Knowledge Intensity in a Set of Latin American Countries: Implications for Productivity

Matilde Mas
University of Valencia and Ivie
André Hofman
University of Santiago de Chile
Eva Benages
University of Valencia and Ivie[1]

Abstract

This article proposes to measure the knowledge intensity of economies with an alternative approach to those based on the aggregation of industries according to their R&D expenditure or the qualification of the workforce. The proposed metric is based on the economic valuation of productive services provided by a set of assets that incorporate knowledge, specifically human capital and information and communication technologies (ICT). Rather than using a single indicator to measure knowledge intensity, we follow an economic approach rooted in a growth accounting methodology, determining the contribution of each individual asset according to the prices of the services they provide. This methodology is applied to four Latin-American (LA) countries, namely Brazil, Chile, Colombia and Mexico, taking the United States and Spain as benchmarks for the period 2000-2016.

Knowledge economy is the term applied to describe an economy where a considerable share of production is based on accumulated knowledge. Despite this term being frequently used, there is no metric that accurately measures how much economic value stems from knowledge. The most widely-used approach classifies productive activities into several categories according to technological intensity, usually on the basis of R&D

1 Matilde Mas is Professor of Economic Analysis at the Universitat de València and Director of International Projects of the Ivie. André Hofman is Professor at USACH, University of Santiago de Chile and coordinator of the LAKLEMS project. Eva Benages is Research Technician at the Ivie and Adjunct Professor at the Universitat de València. Emails: matilde.mas@ivie.es; andre.hofman53@gmail.com; eva.benages@ivie.es.

expenditure or high-skilled labour.[2] Calculations are then made on the percentage that these activities represent in total employment or production.

It is clear that knowledge is generated and disseminated by educated and intelligent individuals. However, it is not only our discoveries of today that matter but the knowledge accumulated by humanity over time. Thus, when measuring the weight of knowledge in the production of goods or services we should concentrate, not only on current discoveries, but on all human capital used in the process, both directly and indirectly, i.e., including that which has been incorporated into capital goods and intermediate products.

There are three important limitations regarding conventional measures of knowledge intensity. The first is that it focuses on the current creation of knowledge rather than how the productive system uses it, which is crucial to analysing certain problems.

The second is that it uses classifications of knowledge intensity in activities based on a single factor: R&D expenditure in the case of manufacturing, and human capital with higher education in services industries. Knowledge, however, is incorporated into production through various channels: qualified labour in general, some capital assets and intermediate inputs. The weight that each of these carries in industries is different, and, therefore, classifying activities based on a single criterion could bias the results.

The third major limitation is that the incorporation of knowledge varies from one country to another within the same industry. The reality is that knowledge is (more or less) present in all industries and not only in those defined as high or medium technology in the usual classifications, which in turn have different degrees of knowledge intensity by country.

In Latin America several studies analyse the growth of trade in knowledge-intensive services. López *et al.* (2014) in their analysis of Latin American competitiveness use this approach in combination with the deployment of ICT. They use segments of information on knowledge-intensive services based on the available data on trade in the following segments: business and professional services, software and informa-

2 See, for example, the definition of KIS (Knowledge Intensive Services) and HTech (High Technology Manufacturing) or KIA classification (Knowledge Intensive Activities), which are used by Eurostat in its "Science, technology, digital society statistics," available at: http://ec.europa.eu/eurostat/data/database. OECD (2015) uses these classifications as well. See also the Tradecan (Trade Competitive Analysis of Nations) methodology, which was developed in 1990 by the Economic Commission for Latin America and the Caribbean (ECLAC).

tion services, and audiovisual, cultural and personal services. Others draw upon the available evidence in the theoretical and empirical literature to assess the position occupied by Latin America in the various areas that have an impact on its competitiveness in those sectors (López and Ramos, 2013).

Other studies examine the knowledge economy through a set of indicators which includes several approaches to measuring the presence of knowledge in productive activities and societies. In addition, in recent years it has become more common to focus on the so-called digital economy and thus, on the analysis of indicators related to the development and diffusion of new technologies. However, these measures are partial as they only take into account a part of what we call the knowledge economy, a broader concept that not only focuses on the use of digital computing technologies, but on the different kinds of productive inputs with a particular degree of knowledge-intensity. In some cases, synthetic indices of the development of knowledge or digitalization—both in the economic system and society—are elaborated, including multiple variables which are aggregated according to statistical criteria or ad hoc weights. However, as stated above, many of these indices are usually partial[3] and have an ambiguous meaning, given that they are not derived from a metric based on clear definitions and evaluation criteria, nor on a precise structure of relationships between variables. In this sense, business accounting and the system of national accounts have advantages for the aggregation, which is based on the relative prices of goods or factors.

This article explores whether it is possible to assess the intensity with which knowledge is used—not its generation or creation—within economies by means of a methodology that is integrated into the conceptual schema, measurement criteria and information systems of national accounts. To answer this question, we can take two different approaches: the development of knowledge satellite accounts and the development of knowledge accounting.

Regarding the first option, the complexity and data requirements of satellite accounts are considerable, given that they aspire to build an in-

3 Some examples are the KEI and KAM indicators published by the World Bank (see Chen and Dahlman (2006) and World Bank (2008a, 2008b) for more details) or the Digital Economy and Society Index (DESI) developed by the European Commission (see more details at: https://ec.europa.eu/digital-single-market/en/desi). All of them take into account different economic and social dimensions to measure the development of the knowledge economy, but exclude some important areas, such as physical capital endowments, institutional characteristics of the labour markets, etc., which may be relevant.

tegrated system that quantifies all dimensions and elements present in the dynamics of a knowledge-based economy. Because of that, although some official statistics institutes have taken preliminary steps in developing such knowledge satellite accounts,[4] they are not available for the majority of countries.

The second alternative takes advantage of the important theoretical and empirical advances achieved in the measurement of physical and human capital (Jorgenson *et al.*, 1987). We have chosen to go in this direction, proposing to measure the weight of knowledge in GDP by calculating the market value of a set of knowledge-based inputs which are incorporated in the production processes. The cornerstone of this approach is the analytical structure of modern growth accounting, which allows us to differentiate the value of various types of physical and human capital service inputs. This methodology was initially proposed by Pérez and Benages (2012) and applied to all the European countries included in the EU KLEMS database. Maudos, Benages and Hernández (2017) updated and expanded this methodology applying it to the Spanish regions for which KLEMS-type data is available.

The proposed methodology can be applied today to those economies whose national accounts systems offer industry data on various types of labour and capital services and their corresponding compensation. Databases that allow these estimates to be carried out have been created and harmonized by projects developed within the framework of WORLD KLEMS, devoted to examining total factor productivity and sources of economic growth.[5] In our case, we will make use of the recently released LAKLEMS database containing information for four Latin-American countries: Brazil, Chile, Colombia and Mexico.

There are many questions we are interested in answering in this study. Is the value added generated by the factors of production incorporating knowledge high enough to speak of knowledge economies? What differences can we observe in the weight of knowledge among industries and among countries? What is the time evolution of knowledge intensity by industry and by economy? Do activities and countries converge in knowledge intensity? How important are knowledge-based factors to the growth of economies and their levels of labour productivity?

4 See Haan and van Rooijen-Horsten (2003) and van Rooijen-Horsten *et al.* (2008).

5 See http://www.worldklems.net/.

To address these issues, the article is structured as follows. Section 1 explores the methodological approach adopted in the context of related economic literature, while section 2 reviews the statistical data, its sources and coverage. Section 3 presents the results both at the aggregate level and for the nine industries for which information is available. Finally, section 4 sets out the main conclusions.

Calculating Knowledge Intensity: Methodological Approach

The most widely-used approach for measuring knowledge intensity in economies is based on classifying manufacturing industries according to technology intensity—measured by the weight of R&D expenditure in relation to GDP—and services industries according to the use of human capital—measured by the percentage of staff with higher education (OECD, 2015; Eurostat, 2013). The first one, the weight of R&D, responds better to the objective of analysing the intensity in which knowledge is created rather than how much knowledge is used. In fact, the classification of manufacturing according to technological intensity was conceived for another purpose: to assess the origin of exogenous technological progress and its role in growth and competitiveness. The focus on R&D activities is justified since technology-intensive companies and industries show a high innovative and commercial dynamism and are especially productive (Hatzichoronoglou, 1997).

It is clear that R&D activities play a key role in generating knowledge. This knowledge is incorporated in the capital assets used in the production process. Machinery and other capital goods are the key vehicles for the use of knowledge. These capital goods are previously produced incorporating the knowledge used in their own production process, and are almost always intensive in human capital and in the use of other machinery. The same can be said of some intermediate products, although the degree in which they incorporate knowledge varies to a greater extent than in the case of machinery.

Since our objective is to measure the weight of knowledge used in current production, we should not concentrate solely on the discoveries of today but rather on all the knowledge accumulated in capital assets throughout time. It is not a question of measuring knowledge but rather which part of the economic value of production remunerates the knowledge accumulated in the used inputs.

The refinement provided by the concept of productive capital offers a greater precision for measuring capital services and allows us to approximate the accounting of knowledge incorporated in the capital stock. Other analytical and statistical improvements in the methodology for measuring assets and their productive services are a consequence of a greater accuracy in aggregation procedures, using Tornqvist indices (OECD, 2001, 2009; Jorgenson *et al.*, 1987). On account of these developments, an improved analysis is now available using sources of growth as well as key variables to estimate the value of production of assets incorporating knowledge. Developments currently underway extend the capital assets to take into account the contribution of intangible assets, many of which are also the result of knowledge accumulated by companies and their organizations.[6] A more accurate measurement of physical and human capital services better assesses the knowledge incorporated in the factors and reduces the weight of the Solow residual (Solow, 1956, 1957). These advances in growth accounting illustrate that, when the contributions of productive factors are measured more precisely, incorporated knowledge is more relevant than total factor productivity (TFP) when explaining improvements in labour productivity.[7]

The methodological and statistical framework of advanced versions of *growth accounting* offers an appropriate scheme to build an *accounting of the use of knowledge in production.* We can consider that knowledge is incorporated into production through the use of different kinds of labour, capital, and intermediate inputs. However, to simplify the presentation of the methodology and relate it to subsequent empirical findings, we only show the case in which the measurement of the product is gross domestic product (GDP) or gross value added (GVA), although the approach will be replicable in similar terms to the case of total production. Thus, we do not consider knowledge incorporated into intermediate inputs, but only content in primary inputs, namely labour and capital. Taking this into account, to assess the contribution of productive factors based on knowledge, first we have to identify which factors contain knowledge,

6 See Corrado, Hulten and Sichel (2006), Marrano and Haskel (2006), Van Ark and Hulten (2007), Fukao *et al.* (2007), Marrano, Haskel and Wallis (2007), Hulten (2008), Corrado *et al.* (2013) and Corrado, Haskel and Jona-Lasinio (2017). From our work's perspective, the services of intangible assets increase the value added generated but the income they yield could be allocated to the heart of the organizations, both to the owners of capital and labour. It is because these assets, by their nature, do not have an external market that determines their price. Therefore, their contribution can be considered to be accounted through the remuneration of other factors.

7 See Aravena, Hofman and Escobar (2018), Coremberg and Pérez (2010), Oulton (2016) and Pérez and Benages (2017) on how a more accurate measurement of productive factors impact TFP.

measure the amount used in different activities, and value their services with appropriate prices.

From this point of view, knowledge intensity in an industry is defined as the value of the knowledge services used in relation to the value of its production. Thus, it can take any value in the interval $[0,1]$. Industries are therefore not classified into categories of greater or lesser intensity, avoiding the discontinuity caused by thresholds which arbitrarily separate some groups from others. However, a certain arbitrariness is unavoidable when considering which assets include knowledge and which do not. Pérez and Benages (2012) take a broader view, considering high- and medium-skilled workers (higher and upper secondary education) as well as machinery and equipment as knowledge-based factors. Workers with basic studies and real estate capital are not considered to incorporate significant knowledge, and are consequently excluded.

An alternative view would be to consider a narrower definition for both inputs. From the capital side, the alternative is to exclude machinery and equipment assets, considering ICT and other intangible assets, besides software, already recognized by the 2008 System of National Accounts (SNA 2008): R&D, mineral explorations and entertainment, literary and artistic originals. From the labour side, a more restrictive view would adapt to the traditional approach of considering only workers with the highest level of tertiary education.

As already mentioned, the knowledge intensity of an industry can take any value in the interval $[0,1]$. One of the implications of this is that, unlike the conventional approach, knowledge intensity in an industry is not constant over time or among countries. Another implication is that the knowledge intensity of an economy is obtained from the knowledge intensity in each of its industries, as well as from the weight of value added of each branch of activity in the aggregate GVA.

Assuming that there are m types of labour and n types of capital and some of these provide knowledge services and others do not, let L_{ij} be the amount of labour of type i used in sector j; K_{hj} the amount of capital of type h used in the same sector j; P^L_{ij} is the unitary wage paid for the labour of type i in sector j; and P^K_{hj} is the user cost of type h capital in sector j. Defining the value added in real terms produced by sector j as V_j and being P^V_j its price, the value added of sector j in nominal terms $(V_j P^V_j)$ is distributed between the different inputs included in the production process so that,

$$V_j P_j^V = \sum_{i=1}^{m} L_{ij} * P_{ij}^L + \sum_{h=1}^{n} K_{hj} * P_{hj}^K \quad (1)$$

Let us assume that the price of the amount used for each type of labour depends on its productivity and that the basis for differences in productivity is the human capital that each type contains. Under these hypotheses, wages can approximate the economic value of the amount of knowledge per unit of each type of labour. According to this criterion, we can consider that the type of labour that offers a lower wage (for workers with lower education levels) does not incorporate knowledge. While the other types of labour do incorporate knowledge, though at different rates according to the number of years or level of education. Alternatively, it can be considered that only workers with tertiary education incorporate knowledge. If we generalize to allow f type of low-skilled labour, the value of labour is decomposed into two parts, the second of which measures the value of human capital services:

$$\sum_{i=1}^{m} L_{ij} * P_{ij}^L = \sum_{i=1}^{f} L_{ij} * P_{ij}^L + \sum_{i=f+1}^{m} L_{ij} * P_{ij}^L \quad (2)$$

Thus, the value of knowledge incorporated through labour (knowledge-intensive labour, KIL) would be given by:

$$KIL_j = \sum_{i=f+1}^{m} L_{ij} * P_{ij}^L \quad (3)$$

The unit value of productive services providing different kinds of labour that incorporate knowledge is not the same. For example, the production services of workers with higher education are more intensive in knowledge than in the case of workers with upper secondary education. By multiplying the amount of each type of labour by its wages, knowledge intensity can be accurately calculated when the wages are a reflection of this intensity. This criterion implies that the value of knowledge that qualified workers have does not depend on education per se but rather on their experience and how it is used by the productive system in general, which is reflected in their wages.

In terms of capital, we assume that the productivity of each asset is reflected in its user cost, which is taken into account in the calculation of the productive capital. The differences in the user cost have become more relevant due to the growing importance of ICT investment, which was a key driving force behind the disaggregation of assets and the distinction between net and productive capital (OECD, 2001, 2009).

The capital user cost has three components: the financial opportunity cost or rate of return, the depreciation rate resulting from the service life of the corresponding asset, and earnings or losses of capital arising from variations in its price. In the long-term, i.e., in the absence of price changes associated with the business cycle (Schreyer, 2009), the component of the user cost that most differentiates certain assets from others is the depreciation rate, which depends on the average service life of the assets. The service life of machinery is shorter than housing or infrastructure, while that of ICT assets is shorter than the majority of machinery and transport equipment. The materials that make up the assets and, in particular, the complexity and vulnerability to obsolescence (i.e., the technology incorporated) makes the economic life shorter (and depreciation faster). Assets that contain more knowledge tend to have a shorter economic life and a more intense depreciation, although there can be exceptions to this rule. In the language of capital theory, more depreciation means greater user cost that should be offset by a greater flow per unit of time of the asset's productive services, because otherwise the decision to invest in it would not be justified.

We assume that the content of knowledge in assets increases proportionately with its user cost. We use as a starting point the hypothesis that assets with a lower user cost —produced by the construction sector— do not incorporate knowledge in a significant way. On the other hand, we can assume that machinery and equipment do, although with the relative intensity reflected by their user cost (e.g. much higher in ICT assets). As before, a more restrictive view for capital would consider that only ICT and intangible assets incorporate knowledge in the production process.

The value added generated by physical capital is broken down into two broad categories: those that do not incorporate knowledge significantly (g assets) and those that do (n-g assets):

$$\sum_{h=1}^{n} K_{hj} * P_{hj}^{K} = \sum_{h=1}^{g} K_{hj} * P_{hj}^{K} + \sum_{h=g+1}^{n} K_{hj} * P_{hj}^{K} \quad (4)$$

Then, the value of knowledge incorporated through physical assets (*knowledge intensive capital, KIK*) would be given by:

$$KIK_j = \sum_{h=g+1}^{n} K_{hj} * P_{hj}^{K} \quad (5)$$

And the value of knowledge-intensive factors or value added based on knowledge (*knowledge intensive value, KIV*) of activity *j* will therefore be:

$$KIV_j = KIL_j + KIK_j \quad (6)$$

The relative knowledge intensity ($\%KIV_j$) of activity *j* is defined as

$$\%KIV_j = \frac{KIL_j + KIK_j}{V_j P_j^V} \quad (7)$$

Given the knowledge content of each industry, the knowledge intensity of an economy depends on the weight of the various branches in the aggregate. If *q* industries exist, the knowledge intensity of the economy as a whole ($\%KIV$) is defined as,

$$\%KIV = \sum_{j=1}^{q} \%KIV_j * \frac{V_j P_j^V}{\sum_{j=1}^{q} V_j P_j^V} \quad (8)$$

The exercises presented later in the article adopt the most restrictive version for measuring the knowledge economy presented in this section. That is, for labour it considers only tertiary-educated workers as knowledge intensive, and for capital only ICT capital following the spirit of the KLEMS project. It would have been interesting to include other intangible assets, besides software, that are already included in the 2008 System of National Accounts, such as R&D, but, so far, only two LAKLEMS countries, Chile and Mexico, have released the required information. The next section describes the data and presents some basic descriptive statistics.

Statistical Data: Sources and Coverage

The estimates of knowledge intensity following the methodology described previously and presented in the next section are based on data from the LAKLEMS database.[8] This database contains information by industry on variables related to labour, capital and total factor productivity and economic growth—value added, output, employment and qualification, gross capital formation by assets and accumulated capital, capital and labour compensation, etc. At the moment, data are available for four Latin-American countries, Brazil, Chile, Colombia and Mex-

8 The LAKLEMS project includes eight countries of Latin America (Chile, Colombia, Costa Rica, Dominican Republic, El Salvador, Honduras, Mexico and Peru) and Argentina and Brazil also form part of the project. LAKLEMS is financed and executed by the Inter-American Development Bank (IADB). A team at the University of Santiago de Chile is responsible for the substantive implementation.

ico, for the period comprised between 1990 and 2016, although the time coverage varies across countries (1995-2013 for Brazil, 1995-2015 for Chile, 1990-2014 for Colombia and 1990-2016 for Mexico). Here, we focus on the period 2000-2016.

Thus, the LAKLEMS database offers all the variables needed to apply the methodology outlined in section 1: value added, capital compensation by asset and labour compensation[9] by educational attainment level.

Labour data are classified by educational attainment distinguishing among three levels: high, medium and low. For our purposes, we consider that workers with high education levels contribute knowledge to the production process, whereas the remaining do not. In the case of physical capital, the LAKLEMS database distinguishes seven capital assets: three ICT assets and four non-ICT assets (Table 1). As stated before, when considering the narrower definition of knowledge intensity, only ICT assets are classified as knowledge-based capital. Thus, according to this, knowledge-based GVA includes the remuneration of high-educated workers and ICT capital.

As explained in section 1, the measure of knowledge intensity is carried out at the sectoral level. Although a greater industry detail is available for some countries, e.g. Mexico, only nine individual industries are considered here, in order to have a common industry classification for all the countries analysed. Table 1 shows a list of these industries.

In addition to the aforementioned countries, two other developed countries are included in the analysis for the purpose of comparison. As this methodology has already been applied to Spain and its regions (Maudos, Benages and Hernández, 2017) and considering that Spain has close historical and economic ties with Latin America, information on this country is also presented in this analysis. The main information sources used are: EU KLEMS database, National Accounts (NA), Labour Force Survey (LFS) and Structure of Earnings Survey (SES), published by the INE (Spanish National Statistical Office), and BBVA Foundation-Ivie database on capital stock. Educational attainment classification, assets' classification and industry detail have been adapted to those offered by LAKLEMS database to obtain comparable results.

On the other hand, and as the benchmark country in terms of pro-

9 In the case of Mexico, there is no information on hours worked by self-employed workers. Thus, labour compensation figures only include labour compensation remunerating employees. For the remaining countries, these figures include both the compensation that remunerates employees and self-employed workers.

Table 1: LAKLEMS Database: Capital Assets and Industry Classification

Available Capital Assets in LAKLEMS Database	LAKLEMS Industry Classification
ICT assets	Agriculture, forestry and fishing
Software	Mining and quarrying
Computing equipment	Manufacturing
Communication equipment	Electricity, gas and water supply
Non ICT assets	Construction
Transport equipment	Wholesale & retail trade; accommodation and food service
Machinery & Equipment (excluding ICT)	Transportation and communications
Non-residential structures	Financial, real state and business services
Residential structures	Other services

Source: Own elaboration.

ductivity and ICT development, the United States is also included in the analysis. In this case, the main data sources are USA KLEMS database[10] and the Integrated Industry-Level Production Accounts, elaborated and updated by BEA (Bureau of Economic Analysis) and BLS (Bureau of Labour Statistics). Again data from these sources have been adapted to LA KLEMS' characteristics.

Table 2 provides an overview of the two sets of variables involved in the methodology presented in section 1: capital and labour inputs classified by capital assets, and types of labour according to the level of educational attainment.

Regarding capital inputs, Table 2 shows the composition of gross fixed capital formation (capital flows) in the four LA countries plus Spain and the United States. As expected, ICT assets have a lower weight in the Latin American economies considered, around 6 per cent on average, this weight being more than double in Spain and the United States. However, there are important differences among the four LA countries. Chile presents the highest share of ICT investment (8.2 per cent) in the last year with available information, and Brazil, the lowest (4.6 per cent), almost half that of Chile. In addition, this share has decreased since 2000 in Brazil, and also in Colombia. In all the countries analysed, residential and non-residential structures are, by far, the main assets, reaching in Brazil and Colombia a high of more than 95 per cent of total investment, over 10 percentage points more than in Spain and the United States.

As expected, due to its initial low base level, ICT capital has experienced a higher rate of growth than non-ICT capital in all countries. According to their lower initial levels, these growth rates are higher in the LA countries, with the only exception of Mexico. The analysis of this struc-

10 See http://www.worldklems.net/data.htm.

Table 2: Descriptive Statistics: Capital and Labour Data. LAKLEMS Countries, Spain and the United States, 2000 and the Latest Available Year

	Brazil		Chile		Colombia		Mexico		Spain		United States	
	a) Gross Fixed Capital Formation: Structure by assets (%)											
	2000	2013	2000	2015	2000	2014	2000	2015	2000	2015	2000	2015
ICT	9.34	4.59	5.43	8.17	8.76	4.67	5.35	5.88	10.57	15.1	21.9	18.41
Software	4.11	1.64	1.75	3.68	1.35	0.53	0.13	0.17	3.18	7.83	10.36	12.16
Computing equipment	1.94	0.76	1.97	2.16	2.37	1.02	1.66	1.29	3.11	2.46	5.44	2.85
Communication equipment	3.29	2.19	1.71	2.33	5.03	3.11	3.55	4.42	4.28	4.81	6.11	3.4
Non ICT	90.66	95.41	94.57	91.83	91.24	95.33	94.65	94.12	89.43	84.9	78.1	81.59
Transport equipment	7.67	13.34	-	-	6.82	6.93	9.93	10.72	10.26	11.45	8.61	10.61
Machinery & Equipment (exclu. ICT)	23.33	12.49	12.65	32.26	16.04	9.44	24.06	29.8	14.88	18.69	21.38	23.37
Non residential structures	32.32	38.86	50.54	43.66	48.93	49.31	32.06	28.19	29.43	30.12	24.42	26.17
Residential structures	27.34	30.72	31.38	15.9	19.44	29.65	28.61	25.42	34.87	24.63	23.68	21.44
Total	100	100	100	100	100	100	100	100	100	100	100	100

	b) Gross Fixed Capital Formation: Average annual growth					
	2000-2013	2000-2015	2000-2014	2000-2015	2000-2015	2000-2015
ICT	6.63	10.30	10.85	4.94	5.64	3.80
Software	7.76	14.30	13.58	3.99	5.02	4.12
Computing equipment	7.63	8.06	14.25	4.10	6.53	5.24
Communication equipment	4.09	7.78	9.52	5.29	6.09	1.89
Non ICT	4.41	4.98	9.74	2.18	-0.81	0.33
Transport equipment	7.91	0.00	11.98	4.18	1.42	3.13
Machinery & Equipment (exclu. ICT)	5.19	7.74	11.27	4.25	0.22	1.98
Non residential structures	3.70	5.04	8.39	0.40	-0.65	-0.88
Residential structures	3.18	1.48	11.35	1.82	-2.19	-0.85
Total	4.65	5.36	9.26	2.31	-0.14	0.91

	c) Labour (hours worked): Share by level of education (%)											
	2000	2015	2000	2015	2000	2015	2000	2016	2000	2015	2000	2015
High	8.66	18.41	22.88	35.2	14.23	21.73	14.04	13.37	26.6	40.74	28.89	37.95
Medium	34.51	42.48	57.63	45.93	40.58	42.34	38.69	46.52	19.56	24	60.72	54.24
Low	56.84	39.12	19.49	18.87	45.19	35.93	47.28	40.1	53.83	35.26	10.39	7.81
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	d) Labour (hours worked): Average annual growth rates					
	2000-2015	2000-2015	2000-2015	2000-2016	2000-2015	2000-2015
High	7.55	4.52	4.77	1.03	3.32	2.11
Medium	3.98	0.13	2.20	2.49	1.84	-0.46
Low	0.03	1.43	0.29	0.31	-2.34	-1.61
Total	2.48	1.65	1.88	1.33	0.48	0.30

Note: In the case of Chile, Transport equipment is included in Machinery & Equipment (excluding ICT).
Source: BEA, BLS, EU KLEMS database, LAKLEMS database, BBVA Foundation-Ivie, INE, World KLEMS and own elaboration.

ture and its evolution is important because capital stock stems from the accumulation of GFCF flows. Therefore, it also affects the distribution by asset of the capital compensation, the magnitude that is going to be used to estimate part of the knowledge-based GVA.

The information for labour qualification, according to the level of education attained, appears in the lower part of Table 2. Since 2000, the general pattern has been, as expected, the reduction of the weight of the lower levels, in favour of the other two. Only in Chile, the less qualified workers have kept constant their share, but at a very low level. In the majority of countries in general, job creation is concentrated mainly among the group of workers with higher educational levels, whereas the growth rate of low-skilled labour is very low, or even negative in the case of Spain and the United States. In this latter country, only high-skilled labour shows a positive growth in the period considered.

Knowledge Intensity Estimates

This section presents the main results of the exercises proposed earlier in the article for measuring the knowledge economy. The first part shows the aggregated results while the second focuses on detail by industries.

Aggregated Results

Chart 1 provides an overview of the share of knowledge economy over total GVA—as given by equation (8)—for the four Latin America countries, Spain and the United States over the period covering the year 2000 to the latest year available. Spain and the United States are included as benchmark, the first representing a large, middle income European country, and the second being the world leader in terms of productivity and in producing and using new technologies. Both countries share very close historical and economic ties with Latin America.

The share of knowledge-based gross value added in total gross value added in the most recent year ranges from a low of 10 per cent in Mexico to a high of 38 per cent in the United States, followed by Spain (37 per cent) and Chile (35 per cent). Colombia (19 per cent) and Brazil (23 per cent) are in an intermediate position. Mexico has kept the share of the knowledge economy rather constant, while Colombia and Chile show an upward trend, more pronounced in the second than the first. Brazil presents a different profile, with a fall from 2000 to 2010 and a slight recovery from then on, although its knowledge intensity in the last year available is below its level in 2000. It is the only country that shows this behaviour: a reduction of knowledge share in the economy. Even in Mexico knowledge share was more than 1 percentage point higher in 2016 than in 2000.

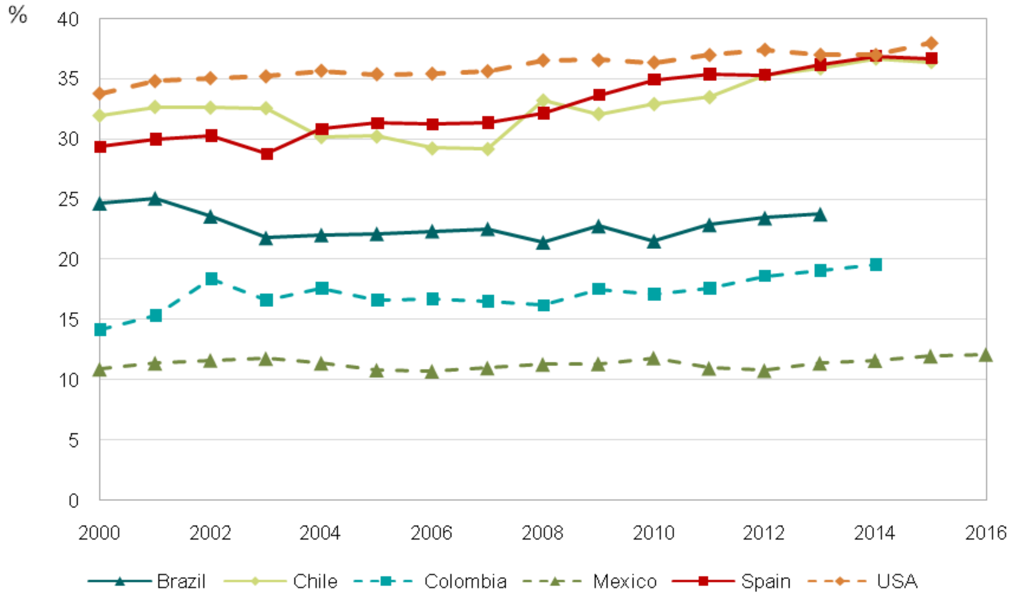
Chart 2 presents the annual growth rates of both knowledge and non knowledge based GVA. For all the countries considered, with the only exception of Brazil, the growth of knowledge-based inputs has been higher during the period analysed. Colombia presents the highest growth rate (6.5 per cent), followed by Chile (4.4 per cent), whereas the United States (2.3 per cent) has the lowest. Among the LA countries, Mexico shows the lowest growth rate (2.6 per cent).

When compared with American countries, it is worth highlighting Spain's rather strong slowdown in non-knowledge based GVA as a consequence of the economic crisis that began in 2008, which basically affected the building industry and the assets it produces, such as dwelling and all type of constructions. It also suffered a sharp increase of unemployment which mainly affected low-skill workers (Table 2). The LA countries do not seem to have been hit in such a strong way.

Chart 3 offers a complementary view summarizing the contributions of both types of inputs to GVA growth. In general, for the Latin American countries the contribution of non-knowledge factors is markedly higher than that of its knowledge counterpart. This is especially noticeable for Mexico, Brazil, and also Colombia. What explains this result, the higher contribution to GVA growth of non-knowledge factors, is the capital accumulation in non-knowledge-based assets, such as dwellings and other non-residential structures, during this period. This is a common feature of all these countries, especially relevant in the case of Colombia and Mexico. Again, Chile shows a more balanced pattern of growth, more similar to that of Spain and the United States. In both countries, knowledge is the main contributor to GVA growth.

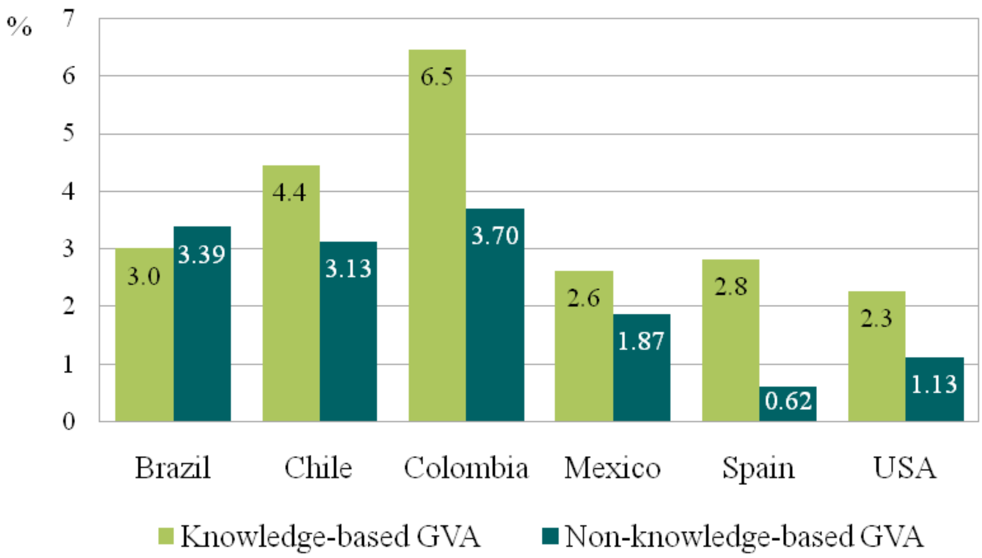
Chart 4 gives a more detailed decomposition of the share of knowledge and non-knowledge inputs of production over total GVA for the year 2000 and the last year available. As expected, te ICT capital compensation share is very small for all countries. The largest contribution corresponds to the United States, Mexico and Spain, close to 4 per cent, and the lowest to Colombia (2.3 per cent). The contribution of knowledge intensive labour, corresponding to workers with the highest level of education, is greater in the United States, Chile and Spain, around 33 per cent in the

Chart 1: Knowledge-Based Gross Value Added (GVA), LAKLEMS countries, Spain and the United States, 2000-2016 (Share of Total GVA)



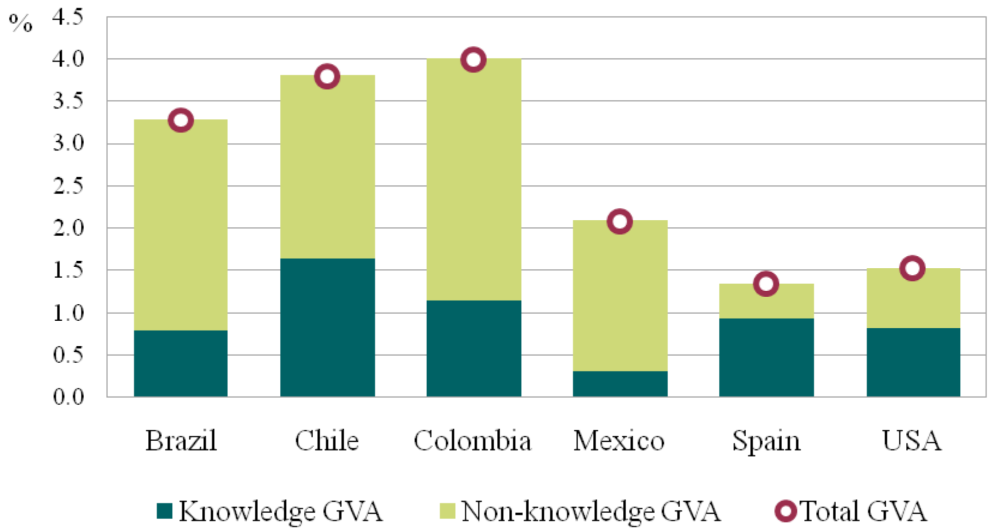
Source: BEA, BLS, EU KLEMS database, LAKLEMS database, BBVA Foundation-Ivie, INE, World KLEMS and own elaboration.

Chart 2: Annual Growth Rate of Knowledge and Non-Knowledge-Based Gross Value Added (GVA), LAKLEMS Countries, Spain and the United States, 2000-2016*



* 2000-2013 for Brazil, 2000-2014 for Colombia and 2000-2015 for Chile, Spain and the United States.
Source: BEA, BLS, EU KLEMS database, LAKLEMS database, BBVA Foundation-Ivie, INE, World KLEMS and own elaboration.

Chart 3: Knowledge and Non-Knowledge Contribution to Annual Gross Value Added (GVA) Growth Rate, LAKLEMS Countries, Spain and the United States, 2000-2016*



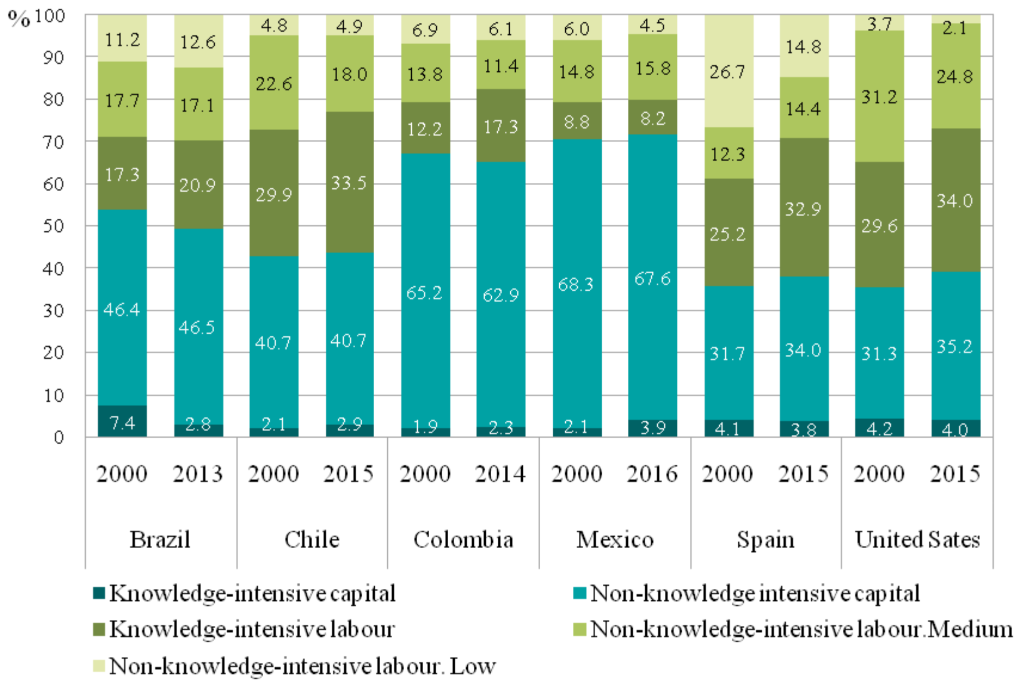
* 2000-2013 for Brazil, 2000-2014 for Colombia and 2000-2015 for Chile, Spain and the United States.
Source: BEA, BLS, EU KLEMS database, LAKLEMS database, BBVA Foundation-Ivie, INE, World KLEMS and own elaboration.

last year available, while in Mexico it is the lowest, 8.2 per cent. These results are the combination of the weight of high-educated workers and the wages they receive. As shown by Table 2, the United States, Chile and Spain are also the two countries with the highest shares of high-educated workers (37.9 per cent, 35.2 per cent and 40.7 per cent, respectively).

The share of non-knowledge-intensive capital is very high in Mexico and Colombia (around 65 per cent), and relatively low in Chile (40.7 per cent), but still higher than in Spain (34 per cent) and the United States (35.2 per cent). Within non-knowledge labour, Chart 4 distinguishes between medium and low levels of qualification. In the four Latin American countries, medium levels have a larger contribution, as in the United States, while in Spain low qualified workers have a higher one. This result is consistent with the weights for each type of labour shown in Table 2. Also worth noting are the low contributions of both knowledge and non-knowledge labour in Mexico and Colombia. Since according to our approach these contributions are computed taking wages as reference, the more general conclusion is that for those two countries the capital share amounts to almost 70 per cent of total GVA and labour the remaining 30 per cent, an income distribution that is more biased toward capital than in the rest of the countries.

Chart 5 complements the informa-

Chart 4: Knowledge and Non-Knowledge Compensation over Gross Value Added (GVA), LAKLEMS Countries, Spain and the United States, 2000-2016* (%)



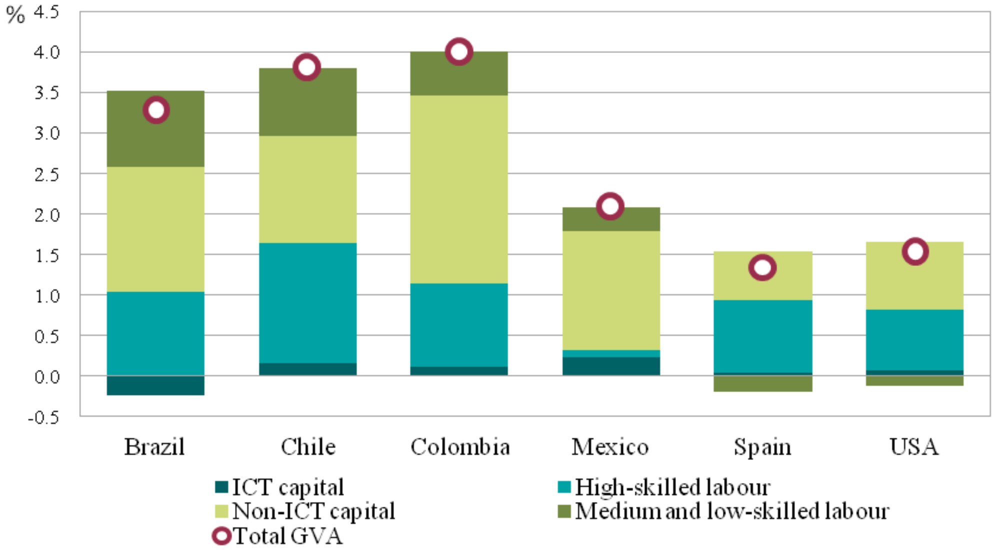
* 2000-2013 for Brazil, 2000-2014 for Colombia and 2000-2015 for Chile, Spain and the United States.
Source: BEA, BLS, EU KLEMS database, LAKLEMS database, BBVA Foundation-Ivie, INE, World KLEMS and own elaboration.

tion provided in Chart 4 offering the contribution of the four types of inputs to GVA growth. Starting with knowledge-intense capital, that is, ICT capital, Mexico shows the largest contribution, while Brazil presents a negative one.[11] Knowledge intensive labour contribution (high-skilled labour) is remarkably high in Chile, and also in Brazil and Colombia, but very low in Mexico. Colombia and Mexico stand out with the highest contributions of non-knowledge intensive capital, and Brazil, Chile and again Colombia with non-knowledge intensive labour. The contribution of the latter is negative in the case of Spain and the United States, whose main driver of growth is high-skilled labour.

In terms of GVA per capita , Chart 6 shows the United States as the country with the highest level, close to $50,000 (2010 US dollar PPP), followed by Spain with around $30,000. Chile is, by far, the Latin Ameri-

11 This may explain why the growth rates of knowledge-based GVA in Brazil are lower than those of non-knowledge GVA (Chart 2).

Chart 5: Knowledge and Non-Knowledge Inputs' Contribution to Annual GVA Growth Rate, LAKLEMS Countries, Spain and the United States, 2000-2016*



* 2000-2013 for Brazil, 2000-2014 for Colombia and 2000-2015 for Chile, Spain and the United States.
Source: BEA, BLS, EU KLEMS database, LAKLEMS database, BBVA Foundation-Ivie, INE, World KLEMS and own elaboration.

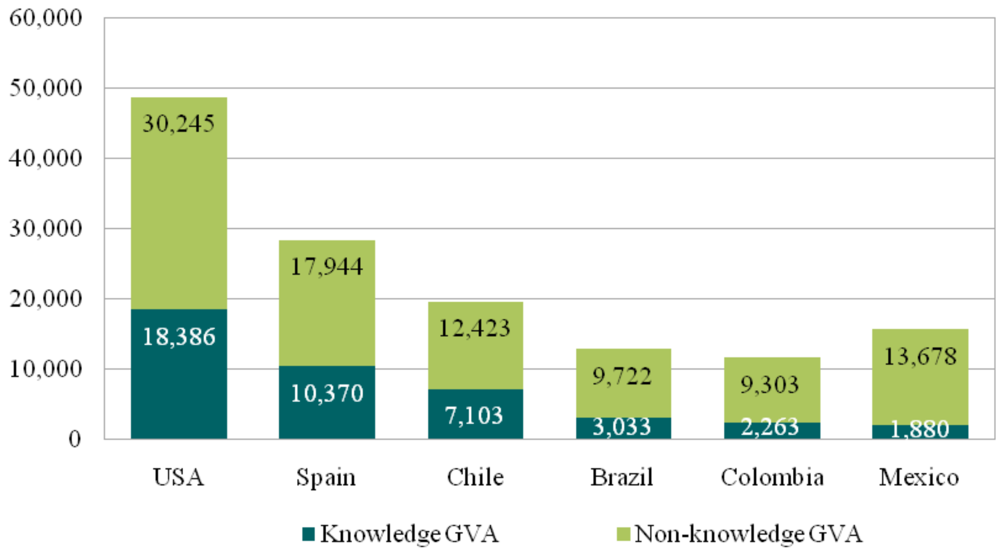
can country with the highest GVA per capita and also with the highest knowledge economy per capita, while for the other three countries it is much lower, especially for Mexico. However, despite having the lower knowledge economy level, Mexico ranks fourth in GVA per capita, after Chile. For the remaining countries, the higher the knowledge-based economy share, the higher the GVA per capita.

Finally, Chart 7 shows the changes in the knowledge-based economy per capita in 2000 and the most recent year available. All countries have benefited from the increase in knowledge-based GVA. But, while Colombia and Chile have almost doubled, the gains reached by Mexico and Brazil are very minor. Even Spain, a more developed country, shows a higher increase than these two countries.

Panel A of Chart 8 shows the relationship between knowledge-based GVA growth and labour productivity performance in each country. As can be observed, it is possible to establish a positive relationship between both variables, as the countries where the use of knowledge-based factors have grown faster are also the countries showing further productivity improvements. Panel B of Chart 8 confirms this result showing that in general the industries that have increased their knowledge-intensity at a faster pace are those that also perform better in terms of labour productivity.

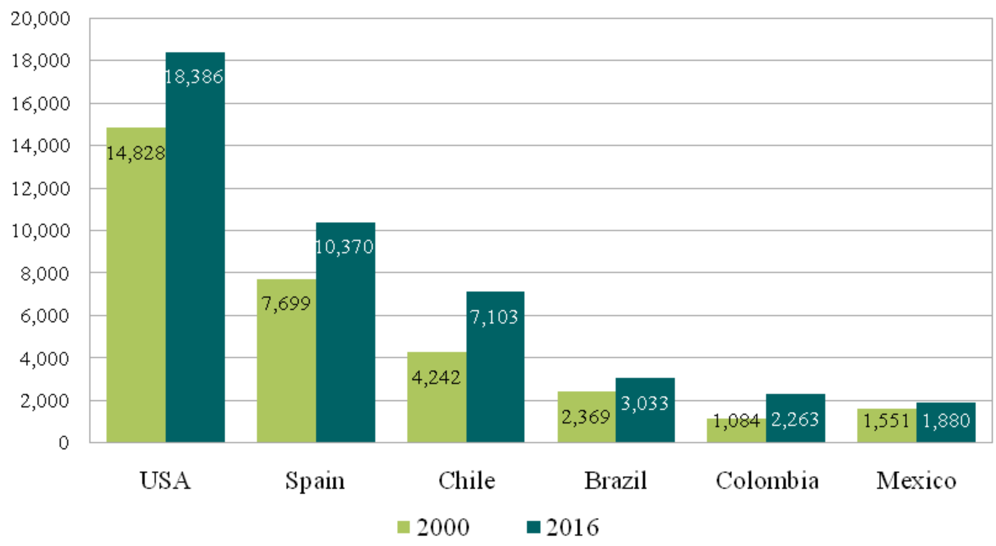
Putting all the pieces of evidence

Chart 6: Real GVA per Capita: Knowledge and Non-Knowledge, LAKLEMS Countries, Spain and the United States, 2016* (2010 US Dollar PPP per Person)



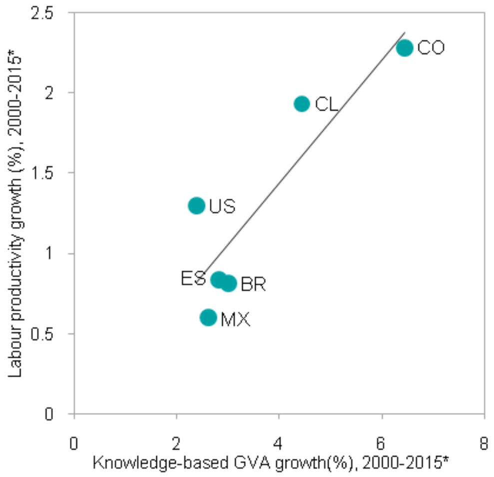
* 2013 for Brazil, 2014 for Colombia and 2015 for Chile, Spain and the United States. Note: Countries are ranked according to knowledge-based GVA. Source: BEA, BLS, EU KLEMS database, LAKLEMS database, BBVA Foundation-Ivie, INE, OECD, World KLEMS and own elaboration.

Chart 7: Real Knowledge-Based GVA per Capita, LAKLEMS Countries, Spain and the United Sates, 2000 and 2016* (2010 US Dollars PPP per Person)

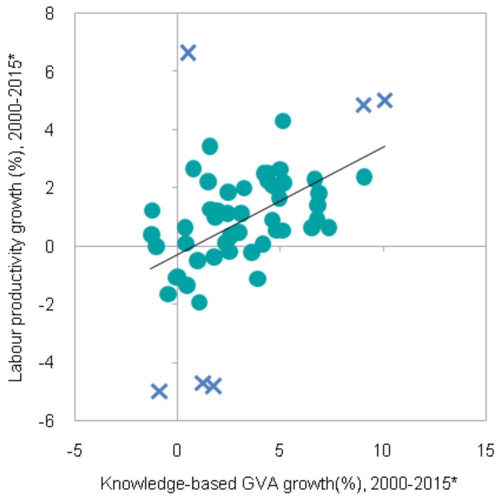


* 2013 for Brazil, 2014 for Colombia and 2015 for Chile, Spain and the United States. Note: Countries are ranked according to knowledge-based GVA. Source: BEA, BLS, EU KLEMS database, LAKLEMS database, BBVA Foundation-Ivie, INE, OECD, World KLEMS and own elaboration.

Chart 8: Labour Productivity and Knowledge-Based GVA Growth, LAKLEMS Countries, Spain and the United States, 2000-2015*



(a) **Labour Productivity and Knowledge-Based GVA Growth by Country**



(b) **Labour Productivity and Knowledge-Based GVA Growth by Country and Industry**

* 2000-2013 for Brazil and 2000-2014 for Colombia. Note: Outliers (marked with an x) in panel b correspond to the sectors Mining and quarrying and Agriculture, forestry and fishing in the case of some LA countries. Source: BEA, BLS, EU KLEMS database, LAKLEMS database, BBVA Foundation-Ivie, INE, OECD, World KLEMS and own elaboration.

together, the picture that emerges is one with sharp differences among the four Latin American countries. Chile stands out for its higher weight of knowledge economy, its dynamic behaviour which in turn translates into a higher contribution to GVA growth. It is the Latin American country which follows a pattern of growth similar to Spain, a European medium range country for developed countries standards. This conclusion is especially true regarding the distribution between capital and labour income shares in total GVA, and also regarding the more similar contribution of the different types of inputs, knowledge and non-knowledge capital and labour. Its per capita income is the closest also to the Spanish one and the split between knowledge and non-knowledge is also the most balanced in per capita terms of the four LA countries.

On the opposite side, Mexico has the lowest share of the knowledge-based economy, presenting a very high share of non-knowledge capital. In fact, it is the country with the largest concentration of this source of growth in its economy. Of the two remaining countries, Colombia shows the most dynamic behaviour from a knowledge-based economy standpoint: the rate of growth of knowledge intense inputs has been the highest of the four Latin American countries, but it has not been, at least not yet, enough to reach the share over the total of Chile, Spain and the United States, the reference countries. Brazil, on the other side, started the period with a higher share of knowledge economy over GVA but has experienced a continuous fall in recent years.

Industry Results

A distinctive characteristic of KLEMS methodology is the emphasis it puts on the importance of industry disaggregation. In fact, the results presented earlier come from the aggregation of industry data as described in section 1 (see equation 8). The available level of industry disaggregation is not homogenous for all countries. As explained earlier in the article, in the case of the LAKLEMS project, information is available for the nine industries listed in Table 1.

Chart 9 depicts knowledge-based GDP by industry for the year 2000 and the last year available. The industry labelled other services, which includes public administration, health and education, is the one with the highest knowledge intensity in all the countries. The only exception being Colombia, for which transportation and communication occupies the first position, and other services the fourth. However, it is this industry that shows the largest increase in the 2000-2014 period.

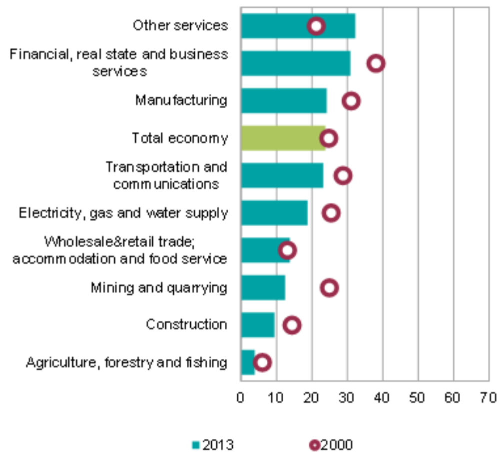
The second most knowledge-intensive industry in almost all the countries analysed is financial, real estate and business services, with the exception of Mexico in which construction takes the second position. For the rest of the countries, this is a more laggard industry in this respect. For instance, in Brazil and Spain it occupies the 8th position, the United States and Colombia 6th, and Chile 4th.

The industries presenting the lowest knowledge intensity are mining and quarrying (9th in Chile and the United States, 8th in Mexico and Colombia, 7th in Brazil and 5th in Spain), and agriculture, forestry and fishing (9th in Brazil, Mexico and Spain, 7th in Chile and the United States, and 5th in Colombia). Electricity, gas and water supply is the less knowledge-intensive industry in Colombia, and occupies the 8th position in Chile and the United States and the 7th in Spain, while in the other two countries it takes a more intermediate position.

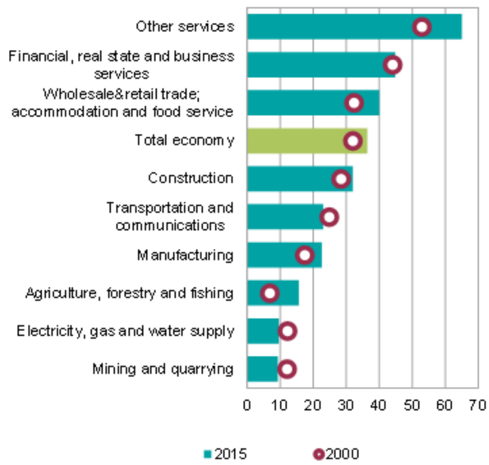
It is also interesting to note that manufacturing, which is more R&D intensive, is not the most knowledge-intensive according to our approach. In all the countries it takes an intermediate position: 3rd in Brazil and the United States, 4th in Spain, 6th in Chile and Mexico, and 7th in Colombia.

It is also worth highlighting that,

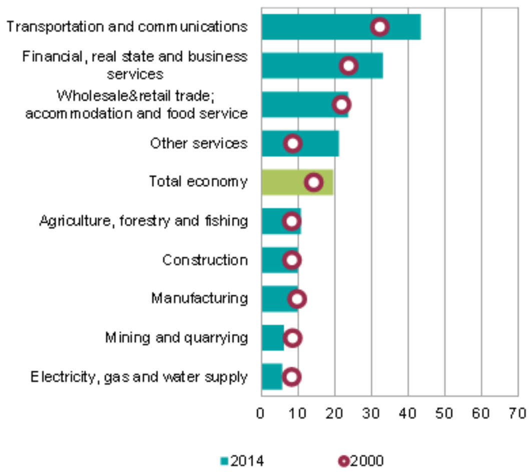
Chart 9: Knowledge-Based GVA by Industry, LAKLEMS Countries, Spain and the United States, 2000 and 2016* (Percentage of each Industry's GVA)



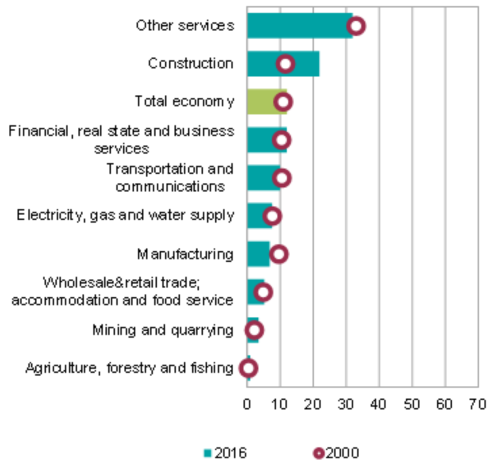
(a) **Brazil**



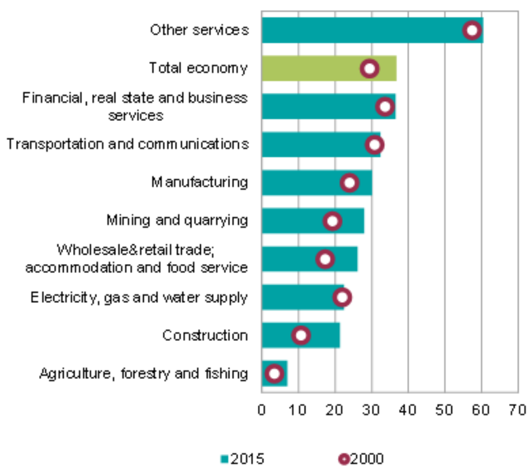
(b) **Chile**



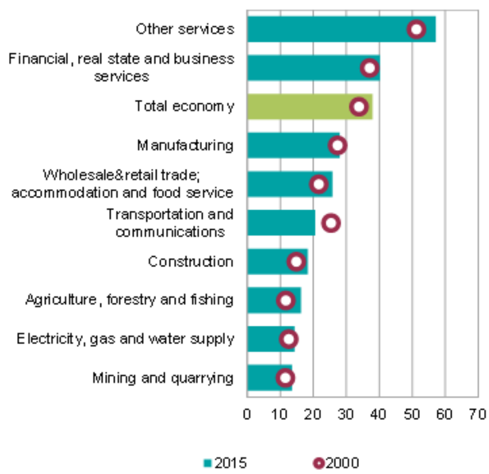
(c) **Colombia**



(d) **Mexico**



(e) **Spain**



(f) **United States**

* 2013 for Brazil, 2014 for Colombia and 2015 for Chile, Spain and the United States. Source: BEA, BLS, EU KLEMS database, LAKLEMS database, BBVA Foundation-Ivie, INE, World KLEMS and own elaboration.

in the case of Spain and the United States, almost all the industries have increased their knowledge intensity, whereas this result does not hold for all the Latin American countries and industries, especially Brazil.

Chart 10 shows the contributions of the two inputs, labour and capital, distinguishing between knowledge intensive—that is, ICT assets for capital and tertiary education for labour—and the rest, which is considered non-knowledge intensive (non-ICT capital and medium- and low-skilled workers), for the last year for which information is available. This information complements the one offered in Chart 4, which presents similar information but related to the total economy.

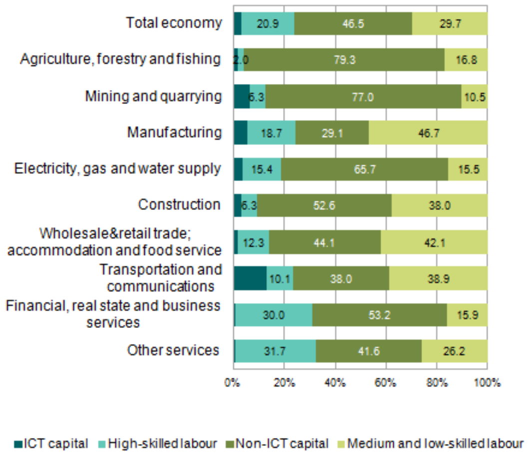
The following observations are of note. First, for all countries, the high knowledge intensity in other services is basically due to the labour component, especially in Chile, Spain and the United States. This is not surprising when we recall that it includes public administration, health and education, activities requiring the presence of high-skilled workers. However, in the case of Brazil and Colombia, non-knowledge-based capital also plays an important role regarding this sector. ICT capital has an important contribution in the transportation and communication industry, mainly for the communication component. This high contribution is especially relevant in Brazil, Colombia and Spain. ICT contribution is also important in the construction industry in Mexico, electricity, gas and water supply in Chile, and manufacturing in Chile and Brazil and financial, real state and business services in Spain and the United States.

Besides other services, labour-knowledge intensity has a very relevant role in financial, real estate and business services in all countries, except Mexico; also in transportation and equipment, and in wholesale & retail trade; accommodation and food service in Chile, Colombia and Spain.

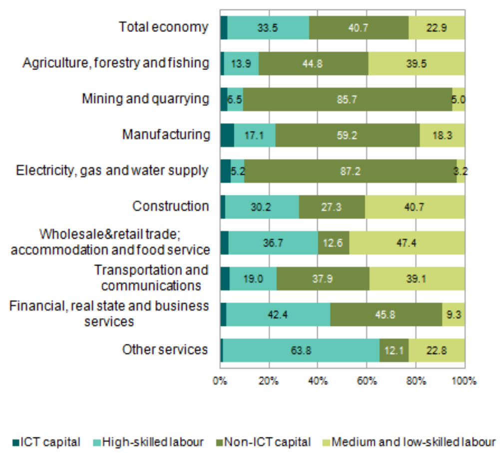
The contributions of the non-knowledge inputs, capital and labour, vary among countries but follow the same pattern for certain sectors. For instance, the contribution of non-ICT capital is very high in all the countries in electricity, gas and water and mining and quarrying (the latter not in Spain). For the remaining industries, the contribution of non-knowledge-intensive labour is higher in Brazil and Chile, and also in Spain and the United States, than in Colombia or Mexico.

As can be seen, there are important differences in terms of knowledge intensity by industry, and also by countries within the same industries. Regarding the first differences, a way to verify how different the contribu-

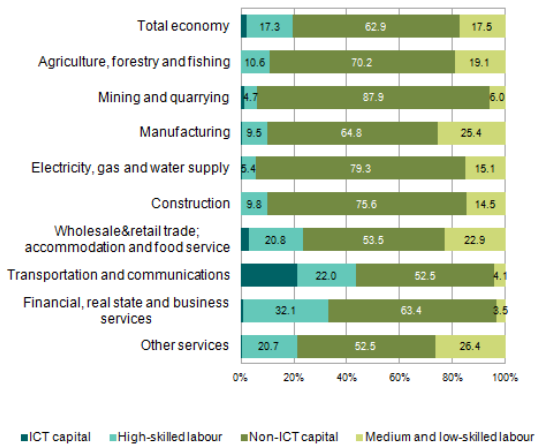
Chart 10: Knowledge and Non-Knowledge Compensation over GVA by Industry, LAKLEMS Countries, Spain and United States, 2016* (%)



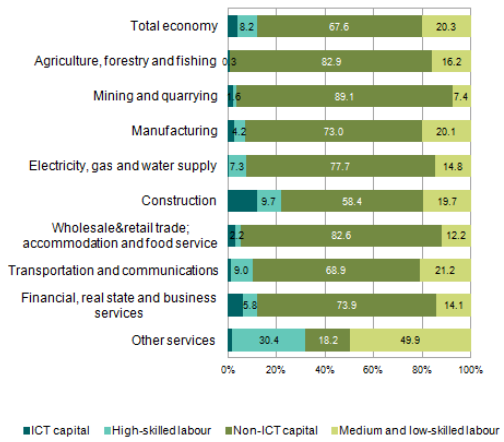
(a) Brazil



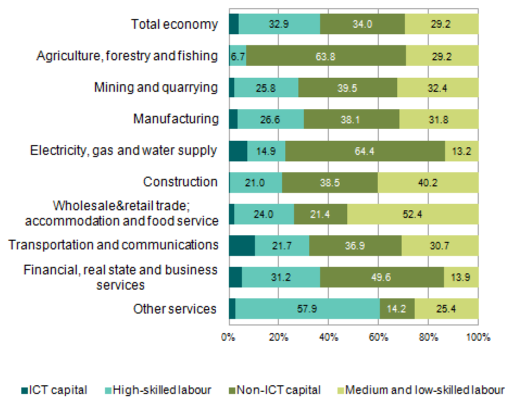
(b) Chile



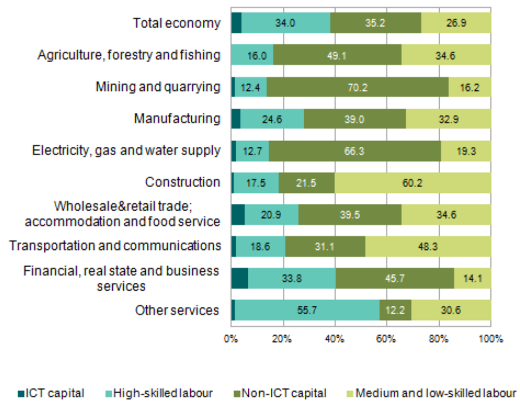
(c) Colombia



(d) Mexico



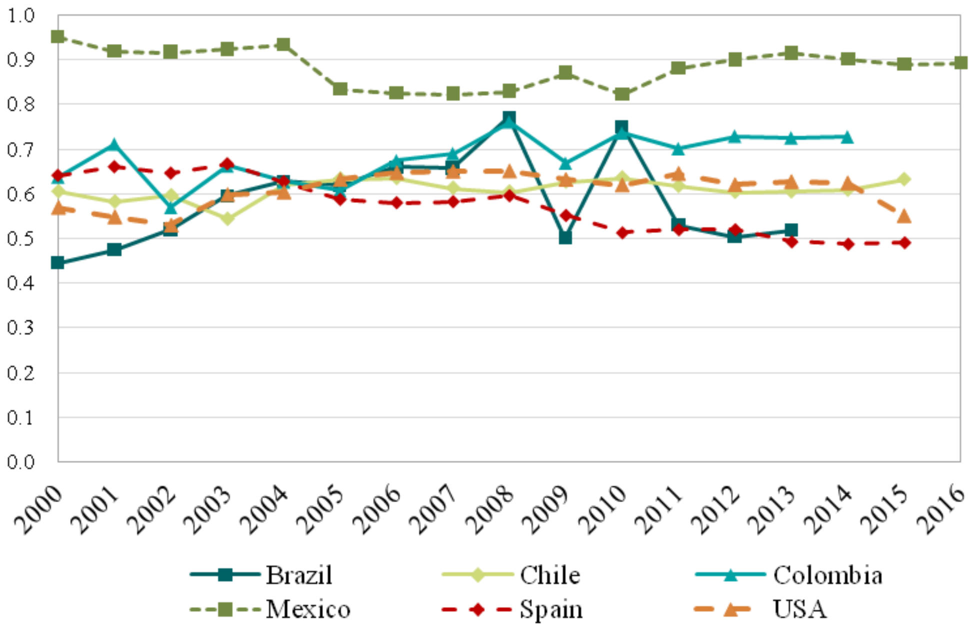
(e) Spain



(f) United States

* 2013 for Brazil, 2014 for Colombia and 2015 for Chile, Spain and the United States. Source: BEA, BLS, EU KLEMS database, LAKLEMS database, BBVA Foundation-Ivie, INE, World KLEMS and own elaboration.

Chart 11: Dispersion of the Knowledge-Based GVA Share Among Sectors, LAKLEMS Countries, Spain and the United States, 2000-2016 (Coefficient of Variation)



Note: Dispersion level is measured with the coefficient of variation. Source: BEA, BLS, EU KLEMS database, LAKLEMS database, BBVA Foundation-Ivie, INE, World KLEMS and own elaboration.

tions of the knowledge-based inputs are within each country's industries is by computing the dispersion (as measured by the coefficient of variation) of their shares over GVA among sectors.

Chart 11 provides this information and identifies Mexico as the country with the highest dispersion, probably due to the high contribution it has in other services and construction industries, as compared with other sectors. Colombia occupies the second position, possibly originated, in this case, by the very high contribution of the transport and communication industry. Brazil follows a rather erratic path, which suggests taking a more in-depth look at the data. Finally, Chile is the Latin American country presenting the lowest dispersion, which means that the production process of the different industries is more homogeneous than in the other three countries.

In this respect, it is interesting to highlight, again, that this characteristic is shared with the United States and Spain, the latter the country with the lowest dispersion. In addition, dispersion has decreased in Spain, the United States and Mexico since 2000, but has increased in Brazil, Colombia and slightly in Chile. In these countries the differences in terms of the use of knowledge-intensive inputs among sectors is increasing. Further research is needed on these results in order to explain the differences in GVA composition by industries and in its performance across Latin American countries.

Conclusion

The proposed metric calculates the knowledge content of the economy based on more accurate and disaggregated measurements of human and physical capital services by sector, provided by LAKLEMS database. In order to compute the size, and composition, of the knowledge economy, we have used a rather restrictive definition of knowledge-based inputs, which considers only ICT assets for capital input, and the highest level of educational attainment in the case of labour. Nine industries in four Latin American economies, plus the United States and Spain, were analysed over the period 2000-2016 or last year available. The United States and Spain are introduced in the analysis as benchmark countries with strong historical, cultural and economic ties with Latin America.

The study confirms that developing economies are moving towards a more knowledge-based pattern of production, even though considerable differences exist among them. In addition, the speed in which they approach the existing standards of more developed countries varies considerably. The share of the knowledge-based economy ranges from around 10 per cent in Mexico, 20-25 per cent in Colombia and Brazil, and a larger weight, around 35 per cent in Chile, similar to that of Spain or the United States. The share of the knowledge economy has remained almost constant in Mexico over the period, while it fell slightly in Brazil, and increased in Colombia, Chile, Spain and the United States.

On a per capita basis, Chile is the Latin American country with the highest knowledge-based GVA, more than double that of Brazil, the second country in the ranking, but still at a great distance from more advanced countries. Mexico is the country that comes last in per capita terms and, in addition, it shows a less dynamic path during the 2000-2016 period.

In three of the Latin American countries, the rate of growth of knowledge-based GVA has been much higher than the non-knowledge counterpart. Colombia showed the most dynamic behaviour, followed by Chile and Mexico. Brazil is the only country experiencing the opposite trend. Chile is the country showing the most balanced split between knowledge and non-knowledge sources of growth.

ICT capital has a low share in total capital in all economies, but it tends to increase with the level of development. Chile and Brazil are the countries which incorporate more ICT into the production process, and Colombia the one with the lowest presence. However, the contribution of ICT capital to GVA growth in all countries exceeds its weight in the economy. From the labour side, skilled labour is the factor contributing the most to the knowledge economy but, again, with important differences among countries. Chile is, by far, the country with the largest contribution of high-educated workers, followed by Colombia and Brazil. However, non-intensive knowledge capital is the main driver of GVA growth in Colombia and Mexico, while Brazil and Chile show a more balanced distribution among the four drivers of growth: knowledge-based and non-knowledge-based capital and labour.

The disaggregation by industries provides further insights on the composition of the knowledge economy. Generally speaking, other services—which basically refer to public administration, health and education—and financial, real estate and business services are, in almost all countries, the industries with the largest contribution of knowledge-based assets. This result originates mainly from the contribution of workers with higher levels of educational attainment. On the contrary, agriculture, forestry and fishing, and mining and quarrying are, broadly speaking, non-knowledge activities, splitting the responsibility between labour and capital depending on the country analysed.

A positive relationship can be established between the increase of knowledge-based GVA and labour productivity performance in each country and sector, as the countries and industries that have increased their use of knowledge-based factors at a faster rate also show further labour productivity improvements.

Overall, we can say that there are important differences among the Latin American countries in terms of knowledge-based economy. In addition, there are also differences in terms of knowledge intensity among different industries within the same country and, with the exception of Mexico, these differences have increased in the Latin American countries during the most recent period. In this sense, further research is needed to provide more insight on the role played by each industry in the knowledge intensity of each country and to identify different sectoral patterns of growth of knowledge-based GVA among Latin-American countries. In addition, comparing the results with those of Spain and the United States, two countries with a more intense use of knowledge-based factors and a higher GDP per capita, provides new research lines that focus on the effects of using knowledge-based factors on productivity and economic performance.

References

Aravena, C., A.A. Hofman, and L.E. Escobar (2018) "Fuentes del crecimiento económico y la productividad en América Latina y el Caribe 1990-2013," *Economia Chilena*, Revista del Banco Central de Chile, Santiago.

Bureau of Economic Analysis (2018) *Industry Economic Accounts, 2018*, Available at: https://www.bea.gov/data/economic-accounts/industry, Accessed November 2018.

Bureau of Labor Statistics (2018) *Current Employment Statistics (CES), 2018*, Available at: https://www.bls.gov/ces/, Accessed November 2018.

BBVA Foundation and Ivie (Instituto Valenciano de Investigaciones Económicas) (2018) *El stock y los servicios del capital en España y su distribución territorial y sectorial (1964-2015)*, Database available at: http://www.fbbva.es/TLFU/microsites/stock09/fbbva_stock08_index.html, Accessed April 2018.

Chen, D.H. and C.J. Dahlman (2006) "The Knowledge Economy, the KAM Methodology and World Bank Operations," Stock No. 37256, Washington DC: World Bank Institute.

Coremberg, A. and F. Pérez (eds.) (2010) *Fuentes del crecimiento y productividad en Europa y América Latina*, Bilbao: BBVA Foundation.

Corrado, C., J. Haskel and C. Jona-Lasinio (2017) "Knowledge Spillovers, ICT and Productivity Growth," *Oxford Bulletin of Economics and Statistics*, Vol. 79, pp. 592-618.

Corrado, C. Haskel, J., Jona-Lasinio, C. and M. Iommi (2013) "Innovation and Intangible Investment in Europe, Japan, and the United States." *Oxford Review of Economic Policy*, Vol. 29, pp. 261-286.

Corrado, C., Hulten, C.R. and D.E. Sichel (2006) "Intangible Capital and Economic Growth," *NBER Working Paper*, No. 11948, Cambridge (MA): National Bureau of Economic Research.

EU KLEMS (2018) *EU KLEMS Growth and Productivity Accounts*, Available at: http://www.euklems.net/, Accessed November 2018.

Eurostat (2013) *Science, Technology and Innovation in Europe, 2013 Edition*, Luxembourg: Publications Office of the European Union.

Fukao, K., S. Hamagata, T. Miyagawa, and K. Tonogi (2007) "Intangible Investment in Japan: Measurement and Contribution to Economic Growth," *RIETI Discussion Paper Series* No. 07-E-034, Tokyo: Research Institute of Economy, Trade and Industry.

Haan, M. de and M. van Rooijen-Horsten (2003) "Knowledge Indicators Based on Satellite Accounts," Final Report for NESIS-Work Package 5.1, The Hague: Statistics Netherlands.

Hatzichoronoglou, T. (1997) "Revision of the High-Technology Sector and Product Classification," *STI Working Paper*, No. 59918, Paris: OCDE.

Hulten, C.R. (2008) "Accounting for the Knowledge Economy," *Economics Program Working Paper Series*, No. 08-13, New York: The Conference Board.

INE (several years) *National Accounts, Base 2010*, Madrid.

INE (several years) *Labour Force Survey*, Madrid.

INE (several years) *Structure of Earnings Survey*, Madrid.

Jorgenson, D.W., F.M. Gollop and B.M. Fraumeni (1987) *Productivity and U.S. Economic Growth*, Cambridge (MA): Harvard Economic Studies.

LA-KLEMS (2018) *Productividad y crecimiento económico en América Latina*, Available at: https://www.cepal.org/cgi-bin/getprod.asp?xml=/la-klems/noticias/paginas/9/40269/P40269.xml&xsl=/la-klems/tpl/p18f-st.xsl&base=/la-klems/tpl/top-bottom.xsl.

López, A., A. Niembro and D. Ramos (2014) "Latin America's Competitive Position in Knowledge-Intensive Services Trade," *CEPAL Review 113*, Santiago.

López, A. and D. Ramos (2013) "¿Pueden los servicios intensivos en conocimiento ser un nuevo motor de crecimiento en América Latina?," *Revista Iberoamericana de Ciencia, Tecnología y Sociedad*, Vol. 8, No. 24, Buenos Aires, Centre for Studies in Science, Development and Higher Education.

Maudos, J., E. Benages, and L. Hernández (2017) *El valor económico de las actividades basadas en el conocimiento en España y sus regiones*, Madrid: Ramón Areces Foundation, 139 pp., Available at: http://sgfm.elcorteingles.es/SGFM/FRA/recursos/doc/Monografias/FRA/2039963963_552017125332.pdf

Marrano, M.G. and J. Haskel (2006) "How Much Does the UK Invest in Intangible Assets?," Working Papers No. 578, London: Queen Mary University London.

Marrano, M.G., J. Haskel and G. Wallis (2007) "What Happened to the Knowledge Economy? ICT, Intangible Investment and Britain's Productivity Record Revisited," Working Paper No. 603, London: Queen Mary, University of London.

OECD (2018) *Purchasing Power Parities (PPP) Statistics*, Available at: https://stats.oecd.org/.

OECD (2015) *OECD Science, Technology and Industry Scoreboard 2015: Innovation for Growth and Society*, Paris: OECD Publishing.

OECD (2009) *Measuring Capital OECD Manual*, Paris: OECD.

OECD (2001) *Measuring Capital OECD Manual*, Paris: OECD.

Oulton, N. (2016) "The Mystery of TFP," *International Productivity Monitor*, No. 31, pp. 68-87, http://www.csls.ca/ipm/31/oulton.pdf.

Pérez, F. and E. Benages (2017) "The Role of Capital Accumulation in the Evolution of Total Factor Productivity in Spain," *International Productivity Monitor*, Vol. 33, pp. 24-50, http://www.csls.ca/ipm/33/Perez_Benages.pdf.

Pérez, F. and E. Benages (2012) *El PIB basado en el conocimiento: importancia y contribución al crecimiento*, Valencia: ABACO. Available at: http://www.observatorioabaco.es/buscador?informe=115.

Solow, R. (1957) "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics*, Vol. 39, pp. 312-330.

Solow, R. (1956) "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics*, Vol. 70, No. 1, pp. 65-94.

Van Rooijen-Horsten, M., M. Tanriseven and M. de Haan (2008) *R&D Satellite Accounts in the Netherlands. A Progress Report*, The Hague: Statistics Netherlands.

Van Ark, B. and C.R. Hulten (2007) "Innovation, Intangibles and Economic Growth: Towards A Comprehensive Accounting of the Knowledge Economy," EPWP#07-02, New York: The Conference Board, December.

World Bank (2008a) *Measuring Knowledge in the World's Economies? Knowledge Assessment Methodology and Knowledge Economy Index*, Knowledge for Development Program, Washington, DC: The World Bank.

World Bank (2008b) *Building Knowledge Economies. Advanced Strategies for Development*, Washington, DC: The World Bank.

World KLEMS (2018) *World KLEMS Data*, Available at: http://www.worldklems.net/data.htm, Accessed November 2018.