main finding is that the share of intangibles in the value of final products has increased from 2000 onwards. This is found for all manufacturing product groups. We also find that for buyer-driven GVCs (like food, textiles and furniture) returns to intangibles are increasingly realized in the distribution stage, that is, in delivery of the final product to the consumer. In contrast, in producer-driven GVCs (like machinery, automotive and electronics) the returns are shifting to activities before the final production stage.

A potentially interesting extension of the results presented in this paper relates to patterns for GVCs for a single product group but different countries-of-finalization. The aggregation level in WIOD is high, as a consequence of which 'bulk products' within a product group are not distinguished from more custom-made products. If offshoring the assembly of bulk products to low-wage countries is much easier, the decline of returns to intangible capital in the final stage of production might be much stronger for products finalized there. Other robustness analysis would be to allow for a non-zero rate of return on tangible capital, and alternative measurement of intangible return for country-industries for which we do not have tangible stock estimates by detailed asset types.

We analysed the realised returns to intangibles and found a strong upward trend in its share in the value of manufacturing products. At the same time investments in intangibles probably increased, for example in order to organize the associated complex supply chains. Shin et al. (2012) found that gross margins to tangibles differ across participants in the GVC of electronics, being highest in pre- and post-production stages. However, they suggest that the (fixed) costs of sustaining a position on either end of the GVC is so high that ultimately returns on investment might very well be similar across all activities. Without additional information on these investments, one cannot determine possible changes in rate of return to intangible investments as opposed to changes in the volume of intangible assets.

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. The development work done by the OECD is certainly a step in the right direction.[17] From the perspective of measuring intangibles' returns, one of the biggest challenge is in the concept and measurement of trade in services of intangibles. Part of these cross-border transactions are market mediated and potentially measurable. But in many cases there is no recorded flow of payments for the use of intangibles within a particular GVC. This is compounded by transfer pricing and other tax evasion practices of multi-national enterprises. As argued above this might be particular binding in determination of the stage in which intangible returns are realized. We also noted the crude nature of current available data on distribution margins which lacks specificity and typically refers to very broad product groups including both domestic and imported goods. Related to this is the classification of factory-free producers. The stage in which the profits are recorded is likely to depend on the industry in which the lead firm (with most of the intangible capital in the GVC) is classified. For example, if a firm like Dell is considered to be a manufacturer rather than a wholesaler, the profits would not be recorded in the distribution stage.

Can these measurement challenges be overcome? We believe that a global value chain framework provides useful suggestions for improving our understanding of intangibles through the national accounts. This is shared by important developments in the international statistical community. Recently, the UNUCE published its *Guide to Measuring Global Production*. Building on this new initiatives are thriving, 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

[17] 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.

extended supply and use tables) as well as expanding survey information on value-added chains and firm characteristics. In the longer terms 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).[18] A deeper understanding of the workings of global value chains is needed before our measurement systems will adequately capture the importance of intangibles in our economy.

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DATA APPENDIX - THE WORLD INPUT-OUTPUT DATABASE (WIOD)[19]

To implement the new GVC metrics, one needs to have a database with linked consumption, production, and income flows within and between countries. For individual countries, this type of information can be found in input-output tables. However, national tables do not provide any information on bilateral flows of goods and services between countries. For this type of information researchers have to rely on data sets constructed on the basis of national input-output tables in combination with international trade data. For this paper, we use the World Input-Output Database (WIOD), 2013 release, that aims to fill this gap. The WIOD provides a time series of world input-output tables from 1995 onwards, distinguishing between 35 industries and 59 product groups. In this Appendix we outline the basic concepts and construction of our world input-output tables.

Basically, a world input-output table (WIOT) is a combination of national input-output tables in which the use of products is broken down according to their origin. In contrast to the national input-output tables, this information is made explicit in the WIOT. For each country, flows of products both for intermediate and final use are split into domestically produced or imported. In addition, for imports, the WIOT shows which foreign *industry* produced the product. This is illustrated by the schematic outline for a WIOT in Appendix Figure 1. It illustrates the simple case of three regions: Countries A and B, and the rest of the world. In the WIOD we will distinguish 40 countries and the rest of the World, but the basic outline remains the same.

The rows in the WIOT indicate the use of output from a particular industry in a country. This can be intermediate use either in the country itself (use of domestic output) or by other countries (in which case it is exported). Output can also be for final use, either by the country itself (final use of domestic output) or by other countries (in which case it

[19] The text in this Appendix is based on Timmer, M., Los, B., & de Vries, G. (2015). "Incomes and Jobs in Global Production of Manufactures: New Measures of Competitiveness Based on the World Input-Output Database". In S.N. Houseman, & M. Mandel (Eds.), Measuring Globalization: Better Trade Statistics for Better Policy, Vol. 2, 121-163, Kalamazoo: W.E. Upjohn Institute for Employment Research.

is exported).[20] Final use is indicated in the right side of the table, and this information can be used to measure the C matrix defined in Section 2. The sum over all uses is equal to the output of an industry, denoted by Q in Section 2.

Appendix Figure 1 Schematic Outline of World Input-Output Table (WIOT)

		Country A Intermediate *Industry*	Country B Intermediate *Industry*	Rest of World Intermediate *Industry*	Country A Final domestic	Country B Final domestic	Rest of Final domestic	Total
Country A	*Industry*	Intermediate use of domestic output	Intermediate use by B of exports from A	Intermediate use by RoW of exports from A	Final use of domestic output	Final use by B of exports from A	Final use by RoW of exports from A	Output in A
Country B	*Industry*	Intermediate use by A of exports from B	Intermediate use of domestic output	Intermediate use by RoW of exports from B	Final use by A of exports from B	Final use of domestic output	Final use by RoW of exports from B	Output in B
Rest of World (RoW)	*Industry*	Intermediate use by A of exports from RoW	Intermediate use by B of exports from RoW	Intermediate use of domestic output	Final use by A of exports from RoW	Final use by B of exports from RoW	Final use of domestic output	Output in RoW
		Value added	Value added	Value added				
		Output in A	Output in B	Output in RoW				

A fundamental accounting identity is that total use of output in a row equals total output of the same industry, as indicated in the respective column in the left-hand part of the table. The columns convey information on the technology of production, as they indicate the amounts of intermediate and factor inputs needed for production. The intermediates can be sourced from domestic industries or imported. This is the B matrix from Section 2. The residual between total output and total intermediate inputs is value-added. This is made up by compensation for production factors. It is the direct contribution of domestic factors to output.

As building blocks for the WIOT, national supply and use tables (SUTs) were used; these are the core statistical sources from which NSIs derive national input-output tables. In short, we derive time series from national SUTs. Benchmark national SUTs are

[20] Final use includes consumption by households, government and nonprofit organisations, and gross capital formation.

linked over time through the use of the most recent National Accounts statistics on final demand categories, as well as through the use of gross output and value-added by detailed industry. This ensures both intercountry and intertemporal consistency of the tables. As such, the WIOT is built according to the conventions of the System of National Accounts and obeys various important accounting identities. National SUTs are linked across countries through detailed international trade statistics to create so-called international SUTs. This is based on a classification of bilateral import flows by end-use category (intermediate, consumer, or investment), in which intermediate inputs are split by country of origin. These international SUTs are used to construct the symmetric world input-output of the industry-by-industry type. Dietzenbacher et al. (2013) provide an in-depth technical discussion.

The construction of the WIOT has a number of distinct characteristics. First, we rely on national supply and use tables (SUTs) rather than input-output tables as our basic building blocks. SUTs are a natural starting point for this type of analysis, as they provide information on both products and industries. A supply table provides information on products produced by each domestic industry, and a use table indicates the use of each product by an industry or final user. The linking with international trade data, which is product-based, and with factor use, which is industry-based, can be naturally made in an SUT framework.[21]

Ideally, we would like to use official data on the destination of imported goods and services. But in most countries these flows are not tracked by statistical agencies. Nevertheless, most do publish an import I/O table constructed with the import proportionality assumption, applying a product's economy-wide import share for all use categories. For the United States, researchers have found that this assumption can be rather misleading, in particular at the industry level (Feenstra and Jensen 2012; Strassner, Yuskavage, and Lee 2009). Therefore, we are not using the official import matrices but instead use detailed trade data to make a split. Our basic data are the bilateral import flows of all countries covered in WIOD from all partners in the world at the HS6-digit product level, taken from the UN COMTRADE database. Based on the detailed

[21] Because industries also have secondary production, a simple mapping of industries and products is not feasible.

description, products are allocated to three use categories: 1) intermediates, 2) final consumption, and 3) investment, effectively extending the UN Broad Economic Categories (BEC) classification. We find that import proportions differ widely across use categories and, importantly, also across country of origin. For example, imports by the Czech car industry from Germany contain a much higher share of intermediates than imports from Japan. This type of information is reflected in our WIOT by using detailed bilateral trade data. The domestic use matrix is derived as total use minus imports. Another novel element in the WIOT is the use of data on trade in services. As yet, no standardized database on bilateral service flows exists. These have been collected from various sources (including the OECD, Eurostat, the IMF and the WTO), checked for consistency, and integrated into a bilateral service trade database.

Value added and factor incomes

The WIOD includes data on hours worked and compensation for three labor types and data on capital stocks and compensation. These series are not part of the core set of national accounts statistics reported by NSIs, and additional material has been collected from employment and labor force statistics. For each country covered, we chose what we considered the best statistical source for consistent wage and employment data at the industry level. In most countries, this was the labor force survey (LFS). In most cases this needed to be combined with an earnings survey, as information on wages is often not included in the LFS. In other instances, an establishment survey or social security database was used. Care has been taken to arrive at series which are time-consistent, as most employment surveys are not designed to track developments over time, and breaks in methodology or coverage frequently occur.

Labor compensation of self-employed persons is not registered in the National Accounts, which, as emphasised by Krueger (1999), leads to an understatement of labor's share. This is particularly important for less advanced economies, which typically feature a large share of self-employed workers in industries like agriculture, trade, business, and personal services. We make an imputation by assuming that the compensation per hour of self-employment is equal to the compensation per hour of employees. For most advanced countries, labor data is constructed by extending and updating the EU KLEMS database (www.euklems.org) using the methodologies, data sources, and concepts described in O'Mahony and Timmer (2009). For other countries additional data has been collected according to the same principles. Capital compensation is derived as gross value-added minus labor compensation as defined above. This is the gross operating surplus (in national accounting terms), including profits and depreciation allowances.

For this paper we split it into returns to tangible and intangible assets as described in section 3 in the main text. For countries for which detailed capital stock data by asset type KT_{ij} was available through the EUKLEMS database, we measure r^{KT} as the depreciation rate for detailed asset types j such that $r_i^{KT}\, KT_i = \sum_j \delta_j^{KT}\, KT_{ij}$. For the other countries we only had overall capital stock KT_i from the WIOD Socio-Economic Accounts. This was used to back out their tangible capital compensation. In WIOD-SEA, we have data on GFCF, GFCF_P (the investment price deflator), and GFCF_K (real gross fixed capital stock at 1995 price). Based on the perpetual inventory method with only the rate of depreciation unknown, we backed it out by noting that: GFCF_K_t =(1- δ) x GFCF$_{K_{1995}} + GFCF_t/GFCF_P$.

Appendix table 1 Value added by labour, intangible and tangible capital in distribution and production of manufacturing goods.
(1a) 1995

	Distribution value added				**Final production stage value added**				**Other production stages value added**				**Final output at purcha-ser's prices**
	Total	Intangible capital (INTAN)	Tangible capital (TAN)	Labour	*Total*	Intangible capital (INTAN)	Tangible capital (TAN)	Labour	*Total*	Intangible capital (INTAN)	Tangible capital (TAN)	Labour	
15t16	29.8	6.5	2.2	21.1	23.7	8.0	4.5	11.1	46.5	12.1	6.1	28.3	2,436,905
17t18	39.0	8.9	2.8	27.3	26.6	5.8	3.5	17.3	34.4	9.5	4.9	20.0	784,490
19	35.0	8.3	2.5	24.2	22.7	4.4	3.0	15.3	42.3	11.2	6.0	25.0	148,363
20	11.5	2.3	0.8	8.4	36.4	7.4	3.9	25.1	52.1	13.9	7.4	30.8	64,586
21t22	18.6	3.8	1.4	13.5	39.3	9.0	6.4	23.9	42.1	11.3	6.2	24.6	310,537
23	32.4	6.8	2.4	23.1	18.4	10.4	3.8	4.3	49.2	15.9	11.8	21.6	312,328
24	28.4	6.2	2.0	20.2	30.0	11.1	4.6	14.4	41.6	11.7	6.7	23.1	534,624
25	23.7	5.4	1.7	16.7	29.5	5.9	5.4	18.2	46.8	13.7	7.1	25.9	143,381
26	24.9	6.4	1.8	16.7	35.0	9.5	6.0	19.4	40.1	11.8	7.0	21.4	83,136
27t28	16.7	3.9	1.2	11.6	38.6	7.9	6.9	23.8	44.7	12.4	7.5	24.9	300,453
29	22.8	4.8	1.7	16.2	31.7	5.1	4.2	22.4	45.5	11.4	6.9	27.3	970,469
30t33	20.7	4.3	1.5	14.9	33.0	7.4	5.0	20.6	46.3	12.0	7.0	27.3	1,088,418
34t35	19.6	4.6	1.4	13.7	29.1	5.0	4.6	19.5	51.3	12.4	7.5	31.5	1,308,914
36t37	44.6	8.4	3.3	33.0	21.5	3.8	2.5	15.3	33.8	8.8	5.1	19.9	559,638
Total	27.2	5.9	2.0	19.3	28.1	7.0	4.4	16.6	44.7	11.7	6.6	26.4	9,046,242

Notes: Value added in the worldwide final output value of manufacturing products. Final output in US$. Own calculations based on the WIOD, 2013 release as described in Timmer et al. (2015).

(1b) 2007.

	Distribution value added				Final production stage value added				Other production stages value added				Final output at purchaser's prices
	Total	Intangible capital (INTAN)	Tangible capital (TAN)	Labour	*Total*	Intangible capital (INTAN)	Tangible capital (TAN)	Labour	*Total*	Intangible capital (INTAN)	Tangible capital (TAN)	Labour	
15t16	30.7	8.4	2.2	20.0	22.7	8.1	4.2	10.4	46.7	14.0	6.0	26.6	3,904,303
17t18	41.0	12.0	3.1	26.0	23.0	4.3	6.0	12.7	35.9	11.5	5.7	18.7	1,136,582
19	37.7	11.0	2.9	23.8	20.6	3.7	4.6	12.3	41.7	12.1	6.9	22.8	240,800
20	19.1	4.9	1.4	12.8	31.8	6.0	5.0	20.8	49.2	14.5	7.1	27.6	69,811
21t22	22.0	5.2	1.7	15.1	35.0	7.3	6.7	21.1	43.0	12.0	7.0	24.0	490,226
23	20.4	5.8	1.4	13.1	17.1	11.2	2.6	3.3	62.5	30.7	9.5	22.3	780,691
24	28.3	7.0	2.1	19.2	25.6	10.2	4.0	11.4	46.2	15.4	7.3	23.5	1,003,419
25	21.7	5.9	1.6	14.3	27.2	5.1	5.9	16.2	51.1	16.7	8.4	25.9	214,586
26	25.5	7.9	1.7	16.0	32.0	9.4	5.8	16.9	42.5	14.8	6.8	20.9	108,964
27t28	16.5	4.6	1.1	10.7	31.9	8.8	5.7	17.4	51.6	17.7	8.5	25.4	467,291
29	20.2	5.5	1.5	13.1	28.7	6.5	4.4	17.8	51.1	15.2	8.8	27.1	1,578,092
30t33	22.1	6.3	1.6	14.2	27.4	6.5	5.0	15.8	50.5	15.5	9.3	25.8	1,875,747
34t35	18.0	5.5	1.2	11.3	25.7	5.6	4.8	15.2	56.3	16.0	9.1	31.2	2,370,388
36t37	45.3	11.0	3.6	30.7	20.2	4.9	3.2	12.1	34.5	10.4	5.5	18.6	922,947
Total	26.7	7.4	1.9	17.4	25.0	7.1	4.6	13.3	48.3	15.2	7.6	25.5	15,163,847

Notes: Value added in the worldwide final output value of manufacturing products. Final output in US$. Own calculations based on the WIOD, 2013 release as described in Timmer et al. (2015).

Appendix table 2 Value added by intangible capital (as %-share of total value), manufacturing product groups.

Name	ISIC rev. 3	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Food	15t16	26.6	27.8	29.1	28.6	28.7	28.4	29.1	29.4	29.0	29.6	30.2	30.2	30.5
Wearing apparel	17t18	24.3	25.9	27.4	26.7	26.4	26.6	26.3	27.5	26.7	27.6	27.9	28.0	27.8
Footwear	19	23.9	24.8	16.2	25.2	24.8	25.0	26.9	25.8	25.9	25.9	26.6	26.4	26.9
Wood	20	23.6	24.4	25.6	24.4	23.4	23.6	23.3	22.7	23.0	24.0	23.9	23.9	25.3
Paper	21t22	24.1	24.7	24.8	24.3	25.1	24.5	23.9	24.5	23.7	25.2	25.4	25.0	24.5
Oil	23	33.0	35.7	37.4	35.1	35.0	40.6	41.1	41.0	43.1	46.1	48.2	48.5	47.8
Chemicals	24	29.0	29.5	30.8	29.7	29.3	29.2	29.1	30.2	29.8	31.4	31.8	32.7	32.6
Rubber	25	25.0	26.9	28.5	27.0	26.3	25.9	25.5	26.0	25.3	26.7	27.0	27.6	27.7
Non-mineral	26	27.7	29.5	30.7	29.0	29.3	29.8	29.4	29.7	29.2	30.2	30.6	32.2	32.0
Steel	27t28	24.2	25.6	26.9	24.7	23.6	25.0	23.9	24.4	25.0	28.2	29.5	30.4	31.1
Machinery	29	21.3	22.4	23.4	22.9	21.4	21.6	20.7	20.9	21.2	23.7	25.2	26.5	27.3
Electrical	30t33	23.8	25.0	26.2	25.1	24.2	24.7	22.0	22.5	23.4	24.9	26.1	27.2	28.3
Transport	34t35	21.9	23.6	24.4	24.0	24.0	24.0	23.4	24.3	23.2	24.6	25.8	26.6	27.1
Furniture and other	36t37	21.0	22.0	23.4	23.2	21.8	22.2	22.0	22.4	22.3	23.8	25.3	26.2	26.4
Total manufacturing		24.6	25.9	26.6	26.3	25.9	26.2	25.9	26.4	26.2	27.7	28.7	29.3	29.6

Notes: Share of value added by intangible capital in the worldwide final output value of manufacturing product groups (in %). Own calculations based on the WIOD, 2013 release as described in Timmer et al. (2015).

Appendix table 3 Value added by intangible capital in final stage (as %-share of all stages), manufacturing product groups.

Name	ISIC rev. 3	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Food	15t16	30.2	29.4	30.4	31.2	34.1	33.9	33.7	33.9	32.2	29.8	28.6	27.7	26.4
Wearing apparel	17t18	24.0	26.0	26.3	23.6	21.8	23.4	21.7	23.2	21.2	21.3	18.3	17.1	15.5
Footwear	19	18.4	19.2	9.4	16.7	16.0	16.1	20.5	16.7	18.5	16.4	15.7	13.3	13.8
Wood	20	31.5	29.5	31.3	31.6	31.0	30.9	30.4	26.8	27.1	26.2	25.2	22.2	23.5
Paper	21t22	37.5	37.7	36.1	36.9	42.3	39.2	36.8	37.5	34.5	35.5	34.8	31.3	29.6
Oil	23	31.4	28.8	28.3	31.6	24.4	23.4	26.4	22.2	26.6	27.6	26.2	23.2	23.5
Chemicals	24	38.2	36.5	35.9	35.5	36.0	34.1	34.2	36.2	34.4	33.4	31.2	31.5	31.3
Rubber	25	23.6	26.8	28.0	26.7	26.6	24.8	24.5	24.7	22.7	21.9	20.6	18.9	18.4
Non-mineral	26	34.3	34.2	34.2	32.8	33.5	32.1	30.8	31.5	30.8	30.8	29.0	29.9	29.3
Steel	27t28	32.8	33.1	33.4	31.3	29.1	31.1	27.2	26.4	27.7	29.6	29.3	28.1	28.2
Machinery	29	23.9	25.5	25.7	27.1	22.8	22.9	21.2	20.2	20.1	21.3	22.6	23.7	23.9
Electrical	30t33	31.3	31.3	31.5	30.5	28.7	30.0	20.1	20.3	22.8	23.2	23.5	23.4	23.1
Transport	34t35	22.8	24.8	23.9	23.9	24.9	23.8	23.8	26.0	22.1	20.1	20.9	20.6	20.8
Furniture and other	36t37	18.1	19.4	20.4	22.1	20.0	23.4	20.5	19.8	18.1	18.7	19.5	19.2	18.7
Total manufacturing		28.3	28.5	28.3	28.8	28.9	28.7	27.3	27.6	26.6	25.8	25.1	24.3	23.8

Notes: Value by intangible capital in the final production stage. Expressed as share in total value added by intangible capital in the worldwide final output value of manufacturing products (%).Own calculations based on the WIOD, 2013 release as described in Timmer et al. (2015).

Appendix table 4 Value added by intangible capital (%-share of product group in all manufacturing products).

Name	ISIC rev. 3	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Food	15t16	29.2	28.9	28.1	28.7	29.4	28.2	30.1	29.9	29.5	28.2	27.4	26.4	26.5
Wearing apparel	17t18	8.5	8.4	8.2	8.3	8.1	8.0	8.1	8.1	7.9	7.5	7.2	7.1	7.0
Footwear	19	1.6	1.6	3.1	1.5	1.5	1.4	1.6	1.5	1.6	1.5	1.4	1.4	1.4
Wood	20	0.7	0.6	0.7	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
Paper	21t22	3.4	3.3	3.1	3.2	3.4	3.3	3.3	3.3	3.2	3.2	3.0	2.8	2.7
Oil	23	4.6	5.2	5.2	4.9	4.7	6.2	6.4	5.8	6.5	7.2	8.3	8.6	8.3
Chemicals	24	7.0	6.9	6.9	7.1	7.2	6.9	7.3	7.9	7.9	7.9	7.5	7.5	7.3
Rubber	25	1.6	1.6	1.6	1.5	1.5	1.4	1.4	1.4	1.3	1.4	1.4	1.4	1.3
Non-mineral	26	1.0	1.1	1.1	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.8	0.8	0.8
Steel	27t28	3.3	3.2	3.1	2.8	2.5	2.7	2.4	2.4	2.6	2.9	3.0	3.2	3.2
Machinery	29	9.3	9.2	8.7	9.0	8.2	8.4	7.9	7.6	8.0	8.6	9.0	9.3	9.6
Electrical	30t33	11.6	11.7	11.9	11.9	12.0	12.9	11.0	10.4	10.8	11.0	11.0	11.6	11.8
Transport	34t35	12.9	13.0	13.0	13.8	14.6	13.8	13.7	14.5	14.0	14.0	14.1	14.1	14.3
Furniture and other	36t37	5.3	5.4	5.4	5.7	5.4	5.3	5.4	5.6	5.4	5.3	5.4	5.5	5.4
Total manufacturing		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Notes: Value added by intangible capital in any stage of GVC of product groups. Expressed as share in total value added by intangible capital in the worldwide final output value of manufacturing products (%). Own calculations based on the WIOD, 2013 release as described in Timmer et al. (2015).