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JOB CREATION POTENTIAL OF HUMAN CENTRIC LIGHTING INDUSTRY IN EUROPE

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ABSTRACT

Semi-structured interviews with stakeholders and an input-output analysis were used to estimate the economic potential of the Human Centric Lighting industry and its possible employment effect in the EU.

The interviews showed that different qualifications are required for HCL business than those commonly applied in lighting solutions. Besides business people, engineers, physicists, lighting designers, HCL also requires the involvement of health consultants, integrator engineers, psychologists, etc.

The input-output analysis indicated that with a hypothesized European market size of 1.4 billion euros by 2020 of the HCL industry[1], which represents around 7% of the European general lighting market and 20-25% of its high-end market segment, there will be a total of 10,000 new jobs in the EU area. The employment multiplier of the HCL industry, measuring the amount of direct, indirect and induced jobs created in the area, is 2.91. This implies that for every HCL job, in total 2.91 jobs (direct, indirect and induced) are created in the economy.

The report is organized as follows. Section 1 provides an introduction of the study into the job potential and a summary of the results, Section 2 provides a description of the methodology used to estimate the job creation potential. The results obtained are presented and discussed in Section 3.

1 The conservative market size estimate in A.T. Kearney, ZVEI and LightingEurope (2013) market study.

EXECUTIVE SUMMARY

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1 | EXECUTIVE SUMMARY

An analysis was made of the macroeconomic impact of an increased market uptake of Human Centric Lighting (HCL) with particular attention to employment effects.[2]

The lighting profession started to recognize the importance of designing lighting installations that takes also non-visual effects of light into account. The International Commission on Illumination (CIE henceforth) proclaims that "we now know conclusively that photoreception in the eye leads not only to vision, but also to **effects on human physiology, mood and behavior,** often summarized as non-visual effects of light." Human Centric Lighting (HCL henceforth) describes lighting that attempts to make also use of non-visual lighting effects in a beneficial way by means of controllability features of various lighting attributes related to intensity, spectral composition, duration and timing of the light exposure. Obviously, any lighting solution addressing the non-visual effects of light[3], should also address the visual aspects. While innovative ways to beneficially affect human health, behavior and comfort started to be used, the market readiness of HCL still needs to grow to benefit from its full functional and economical potential.

To analyze the new job creation generated by increased adoption of HCL a survey (interview) technique and an economic input-output model were used.

The interviews with 21 stakeholders showed that different qualifications are required than those commonly applied in lighting solutions. Besides business people, engineers, physicists, lighting designers who have been traditionally hired in the lighting industry, HCL also requires the involvement of health consultants, psychologists, integrator engineers (related to integrated system and building management system), etc. The additional job skills go back to the difference between conventional lighting and HCL lighting. While conventional lighting is product based, made to fit in multiple applications and rests its sales on the concept of "total cost of ownership" (energy efficiency), HCL lighting is system based. This means that HCL is not a one fit-for-all solution, but application dependent and hinges its marketing strategy on the concept of "total benefits of use" (better vision, productivity, wellbeing).

The input-output analysis indicates that with an estimated market size of 1.4 billion euros generated by the adoption of HCL[5] by 2020, which represents around 7% of the European general lighting market and 20-25% of its high-end market segment, there will be a total creation of 10,000 full-time jobs throughout the EU economy by the year 2020. This will result in a net GDP increase of roughly 2 billion euros in annual terms. The employment multiplier of the HCL industry, measuring the amount of direct, indirect and induced jobs created in the area, is 2.91. This implies that for every HCL job, in total 2.91 jobs (direct, indirect and induced) are created in the economy. Sector specific estimates indicate that the increase in HCL product adoption is expected to generate a net job gain for many economic sectors. Overall, the biggest gain is in the HCL sector itself, for which projections forecast a total net increase of 3,400 jobs by 2020. The electrical equipment sector, excluding HCL, would gain additional 1,900 jobs. Furthermore public administration and defense; compulsory social security, retail trade, activities of households as employers, undifferentiated goods- and services-producing activities of households for own use and professional, scientific, technical, administrative and support service activities are also forecasted to register significant net job gains.

2 Given the absence of data regarding the HCL industry, results in this section depict possible scenarios that are sensitive to the underlying model and assumptions. The study is conducted using a conservative approach in order to limit the risk of overvaluing outcomes.

3 Non-visual effects of lighting are also called non-image-forming (NIF) effects.

4 The input-output model depicts inter-industry relationships showing how outputs from an industry become inputs to another industry. We will estimate how different sectors relate to Human Central Lighting industry both as customers and suppliers in order to estimate the potential job creation effects.

5 As estimated by the A.T. Kearney HCL market model, the conservative scenario.

METHODOLOGY

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2 | METHODOLOGY

The job potential of Human Centric Lighting (HCL) was analysed using two approaches, answering different questions about employment creation:

1. First, based on stakeholder consultation (mostly representatives of the lighting industry) we attempt to uncover which types of jobs are important in the development, production, sales and operation of HCL solutions, whether there is need for different types of jobs and in which sectors they are to be found. The analysis at this stage is a descriptive one.

2. Second, we estimate the macroeconomic impact in the overall economic activity as a result of a change in demand for HCL using the Input-Output approach (see D'Hernoncourt, Cordier and Hadley (2011)). Based on the comprehensive system of interactions and interdependencies in the input-output model, we aim to estimate how different sectors relate to the Human Central Lighting industry both as customers and suppliers in order to estimate its job creation potential. Unfortunately, published input-output tables do not reach the desired level of detail to analyze HCL as separated industry from the macro sector "Manufacturing of electrical equipment". Ideally, we would like to know how much output the HCL sector produces which is bought by other economic sectors and how much input from other economic sectors the HCL sector acquires. However, as mentioned the available statistics provide inputs bought/sold by the aggregate sector "Manufacturing of electrical equipment" (CPA_C27)[6] of which the HCL sector forms part. To solve the above problem and isolate HCL we rely on the work of Wolsky (1984) and disaggregate "Manufacturing of electrical equipment" (CPA_C27) into two distinct sectors, one of which is HCL and a second one that includes all the remaining activities in CPA_C27.

2.1 Measured Output and Employment Impacts

We distinguish between **direct** employment creation (those employed in the HCL sector itself), **indirect** employment creation (those employed in sectors supplying the inputs required by the HCL sector) and **induced** employment creation (those employed in sectors that provide goods and services to meet the consumption demand of additional directly and indirectly employed workers). We therefore calculate both type I and type II multipliers (Table 1).

Table 1: Composition of Total Impact

Type I Multipliers	Type II Multipliers
Direct Impact + Indirect (Businesses) Impact	Direct Impact + Indirect (Businesses) Impact + Induced (Households) Impact
Total Impact	Total Impact

6 A more detailed analysis would have required to disaggregate the "Manufacture of electric lighting equipment" (CPA_C27.4) instead of "Manufacturing of electrical equipment" sector (CPA_C27). Unfortunately as indicated input-output tables are not provided with this level of detail. CPA refers to Statistical Classification of Products by Activity in EU, 2008 version (CPA 2008).

Type I multipliers account for the direct and indirect impacts based on how goods and services are supplied within the studied economy. Direct impacts represent direct or initial injection of new economic activity (increased output of HCL to meet the increased demand), while indirect effects represent the indirect spending or businesses buying and selling to each other (the sum of inter-industry purchases). Indirect effects are typically largely linked to the manufacturing stage of the original demand increase. Total indirect employment creation thus depends on the output purchased from each sector (strength of the inter-industry relationship) as well as the employment per unit of output in each of these sectors (labor intensity).

Type II multipliers not only account for these direct and indirect effects, but they also account for induced impacts which reflect the household spending earned from the direct and indirect effects (impacts associated with employee expenditures). In particular, induced employment is the additional employment generated to meet the extra consumption demand arising from the higher household incomes created by direct and indirect effects, following the initial increase in demand for HCL. For instance, the extra workers in the fixtures industry, architecture industry, spend their incomes on a whole range of goods thus creating extra employment in these sectors, and yet further spending may result from these incomes.

We start our empirical analysis from the input-output table (also called transaction matrix) which specifies how different sectors of the economy buy (purchase inputs) from and sell (deliver outputs) to each other. Its rows represent suppliers and contain data on the repartition of sales to respective purchasing industries and final consumers. Read by column, the input-output table shows how much an industry buys from all other industries. For consistency between different types of goods and services, the table expresses each element in monetary or value terms.

For the EU27, the latest input-output tables available are from 2011[7]. These tables have 65 industrial sectors. We aggregate the input-output table to match the number of sectors available in the KLEMS dataset that are used to extract series of labor productivity by sector[8]. This aggregation process leads us from the original 65 sectors to 34 main macro-sectors contained in Table A1 (in Appendix) that are used in the study.

The initial monetary entries in the transaction matrix can then be converted into ratios called technical coefficients. This is achieved by dividing each cell of the transaction matrix by its column sum/total (output at basic prices).

7 http://ec.europa.eu/eurostat/web/esa-supply-use-input-tables/data/workbooks. Notice IO tables for a wide range of countries over long time periods are not available. Therefore, the results might underestimate the total effect if over time there is a significant increase in the HCL adoption rates. The broad production processes are relatively stable over time. However, the finely classified inputs might change over time. For example the "Manufacture of electric lighting equipment" may over time switch from "traditional lighting" to HCL. However, the overall amount of "lighting" used by the "Manufacture of electric lighting equipment" sector is unlikely to undergo major changes.

8 The EU KLEMS project, a study of Productivity in the European Union can be accessed on the following website: http://www.euklems.net

9 Direct are the impacts on the same industry for which the demand increases. Indirect are the effects on other industries.

The technical coefficients matrix indicates how much output a specific given industry requires from each industry in the economy to produce one euro of its own output. In this sense, it illustrates the immediate indirect[9] impact on all sectors if the output in a specific industry increases with one euro. We indicate this matrix with AII. The assumption of constant technical coefficients is essential here. It implies that the demands for factors of production remain strictly proportional to output as well as to any changes in the future. Therefore, effects of any technical efficiency improvement are not included.

Along with inter-industry relationships an important role is played by the "household" sector (i.e., final consumers and employees). Without the inclusion of the household sector the structure of the input-output model does not allow to capture induced effects generated by an expansion of the final demand. In other words, when excluding the household sector we do not account for the extra impacts coming from households spending their additional income. Consequently, in order to calculate the type II (direct + indirect + induced) output and employment impacts, we need to include households in the analysis. In other words, we treat households as a separate sector (for final consumption and labor provided to the rest of the economy) and therefore include in the total impact the induced effects generated by additional household disposable income.

More specifically, we add an extra row and column in the input-output model (see Table 2) and as well in the Technical Coefficient matrix for "Compensation of employees" and "Final consumption expenditure by households" coefficients respectively.

Table 2: Diagram of the Input-Output Model

		Purchasing sectors (buyers)					
		Intermediate Demand			Final Demand		Total Output
		Other Industries	Electrical Equipment (without HCL)	HCL	Of which Household consumption	Total final demand	
Producing sectors (sellers)	Other Industries	Inter industry transactions Businesses purchase from other businesses to produce their own goods / services. This is intermediate demand or xij (output of industry i sold to industry j)			Households buy the output of businesses		
	Electrical Equipment (without HCL)						
	HCL						
	Compen-sation of employees	Households sell labor & other inputs to busi-ness as inputs to production					
	Total Input						

The modified Technical Coefficient matrix A reads:

$$A = \begin{bmatrix} A_{II} & A_{IH} \\ A_{HI} & A_{HH} \end{bmatrix}$$

where A_{II} is the original Technical Coefficients matrix, or the amount of industry i required per unit of industry j. A_{IH} is the amount of industry I required per unit of total household income from all sources. A_{HI} is the income paid to households per unit of output of industry i (compensation of employees divided by the total output of the industry). Finally, A_{HH} is the household expenditure per unit of exogenous household income. The latter is set to zero.

2.2 The Disaggregation Challenge

As previously indicated in order to isolate the impact of the HCL industry we use Wolsky (1984)'s disaggregating solution to separate the HCL sector from the macro sector "Manufacturing of electrical equipment" (CPA_C27). Wolsky (1984)'s solution combines relatively detailed knowledge of a particular industry with the information about the rest of the economy embedded in the available economy-wide matrices.

The exercise consists of disaggregating the sector CPA_C27 "Manufacturing of electrical equipment" into two subsectors: i) HCL; and ii) the rest. The most important parameters of this procedure are the weighting factors of each of the newly distinct sectors. Thus, as first step we have to estimate, for the year on which the available input-output table is based, the ratio of the gross output of the resulting new sector (HCL) to the gross output of the aggregate in which that sector has been lumped. As a general proxy, the gross output is replaced with the demand value of the specific sector. We indicate with w2 the HCL output ratio (over the total aggregate) and with w1 the portion of the rest of the sector. Note that w1 + w2 = 1.

Using information reported in A.T. Kearney market study we estimate w2 = 0.0008 (A.T. Kearney reports an HCL demand of 0.1 billion in 2011 while demand of the entire sector from the I/O table was 129 billion leading to w2 = 0.1/129=0.0008). The values of w1, w2 and the aggregated matrix can be used to bound the rest of the unknown parameters necessary to construct the new disaggregated technical coefficient matrix (AA). More technical details are to be found in the Appendix.

Finally, we compute the type II Leontief inverse matrix which contains the total (direct + indirect + induced) impact in the economy of a one unit increase in output in a particular sector. It is calculated using the following formula:

$$L = (I\text{-}AA)^{-1}$$

Where L is the Leontief type II matrix, I is the identity matrix and AA is the disaggregated matrix of technical coefficients or the Direct Requirements Matrix[10].

2.3 Impact Analysis – Employment Multiplier Calculation

Based on the Leontief inverse matrices, we calculate the indirect and induced impacts of the increase in demand for HCL on the input of each sector of the EU economy described by the matrix.

Output effects

$$O_{MULTj} = \sum_i L_{ij}$$

We compute the output multiplier (O_{MULTj}) for a particular industry as the column sum of industry rows from the specific Leontief inverse matrix. Further, multiplying a change in the final demand for an individual industry's output by that industry's type I (respectively type II) output multiplier generates an estimate of direct and indirect (respectively direct, indirect and induced) impacts on output throughout the economy.

10 The type I Leontief inverse matrix is computed as $L=(I\text{-}A_{ij})^{-1}$.

Employment effects

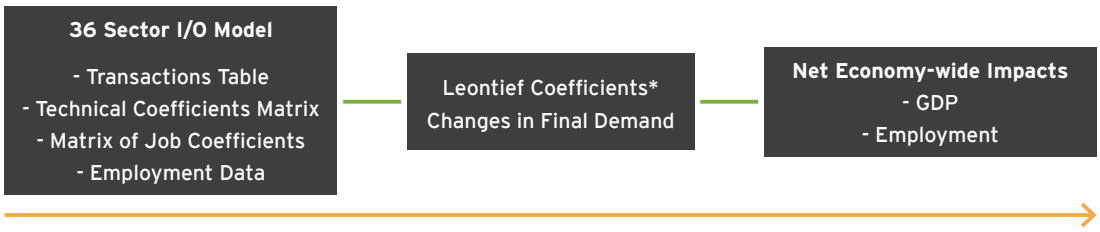
The employment effects ($E_{eff,j}$) estimate reflects the impact upon employment throughout the economy (direct and indirect effect if type I inverse matrix is used, augmented by the induced effect if type II inverse is used) arising from a change in final demand for industry j's output of 1 unit.

$$E_{MULTj} = \sum_i \; w_i L_{ij} / w_j$$

Where E_{MULTj} stands for the employment multiplier. In its simplest terms, the employment multiplier measures the amount of direct, indirect and induced jobs created in the area. Direct jobs are related to the specific industry, while indirect jobs are those that support the industry. Induced jobs are those that are a result of direct/indirect employee's spending money in the community. If for example the HCL industry has an employment multiplier of 2.91, then for every HCL job in total 2.91 jobs (direct, indirect and induced) are created in the economy.

Figure 1 provides a graphical representation of all steps followed in our analysis.

Figure 1 – Input-Output Model



Simplifying assumptions underlying the multiplier calculations

The basic assumptions in the input-output analysis include the following:

- Fixed prices - there is unlimited labor and capital available at fixed prices – so that, any change in the relative demand for productive factors will not induce any change in their relative cost.[11] In other words, additional workers with the necessary new skill profiles are readily available at prevailing wage rates. Hence, no relative price changes. The fact that we do not consider prices in the I-O analysis produces approximate estimates that could under or overestimate the real effect.
- Lack of resource constraints – multipliers assume that extra output can be produced in one area of activity without taking away resources from other activities. Hence, no crowding out effects.
- The relationship between labor and output in all industries is linear, that is, if one FTE employee produces 100 units of output, then two FTE employees would produce 200 units of output. In other words, each industry exhibits constant returns to scale in production.
- Fixed ratios for intermediate inputs to production and outputs from production in each industry. Since relative prices do not change, there will be no changes in the mix of inputs used in production.
- Absence of budget constraints – changes in household or government consumption occur without reducing demand elsewhere.

11 Computable general equilibrium (CGE) models can relax the assumption of fixed prices in the I-O models.

RESULTS AND DISCUSSION

3

3 | RESULTS AND DISCUSSION

3.1 Survey Results

Based on the survey results with 21 stakeholders we found that HCL requires more diverse qualifications than non-HCL solutions. Besides business people, engineers, physicists, lighting designers who have been traditionally hired in the lighting industry, HCL also requires the involvement of health consultants, psychologists, integrator engineers (related to integrated system and building management system), etc.

While innovative ways to beneficially affect human health, behavior and comfort started to be used, the market readiness of HCL still needs to grow to benefit from its full functional and economical potential. Scientific evidence for HCL benefits in practical applications in real life settings is scarce. Hence, there is ample opportunity for job creation in research and development. As one respondent put it "when a product stops being a light to show a task and becomes a psychological and/or physiological intervention, the need for proving the benefits of the product / application will increase, but industry currently cannot do this internally." In addition, the lighting plan for an indoor space is important. Thus, the position of the lighting designer will become more and more important.

Different parts of the HCL value chain may experience different changes in employment. The development process is seen in need of people with disparate knowledge. For sales of HCL solutions, knowledge of physical and economic benefits is important but current sales forces do not appear to be adequately prepared for this task which leaves room for consultants to advise building owners and architects on the additional benefits of HCL lighting. Furthermore, the changes in the employment engaged in the operation of HCL solutions may depend on the application fields deploying them. "Simple HCL systems can be fully automatic requiring no user input. Slightly more advanced system may allow users to choose lighting based upon how they currently feel or what their current needs are. HCL for schools could be another level up requiring an amount of training to understand what is good or not. However HCL for hospitals for example could require a large amount of manual intervention which will require trained users who understand the implications of what they are doing". Finally, HCL specific maintenance is forecasted to become a significantly pressing issue and would require more HCL specialists. While the basic fundamentals of the maintenance process might not change, the need for prompt repair of any failures is thought to become very important because any problems could potentially change the HCL impact, and possibly in an unwanted direction.

3.2 Input-Output Analysis Results

Based on the Input-Output Model, we estimate that if HCL sales were to increase up to 1.4 billion euros (A.T. Kearney market volume estimate for 2020, conservative scenario), annual GDP would increase by approximately 2 billion euros and employment would increase by 9,758 jobs in 2020. Also, we find that if HCL sales were to increase up to 0.5 billion euros (A.T. Kearney market volume for 2018, conservative scenario), annual GDP would increase by 0.6 billion euros and employment would increase by 3,000 jobs in 2018. Table 3 contains the impact (multiplier) on total employment and output in the HCL industry.

We interpret the type I employment multiplier as follows: when the HCL sector increases employment by one employee, total employment in the EU economy increases by 2.4 jobs from direct and indirect linkages. In turn, the type II employment multiplier shows that when the HCL sector realizes a one employee change, total employment in the EU area changes by 2.91 jobs from direct, indirect and induced linkages. Also, for a 1 euro extra unit of final demand for HCL, the total direct, indirect and induced impacts amount to 1.55 euros.

Table 3: Economy -wide Output and Employment HCL Multipliers & Effects

HCL Demand Increase up to 1.4 billion	Human Centric Lighting	
	(type I)	(type I)
Output		
Multiplier	1.38	1.55
Effects (net change in billion)	1.8	2.0
Employment		
Multiplier	2.40	2.91
Effects (net change employees)	8,057	9,758

Source: Authors' calculations

Table 4 presents a breakdown of output and employment effects across different economic sectors. Sector specific estimates show that the increase in market uptake of HCL is expected to generate additional economic activity and net job gain for all economic sectors. Overall, the biggest gain is in the HCL sector itself, which is projected to experience a total net increase of 3,358 jobs by 2020. This is the direct employment created as a result of the increase in HCL market uptake. Electrical equipment (CPA_C27), without HCL, would gain an additional 1,882 jobs. Public administration and defense; compulsory social security (CPA_O84), Retail trade, except of motor vehicles and motorcycles (CPA_G47), Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use (CPA_T), Professional, scientific, technical, administrative and support service activities (CPA_M-N)[12] and Postal and courier activities (CPA_H53) are the sectors forecasted to register significant net job gains.

Note that the combined level of indirect and induced employment (output) generated by the increase in HCL market uptake is larger than the direct employment (output) itself. Ignoring these effects is therefore likely to give a misleading picture of the impact of HCL increase on total employment (output).

The input-output results presented so far reflect total effects; i.e., they add up the direct, indirect and induced effect of a change in demand for HCL on employment across all industries in the EU economy. Next, we present direct and indirect effects only of the previously analyzed increases in demand for HCL. The concern is that we might overestimate the induced effects.

12 CPA_M71 Architectural and engineering services; technical testing and analysis services; CPA_M72 Scientific research and development services

The reason is the following. We use the total household expenditure statistic from the input-output table (or final use at purchasers' prices) as denominator when calculating the household expenditure coefficients (A_{IH}). This statistic includes household purchases that are bought with unearned income (pensions, dividends, etc.). In other words, not all household expenditure results from "Income from employment" paid to households. As a consequence, the resulting type II Leontief inverse matrix tends to overestimate the induced effects of changes in the economy by artificially inflating the effect of earned income in generating further rounds of household spending.

Considering the direct and indirect effects only, we estimate that if HCL sales were to increase up to 1.4 billion euros (A.T. Kearney market volume estimate in billion euros for 2020, conservative scenario), annual GDP would increase by 1.8 billion euros and employment would increase by 8,057 jobs in 2020. Also, we find that if HCL sales were to increase up to 0.5 billion euros (A.T. Kearney market volume in billion euros in 2018, conservative scenario), annual GDP would increase in 2018 by 0.55 billion euros and employment would increase by 2,476 jobs.

Again, we breakdown the direct + indirect output and employment effects across different economic sectors in Table 5. As before, sector specific estimates show that the increase in market uptake of HCL is expected to generate net job gain for all economic sectors. Overall, the biggest gain is in the HCL sector, which is projected to experience a total net increase of 3,357 jobs by 2020. Electrical equipment (CPA_C27), without HCL, would gain an additional 1,878 jobs. Public administration and defense; compulsory social security (CPA_084), Basic metals and fabricated metal products, except machinery and equipment (CPA_C24-C25) and Retail trade, except of motor vehicles and motorcycles (CPA_G47) are some of the sectors forecasted to register largest significant net job gains.

Table 4: Sector Specific Total Output and Employment Impacts

Code	Sector Description	Total Output Effects 2018 (million euro)	Total Output Effects 2020 (million euro)	Total Employment Effects 2018 (employees)	Total Employment Effects 2020 (employees)
CPA_A	AGRICULTURE, FORESTRY AND FISHING	2.36	7.67	26	85
CPA_B	MINING AND QUARRYING	1.56	5.09	3	9
CPA_C10-C12	Food products, beverages and tobacco	5.44	17.69	19	61
CPA_C13-C15	Textiles, wearing apparel, leather and related products	1.34	4.35	8	26
CPA_C16-C18	Wood and paper products; printing and reproduction of recorded media	4.17	13.58	20	66
CPA_C19	Coke and refined petroleum products	2.96	9.64	1	2
CPA_C20-C21	Chemicals and chemical products	6.87	22.36	13	43
CPA_C22-C23	Rubber and plastics products, and other non-metallic mineral products	7.45	24.23	35	114
CPA_C24-C25	Basic metals and fabricated metal products, except machinery and equipment	27.04	87.97	116	377
CPA_C26	Optical equipment	3.97	12.93	15	50
CPA_C28	Machinery and equipment n.e.c.	0.34	1.10	1	5
CPA_C29-C30	Transport equipment	4.20	13.66	11	36
CPA_C31-C33	Other manufacturing; repair and installation of machinery and equipment	4.41	14.34	26	83
CPA_D_E	ELECTRICITY, GAS AND WATER SUPPLY	4.13	13.44	8	25
CPA_F	CONSTRUCTION	10.65	34.64	70	228
CPA_G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	4.43	14.43	20	66
CPA_G46	Wholesale trade, except of motor vehicles and motorcycles	2.94	9.57	10	33
CPA_G47	Retail trade, except of motor vehicles and motorcycles	15.82	51.48	139	453
CPA_H49-52	Transport and storage	6.29	20.46	18	58
CPA_H53	Postal and courier activities	13.34	43.40	126	410
CPA_I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	0.87	2.84	11	35
CPA_J58_J60	Publishing, audiovisual and broadcasting activities	4.66	15.16	21	68
CPA_J61	Telecommunications	2.19	7.12	5	15
CPA_J62_J63	IT and other information services	3.10	10.08	18	59
CPA_K64_K66	FINANCIAL AND INSURANCE ACTIVITIES	3.30	10.74	13	41
CPA_L68B_ L68A	REAL ESTATE ACTIVITIES	10.79	35.12	10	31
CPA_M_N	PROFESSIONAL, SCIENTIFIC, TECHNICAL, ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	13.89	45.18	128	417
CPA_O84	Public administration and defense; compulsory social security	28.12	91.51	292	949
CPA_O85	Education	0.95	3.11	14	47
CPA_Q86-Q88	Health and social work	1.22	3.96	17	56
CPA_R90-R93	Arts, entertainment and recreation	1.59	5.17	18	60
CPA_S94_S96	Other service activities	1.18	3.84	19	61
CPA_T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	1.73	5.64	138	449
CPA_C27 (disaggregated)	Electrical equipment (without HCL)	149.5	486.3	578	1882
CPA_C27 (disaggregated)	HCL	266.7	867.9	1032	3358
Total		619	2016	2999	9758

Table 5: Sector Specific Direct + Indirect Output and Employment Impacts

Code	Sector Description	Total Output Effects 2018 (million euro)	Total Output Effects 2020 (million euro)	Total Employment Effects 2018 (employees)	Total Employment Effects 2020 (employees)
CPA_A	AGRICULTURE, FORESTRY AND FISHING	0.529	1.723	6	19
CPA_B	MINING AND QUARRYING	1.112	3.617	2	6
CPA_C10-C12	Food products, beverages and tobacco	0.668	2.174	2	7
CPA_C13-C15	Textiles, wearing apparel, leather and related products	0.435	1.416	3	8
CPA_C16-C18	Wood and paper products; printing and reproduction of recorded media	3.166	10.301	15	50
CPA_C19	Coke and refined petroleum products	1.672	5.440	0	1
CPA_C20-C21	Chemicals and chemical products	5.577	18.148	11	35
CPA_C22-C23	Rubber and plastics products, and other non-metallic mineral products	6.538	21.274	31	101
CPA_C24-C25	Basic metals and fabricated metal products, except machinery and equipment	25.857	84.136	111	360
CPA_C26	Optical equipment	3.630	11.811	14	46
CPA_C28	Machinery and equipment n.e.c.	0.005	0.015	0	0
CPA_C29-C30	Transport equipment	3.841	12.497	10	33
CPA_C31-C33	Other manufacturing; repair and installation of machinery and equipment	2.660	8.657	15	50
CPA_D_E	ELECTRICITY, GAS AND WATER SUPPLY	3.230	10.511	6	20
CPA_F	CONSTRUCTION	6.969	22.677	46	149
CPA_G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	2.728	8.876	12	40
CPA_G46	Wholesale trade, except of motor vehicles and motorcycles	1.374	4.470	5	15
CPA_G47	Retail trade, except of motor vehicles and motorcycles	12.049	39.205	106	345
CPA_H49-52	Transport and storage	2.452	7.979	7	23
CPA_H53	Postal and courier activities	9.215	29.984	87	283
CPA_I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	0.582	1.895	7	23
CPA_J58_J60	Publishing, audiovisual and broadcasting activities	0.917	2.985	4	13
CPA_J61	Telecommunications	1.084	3.528	2	8
CPA_J62_J63	IT and other information services	1.533	4.989	9	29
CPA_K64_K66	FINANCIAL AND INSURANCE ACTIVITIES	2.558	8.324	10	32
CPA_L68B_ L68A	REAL ESTATE ACTIVITIES	5.572	18.129	5	16
CPA_M_N	PROFESSIONAL, SCIENTIFIC, TECHNICAL, ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	4.035	13.129	37	121
CPA_O84	Public administration and defence; compulsory social security	21.843	71.073	227	737
CPA_O85	Education	0.604	1.965	9	30
CPA_Q86-Q88	Health and social work	0.506	1.648	7	23
CPA_R90-R93	Arts, entertainment and recreation	0.117	0.380	1	4
CPA_S94_S96	Other service activities	0.255	0.830	4	13
CPA_T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0.692	2.250	55	179
CPA_C27 (disaggregated)	Electrical equipment (without HCL)	149.152	485.320	577	1878
CPA_C27 (disaggregated)	HCL	266.597	867.470	1032	3357
Total		549.75	1788.82	2,476	8,057

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APPENDIX: INPUT-OUTPUT ANALYSIS

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Disaggregating in the input-output model

The disaggregated technical coefficient matrix is the sum of an augmented matrix and a distinguishing matrix. Aaug (the augmented matrix) augments the aggregated technical coefficient matrix A by assuming that the pertinent sector to be disaggregated arose from the aggregation of two essentially identical sectors. More specifically, the pertinent column of A is replaced by as many identical columns as there are sectors to be created. The matching row of A is replaced by the same number of rows, each of which is the product of a weighting factor and the original row of A.

$$Aaug = \begin{bmatrix} A(1: n-1,1: n-1) & A(1: n-1, n) & A(1: n-1, n) \\ w_1 * A(n,1: n-1) & w_1 * A(n, n) & w_1 * A(n, n) \\ w_2 * A(n+1,1: n-1) & w_2 * A(n, n) & w2 * A(n, n) \end{bmatrix}$$

To disaggregate, more information than the one embedded in the augmented matrix needs to be considered. This is because the augmented matrix describes the newly created sectors as being essentially the same. However, we must distinguish them one from another.

$$Adist = \begin{bmatrix} 0(1: n-1,1: n-1) & w_2 \delta_i ones(1, 1: n-1) & w_2 \delta_i ones(1, 1: n-1) \\ ones(1, 1: n-1) * \sigma_i & (\frac{1}{2}\delta_n + Y) w_2 + \sigma_n & -(\frac{1}{2}\delta_n + Y) w_1 + \sigma_n \\ -ones(1, 1: n-1) * \sigma_i & (\frac{1}{2}\delta_n - Y) w_2 - \sigma_n & -(\frac{1}{2}\delta_n - Y) w_1 - \sigma_n \end{bmatrix}$$

Where δ_i represents the difference between the n^{th} and $(n+1)^{th}$ sectors in their demand for input from the it^h sector; σ_j represents the departure from average in what the n^{th} and $(n+1)^{th}$ sectors supply to the j^{th} sector; δ_n, σ_n and Y manifest like quantities for intra-aggregate exchanges. Following Wolsky (1984), we use knowledge of w1, w2 and A to bound the above parameters. The disaggregated input-output matrix takes the following form:

$$AA = Aaug + Adist$$

Table A1: Industrial Sectors Aggregation

	Code in 65x65 IOT	Description in 65x65 IOT	Code in 34x34 IOT	Description in 34x34 IOT
1	CPA_A01	Products of agriculture, hunting and related services	CPA_A	Agriculture, forestry and fishing
2	CPA_A02	Products of agriculture, hunting and related services		
3	CPA_A03	Fish and other fishing products; aquaculture products; support services to fishing		
4	CPA_B	Mining and quarrying	CPA_B	Mining and quarrying
5	CPA_C10-C12	Food products, beverages and tobacco products	CPA_C10-C12	Food products, beverages and tobacco products
6	CPA_C13-C15	Textiles, wearing apparel and leather products	CPA_C13-C15	Textiles, wearing apparel and leather products
7	CPA_C16	Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	CPA_C16-C18	Wood and paper products; printing & reproduction of recorded media
8	CPA_C17	Paper and paper products		
9	CPA_C18	Printing and recording services		
10	CPA_C19	Coke and refined petroleum products	CPA_C19	Coke and refined petroleum products
11	CPA_C20	Chemicals and chemical products	CPA_C20-C21	Chemicals and chemical products
12	CPA_C21	Basic pharmaceutical products and pharmaceutical preparations		
13	CPA_C22	Rubber and plastics products	CPA_C22-C23	Rubber & plastic products;other non-metallic mineral products
14	CPA_C23	Other non-metallic mineral products		
15	CPA_C24	Basic metals	CPA_C24-C25	Basic metals and fabricated metal products, except machinery and equipment
16	CPA_C25	Fabricated metal products, except machinery and equipment		
17	CPA_C26	Computer, electronic and optical products	CPA_C26	Computer, electronic and optical products
18	CPA_C27	Electrical equipment	CPA_C27	Electrical equipment
19	CPA_C28	Machinery and equipment n.e.c.	CPA_C28	Machinery and equipment n.e.c.
20	CPA_C29	Motor vehicles, trailers and semi-trailers	CPA_C29-C30	Transport equipment
21	CPA_C30	Other transport equipment		
22	CPA_C31_C32	Furniture; other manufactured goods	CPA_C31-C33	Other manufacturing, repair and installation of machinery and equipment
23	CPA_C33	Repair and installation services of machinery and equipment		
24	CPA_D35	Electricity, gas, steam and air-conditioning	CPA_D_E	Electricity, gas and water supply
25	CPA_E36	Natural water; water treatment and supply services		
26	CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services		
27	CPA_F	Constructions and construction works	CPA_F	Constructions and construction works
28	CPA_G45	Wholesale and retail trade and repair services of motor vehicles and motorcycles	CPA_G45	Wholesale and retail trade and repair services of motor vehicles and motorcycles
29	CPA_G46	Wholesale trade services, except of motor vehicles and motorcycles	CPA_G46	Wholesale trade services, except of motor vehicles and motorcycles
30	CPA_G47	Retail trade services, except of motor vehicles and motorcycles	CPA_G47	Retail trade services, except of motor vehicles and motorcycles
31	CPA_H49	Land transport services and transport services via pipelines	CPA_H49-52	Transport and storage
32	CPA_H50	Water transport services		
33	CPA_H51	Air transport services		
34	CPA_H52	Warehousing and support services for transportation		

	Code in 65x65 IOT	Description in 65x65 IOT	Code in 34x34 IOT	Description in 34x34 IOT
35	CPA_H53	Postal and courier services	CPA_H53	Postal and courier services
36	CPA_I	Accommodation and food services	CPA_I	Accommodation and food services
37	CPA_J58	Publishing services	CPA_J58_J60	Publishing, audiovisual and broadcasting services
38	CPA_J59_J60	Motion picture, video and television programme production services, sound recording and music publishing; programming and broadcasting services		
39	CPA_J61	Telecommunications services	CPA_J61	Telecommunications services
40	CPA_J62_J63	Computer programming, consultancy and related services; information services	CPA_J62_J63	Computer programming, consultancy and related services; information services
41	CPA_K64	Financial services, except insurance and pension funding	CPA_K64_K66	Financial and insurance activities
42	CPA_K65	Insurance, reinsurance and pension funding services, except compulsory social security	CPA_L68B_L68A	Real estate activities
43	CPA_K66	Services auxiliary to financial services and insurance services		
44	CPA_L68B	Real estate services (excl. imputed rents)		
45	CPA_L68A	Of which: imputed rents of owner-occupied dwellings		
46	CPA_M69_M70	Legal and accounting services; services of head offices; management consulting services	CPA_M69_M75, CPA_N77_N82	Professional, scientific, technical, administrative, and support service activities
47	CPA_M71	Architectural and engineering services; technical testing and analysis services		
48	CPA_M72	Scientific research and development services		
49	CPA_M73	Advertising and market research services		
50	CPA_M74_M75	Other professional, scientific and technical services; veterinary services		
51	CPA_N77	Rental and leasing services		
52	CPA_N78	Employment services		
53	CPA_N79	Travel agency, tour operator and other reservation services and related services		
54	CPA_N80-N82	Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services		
55	CPA_O84	Public administration and defence services; compulsory social security services	CPA_O84	Public administration and defense services; compulsory social security services
56	CPA_P85	Education services	CPA_P85	Education services
57	CPA_Q86	Human health services	CPA_Q86-Q88	Health and social work
58	CPA_Q87_Q88	Social work services		
59	CPA_R90-R92	Creative, arts and entertainment services; library, archive, museum and other cultural services; gambling and betting services	CPA_R90-R93	Arts, entertainment and recreation
60	CPA_R93	Sporting services and amusement and recreation services		
61	CPA_S94	Services furnished by membership organizations	CPA_S94_S96	Other service activities
62	CPA_S95	Repair services of computers and personal and household goods		
63	CPA_S96	Other personal services		
64	CPA_T	Services of households as employers; undifferentiated goods and services produced by households for own use	CPA_T	Services of households as employers; undifferentiated goods and services produced by households for own use
65	CPA_U	Services provided by extraterritorial organisations and bodies	Not used as all its values are zero	

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