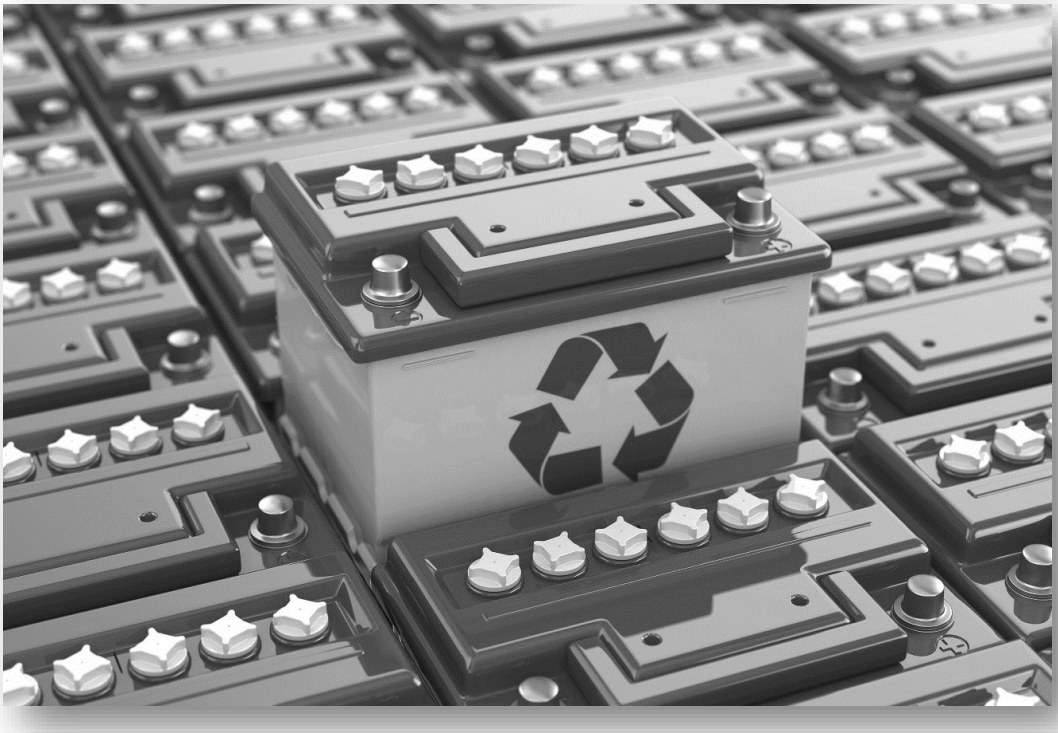
Economic Contribution of the European Lead Battery Industry

Prepared for:
Association of European Automotive and Industrial Battery Manufacturers (EUROBAT)

International Lead Association (ILA)

JANUARY 2022



EBPO

Contents

Summary Findings

Europe's lead battery industry makes a significant contribution to the continent's economy, as well as to society's decarbonization process. It is one of the industries that will assist in realizing the EU Green Deal, laying the foundation for a Zero Emission economy by 2050.[1] But first and foremost, the industry generates economic impacts that affect numerous industry sectors. It contributes to the economy in the following ways:

- Battery manufacturing, recycling, and mining companies employ workers and generate business income. These represent direct effects and are referred to as the "European lead battery industry."
- Battery manufacturing, recycling, and mining companies purchase goods and services from other companies. These represent indirect effects.
- Workers at battery manufacturing, recycling, and mining companies, as well as workers at supplier companies, spend their after-tax income on consumer goods. These represent induced effects.
- The lead battery industry supports small and medium enterprises (SMEs). Thirty-five percent of companies are medium enterprises and 4 percent are small enterprises.[2]
- Lead battery companies innovate through ongoing research and development. Industry-wide, companies report spending nearly 40 million EUR on R&D annually. This spending contributes to the industry's future growth and productivity.
- The industry uses high levels of recycled content. According to survey respondents, over 60 percent of the inputs to production come from recycled content. Other sources report that the recycled content in a new lead battery ranges from 67-80%.[3]
- The downstream industry activity enabled through usage of lead batteries is extensive: €7.3 trillion worth of GDP covering retail, construction, and healthcare applications.
- Approximately €2 billion of EU-27 country exports of lead-acid batteries are consumed by non-EU countries such as the United Kingdom, United States, Russia, Switzerland, and China.

---

1 Charge the Future, https://chargethefuture.org/.

2 The European Commission defines medium enterprises as having fewer than 250 employees. It defines small enterprises as having fewer than 50 employees. See https://ec.europa.eu/growth/smes/sme-definition_en.

3 European Commission, "Assessment of Options to Improve Particular Aspects of the EU Regulatory Framework on Batteries," 2020, https://bit.ly/3AaP1ZB. Charge the Future, "Setting the standard for Europe's circular economy," 2019, https://bit.ly/3D9Oj0H.

The European lead battery industry (battery manufacturing, container and separator manufacturing, accessories, assembly equipment, recycling, primary lead producers and mining companies) directly employs approximately 31,700 workers ("direct effects"). In addition, it supports about 75,000 jobs in other companies supplying into this Industry ("indirect effects") and 77,500 jobs from worker spending in different industries ("induced effects"). **Together, these total over 184,000 jobs.** Beyond jobs, the European lead battery industry annually supports the following[4]:

- 7.6 billion EUR in labor income,
- 14.7 billion EUR in gross domestic product (GDP),
- 36.5 billion EUR in output or overall economic impact, and
- 1.9 billion EUR in social security payments.

The industry also contributes to wider economic growth by enabling households and businesses to be more productive. Numerous downstream industries rely on lead batteries to operate, with the largest users being motor vehicle repair, construction, and transportation.

[4] Impacts are based on 2019 industry activity in 30 countries. GDP represents the total value of goods produced and output represents total sales made. GDP is smaller than output because it excludes the cost of inputs. Labor income is a subset of GDP and GDP is a subset of output. These figures should not be combined.

1. Introduction

This report estimates the economic contribution of the lead battery industry in Europe. For this analysis, Europe includes the 27 countries in the European Union plus Norway, Switzerland, and the United Kingdom. EBP conducted the analysis with 2019 data using input-output analysis, a commonly used method for measuring the economic impact of industry activities. This method allowed us to measure the activity of the entire lead battery value chain.

— Input-output analysis estimates the multiplier effects of direct industry activity such as jobs, wages, and sales. The research team measured direct activity stemming from the European lead battery industry using an online survey. The online survey was administered using SurveyMonkey; it was open from March 8 to June 15, 2021. The survey received 27 responses that together captured direct activity in all 30 countries in the study region.

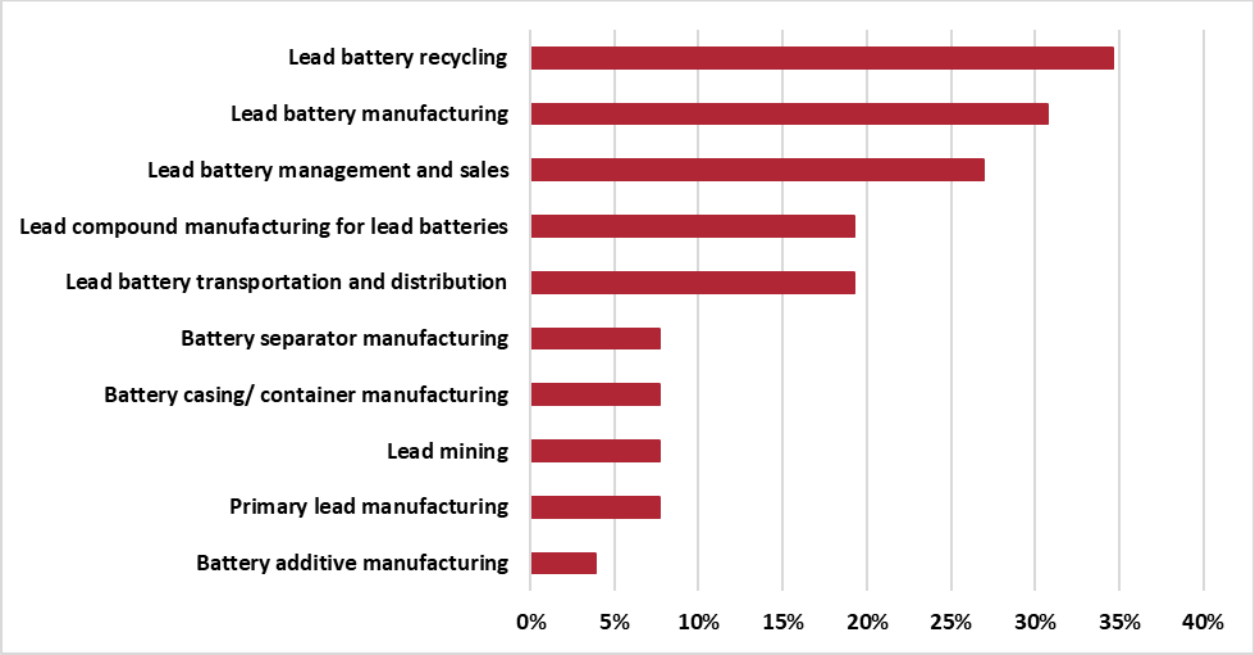
— The response rate among the Association of European Automotive and Industrial Battery Manufacturers (EUROBAT) members involved in battery manufacturing and supply chain activities was over 70 percent, with all the largest companies in the industry responding. The response rate among International Lead Association (ILA) members involved in lead production was about 66 percent. To account for non-respondents and non-members, the team used smelter capacity as a proxy for economic output, as described later. Based on the survey results and interpolation, the following analysis is assumed to capture virtually the entire lead battery industry in Europe.

— The survey data summarized in Figure 1-1 provides a sense of the types of services provided by companies in the lead battery industry.[5] The top three services provided are lead battery recycling (34.6% of respondents), lead battery manufacturing (30.8%), and lead battery management and sales (26.9%). Please note that there is a distinction to be made between services rendered (Figure 1-1) and the distinct industries responsible for providing them that is often a many to one relationship. The estimation of impacts therefore focuses on the survey respondent's identification of their primary NACE category of business.[6]

[5] Respondents could select more than one service area. Also, several battery manufactures are integrated operators, meaning they manufacture and recycle batteries.

[6] NACE stands for Nomenclature des Activités Économiques dans la Communauté Européenne. It is a European industry classification system.

Figure 1-1. Services Provided by Survey Respondents

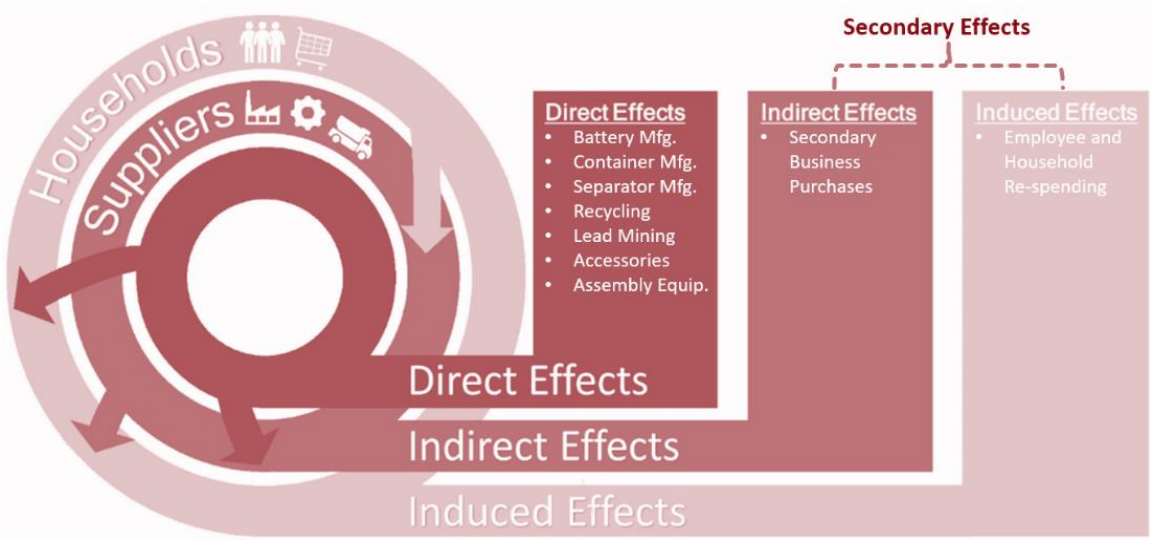


Source: EBP analysis of survey data

2. Economic Impacts

Economic impacts come in three forms: direct effects, indirect effects, and induced effects. Direct effects result from expenditures associated with battery production, assembly, and recycling. Specifically, they arise from initial purchasing of goods, labor, and materials associated with the battery supply chain. Indirect effects represent the purchase of goods and services by suppliers to meet the demands of direct activity. Induced effects represent the income earned by workers being re-spent in the economy on household goods and services. Figure 1-2 illustrates the relationship among these different effects.

Figure1-2. Relationship among Direct, Indirect, and Induced Effects



Source: EBP

As indicated by the arrows in the diagram, direct effects of battery production generate indirect effects because of the need to supply direct activities with goods and services, as well as induced effects from labor income spending by both direct and indirect workers. EBP's analysis goes beyond this one-dimensional process by estimating the impact of businesses comprising the entire European lead battery industry value chain, which operates across multiple countries and is fueled by a global supply chain enabled through bilateral trade.

There are four primary measures of economic impact. They do not include social security payments, which are presented in Section 2.4. The primary impact measures are the following:

- Employment represents full-time and part-time jobs within a region for a given industry. This means that one person working multiple jobs may be represented twice if they work two part-time jobs.
- Income represents employees' level of compensation inclusive of wages, salaries, and benefits. Unlike labor income, it does not include proprietor income or payroll taxes.
- Value added (gross domestic product) is measured as the difference between an industry's economic output and the value of intermediate inputs to its production process. It includes labor costs, taxes, and any other proprietor or property income.
- Output represents the total measure of economic activity for an industry in a region. This measure is computed as the cost of intermediate inputs of production for the industry, plus value-added activity. Output is most equated to revenues, sales, or turnover.

2.1. Total Impacts

In 2019, the European lead battery industry generated about 14.7 billion EUR of value added or gross domestic product (GDP) across Europe (Table 2-1). Of this, about 3.4 billion EUR comes from direct industry operations, with the remaining 11.3 billion EUR generated through indirect supply chain purchasing and induced worker income re-spending. The 14.7 billion EUR of GDP supports about 184,400 workers in 30 countries who earn a combined wage of approximately 7.6 billion EUR.

Table 2-1. Economic Impacts of the Lead Battery Industry

Impact Type	Employment	Income (Million EUR)	Value Added (Million EUR)	Output (Million EUR)
Direct Effects	31,688	2,012	3,402	11,930
Supplier Effects (Indirect)	75,200	2,880	5,450	12,934
Worker Spending Effects (Induced)	77,534	2,677	5,799	11,630
Total	**184,423**	**7,569**	**14,650**	**36,494**

Source: EBP analysis

The 7.6 billion EUR in wages amounts to an average compensation of 41,200 EUR per year, which exceeds the 31,080 EUR per capita average across all sectors and countries in 2019. This indicates that the lead battery industry pays above-average wages to its employees.

Table 2-2 shows direct economic impacts for a selection of top activities that were captured by the survey. (Note that for the purpose of discussing the lead battery industry, these direct industries/activities are what are being measured.) Among these impacts, activities related to the manufacture of batteries and accumulators account for the most impact, followed by manufacture of basic precious and other non-ferrous metals, which includes primary and secondary (recycling) lead smelting activities.

Table 2-2. Direct Economic Impacts by Activity Type

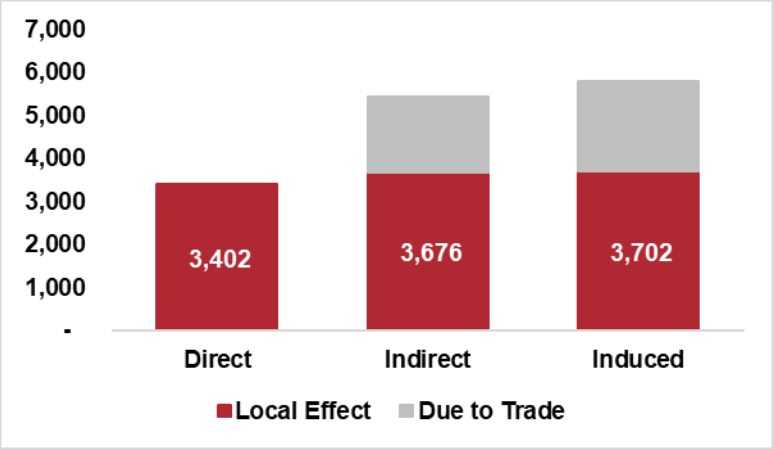
Activity Type	Employment	Income (Million EUR)
Lead Battery Manufacturing	17,495	1,257.1
Primary & Secondary Smelting	11,182	576.2
Lead Mining	1,652	109.7
Battery Casing & Components	644	22.1
Battery Assembly Equipment	370	24.1
Battery Separators	345	22.4
Total	31,688	2,011.7

Source: EBP analysis

Figure 2-1 on the following page separates direct, indirect, and induced value added based on whether it derives from trade effects or not—i.e., whether the impact of activity is due to local activity or fueled by demand from other parts of the lead battery manufacturing sector in other countries via trade. Of the 14.7 billion EUR in value added generated in 2019, about 3.4 billion EUR was generated through direct activities of the battery industry. This 3.4 billion EUR generated an

additional localized impact of 7.4 billion EUR due to present manufacturing activities through local purchasing and worker income re-spending. When international purchases between member states were considered, the effects increased by another 3.4 billion EUR due to such things as German manufacturing activity creating additional demand purchases of materials from the Netherlands, thereby creating an effect in the manufacturing sectors in the Netherlands. The next sections explore this interrelationship further by digging into the industries responsible for generating impacts; the countries in which they operate; and the broader representation of their supply chain benefits and social security payments.

Figure 2-1. Breakout of Economic Impacts (Million EUR GDP)

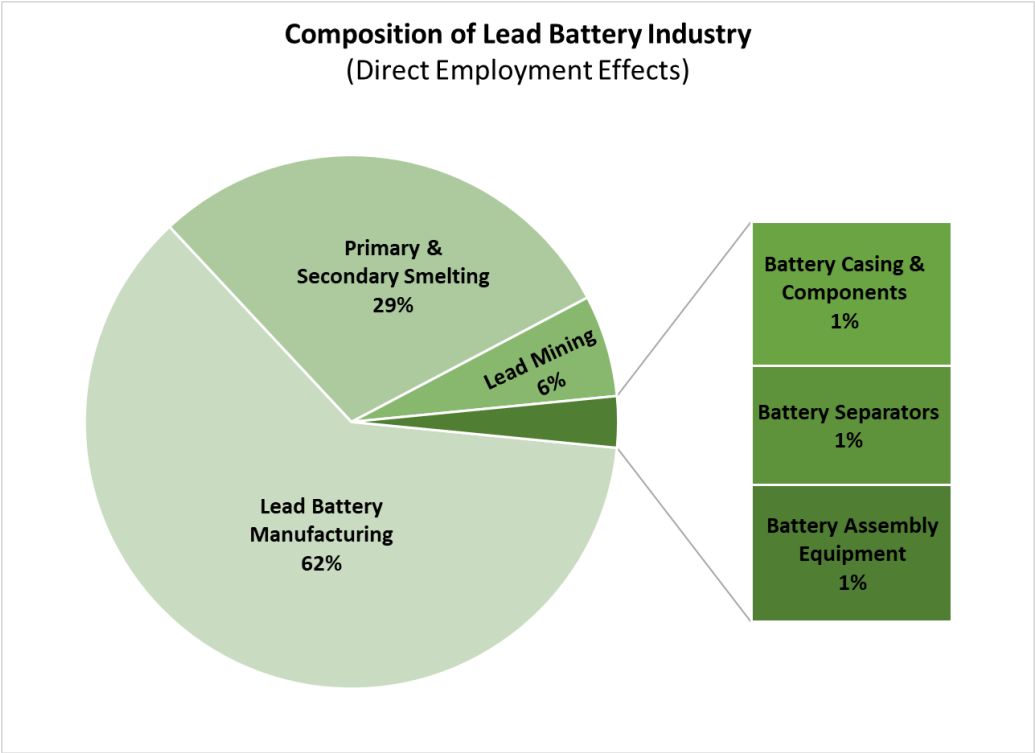


Source: EBP analysis

2.2. Industry-level Impacts

Figure 2-2 on the following page shows an industry breakdown of the estimated 31,700 workers employed directly within the lead battery industry. About 60 percent of direct jobs fall within the electrical equipment industry sector, which includes battery manufacturing. Nearly 30 percent of direct jobs are in the basic metals and mining sectors. The smallest share of workers — about 3 percent — work in the rubber, plastic, and paper manufacturing industries. This includes companies engaged in casing and battery separator production.

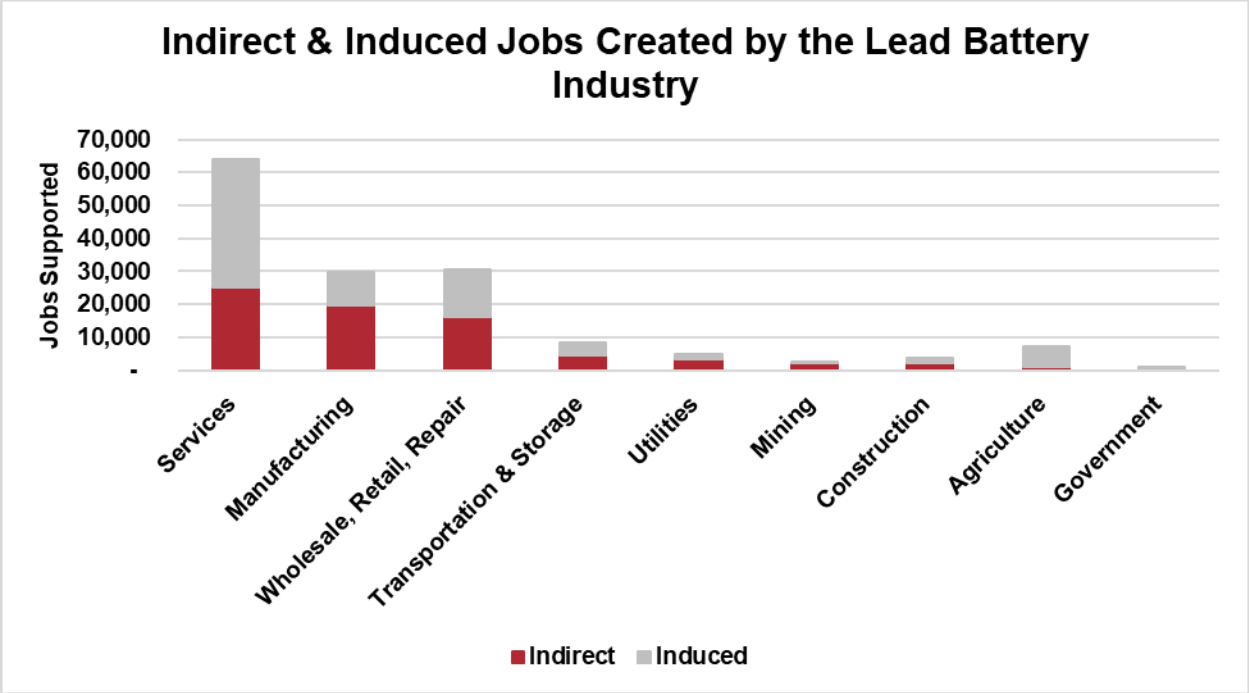
Figure 2-2. Composition of Lead Battery Industry (Direct Employment Effects)



Source: EBP analysis

These direct effects spur supply chain purchasing effects (indirect) that ripple through the economy as suppliers of suppliers tracing back to primary extraction are impacted by the direct effects of businesses. As the direct and indirect effects are quantified with respect to workers earning wages, we can also quantify the induced effects as those workers then spend that money within their economy on further consumption of goods and services. Figure 2-3 highlights the industries impacted by indirect and induced effects. Note that the services sector is a broad conglomeration of sectors ranging from business services and telecommunications to health care, food, and accommodation services.

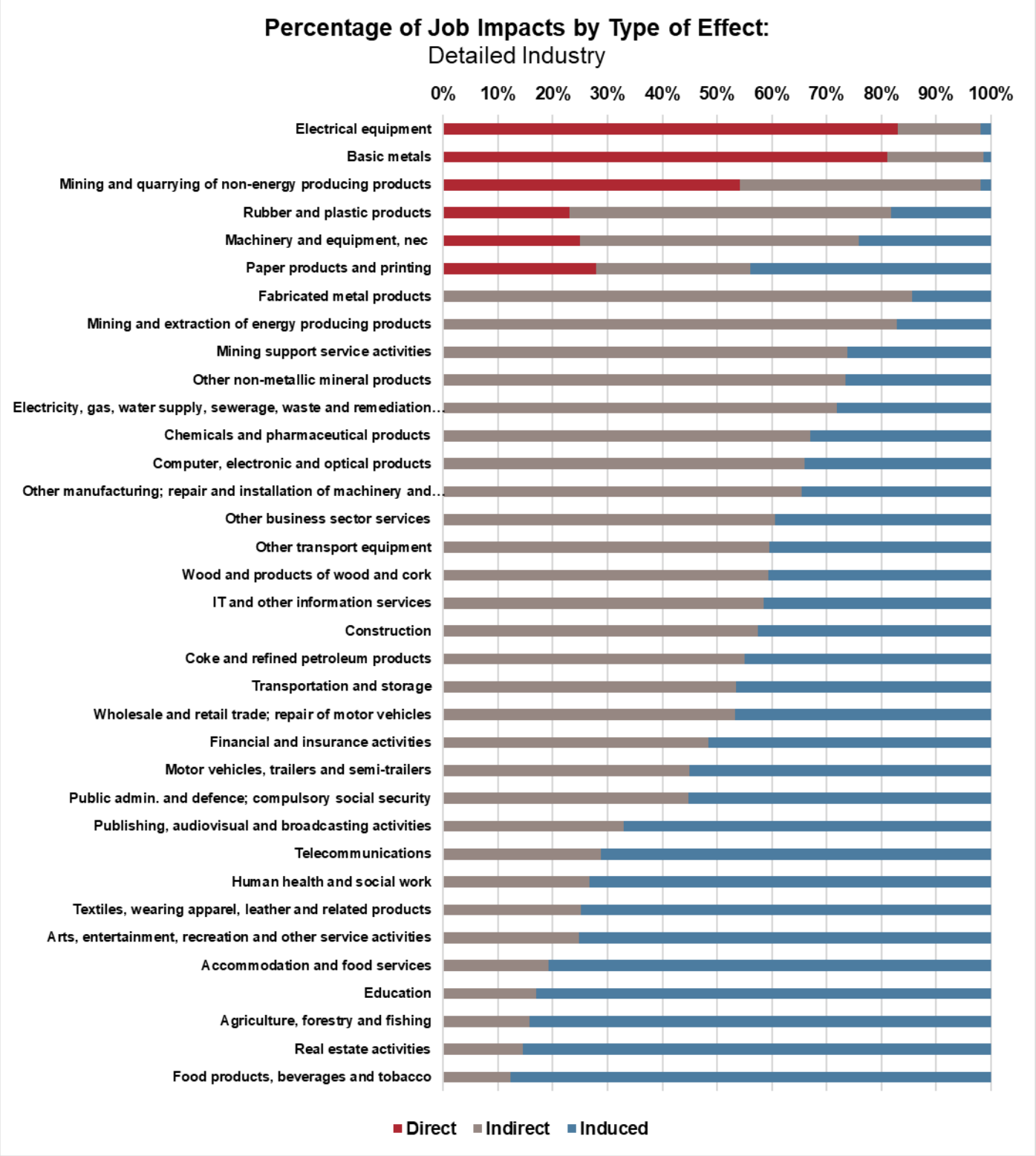
Figure 2-3. Indirect & Induced Jobs Created by the Lead Battery Industry



Source: EBP analysis

To give a clearer picture of the impacts, Figure 2-4 further breaks out the preceding figure to give an idea how the industries impacted by the lead battery industry vary depending on the type of economic effects (direct, indirect, induced). Note the direct effects in red and the industries being represented. These direct effects consume additional services from other businesses in the region (who also consume additional services from other businesses tracing all back to basic components) as shown in grey. Both red and grey industrial activity enables worker income re-spending in the economy (blue)—which is why the relative magnitude of employment effects shown in blue place a higher emphasis on household goods and services.

Figure 2-4. Percentage of Job Impacts by Type of Effect



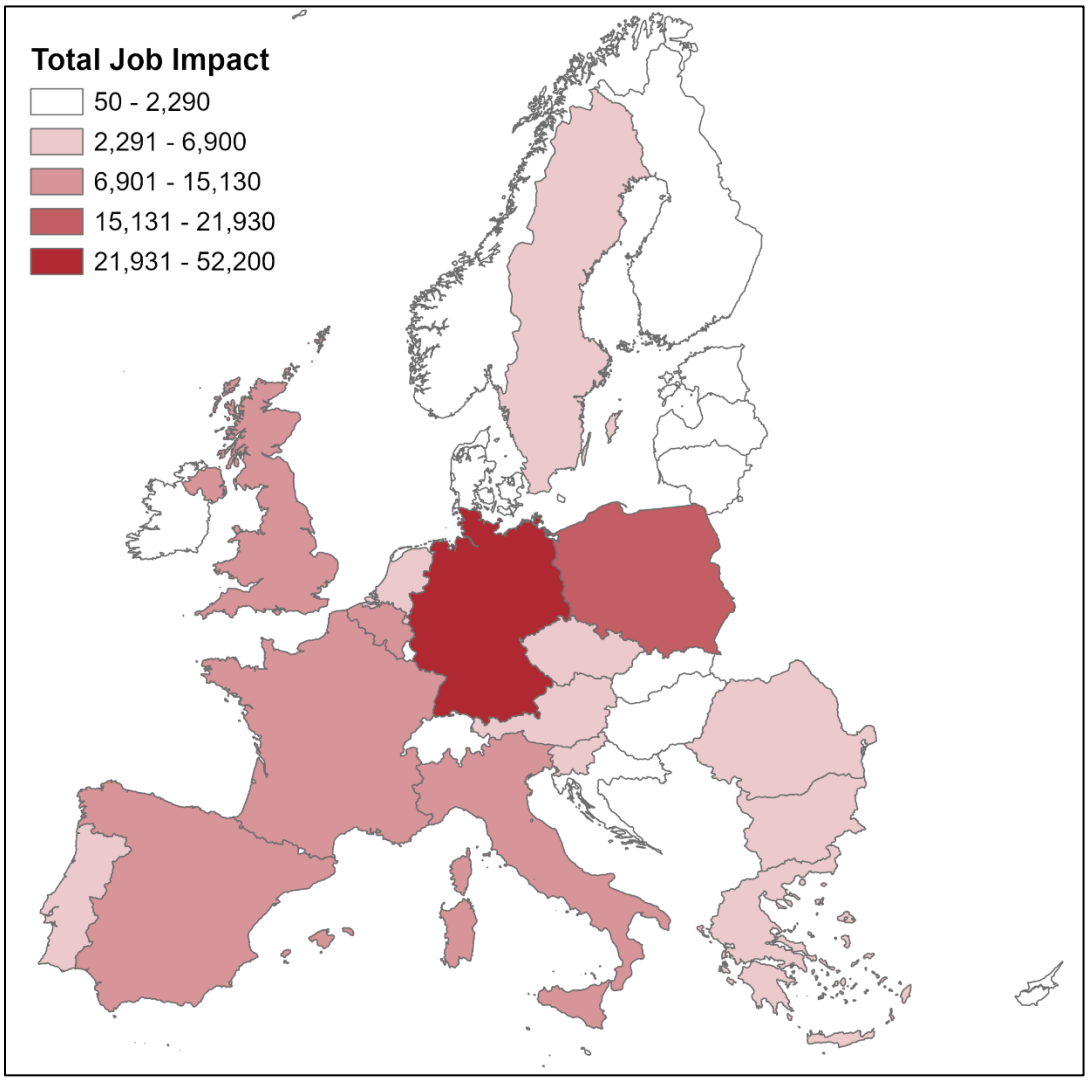
Source: EBP analysis

2.3. Country-Level Impacts

Figure 2-5 shows the distribution of total job impacts across European countries. Countries are shaded according to the number of jobs the lead battery industry supports. The darker the shade, the greater the number of jobs.

Jobs are highest in Germany, which accounts for 28 percent of the total impact. Poland accounts for 12 percent of total jobs, Italy accounts for 8 percent, and France, Spain, and the UK each account for 6 percent.

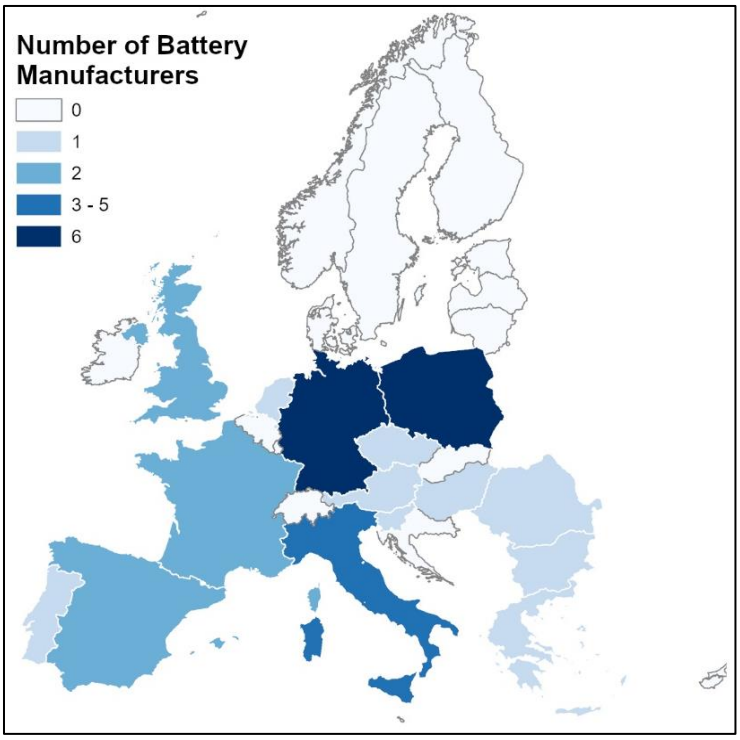
Figure 2-5. Geographic Distribution of Total Job Impacts



Source: EBP analysis

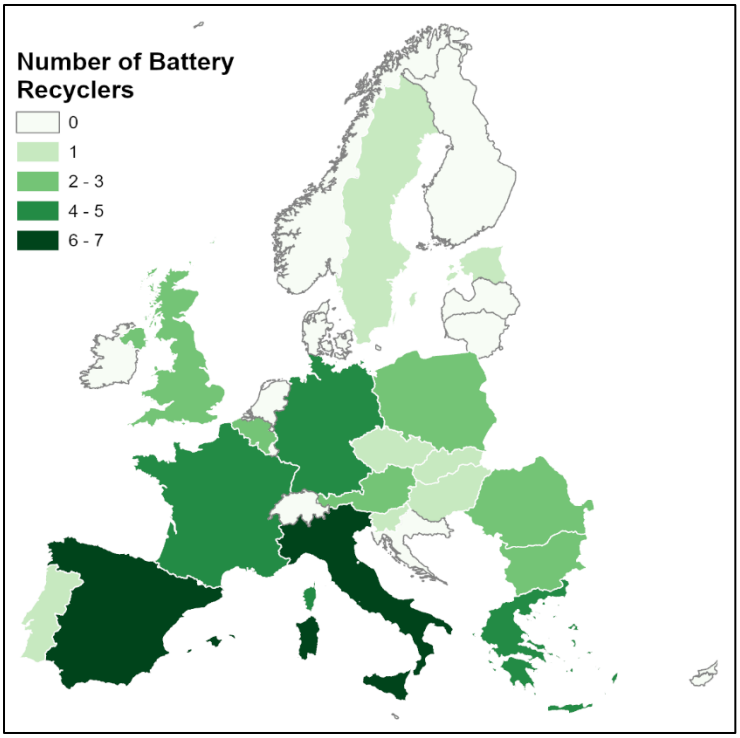
Figures 2-6, 2-7, and 2-8 show the number of battery manufacturers, battery recyclers, and primary lead producers by country, respectively. Not surprisingly, the countries with the most jobs also have the most companies. Germany and Poland have the most manufacturers (6 each), whereas Italy has the most recyclers (7) followed closely by Spain (6). Germany and Poland also have the most lead producers (3 and 2, respectively).

Figure 2-6. Number of Battery Manufacturers by Country



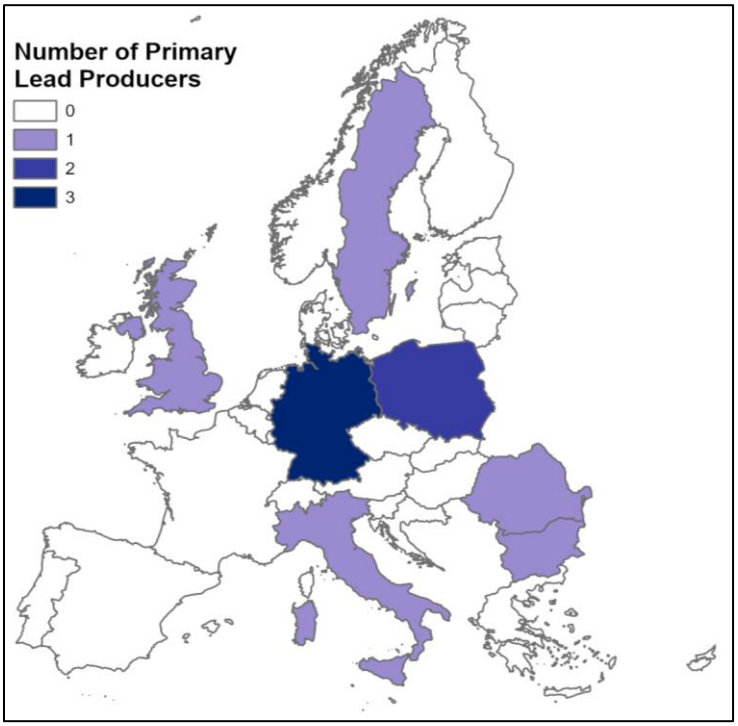
Source: EBP analysis of ILA data

Figure 2-7. Number of Battery Recyclers by Country



Source: EBP analysis of ILA data

Figure 2-8. Number of Primary Lead Producers by Country



Source: EBP analysis of ILA data

Table 2-3 provides more detail on the lead battery industry's impact by country. In order of value added, Germany, Italy, France, Belgium, and the UK see the largest impact. Note how Belgium is not among the top five countries by employment. Similarly, Poland *is* among the top five countries by employment but not when measured by value added. This illustrates how measures of economic impact can vary based on industry mix, labor productivity, and other dynamics.

Table 2-3. Economic Impacts by Country (in order of value added)

Country	Employment	Income (Million EUR)	Value Added (Million EUR)	Output (Million EUR)
Germany	52,197	2,698.5	4,890.1	11,142.6
Italy	15,126	559.1	1,237.3	3,426.7
France	11,980	682.1	1,213.8	2,786.3
Belgium	10,009	602.2	1,205.2	4,076.5
United Kingdom	10,678	585.4	1,047.5	2,331.8
Spain	11,286	433.9	831.2	2,204.7
Poland	21,930	336.3	761.1	2,110.9
Sweden	3,546	211.5	445.4	1,004.0
Switzerland	2,289	199.4	402.8	975.3
Austria	3,596	187.6	379.4	871.1
Portugal	6,320	179.1	357.3	807.5
Netherlands	3,391	164.8	329.5	739.7
Greece	5,579	155.2	329.3	755.4
Romania	6,920	69.3	174.4	466.3
Norway	772	65.3	146.7	268.8
Czech Republic	3,595	64.1	137.4	371.6
Denmark	892	58.8	100.8	212.2
Bulgaria	5,001	38.9	97.6	389.0
Finland	934	49.2	96.8	231.5
Ireland	534	34.4	94.3	204.9
Slovenia	1,849	56.4	91.7	260.5
Luxembourg	651	46.0	85.7	305.3
Slovak Republic	1,646	27.9	69.0	207.7
Hungary	2,174	33.9	66.4	187.5
Estonia	572	13.7	26.3	76.0
Lithuania	317	4.6	11.2	23.7
Croatia	352	6.2	11.0	24.8
Latvia	181	2.5	5.4	13.2
Cyprus	60	1.7	3.3	7.5
Malta	47	1.2	2.6	10.9
Total	**184,423**	**7,569.0**	**14,650.3**	**36,493.8**

Source: EBP analysis

Note: Rows do not sum exactly to totals due to rounding.

Figure 2-9 shows the flow of economic activity from the country where primary lead battery activity occurs to the country it generates economic effects on through trade. The thicker the line, the greater the magnitude of impact in Euros of economic activity being generated. Notice how flows are concentrated among Germany, France, and the UK — Europe's largest economies overall.

Figure 2-9. Economic Flows among European Countries

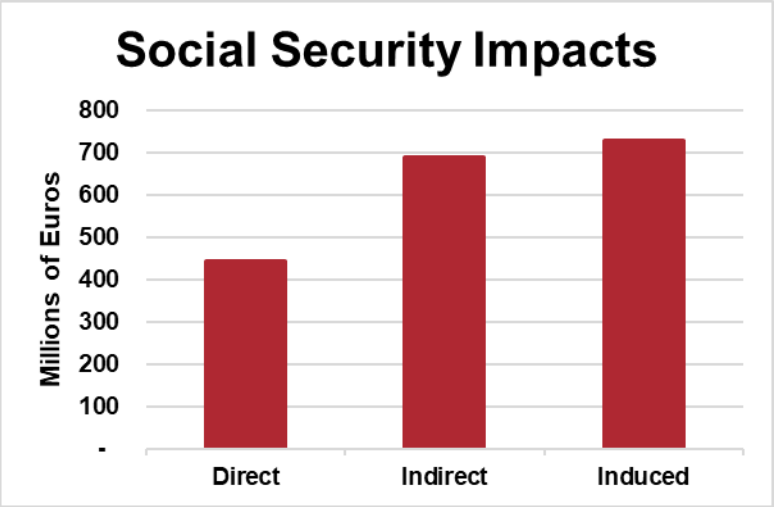
Source: EBP analysis

The flow lines capture impacts generated solely through trade. The predominant impacts of industry are from local activity taking place within the same country. Therefore, care should be taken in understanding the above graphic, as much of the impacts might not be visible because there is less impact via trade taking place because activity is mostly local.

2.4. Social Security Payments

Section 1 noted that the European lead battery industry including suppliers generated approximately 7.6 billion EUR in income in 2019 and 14.7 BEUR in GDP. In addition to employee compensation, the industry generates 1.9 billion EUR annually in social security payments to national governments. To estimate this value, EBP used OECD data on the amount of social security payments made as a percent of a given country's GDP.[7] Figure 2-10 shows the breakdown of social security payments by direct, indirect, and induced effect.

Figure 2-10. Social Security Payments (Million EUR)



Source: EBP analysis using Eurostat data

Note that the social security impacts are exclusively considering the following:

- Unemployment insurance benefits and supplements
- Accidents
- Injury and sickness benefits
- Old age
- Disability and survivors' pensions
- Family allowances
- Reimbursements for medical and hospital expenses or provision of hospital or medical services

These types of contributions are collected from both employees and employers as a way of funding social benefits.

[7] https://data.oecd.org/tax/social-security-contributions.htm

2.5. Downstream Battery Users

The effects of European lead batteries do not stop with the manufacturing supply chain. Downstream users of lead batteries consume them as industrial inputs to production and operation, while households use them to power their vehicles and a host of other applications. We estimated the direct downstream effects of lead batteries by looking at the relative economic value of industry activity that consumes lead acid batteries, and the subset of which does so via European manufactured batteries (as opposed to those that are imported). The role of lead batteries in enabling broader economic activity is significant. Table 2-4 shows the economic contribution of battery affected industries as a share of the European economy in 2019.

Table 2-4. Estimation of Downstream User Created Impacts

	Employment	Income (MEUR)	Value Added (MEUR)	Output (MEUR)
Battery Affected Industry	103,911,900	3,935,676	7,263,342	14,614,192
Overall Economy	233,473,908	9,227,221	17,371,341	35,465,450
Percent of Economy Impacted	45%	43%	42%	41%

Source: EBP analysis using Avicenne data

Table 2-5 on the following page uses Avicenne demand data to show the amount of economic activity by battery affected industry. The table is ordered by output to show which industries rely most on lead batteries for sales. Wholesale and retail businesses that sell lead batteries for vehicles are the biggest users, followed by construction and transportation services.

Note that motor vehicle manufacturing is not among the top five users, likely because many batteries are sold to replace new batteries and are therefore captured under wholesale and retail trade (wholesalers that sell to vehicle repair shops and retailers that sell to households). Other industries in Table 2-5 reflect the use of lead batteries for energy storage and backup needs, including human health (hospitals), education (schools), and telecommunications (cell towers).

Table 2-5. Downstream User Created Impacts Utilizing Lead Batteries

Industry Description	Employment	Income (MEUR)	Value Added (MEUR)	Output (MEUR)
Wholesale and retail trade; repair of motor vehicles	21,492,879	692,246.92	1,221,481.33	2,233,541.65
Construction	9,347,060	323,111.47	572,373.08	1,469,670.23
Transportation and storage	7,401,230	313,723.70	537,084.61	1,291,926.75
Other business sector services	11,554,873	413,052.20	732,452.46	1,335,715.34
Real estate activities	1,015,605	38,238.74	756,170.25	991,539.97
Public admin. and defence; compulsory social security	6,405,305	352,594.60	470,571.75	702,369.35
Financial and insurance activities	2,418,505	186,510.16	365,522.22	772,798.81
Human health and social work	9,790,622	374,283.03	502,070.87	757,113.95
Machinery and equipment, nec	1,922,085	116,190.30	182,318.88	505,520.70
Food products, beverages and tobacco	1,917,771	78,082.28	140,073.08	549,380.62
Motor vehicles, trailers and semi-trailers	1,108,621	71,995.82	124,880.55	470,562.87
Agriculture, forestry and fishing	6,878,825	46,620.46	163,501.15	383,321.04
Education	6,299,181	284,550.37	335,893.62	422,463.29
Other manufacturing; repair and installation of machinery and equipment	2,248,521	95,922.90	148,182.13	344,747.05
Accommodation and food services	4,560,115	103,406.89	185,862.54	359,120.06
Arts, entertainment, recreation and other service activities	4,092,717	112,170.65	204,216.93	346,038.24
IT and other information services	1,580,640	103,596.00	161,509.49	306,048.75
Computer, electronic and optical products	773,858	50,887.76	98,402.35	268,680.41
Coke and refined petroleum products	93,487	11,365.30	27,097.77	259,707.59
Electrical equipment	969,122	48,840.20	79,954.71	228,923.62
Telecommunications	433,976	29,692.89	89,979.98	190,835.44
Publishing, audiovisual and broadcasting activities	658,817	40,834.16	79,107.22	169,029.98
Other transport equipment	337,138	26,651.06	40,980.97	133,860.85
Wood and products of wood and cork	422,867	12,115.81	19,655.10	66,014.22
Mining and quarrying of non-energy producing products	155,808	6,617.08	15,844.17	36,179.62
Mining support service activities	32,272	2,374.83	8,154.53	19,081.11
Total	**103,911,900**	**3,935,675.56**	**7,263,341.74**	**14,614,191.50**

Source: EBP analysis using Avicenne data

3. Lead Acid Battery Markets

To understand the use market for lead acid batteries, we can examine trade data to understand for the EU-27 region where the markets are that Europe is both importing from as well as exporting to. Specifically, we rely on the United Nation's COMTRADE database to look at international trade for two commodities in particular:

- (850710) - Electric accumulators; lead-acid, of a kind used for starting piston engines
- (850720) - Electric accumulators; lead-acid, other than for starting piston engines

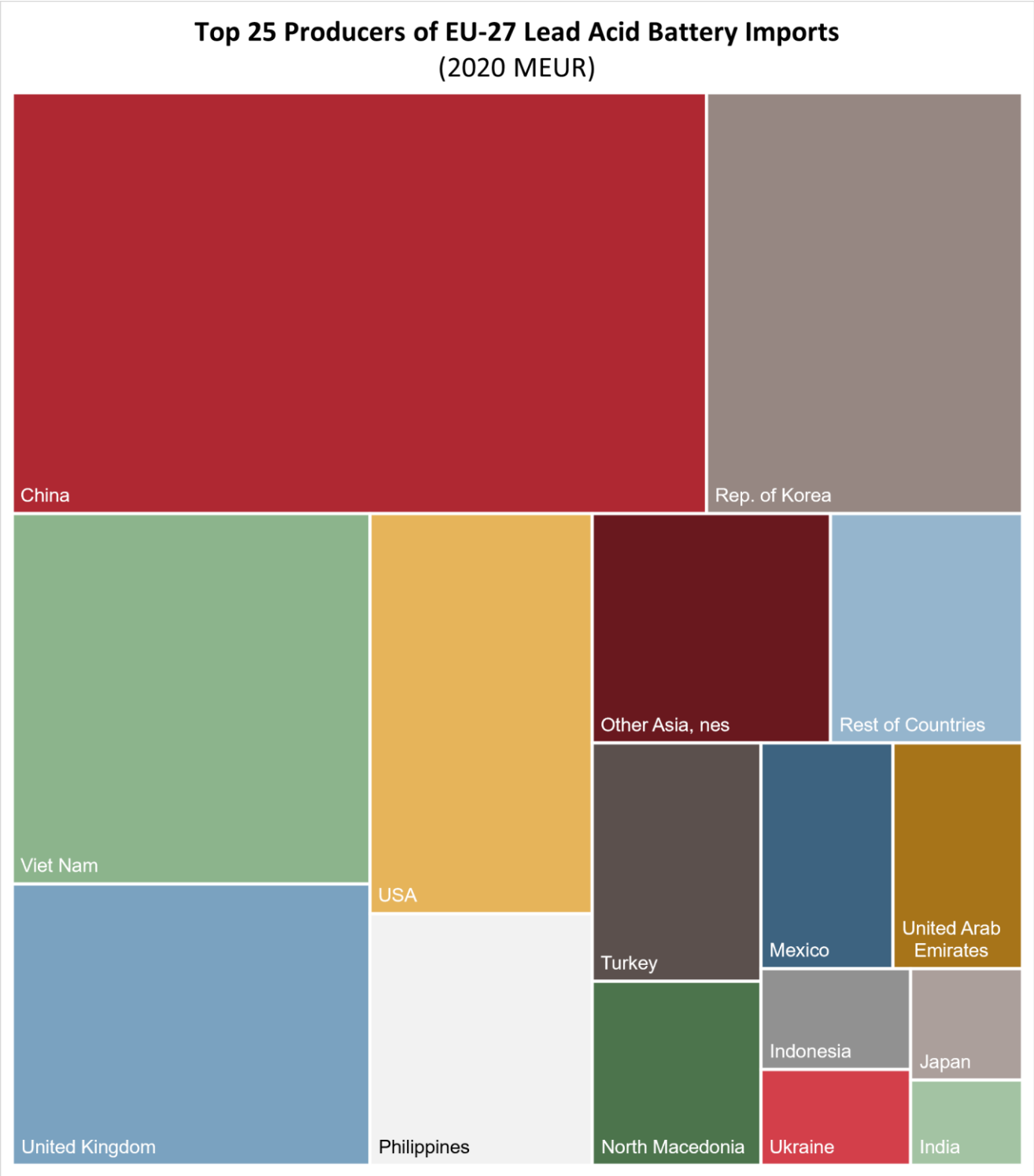
These commodities are classified using the Harmonized System (HS) and enable the reader to understand the scale of trade taking place. This data represents trade activities in 2020 that have been price adjusted using historical exchange rates to convert from USD to EUR.[8]

3.1. Import Markets

For the imports of lead acid batteries coming from non-EU countries, the following tree diagram (Figure 3-1) shows the relative value of consumption by country for the top 15 countries (plus a "rest of" category that describes the remaining value). Note that the European import market for lead acid batteries is quite concentrated, with the top 15 countries covering over 95 percent of the value of imports. Most prominent among them are China, Korea, and Vietnam, followed by the United Kingdom and United States. It is estimated that a total of €1.4 Billion Euros (1,406.1 MEUR) worth of lead acid batteries were imported into the EU in 2020, with over 61 percent of them being for non-piston engines.

[8] Note that UN COMTRADE data presents the nominal value of trade in US Dollars. We explicitly used a 2020 average exchange rate of 0.877 to put it in terms of EUROS based on historical average data from ExchangeRates.org.uk.

Figure 3-1. Top 25 EU-27 External Import Markets



Source: EBP analysis using 2020 United Nations' COMTRADE Data

Table 3-1 shows the value of EU-27 imports from outside countries, along with a breakout for the involved commodities. This table mirrors the data depicted in the preceding tree diagram.

Table 3-1. EU Sources of Imports

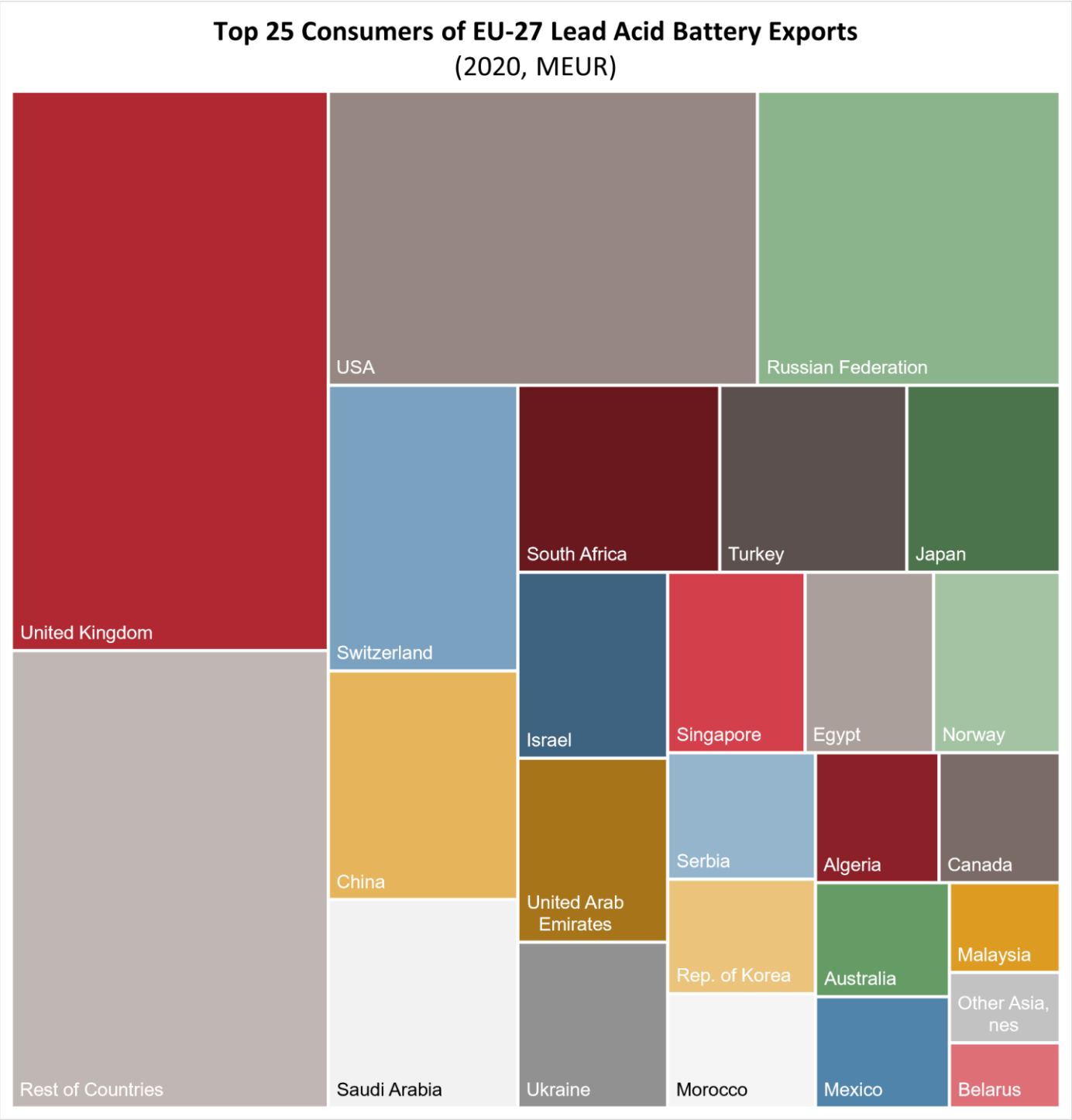
Consumers of EU-27 Imports of Lead Acid Accumulators (2020 MEUR)			
Country	**For Starting Piston Engines**	**For Non-Piston Engines**	**Total**
China	85.6	293.8	379.4
Rep. of Korea	155.5	17.0	172.5
Viet Nam	23.1	148.7	171.9
United Kingdom	45.7	85.0	130.6
United States	33.0	82.5	115.4
Philippines	0.0	72.5	72.5
Other Asia, nes	20.8	50.2	71.0
Turkey	44.8	7.4	52.2
North Macedonia	30.1	10.1	40.3
Mexico	33.5	5.2	38.7
United Arab Emirates	0.0	37.8	37.8
Indonesia	17.3	2.3	19.6
Ukraine	18.4	0.1	18.6
Japan	14.3	1.8	16.2
India	0.2	12.1	12.3
Rest of Countries	*22.4*	*34.6*	*57.0*
Total	**544.8**	**861.3**	**1,406.1**

Source: EBP analysis using 2020 United Nations' COMTRADE Data

3.2. Export Markets

Compared to the list of countries which the EU imports lead acid batteries from, its export market is more diffuse. The top 25 trade partners account for over 86 percent of all export activity by value. For 2020, approximately €2.0 billion (1,957 MEUR) worth of lead acid battery exports are traded with non-EU countries. The top external markets (by value, based on size of the square) are the United Kingdom, United States, Russia, Switzerland, China, and South Africa as shown in Figure 3-2.

Figure 3-2. Top 25 EU-27 External Export Markets



Source: EBP analysis using 2020 United Nations' COMTRADE Data

Table 3-2 explicitly shows the value of EU-27 exports to the countries, along with a breakout for the involved commodities. This table mirrors the data depicted in the preceding tree diagram.

Table 3-2. EU-27 Export Markets

Consumers of EU-27 Exports of Lead Acid Accumulators (2020 MEUR)			
Country	For Starting Piston Engines	For Non-Piston Engines	Total
United Kingdom	213.4	112.3	325.7
United States	124.2	107.1	231.2
Russian Federation	78.4	84.8	163.2
Switzerland	51.0	48.5	99.5
China	50.8	28.8	79.6
Saudi Arabia	47.8	24.7	72.5
South Africa	61.0	8.3	69.3
Turkey	37.8	26.4	64.2
Japan	44.3	8.3	52.7
Israel	26.9	24.3	51.2
United Arab Emirates	24.9	25.7	50.6
Ukraine	30.6	14.9	45.5
Singapore	23.2	22.2	45.5
Egypt	18.7	23.7	42.5
Norway	22.9	19.0	41.9
Serbia	27.7	6.6	34.3
Rep. of Korea	18.9	12.1	31.0
Morocco	22.2	8.7	30.9
Algeria	23.3	6.2	29.6
Canada	7.7	21.2	28.9
Australia	5.0	23.0	28.0
Mexico	21.0	6.3	27.4
Malaysia	7.0	11.3	18.2
Other Asia, nes	9.0	5.2	14.3
Belarus	8.9	4.3	13.2
Rest of Countries	*114.2*	*152.0*	*266.1*
Total	**1,120.7**	**836.1**	**1,956.8**

Source: EBP analysis using 2020 United Nations' COMTRADE Data

4. Companies Surveyed

The following companies responded to the survey. They represent a mix of manufacturers, lead recyclers, and mining companies.

- Accumalux Group
- AMER-SIL SA
- Banner GmbH
- Boliden Bergsöe AB
- Britannia Refined Metals Ltd
- Campine nv
- Clarios EMEA
- Ecobat, LLC
- Enersys
- Envirowales Limited
- Exide Technologies
- FIAMM Energy Technology S.p.A.
- FRÖTEK - Kunststofftechnik GmbH
- Hollingsworth and Vose
- HOPPECKE Batterien & Co. KG
- Kovohutě Příbram nástupnická, a.s.
- Metallo Belgium NV
- Midac spa
- Rosendahl Nextrom GmbH
- SOMINCOR - Sociedade Mineira de Neves Corvo, S.A.
- sovema group spa
- Sunlight Systems S.A.
- TBS Engineering Ltd
- Unknown
- Water Gremlin Aquila Company SpA
- WEGMANN automotive GmbH
- Zinkgruvan Mining AB

5. Appendices

A1 Input-Output Model Methodology

EBP developed a custom multiplier model to estimate the simultaneous economic responses stemming from activity taking place in the lead battery industry across multiple European counties. Given the trade linkages among the 30 countries in the analysis, we simulated the effects using a multiregional input-output model (MRIO model).

We derived the model using the Leontief inverse process. However, it departs from the usual single-region estimation process when it endogenizes a portion of the export/import activity related to trade among the 30 countries. The table below illustrates a typical multiregional model layout, with the off diagonals representing trade between regions taking place.

Country 1 Input-Output	Country 1 (Export) Country 2 (Import)
Country 2 (Export) Country 1 (Import)	Country 2 Input-Output

The diagonals in grey represent the individual models for each country. This appendix documents the sources, processes, and assumptions underlying the model. It also discusses data necessary to estimate certain impacts and the process of filling gaps in the survey results.

Data Sources and Methods

EBP used the following data sources to develop the multi-regional multiplier model:

- OECD Inter-Country Input-Output (ICIO) tables (2018 edition)
- OECD Country by Industry Employment by NACE
- Eurostat Full International and Global Accounts for Research in input-Output analysis (FIGARO) tables
- Switzerland Federal Statistical Office employee compensation data
- Eurostat Social Security contribution data

We used OECD Inter-Country Input-Output tables as the basis for the model because they offer three main benefits: First, consistency in structure and industry detail made it easier to relate the countries together and to draw equivalence between sectors of the economy to put things on an even footing for discussions. Second, the data is in consistent units (USD), which simplified the exercise by removing the bulk of currency conversion from the task for non-EU countries (and could easily convert to euro equivalent denominations through a constant exchange rate factor). Third, OECD has detail on the composition of imported activity by industry from each country, rather than a single total imports line by industry without full detail. This provided a robust platform to generate an economic model from because it satisfies the following three criteria:

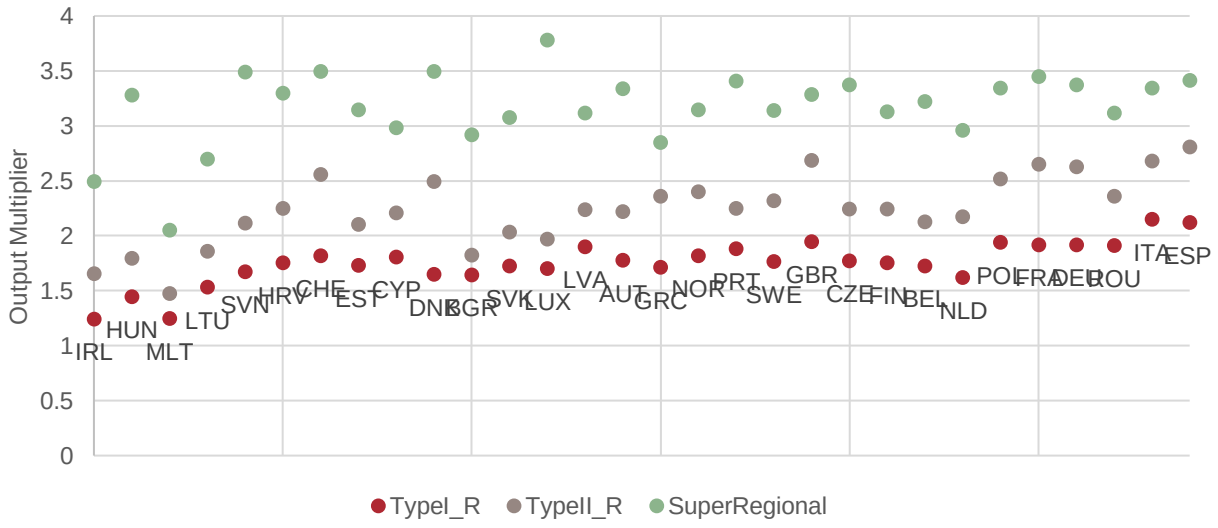
1. Exports, imports, and their use in both countries are explicit
2. Both models are enumerated based upon a common sectoring description
3. Both models are in common units of measurement

We evaluated Eurostat FIGARO tables as an alternative option to the OECD tables, but they do not have the necessary countries (though they do offer more sectoral detail). One added challenge was the inclusion of employment by industry, which is not typically a standard part of input-output tables. OECD has the most readily usable data on employment by country and industry, but still suffers from issues of suppression in the form of aggregated industries. We addressed this by distributing jobs among aggregated sectors on the basis of respective economic output, which is tantamount to assuming similar industries have constant productivity.

A2 Estimation of Total Multiplier Effects and Employment

EBP also estimated multiplier effects related to worker income re-spending. Since the information for each region related to household consumption was already present, the challenge was to estimate worker industry compensation. We estimated this by taking employee compensation as a share of value added from the FIGARO model and applying it to the OECD model. For the inclusion of Switzerland into the model, we harvested equivalent data from the Federal Statistical Office of Switzerland. This enabled the endogenization of household behavior for the induced behavior.

As an example, the figure below shows a summary of multiplier magnitudes for the basic metals industry sector. TypeI_R multipliers capture the direct and indirect (supply chain purchase) impacts of a country on itself. TypeII_R multipliers capture the TypeI_R plus induced impacts (total economic impacts) generated by a country on itself. Superregional multipliers depict the additional indirect and induced impacts generated in other countries through bilateral trade (that are not felt in the country where the shock originated).



Source: EBP analysis of OECD Data

Estimation of Social Security Contributions

To estimate the value of social security contributions collected from economic activity, EBP gathered information about contributions as a percent of GDP using OECD data as the primary source.[9] This information is at a country-level and lacks per-industry industry detail. OECD data is not inclusive of all 30 countries in the analysis; it lacks the following countries:

- Bulgaria
- Croatia
- Cyprus
- Malta
- Romania

We filled in the missing pieces of information using Eurostat data from the Main National Accounts Tax Aggregates series (social security funds as a percent of GDP).[10]

[9] https://data.oecd.org/tax/social-security-contributions.htm
[10] https://ec.europa.eu/eurostat/databrowser/view/gov_10a_taxag/default/table?lang=en

A3 Imputation of Direct Effect Measures

Survey responses captured 137 distinct combinations of country-industry activities across all 30 countries. Gaps in collected data due to availability or confidentiality of data meant that not all primary measures of activity were available. To calculate direct impacts, EBP imputed this data using economic relationships present in the constructed MRIO model. The table below shows the distinct number of activities tabulated based on the completeness of responses.

Has Employment	Has Payroll	Has Revenue	Number of Respondents
1	1	1	46
1	0	1	27
1	1	0	5
0	0	1	54
0	1	1	1
1	0	0	3
0	1	0	1

To fill in the missing measures, we applied the heuristics described below.

Missing information about employment:

- If a respondent provided business revenue, we estimated the level of employment by multiplying the provided revenue by a ratio of the equivalent country-industry's employment per unit of output from the economic model.
- If a respondent did not provide business revenue, we estimated the level of employment by multiplying the provided payroll by a ratio of the equivalent country-industry's employee compensation per unit of output from the economic model.

Missing information about employee compensation:

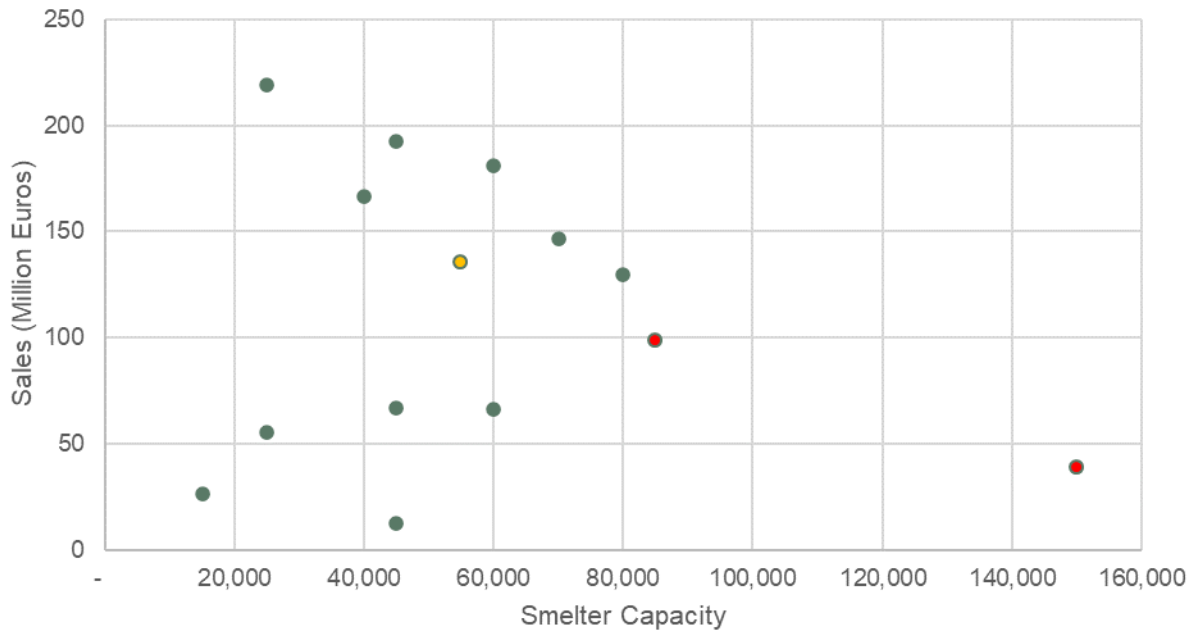
- If a respondent provided business revenue, we estimated the level of employee compensation by multiplying the provided revenue by a ratio of the equivalent country-industry's employee compensation per unit of output from the economic model.
- If a respondent did not provide business revenue, we estimated the level of employee compensation by multiplying the provided employment by a ratio of the equivalent country-industry's employee compensation per worker from the economic model.

Missing information about business revenue:

- If a respondent provided employment, we estimated the level of revenue by multiplying the provided employment by a ratio of the equivalent country-industry's output per worker from the economic model.
- If a respondent did not provide employment, we estimated the level of revenue by multiplying the provided employee compensation by a ratio of the equivalent country-industry's employee compensation per unit of output from the economic model.

A4 Imputation of Missing Lead Producers

Not all lead producers responded to the survey. To fill in absent sales figures for these missing companies, we attempted to use the relationship between ILA-provided smelter capacity and sales figures from the subset of survey respondents matching the provided list. The figure below shows the relationship.



Note that there appear to be two conflicting linear trends present in the plot—both increasing and decreasing trends of sales as capacity increases. As a point of clarity, almost all survey respondents provided sales data, meaning we are not witnessing an artifact of the process of filling out direct effects. The only one in this sample that did not provide sales data is represented by the yellow dot on the chart. The red dots indicate the survey respondents that were classified as primary lead smelting; all the rest were classified as secondary smelters (primarily engaged in other activities).

It is expected that the relationship between capacity and sales is a much more tenuous one for industries classified as 'secondary' due to their activities in other parts of the lead battery supply chain. To try and acknowledge this distinction, we took an average sales-per-smelter capacity for primary versus secondary activity respondents and applied the ratios to the out-of-survey population that had to be imputed.

To validate the reasonableness of our estimates, we compared smelter capacity and sales activity of survey respondents to the non-respondents to see how the percentages compared. We found that the survey respondents equaled approximately 37 percent of smelter capacity but accounted for roughly 52 percent of sales.

A5 Avoidance of Double-Counting Business Activity

Because of the decision to model suppliers (smelters, manufacturing equipment producers, battery terminals, lead mining) alongside explicit lead acid battery manufacturing activity, an explicit adjustment had to be made so that the same suppliers captured as a direct effect were not being recounted as a simultaneous indirect effect of battery manufacturers. To do this, we explicitly zeroed out the indirect effect of battery manufacturers (and corresponding proportion of induced activity) tied to sectors being modeled as directs (primary/secondary smelting, lead mining, battery manufacturing equipment manufacturing, support services for mining, battery components/separators). In this manner, the above figures are distinct and additive as we have presented them.

A6 Methodology for Estimating Downstream Effects

To estimate the downstream effects of the lead battery industry, three things had to occur: First, an estimate of the magnitude of demand for batteries for each industry had to be estimated. To do this, the raw form of the economic model communicating the industry consumption of European commodities was used to identify how much demand for electrical component manufacturing was present in each industry.

Second, a refined estimate of battery demand had to be backed out of the electrical equipment sector of the economic model. Intuitively, we know that on an industry-by-industry basis, more or less of the electrical equipment sector might be related to purchases of batteries for various end uses; we needed a method for estimating how much. As a note, the economic model defines the electrical component sector using the following NACE codes:

C.27 - Manufacture of electrical equipment

- C.27.1 - Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus
- C.27.11 - Manufacture of electric motors, generators and transformers
- C.27.12 - Manufacture of electricity distribution and control apparatus
- C.27.2 - Manufacture of batteries and accumulators
- C.27.20 - Manufacture of batteries and accumulators
- C.27.3 - Manufacture of wiring and wiring devices
- C.27.31 - Manufacture of fibre optic cables
- C.27.32 - Manufacture of other electronic and electric wires and cables
- C.27.33 - Manufacture of wiring devices
- C.27.4 - Manufacture of electric lighting equipment
- C.27.40 - Manufacture of electric lighting equipment
- C.27.5 - Manufacture of domestic appliances
- C.27.51 - Manufacture of electric domestic appliances
- C.27.52 - Manufacture of non-electric domestic appliances
- C.27.9 - Manufacture of other electrical equipment
- C.27.90 - Manufacture of other electrical equipment

To resolve this estimation problem, we had to assume that the industry technology matrix (production process determining what an industry uses to produce goods) was broadly similar to the United States model. This allowed us to leverage the U.S. model's explicit accounting of the battery industry relative to background electrical equipment industries. Note that we are deliberate here in our usage of the term "battery industry"—there are no available models that distinguish between lead battery versus other types of batteries available. If we aggregate the U.S. model to the sectoring of the European economic model we derived, we get the following split in electrical equipment demand for battery versus background components:

Industry From Economic Model	%Battery	% Non Battery
Agriculture, forestry and fishing	91%	9%
Mining and extraction of energy producing products	0%	100%
Mining and quarrying of non-energy producing products	75%	25%
Mining support service activities	75%	25%
Food products, beverages and tobacco	0%	100%
Textiles, wearing apparel, leather and related products	0%	100%
Wood and products of wood and cork	9%	91%
Paper products and printing	0%	100%
Coke and refined petroleum products	26%	74%
Chemicals and pharmaceutical products	0%	100%
Rubber and plastic products	0%	100%
Other non-metallic mineral products	0%	100%
Basic metals	0%	100%
Fabricated metal products	0%	100%
Computer, electronic and optical products	9%	91%
Electrical equipment	1%	99%
Machinery and equipment, nec	7%	93%
Motor vehicles, trailers and semi-trailers	13%	87%
Other transport equipment	13%	87%
Other manufacturing; repair and installation of machinery and equipment	0%	100%
Electricity, gas, water supply, sewerage, waste and remediation services	0%	100%
Construction	0%	100%
Wholesale and retail trade; repair of motor vehicles	33%	67%
Transportation and storage	2%	98%
Accommodation and food services	2%	98%
Publishing, audiovisual and broadcasting activities	1%	99%
Telecommunications	1%	99%
IT and other information services	1%	99%
Financial and insurance activities	48%	52%
Real estate activities	13%	87%
Other business sector services	10%	90%
Public admin. and defence; compulsory social security	14%	86%
Education	0%	100%
Human health and social work	15%	85%
Arts, entertainment, recreation and other service activities	4%	96%

Using these numbers, we adjusted the estimation of end users in the model by taking the demand for electrical equipment by each industry and multiplying it by the percent of component demand that is battery from the table above (by industry). This was then normalized to give a method of allocating demand for batteries to end use, that if done properly would broadly mimic the distribution of the Avicenne sales data while providing the necessary detail to model downstream jobs and GDP supported in the report.

To compare the allocation basis to actual numbers, the third step involved cleaning and interpreting the Avicenne data relative to our method of allocation. We took the 2019 European domestic demand data and aggregated it to a higher level of detail and estimated the share of demand from it (see following table). This was explicitly calculated by taking the 7.4 billion Euros

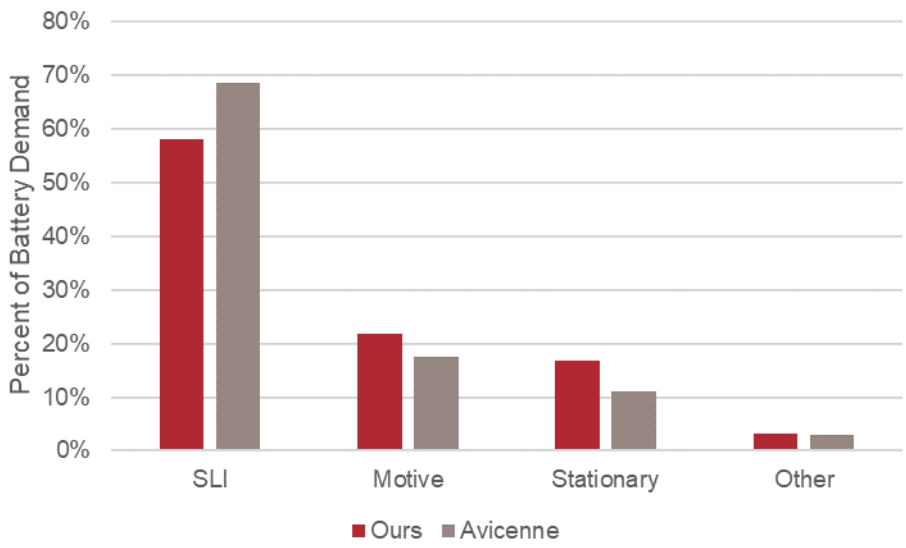
of domestic demand and deflating it by the 2019 proportion of domestic supply versus imported goods to arrive at the components going toward downstream local demand applications (equal to about 6 billion Euros in lead-acid battery sales).

Aggregated Type	End User	2019 Sales (MEUR)	% of Demand
SLI	SLI	4,005	67.1%
Motive	E-Bikes, Golf Carts	45	0.8%
Motive	Motive	1,039	17.4%
Stationary	Stationary	724	12.1%
Other	Others	153	2.6%
Total		**5,966**	**100%**

If we classify the sectors in our economic model to equivalent use type we get the following:

Model Sector	Allocation	Battery Use Type
Wholesale and retail trade; repair of motor vehicles	**23%**	SLI
Motor vehicles, trailers and semi-trailers	**18%**	Motive
Machinery and equipment, nec	**12%**	SLI
Computer, electronic and optical products	**10%**	SLI
Agriculture, forestry and fishing	6%	Stationary/SLI
Other business sector services	5%	Stationary
Financial and insurance activities	5%	Stationary
Other transport equipment	**4%**	Motive
Public admin. and defence; compulsory social security	3%	Other
Real estate activities	3%	Stationary
Human health and social work	2%	Stationary
Electrical equipment	**2%**	Stationary/SLI
Coke and refined petroleum products	1%	Stationary/SLI
Mining and quarrying of non-energy producing products	1%	Stationary/SLI
Transportation and storage	**1%**	Motive/SLI
Construction	1%	Stationary/SLI
Arts, entertainment, recreation and other service activities	1%	Stationary
Mining support service activities	0%	Stationary/SLI
Wood and products of wood and cork	0%	Stationary
Telecommunications	0%	Stationary
Accommodation and food services	0%	Stationary
IT and other information services	0%	Stationary
Other manufacturing; repair and installation of machinery and equipment	0%	Stationary/SLI
Publishing, audiovisual and broadcasting activities	0%	Stationary
Education	0%	Stationary
Food products, beverages and tobacco	0%	Stationary

Note that the percentages should be interpreted as the relative share of battery demand across all industries. By aggregating and comparing the model to aggregated Avicenne sales data, we end up with the following:



Based on similarities in the share of battery demand by end use, we can conclude that our methodology is reasonable in its application and able to be used to estimate the downstream users. The result is that we can take the regional demand (not including imports) for batteries by Avicenne and allocate it out to industries to get the magnitude of battery inputs to production, which are used to estimate downstream effects.

A note on downstream effects: The proper interpretation of downstream effects can be thought of as lead acid batteries are a vital input to industries both as an input to manufacturing but also to support operations. The 6 billion Euro domestically produced battery market is used as inputs to production and operations for wide-ranging economic activities responsible for 7.3 trillion Euro of the region's GDP, as shown below and on the following page.[11]

	Employment	Compensation	GDP	Output
Battery Affected Industry	103,911,900	3,935,676	7,263,342	14,614,192
Total Economic Activity	233,473,908	9,227,221	17,371,341	35,465,450
Percent of Total Activity	45%	43%	42%	41%

[11] Note this is inclusive of non-EU countries like Norway, Switzerland, and the UK from the economic model used to derive earlier impacts.

Impacted Industries				
Industry Desc.	**Emp**	**Compensation (MEUR)**	**GDP (MEUR)**	**Output (MEUR)**
Wholesale and retail trade; repair of motor vehicles	21,492,879	$ 692,247	$ 1,221,481	$ 2,233,542
Construction	9,347,060	$ 323,111	$ 572,373	$ 1,469,670
Transportation and storage	7,401,230	$ 313,724	$ 537,085	$ 1,291,927
Other business sector services	11,554,873	$ 413,052	$ 732,452	$ 1,335,715
Real estate activities	1,015,605	$ 38,239	$ 756,170	$ 991,540
Public admin. and defence; compulsory social security	6,405,305	$ 352,595	$ 470,572	$ 702,369
Financial and insurance activities	2,418,505	$ 186,510	$ 365,522	$ 772,799
Human health and social work	9,790,622	$ 374,283	$ 502,071	$ 757,114
Machinery and equipment, nec	1,922,085	$ 116,190	$ 182,319	$ 505,521
Food products, beverages and tobacco	1,917,771	$ 78,082	$ 140,073	$ 549,381
Motor vehicles, trailers and semi-trailers	1,108,621	$ 71,996	$ 124,881	$ 470,563
Agriculture, forestry and fishing	6,878,825	$ 46,620	$ 163,501	$ 383,321
Education	6,299,181	$ 284,550	$ 335,894	$ 422,463
Other manufacturing; repair and installation of machinery and equipment	2,248,521	$ 95,923	$ 148,182	$ 344,747
Accommodation and food services	4,560,115	$ 103,407	$ 185,863	$ 359,120
Arts, entertainment, recreation and other service activities	4,092,717	$ 112,171	$ 204,217	$ 346,038
IT and other information services	1,580,640	$ 103,596	$ 161,509	$ 306,049
Computer, electronic and optical products	773,858	$ 50,888	$ 98,402	$ 268,680
Coke and refined petroleum products	93,487	$ 11,365	$ 27,098	$ 259,708
Electrical equipment	969,122	$ 48,840	$ 79,955	$ 228,924
Telecommunications	433,976	$ 29,693	$ 89,980	$ 190,835
Publishing, audiovisual and broadcasting activities	658,817	$ 40,834	$ 79,107	$ 169,030
Other transport equipment	337,138	$ 26,651	$ 40,981	$ 133,861
Wood and products of wood and cork	422,867	$ 12,116	$ 19,655	$ 66,014
Mining and quarrying of non-energy producing products	155,808	$ 6,617	$ 15,844	$ 36,180
Mining support service activities	32,272	$ 2,375	$ 8,155	$ 19,081
Total	**103,911,900**	**$ 3,935,676**	**$ 7,263,342**	**$ 14,614,192**