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ABSTRACT: Technologies that are used in different production processes of miscellaneous industries are known as cross-sectional technologies. The economic importance of these technologies normally is measured by economic benchmarks of the producing industry. However, the impact of these technologies for the whole economy is often not exactly known. By using a modified input-output approach, it is shown for the welding technology how much the economic importance of a cross-sectional technology exceeds the economic importance of the technology producing industry.

KEYWORDS: Cross-sectional technologies; benchmark; input-output analysis; decomposition; multipliers

1. Introduction

Technologies that are used in different production processes of miscellaneous industries are known as cross-sectional technologies (CST). To quantify the economic importance of such technologies in terms of their contribution to the gross value added is difficult, because general national income and product accounts as well as input-output (I-O) accounts show statistical results for branches or groups of products but not for technologies. Measuring the economic contribution of a CST by the output of the technical goods, would take into account only the contribution of the production of the technological goods. This approach leads to a statistical underestimating of CST. Therefore, the contribution to the gross value added of those manufacturing processes using CST in so-called user-industries is also taken into account.

For the approach the open static I-O model is applied that shows the economic impacts of a known final demand. The effects of a CST consist of two parts: (a) the effects of the demand for the technical goods of a CST, including all the intermediate goods that are necessary for the production of the technology and (b) the effects that come from using a CST in manufacturing processes of user-industries. The results show the importance of a CST in a given economic situation.

As an example for a typical CST the welding technology is chosen, because it is applied in various industries. Furthermore, there is a tight connection to industries, which deliver auxiliaries and additional goods for the welding processes – the so-called complementary (CPL) goods industries.

The following formal description of the effects of manufacturing and using a CST starts with some remarks on the general case of analyzing a final demand in one or more industries. In a next step, total and direct effects are derived, and multipliers and indirect effects are defined. After these methodological considerations the characteristics of the three cases CST industry, CPL-goods industries and user-industries are developed. Furthermore, the used data sources are described and the empirical results for the welding technology are presented. Finally, in a conclusion the main results are emphasized.

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2. Methodological considerations

To evaluate the importance of a CST, effects on value added and employment are used as main economic indicators. Effects on output are only used to calculate the value added and employment effects. On industry level there are effects from manufacturing as well as effects from using CSTs. Therefore, the approach in this paper can be named as a multi-level decomposition analysis for CST manufacture and its use. Figure 1 shows how the total effects on the chosen indicators will be developed.

Type of Effect	Effect	Description
Direct	I	Output, value added and employment in the CST manufacturing industry.
	II	Output, value added and employment in complementary (CPL) goods industries of CSTs.
	III	Part of the value added and employment in so-called user-industries that comes from using a CST.
Indirect	IV	Output, value added and employment of intermediate goods for the CST manufacturing industry.
	V	Part of the value added and employment of intermediate goods for manufacturing processes in user-industries induced by the application of a CST.

Figure 1: Economic effects of a CST.

While the first three issues are direct effects that normally can be collected from statistical data or calculated with shares from value added and employment from I-O data respectively, the last two issues are so-called intermediate or indirect effects that will be received from an I-O model[1]. Finally, the sum over all effects shows the economic significance of a cross-sectional technology for both indicators for a selected period.

2.1. Total effects

The classical I-O model

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1} \cdot \mathbf{f} \tag{1}$$

allows the analysis of the effects of a final demand on gross output. The main issue of this model is the LEONTIEF-inverse matrix $(\mathbf{I} - \mathbf{A})^{-1}$ that reflects the intermediate structure of an economy. For an analysis of a final demand in more than one industry, it is useful to transform the $(n \times 1)$-vector $\mathbf{f}$ in a diagonal matrix $diag(\mathbf{f})$ with m elements $(m \leq n)$ $F_{ij} \neq 0$ and $(n-m)$ elements $F_{ij} = 0, i = j = 1,...,n$, on its main-diagonal. This ensures that the effects induced in each industry can be treated separately. The I-O model then is

[1] A further effect – classified between effect IV and V - for intermediate goods in industries that manufacture complementary goods for a CST could also be analysed. But in practice it will not be very significant.

$$\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1} \cdot diag(\mathbf{f}) \tag{2}$$

The results show up in the $(n \times n)$-matrix $\mathbf{X}$ with elements X_{ij}. In each column j it contains output effects from the final demand in industry $i, i = j$. The total effects on gross output from a final demand in industry i can be calculated for column j as

$$X_j = \sum_{i=1}^{n} X_{ij} \tag{3}$$

For all n industries this leads to a $(1 \times n)$-vector $\mathbf{x}$ with elements X_j of total output effects. In the whole economy the total effect on gross output is

$$X = \sum_{j=1}^{n} X_j = \sum_{j=1}^{n} \sum_{i=1}^{n} X_{ij} \tag{4}$$

By using the result from (2) together with the diagonal matrix $diag(\mathbf{q}_Y)$ with coefficients $y_{ij}, i = j = 1,...,n$, for the ratio between value added and output of industry i, the effects on value added appear in the $(n \times n)$-matrix $\mathbf{Y}$ that is

$$\mathbf{Y} = diag(\mathbf{q}_Y) \cdot \mathbf{X} \tag{5}$$

In a similar way the effects on employment can be obtained as

$$\mathbf{E} = diag(\mathbf{q}_\pi) \cdot \mathbf{Y} \tag{6}$$

with $diag(\mathbf{q}_\pi)$ as the diagonal matrix of inverse coefficients of the labor productivity $\pi_{ij}, i = j = 1,...,n$ that is defined as ratio between value added and employment in industry i from I-O data.

The total effects on value added and employment for each industry i as well as for the whole economy can be calculated in analogy to (3) and (4).

2.2. Direct effects

As a result of the structure of the LEONTIEF-inverse matrix, the direct effect on output of a final demand $F_{ij} \neq 0, i = j$, in industry i is part of the total output effect in the same industry that is an element of the main-diagonal of matrix $\mathbf{X}$.

$$X_{ij}^{direct} = F_{ij} , \quad i = j \tag{7}$$

Using the coefficients of value added y_{ij} and the labor productivity $\pi_{ij}, i = j$, of industry i the direct effects on value added and employment are

$$Y_{ij}^{direct} = y_{ij} \cdot X_{ij}^{direct} , \quad i = j \tag{8}$$

and

$$E_{ij}^{direct} = \frac{1}{\pi_{ij}} \cdot Y_{ij}^{direct}, \quad i = j. \tag{9}$$

2.3. Multipliers

The results for a CST can vary with the actual demand for CST- and CPL-goods as well as for the goods of the user-industries. Therefore, multipliers are calculated as indicators for each type of industry (CST-, CPL-, and user-industries). These multipliers give a hint for the true importance of a CST that is independent from the actual demand for (specific) goods, because they are normalized to a single unit of additional output, value added or employment, respectively.

For each industry i a set of three multipliers for total effects on gross output, gross value added and gross employment of a final demand $F_{ij} \neq 0, i = j$, is developed. These multipliers give the ratio of the total effects to the direct effect on the particular aggregate. Using (3) and (7) the multipliers for the total effects on gross output are

$$m_{X_i} = X_j \big/ X_{ij}^{direct}, \quad i = j \tag{10}$$

In analogy, the multipliers for the total effects on gross value added and gross employment can be written as

$$m_{Y_i} = Y_j \big/ Y_{ij}^{direct}, \quad i = j \tag{11}$$

and

$$m_{E_i} = E_j \big/ E_{ij}^{direct}, \quad i = j. \tag{12}$$

2.4. Intermediate effects

The indirect effects of a final demand in industry i that occur in connection with the intermediate structure of the economy, depicted by an I-O table, result from the difference of the total and the direct effects. They can be obtained either from the total effects as in (3) or by combining each of the direct effects with the corresponding multiplier. In the latter case for industry i the intermediate effects on gross output, gross value added and gross employment are

$$X_j^{intermed.} = (m_{X_i} - 1) \cdot X_{ij}^{direct}, \quad i = j \tag{13}$$

$$Y_j^{intermed.} = (m_{Y_i} - 1) \cdot Y_{ij}^{direct}, \quad i = j \tag{14}$$

$$E_j^{intermed.} = (m_{E_i} - 1) \cdot E_{ij}^{direct}, \quad i = j \tag{15}$$

2.5. The case of CST industry

With regard to the I-O model in (2) the analysis of the CST industry itself is a special case, because only the element of $diag(\mathbf{f})$ that belongs to the CST industry is non-zero, whereas all the others are zero. For this reason, the model in (2) can be reduced to the classical one in (1). Nevertheless, also in case of CST manufacturing the notation that is derived from the I-O model in (2) will be used.

The results for the CST industry can be obtained as described in (3) to (15). In the matrices $\mathbf{X}$, $\mathbf{Y}$ and $\mathbf{E}$, there is only one column j that is non-zero. Therefore, there is also only one element X_j, Y_j and E_j of the vectors of total effects on output, value added and employment that is non-zero.

2.6. The case of complementary goods industries

Applying a CST often needs additional auxiliary materials and services that are complementary to the use of the CST. Those CPL goods industries, however, usually produce also products for other purposes, so that only a share of its output should be taken into account. The output of CPL goods from these industries induced by the use of a CST in other industries is defined by

$$\mathbf{X}_{CPL} = diag(\mathbf{q}_c) \cdot \mathbf{X} \tag{16}$$

with $diag(\mathbf{q}_c)$ as a diagonal matrix of coefficients $c_{ij}, i = j = 1,...,n$ that show the share of CPL goods on total output of industry i. To specify the c_{ij} additional statistical information – e.g. from industrial associations – is needed. Matrix $\mathbf{X}$ contains the total output effects from the final demand in all m CPL goods industries $i, i = 1,...,m \leq n$. All the other effects in CPL goods industries can be calculated as described above for the general case.

2.7. The case of CST user-industries

In principle, the analyzed CST could be applied in every industry. But in contrast to the CST- and CPL-goods industries, the appropriate share of output that can be deducted to using a CST cannot be quantified exactly, but must be developed by an auxiliary calculation. Therefore, the diagonal matrix $diag(\mathbf{q}_u)$ is used that contains coefficients $u_{ij}, i = j = 1,...,n$, for the share of value added which is induced from the application of a CST in industry i. Some of these coefficients are zero, because not all n industries are CST user-industries. To specify the coefficients, additional information is needed again. The part of value added of the user-industries, which should be taken into account, is

$$\mathbf{Y}_{User} = diag(\mathbf{q}_u) \cdot \mathbf{Y} \tag{17}$$

All further effects on value added and employment in the CST user-industries can be obtained from the equations above for the general case.

For the calculation of the overall effects of the manufacturing and use of a CST the intermediate effects on value added and employment in the user-industries have to be adjusted, because they contain some of the effects that already have been described for the CST- and CPL-goods industries. This double counting occurs, because a part of the domestic output of CST and CPL goods industries – as well as their corresponding intermediate goods – belongs to the intermediate goods of the user-industries. The adjustment can be done by subtracting exports and capital goods within the domestic output of CST and CPL goods industries. While exports of CST and CPL goods are not influencing value added of the user-industries at all, capital goods are considered in user-industries as consumption of fixed capital. The remaining part of the domestic output of CST and CPL goods industries is demanded by the user-industries for using a CST within their production processes and therefore is part of their intermediate goods.

The domestic output of CST and CPL goods industries without exports and the demand for capital goods $^{*}\mathbf{X}_{CST}$ and $^{*}\mathbf{X}_{CPL}$ is calculated by combining the total effects on output with the diagonal matrices of the export rates $diag(\mathbf{q}_{Ex})$ and the rates for the demand for capital goods $diag(\mathbf{q}_{I})$.

$$^{*}\mathbf{X}_{CST} = diag(\mathbf{q}_{Ex}) \cdot diag(\mathbf{q}_{I}) \cdot \mathbf{X}_{CST} \tag{18}$$

$$^{*}\mathbf{X}_{CPL} = diag(\mathbf{q}_{Ex}) \cdot diag(\mathbf{q}_{I}) \cdot \mathbf{X}_{CPL} \tag{19}$$

Using (5) leads to the corresponding value added $^{*}\mathbf{Y}_{CST}$ and $^{*}\mathbf{Y}_{CPL}$. Finally, subtracting $^{*}Y_{CST}$ and $^{*}Y_{CPL}$ from the total effect on value added of using a CST, which can be obtained by the application of (3) and (4), results in the adjusted intermediate effects on value added in the user-industries.

$$^{*}Y_{User} = Y_{User} - (^{*}Y_{CST} + {}^{*}Y_{CPL}) \tag{20}$$

Analogously to the effect on value added the indirect effects on employment could be adjusted.

3. Data sources

The analysis is based primarily on data from the German Federal Statistical Office, especially I-O tables for Germany for the year 2000. To analyze the impacts of welding technology the I-O table was extended by a column and a row for welding engineering using further information about the intermediate consumption of welding engineering and its application in different industries. In addition, statistics of production for the year 2002 were applied to gain information about the demand for welding machines and related products. The German Federal Statistical Office also supplies special labor market data that was used. These data is presented in a matrix whose columns contain about 70 industries and whose rows give information about 146 professions. Each element gives the number of employees of a certain profession in a certain industry. The data collected originate from a micro census of the German National Statistical Office of the year 1999. Moreover, the German Welding Society (DVS), an association for welding and related technologies, provided information about the share of CPL-goods for welding from the total output of the CPL-goods industries as well as the share of welding activities in different professions.

4. Empirical Results

Welding machines and robots are technological high developed special devices, used as well in simple but also in high specialized manufacturing processes for capital goods and durable goods. The welding technology is connected to many intermediate industries. On the one hand the input side of the user-industries includes the welding machine itself. On the other hand there are a lot of supplement input goods – electrodes, welding gas, other supporting goods, control machines – which are also necessary in welding processes (CPL-goods). However, in the presented approach the technical goods for welding are distinguished from the welding processes as part of the production processes in user-industries.

To estimate the direct effects set off by the demand for welding technology, the production statistics of the year 2002 published by the Federal Statistical Office of Germany is evaluated. In this statistics the output of detailed product groups of all industries are published. The output, however, can be used as indicator for the demand for welding technology, because it contains only domestic output for sales and not for stock (table 1). The demand for welding technology comes up to 1.4 billion € in 2002 (*effect I*). Because of the lack of data about welding engineering, an identical ratio between value added and output in that industries as well as in the industry of mechanical engineering of about 40 percent is assumed, that gives a value added of about 0.6 billion for welding engineering. Furthermore, assuming an identical labor productivity in the industry of welding technology and in the industry of mechanical engineering of 54,744 € per employee, the demand for welding technology gives work for about 16,660 persons in that industry.

Table 1: Domestic output of welding technology, Germany 2002

	Value in mills €	Structure in %
1. Soldering and welding machines, devices and equipment		
1.1 Non-electric machines	91	6.3
1.2 Electric equipment for soldering	59	4.1
1.3 Devices for resistance welding of metals	311	21.5
1.4 Devices for arc and plasma welding	64	4.4
1.5 Other devices for resistance welding of metals	189	13.0
1.6 Other devices for arc and plasma welding	123	8.5
1.7 Other devices for welding and injection of metals	91	6.2
1.8 Other devices for welding of non-metals	366	25.3
Total welding machines	1,294	89.2
2. Welding robots	156	10.8
Total	1,450	100.0

[1] Federal Statistical Office of Germany, 2002.

In connection with welding processes, additional and complementary goods are necessary. Therefore, besides the direct effects of the demand for of welding technology also the direct effects of the demand for complementary goods for the welding process have to be included (*effect II*). Complementary goods for the welding process are all additional goods and auxiliaries for welding, working clothes with a special protection function, safety goggles, ventilation systems necessary during the welding process, machines for quality tests for welded points and seams, welding gas as wells as services for further education for the welders (table 2).

Table 2: Complementary goods for welding, Germany 2002

	Total demand	Share of demand for welding	Demand induced by welding	Share of value added	Value added ascribed to welding	Employees
	in mills €	in %	in mills €	in %	in mills €	in persons
Additionals and auxiliaries for welding	280	100.0	280	32.1	90	1,593
Working clothes, safety goggles	309	5.0	15	25.7	4	102
Ventilation systems, machines for quality tests	458	5.0	23	41.1	9	170
Welding gases	1,067	30.0	320	27.9	89	1,012
Educational services for the welders	115	100.0	115	82.9	95	2,333
Total	2,229		753		288	5,210

Author's calculation according to data of the German Federal Statistical Office and German Welding Society (DVS), 2002.

The demand for additionals and auxiliaries for welding amounts to 280 million €. Multiplying the output with the average ratio of value added to output of mechanical engineering of 32 percent leads to a value added of 90 million € in 2002. Furthermore, the adequate part of the output of working clothes with a special protection function and safety goggles, necessary for welding processes must be taken into account. There is no information about the actual proportion of those devices used for carrying out welding processes, however, the German Welding Society (DVS) assumes that 5 percent of the annual demand of those goods are used for welding. Against this background, the output of working clothes and protection devices for the welders amounts to 15 million €. Multiplying the demand with the specific value added ratio for the clothing industry of 26 percent, a value added of 4 million € is induced by the demand of protection devices for welders.

The demand and value added of ventilation systems and machines for quality tests occurring in connection with the welding processes are calculated in an analogous way. Because of the lack of data, again a 5 percent share (23 million € in 2002) of the total demand of those machines and systems is ascribed to the welding processes. This demand for ventilation systems and machines for quality tests during the welding process induces a value added of 9 million €.

The total demand for gas manufactured in the chemical industry, which is suitable for welding processes, amounts to 1.1 billion €. This gas used is for different purposes, however, the German Welding Society assumes that 30 percent of the demand for gas, that is 320 million €, is used in connection with the application of welding technology. Assuming that the average value added ratio of the chemical industry of 28 percent is also suitable for the production of welding gas, a value added of 89 million € and 1,012 employees are induced by welding processes.

An additional source of value added in connection with the application of welding technology is educational services for the welders. Analyzing a publication concerning the educational activities of the German Welding Society (DVS 2000), 105.000 employees have attended an educational training and passed a test approved by the Association of Technical Inspection for a continued education in welding techniques. The education enclosed 15 million lessons in the year 2000. From the cost accounting of the Association, expenditures of 7.7 € per hour are taken as a basis for further estimation. Assuming that these expenditures can be interpreted as output, the output or rather the demand for further education in welding techniques sums up to 115 million €. With an average ratio for value added in education of 83 percent a value added of 95 million € is induced by further education activities in welding engineering.

Summing up the total effects of the demand for complementary goods for the welding technology (*effect II*), a total demand of 753 million € and a total value added of 288 million € result. Based on the average labor productivities in the different industries, 5,210 employees are connected with this value added. Relating those numbers of value added of the complementary effects of welding (*effect II*) to the value added caused by the direct demand for welding technology (*effect I*), the latter is 44 percent of the former. One unit value added induced by the demand for welding technology leads to a value added of more than 0.4 units of the originate impulse in the industries of complementary goods.

A further contribution of the welding technology to the economy-wide value added comes from effects of using these CST. However, only a share of the total value added in the different industries can be ascribed to the welding technology. Because of the lack of data, an auxiliary calculation is carried out using the so-called industry-by-professions matrix of the German Federal Statistical Office. Assuming constant labor productivities, the share of welders to all professions in an industry is now used as an indicator for estimating the share of total value added per industry, which can be ascribed to welding processes (table 3). Multiplying the number of professional welders with the average labor productivity in a certain industry leads to an estimation of the value added in that industry, which is caused by the application of welding technology during the manufacturing processes. Summing up the disaggregated numbers by industry leads to 179,000 welders in the whole economy which bring about a value added of more than 9 billion €.

Table 3: Estimation of value added of welding processes by industries, Germany 2002

	Full-time welders and welding robot drivers	*	Labor productivity	=	Value added of welding processes	Value added of welding processes / gross value added of the industry
	in 1000		in 1000 €		in bills €	in %
Industry	148		55.6		8.2	1.9
Manufacturing	145		53.6		7.8	2.0
thereof:						
Metal production and processing	14		45.5		0.7	5.0
Manufacturing of metal products	39		48.7		1.9	5.1
Mechanical engineering	22		54.8		1.2	2.0
Production and distribution of electricity	3		143.7		0.4	2.0
Communication engineering	3		54.3		0.2	1.5
Medical and measuring technology, precision mechanics	2		56.9		0.1	0.7
Production of automobiles	53		58.7		3.1	7.2
Production of other vehicles	5		52.6		0.3	3.9
Construction	11		41.4		0.5	0.5
Service activities	9		52.7		0.5	0.0
thereof:						
Traffic services, pipeline transport	2		29.3		0.1	0.3
Services for enterprises	2		59.5		0.1	0.1
Other industries	11		46.7		0.5	2.3
Total industries	179		52.5		9.4	0.5

Author's calculations according to data of the German Federal Statistical Office, 1999 and 2000.

However, besides the full-time welders, whose activities are ascribed to 100 percent to welding, there are a lot of workers, which carry out different activities during their working time. For this reason it is assumed that there exist a lot of employees that are occupied by welding activities only occasionally. The contribution of value added of those so-called part-time welders must also be taken into account. It is assumed that in selected professions, which are closely related to welding, 5 percent of the total working hours can be ascribed to welding processes. In this context, the number of working hours of other professions, which are spent for welding, can be obtained. Based on this number of working hours a fictive number of full-time equivalent welders of about 88,500 persons can be estimated. Using the industry-specific labor productivities, this leads to a value added of 4.6 billion €.

All in all, from the nearly 267,000 full-time and full-time equivalent welders, a value added of 14 billion € results from the application of the welding technology in the whole economy (*effect III*). Comparing this effect to *effect I*, the former is about 21 times as high as the latter. One unit value added induced by the demand for welding technology leads to 21 units value added in the welding intensive industries.

Having quantified all direct effects of the demand for welding technology and the application of the welding technology in the different industries, in a further step, the effects of intermediate linkages (*effect IV*) of the production of welding technology are evaluated. Those indirect or intermediate effects occur in industries, which deliver intermediate goods for the welding engineering. For this reason, one can state that the demand for welding technology induces output, value added and employment in the intermediate industries. Together, both effects, the direct and the intermediate one, give the total effect in the whole economy. The relation between the direct effect on output and the corresponding total effect can be represented by the output multiplier of welding engineering that is 1.73, which can be calculated with a LEONTIEF I-O model (table 4). That means, that one unit demand for welding technology induces 0.73 units of additional output in the intermediate industries. The corresponding value added multiplier is 1.75, and the employment multiplier is 1.55 that means because of the intermediate linkages every 100 working places in the welding technology industry secure about 55 working places in other industries.

Table 4: Economic effects of the demand for welding technology in Germany 2002

Direct effects in the industry for welding technology	
Output (in mills €)	1,450
Value added (in mills €)	653
Employees	16,660
Multipliers	
Gross output	1.73
Gross value added	1.75
Gross employment	1.55
Total effects in the whole economy[1]	
Gross output (in mills €)	2,504
Gross value added (in mills €)	1,141
Employees	25,744
Intermediate effects in the total economy	
Gross output (in mills €)	1,054
Gross value added (in mills €)	487
Employees	9,084

Author's calculation. - [1] Total effects summing direct and indirect effects.

Applying those multipliers on the actual demand for welding technology of the year 2002, the corresponding intermediate effects on output are more than 1 billion € and the intermediate effect on value added is about 490 million €. Almost 9,100 employees in the intermediate industries are depending on the demand for welding technology.

The last contribution of welding technology to the total economy is the intermediate effects of the application in the welding intensive user-industries (*effect V*). Here an industry is classified as welding intensive, if the share of welders to all employees exceeds the threshold of 3 percent. In this case, the seven industries metal production and processing, manufacturing of metal products, mechanical engineering, manufacturing of automobiles, ship and aircraft production, construction as well as repairing services are classified as welding intensive. However, only the share of the intermediate effects that is induced by the welding processes can be ascribed to the welding technology. For each user industry this share is an combined weighted average, on the one hand, of the welding intensity of the intermediate industries and, on the other hand, the share of welding to all processes in each user industry. Again, the welding intensity of an industry is approximated by the number of welders related to the number of all employees in that industry. Those combined shares are presented in table 5. Summing up over the seven user-industries, the result is an intermediate effect on value added induced by welding of 4.9 billion €.

Table 5: Intermediate value added by welding processes in user industries, Germany 2002

	Gross value added (direct)	Multiplier for value added	Gross value added		Combined average share of value added by welding	Intermediate value added by welding
			total	intermediate		
	in bills €		in bills €	in bills €	in %	in mills €
Metal production and processing	13.1	2.36	30.8	17.8	1.9	338
Manufacturing of metal products	37.4	1.91	71.6	34.1	2.3	771
Mechanical engineering	60.5	2.03	123.1	62.6	1.4	845
Production of automobiles	43.3	3.25	140.7	97.5	2.1	2,076
Production of other vehicles	7.2	2.22	16.0	8.8	2.3	201
Construction	97.5	1.95	189.7	92.3	0.5	498
Repairing services	28.8	1.66	47.9	19.1	0.9	172
Total	287.8	-	619.9	332.1	-	4,901

Author's calculations.

However, this number of value added contains some effects that are already considered in *effect I*, *II* and *IV*. This double counting shows up, because parts of the direct effects on value added of the demand for welding technology (*effect I*: 0.6 billion €), as well as its intermediate effects (*effect IV*: 0.5 billion €) and the direct effects of the demand for complementary goods (*effect II*: 0.3 billion €) are integrated in the intermediate effects on value added in the user-industries. Therefore, those effects must be subtracted, so that 3.5 billion € remain as intermediate effects on value added adjusted for double counting. This adjusted value added induces an employment of 64,160 workers in the whole economy.

5. Conclusion

In this analysis, an alternative method for the calculation of the contribution of a CST to the total economy was presented. For the example welding technology it was shown that the total contribution of this technology to gross value added in the whole economy in Germany in 2002 was about 19 billion €, which corresponds to an gross employment of more than 362,000 persons (table 6). From this total contribution 93 percent for both, value added and employment, resulted from the application of welding technology in user-industries.

Table 6: Contribution of welding technology to gross value added and gross employment, Germany 2002

Effect		Gross value added		Standardized (Effect I=1)	Employees	
		in mills €	in %		Persons	in %
I	Demand for welding technology	653	3.5	1.0	16,660	4.6
II	Demand for complementary goods	288	1.5	0.4	5,210	1.4
III	Application of welding technology	13,961	74.0	21.4	267,124	73.7
IV	Indirect effects of the demand for welding techn.	487	2.6	0.7	9,084	2.5
V	Intermediate effects of the application of welding technology	3,473	18.4	5.3	64,160	17.7
	Total	18,862	100.0	28.9	362,237	100.0

Author's calculations.

Although, the method goes further than commonly used benchmarks by decomposing the different effects and analyzing them in a detailed manner, the total results of the analysis may still underestimate the real economic impact of the CST industry welding engineering for several reasons: (i) There may be more than the considered number of CPL-goods industries. (ii) The information about the share of CPL-goods for welding of the total output of CPL-goods industries was only estimated approximately, and (iii) only a selected number of user-industries was taken into account.

6. References

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