Digital Tasks and ICT Capital:

Methodologies and Data

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Abstract

This report describes the data and documents the data collection and adjustment procedures for a project called 'Comparative Advantage in the Digital Era'. This project uses granular information on the tasks being performed by workers in different occupations on the one hand and different asset types of capital on the other hand to pin down comparative advantages in digital tasks and ICT capital. Given the nature of the project, the data work focuses on the adjustment of the underlying occupation and industry-specific employment data and the asset-type and industry-specific capital stock data to match the figures in the Intern-Country Input Output tables. The latter are a key ingredient for the calculation of endowment based comparative advantages. Finally, it explains the Survey on Italian Occupations (*Indagine Campionaria sulle Professioni,* ICP), a unique database on the characteristics of occupations in the Italian and its US-American counterpart, the O*NET database. The data work documented in this report builds the foundation for the further work of the aforementioned project.

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Introduction

This paper provides an overview of the methodologies to compile the numerous samples used across the different work packages of a comprehensive project on 'Comparative Advantage in the Digital Era'.[1]

Although some of the main data sets of the project are used throughout several work packages, there are also several particularities and differences in countries and years covered, as well as in the indicators used. Figure 1 summarises the structure of the project.

Figure 1 / Content of and relationships between work packages
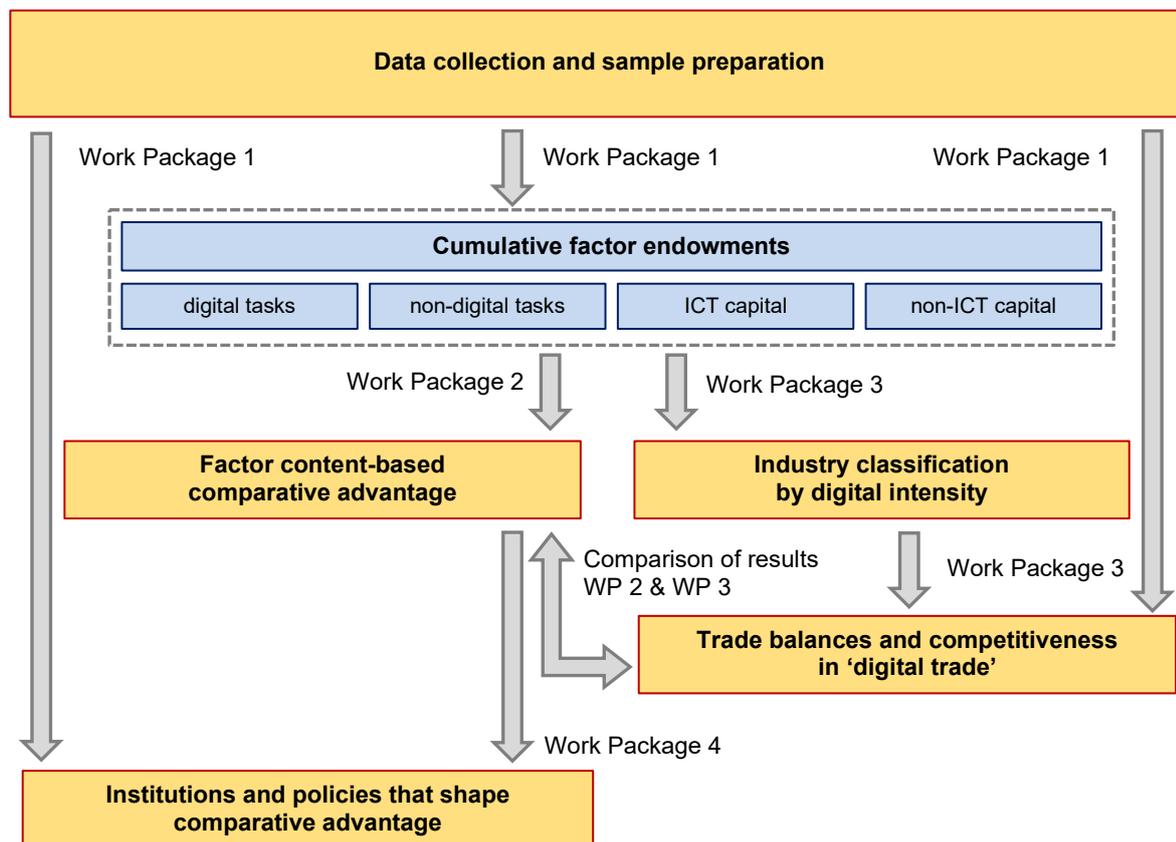
Source: wiiw representation.

The data and methodologies presented in this technical report are mainly used and analysed in Work Package 2. This report is to be seen as a technical input to the two papers resulting from Work Package 2: 'Comparative Advantages in the Digital Era – A Heckscher-Ohlin-Vanek Approach' and 'The Race for Digital Leadership: Is Europe losing out to the US?'. For each of these papers, the information provided is organised in two parts: (i) the description of the data; and (ii) the data adjustments and

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[1]   For further information, see the project website at: https://wiiw.ac.at/comparative-advantage-in-the-digital-era-new-insights-into-trade-in-digital-tasks-and-ict-capital-pj-244.html

imputations. The main data sources described in this report are related to (i) digital tasks and ICT capital; (ii) data on factor endowments, notably employment data at the occupation-industry level and capital stock data at the asset type-industry level; and (iii) the inter-country input-output database, which is either the World Input-Output Database or the OECD Inter-Country Input-Output (ICIO) database. Moreover, the adjustment procedures for missing data are presented.

1. Comparative Advantages in the Digital Era – A Heckscher-Ohlin-Vanek Approach

1.1. DATA

The paper identifies and analyses the comparative advantages of 25 EU member states for the year 2012. Therefore, the data preparations focus on that year, although some data are also prepared for additional years.

1.1.1. European Labour Force Survey

The Labour Force Survey (LFS) of the European Union is a collection of national LFSs conducted by the national statistical offices of member states.[2] The LFS is the largest European household sample survey and is conducted on a quarterly basis. The survey includes people aged 15 years and over. Although the national statistical offices are responsible for conducting the LFS, the surveys are harmonised as the statistical offices use (i) the same concepts and definitions (in line with ILO guidelines); and (ii) the same classifications for industries (NACE), occupations (ISCO), educational attainment (ISCED) and regions (NUTS). Moreover, the same set of characteristics is collected by each member state.

For the analysis of comparative advantages, the number of employed persons is the main variable of interest. Equally important are the economic activities (NACE Rev.2 industries at the 1-digit level) to which these employed persons are assigned, as well as their occupation (reported at the ISCO-08 3-digit level). In contrast, no use is made of additional characteristics such as nationality, age, sex, marital status, part-time or full-time employment status, educational attainment level, or participation in education and training. A list of the ISCO-08 3-digit occupations is reported in Appendix Table A.1.

The LFS data are available for the period 1983 to 2019. The data used follow the methodologies applicable until the 2020 data collection.[3]

1.1.2. EU KLEMS

The EU KLEMS Growth and Productivity Accounts provide useful information on different categories of inputs, including capital (K), labour (L), energy (E), material (M) and service inputs (S) at the sectoral level (Timmer et al., 2007). The EU KLEMS are denoted as Growth and Productivity Accounts because the detailed information on inputs allows the calculation of (real) productivity and growth measures at the industry level.

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[2]   See: https://ec.europa.eu/eurostat/web/microdata/european-union-labour-force-survey

[3]   The methodology was adjusted in the year 2021. See: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=EU_labour_force_survey

The most recent edition of the EU KLEMS is the EU KLEMS Release 2019.[4] It provides measures of economic growth, productivity, employment, capital formation, and technological change at the industry level (NACE Rev.2) for all EU member states, Japan and the United States. All productivity measures have been developed using growth accounting techniques and, for the first time, the EU KLEMS Release 2019 includes supplementary indicators on intangible assets (Adarov and Stehrer, 2019).

For the EU countries, the EU KLEMS is based on Eurostat data, in particular data from the European System of National Accounts (ESA).[5] Although the EU KLEMS database now includes all member states, the coverage of individual indicators varies across member states and it turns out that, for some countries, Eurostat provides additional data. This is also true for the data on capital stock (and various asset types) needed in this analysis. Therefore, the EU KLEMS Release 2019 data, covering the period 1995-2017, is supplemented with more recent ESA data available from Eurostat. The EU KLEMS data is used because for some countries (Germany and Spain) data were published at the time the EU KLEMS Release 2019 was set up but are no longer provided on Eurostat. This combined data will be simply referred to as EU KLEMS.

As mentioned, the key variable used from the EU KLEMS is the capital stock. More precisely, what is needed are capital stocks related to information and communication technologies (ICT) or ICT capital for short. For this purpose, the detailed sub-categories of capital stocks (see Figure 2) are required.

Figure 2 / Asset breakdown according to the System of National Accounts and EU KLEMS
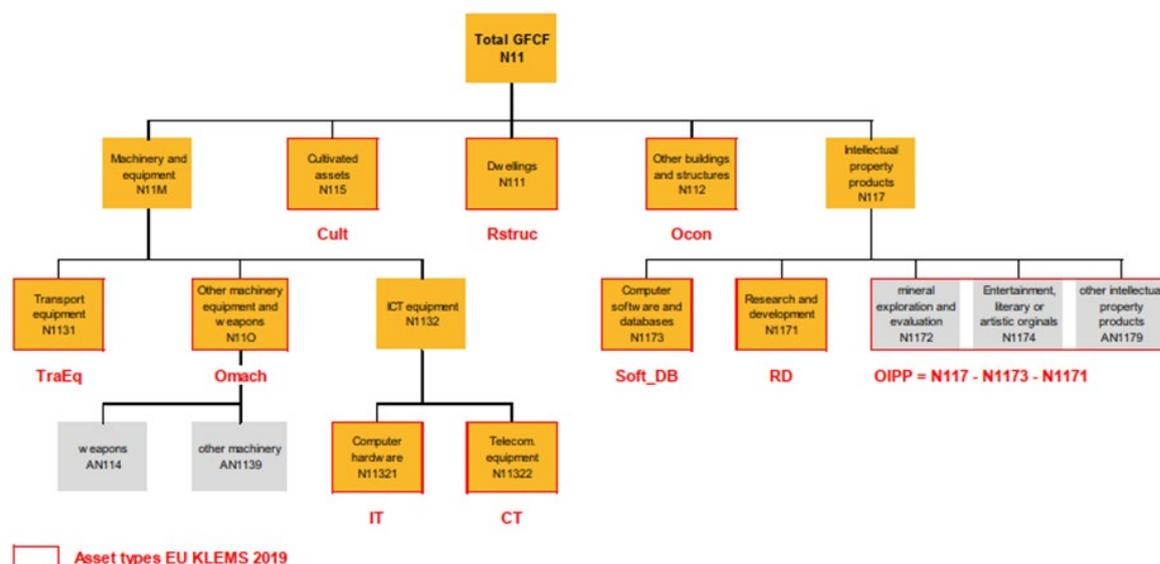
Note: Asset types are based on ESA 2010 definition. Those with a code are available at Eurostat (yellow/orange), others are not (grey). The "N" in front of the asset code indicates net stocks (net of depreciation).
Source: Adarov and Stehrer (2019).

The relevant measure, ICT capital, net of depreciation, is defined to include three items (marked by red rectangles in Figure 2) from the various asset types that make up gross fixed capital formation. These are:

(i)   Computer hardware (N11321);

(ii)   Telecom equipment (N11322); and

(iii)   Computer software and databases (N1173).

Hence, the definition of ICT capital employed includes tangible assets – computer hardware and telecom equipment – and intangible assets – computer software and databases. The latter are the only asset types included in the category 'computerised information' within the intangible assets in Adarov and Stehrer (2019).

All other asset types are labelled non-ICT capital and are defined as gross fixed capital formation (GFCF) less ICT capital for each country and industry.

1.1.3.   Survey on Italian Occupations

The Survey on Italian Occupations (*Indagine Campionaria sulle Professioni,* ICP) is a unique data set compiled by the National Institute for Public Policy Analysis of Italy (INAPP). The data are based on a survey of Italian firms and provide very detailed information about the task content of occupations.

Following closely the approach applied in the well-known American O*NET database, the ICP focuses on occupations that provide an extensive amount of information on skills, tasks, work content, technology and organisational characteristics of the workplace. As a result, a growing number of studies rely on the ICP to analyse, among other things, the impact of digitalisation on employment (Cirillo et al., 2021); the relationship between task specialisation and labour market transitions (Cassandro et al., 2021); the role of organisational factors in shaping the Italian occupational structure (Cetrulo et al., 2020); and the diffusion of telework and its implications in terms of inequalities (Cetrulo et al., 2022). The information is collected at the 5-digit occupational level (i.e. 811 occupational codes), ensuring representativeness with respect to sector, occupation, firm size and geographical domain (macro-regions). Occupation-level variables are built, relying on survey-based worker-level information – 16,000 Italian workers are included in the sample – as well as on post-survey validation by focus groups of experts. The survey was carried out in two waves: 2007 and 2012.

The occupations follow the Classificazione delle Professioni (CP) provided by the Italian National Statistical Institute (ISTAT) as of 2011. The structure of the CP is based on the logic of the International Standard Classification of Occupations (ISCO). For this reason, a crosswalk between the two classifications is easily possible.

To measure digital comparative advantages, we rely on the ICP-based digital tasks (DTI) and digital use (DUI) indicators, which are defined at the 4-digit level of occupations according to the CP, as described at length in Cirillo et al. (2021). The scores of the digital indicators of each CP occupation are transposed to the ISCO-08 classification and then aggregated to the 3-digit ISCO level.

According to the role played by IT technologies in each occupation, digitalisation may assume very different shapes (e.g. developers vs users of digital technologies). As a result, aggregate indicators and proxy variables may risk missing the target, providing an inaccurate measurement of digitalisation and/or overlooking important heterogeneities. The ICP-based indicators proposed by Cirillo et al. (2021) allow measurement of the digitalisation of occupations in a highly detailed way. Relying on such indicators, it is possible to distinguish between occupations for which digital tools are marginal or irrelevant and, at the other extreme, those directly involved in the development of such technologies. The DUI – the 'broader' digitalisation indicator of the two proposed by Cirillo et al. (2021) – measures how often and how well workers in any professional group interact with digital technology. This indicator builds on two rather generic ICP items: 'working with computers' and 'using e-mail as part of one's occupation'. Stemming from the ICP 'General workplace activities' section, the first item captures the proficiency of respondents in using computers. The second item, from the 'Working conditions' section, lists how often respondents use e-mail as part of their work. Despite being generic, the DUI represents a useful signal of digitalisation of the workplace, beyond the activities of the individual employee.

The narrower and more fine-grained measure of digitalisation proposed by Cirillo et al. (2021) is the DTI. The latter is built exploiting a free-form section included in the 2012 wave of the ICP, wherein individual workers – using their own words in a lightly co-ordinated manner – describe up to 15 work activities (or tasks) characterising their occupation. For each task, the respondents report a score, indicating its importance. Operationally, the DTI is built following three steps. First, 5,700 individual words used to describe tasks are analysed, ending up with 51 items identified as expressly denoting digital technology, e.g. informatics (IT), network, database, computer, or describing it in a specific context, such as programming, information, recording, network. Second, task descriptors using such words are analysed 'in context' to rule out false positives. This process leads to the identification of 131 activities that explicitly involve digital technologies and thus define 'highly digital' occupations. Third, the DTI is derived by computing, for each occupation, the weighted average, i.e. the 'importance score' of the digital tasks compared with all the tasks used to describe the occupation. As Cirillo et al. (2021) underline, the DTI allows measurement of the digitalisation of tasks at both the extensive margin, i.e. whether digital tasks are carried out at all, and the intensive margin, i.e. how important they are relative to the other tasks in that occupation.

1.1.4. World Input-Output Database

The calculation of primary factor embodiments in trade requires country-industry specific information on sourcing structures. This kind of information is available in international input-output tables. As the analysis is limited to the year 2012, this paper uses the input-output table from the World Input-Output Database (WIOD) Release 2016 (Timmer et al., 2015).

The WIOD database contains information about inter-industry and final demand flows for 43 countries and the rest of the world for the period 2000-2014. It features 56 industries – corresponding to NACE Rev.2 industries, mainly at the level of divisions (2-digit industries) and occasionally to NACE Rev.2 sections (1-digit industries).[6]

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[6]   NACE Rev.2 1-digit industries are assigned letters, while 2-digit industries (and higher) are denoted by numbers.

Figure 3 illustrates the general structure of the global input-output table in WIOD for three countries (A, B and C) and three industries (mining, steel and cars).

Figure 3 / Stylised representation of the Global Input-Output Table in WIOD

The table consists of three major blocks: the inter-industry block, containing the inter-industry flows of intermediate goods between firms; the final demand block, containing the country-specific final demand for final outputs produced by each country-industry; and the payment sector block. The last of these summarises the total value added and outputs produced in each of the sectors.

In the inter-industry block and the final demand block, the demand for goods and services of a sector are arranged along the columns of the buying unit. Similarly, the amount of goods and services produced by sellers is identifiable along the rows. With both blocks, the main diagonal contains domestic sales, while off-diagonal cells feature international sales.

Total output produced by any country-industry is found in the table both in the final column on the right (as the sum of all sales by a specific country-industry to intermediate users and final users) and at the bottom of the payment sector, as – by definition – output is equal to the sum of inter-industry demand of a specific country-industry and the value added generated in the same industry.

1.2.   DATA ADJUSTMENTS AND IMPUTATIONS

1.2.1.   Employment data

The European Labour Force Survey (LFS) is the primary source for the employment data. It provides data on employment at both the occupation level, following the International Standard Classification of Occupations (ISCO), and at the industry level, following the statistical classification of economic activities in the European Community, Revision 2 (NACE Rev.2.)

Employment data is available upon request from Eurostat at the combined ISCO 3-digit and NACE Rev.2 1-digit level in the LFS. From previous research projects, wiiw also has access to data for ISCO 3-digit level and NACE Rev.2 2-digit level from the LFS for EU member states for the years 2007 and 2012. These data are important because the World Input-Output Database (WIOD) Release 2016 contains mainly (although not exclusively) industries at the 2-digit level (industry divisions).

Table 1 / Differences in the sum of detailed employment and total employment reported in the LFS, 2012

	(1) Total LFS employment	(2) Sum of LFS employment by Occupation Minor Groups (ISCO-08) and Industry Divisions (NACE Rev.2)	(3) Absolute difference (2) – (1)	(4) Relative difference (%) (3) / (1)
AT	4,084,392	4,084,487	95	0.00
BE	4,524,378	4,523,914	-464	-0.01
BG	2,933,968	2,933,974	6	0.00
CH	4,351,420	0	-4,351,420	-100.00
CY	385,129	385,227	98	0.03
CZ	4,889,055	4,886,479	-2,576	-0.05
DE	39,717,536	39,126,490	-591,046	-1.49
DK	2,644,916	2,678,628	33,712	1.27
EE	614,932	613,878	-1,054	-0.17
EL	3,695,298	3,694,978	-320	-0.01
ES	17,632,496	17,193,142	-439,354	-2.49
FI	2,483,065	2,471,416	-11,649	-0.47
FR	25,807,572	25,181,504	-626,068	-2.43
HR	1,566,167	1,563,115	-3,052	-0.19
HU	3,826,428	3,827,167	739	0.02
IE	1,880,426	1,782,354	-98,072	-5.22
IT	22,565,976	22,565,971	-5	-0.00
LT	1,275,902	1,275,726	-176	-0.01
LU	237,625	231,441	-6,184	-2.60
LV	875,678	864,315	-11,363	-1.30
MT	173,355	170,273	-3,082	-1.78
NL	8,345,777	7,299,033	-1,046,744	-12.54
PL	15,589,136	15,573,713	-15,423	-0.10
PT	4,547,050	4,546,853	-197	-0.00
RO	8,606,119	8,605,051	-1,068	-0.01
SE	4,657,359	4,608,606	-48,753	-1.05
SI	923,920	916,466	-7,454	-0.81
SK	2,329,322	2,326,970	-2,352	-0.10
UK	29,691,496	29,392,722	-298,774	-1.01

Note: Detailed industry level is the ISCO 3-digit (Occupation Minor Groups) and NACE 2-digit (Industry Divisions) level.
Source: LFS.

Coverage of this more detailed ISCO 3-digit and NACE 2-digit level data is very good for most EU countries, but for certain countries there are a significant number of missing cells. As a consequence, the totals differ slightly from the employment totals in the published LFS data. Table 1 shows the relevant employment totals for the year 2012. These are the sum of employment at the Occupation Minor Groups (ISCO-08 3-digit code) and Industry Divisions (NACE 2-digit code) on the one hand (column 2), and the total employment as reported in the published LFS (column 1) at the country level on the other hand. The resulting absolute differences (column 3) and relative differences (column 4) are also reported.

We rescale and impute some of the missing employment data and choose a relative difference at the country level of 5% as the cut-off point, necessitating imputations for Ireland and the Netherlands. These imputations are carried out using the industry structure of reference countries based on the differences between employment numbers reported by Occupation Minor Groups on the one hand, and the sums of Occupation Minor Groups and Industry Divisions over all Industry Divisions on the other hand.

The adjustment procedure for the LFS data ('adjustment between LFS series') proceeds in up to three steps, depending on the country-specific fit of the data and the industry level included in the WIOD Release 2016.

An additional adjustment is needed to make the LFS data fit the country-industry totals of the WIOD database. As the entire supply-use structures and gross output data originate from the WIOD database, we decided to rescale the LFS data to the WIOD data to ensure consistency between employment and gross output figures, as this is obviously relevant for labour requirements per unit of output.

1.2.1.1. Adjustments between LFS series

Step 1: Using public LFS data at the NACE Rev.2 1-digit industry level (Sections), where sufficient

The ultimate objective is to bring the data to the industry classification used in the WIOD Release 2016. The WIOD industry structure is based on NACE Rev.2 and is a mixture of Divisions (e.g. within the manufacturing industries) and Sections (e.g. Mining).[7]

The fact that the target industry structure is a mixture of NACE Rev.2 Divisions and Sections allows for another data adjustment. Once the employment numbers by Occupation Minor Groups and Industry Divisions have been aggregated to the WIOD industry levels, the WIOD industries that are at the level of Sections (NACE Rev.2 1-digit industries) are rescaled to match the numbers by Occupation Minor Groups and Industry Sections. This is the case for mining and quarrying (Section B), construction (Section F), accommodation and food service activities (Section I), administrative and support service activities (Section N), human health and social work activities (Section Q), arts, entertainment and recreation and other service activities (Sections R and S), activities of households as employers; undifferentiated goods- and services-producing activities of households for own use (Section T), and activities of extraterritorial organisations and bodies (Section U).

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[7]   A full list of the WIOD industries is found in Appendix Table A.2.

Step 2: Imputation of missing observations in countries with unsatisfactory fit of the data

The second step consists of imputing data for countries with missing cells for some of the ISCO 2-digit and NACE Rev.2 2-digit data. For this purpose, we compute the shares of employment by Occupation Sub-Major Groups and Industry Divisions on employment numbers of Occupation Sub-Major Groups. Summing these shares over the Occupation Sub-Major Groups allows identification of the Occupation Minor Groups with missing employment data in the disaggregation by Occupation Sub-Major Groups and Industry Divisions. Thereby, we mark all Industry Divisions in each Occupation Minor Group with missing employment numbers for Ireland and the Netherlands as potentially missing data.

By performing the same share computations for reference countries (the UK for Ireland; Belgium and the UK for the Netherlands), we find Industry Divisions that report employment numbers in the reference countries but are marked as potentially missing data in the imputation countries. Here, we assume that the reference countries and imputation countries share the same industry structure, implying that the missing employment numbers in the imputation countries must be allocated to the cells that were identified as missing in the classification by Occupation Minor Groups and Industry Divisions.

Then, we compute the employment shares of one of these identified cells by Occupation Minor Groups and Industry Divisions in the reference countries relative to all identified partitions within the same Occupation Sub-Major Group. Finally, we multiply these shares with the number of employed we found to be missing between the classification by Occupation Sub-Major Groups and the sums of Occupation Sub-Major Groups and Industry Divisions over all Industry Divisions above. This gives us the imputed data. In the case of the Netherlands, if a given observation by Occupation Minor Groups and Industry Divisions reported employment numbers in both reference countries, the shares were weighted as a simple average between the shares of Belgium and the UK. This imputation relies on two assumptions. First, the difference between the sum of employment by Occupation Minor Groups and Industry Divisions and the total LFS employment is due to Occupation-Industry combinations not captured by the survey. Conversely, this means that the combinations that exist at this level in the original data set report correct numbers. Secondly, the industry structure in the reference countries is the same as that of the imputation countries, or at least similar enough to act as a proxy.

For both Ireland and the Netherlands, the missing data are found across all combinations of Occupation Minor Groups and Industry Divisions.

Further investigations revealed that the missing data for Spain in Table 1 (439,354 in absolute terms, or 2.5% in relative terms) can be attributed to a single Occupation Sub-Major Group, namely Group 41 General and Keyboard Clerks. Therefore, we run the same imputation steps described above for this single Occupation Sub-Major Group by taking France and Portugal as reference countries.

Step 3: Ensure correct employment by ISCO Occupation Sub-Major Groups at the country level

In a final step, we rescale each employment cell by Occupation Minor Groups and Industry Sections to equal parts, such that their sums over Industry Sections match the employment numbers by Occupation Sub-Major Groups at the country level. The country totals of the adjusted employment numbers by Occupation Minor Groups and Industry Divisions are presented in Table 2.

Table 2 / Total employment compared with initial and adjusted detailed employment data, 2012

	(1) Total LFS Employment	(2) Sum of LFS Employment by Occupation (ISCO-08) and Industry (NACE Rev.2)	(3) Adjusted Sum of LFS Employment by Occupation Minor Groups (ISCO-08) and Industry Divisions (NACE Rev.2)
AT	4,084,392	4,084,487	4,084,394
BE	4,524,378	4,523,914	4,524,371
BG	2,933,968	2,933,974	2,933,968
CH	4,351,420	0	0
CY	385,129	385,227	385,133
CZ	4,889,055	4,886,479	4,888,986
DE	39,717,536	39,126,490	39,713,296
DK	2,644,916	2,678,628	2,642,349
EE	614,932	613,878	614,157
EL	3,695,298	3,694,978	3,695,274
ES	17,632,496	17,193,142	17,632,498
FI	2,483,065	2,471,416	2,477,046
FR	25,807,572	25,181,504	25,711,646
HR	1,566,167	1,563,115	1,563,862
HU	3,826,428	3,827,167	3,826,419
IE	1,880,426	1,782,354	1,872,104
IT	22,565,976	22,565,971	22,565,978
LT	1,275,902	1,275,726	1,275,900
LU	237,625	231,441	235,737
LV	875,678	864,315	868,022
MT	173,355	170,273	164,691
NL	8,345,777	7,299,033	8,253,543
PL	15,589,136	15,573,713	15,576,170
PT	4,547,050	4,546,853	4,547,042
RO	8,606,119	8,605,051	8,606,091
SE	4,657,359	4,608,606	4,630,583
SI	923,920	916,466	919,284
SK	2,329,322	2,326,970	2,328,622
UK	29,691,496	29,392,722	29,584,589

Note: Detailed industry level is the ISCO 3-digit (Occupation Minor Groups) and NACE 2-digit (Industry Divisions) level.
Sources: LFS; author's own adjustments.

1.2.1.2. Rescaling of LFS employment to WIOD Release 2016 employment

Once all available information on LFS data is used in the best way possible to arrive at employment levels that fit the publicly available series, a rescaling to the WIOD employment data is made. This rescaling takes place at the country-industry-occupation level (a 'cell'), where the industries are those of the WIOD Release 2016 classification.

The objective is to rescale the adjusted LFS data shown in column 2 in Table 3, to the employment level recorded in WIOD Release 2016 (column 1 in Table 3). Owing to the lack of additional information, the general approach is simply to rescale the LFS data to make it fit the WIOD data, using country-industry specific adjustment factors.

However, before performing this general rescaling, two particular adjustments of zeros need to be made. First, we set to zero all positive LFS employment figures in cells that belong to country-industries that have a zero entry in the WIOD data. This concerns mainly the sector 'activities of extraterritorial organisations and bodies' (NACE Rev.2 Sector U). Second, where the country-industry-level employment is positive in the WIOD data, but zero in the LFS data, the adjustment factors are not operational. This concerns individual sectors in Luxembourg (C17, C21, C30), Slovakia (A03) and Malta (C19). For these cases, the shares of occupations within the relevant industry from reference countries (Belgium for Luxembourg; Czechia for Slovakia; and Greece for Malta) are used. These shares from reference countries are then multiplied by the WIOD industry employment for the concerned industries. The results are shown in column 3.

Table 3 / Comparison between employment from LFS data and WIOD, including adjustment factors, 2012

	(1) Employment in WIOD	(2) Adjusted LFS Employment*	(3) Adjusted LFS Employment after corrections for zeros	(4) LFS Employment rescaled to WIOD (identical to (1))	(5) adj. factor weighted avge (3) / (1)	(6) adj. factor simple avge	(7) adj. factor min.	(8) adj. factor max.
AT	4,211,030	4,084,394	4,078,751	4,211,030	0.9686	1.0346	0.4334	2.1456
BE	4,551,500	4,524,372	4,485,898	4,551,500	0.9856	1.1969	0.2661	2.7346
BG	3,474,040	2,933,968	2,927,135	3,474,040	0.8426	0.9877	0.2725	2.3825
CY	388,970	385,133	383,764	388,970	0.9866	1.0887	0.3481	3.3848
CZ	5,064,670	4,888,986	4,888,735	5,064,670	0.9653	1.1729	0.4154	5.4599
DE	42,060,000	39,713,296	39,686,412	42,060,000	0.9436	1.0564	0.2856	1.6961
DK	2,741,000	2,642,349	2,640,632	2,741,000	0.9634	1.0274	0.2145	2.0933
EE	589,300	614,157	613,974	589,300	1.0419	1.1034	0.6558	3.7445
EL	4,105,270	3,695,274	3,693,426	4,105,270	0.8997	0.9526	0.4547	2.2358
ES	18,337,700	17,632,498	17,629,082	18,337,700	0.9614	1.0795	0.5204	2.3077
FI	2,537,600	2,477,046	2,476,377	2,537,600	0.9759	0.9975	0.6586	1.6489
FR	27,197,000	25,711,646	25,692,020	27,197,000	0.9447	1.2482	0.2773	3.8510
HR	1,571,850	1,563,862	1,563,747	1,571,850	0.9948	0.9819	0.0393	1.2081
HU	4,008,240	3,826,419	3,824,074	4,008,240	0.9541	0.9895	0.3753	1.8966
IE	1,838,510	1,872,104	1,870,266	1,838,510	1.0173	1.5430	0.1758	22.9128
IT	24,764,800	22,565,978	22,553,388	24,764,800	0.9107	1.0341	0.4405	2.1082
LT	1,273,730	1,275,900	1,275,666	1,273,730	1.0015	1.0035	0.9875	1.0928
LU	379,120	235,737	224,311	379,120	0.5917	0.7398	0.0733	7.6514
LV	874,810	868,022	867,821	874,810	0.9920	1.2581	0.3379	9.5424
MT	178,840	164,691	164,787	178,840	0.9214	2.8708	0.0514	89.0130
NL	8,827,000	8,253,544	8,142,485	8,827,000	0.9225	1.5033	0.3004	4.9600
PL	15,474,900	15,576,170	15,574,982	15,474,900	1.0065	1.0190	0.4818	1.8107
PT	4,581,440	4,547,043	4,545,020	4,581,440	0.9921	1.1096	0.3305	2.1075
RO	8,627,800	8,606,091	8,557,083	8,627,800	0.9918	0.9848	0.5895	1.3155
SE	4,628,000	4,630,583	4,589,452	4,628,000	0.9917	0.9692	0.2557	2.1637
SI	937,600	919,284	919,284	937,600	0.9805	1.0686	0.2529	3.0133
SK	2,209,520	2,328,622	2,322,634	2,209,520	1.0512	1.1992	0.4049	4.4934
UK	29,693,000	29,584,589	29,533,492	29,693,000	0.9946	1.1898	0.5680	3.1876

Note: * These figures correspond to column 3 in Table 2. Adj.= adjustment; avge=average; min.= minimum; max.= maximum. Averages are across country-industry-occupation level cells. Similarly, minimums and maximums are those at the level of country-industry-occupations.

After this adjustment, all figures are scaled up or down as necessary, using the aforementioned country-industry-specific adjustment factors. As shown in columns (5) and (6), the overall adjustment of

employment figures is mild. For example, in the case of Austria, the weighted adjustment factor is 0.96, while it is 0.91 for Italy, implying that the WIOD employment figures are higher than those in the LFS data in these cases. There are, however, also cases where the converse is true, such as Estonia. In individual cells, there are, however, significantly larger discrepancies between the employment figures in the LFS data and the WIOD data. As we feel obliged to stick to the WIOD employment figures for consistency reasons (as explained above), there is little we can do about these discrepancies as we do not have any information about their source.

1.2.2.   ICT capital and non-ICT capital

As described in section 2.2, the relevant asset types from the EU KLEMS are computer hardware, telecom equipment, and computer software and databases, which together form ICT capital.

These asset types are available in the Eurostat data at the 2-digit NACE Rev.2 level which is sufficient to match them to the WIOD industry structure. The industry structure in the EU KLEMS Release 2019, however, is somewhat more aggregated than in WIOD. For this reason, the preferred source of data for ICT capital is the original Eurostat data. The EU KLEMS data is then only used when there is more detailed information in the EU KLEMS Release 2019 than in Eurostat because data is no longer published in Eurostat, which is the case for Germany and Spain. Moreover, a number of countries do not provide information for detailed asset types either in Eurostat or in the EU KLEMS database. For both instances, some data imputations were necessary, which are explained in the following two sub-sections.

1.2.2.1.   'Refining' the industry structure of the EU KLEMS database to fit that of WIOD

For countries for which only EU KLEMS Release 2019 can be used, the available industry-level ICT capital data was assigned to (more detailed) WIOD industries in relation to the gross output share of the more disaggregated industries in the broader EU KLEMS industry. An example would be the agricultural sector, which in the EU KLEMS data is provided at the division level (=1 digit), whereas WIOD features three agricultural industries at the NACE Rev.2 2-digit level (A01 – crop and animal production, hunting and related service activities; A02 – forestry and logging; and A03 – fishing and aquaculture).

1.2.2.2.   Imputation of missing capital stock data

More adjustment is needed for countries which provide information for detailed asset types neither in Eurostat nor in the KLEMS database, but only at the aggregate (economy) or at the level of NACE divisions (1-digit). These countries are Bulgaria, Estonia, Hungary, Ireland, Poland, Portugal, Slovenia, Lithuania and Romania. For these countries, reference countries were selected (Table 4).

Table 4 / Countries for which industry-level data had to be imputed with the help of reference countries

Country with missing data	Reference countries
Bulgaria	Greece, Slovakia
Estonia	Finland, Latvia
Hungary	Austria, Czechia
Ireland	United Kingdom, the Netherlands
Poland	Czechia, Slovakia
Portugal	Spain, France
Slovenia	Slovakia, Austria
Lithuania	Finland
Romania	Greece, Slovakia

Note: As reference countries, neighbouring countries were chosen or countries where there is reason to believe that they share important structural features (e.g. a high share of headquarters of foreign multinational enterprises). For Romania, even less data were available: for the asset categories making up the ICT capital, not even the economy-wide totals were available. This was solved by obtaining the economy total via a regression-based imputation.

In cases where capital stock data are available only at the economy level or at NACE divisions (1-digit), the capital intensity of the reference country or countries is calculated at the WIOD industry level, where the capital intensity is defined as industry-level capital stock of the respective asset type divided by industry-level gross output. These intensities are then assumed and adopted for the country with the missing data. To impute capital stocks at the detailed industry level for countries where these are missing, the industry-level capital intensities of the reference country(ies) are multiplied with the industry-level gross output of the country with missing data. Unless countries have identical capital intensities and identical industry structures, the economy-level capital stocks (of the respective asset type) will not equal the sum of these imputations. Hence each imputed industry-level capital stock is adjusted with an adjustment factor that is simply the ratio between the sum of the (interim) imputations for the values of the industry-level capital stocks and the reported aggregated capital stock. Therefore, we rescale the imputed industry-level capital stocks such that the sum equals the reported economy-level capital stocks.

In cases where some sectoral break-up is available (e.g. for NACE Rev.2 C - manufacturing), the same procedure is applied, but the industry-level capital intensities of the reference countries are adjusted by the ratio between the sum of sub-sector totals and the available sub-sector capital stock (e.g. manufacturing). Therefore, we rescale the imputed industry-level capital stocks so that their sums match the sub-sector totals.

Table 5 shows the result of the data imputation approach for capital stocks at the sectoral level for Slovenia, in which Austria and Slovakia were used as reference countries. As Slovenia reports capital stocks only at the level of divisions (NACE Rev.2 1-digit industries), the more detailed industries within the agricultural sector, the manufacturing sector and many services sectors need to be imputed. The column labelled imputed values shows the result of multiplying the average of Austrian and Slovenian industry-level capital intensities with Slovenia's industry-level gross outputs (taken from WIOD). These initial imputations were then adjusted with the help of the adjustment factor.

Table 5 / Data adjustment process for each of the asset types of ICT capital stocks, Slovenia, 2012

NACE industry	Computer hardware (N11321)				Telecom equipment (N11322)				Computer software (N1173)			
	Reported data	Imputed value	Adj. Factor	Resulting capital stock	Reported data	Imputed value	Adj. Factor	Resulting capital stock	Reported data	Imputed value	Adj. Factor	Resulting capital stock
A	**0.1**				**13.5**				**4.7**			
A01		0.6	7.7	0.1		6.4	0.5	12.1		3.4	1.0	3.4
A02		0.1	7.7	0.0		0.6	0.5	1.1		1.3	1.0	1.3
A03		0.1	7.7	0.0		0.1	0.5	0.3		0.0	1.0	0.0
B	1.9	0.2	0.1	1.9	0.4	0.8	1.9	0.4	1.7	4.4	2.6	1.7
C	**23.5**				**42.1**				**100.1**			
C10-C12		0.6	2.4	0.3		4.9	1.5	3.2		20.8	2.7	7.8
C13-C15		0.2	2.4	0.1		2.7	1.5	1.8		9.3	2.7	3.5
C16		0.5	2.4	0.2		1.3	1.5	0.9		3.7	2.7	1.4
C17		1.1	2.4	0.5		2.2	1.5	1.5		7.4	2.7	2.8
C18		0.2	2.4	0.1		4.1	1.5	2.7		8.9	2.7	3.4
C19		0.0	2.4	0.0		0.0	1.5	0.0		0.0	2.7	0.0
C20		4.2	2.4	1.8		2.0	1.5	1.3		13.0	2.7	4.9
C21		14.0	2.4	5.9		4.9	1.5	3.2		23.5	2.7	8.9
C22		1.4	2.4	0.6		5.3	1.5	3.5		14.2	2.7	5.4
C23		1.2	2.4	0.5		3.5	1.5	2.3		14.3	2.7	5.4
C24		0.7	2.4	0.3		2.6	1.5	1.7		15.4	2.7	5.8
C25		4.5	2.4	1.9		8.6	1.5	5.7		32.5	2.7	12.3
C26		6.6	2.4	2.8		1.5	1.5	1.0		15.8	2.7	6.0
C27		9.2	2.4	3.9		5.9	1.5	3.9		26.6	2.7	10.0
C28		2.8	2.4	1.2		4.4	1.5	2.9		21.0	2.7	7.9
C29		5.1	2.4	2.2		3.8	1.5	2.5		22.7	2.7	8.6
C30		0.0	2.4	0.0		0.5	1.5	0.3		1.7	2.7	0.6
C31-C32		1.1	2.4	0.5		4.4	1.5	2.9		7.9	2.7	3.0
C33		2.0	2.4	0.8		1.4	1.5	0.9		6.5	2.7	2.5
D	24.3	123.7	5.1	24.3	14.3	14.8	1.0	14.3	20.9	24.2	1.2	20.9
E	**2.5**				**2.6**				**4.5**			
E36		3.2	2.0	1.6		1.8	3.6	0.5		15.9	4.0	3.9
E37-E39		1.9	2.0	0.9		7.5	3.6	2.1		2.2	4.0	0.6
F	2.5	6.8	2.7	2.5	1.6	9.5	6.0	1.6	4.5	34.5	7.7	4.5
G	**26.2**				**48.2**				**60.6**			
G45		1.9	1.3	1.4		5.3	1.4	3.7		10.4	2.5	4.2
G46		16.3	1.3	12.5		25.2	1.4	17.9		80.1	2.5	32.2
G47		16.0	1.3	12.3		37.5	1.4	26.6		60.2	2.5	24.2
H	**9.2**				**14.1**				**17.1**			
H49		43.6	9.5	4.6		5.9	2.1	2.8		27.8	5.6	4.9
H50		0.1	9.5	0.0		3.7	2.1	1.8		3.7	5.6	0.7
H51		0.4	9.5	0.0		0.6	2.1	0.3		2.9	5.6	0.5
H52		26.7	9.5	2.8		14.2	2.1	6.7		36.1	5.6	6.4
H53		17.0	9.5	1.8		5.4	2.1	2.6		26.0	5.6	4.6
I	8.4	6.9	0.8	8.4	5.3	7.3	1.4	5.3	3.3	5.6	1.7	3.3
J	**523.0**				**68.9**				**150.7**			
J58		0.5	2.0	0.2		3.2	1.3	2.4		10.9	2.7	4.0
J59-J60		22.5	2.0	11.3		5.4	1.3	4.0		10.7	2.7	3.9
J61		1012.6	2.0	507.2		56.2	1.3	41.9		311.5	2.7	114.2
J62-J63		8.6	2.0	4.3		27.7	1.3	20.6		77.8	2.7	28.5
K	**16.4**				**48.5**				**176.5**			
K64		11.0	0.8	13.6	0.0	26.8	0.7	38.5		137.0	1.0	140.0
K65		2.0	0.8	2.5	0.0	5.8	0.7	8.3		31.7	1.0	32.4
K66		0.2	0.8	0.3	0.0	1.2	0.7	1.7		4.0	1.0	4.1
L	4.2	2.5	0.6	4.2	4.9	4.6	0.9	4.9	4.9	9.3	1.9	4.9
M	**14.0**				**29.8**				**78.7**			
M69-M70		2.4	4.2	0.6		22.2	2.1	10.6		40.3	1.3	30.4
M71		5.9	4.2	1.4		19.0	2.1	9.1		31.8	1.3	24.0
M72		29.0	4.2	6.9		12.9	2.1	6.1		15.5	1.3	11.7
M73		0.8	4.2	0.2		2.9	2.1	1.4		9.0	1.3	6.8
M74-M75		20.9	4.2	5.0		5.3	2.1	2.5		7.8	1.3	5.9
N	4.7	79.5	16.9	4.7	3.9	18.7	4.8	3.9	6.2	24.3	3.9	6.2
O	50.5	25.3	0.5	50.5	56.5	32.8	0.6	56.5	107.8	64.0	0.6	107.8
P	8.1	18.9	2.3	8.1	27.8	15.1	0.5	27.8	15.0	30.6	2.0	15.0
Q	7.0	177.0	25.3	7.0	20.0	7.0	0.4	20.0	16.0	28.6	1.8	16.0
R	0.0	0.0	3.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	2.0	0.0
R-S	14.9	44.5	3.0	14.9	17.9	15.3	0.9	17.9	12.1	24.5	2.0	12.1
S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	**741.5**	**741.5**	**0.0**	**741.5**	**420.5**	**420.5**	**0.0**	**420.5**	**785.2**	**785.2**	**0.0**	**785.2**

Note: Adj. factor= Adjustment factor. Reference countries are Austria and Slovenia.

1.2.3. Italian ICP data

The digital task and digital use indicators at the 4-digit Italian national occupation level (*Nomenclatura e classificazione delle unità professionali*, NUP) were mapped into the 3-digit ISCO-08 classification. This mapping is feasible because the NUP is based on the logic of the ISCO.

This mapping functions well except for ISCO code 323 (traditional and complementary medicine associate professionals). Hence the digital task and digital use scores for ISCO code were imputed using the score of ISCO code 223 (traditional and complementary medicine professionals).

1.2.4. World Input-Output Database

The WIOD database is a complete data set without any missing observations. Therefore, no imputations were necessary. Also, as explained above, the LFS employment data were rescaled to fit the WIOD data.

For this reason, the sole adjustment to be made was to 'trim down' the original WIOD input-output table featuring 44 reporters to the 25 EU economies that are part of the analysis of this paper. In order words, the EU25 is considered to be 'the world'. The list of WIOD countries, identifying the countries included, is given in Appendix A.

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2. The Race for Digital Leadership: Is Europe losing out to the US?

2.1. DATA

The paper identifies and analyses the comparative advantages of 25 EU member states and the US for the years 2012 and 2018. Much of the European data are those from Paper A.1. This is especially true for European employment data, again stemming from the European Labour Force Survey (LFS). However, as we have detailed employment data only until 2012, some estimations for EU employment data had to be made for the year 2018. Moreover, for the US, additional sources for occupation-industry data (US Bureau of Labor Statistics, BLS) and the digital task content of occupations (O*NET) are required. An additional complication is that the US data at this level of detail are available only at the industry and occupation classifications common in the US, and so (non-unique) crosswalks were necessary.

Finally, in order to make use of international input-output data for 2018, recourse to the OECD Inter-Country Input-Output (ICIO) database was required (instead of WIOD).

2.1.1. European Labour Force Survey

For the EU countries, the employment data are again taken from the LFS. However, more adjustments have to be made for the year 2018; these are further explained in the following chapter on data adjustments and imputations.

2.1.2. US Occupational Employment and Wage Statistics

The Occupational Employment and Wage Statistics (OEWS) survey is a semi-annual survey, measuring occupational employment and wage rates in the US economy.[8] It is conducted jointly by the State Workforce Agencies (SWAs) and the Bureau of Labor Statistics (BLS) and covers wage and salary workers in non-farm establishments. The OEWS survey includes more than 800 unique occupations.

Although the survey has a comprehensive coverage of employment, its data do not capture the self-employed, owners and partners in unincorporated firms, household workers, and unpaid family workers. Employment is defined by the OEWS survey as the number of full-time or part-time employees.[9]

Industry Coding System. The OEWS deploys the North American Industry Classification System (NAICS) to categorise economic activities (i.e. industries). To ensure that the classification of industries keeps up with the evolving economy, NAICS is updated every five years (most recently in 2022).

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[8]   The data are available at: https://www.bls.gov/oes/tables.htm

[9]   This includes workers on paid vacations or other types of paid leave; workers on unpaid short-term absences; salaried officers, executives and staff members of incorporated firms; employees temporarily assigned to other units; and employees for whom the reporting unit is their permanent duty station, regardless of whether that unit prepares their salary.

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Therefore, for the purpose of this paper, the NAICS 2012 and the NAICS 2017 classifications are relevant.[10]

NAICS uses a 6-digit hierarchical coding system to classify all industries into 20 industry sectors at 2-digit (Sector) level, 3-digit (Sub-sector), 4-digit (Industry Group), 5-digit (NAICS Industry) and 6-digit (National Industry) levels. Five sectors at the 2-digit (Sector) level primarily produce goods, whereas 15 sectors offer only services. Figure 4 shows the economic sectors in NAICS.[11]

The OEWS survey leaves out a significant portion of the agricultural sector, aside from logging (NAICS 113310), support activities for crop production (NAICS 1151), support activities for animal production (NAICS 1152), and private households (NAICS 814) under the 'other services (except public administration)' sector (NAICS 81). The OEWS data also include information from the US Postal Service and the government executive branch.

Figure 4 / NAICS sectors (2-digit industries)
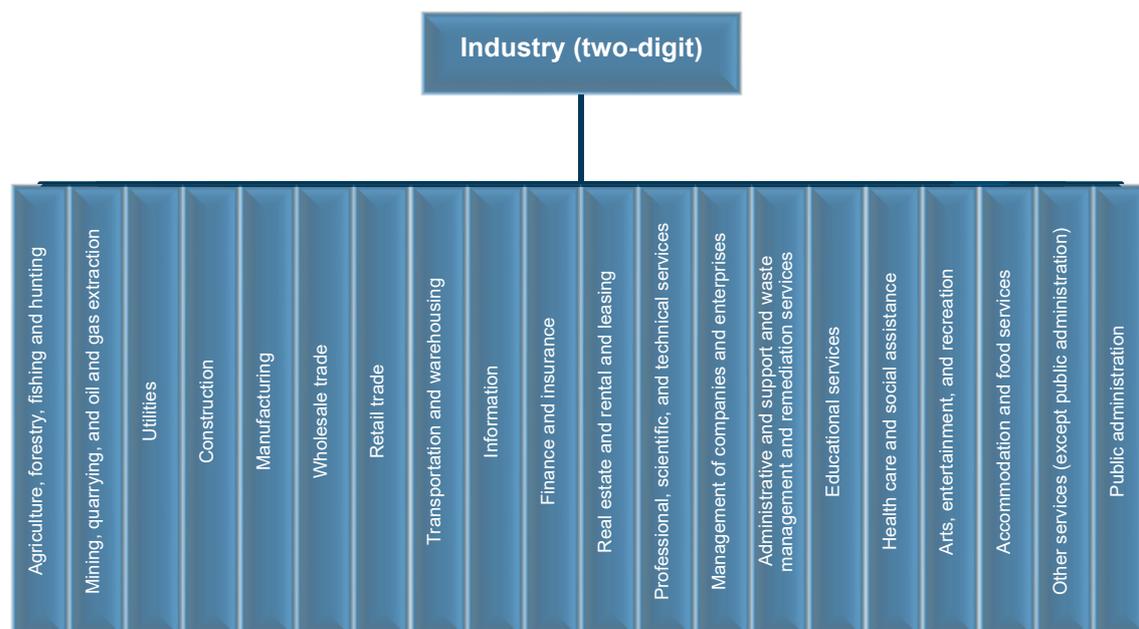
Note: These 2-digit sectors are constant over the 2012 and 2018 versions of the NAICS classification.
Source: US Census Bureau.

Occupational Coding System. With regard to occupations, the OEWS uses the Standard Occupational Classification (SOC). Like its European (and international) counterpart – ISCO – the SOC is regularly reviewed, most recently in 2018. Correspondence tables are provided to perform a crosswalk between different versions of the SOC. For the time span covered here, however, only the SOC 2010 is relevant, as the survey for 2018 was conducted using the SOC 2010.

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[10] For details, see: https://www.census.gov/naics/?99967

[11] The titles of the industries have not undergone modifications over the years. Manufacturing (31-33), retail trade (44-45), and transportation and warehousing (48-49) are split into two respectively three 2-digit codes.

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As with NAICS, SOC has a hierarchical structure with levels ranging from two to six digits. Each level contains a group of increasingly specific categories of occupations. Depending on their occupational description, all workers are assigned to one of the 'detailed' occupations (6-digit level). Figure 5 shows the major group occupations according to the SOC 2010. At this detailed level of occupations, there are 840 occupational categories in the 2010 version of the SOC.[12] Although included in the figure, it should be noted that the major group 'military specific occupations' and all its sub-groups are not included in the OEWS estimations.

Figure 5 / SOC major groups (2-digit occupations), 2010 version
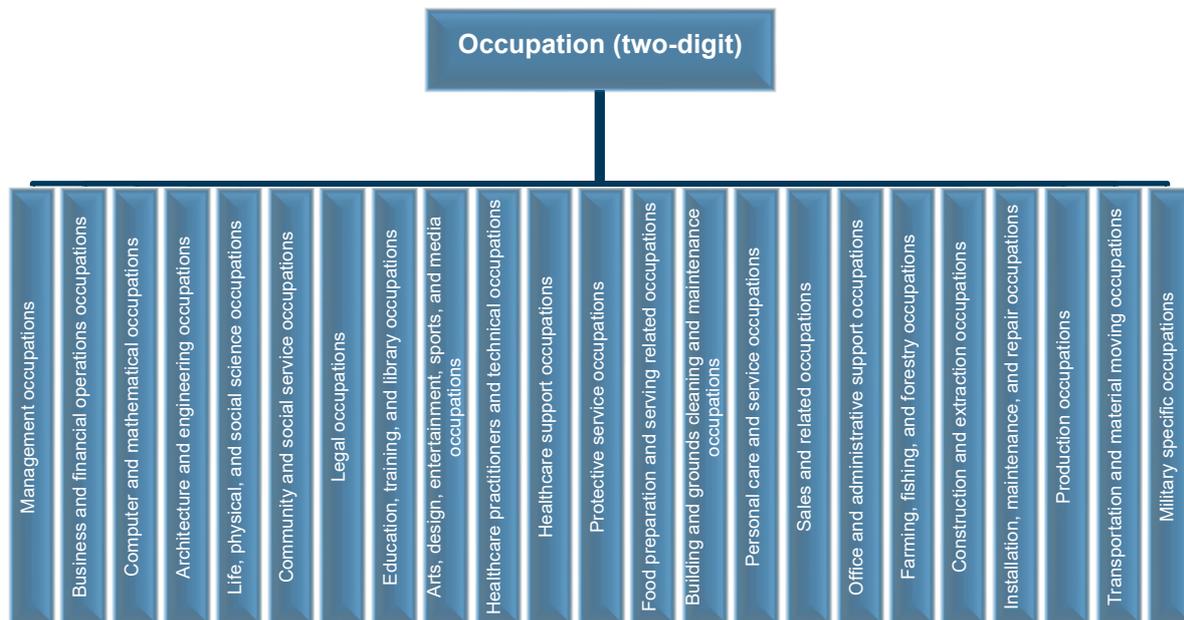
Note: The 2-digit sectors are constant over the 2012 and 2018 versions of SOC.
Source: US Bureau of Labor Statistics

In response to a request, the BLS emphasised that the industry-occupation-specific employment data, provided at the detailed SOC level (6-digit) and the NAICS industry groups (4-digit), constitute estimates. This is why, in addition to the omitted workers pointed out above, the sum of all detailed industry-occupation-specific employees is lower than the total US employment. For this reason, a second data set for US employment is also used.

2.1.3. Labour Force Statistics from the Current Population Survey

The Current Population Survey (CPS) is a monthly survey of households conducted for the BLS by the Bureau of the Census. The Labour Force Statistics (LFS) collected in the framework of the CPS provide comprehensive data on the labour force, employment, unemployment, persons not in the labour force, hours of work, earnings and other labour market-related characteristics.[13]

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12   Further occupational groupings consist of 460 broad occupations (5-digit), 97 minor groups (3- and 4-digit), and 23 major groups (2-digit).

13   The data are available at: https://www.bls.gov/cps/cps_aa2018.htm#empstat

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Compared with the OEWS survey, the LFS from the CPS are wider in scope and coverage. They contain employment by detailed occupations and by industries, but also by age, sex, ethnic group and other demographic characteristics. However, the combined industry-occupation information on employment is available only at an aggregate level that is similar to, but slightly cruder than, the 2-digit NAICS industries (sectors) and 2-digit SOC occupations (major groups). Overall, the LFS survey has fewer omissions and the sum of available industry-occupation employments is higher than that of the OEWS survey.

Corresponding to the OEWS survey, data from the LFS survey for the years 2012 and 2018 are used.

2.1.4. O*NET

The Occupational Information Network (O*NET) is a publicly available electronic list[14] of all existing occupations in the US, which replaced the (printed) *Dictionary of Occupational Titles* two decades ago. The occupations in O*NET are reported according to the SOC system.

The O*NET database is updated on a quarterly basis[15] and contains a large set of variables that describe work and worker characteristics of the respective occupation.[16] The database primarily serves a practical purpose. It assists job seekers in understanding the opportunities and requirements of the US job market. In addition, the O*NET database has been used intensively by researchers, including economists, to describe and analyse job profiles, skill requirements, and tasks and activities performed by workers in a specific job.

Of the numerous worker and job-oriented data categories, the file containing the 'Detailed Work Activity' of occupations is used, in combination with the 'Task Ratings' and the 'Task Statements' files. The 'Task Ratings' file provides information on the relative importance of the tasks performed in individual occupations on a scale ranging from 0 to 100, while the 'Task Statements' file holds descriptions of the task associated with each of the occupations and is used to perform a keyword search for 'digital tasks' within the core tasks. Details of the procedure to develop an index for digital task intensity of each occupation are provided in Section 2.2.4.

The current version[17] of the O*NET database is version 26, but all previous versions are available.[18] In order to have data as close as possible to the year 2012 and the period of the Italian ICP data, the O*NET 17.0 from July 2012 is used. For the year 2018 we use the O*NET 23.3 version from May 2019, as this captures the occupations as of 2018.[19]

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[14]   See: https://www.onetcenter.org

[15]   Main updates are made in the third quarter of each year.

[16]   See: https://www.onetcenter.org/database.html#individual-files.

[17]   As of September 2021.

[18]   See: https://www.onetcenter.org/db_releases.html.

[19]   The O*NET surveys cannot be perfectly assigned to any particular year, because although the surveys for all occupations are updated on a regular basis, not all occupations are updated at the same time.

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2.1.5.   OECD Inter-Country Input-Output Database

The OECD Inter-Country Input-Output (ICIO) Database is an international input-output database and an alternative to the WIOD described above. Compared with the WIOD, the OECD ICIO has a less detailed industry structure – originating from NACE Rev.2 industries (a mixture of divisions (2-digit industries) and sections (1-digit industries) – and features fewer industries (45), but contains more countries (63 plus the rest of the world) and covers a longer time span (1995-2018). Although the country coverage is less of an issue, OECD ICIO is chosen as the data source for the international input-output table because it includes data for the year 2018.

In order to ensure better comparability with the results in Paper 1, the industry structure of the OECD ICIO is slightly adjusted by merging some industries, notably the three separate mining and quarrying industries in the database. The details of the resulting adjusted OECD ICIO industry structure are provided in Appendix Table A.4-

2.2.   DATA ADJUSTMENTS AND IMPUTATIONS

2.2.1.   European Labour Force Survey

The preparation and necessary adjustments of the employment data for 2012 have been described in detail in the previous chapter. For 2018, the situation is more complicated because there is access to employment data only at the ISCO-08 3-digit occupation and NACE Rev.2. 1-digit level.[20]

The first task was therefore to 'refine' the available EU LFS and obtain 3-digit ISCO and 2-digit industry information for 2018. An econometric approach exploiting the 2012 data is chosen to estimate the 3-digit ISCO and 2-digit industry data for those industries in which the adjusted OECD ICIO industry structure corresponds to NACE Rev.2 divisions (2-digit industries). More precisely, the following model using employment data for 2012 is estimated in log form:

(1) $ln \, emp^{ctry}_{occ3d,ind2d} = \alpha + \beta_{occ} \cdot ln \, emp^{ctry}_{occ3d,ind1d} + \beta_{ind} \cdot ln \, emp^{ctry}_{ind_{2d}} + \mu_{ctry\_x\_occ3d} + \lambda_{ind2d\_x\_occ3d} + \varepsilon$

where $emp^{ctry}_{occ3d,ind2d}$ is employment at the country-ISCO 3-digit and OECD ICIO industry level; $emp^{ctry}_{occ3d,ind1d}$ is employment at the country-ISCO 3-digit and NACE Rev.1 industry level; and $emp^{ctry}_{ind_{2d}}$ is employment at the country-OECD ICIO industry level taken directly from the OECD ICIO database. Furthermore, the regression includes country times occupation fixed effects ($\mu_{ctry\_x\_occ3d}$) and industry times occupation fixed effects ($\lambda_{ind2d\_x\_occ3d}$).

Both regressors are available also for the year 2018, which allows us to apply the estimated coefficients and the fixed effects to the 2018 data.

This econometric procedure implies that for any country-occupation-industry for which data are available for 2012, there is also no estimate for 2018. Note, however, that these estimated data for 2018 are used only for occupation-industry combinations where the OECD ICIO industry structure is at the 2-digit industry level.

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[20]   Some adjustment had to be made for Bulgaria, Romania and Spain as occupation data are available only at the 2-digit occupation level.

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After applying the estimated coefficients to the 2018 data, a further adjustment is made. All estimates for the country-ISCO 3-digit and OECD ICIO industry level are rescaled so that the sum of OECD ICIO industries to the NACE 1-digit level equals the actual LFS data. Examples of the procedure are shown for two occupations – 213 and 411 – for the Austrian manufacturing sector (NACE Rev.2 division C) in Table 6.

Table 6 / Example for adjustment: 3-digit occupation-2-digit industry employment data, Austria 2018

(a)   Occupation 213: Life science professionals

OECD ICIO industry	NACE 1-digit	ISCO 3-digit	Employment 2012	Estimated employment 2018	Ratio	Estimated employment 2018 - rescaled
10T12	C	213	105	275		297
13T15	C	213		-		-
16	C	213		-		-
17T18	C	213		-		-
19	C	213		-		-
20	C	213	254	157		169
21	C	213	801	438		472
22	C	213		-		
23	C	213		-		-
24	C	213	88	110		118
25	C	213		-		-
26	C	213		-		-
27	C	213	154	100		107
28	C	213		-		-
29	C	213		-		-
30	C	213		-		-
31T33	C	213		-		-
			1,402	1,080	1.0766	1,163

(b)   Occupation 411: General office clerks

OECD ICIO industry	NACE 1-digit	ISCO 3-digit	Employment 2012	Estimated employment 2018	Ratio	Estimated employment 2018 - rescaled
10T12	C	411	1,853	2,674		2,724
13T15	C	411	612	1,036		1,056
16	C	411	1,187	939		957
17T18	C	411	1,561	1,274		1,298
19	C	411		-		-
20	C	411	711	918		935
21	C	411	1,015	1,238		1,262
22	C	411	648	995		1,014
23	C	411	1,562	1,551		1,581
24	C	411	597	743		757
25	C	411	2,603	2,296		2,339
26	C	411	1,305	1,246		1,270
27	C	411	1,544	1,022		1,042
28	C	411	3,583	1,837		1,872
29	C	411	1,179	1,177		1,199
30	C	411	562	553		564
31T33	C	411	3,307	2,369		2,414
			23,829	21,869	1.019	22,286

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It should be reiterated that these estimated values for employment only need to be imputed in cases where the OECD ICIO industry structure is at the 2-digit level of the NACE Rev.2 industry classification.

Equally important is the fact that the imputation of these estimated values does not change in any way the total amount of employment at the 3-digit occupation level. This is ensured by the rescaling of the sum of the occupation-specific 2-digit industry employment to the occupation-specific 1-digit industry employment. The procedure may introduce some measurement error at the 2-digit industry level, but it does not affect the country-level (nor the 1-digit industry-level) results for employment and subsequent indicators derived from it.

2.2.2.   US Occupational Employment and Wage Statistics

The adjustment procedure involves several steps. All steps of the procedure are performed for the employment data in the years 2012 and 2018. The basic unit of analysis is the combination of detailed occupation-industry data from the OEWS.

Step 1: Fill missing data where the missing sub-unit could be identified

The OEWS data set is the result of a survey providing information on occupational wage and employment at the industry. Although comprehensive, the data set does not cover employment in the entire US labour market.

In addition to the general lack of certain groups of occupations (e.g. military professions), there are also numerous missing individual 4-digit NAICS and 6-digit SOC cells. These are explained by insufficient reliability of the data (according to BLS quality criteria) or the need to protect survey respondents' confidentiality (particular occupational employment and wage information may not be published).

Given that the OEWS surveys wages and employment figures, there are instances where only data for one of the two indicators are available. In such cases, the concerned industry-occupation cell is included in the data set and the missing observation (e.g. the employment) appears in the data with the unpublished estimate or marked as 'NA'. If neither an employment estimate nor a wage estimate could be published, the occupation will not be shown in the data. Therefore, in the OEWS there are two types of missing data: industry-occupation cells that appear in the data but lack sufficient information on employment or salary; and occupational observations, which are entirely absent in the data.

The first step of the adjustment procedure of the OEWS data consists of filling the 'NA' rows (i.e. the first type of missing observations). The objective is to find an employment value at a 'detailed' SOC level, and the main idea is to identify the unique occupational 'NAs' for each industry at different SOC levels. The strategy for adding additional occupations (missing observations of type 1) is performed from the less detailed level (total) to the more detailed level (major-minor-broad-detailed) in 10 iterations.

Iteration 1: Within each industry, values for the major-level occupational groups that had no missing data at their minor level are inserted (obtained as the sum over the minor-level occupations).

Iteration 2: All major-level missing occupations that are a single missing observation in that industry (total level) are filled in during the second stage.

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Iteration 3: Same procedure as in iteration 1, but at the level of minor-level occupations (using the sum over broad-level occupation data, if complete).

Iteration 4: Same procedure as in iteration 2 for data at the minor level.

Iteration 5: Same procedure as in iterations 1 and 3, but at the level of broad occupations (using the sum over detailed occupations data, if complete).

Iteration 6: Same procedure as in iterations 2 and 4 for data at the broad level of occupations.

In the following iterations 7-10, further opportunities to uncover unique missing observations at the detailed level inside various SOC classes are exploited.

Iteration 7: At the level of 'detailed' occupations, missing cells that were the only missing observation in that industry were filled.

Iteration 8: At the level of 'detailed' occupations, missing cells that were the only missing observation at the major level of occupations in that industry were filled.

Iteration 9: At the level of 'detailed' occupations, missing cells that were the only missing observation at the minor level of occupations in that industry were filled.

Iteration 10: At the level of 'detailed' occupations, missing cells that were the only missing observation at the broad level of occupations in that industry were filled.

Table 7 shows the data from the industry perspective, the employment at 2-digit NAICS industries before and after filling of missing cells for the years 2012 and 2018. As can be seen in the tables, the above procedure (iterations 1-10) allowed reducing the missing rate to 0.38% in 2012 (panel a) and 0.88% in 2018 (panel b). Furthermore, except for the 'transportation and warehousing' industry, across the 2-digit industries, the missing rate is quite low. Note that in this context the missing rate means the percentage of employments with 'NA' entries in the OEWS data. Hence, despite these low missing rates, the total employment in the OEWS is significantly lower than the actual total employment in the US economy (this will be dealt with in the subsequent steps, outlined below).

Table 8 shows the same data from the occupational perspective before and after the adjustment procedure, again for the years 2012 (panel a) and 2018 (panel b). The missing rates before and after adjustment are identical to those in the industry perspective (see Table 7).

Table 9 shows the data from both industry and occupation perspectives after adjustment for the years 2012 (panel a) and 2018 (panel b). This table is essentially a combination of Tables 7 and 8. Therefore, the summation of rows and columns result in the same values we observed in those tables.

It is worth mentioning that the industry-level employment from the OEWS, although missing a few occupations (military) and providing only partial coverage of others (agricultural workers), is the best estimate at hand for the employment level at required level of detail for both occupations and industries. However, numerous further data adjustment steps have to be made in order to make use of the data and to compare it with the European employment data.

Table 7 / Employment at 2-digit NAICS industries before and after filling of missing cells

(a) 2012

NAICS sector code	NAICS sector	Industry-level employment (1)	Employment share of sector (in %) (2)	Sum of 'detailed' employment pre-adjustment (3)	Missing in % pre-adjustment (4) = [(1)-(3)] / (1)	Sum of 'detailed' employment post-adjustment (3')	Missing in % post-adjustment (4') = [(1) - (3')] / (1)	Employments assigned (5) = (3') - (3)	Assignments in % of industry-level employment (6) = (5) / (1)
11	Agriculture, forestry, fishing and hunting	393,840	0.30	390,170	0.93	392,790	0.27	2,620	0.67
21	Mining, quarrying, and oil and gas extraction	783,110	0.60	773,380	1.24	778,470	0.59	5,090	0.65
22	Utilities	552,740	0.42	546,350	1.16	549,010	0.67	2,660	0.48
23	Construction	5,611,950	4.31	5,572,390	0.70	5,591,380	0.37	18,990	0.34
31	Manufacturing (31-33)	11,866,530	9.11	11,686,330	1.52	11,775,040	0.77	88,710	0.75
42	Wholesale trade	5,623,520	4.32	5,573,290	0.89	5,597,250	0.47	23,960	0.43
44	Retail trade (44-45)	14,982,690	11.50	14,882,630	0.67	14,941,680	0.27	59,050	0.39
48	Transportation and warehousing (48-49)	5,014,660	3.85	4,936,900	1.55	4,984,870	0.59	47,970	0.96
51	Information	2,688,380	2.06	2,635,200	1.98	2,660,770	1.03	25,570	0.95
52	Finance and insurance	5,535,010	4.25	5,480,260	0.99	5,516,770	0.33	36,510	0.66
53	Real estate and rental and leasing	1,928,950	1.48	1,901,870	1.40	1,920,800	0.42	18,930	0.98
54	Professional, scientific and technical services	7,768,630	5.96	7,713,840	0.71	7,746,100	0.29	32,260	0.42
55	Management of companies and enterprises	2,003,680	1.54	1,970,270	1.67	1,996,030	0.38	25,760	1.29
56	Administrative and support and waste management and remediation services	7,991,270	6.13	7,803,040	2.36	7,899,750	1.15	96,710	1.21
61	Educational services	12,683,810	9.74	12,657,960	0.20	12,669,230	0.11	11,270	0.09
62	Health care and social assistance	17,720,100	13.60	17,656,270	0.36	17,689,490	0.17	33,220	0.19
71	Arts, entertainment, and recreation	1,937,910	1.49	1,903,870	1.76	1,921,450	0.85	17,580	0.91
72	Accommodation and food services	11,675,540	8.96	11,659,190	0.14	11,665,390	0.09	6,200	0.05
81	Other services (except public administration)	3,809,380	2.92	3,765,470	1.15	3,784,640	0.65	19,170	0.50
99	Public administration	9,716,010	7.46	9,701,730	0.15	9,708,450	0.08	6,720	0.07
		130,287,710	**100.00**	**129,210,410**	**0.83**	**129,789,360**	**0.38**	**578,950**	**0.44**

Note: Columns (1) and (2) represent data from the total level, whereas columns (3) and (3') contain data from the detailed level in OEWS survey at industry and occupation clusters.

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Table 7 / (contd.) Employment at 2-digit NAICS industries before and after filling of missing cells

(b) 2018

NAICS sector code	NAICS sector	Industry-level employment (1)	Employment share of sector (in %) (2)	Sum of 'detailed' employment pre-adjustment (3)	Missing in % pre-adjustment (4) = [(1)-(3)] / (1)	Sum of 'detailed' employment post-adjustment (3')	Missing in % post-adjustment (4') = [(1) - (3')] / (1)	Employments assigned (5) = (3') - (3)	Assignments in % of industry-level employment (6) = (5) / (1)
11	Agriculture, forestry, fishing and hunting	427,090	0.30	419,820	1.70	424,290	0.66	4,470	1.05
21	Mining, quarrying, and oil and gas extraction	651,870	0.45	628,150	3.64	639,480	1.90	11,330	1.74
22	Utilities	553,840	0.38	540,730	2.37	549,960	0.70	9,230	1.67
23	Construction	7,166,320	4.95	7,104,720	0.86	7,130,030	0.51	25,310	0.35
31	Manufacturing (31-33)	12,527,140	8.66	12,294,050	1.86	12,424,260	0.82	130,210	1.04
42	Wholesale trade	5,797,820	4.01	5,751,550	0.80	5,774,240	0.41	22,690	0.39
44	Retail trade (44-45)	16,002,170	11.06	15,616,560	2.41	15,701,270	1.88	84,710	0.53
48	Transportation and warehousing (48-49)	6,032,300	4.17	5,622,750	6.79	5,699,080	5.52	76,330	1.27
51	Information	2,793,880	1.93	2,756,640	1.33	2,776,630	0.62	19,990	0.72
52	Finance and insurance	5,918,880	4.09	5,890,370	0.48	5,908,640	0.17	18,270	0.31
53	Real estate and rental and leasing	2,197,420	1.52	2,160,410	1.68	2,177,160	0.92	16,750	0.76
54	Professional, scientific and technical services	9,118,360	6.30	9,053,830	0.71	9,091,080	0.30	37,250	0.41
55	Management of companies and enterprises	2,372,520	1.64	2,359,390	0.55	2,368,950	0.15	9,560	0.40
56	Administrative and support and waste management and remediation services	9,265,620	6.40	8,904,870	3.89	9,059,530	2.22	154,660	1.67
61	Educational services	13,149,990	9.09	13,081,780	0.52	13,125,420	0.19	43,640	0.33
62	Health care and social assistance	20,621,180	14.25	20,527,700	0.45	20,579,640	0.20	51,940	0.25
71	Arts, entertainment and recreation	2,422,590	1.67	2,311,580	4.58	2,361,060	2.54	49,480	2.04
72	Accommodation and food services	13,872,290	9.58	13,833,120	0.28	13,857,340	0.11	24,220	0.17
81	Other services (except public administration)	4,178,720	2.89	4,130,720	1.15	4,154,480	0.58	23,760	0.57
99	Public administration	9,663,350	6.68	9,657,480	0.06	9,659,610	0.04	2,130	0.02
		144,733,350	**100.00**	**142,646,220**	**1.44**	**143,462,150**	**0.88**	**815,930**	**0.56**

Note: Columns (1) and (2) represent data from the total level, whereas columns (3) and (3') contain data from the detailed level in OEWS survey at industry and occupation clusters.

Table 8 / Employment at 2-digit SOC occupations before and after filling of missing cells

(a) 2012

SOC occupation code (major)	Occupation	National employment (1)	Employment share of occupation (in %) (2)	Sum of 'detailed' employment pre-adjustment (3)	Missing in % pre-adjustment (4) = [(1)-(3)] / (1)	Sum of 'detailed' employment post-adjustment (3')	Missing in % post-adjustment (4') = [(1) - (3')] / (1)	Employments assigned (5) = (3') - (3)	Assignments in % of industry-level employment (6) = (5) / (1)
11-0000	Management	6,390,440	4.90	6,358,920	0.49	6,370,100	0.32	11,180	0.17
13-0000	Business and financial operations	6,419,370	4.93	6,376,860	0.66	6,398,430	0.33	21,570	0.34
15-0000	Computer and mathematical	3,578,210	2.75	3,547,490	0.86	3,558,740	0.55	11,250	0.31
17-0000	Architecture and engineering	2,356,530	1.81	2,291,990	2.74	2,332,670	1.04	40,680	1.73
19-0000	Life, physical and social science	1,104,090	0.85	1,072,140	2.89	1,087,910	1.51	15,770	1.43
21-0000	Community and social service	1,882,090	1.44	1,862,910	1.02	1,869,390	0.68	6,480	0.34
23-0000	Legal	1,023,020	0.79	1,007,650	1.50	1,020,570	0.24	12,920	1.26
25-0000	Education, training and library	8,374,940	6.43	8,342,540	0.39	8,366,210	0.10	23,670	0.28
27-0000	Arts, design, entertainment, sports and media	1,750,100	1.34	1,694,650	3.17	1,726,870	1.37	32,220	1.84
29-0000	Healthcare practitioners and technical	7,649,960	5.87	7,616,480	0.44	7,632,460	0.23	15,980	0.21
31-0000	Healthcare support	3,915,460	3.01	3,901,350	0.36	3,908,970	0.17	7,620	0.19
33-0000	Protective service	3,207,800	2.46	3,188,490	0.60	3,203,710	0.13	15,220	0.47
35-0000	Food preparation and serving related	11,546,900	8.86	11,513,250	0.29	11,537,110	0.09	23,860	0.21
37-0000	Building and grounds cleaning and maintenance	4,246,250	3.26	4,234,970	0.27	4,239,070	0.17	4,100	0.10
39-0000	Personal care and service	3,810,780	2.92	3,762,840	1.26	3,781,040	0.79	18,200	0.48
41-0000	Sales and related	13,835,110	10.62	13,754,980	0.58	13,809,570	0.19	54,590	0.39
43-0000	Office and administrative support	21,355,370	16.39	21,232,420	0.58	21,285,190	0.33	52,770	0.25
45-0000	Farming, fishing and forestry	427,630	0.33	417,780	2.30	421,470	1.47	3,690	0.86
47-0000	Construction and extraction	4,978,290	3.82	4,914,810	1.28	4,940,380	0.77	25,570	0.51
49-0000	Installation, maintenance and repair	5,069,600	3.89	5,002,750	1.32	5,040,920	0.57	38,170	0.75
51-0000	Production	8,594,170	6.60	8,449,260	1.69	8,533,960	0.71	84,700	0.99
53-0000	Transportation and material moving	8,771,670	6.73	8,665,880	1.21	8,724,620	0.54	58,740	0.67
		130,287,780	100.00	129,210,410	0.83	129,789,360	0.38	578,950	0.44

Note: Columns (1) and (2) represent data from the national-level occupational information without industry clusters, whereas columns (3) and (3') contain data from the detailed level in OEWS survey at industry and occupation clusters. The major group 55-0000, 'military specific occupations' and all its sub-groups are not included in the OEWS estimations.

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Table 8 / (contd.) Employment at 2-digit SOC occupations before and after filling of missing cells

(b)   2018

SOC occupation code (major)	Occupation	National employment (1)	Employment share of occupation (in %) (2)	Sum of 'detailed' employment pre-adjustment (3)	Missing in % pre-adjustment (4) = [(1)-(3)] / (1)	Sum of 'detailed' employment post-adjustment (3')	Missing in % post-adjustment (4') = [(1) - (3')] / (1)	Employments assigned (5) = (3') - (3)	Assignments in % of industry-level employment (6) = (5) / (1)
11-0000	Management	7,616,640	5.26	7,572,660	0.58	7,587,740	0.38	15,080	0.20
13-0000	Business and financial operations	7,721,260	5.33	7,666,680	0.71	7,689,030	0.42	22,350	0.29
15-0000	Computer and mathematical	4,384,280	3.03	4,334,490	1.14	4,362,230	0.51	27,740	0.63
17-0000	Architecture and engineering	2,556,210	1.77	2,495,400	2.38	2,525,750	1.22	30,350	1.19
19-0000	Life, physical and social science	1,171,900	0.81	1,133,050	3.32	1,156,680	1.34	23,630	2.02
21-0000	Community and social service	2,171,810	1.50	2,150,470	0.98	2,163,010	0.41	12,540	0.58
23-0000	Legal	1,127,900	0.78	1,121,660	0.55	1,123,370	0.40	1,710	0.15
25-0000	Education, training and library	8,779,760	6.07	8,738,630	0.47	8,766,910	0.15	28,280	0.32
27-0000	Arts, design, entertainment, sports and media	1,951,170	1.35	1,879,190	3.69	1,915,730	1.89	36,540	1.87
29-0000	Healthcare practitioners and technical	8,646,720	5.97	8,580,770	0.76	8,617,260	0.34	36,490	0.42
31-0000	Healthcare support	4,117,450	2.84	4,088,070	0.71	4,105,590	0.29	17,520	0.43
33-0000	Protective service	3,437,410	2.38	3,389,660	1.39	3,411,160	0.77	21,500	0.63
35-0000	Food preparation and serving related	13,374,630	9.24	13,286,190	0.66	13,334,330	0.30	48,140	0.36
37-0000	Building and grounds cleaning and maintenance	4,421,970	3.06	4,349,200	1.65	4,368,380	1.23	19,180	0.43
39-0000	Personal care and service	5,451,320	3.77	5,387,860	1.16	5,418,170	0.62	30,310	0.56
41-0000	Sales and related	14,542,290	10.05	14,436,080	0.73	14,491,530	0.35	55,450	0.38
43-0000	Office and administrative support	21,828,990	15.08	21,586,180	1.11	21,672,580	0.72	86,400	0.40
45-0000	Farming, fishing and forestry	478,190	0.33	444,980	6.94	453,900	5.46	8,920	1.87
47-0000	Construction and extraction	5,962,670	4.12	5,865,290	1.63	5,898,130	1.10	32,840	0.55
49-0000	Installation, maintenance and repair	5,628,890	3.89	5,528,390	1.79	5,574,180	0.99	45,790	0.81
51-0000	Production	9,115,520	6.30	8,846,800	2.95	8,974,390	1.60	127,590	1.40
53-0000	Transportation and material moving	10,244,240	7.08	9,764,520	4.68	9,852,100	4.02	87,580	0.85
		144,731,220	**100.00**	**142,646,220**	**1.44**	**143,462,150**	**0.88**	**815,930**	**0.56**

Note: Columns (1) and (2) represent data from the national level occupational information without industry clusters, whereas columns (3) and (3') contain data from the detailed level in OEWS survey at industry and occupation clusters. The major group 55-0000, 'military specific occupations' and all its sub-groups are not included in the OEWS estimations.

Table 9 / Employment at 2-digit NAICS industries and SOC occupations after filling of missing cells

(a)   2012

Occupations industry title /	Management	Business and Financial Operations	Computer and Mathematical	Architecture and Engineering	Life, Physical, and Social Science	Community and Social Service	Legal	Education, Training, and Library	Arts, Design, Entertainment, Sports, and Media	Healthcare Practitioners and Technical	Healthcare Support	Protective Service	Food Preparation and Serving Related	Building and Grounds Cleaning and Maintenance	Personal Care and Service	Sales and Related	Office and Administrative Support	Farming, Fishing, and Forestry	Construction and Extraction	Installation, Maintenance, and Repair	Production	Transportation and Material Moving	Industry Total
Agriculture, forestry, fishing and hunting	7,280	2,390	130		2,750			280	90	110		420		4,180	4,310	2,410	20,450	284,510	780	7,890	12,860	41,950	**392,790**
Mining, quarrying, and oil and gas extraction	47,440	30,010	9,260	48,960	22,920		2,660		300	3,510		1,140	390	1,550		8,980	61,090	50	317,030	57,990	52,820	112,370	**778,470**
Utilities	35,110	36,920	13,860	48,770	7,820		810	100	1,650	1,910		5,590		3,310		10,450	107,820	380	30,370	149,110	85,220	9,810	**549,010**
Construction	351,680	187,830	10,590	65,180	190	120	910		4,920	4,060		3,420	590	32,710	550	117,860	571,010	440	3,489,230	485,260	80,270	184,560	**5,591,380**
Manufacturing (31-33)	673,450	437,620	275,850	758,820	109,110	70	4,740	300	71,410	18,340	780	14,670	34,840	67,430	280	371,210	1,118,380	27,070	185,300	586,380	6,032,190	986,800	**11,775,040**
Wholesale trade	371,180	257,120	178,830	53,820	10,190	200	3,150	450	59,580	16,810	1,040	3,760	3,030	26,420	840	1,506,270	1,291,730	43,320	16,510	359,130	272,930	1,120,940	**5,597,250**
Retail trade (44-45)	333,590	127,520	51,280	3,330	80	120	960	5,920	95,480	488,930	45,020	51,080	480,410	123,250	70,670	8,352,970	2,550,930	18,830	33,980	691,710	396,910	1,018,710	**14,941,680**
Transportation and warehousing (48_49)	163,050	94,340	27,150	23,160	1,050	50	1,410	580	1,960	4,660	0	20,050	6,200	33,020	26,660	66,390	1,356,480	850	26,710	296,520	67,890	2,766,690	**4,984,870**
Information	191,480	181,030	437,340	42,350	1,080	320	7,490	16,050	453,580	720		3,050	52,470	12,510	52,580	345,500	501,410		4,750	278,370	43,550	35,140	**2,660,770**
Finance and insurance	425,870	1,295,740	329,910	1,000	2,520	4,700	48,830	210	15,370	31,090	1,340	8,040	410	10,860	650	779,960	2,548,180	170	840	8,040	780	2,260	**5,516,770**
Real estate and rental and leasing	194,960	95,180	11,350	1,840		1,280	6,790	50	12,650	4,520	1,610	27,390	17,520	156,710	21,110	469,180	416,340	560	22,070	329,950	8,400	121,340	**1,920,800**
Professional, scientific and technical services	621,330	1,131,200	1,249,940	839,330	322,840	8,720	621,660	12,270	314,960	167,030	67,010	14,820	4,740	27,820	34,170	342,020	1,671,340	3,350	58,620	61,470	113,070	58,390	**7,746,100**
Management of companies and enterprises	388,250	415,150	210,550	63,080	16,990	15,710	22,290	6,550	34,130	27,480	5,350	10,770	15,170	9,500	9,340	94,010	533,520	1,070	6,680	41,730	18,610	50,100	**1,996,030**
Administrative and support and waste management and remediation services	249,000	275,590	151,020	61,540	18,930	12,680	24,730	70,860	35,070	154,630	102,480	738,390	63,620	1,685,730	62,810	470,070	1,688,450	8,920	227,190	214,340	723,160	860,540	**7,899,750**
Educational services	592,020	254,430	209,160	23,440	174,170	288,100	3,660	7,490,850	246,230	259,930	38,100	118,120	430,920	507,960	227,820	40,660	1,291,640	2,870	39,380	146,750	16,060	266,960	**12,669,230**
Health care and social assistance	624,150	272,300	109,390	4,050	86,420	967,110	4,360	458,910	33,880	5,971,180	3,457,340	72,680	528,320	448,600	1,499,960	63,410	2,719,540	600	15,950	136,260	94,940	120,140	**17,689,490**
Arts, entertainment and recreation	68,730	48,640	5,280	630	1,790	760	220	32,590	187,640	6,750	4,020	87,370	292,750	171,140	563,280	155,830	176,140	2,510	8,320	65,120	3,700	38,240	**1,921,450**
Accommodation and food services	291,900	40,770	2,200	260			40	810	15,130	2,790	7,100	70,620	9,397,710	579,500	135,970	335,290	413,090	870	3,420	101,060	70,860	196,000	**11,665,390**
Other services (except public administration)	182,310	232,160	29,540	6,650	9,080	101,000	7,960	65,390	80,350	10,760	41,430	42,080	91,260	100,700	758,190	208,500	549,790	990	12,920	631,460	275,940	346,180	**3,784,640**
Public administration	557,320	982,490	246,110	286,460	299,980	468,450	257,900	204,040	62,490	457,250	136,350	1,910,250	116,760	236,170	311,850	68,600	1,697,860	24,110	440,330	392,380	163,800	387,500	**9,708,450**
	6,370,100	6,398,430	3,558,740	2,332,670	1,087,910	1,869,390	1,020,570	8,366,210	1,726,870	7,632,460	3,908,970	3,203,710	11,537,110	4,239,070	3,781,040	13,809,570	21,285,190	421,470	4,940,380	5,040,920	8,533,960	8,724,620	**129,789,360**

Note: Columns and rows represent data from the detailed level in OEWS survey at industry and occupation clusters. The major group 55-0000, 'military specific occupations' and all its sub-groups are not included in the OEWS estimations. The blank cells indicate that no occupational observation is recorded for some industries in the survey.

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Table 9 / (contd.) Employment at 2-digit NAICS industries and SOC occupations after filling of missing cells

(b)   2018

industry title / occupations	Management	Business and Financial Operations	Computer and Mathematical	Architecture and Engineering	Life, Physical, and Social Science	Community and Social Service	Legal	Education, Training, and Library	Arts, Design, Entertainment, Sports, and Media	Healthcare Practitioners and Technical	Healthcare Support	Protective Service	Food Preparation and Serving Related	Building and Grounds Cleaning and Maintenance	Personal Care and Service	Sales and Related	Office and Administrative Support	Farming, Fishing, and Forestry	Construction and Extraction	Installation, Maintenance, and Repair	Production	Transportation and Material Moving	Industry Total
Agriculture, Forestry, Fishing and Hunting	8,040	1,970	80	30	3,210		430	60	270	40	440			4,880	4,200	2,580	20,450	311,570	320	8,670	12,790	44,260	**424,290**
Mining, Quarrying, and Oil and Gas Extraction	36,680	30,730	10,070	31,090	17,280		4,230		430	4,380		980	90	1,010		12,520	53,470	80	242,150	54,830	46,640	92,820	**639,480**
Utilities	40,730	45,020	21,430	51,580	9,040		1,390	50	2,150	2,350		6,390		2,270		8,780	93,940	310	30,700	147,390	78,960	7,480	**549,960**
Construction	463,480	241,540	16,580	89,320	1,200	60	1,550	30	9,870	11,440		5,850	1,260	38,100	550	159,650	680,310	340	4,445,430	613,030	116,250	234,190	**7,130,030**
Manufacturing (31-33)	699,910	489,440	291,890	807,240	120,750	110	6,630	40	83,280	26,920	930	10,700	69,870	62,360	940	416,310	1,107,320	34,340	195,220	622,550	6,403,860	973,650	**12,424,260**
Wholesale Trade	441,500	296,960	172,950	63,450	14,780	470	3,680	200	78,380	30,290	850	3,750	8,740	27,290	1,330	1,362,740	1,255,410	42,890	29,480	394,670	324,210	1,220,220	**5,774,240**
Retail Trade (44-45)	419,710	161,020	47,450	2,730	160	980	2,250	10,890	121,570	534,980	33,990	48,080	544,010	65,970	102,570	8,754,960	2,717,620	20,260	35,460	768,450	306,250	1,001,910	**15,701,270**
Transportation and Warehousing (48_49)	175,980	110,820	28,500	26,500	740	0	1,490	2,370	3,690	6,930	0	44,830	7,660	33,050	16,800	70,330	1,471,080	1,540	33,540	329,390	69,910	3,263,930	**5,699,080**
Information	223,470	240,860	573,170	40,130	1,700	60	9,860	19,870	446,150	2,200	210	5,120	54,320	6,770	74,380	313,940	422,860		9,660	266,930	26,930	38,040	**2,776,630**
Finance and Insurance	512,260	1,494,300	415,720	3,370	3,500	9,690	51,880	220	19,060	49,950	850	9,240	380	8,850	830	906,910	2,406,580	40	930	10,550	1,650	1,880	**5,908,640**
Real Estate and Rental and Leasing	275,930	128,580	18,710	2,320	270	1,680	7,810	100	22,280	4,760	0	27,930	16,770	134,820	23,040	467,550	445,540	110	26,520	410,670	11,820	149,950	**2,177,160**
Professional, Scientific, and Technical Services	881,430	1,406,400	1,591,330	937,810	330,860	9,610	690,680	14,470	366,450	224,490	88,490	12,790	8,080	30,800	38,020	424,560	1,672,350	4,090	80,260	76,740	132,320	69,050	**9,091,080**
Management of Companies and Enterprises	465,540	535,350	274,020	75,420	17,900	21,180	27,100	5,110	44,930	43,350	10,310	9,700	13,800	9,920	11,970	107,120	565,500	1,190	10,650	42,900	23,940	52,050	**2,368,950**
Administrative and Support and Waste Management and Remediation Services	296,800	396,690	222,160	72,080	27,100	16,830	21,330	63,750	48,400	155,150	101,370	827,990	99,620	1,933,980	74,350	490,810	1,809,670	2,880	232,650	225,980	764,500	1,175,440	**9,059,530**
Educational Services	658,170	318,830	229,670	23,650	179,070	345,430	5,950	7,745,410	259,500	274,360	42,810	163,940	410,310	476,170	229,510	37,920	1,252,380	3,340	38,760	158,130	15,270	256,840	**13,125,420**
Health Care and Social Assistance	725,430	357,690	140,740	4,600	111,870	1,136,880	6,520	566,500	36,980	6,758,700	3,635,810	76,050	527,720	426,040	2,776,090	70,900	2,832,980	2,360	17,960	152,910	82,480	132,430	**20,579,640**
Arts, Entertainment, and Recreation	96,170	72,920	8,810	950	2,180	1,490	400	49,790	197,570	10,990	4,360	110,800	326,810	184,250	739,280	171,460	223,130	2,450	10,790	82,280	4,380	59,800	**2,361,060**
Accommodation and Food Services	348,470	60,150	3,980	330		30	170	1,460	16,980	5,970	10,050	78,640	11,085,130	619,370	165,930	458,180	475,770	1,360	4,690	131,760	100,200	288,720	**13,857,340**
Other Services (except Public Administration)	225,600	264,130	35,790	7,940	13,540	115,500	8,700	67,020	88,760	13,320	60,420	43,290	88,300	89,390	877,840	198,090	580,140	2,410	14,070	672,930	275,210	412,090	**4,154,480**
Public Administration	592,440	1,035,630	259,180	285,210	301,530	503,010	271,750	219,200	69,240	456,460	115,100	1,924,650	71,460	213,090	280,540	56,220	1,586,080	22,340	438,890	403,420	176,820	377,350	**9,659,610**
	7,587,740	**7,689,030**	**4,362,230**	**2,525,750**	**1,156,680**	**2,163,010**	**1,123,370**	**8,766,910**	**1,915,730**	**8,617,260**	**4,105,590**	**3,411,160**	**13,334,330**	**4,368,380**	**5,418,170**	**14,491,530**	**21,672,580**	**453,900**	**5,898,130**	**5,574,180**	**8,974,390**	**9,852,100**	**143,462,150**

Note: Columns and rows represent data from the detailed level in OEWS survey at industry and occupation clusters. The major group 55-0000, 'military specific occupations' and all its sub-groups are not included in the OEWS estimations. The blank cells indicate that no occupational observation is recorded for some industries in the survey.

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Step 2: Imputation of agricultural jobs

When further processing the data, the fact that some industries are not covered needs to be taken into account as this implies that some occupations are under-represented or not covered at all. This chiefly concerns the primary sector, including agriculture, forestry and fisheries.

Table 10 / List of imputed SOC occupations from CPS LFS data

NAICS 4-digit code	NAICS cluster	SOC detailed code	SOC occupation name	SOC cluster	imputed employment 2012	imputed employment 2018
1111	11	45-2011	Agricultural inspectors	45	1,778	2,444
1112	11	45-2011	Agricultural inspectors	45	1,778	2,444
1113	11	45-2011	Agricultural inspectors	45	1,778	2,444
1114	11	45-2011	Agricultural inspectors	45	1,778	2,444
1119	11	45-2011	Agricultural inspectors	45	1,778	2,444
1121	11	45-2011	Agricultural inspectors	45	1,778	2,444
1122	11	45-2011	Agricultural inspectors	45	1,778	2,444
1123	11	45-2011	Agricultural inspectors	45	1,778	2,444
1124	11	45-2011	Agricultural inspectors	45	1,778	2,444
1111	11	45-2041	Graders and sorters, agric. producers	45	13,111	9,444
1112	11	45-2041	Graders and sorters, agric. producers	45	13,111	9,444
1113	11	45-2041	Graders and sorters, agric. producers	45	13,111	9,444
1114	11	45-2041	Graders and sorters, agric. producers	45	13,111	9,444
1119	11	45-2041	Graders and sorters, agric. producers	45	13,111	9,444
1121	11	45-2041	Graders and sorters, agric. producers	45	13,111	9,444
1122	11	45-2041	Graders and sorters, agric. producers	45	13,111	9,444
1123	11	45-2041	Graders and sorters, agric. producers	45	13,111	9,444
1124	11	45-2041	Graders and sorters, agric. producers	45	13,111	9,444
1111	11	45-2021	Animal breeders	45	667	556
1112	11	45-2021	Animal breeders	45	667	556
1113	11	45-2021	Animal breeders	45	667	556
1114	11	45-2021	Animal breeders	45	667	556
1119	11	45-2021	Animal breeders	45	667	556
1121	11	45-2021	Animal breeders	45	667	556
1122	11	45-2021	Animal breeders	45	667	556
1123	11	45-2021	Animal breeders	45	667	556
1124	11	45-2021	Animal breeders	45	667	556
1133	11	45-4011	Forest and conservation workers	45	9,000	16,000
1133	11	45-4021	Fallers	45	49,000	58,000
1141	11	45-3031	Fishing and hunting workers	45	33,000	39,000
1111	11	11-9013	Farmers, ranchers, other agric. managers	11+13	104,889	110,111
1112	11	11-9013	Farmers, ranchers, other agric. managers	11+13	104,889	110,111
1113	11	11-9013	Farmers, ranchers, other agric. managers	11+13	104,889	110,111
1114	11	11-9013	Farmers, ranchers, other agric. managers	11+13	104,889	110,111
1119	11	11-9013	Farmers, ranchers, other agric. managers	11+13	104,889	110,111
1121	11	11-9013	Farmers, ranchers, other agric. managers	11+13	104,889	110,111
1122	11	11-9013	Farmers, ranchers, other agric. managers	11+13	104,889	110,111
1123	11	11-9013	Farmers, ranchers, other agric. managers	11+13	104,889	110,111
1124	11	11-9013	Farmers, ranchers, other agric. managers	11+13	104,889	110,111

Note: 1111=oilseed and grain farming, 1112=vegetable and melon farming, 1113=fruit and tree nut farming, 1114=greenhouse, nursery and floriculture production, 1119=other crop farming, 1121=cattle ranching and farming, 1122=hog and pig farming, 1123=poultry and egg production, 1124=sheep and goat farming. NAICS cluster 11=agriculture, forestry, fishing and hunting (NAICS 11); SOC Cluster 45=farming, fishing and forestry occupations (SOC 45); SOC Cluster 11+13=management, business, and financial operations occupations (SOC 11-0000 management occupations and SOC 13-0000 business and financial operations occupations).
Source: Labour Force Statistics (LFS) from the Current Population Survey (Table 11).

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Data for detailed occupations are available from the CPS LFS survey.[21] The limitation here, of course, is that in the detailed statistics on SOC occupations, the information on industries is missing. However, for the type of jobs imputed, which are comprehensively listed in Table 10, it is reasonable to assume that they are predominantly found in the agricultural sector (NAICS sector 11). This is the assumption made here. For the SOC occupations 'agricultural inspectors' (45-2011), 'graders and sorters, agricultural producers' (45-2041), 'animal breeders' (45-2021) and 'farmers, ranchers, and other agricultural managers' (11-9013), the number of employments is assigned in equal proportions to nine agricultural NAICS 4-digit industries (1111, 1112, 1113, 1114, 1119, 1121, 1122, 1123, 1124).

As these imputations rely on an assumption (regarding the corresponding industry), they give rise to potential measurement bias. However, these additions avoid an even greater bias, which would arise when the data is rescaled to the OECD ICIO industry-level employment. As the employment numbers in the agricultural sector from the OEWS survey are much lower, the upscaling of existing occupations would be massive, even though they might not be the most important agricultural occupations. For this reason, the imputation of some typical agricultural and forestry- and fishery-related employment appears to be the preferable and less inaccurate approach.

Step 3: Addition of CPS LFS data and rescaling of OEWS data to CPS LFS levels

In a next step, the information from the CPS LFS survey is used and added to the OEWS data. The latter remains the basis of the analysis because of the finer occupation-industry-level information available. The advantage of the CPS LFS survey is more complete[22] as revealed by the cross-tabulation at the combined level of 'NAICS clusters' (Table 11). These NAICS clusters are similar but not identical to NAICS sectors (2-digit industries) and SOC major groups (2-digit occupations). As shown in Table 11, the NAICS cluster totals (row sums in the table) and SOC cluster totals (column sums in the table) are in general higher in the CPS LFS data. In individual cells, however, the difference can go in either direction, and in a few cases, there are substantial deviations between the numbers of the two data sources. The OEWS 4-digit NAICS industry and detailed SOC occupation data are rescaled within the NAICS-SOC clusters to match the CPS LFS level.

As both data sets, the OEWS and the CPS LFS, are based on surveys, it is a priori not clear which is more reliable. For this reason, both data sets – the original OEWS (including the additions in Step 2) and the rescaled data – are kept and used.

There are a few exceptions to the rescaling procedure, however. First, imputed employments in agricultural, forestry and fishing industries from Step 2 are not rescaled as these are already values from the CPS LFS. Second, for some protective services jobs (in SOC cluster 33), the rescaling factors are implausibly high and the LFS CPS data appear to be less reliable.

Table 11 also shows that information for occupations of the armed forces are missing in both data sets.

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[21] Table 11 of the CPS LFS survey, available at: https://www.bls.gov/cps/cps_aa2018.htm#empstat

[22] See Table 17. Available at: https://www.bls.gov/cps/cps_aa2018.htm#empstat

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Table 11 / Comparison of US employment at the level of NAICS and SOC 'clusters' in OEWS and CPS LFS, 2018

(a)   Employment at NAICS and SOC cluster level in the OEWS data

	SOC cluster / NAICS cluster	Management, business, and financial operations occupations 11+13	Professional and related occupations 15+17+19+21+23+25+27+29	Service occupations, except protective 31+35+37+39	Protective service occupations 33	Sales and related occupations 41	Office and administrative support occupations 43	Farming, fishing, and forestry occupations 45	Construction and extraction occupations 47	Installation, maintenance, and repair occupations 49	Production occupations 51	Transportation and material moving occupations 53	Armed forces* 55	NAICS Total
Agriculture and related	11	953,671	3,360	8,490	420	2,410	20,450	510,864	780	7,890	12,860	41,950		1,563,145
Mining, quarrying, and oil and gas extraction	21	77,450	87,610	1,940	1,140	8,980	61,090	50	317,030	57,990	52,820	112,370		778,470
Transportation and utilities	22_48_49	329,420	134,940	69,190	25,640	76,840	1,464,300	1,230	57,080	445,630	153,110	2,776,500		5,533,880
Construction	23	539,510	85,970	33,850	3,420	117,860	571,010	440	3,489,230	485,260	80,270	184,560		5,591,380
Manufacturing - Durable goods	31_33_dura	779,470	970,950	30,820	10,450	205,560	689,970	6,800	159,860	329,490	3,737,160	441,420		7,361,950
Manufacturing - Nondurable goods	31_33_ndur	331,600	267,690	72,510	4,220	165,650	428,410	20,270	25,440	256,890	2,295,030	545,380		4,413,090
Wholesale trade	42	628,300	323,030	31,330	3,760	1,506,270	1,291,730	43,320	16,510	359,130	272,930	1,120,940		5,597,250
Retail trade	44_45	461,110	646,100	719,350	51,080	8,352,970	2,550,930	18,830	33,980	691,710	396,910	1,018,710		14,941,680
Information	51	372,510	958,930	117,560	3,050	345,500	501,410		4,750	278,370	43,550	35,140		2,660,770
Financial activities	52_53	2,011,750	472,110	210,210	35,430	1,249,140	2,964,520	730	22,910	337,990	9,180	123,600		7,437,570
Professional and business services	54_55_56	3,080,520	4,462,990	2,087,740	763,980	906,100	3,893,310	13,340	292,490	317,540	854,840	969,030		17,641,880
Education and health services	61_62	1,742,900	16,330,840	7,139,020	190,800	104,070	4,011,180	3,470	55,330	283,010	111,000	387,100		30,358,720
Leisure and hospitality	71_72	450,040	256,890	11,151,470	157,990	491,120	589,230	3,380	11,740	166,180	74,560	234,240		13,586,840
Other services	81_other	414,470	310,730	991,580	42,080	208,500	549,790	990	12,920	631,460	275,940	346,180		3,784,640
	81_privhh													
Public administration	99	1,539,810	2,282,680	801,130	1,910,250	68,600	1,697,860	24,110	440,330	392,380	163,800	387,500		9,708,450
Occupation Total		*13,712,531*	*27,594,820*	*23,466,190*	*3,203,710*	*13,809,570*	*21,285,190*	*647,824*	*4,940,380*	*5,040,920*	*8,533,960*	*8,724,620*		*130,959,715*

Table 11 / (contd.) Comparison of US employment at the level of NAICS and SOC 'clusters' in OEWS and CPS LFS, 2018

(b)   Employment at NAICS and SOC cluster level in the CPS LFS data

	SOC cluster NAICS cluster	Management, business, and financial operations occupations 11+13	Professional and related occupations 15+17+19+21+23+ 25+27+29	Service occupations, except protective 31+35+37+39	Protective service occupations 33	Sales and related occupations 41	Office and administrative support occupations 43	Farming, fishing, and forestry occupations 45	Construction and extraction occupations 47	Installation, maintenance, and repair occupations 49	Production occupations 51	Transportation and material moving occupations 53	Armed forces* 55	NAICS Total
Agriculture and related	11	1,032,000	41,000	14,000	84,000	15,000	83,000	966,000	15,000	36,000	41,000	98,000		2,425,000
Mining, quarrying, and oil and gas extraction	21	144,000	109,000	4,000	10,000	11,000	51,000	-	246,000	55,000	51,000	102,000		783,000
Transportation and utilities	22_48_49	912,000	418,000	30,000	164,000	130,000	1,729,000	1,000	186,000	560,000	377,000	4,044,000		8,551,000
Construction	23	2,149,000	302,000	18,000	49,000	124,000	543,000	3,000	6,992,000	585,000	185,000	232,000		11,182,000
Manufacturing - Durable goods	31_33_dura	1,661,000	1,649,000	12,000	93,000	313,000	783,000	4,000	246,000	441,000	3,872,000	757,000		9,831,000
Manufacturing - Nondurable goods	31_33_ndur	969,000	647,000	14,000	145,000	289,000	460,000	52,000	67,000	269,000	2,231,000	587,000		5,730,000
Wholesale trade	42	516,000	179,000	6,000	51,000	1,297,000	557,000	33,000	27,000	126,000	133,000	747,000		3,672,000
Retail trade	44_45	940,000	1,031,000	55,000	620,000	8,766,000	2,678,000	13,000	74,000	577,000	472,000	1,372,000		16,598,000
Information	51	611,000	1,159,000	6,000	67,000	319,000	379,000	-	14,000	291,000	33,000	39,000		2,918,000
Financial activities	52_53	4,498,000	967,000	54,000	309,000	2,381,000	2,060,000	-	62,000	161,000	43,000	115,000		10,650,000
Professional and business services	54_55_56	4,777,000	6,510,000	622,000	2,909,000	648,000	2,149,000	14,000	161,000	282,000	303,000	575,000		18,950,000
Education and health services	61_62	3,381,000	19,706,000	183,000	7,239,000	109,000	3,525,000	4,000	77,000	216,000	181,000	421,000		35,042,000
Leisure and hospitality	71_72	2,096,000	983,000	204,000	8,530,000	1,006,000	783,000	6,000	45,000	107,000	128,000	380,000		14,268,000
Other services	81_other	711,000	989,000	29,000	2,246,000	362,000	634,000	3,000	15,000	1,152,000	489,000	336,000		6,966,000
	81_privhh	3,000	7,000	-	754,000	-	4,000	-	-	-	1,000	8,000		777,000
Public administration	99	1,451,000	1,888,000	1,954,000	383,000	35,000	1,238,000	23,000	111,000	153,000	79,000	105,000		7,420,000
Occupation Total		25,851,000	36,585,000	3,205,000	23,653,000	15,805,000	17,656,000	1,122,000	8,338,000	5,011,000	8,619,000	9,918,000		155,763,000

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Step 4: Crosswalk to ISIC Rev.4 / NACE Rev.2 industry classification.

Both the European employment data and the OECD ICIO employment data use the NACE Rev.2 industry classification (which at the 2-digit level is equal to ISIC Rev.4 classification). Therefore the (rescaled) OEWS employment data is transformed from the NAICS classification to the NACE Rev.2 classification. To be precise, the reclassification is made to the industry structure in the (slightly aggregated) OECD ICIO industry structure, which is – as described above – a mixture of NACE 1-digit and NACE 2-digit industries. This crosswalk is performed at the NAICS 4-digit industry level. For the crosswalk from NAICS to OECD ICIO industries, the official correspondence file for NAICS 2012 to ISIC 4 (for the year 2012) and the correspondence file for NAICS 2017 to ISIC 4 (for the year 2018) are used.[23]

As the crosswalk involves several NAICS to ISIC combinations, which are not unique, some assignment ratios had to be made. In most cases, this is greatly facilitated by the fact that the names of one of the (non-unique) ISIC industries are almost identical to those of the corresponding NAICS industry. In such cases, the bulk of the value, between 90% and 99%, is assigned to this closely corresponding industry. The detailed assignment factors are shown in Table 12.

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[23] The correspondence files are available at the BLS website at: https://www.bls.gov/ces/naics/

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Table 12 / Assignment of employments in non-unique correspondences between NAICS and NACE industries

NAICS code(4-digit)	Corresponding OECD ICIO industry	Assignment factor	NAICS code(4-digit)	Corresponding OECD ICIO industry	Assignment factor
1119	01T03	0.90	3314	25	0.74
1119	10T12	0.10	3314	27	0.01
1133	01T03	0.67	3315	24	0.99
1133	16	0.33	3315	28	0.01
1152	01T03	0.99	3322	25	0.85
1152	69T75	0.01	3322	27	0.01
2131	05T09	0.90	3322	28	0.12
2131	41T43	0.10	3322	31T33	0.02
2213	35	0.15	3323	25	0.90
2213	36T39	0.75	3323	28	0.09
2213	49	0.10	3323	30	0.01
2382	01T03	0.01	3324	25	0.95
2382	31T33	0.01	3324	28	0.04
2382	41T43	0.97	3324	29	0.01
2382	77T82	0.01	3326	25	0.99
3117	01T03	0.02	3326	31T33	0.01
3117	10T12	0.98	3329	17T18	0.01
3119	05T09	0.01	3329	20	0.01
3119	10T12	0.99	3329	22	0.01
3121	10T12	0.98	3329	24	0.01
3121	20	0.01	3329	25	0.95
3121	35	0.01	3329	28	0.01
3133	13T15	0.98	3331	25	0.05
3133	22	0.02	3331	28	0.90
3141	13T15	0.95	3331	30	0.05
3141	22	0.05	3332	28	0.95
3149	13T15	0.95	3332	31T33	0.05
3149	22	0.05	3333	26	0.90
3159	13T15	0.98	3333	27	0.05
3159	22	0.02	3333	28	0.03
3219	16	0.90	3333	30	0.01
3219	22	0.05	3333	31T33	0.01
3219	31T33	0.05	3334	25	0.02
3221	17T18	0.99	3334	28	0.98
3221	23	0.01	3335	25	0.01
3222	13T15	0.01	3335	28	0.99
3222	17T18	0.96	3336	27	0.01
3222	22	0.01	3336	28	0.97
3222	24	0.01	3336	29	0.01
3222	25	0.01	3336	30	0.01
3231	13T15	0.01	3339	25	0.02
3231	17T18	0.97	3339	26	0.02
3231	25	0.01	3339	27	0.02
3231	77T82	0.01	3339	28	0.90
3241	16	0.01	3339	30	0.02
3241	19	0.98	3339	31T33	0.02
3241	23	0.01	3342	26	0.98
3251	19	0.01	3342	27	0.01
3251	20	0.90	3342	30	0.01
3251	21	0.09	3346	17T18	0.01
3252	20	0.10	3346	26	0.99
3252	22	0.90	3351	13T15	0.01
3254	20	0.20	3351	27	0.99
3254	21	0.80	3359	23	0.01
3259	20	0.90	3359	27	0.99
3259	23	0.02	3362	28	0.10
3259	28	0.02	3362	29	0.90
3259	77T82	0.06	3363	13T15	0.06
3261	22	0.97	3363	22	0.00
3261	27	0.01	3363	23	0.00
3261	29	0.01	3363	25	0.00
3261	31T33	0.01	3363	27	0.03
3262	22	0.99	3363	28	0.00
3262	27	0.01	3363	29	0.90
3279	23	0.99	3363	30	0.01
3279	31T33	0.01	3364	28	0.01
3312	24	0.09	3364	30	0.99
3312	25	0.89	3365	29	0.00
3312	27	0.01	3365	30	1.00
3312	30	0.01	3366	30	1.00
3313	24	0.25	3366	31T33	0.00
3313	25	0.74	3369	29	0.01
3313	27	0.01	3369	30	0.99
3314	24	0.25	3372	16	0.20
			3372	22	0.02

Contd.

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Table 12 / (contd.) Assignment of employments in non-unique correspondences between NAICS and NACE industries

NAICS code (4-digit)	Corresponding OECD ICIO industry	Assignment factor	NAICS code (4-digit)	Corresponding OECD ICIO industry	Assignment factor
3372	25	0.03	5612	84	0.01
3372	31T33	0.75	5614	77T82	0.99
3379	13T15	0.01	5614	84	0.01
3379	16	0.07	5617	41T43	0.10
3379	22	0.01	5617	77T82	0.01
3379	25	0.01	5617	90T96	0.89
3379	31T33	0.90	5619	13T15	0.00
3391	21	0.80	5619	77T82	0.99
3391	28	0.20	5619	84	0.01
3391	30	0.00	7115	31T33	0.00
3391	31T33	0.00	7115	69T75	0.01
3399	13T15	0.01	7115	90T96	0.99
3399	16	0.01	7139	49	0.00
3399	17T18	0.01	7139	77T82	0.00
3399	20	0.01	7139	90T96	1.00
3399	22	0.01	7211	55T56	0.99
3399	23	0.01	7211	90T96	0.01
3399	25	0.01	8111	29	0.04
3399	26	0.01	8111	45T47	0.95
3399	27	0.01	8111	69T75	0.01
3399	28	0.01	8112	31T33	0.99
3399	30	0.01	8112	90T96	0.01
3399	31T33	0.89	8113	31T33	0.99
4412	31T33	0.01	8113	45T47	0.01
4412	45T47	0.99	8113	77T82	0.00
4422	45T47	0.99	8114	31T33	0.90
4422	90T96	0.01	8114	45T47	0.05
4431	31T33	0.01	8114	90T96	0.05
4431	45T47	0.99	8129	52	0.01
4431	90T96	0.00	8129	61	0.01
4442	45T47	0.99	8129	69T75	0.01
4442	90T96	0.01	8129	90T96	0.97
4483	45T47	0.99			
4483	90T96	0.01			
4511	45T47	0.99			
4511	90T96	0.01			
4539	23	0.00			
4539	45T47	1.00			
4879	49	0.90			
4879	51	0.10			
4881	31T33	0.00			
4881	52	0.99			
4881	77T82	0.01			
4882	31T33	0.00			
4882	52	0.99			
4882	77T82	0.01			
4883	31T33	0.00			
4883	36T39	0.09			
4883	52	0.90			
4883	77T82	0.01			
4884	52	0.99			
4884	77T82	0.01			
4889	05T09	1.00			
4889	52	0.00			
5151	58T60	0.90			
5151	61	0.10			
5152	58T60	0.90			
5152	61	0.10			
5182	62T63	0.99			
5182	69T75	0.01			
5191	58T60	0.03			
5191	62T63	0.96			
5191	90T96	0.01			
5239	64T66	0.99			
5239	68	0.01			
5416	64T66	0.01			
5416	69T75	0.99			
5419	69T75	0.90			
5419	77T82	0.10			
5419	86T88	0.00			
5511	64T66	0.05			
5511	69T75	0.95			
5612	77T82	0.99			

Sources: BLS (correspondence files), authors' own assignments.

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Step 5: Rescaling of OEWS data to fit the OECD ICIO industry-level employment

Table 13 shows the industry-level data at the OECD ICIO industry structure before and after the rescaling of the OEWS data (both OEWS series) to the OECD ICIO, along with the data from OECD ICIO.

Table 13 / Rescaling of OEWS data to fit the OECD ICIO industry structure, 2018

| OECD ICIO code | OECD ICIO industry name | Industry-level employment initial OEWS and CPS LFS data | | OEWS data after rescaling | Total employment | |
		OECD ICIO employment	OEWS employment	OEWS employment Rescaled to CPS LFS	OEWS	OECD ICIO employment	OEWS employment Rescaled to CPS LFS
01T03	Agriculture	2,200,900	1,607,137	2,084,189	2,200,900	164,391,104	163,116,896
05T09	Mining	676,400	641,042	792,990	676,400	164,391,104	163,116,896
10T12	Food products, beverages and tobacco	1,915,800	1,859,483	2,127,904	1,915,800	164,391,104	163,116,896
13T15	Textiles, textile products, leather and footwear	390,900	390,478	441,026	390,900	164,391,104	163,116,896
16	Wood and products of wood and cork	426,400	422,330	530,729	426,400	164,391,104	163,116,896
17T18	Paper products and printing	805,500	772,088	930,575	805,500	164,391,104	163,116,896
19	Coke and refined petroleum products	112,300	109,143	166,564	112,300	164,391,104	163,116,896
20	Chemical and chemical products	540,600	594,294	853,035	540,600	164,391,104	163,116,896
21	Pharmaceuticals, medicinal chemical products	298,000	480,304	701,106	298,000	164,391,104	163,116,896
22	Rubber and plastics products	727,200	723,829	855,698	727,200	164,391,104	163,116,896
23	Other non-metallic mineral products	421,700	420,177	552,587	421,700	164,391,104	163,116,896
24	Basic metals	415,900	233,733	279,078	415,900	164,391,104	163,116,896
25	Fabricated metal products	1,596,800	1,587,075	1,882,626	1,596,800	164,391,104	163,116,896
26	Computer, electronic and optical equipment	1,120,100	1,115,163	1,620,293	1,120,100	164,391,104	163,116,896
27	Electrical equipment	396,200	426,271	537,954	396,200	164,391,104	163,116,896
28	Machinery and equipment, nec	1,128,100	1,083,057	1,356,736	1,128,100	164,391,104	163,116,896
29	Motor vehicles, trailers and semi-trailers	912,900	960,600	1,114,747	912,900	164,391,104	163,116,896
30	Other transport equipment	696,600	663,001	930,459	696,600	164,391,104	163,116,896
31T33	Manufacturing nec;	1,028,000	1,063,894	1,438,612	1,028,000	164,391,104	163,116,896
35	Electricity, gas, steam and air conditioning supply	517,400	509,495	972,553	517,400	164,391,104	163,116,896
36T39	Water supply; sewerage, waste management	479,000	470,129	328,514	479,000	164,391,104	163,116,896
41T43	Construction	9,012,800	7,307,897	11,193,560	9,012,800	164,391,104	163,116,896
45T47	Wholesale and retail trade	23,643,600	22,343,812	21,498,650	23,643,598	164,391,104	163,116,896
49	Land transport and transport via pipelines	2,645,600	2,257,952	3,046,736	2,645,600	164,391,104	163,116,896
50	Water transport	64,700	78,110	101,629	64,700	164,391,104	163,116,896
51	Air transport	506,400	494,023	634,591	506,400	164,391,104	163,116,896
52	Warehousing and support activities for transportation	1,978,400	1,790,754	2,396,979	1,978,400	164,391,104	163,116,896
53	Postal and courier activities	1,359,300	1,043,370	1,270,439	1,359,300	164,391,104	163,116,896
55T56	Accommodation and food service activities	14,088,100	13,837,367	7,055,143	14,088,099	164,391,104	163,116,896
58T60	Publishing, audiovisual and broadcasting activities	1,806,500	1,395,067	1,408,160	1,806,500	164,391,104	163,116,896
61	Telecommunications	758,600	784,089	850,543	758,600	164,391,104	163,116,896
62T63	IT and other information services	2,740,400	2,686,822	2,988,291	2,740,400	164,391,104	163,116,896
64T66	Financial and insurance activities	6,541,100	6,041,405	8,150,752	6,541,100	164,391,104	163,116,896
68	Real estate activities	2,160,900	1,603,700	1,941,419	2,160,900	164,391,104	163,116,896
69T75	Professional, scientific and technical activities	10,580,300	9,203,017	9,163,969	10,580,300	164,391,104	163,116,896
77T82	Administrative and support service activities	10,314,600	7,216,054	7,211,303	10,314,600	164,391,104	163,116,896
84	Public administration and defence	13,508,700	9,673,132	7,430,441	13,508,700	164,391,104	163,116,896
85	Education	14,407,400	13,125,420	18,181,710	14,407,401	164,391,104	163,116,896
86T88	Human health and social work activities	20,731,699	20,579,640	16,860,290	20,731,700	164,391,104	163,116,896
90T96	Arts, entertainment and recreation; Other services	9,461,100	7,080,483	12,806,825	9,461,100	164,391,104	163,116,896

Sources: OEWS; Labour Force Statistics (LFS) from the Current Population Survey; OECD ICIO.

The next step consists of a second rescaling of the data. This rescaling is relatively small because the OEWS data (in the form adjusted to mirror the CPS LFS data) is less than 10% below the OECD ICIO industry-level employment data (at the OECD ICIO industry structure). For the reason discussed above,

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in most cases, the data series that is rescaled to match the CPS LFS data is higher and therefore closer to the OECD industry-level employment data (and also to the economy total). However, there are also instances where the rescaled industry-level employment data is further off the OECD ICIO data, especially in those industries in which the rescaled data is higher than the OECD ICIO employment data (e.g. OECD ICIO industry 16 – 'wood and products of wood and cork'). Therefore, as it is not clear which of the two employment surveys is more accurate and it is in any case necessary to rescale the data to the OECD ICIO industry level, a pragmatic approach is chosen. The approach consists of using the OEWS data series – 'original' OEWS data or the CPS LFS rescaled OEWS data – which is closer to the OECD ICIO data at the industry level. In this, upward and downward deviations are treated equally.

Step 6: Crosswalk from SOC 2010 occupations to ISCO-08 occupations

Transforming the OEWS data from detailed SOC 2010 occupations into ISCO-08 occupations – at the 3-digit level – is performed using the official crosswalk file provided by the BLS.[24]

In this crosswalk, there is a minor challenge and a major challenge.

Table 14 / Adjustment of SOC codes in OEWS data to match with SOC-ISCO crosswalk file, 2012 and 2018

(a) 2012

25-3098 Substitute teachers	25-3099 Teachers and instructors, all other
45-3031 Fishing and hunting workers	45-3011 Fishers and related fishing workers (imperfect match in codes)

(b) 2018

Original SOC code in OEWS data set	Recoded to
13-1020 Buyers and purchasing agents	13-1022 Wholesale and retail buyers, except farm products *(note: could also be recoded to 13-1021)*
15-2090 Miscellaneous mathematical science occupations	15-2099 Mathematical science occupations, all other
21-1018 Substance abuse, behavioural disorder and mental health counsellors	21-1011 Substance abuse and behavioural disorder counsellors
25-3097 Teachers and instructors, all other, except substitute teachers	25-3099 Teachers and instructors, all other
25-3098 Substitute teachers	25-3099 Teachers and instructors, all other
29-2010 Clinical laboratory technologists and technicians	29-2012 Medical and clinical laboratory technicians *note: could also be recoded to 29-2011 Medical and clinical laboratory technologists)*
39-1010 First-line supervisors of entertainment and recreation workers	39-1011 Gaming supervisors
39-7010 Tour and travel guides	39-7012 Travel guides *(note: could also be recoded to 39-7011 Tour guides and escorts)*
45-3031 Fishing and hunting workers	45-3011 Fishers and related fishing workers (imperfect match in codes)
47-4090 Miscellaneous construction and related workers	47-4099 Construction and related workers, all other
51-2028 Electrical, electronic, electromechanical assemblers	51-2022 Electrical and electronic equipment assemblers
51-2098 Assemblers and fabricators, all other including team assemblers	51-2099 Assemblers and fabricators, all other
53-1048 First-line supervisors of transportation and material moving workers	53-1031 First-line supervisors of transportation and material-moving machine and vehicle operators

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[24]   The crosswalk is available at: https://www.bls.gov/soc/isco_soc_crosswalk.xls

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The comparatively minor issue is that for two (in 2012) and 13 (in 2018) SOC occupational codes, there is no counterpart in the crosswalk file. These discrepancies are explained by minor adjustments of SOC 2010 codes over time and some deviations from the official detailed occupation codes within the OEWS data.[25] These discrepancies can be easily remedied by recodings of the concerned employments to corresponding SOC 2010 codes in the crosswalk file. The complete list of recodings is provided in Table 14.

The major challenge during the crosswalk is that numerous SOC occupations of the 827 occupations in 2012 (809 occupations in 2018) do not have a unique correspondence to an ISCO-08 minor group occupation (3-digit). This leaves 121 SOC codes with more than one potential target ISCO-08 industry. For all these cases, for the employment within the SOC occupational category,[26] assignment factors had to be defined. This was done by comparing the description of the SOC code and the description of the potential target ISCO-08 categories. The chosen assignment factors for some non-unique SOC occupations are shown in Table 15.[27]

Table 15 / Assignment factors for non-unique cases in the SOC 2010 to ISCO-08 crosswalk file

SOC code	ISCO code	Assignment factor	SOC description	ISCO description
11-1011	111	0.10	Chief executives	Legislators and senior officials
11-1011	112	0.90	Chief executives	Managing directors and chief executives
11-1021	111	0.20	General and operations managers	Legislators and senior officials
11-1021	112	0.20	General and operations managers	Managing directors and chief executives
11-1021	134	0.20	General and operations managers	Professional services managers
11-1021	142	0.20	General and operations managers	Retail and wholesale trade managers
11-1021	522	0.20	General and operations managers	Shop salespersons
11-2031	111	0.00	Public relations and fundraising managers (#)	Legislators and senior officials
11-2031	121	0.50	Public relations and fundraising managers (#)	Business services and administration managers
11-2031	122	0.50	Public relations and fundraising managers (#)	Sales, marketing and development managers
11-3031	121	0.50	Financial managers	Business services and administration managers
11-3031	134	0.50	Financial managers	Professional services managers
11-9021	132	0.90	Construction managers	Manufacturing, mining, construction, and distribution managers
11-9021	711	0.10	Construction managers	Building frame and related trades workers

Together with the recodings above, applying these assignment factors to all OEWS data at the OECD ICIO industry and SOC occupation level allows for a complete translation of the industry-occupation employments to ISCO-08 industry classification.

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[25]   It seems that in a few instances in 2018, broad-level instead of detailed occupations are included.

[26]   Given the structure of the data set, all employments are at the level of OECD ICIO and SOC.

[27]   A complete list of the assignment factors is available upon request.

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2.2.3. Labour Force Statistics from the Current Population Survey

As the CPS LFS data are not used as the primary source for US employment data, no adjustments are necessary. Rather, the industry-occupation level data at the 'cluster' level from the CPS LFS is used to rescale the OEWS employment data, as described in the previous section.

2.2.4. O*NET data

The versions of the O*NET database used (12.0, published in 2007; 17.0, published in 2012; and the newest version, 26.0, published in August 2021) include data on the importance of tasks for, respectively, 778, 896, and 873 O*NET-SOC groups. Importantly, there are some highly digital occupation groups, most prominently data scientists, for which no data on the importance exists even in the newest version. In the case of O*NET, the number of core tasks is not limited.[28] The maximum number of core tasks in the sample is 38 (for special education teachers).

The files 'Task Ratings' and 'Task Statements' in the O*NET database are merged in order to construct a digital task index that mirrors – to the fullest extent possible – the ICP digital task index. The latter is the result of a count index resulting from a digital keyword search over the (up to 15) core tasks for each of the 796 5-digit ISCO occupation groups. If one of the digital keywords (e.g. 'computer') is included in the description of a core task, this core task is considered to be a digital task and is assigned a classification of 1. The digital task score of each individual occupation is then simply the ratio of digital to non-digital tasks. This way, out of more than 6,200 tasks, Cirillo et al. (2021) classified 131 tasks as digital.

Although the ICP digital task indicator serves as guidance, some adjustments were made to the way the indicator is constructed. First, the list of keywords had to be adjusted to ensure that the descriptions in the 'Task Statements' in the O*NET database were appropriately captured. Second, the 'Task Ratings' could be used to replace the binary (1 or 0) classification of tasks as digital or not digital with a score that ranges from 0 to 100,[29] which reflects the importance of the respective task for an occupation.

As the number of core tasks of an occupation is unrestricted in the O*NET database, the number of core tasks and the number of digital core tasks is higher than for the ICP data. Out of the number of core tasks (9,655 in O*NET 12.0, 13,962 in O*NET 23.3), we heuristically classify, respectively, 255 and 579 tasks as digital (between around 2.7% and 4.2% of core tasks) with (i) the help of the list of digital keywords; (ii) a manual check of the resulting tasks and further exclusions in case the keywords pick up tasks that are clearly not digital in nature; and (iii) a manual check of core tasks of highly digital occupation groups (e.g. programmers) to classify digital tasks that were not picked up by the keywords. As an example for (ii), an unrefined search using the keyword 'computer' would include the task 'Inspect, test, and listen to defective equipment to diagnose malfunctions, using test instruments such as handheld computers, motor analysers, chassis charts, or pressure gauges.'

Finally, instead of calculating the share of digital tasks in total tasks per occupation group – as is done with the ICP index – the 'Task Ratings' allow a weighting of the importance of each task. Therefore, the

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[28] This contrasts with the approach in the Italian ICP data, where the maximum number of core tasks is 15.

[29] In principle, this score ranges from 0 to 100, but because the analysis focuses on core tasks, the scores are typically high, with a mean between 88 and 90 and a minimum value of 67 across all O*NET database versions used in the analysis.

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final digital task index using O*NET data is calculated as the share of digital task ratings in total task ratings per occupation group. For an overview of the differences between the two digital task indices, we plot them below by industry for Italy.

Figure 6 / Digital task indices by industries, comparison between ICP and O*NET, Italy
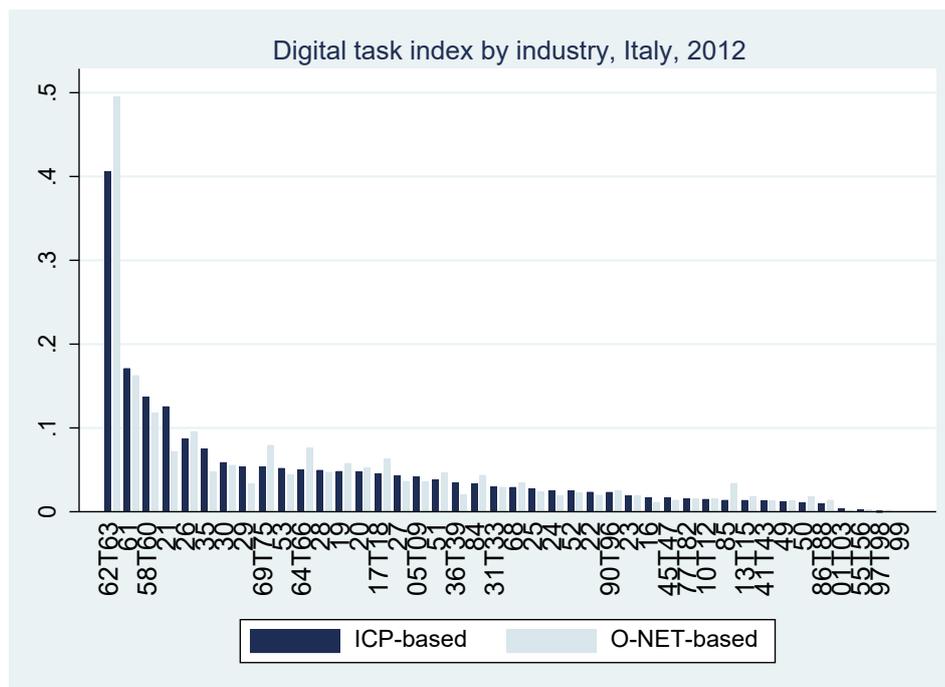
Note: Data from ICP and O*NET for the year 2012.
Source: Cirillo et al. (2021) based on ICP data, authors' own calculations based on O*NET database 17.0.

2.2.5. OECD Inter-Country Input-Output Database

Like the WIOD database, the OECD ICIO database is a complete data set without any missing observations, which means that no imputations were necessary. Also, all necessary rescaling is performed to match the OECD ICIO industry-level data.

For this reason, the sole adjustment to be made was to 'trim down' the (adjusted) OECD ICIO input-output table featuring 44 reporters to the 26 economies (25 EU countries plus the US) that are part of the analysis of this paper. In order words, the EU25 plus the US are considered to be 'the world economy' for the purpose of this analysis.

3. Literature

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4. Appendix

Appendix Table A.1 / List of ISCO-08 3-digit occupations

ISCO-08 (3-digit)	Description of ISCO code
11	Commissioned armed forces officers
21	Non-commissioned armed forces officers
31	Armed forces occupations, other ranks
111	Legislators and senior officials
112	Managing directors and chief executives
121	Business services and administration managers
122	Sales, marketing and development managers
131	Production managers in agriculture, forestry and fisheries
132	Manufacturing, mining, construction and distribution managers
133	Information and communications technology service managers
134	Professional services managers
141	Hotel and restaurant managers
142	Retail and wholesale trade managers
143	Other services managers
211	Physical and earth science professionals
212	Mathematicians, actuaries and statisticians
213	Life science professionals
214	Engineering professionals (excluding electrotechnology)
215	Electrotechnology engineers
216	Architects, planners, surveyors and designers
221	Medical doctors
222	Nursing and midwifery professionals
223	Traditional and complementary medicine professionals
224	Paramedical practitioners
225	Veterinarians
226	Other health professionals
231	University and higher education teachers
232	Vocational education teachers
233	Secondary education teachers
234	Primary school and early childhood teachers
235	Other teaching professionals
241	Finance professionals
242	Administration professionals
243	Sales, marketing and public relations professionals
251	Software and applications developers and analysts
252	Database and network professionals
261	Legal professionals
262	Librarians, archivists and curators
263	Social and religious professionals
264	Authors, journalists and linguists
265	Creative and performing artists

Contd.

Appendix Table A.1 / (contd.) List of ISCO-08 3-digit occupations

ISCO-08 (3-digit)	Description of ISCO code
311	Physical and engineering science technicians
312	Mining, manufacturing and construction supervisors
313	Process control technicians
314	Life science technicians and related associate professionals
315	Ship and aircraft controllers and technicians
321	Medical and pharmaceutical technicians
322	Nursing and midwifery associate professionals
323	Traditional and complementary medicine associate professionals
324	Veterinary technicians and assistants
325	Other health associate professionals
331	Financial and mathematical associate professionals
332	Sales and purchasing agents and brokers
333	Business services agents
334	Administrative and specialised secretaries
335	Regulatory government associate professionals
341	Legal, social and religious associate professionals
342	Sports and fitness workers
343	Artistic, cultural and culinary associate professionals
351	Information and communications technology operations and user support technicians
352	Telecommunications and broadcasting technicians
411	General office clerks
412	Secretaries (general)
413	Keyboard operators
421	Tellers, money collectors and related clerks
422	Client information workers
431	Numerical clerks
432	Material-recording and transport clerks
441	Other clerical support workers
511	Travel attendants, conductors and guides
512	Cooks
513	Waiters and bartenders
514	Hairdressers, beauticians and related workers
515	Building and housekeeping supervisors
516	Other personal services workers
521	Street and market salespersons
522	Shop salespersons
523	Cashiers and ticket clerks
524	Other sales workers
531	Child care workers and teachers' aides
532	Personal care workers in health services
541	Protective services workers
611	Market gardeners and crop growers
612	Animal producers
613	Mixed crop and animal producers
621	Forestry and related workers
622	Fishery workers, hunters and trappers

Contd.

Appendix Table A.1 / (contd.) List of ISCO-08 3-digit occupations

ISCO-08 (3-digit)	Description of ISCO code
631	Subsistence crop farmers
632	Subsistence livestock farmers
633	Subsistence mixed crop and livestock farmers
634	Subsistence fishers, hunters, trappers and gatherers
711	Building frame and related trades workers
712	Building finishers and related trades workers
713	Painters, building structure cleaners and related trades workers
721	Sheet and structural metal workers, moulders and welders, and related workers
722	Blacksmiths, toolmakers and related trades workers
723	Machinery mechanics and repairers
731	Handicraft workers
732	Printing trades workers
741	Electrical equipment installers and repairers
742	Electronics and telecommunications installers and repairers
751	Food processing and related trades workers
752	Wood treaters, cabinet-makers and related trades workers
753	Garment and related trades workers
754	Other craft and related workers
811	Mining and mineral processing plant operators
812	Metal processing and finishing plant operators
813	Chemical and photographic products plant and machine operators
814	Rubber, plastic and paper products machine operators
815	Textile, fur and leather products machine operators
816	Food and related products machine operators
817	Wood processing and papermaking plant operators
818	Other stationary plant and machine operators
821	Assemblers
831	Locomotive engine drivers and related workers
832	Car, van and motorcycle drivers
833	Heavy truck and bus drivers
834	Mobile plant operators
835	Ships' deck crews and related workers
911	Domestic, hotel and office cleaners and helpers
912	Vehicle, window, laundry and other hand cleaning workers
921	Agricultural, forestry and fishery labourers
931	Mining and construction labourers
932	Manufacturing labourers
933	Transport and storage labourers
941	Food preparation assistants
951	Street and related service workers
952	Street vendors (excluding food)
961	Refuse workers
962	Other elementary workers

Appendix Table A.2 / List of the WIOD industries

WIOD code	Industry description
A01	Crop and animal production, hunting and related service activities
B	Mining and quarrying
C10-C12	Manufacture of food products, beverages and tobacco products
C13-C15	Manufacture of textiles, wearing apparel and leather products
C16	Manufacture of wood and of products of wood and cork, except furniture
C17	Manufacture of paper and paper products
C18	Printing and reproduction of recorded media
C19	Manufacture of coke and refined petroleum products
C20	Manufacture of chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	Manufacture of rubber and plastic products
C23	Manufacture of other non-metallic mineral products
C24	Manufacture of basic metals
C25	Manufacture of fabricated metal products, except machinery and equipment
C26	Manufacture of computer, electronic and optical products
C27	Manufacture of electrical equipment
C28	Manufacture of machinery and equipment n.e.c.
C29	Manufacture of motor vehicles, trailers and semi-trailers
C30	Manufacture of other transport equipment
C31_C32	Manufacture of furniture; other manufacturing
C33	Repair and installation of machinery and equipment
D35	Electricity, gas, steam and air conditioning supply
E36	Water collection, treatment and supply
E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery
F	Construction
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
G46	Wholesale trade, except of motor vehicles and motorcycles
G47	Retail trade, except of motor vehicles and motorcycles
H49	Land transport and transport via pipelines
H50	Water transport
H51	Air transport
H52	Warehousing and support activities for transportation
H53	Postal and courier activities
I	Accommodation and food service activities
J58	Publishing activities
J59_J60	Motion picture, video and television, sound recording, music publishing, broadcasting
J61	Telecommunications
J62_J63	Computer programming, consultancy and related activities; information service activities
K64	Financial service activities, except insurance and pension funding
K65	Insurance, reinsurance and pension funding, except compulsory social security
K66	Activities auxiliary to financial services and insurance activities
L68	Real estate activities
M69_M70	Legal and accounting activities; activities of head offices; management consultancy
M71	Architectural and engineering activities; technical testing and analysis
M72	Scientific research and development
M73	Advertising and market research
M74_M75	Other professional, scientific and technical activities; veterinary activities
N	Administrative and support service activities
O84	Public administration and defence; compulsory social security
P85	Education
Q	Human health and social work activities
R_S	Other service activities
T	Activities of households as employers
U	Activities of extraterritorial organisations and bodies

Appendix Table A.3 / List of the WIOD countries, indicating those included in the analysis

Country code	Country name	Included
AUS	Australia	O
AUT	Austria	X
BEL	Belgium	X
BGR	Bulgaria	X
BRA	Brazil	O
CAN	Canada	O
CHE	Switzerland	O
CHN	China	O
CYP	Cyprus	O
CZE	Czechia	X
DEU	Germany	X
DNK	Denmark	X
ESP	Spain	X
EST	Estonia	X
FIN	Finland	X
FRA	France	X
GBR	United Kingdom	X
GRC	Greece	X
HRV	Croatia	O
HUN	Hungary	X
IDN	Indonesia	O
IND	India	O
IRL	Ireland	X
ITA	Italy	X
JPN	Japan	O
KOR	South Korea	O
LTU	Lithuania	X
LUX	Luxembourg	X
LVA	Latvia	X
MEX	Mexico	O
MLT	Malta	O
NLD	Netherlands	X
NOR	Norway	O
POL	Poland	X
PRT	Portugal	X
ROU	Romania	X
RUS	Russia	O
SVK	Slovakia	X
SVN	Slovenia	X
SWE	Sweden	X
TUR	Turkey	O
TWN	Taiwan	O
USA	United States	O/X

Note: Classification based on NACE Rev.2. X=included in sample; O= not included in sample. The United States is included only in the paper on the EU-US comparison.

Appendix Table A.4 / List of the OECD ICIO industries used in the analysis

Original OECD ICIO code	OECD ICIO structure used	OECD ICIO industry name
01T02	01T03	Agriculture
03	01T03	Agriculture
05T06	05T09	Mining
07T08	05T09	Mining
09	05T09	Mining
10T12	10T12	Food products, beverages and tobacco
13T15	13T15	Textiles, textile products, leather and footwear
16	16	Wood and products of wood and cork
17T18	17T18	Paper products and printing
19	19	Coke and refined petroleum products
20	20	Chemical and chemical products
21	21	Pharmaceuticals, medicinal chemical and botanical products
22	22	Rubber and plastics products
23	23	Other non-metallic mineral products
24	24	Basic metals
25	25	Fabricated metal products
26	26	Computer, electronic and optical equipment
27	27	Electrical equipment
28	28	Machinery and equipment, nec
29	29	Motor vehicles, trailers and semi-trailers
30	30	Other transport equipment
31T33	31T33	Manufacturing n.e.c.; repair and installation of machinery and equipment
35	35	Electricity, gas, steam and air conditioning supply
36T39	36T39	Water supply; sewerage, waste management and remediation activities
41T43	41T43	Construction
45T47	45T47	Wholesale and retail trade; repair of motor vehicles
49	49	Land transport and transport via pipelines
50	50	Water transport
51	51	Air transport
52	52	Warehousing and support activities for transportation
53	53	Postal and courier activities
55T56	55T56	Accommodation and food service activities
58T60	58T60	Publishing, audiovisual and broadcasting activities
61	61	Telecommunications
62T63	62T63	IT and other information services
64T66	64T66	Financial and insurance activities
68	68	Real estate activities
69T75	69T75	Professional, scientific and technical activities
77T82	77T82	Administrative and support service activities
84	84	Public administration and defence; compulsory social security
85	85	Education
86T88	86T88	Human health and social work activities
90T93	90T96	Arts, entertainment and recreation; Other service activities
94T96	90T96	Arts, entertainment and recreation; Other service activities
97T98	97T98	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use

Note: Classification based on NACE Rev.2. Divisions (2-digit) are combined to sections (1-digit) in cases where the WIOD industry structure is less detailed than the original OECD ICIO classification.