Knowledge based activities. An accounting approach

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2º Taller LA KLEMS

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Based on:

- Pérez, Francisco and Eva Benages: *Knowledge accounting: an economic approach, Presented at the 3rd WORLD KLEMS Conference, Harvard, 2012*

- Maudos, Joaquin, Benages, Eva and Laura Hernández: *El valor Económico de las Actividades basadas en el Conocimiento en España y sus regiones, Fundación Ramón Areces, 2017.*

Motivation

What is a knowledge-based economy?

"A knowledge-based economy is one where organizations and people efficiently acquire, create, disseminate and use knowledge for greater economic and social development." (World Bank 2004)

Why is a knowledge-based economy important?

FACT: "Economies that base their production on the use of more qualified productive resources reach higher levels of productivity. Thus, the higher the share of the returns remunerating knowledge-based factors of production on aggregated income, the higher the income per capita"

Motivation

How is a knowledge-based economy measured?

The most common approach is to identify the activities or sectors with more R&D investment and highly qualified employment, and calculate their contribution to GDP and employment in the economy.

Based on this approach, the OECD usually refers to knowledge economy as digital economy, highlighting ICT-intensive sectors, such as, e-commerce, transport, education, health, etc.

Other approaches build indexes (i.e. Digital Economy and Society (Eurostat DESI Index) or KEI (Knowledge Economy Index), World Bank) based on various indicators on ICT use, human capital, information infrastructures, etc.

Motivation

What are the limitations to the approaches commonly used to measure the knowledge economy?

- They usually focus on sectors that create knowledge (ICT producers) and less so on sectors that use knowledge
- They focus only on a few factors such as skilled workers or R&D, excluding other important factors, such as intangible assets or other types of capital that use knowledge
- The intensity of the same knowledge-intensive sectors may differ among countries (research/innovative effort, level of human capital, etc.)
- The industry classification according to knowledge intensity depends on the selected threshold based on variables such as R&D&i intensity or educational level. Hence, a variation in the threshold would affect the weight of the knowledge economy

PROPOSED METHODOLOGY

Knowledge-based economy is defined as the knowledge embedded in both production factors, labour and capital.

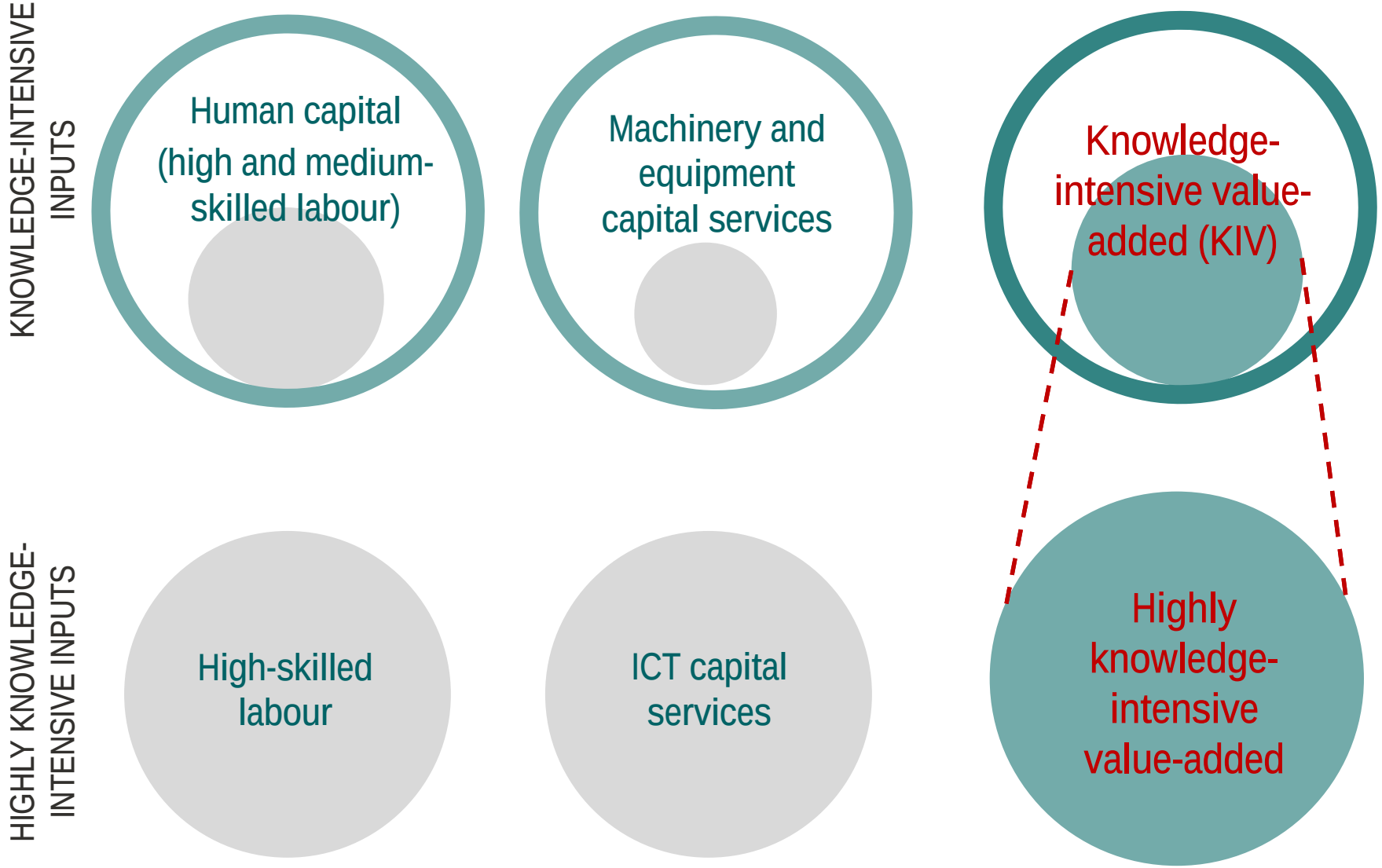
The approach consists of measuring the value of knowledge-based activities taking growth accounting methodology as its framework, which measures the contribution by each productive input (basically, capital and labour) to gross value added (GVA).

The idea consists of measuring the knowledge-based economy by calculating which part of the GVA is dedicated to remunerating the production factors that incorporate knowledge:

- In the case of labour, the distinction among knowledge and non-knowledge is based on on the distribution by level of educational attainment and occupation
- In the case of capital, this distinction is based on the distribution by asset type.

Methodology

2 x 2 categories of knowledge inputs used in productive activities



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Methodology

- L_{ij} is the amount of labor of type *i* used in sector *j*
- K_{hj} is the amount of capital of type *h* used in sector *j*
- P_{ij}^{L} is the unitary wage paid for labor of type *i* in sector *j*
- P_{hj}^{K} is the user cost of type *h* capital in sector *j*
- V_j is the quantity of sector *j* value added
- P_j^{V} is the price of sector *j* value added

The value added (GVA) of sector *j* is distributed among the different inputs included in the production process so that,

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

We decompose the value of labor and capital services into two parts, one that incorporates knowledge and another one that does not:

$$\sum_{i=1}^{m} L_{ij} \cdot P_{ij}^L = \sum_{i=1}^{f} L_{ij} \cdot P_{ij}^L + \sum_{i=f+1}^{m} L_{ij} \cdot P_{ij}^L \qquad \sum_{h=1}^{n} K_{hj} \cdot P_{hj}^K = \sum_{h=1}^{g} K_{hj} \cdot P_{hj}^K + \sum_{h=g+1}^{n} K_{hj} \cdot P_{hj}^K$$

assuming that there are *f* types of low-skilled labor and *g* assets that don't incorporate knowledge significantly.

Methodology

Assumption of **non-separability**: the knowledge of a qualified worker is a contribution to the production process non-separable from the contribution of unqualified labor by the same worker (similarly, in knowledge intensive capital the contribution of non knowledge components of this capital, like the iron of the machine, is not separable from the contribution of knowledge-intensive capital).

Value of knowledge intensive labor (KIL)

$$KIL_j^{ns} = \sum_{i=f+1}^{m} L_{ij} \cdot P_{ij}^{L}$$

Value of knowledge intensive capital (KIK)

$$KIK_j^{ns} = \sum_{h=g+1}^{n} K_{hj} \cdot P_{hj}^{K}$$

Knowledge-intensive value added (KIV): $KIV_j^{ns} = KIL_j^{ns} + KIK_j^{ns}$

Knowledge intensity (ç) of an activity *j*: $\varsigma_j^{ns} = KIV_j^{ns} / (V_j P_j^{V})$

Knowledge intensity (Ç) of the economy depends on the weight of the various industries in the aggregate, on the basis of the value-added generated:

$$\text{Ç} = \sum_{j=1}^{q} \varsigma_j^{ns} \cdot \left(\frac{V_j P_j^{V}}{\sum_{j=1}^{q} V_j P_j^{V}}\right)$$

AN EXTENSION BASED ON MAUDOS ET AL (2017)

Identification of the knowledge-based factors

a) Knowledge-intensive labour

Table 1

	High-skilled occupations (ISCO 1-3)	Mid-skilled occupations (ISCO 4-8)	Unskilled occupations (ISCO 9)
Tertiary education (ISCED11 5-8, ISCED97 5-6)	Knowledge-intensive labour		Non-Knowledge intensive labour
Upper secondary education (ISCED 3-4)	Knowledge-intensive labour		Non-Knowledge intensive labour
Below upper secondary education (ISCED 0-2)	Knowledge-intensive labour	Non-Knowledge intensive labour	

b) Knowledge-intensive capital

Table 2

1. Non-knowledge-intensive assets
1.1. Dwellings
1.2. Non-residential structures
2. Knowledge-intensive assets
2.1. Transport equipment
2.2. Machinery, equipment and other assets
2.3. ICT assets
2.4. Intangible assets (included in NA)

SOME RESULTS (EU KLEMS DATA)

Data

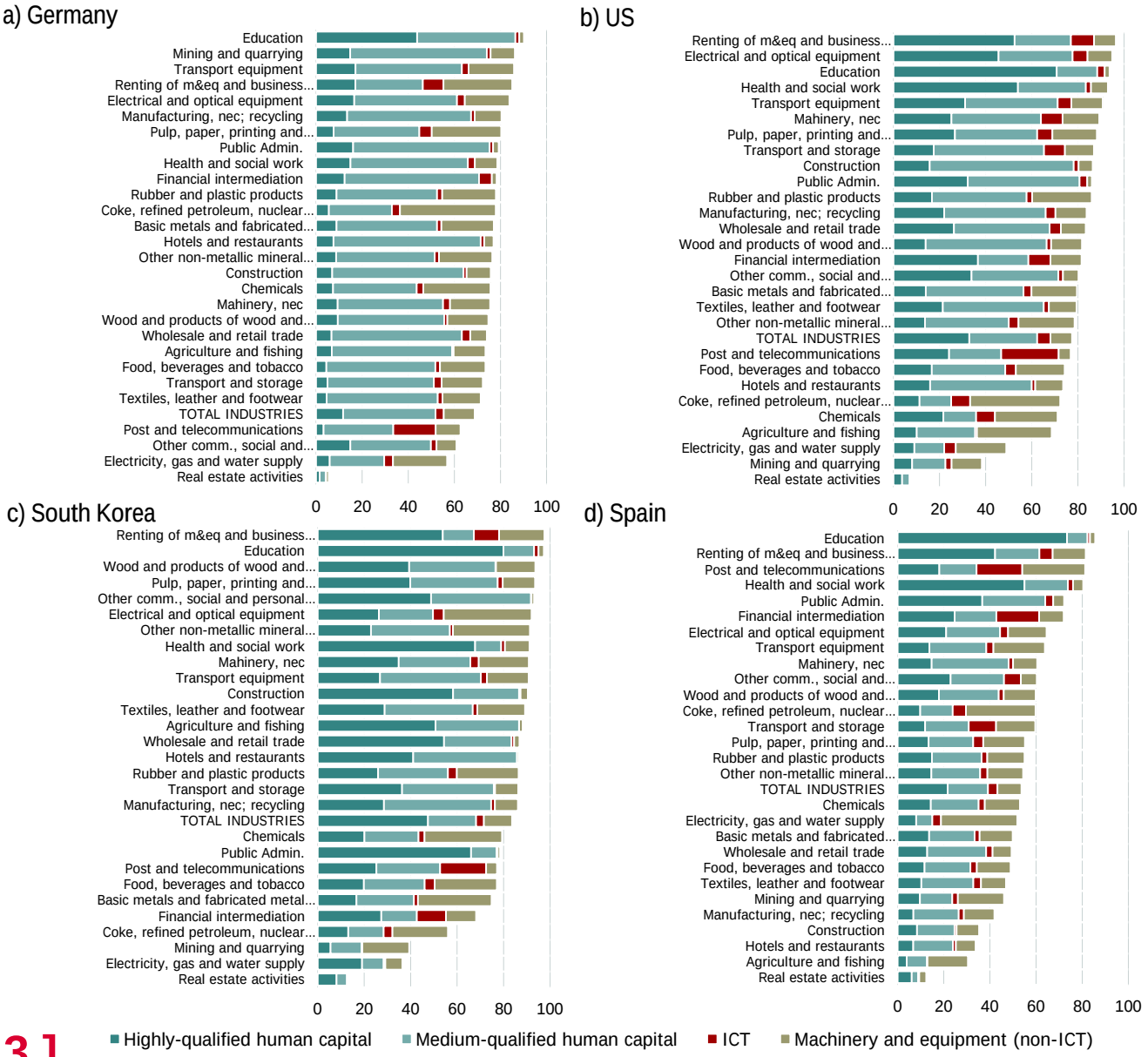
- EU KLEMS database
- 18 countries
- 28 industries
- 1980-2007

Table 3. Countries and period coverage

Countries	Period covered
Germany	1980-2007
Australia	1980-2007
Austria	1980-2007
Korea	1977-2005
Denmark	1980-2007
United States	1970-2007
Slovenia	1995-2006
Spain	1980-2007
Finland	1970-2007
France	1980-2007
Ireland	1995-2005
Italy	1970-2007
Japan	1970-2006
The Netherlands	1979-2007
Portugal	1995-2005
United Kingdom	1970-2007
Czech Republic	1995-2007
Sweden	1993-2007

It allows to compare knowledge intensity by industries and countries

FIGURE 1. GVA knowledge intensity by industries, 2007. (percentage)



Note: 2005 for South Korea. Source: EU KLEMS and own calculations.

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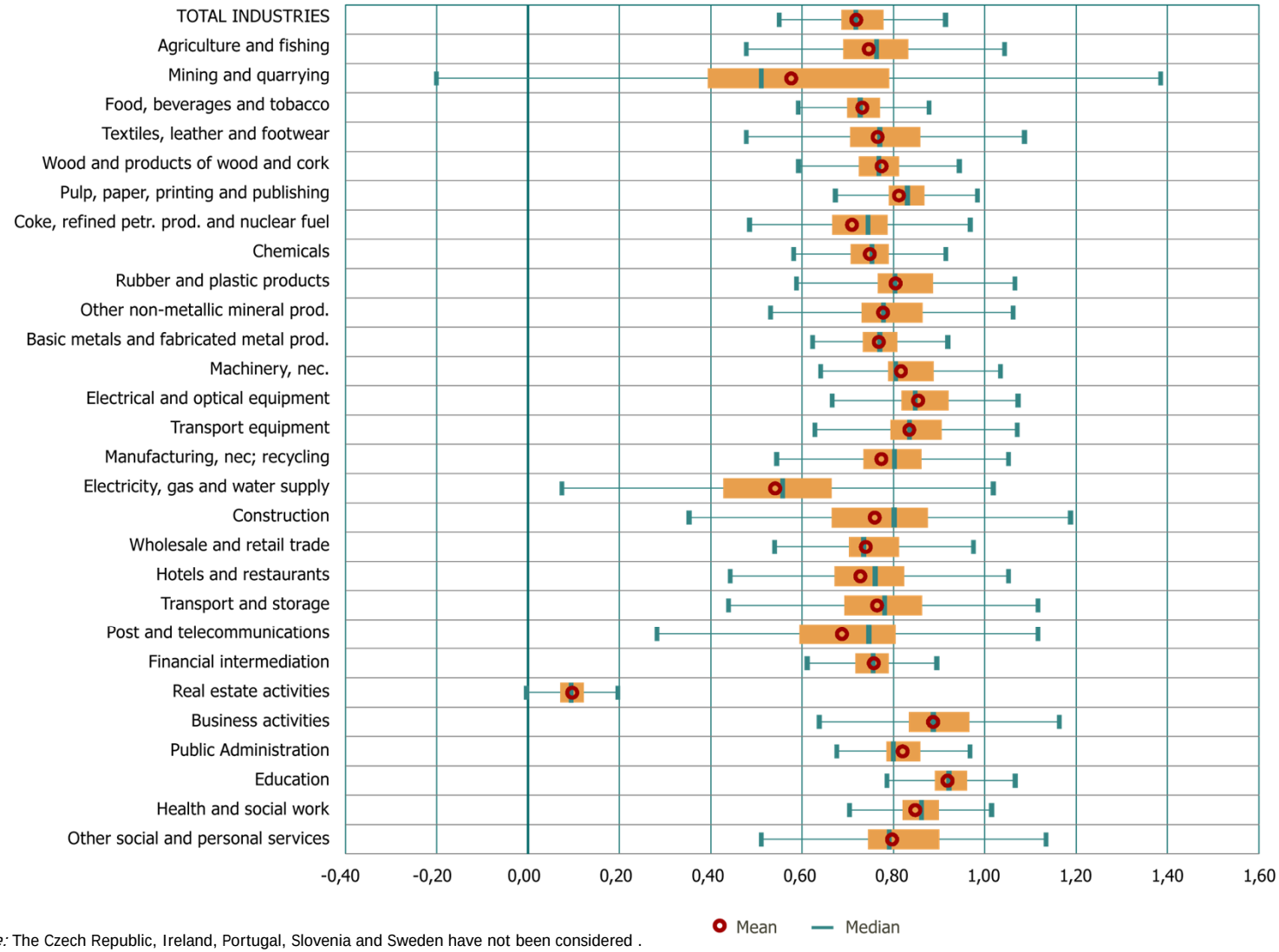
And the dispersion of knowledge intensity by industries and countries

FIGURE 2. Boxplot of GVA knowledge intensity by industries, 2005



Note: The Czech Republic, Ireland, Portugal, Slovenia and Sweden have not been considered .
Source: EU KLEMS and own calculations.

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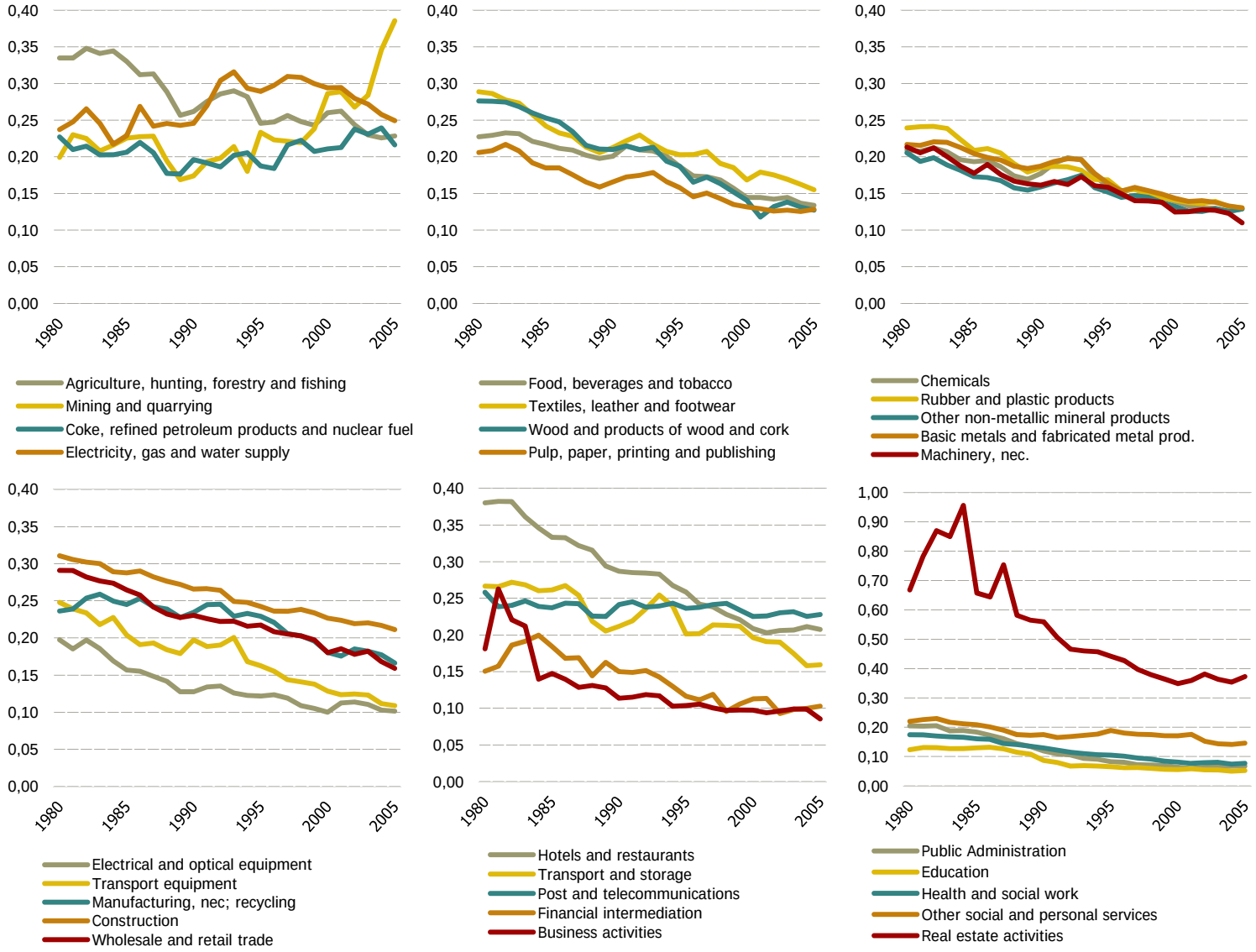
The evolution of the dispersion for industries over time

FIGURE 3. σ-convergence in GVA knowledge intensity by industries,1980-2005.
(coefficient of variation)



Note: The Czech Republic, Ireland, Portugal, Slovenia and Sweden have not been considered .
Source: EU KLEMS and own calculations.

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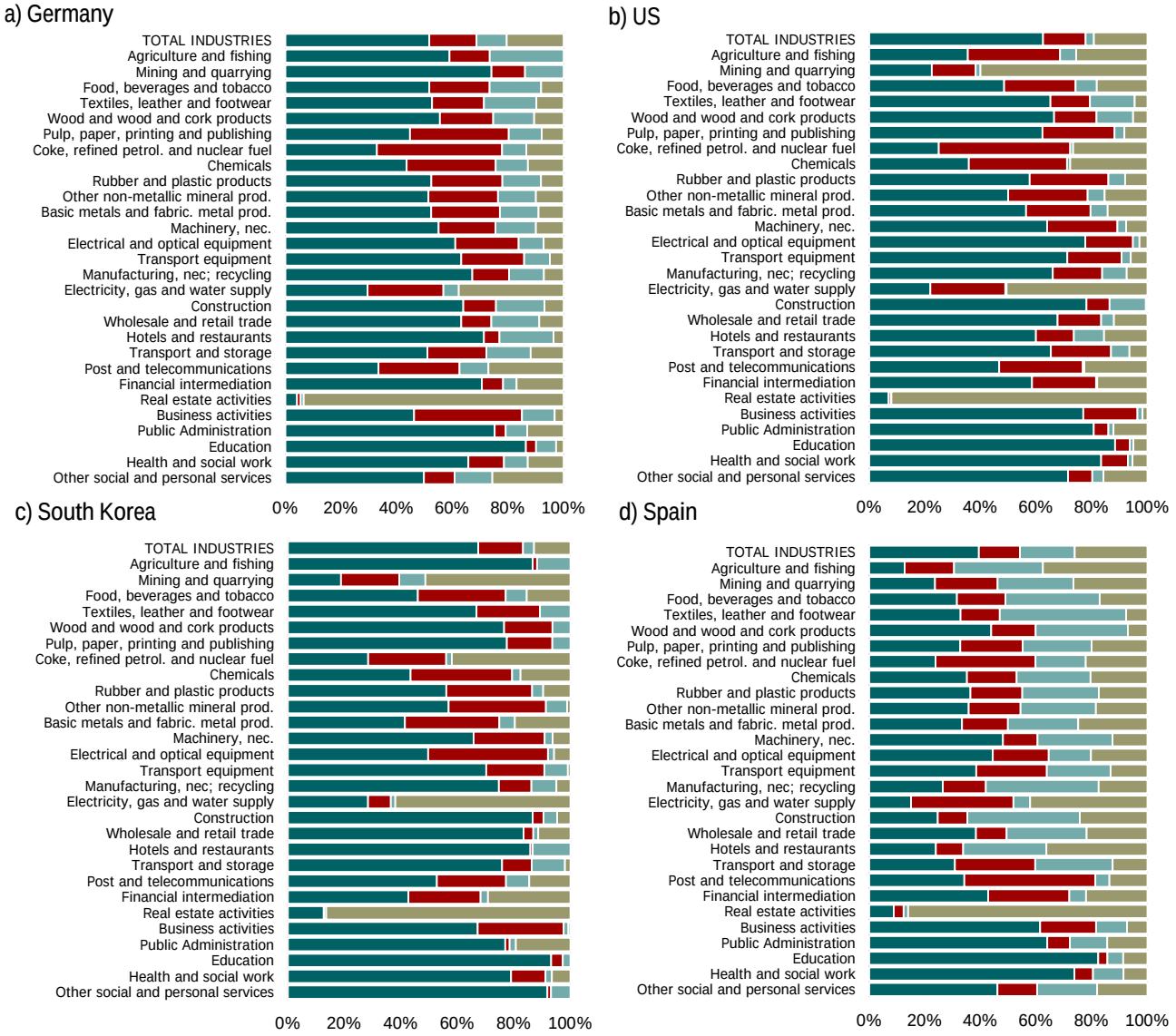
As well as the contribution of knowledge to productivity

FIGURE 4. Labour productivity by components and indutries, 2007.
(percentage)



Note: 2005 for South Korea. *Source:* EU KLEMS and own calculations.

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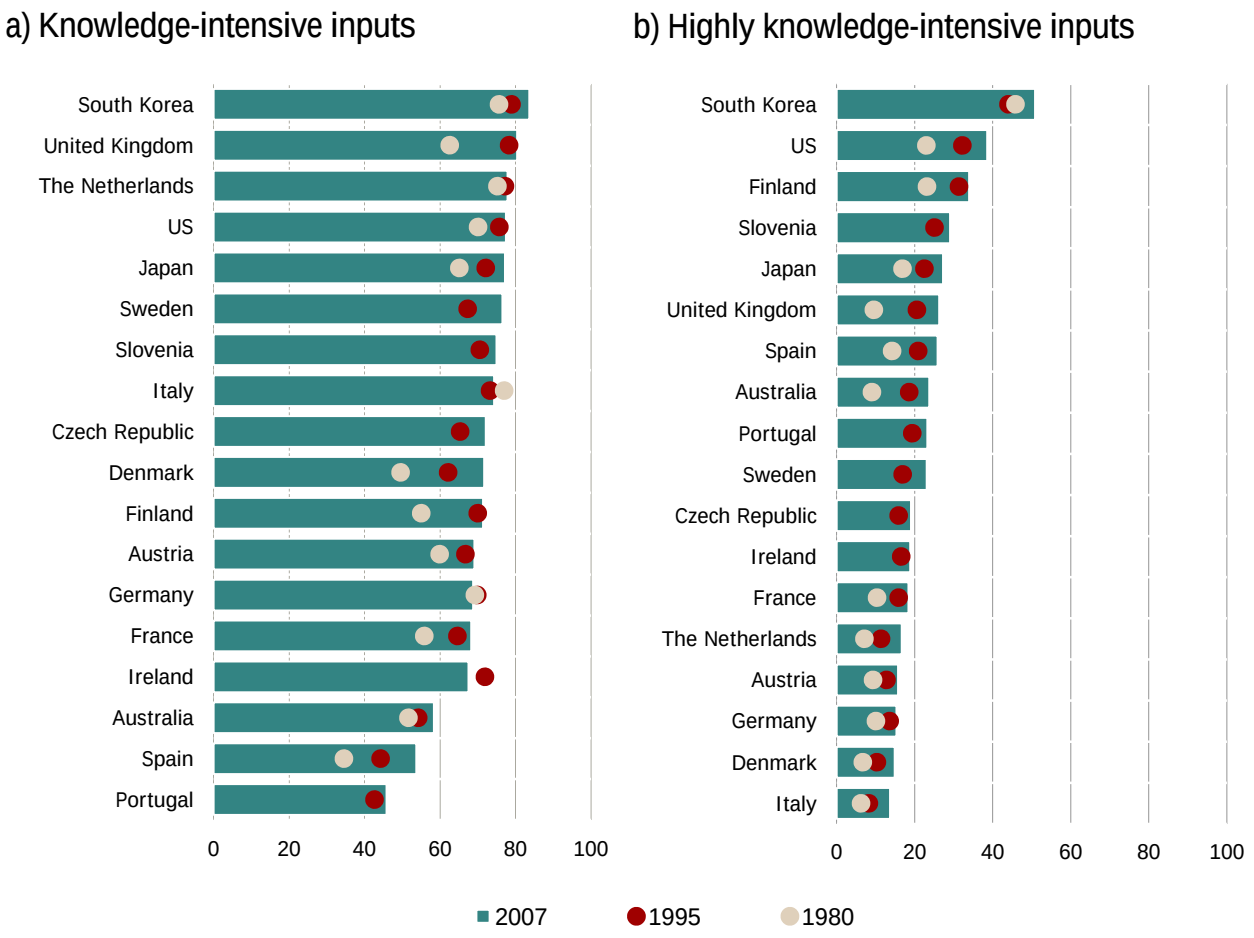
Industry results: summary

- Human capital is more determinant in establishing differences in knowledge intensity than machinery, among sectors and within sectors.
- Knowledge intensity in the same industry varies notably among countries and warns us of the risk of classifying industries in categories by technological intensity.
- The time series show that the use of knowledge is an increasingly common feature of the countries in the sample.
- Differences among countries in labor productivity for each sector are primarily associated with the contribution of highly qualified labor.

Aggregate results: knowledge intensity by countries

FIGURE 5. GVA knowledge intensity by countries, 1980, 1995 y 2007.
(percentage)



Note: 2005 for Ireland, Portugal and South Korea and 2006 for Japan and Slovenia.
Source: EU KLEMS and own calculations.

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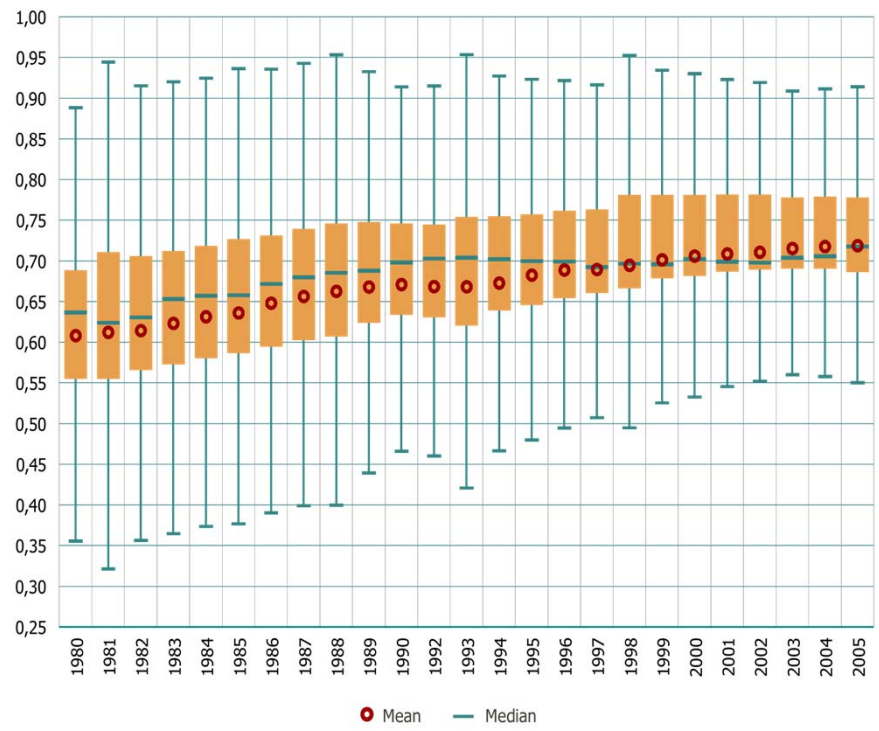
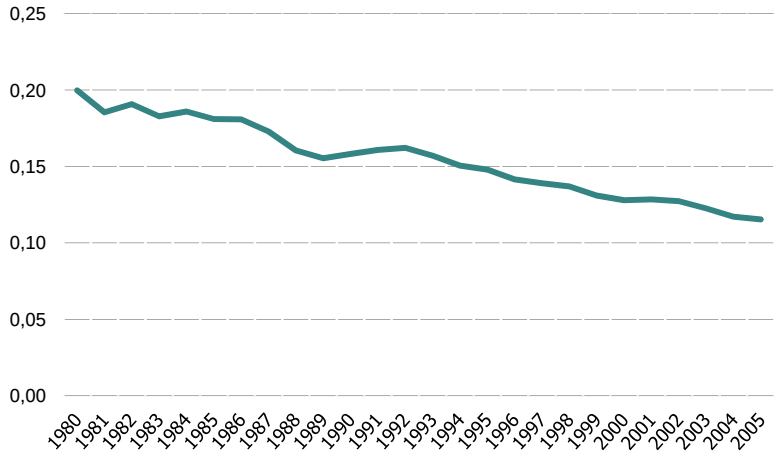
Aggregate results: dispersion and convergence

FIGURE 6. Boxplot of GVA knowledge intensity by countries, 1985-2005



Note: The Czech Republic, Ireland, Portugal, Slovenia and Sweden have not been considered .
Source: EU KLEMS and own calculations.

FIGURE 7. -convergence in GVA knowledge intensity. Total industries, 1980-2005.
(coefficient of variation)



Note: The Czech Republic, Ireland, Portugal, Slovenia and Sweden have not been considered .
Source: EU KLEMS and own calculations.

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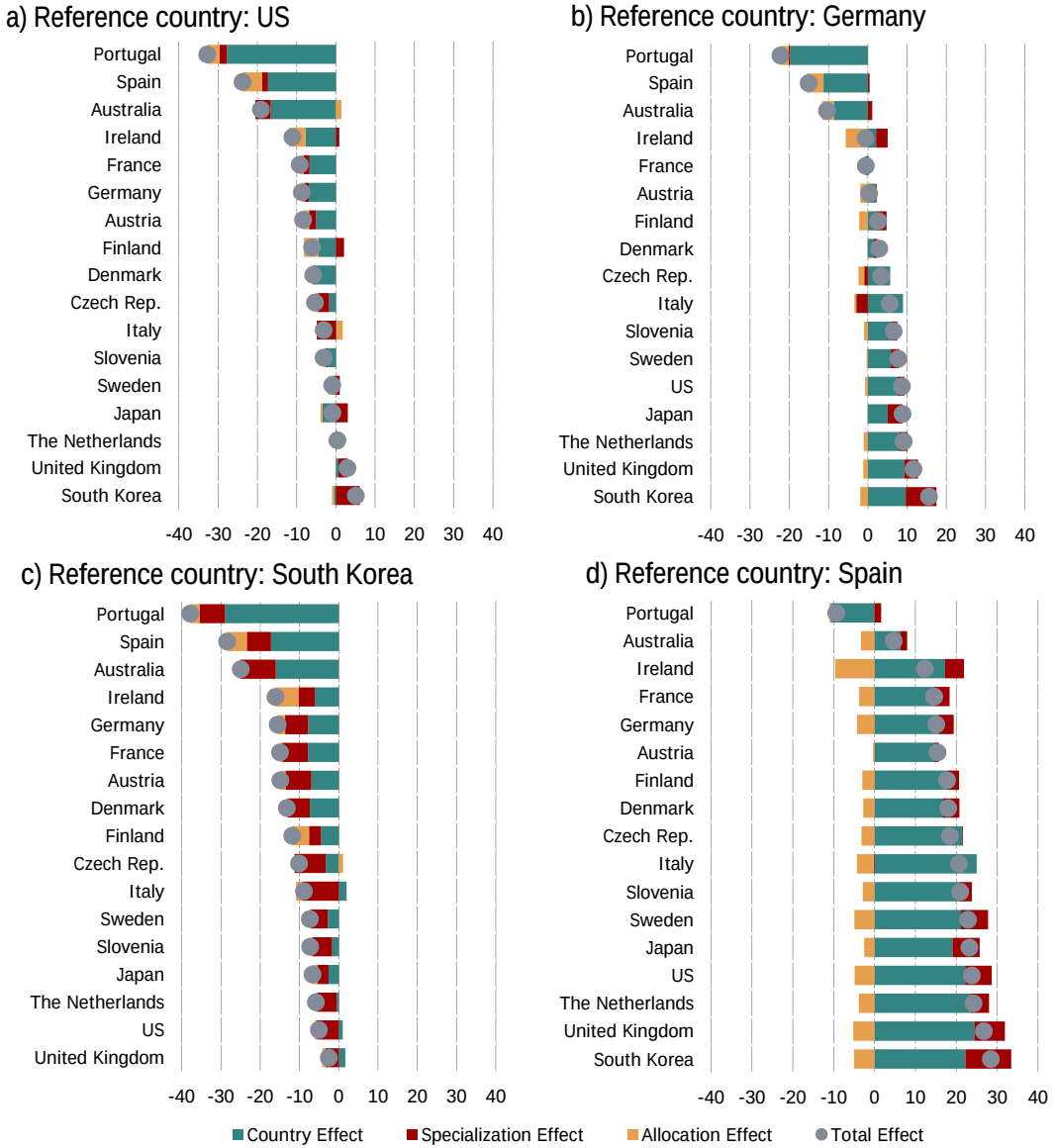
Aggregate results: determinants of differences

FIGURE 8. Knowledge-intensity shif-share analysis. 2007
(absolute differences in percentage points on GVA)



Note: 2006 for Japan and Slovenia and 2005 for Ireland, Portugal and South Korea. 2005 for Figure 3c.
Source: EU KLEMS and own calculations.

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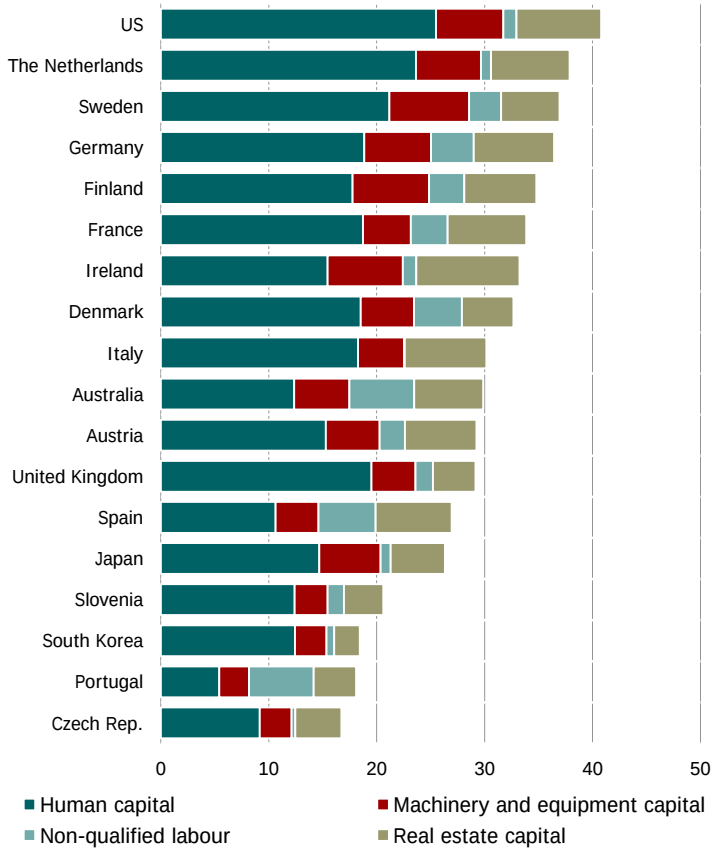
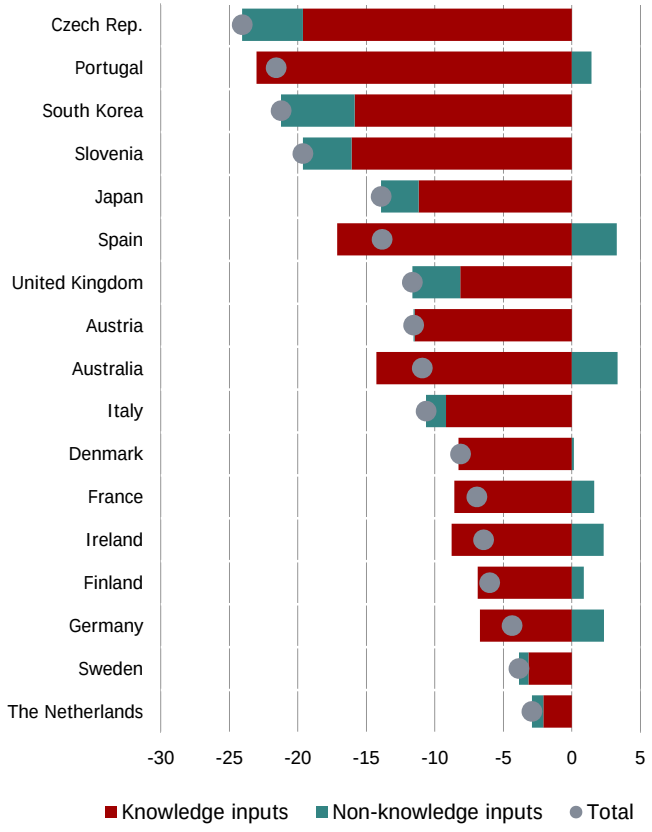
Aggregate results: knowledge and productivity

FIGURE 10. Labour productivity by components, 2007.
(2000 PPS euros per hour worked)



Note: 2006 for Japan and Slovenia and 2005 for Ireland, Portugal and South Korea.
Source: EU KLEMS and own calculations.

FIGURE 11. Decomposition of the differences in labour productivity. Reference country: US, 2007
(absolute differences in percentage points on GVA)



Note: 2006 for Japan and Slovenia and 2005 for Ireland, Portugal and South Korea.
Source: EU KLEMS and own calculations.

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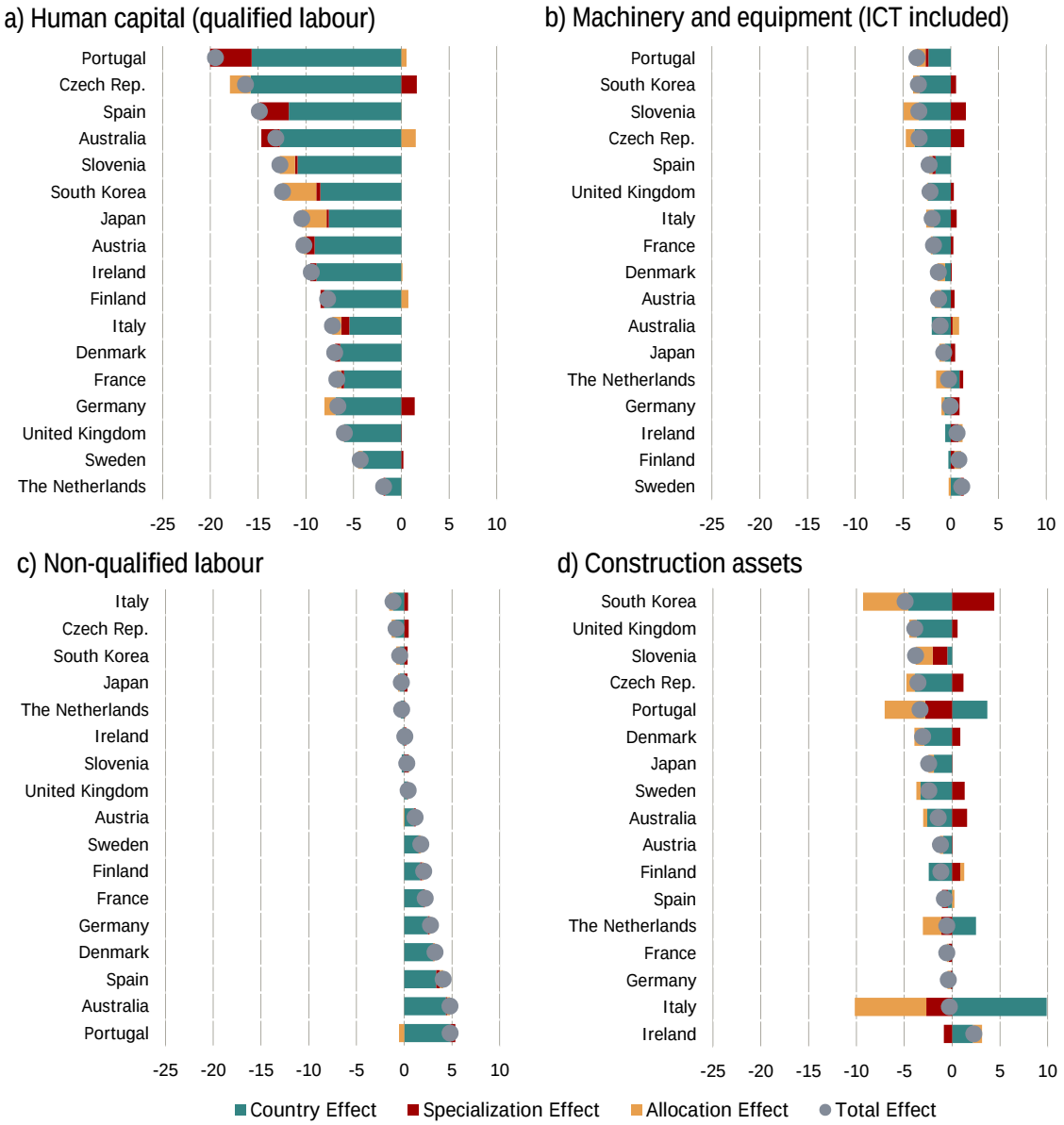
Aggregate results: knowledge (by factors) and productivity

FIGURE 12. Labour productivity components shif-share analysis. Reference country: US, 2007
(absolute differences in 2000 PPS euros per hour worked)



Note: 2006 for Japan and Slovenia and 2005 for Ireland, Portugal and South Korea. *Source:* EU KLEMS and own calculations.

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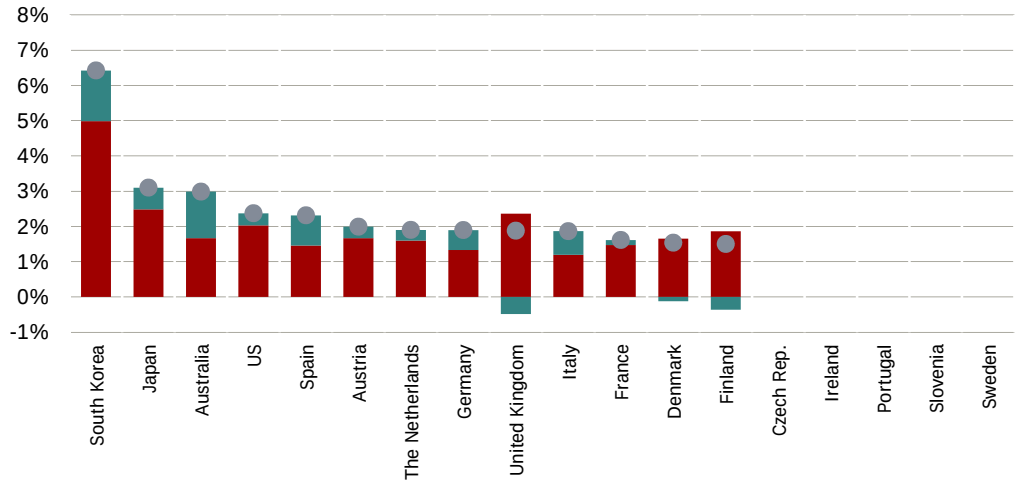
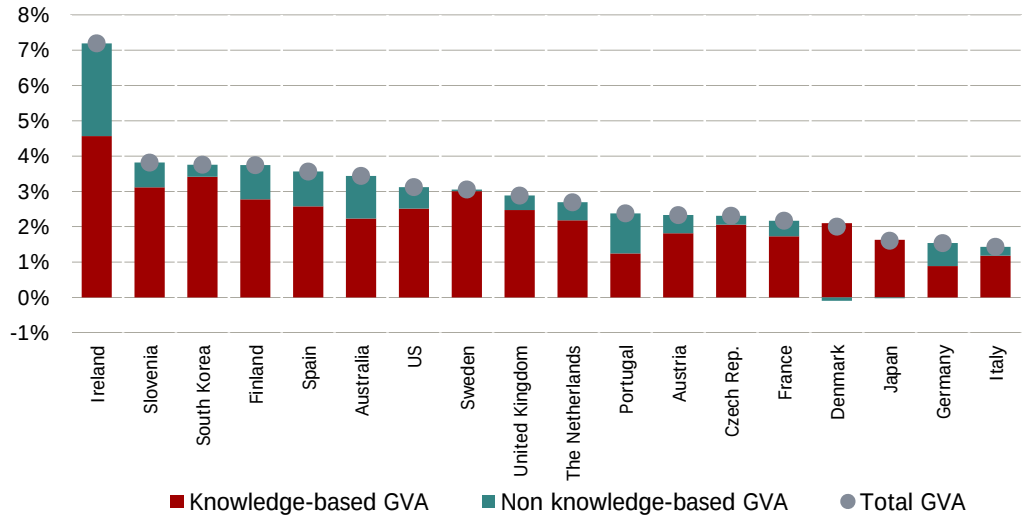
Aggregate results: knowledge and GVA growth

FIGURE 13. Knowledge contribution to the annual growth of GVA. 1980-1995 and 1995-2007 (percentage points)

a) 1980-1995



b) 1995-2007



Note: 1990-2006 for Japan and Slovenia and 1990-2006 for Ireland, Portugal and South Korea in figure 10b.
Source: EU KLEMS and own calculations.

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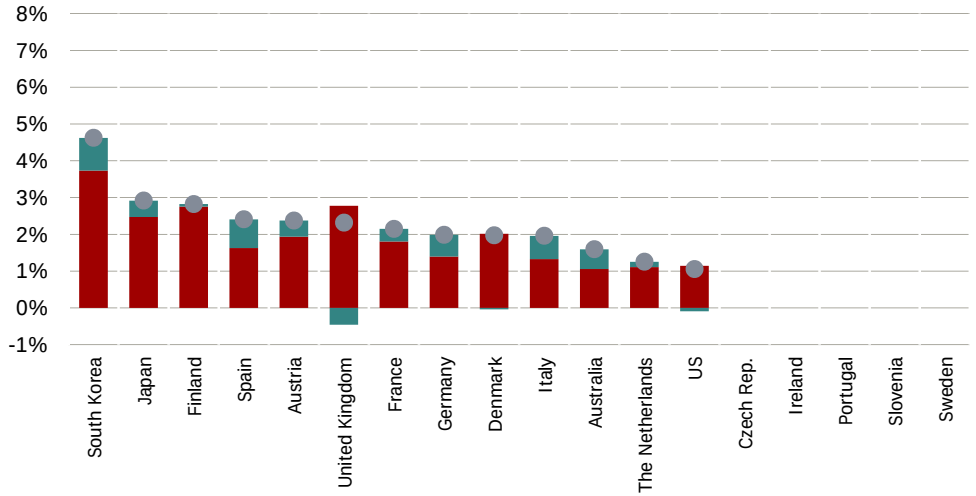
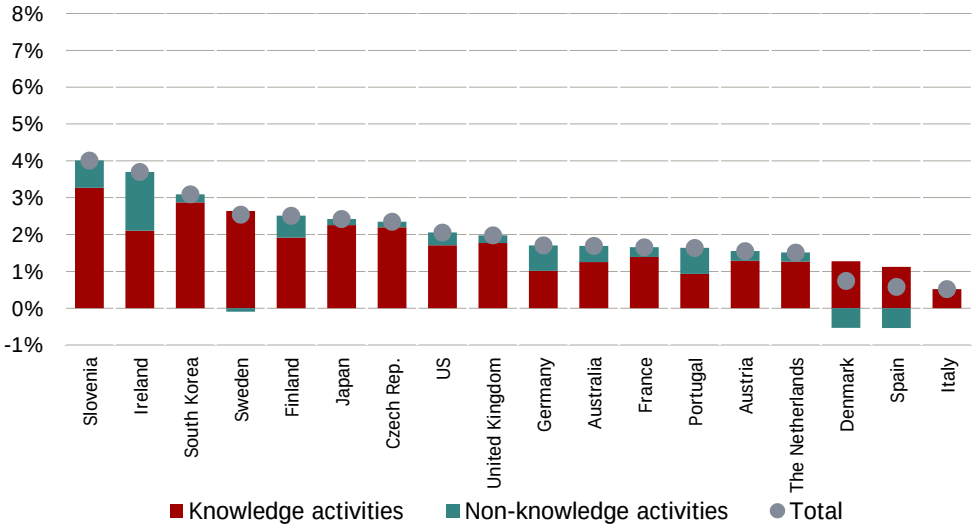
Aggregate results: knowledge and productivity growth

FIGURE 14. Knowledge contribution to the annual growth of labour productivity. 1980-1995 and 1995-2007 (percentage points)

a) 1980-1995



b) 1995-2007



Note: 1990-2006 for Japan and Slovenia and 1990-2006 for Ireland, Portugal and South Korea in figure 14b.
Source: EU KLEMS and own calculations.

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Aggregate results

- Recently, in several advanced economies the intensity of the use of knowledge has been higher than 75%. The increasing intensity is associated primarily with higher education and ICT.
- Country differences in knowledge intensity decrease, due to the positive evolution of less developed countries.
- The main differences among countries are based on intra-industry specialization, rather than inter-industry specialization.
- The disadvantages in country productivities in comparison with the US stem from the high use of knowledge-intensive factors in the American economy.
- From 1980 to 2007 knowledge has played a crucial role in the growth of GVA and productivity in almost all developed countries.

Knowledge accounting: conclusions

The results of applying the proposed metric of the use of knowledge-based factors in productive activities show that:

- Today advanced economies are extensively based on knowledge: more than half of the GVA remunerates human capital and machinery, factors which incorporate knowledge to the production processes.

- Knowledge is an increasingly common feature of all activities: the factors which incorporate it are the basis for competitiveness and growth.

- The differences among countries in knowledge intensity stem primarily from intra-industry differences: due to the very different activities being carried out within them and to their different weight in each economy.

Knowledge accounting: policy implications

- The conventional country classification by categories of technological intensity prevents us from showing that the same industry can differ in the intensity of knowledge among countries → what is critical for promoting the use of knowledge is the renewal of the productive fabric in each industry.

- The differences among industries in the intensity of use of human capital and machinery do not respond to the dichotomy manufacturing *vs.* services → manufacturing is not superior in the use of knowledge.

- The highest contributions of knowledge to productivity lie on a better use of human capital, particularly, of the workers with higher education → if education does not meet the needs of industry or if employment offered by firms does not exploit de potential of education, more value added cannot be generated nor wages can increase.

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