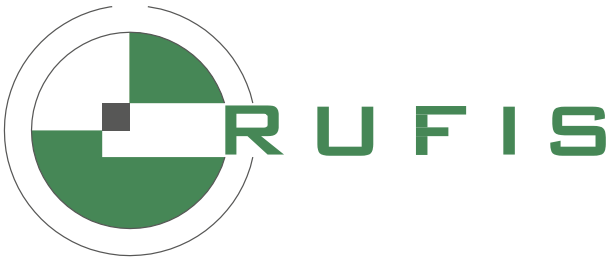

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Macroeconomic and sectoral value added by the production and application of joining technology in Germany, in selected countries in Europe as well as in the EU as a whole

Short version of the expert report

To DVS

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1 Introductory remarks and objective of the investigation

For more than 15 years, DVS has regularly arranged for the economic significance of various joining technologies to be investigated in scientific expert reports. The origin of this series of expert reports was in 2001 with an analysis of the value added and employment connected with the production and application of welding technology in Germany. In 2005, this study was updated and extended to other joining technologies going beyond welding. The investigation region was then expanded in 2009. Other countries within Europe which were important for joining technologies were analysed in addition to Germany. These included France, Italy, the Netherlands, Poland and the United Kingdom as well as EU27. In 2013, there was a new edition of the preceding study from 2009. At that time, the Czech Republic was now included in the canon of the countries to be investigated instead of Poland.

The present expert report is a new edition and update of this series of investigations over many years. As in the four preceding studies, the economic significance of various joining technologies in Germany and in selected countries in Europe was quantified. In detail, these include not only Germany but also France, Italy, the Netherlands, Poland, Romania and the United Kingdom. Furthermore, EU28 is investigated as a superordinate region.

There are slight methodological differences between the analyses of Germany and the other EU countries. On the European level, the data availability does not exist for all the aspects investigated in Germany. Thus, the analysis of the other European countries must turn out to be less detailed than for Germany. In the longitudinal comparison too, the five studies are comparable with each other to a limited extent only. On the one hand, the investigated technologies have been expanded from welding to joining since 2005. On the other hand, the group of countries to be investigated has changed. Furthermore, the utilised methods (particularly the input-output analysis) have also been refined ever more in the course of time. However, parameters which had to be estimated by experts from the environment of DVS for lack of data availability were ultimately adjusted too when more recent findings made this necessary.

2 Overview of the considered technologies

The manufacturing procedures of joining, cutting and coating (below, abbreviated as: JCC technology), all technologies which DVS represents as a society for welding and allied procedures, are highly specialised procedures. These are utilised for the manufacture and processing of investment and durable consumer goods in the manufacturing sector and the building trade and for services in the repair sector. Many goods could not be manufactured at all without the utilisation of JCC technology. Accordingly, a substantial proportion of the created value (i.e. the value added) of these investment and consumer goods may be directly attributed to the utilisation of JCC technology.

In addition to the utilisation of JCC technology as manufacturing procedures at the users of these procedures, the technology is closely interlinked with many sectors via the required complementary intermediate inputs on the procurement side too. These complementary consumer goods and services (i.e. needed in connection with the JCC processes) include welding electrodes and consumables, welding gases, adhesives, rivets, venting and testing machines, protective equipment as well as training and further education services for the users.

However, the characteristic of JCC technology as a cross-sectional technology which is used in many sectors and, with regard to the utilised materials and the applied technologies, is closely related to suppliers and customers hinders the statistical recording and estimation of its macroeconomic significance. In the production reporting from the Federal Statistical Office, an inland production value of around Euro 3.7 billion is specified for Germany in 2015 for the manufacture of machines, devices and robots which can be utilised for joining, cutting and coating. This corresponds to a proportion of just 0.18 % of the manufacturing sector (in 2015: Euro 2,012 billion).

If, as often happens, the macroeconomic contribution made by JCC technology were now quantified merely via the production values of its devices and machines with their corresponding value added, then solely the contribution originating from the manufacture of the technology would be recorded. That would be a considerable underestimate of the contribution made by JCC technology to the overall economy. For this reason, not only the value added contribution from the production of JCC technology but also the value added contribution made by joining, cutting and coating technology processes in the user sectors should be included too. As already shown in the German studies from 2001, 2005, 2009 and 2013, this will exceed the value added contribution made by the production of JCC technology many times over.

The objective of the latest study was to evaluate all the available statistical information in the form of a summary in order to estimate the value added contribution made by joining, cutting and coating technology (i.e. by the manufacture and application of JCC technology) in the investigated national economies in 2015 - that was the latest data boundary at the time when the study was elaborated. Not only publications from the Federal Statistical Office (DESTATIS) for Germany but also publications from the European Office for Statistics (EUROSTAT) for the other European countries are evaluated as data sources. The data is supplemented by information from the International Federation of Robotics as well as expert knowledge from DVS.

In analogy to the preceding studies, the various value added sources of the manufacture and utilisation of JCC devices are systematised as follows for the sake of better transparency:

Effect I: Direct value added and employment effects resulting from the manufacture of JCC technology.

Effect II: Direct value added and employment effects resulting from the manufacture of the required complementary raw, ancillary and operating materials (welding electrodes and gases, adhesives, rivets and similar items) as well as services (training and further education) for the utilisation of JCC technology.

Effect III: The proportional direct value added and employment effects which are accounted for by the JCC processes and originate from the manufacture of the goods in the joining-intensive sectors, i.e. the proportional direct effects arising when JCC technology is applied.

In addition to the three direct effects, a distinction was made between two more, indirect effects as a consequence of intermediate input demand (induced by the direct effects) in other sectors in the preceding studies. These indirect effects were quantified with the aid of input-output model calculations. These were:

Effect IVa: Indirect (i.e. caused by the intermediate input interlinks with other sectors) value added and employment effects resulting from the manufacture of JCC technology, i.e. the indirect effects belonging to Effect I.

Effect IVb: Indirect (i.e. caused by the intermediate input interlinks with other sectors) value added and employment effects resulting from the manufacture of the complementary goods, i.e. the indirect effects belonging to Effect II.

This now results in the overall effect as the total of Effects I, II, III, IVa and IVb. Furthermore, the ratio of Effect I to the overall effect is always interesting with regard to the value added.

The results of the four preceding studies are compared in the overview below. However, because of deviations with regard to the investigated technologies and regions, a comparison over the course of time is possible to a limited extent only. Different methods were also utilised for the estimation of the employment effects in particular. Furthermore, the indirect Effects IVa and IVb cannot be quantified on the European level for lack of data availability. Thus, the European results tend to constitute a lower limit. Because of the worse data basis, Effect III for the other European countries was established with a method deviating from that for Germany.

Table 1: Comparison of the core results of the studies until now

Study	Data boundary	Region	Technology	Value added (in € billion)	Employment (in 1,000)
2001	1999	Germany	Welding	16	428
2005	2003	Germany	Welding	19	455
2005	2003	Germany	All joining technologies	27	638
2009	2007	Germany	All joining technologies	24	421
2009	2007	EU27	All joining technologies	86	2,026
2013	2011	Germany	All joining technologies	23	395

Our own calculations

In the past studies, some data and information could not be taken from official statistical data sources such as the Federal Statistical Office or EUROSTAT. In this case, reference was made to estimates by experts. However, some of these estimates by experts are not available for the new study.

Going beyond the preceding studies, additive manufacturing is now also being included in the latest study as a new technology. Hardly any data about this technology can yet be found in the official statistical sources. Thus, it is necessary to refer to alternative data sources - such as surveys of companies. Therefore, additive manufacturing has not yet been subsumed under Effects I, II and III but its significance is instead portrayed separately.

3 Production, value added and employment effects

3.1 Summary of the value added and employment effects in comparison with the preceding expert report

For Germany, the overall effect of the value added including the indirect effects (i.e. here, the total of Effects I, II, III, IVa and IVb) resulted in Euro 27.3 billion from the production and application of JCC technology as well as the associated employment of nearly 451,000 people in full-time equivalents, i.e. including the part-time joining technologists. If solely the total of the direct Effects I, II and III (it was possible to establish counterparts to these on the European level too) is considered for Germany, then the resulting value added is nearly Euro 25 billion (Effect I: Euro 1.4 billion, Effect II: Euro 1.4 billion and Effect III: Euro 21.9 billion) with the employment of 413,000 people (Effect I: 17,400, Effect II: 21,000 and Effect III: 374,300). With regard to the value added, the indirect effects neglected here account for just nearly 10 % of the overall effect, i.e. Euro 2.6 billion is triggered as indirect effects via the intermediate input demand (Effects IVa and IVb).

In the preceding study, a direct overall effect of Euro 22.9 billion was established for the value added as the total of all the Effects I to IVb. The value added contribution made by JCC technology and JCC processes has grown by Euro 4.4 billion or 19 % compared with 2011. However, some of the deviations from the preceding study with regard to the value added may also be attributed to a deviating methodology (altered proportions of the production values to be taken into account and deviating methodology for estimating the joining technologists). If the number of gainfully employed people in Germany resulting from the overall effect of the production and application of JCC technology (451,000 full-time-equivalent people) is compared with those from the preceding expert report (395,000), then the currently estimated number of employees is 56,000 or 14 % above that in the preceding study. In comparison with the preceding expert report, the total value added has grown more strongly than the total employment. This is caused by the increased working productivities in Germany which diminish the employment effect.

The following results were obtained on the European level (EU28): The *direct* overall effect resulting from the production and application of JCC technology (total of Effects I to III) on the value added in Europe amounted to nearly Euro 61 billion in 2015. In the preceding study, the total of Effects I to III reached Euro 65 billion. Thus, it turned out to be somewhat lower at present. In 2015, nearly 1.1 million full-time gainfully employed people in Europe who dealt directly with the manufacture of JCC technology, the complementary goods as well as their application in the joining-intensive sectors were connected with the direct overall effect on the value added. A nearly identical employment effect (1.2 million) was reached in the preceding study.

Table 2: Value added and employment effects in Germany and EU28 and comparison with the preceding study; overview

Germany in 2015							
Effect	I	II	III	Total of I-III	IVa	IVb	Overall effect
Value added in € billion	1.4	1.4	21.9	24.8	1.6	1.0	27.3
Employment in 1,000	17.4	21.0	374.3	412.7	23.5	14.5	450.6
EU28 in 2015							
Effect	I	II	III	Total of I-III	IVa	IVb	Overall effect
Value added in € billion	4.3	4.0	52.5	60.8	-	-	60.8
Employment in 1,000	78.6	62.6	950.7	1.091.9	-	-	1.091.9
Germany in 2011							
Effect	I	II	III	Total of I-III	IVa	IVb	Overall effect
Value added in € billion	1.3	0.9	18.8	21.0	1.2	0.6	22.9
Employment in 1,000	18.0	16.0	332.0	366.0	18.0	9.3	395.0
EU27 in 2010							
Effect	I	II	III	Total of I-III	IVa	IVb	Overall effect
Value added in € billion	2.7	2.5	60.0	65.2	-	-	65.2
Employment in 1,000	45.0	36.0	1,124.0	1,205.0	-	-	1,205.0

Our own calculations

In 2015, the overall effect of Germany as far as the value added was concerned had an almost 45 % share of the European value added. In the preceding expert report, it was still 35 %. Germany was able to expand its great significance with regard to the creation of value added by JCC within Europe even further. In 2015, the overall effect of Germany as far as the employment was concerned had a 41 % share of the European employment. In the preceding expert report, it was still 33 %. With regard to the employment too, the significance of Germany has grown in comparison with the preceding study.

If the contributions made by the individual effects to the overall effect are compared with each other, then it is possible to establish the following: The largest proportions of the value added and the employment are created by the application of JCC technology. Euro 21.9 billion of the total value added amounting to Euro 27.3 billion is created in this field (Effect III). As far as the employment is concerned, 374,000 of the 451,000 gainfully employed people in total are active in the application of JCC technology.

A similar pattern can be recognised for Europe. However, during the interpretation, it must be borne in mind that no input-output analyses were made for EU28. Thus, only the direct Effects I to III were calculated. Euro 52.5 million of the total value added by JCC amounting to nearly Euro 61 million is created in application. 951,000 of the nearly 1.1 million gainfully employed people on the European level are active in the application of JCC technology.

When the individual Effects I, II, III, IVa and IVb are compared with those in the preceding expert report, it must be borne in mind that, in the current expert report, certain methodological changes were made and deviating data sources were used. Methodological changes always occurred whenever it could be assumed that the new method led to a better estimation or whenever a missing data source necessitated the methodological change. There were the most important methodological changes in Effect II in which the adhesives were calculated as a deviation from the preceding expert report. Furthermore, the materials testing machines were recorded with higher contributions in Effect II. Important data sources (i.e. the economic sectors / occupations matrices) were not available in Effect III. Thus, the numbers of gainfully employed

people could only be estimated via the indicator variable of the visible steel consumption. In the preceding expert report, there were also two more estimation methods on the basis of additional data sources.

No uniform trends emerged from the detailed comparison of the individual effects with each other and with the results in the preceding expert report in Germany and Europe. In Effect I, the value added in Germany has remained approximately constant in comparison with the preceding study, i.e. Euro 1.4 billion and Euro 1.3 billion. In Europe, it has risen strongly from Euro 2.7 billion at that time to Euro 4.3 billion now. The number of the gainfully employed people in Germany in Effect I has also remained approximately constant: There were 18,000 in the preceding expert report and 17,400 is being reached at present. In Europe, the employment resulting from Effect I has risen strongly from 45,000 to 78,600.

The value added in Effect II in Germany has increased from Euro 0.9 billion at that time to Euro 1.4 billion now. In Europe, Effect II rose from Euro 2.5 billion to Euro 4 billion now. With regard to the gainfully employed people in Germany, 16,000 people were estimated at that time and 21,000 at present. Thus, the number of gainfully employed people in Effect II has grown by almost one third. In Europe, the number of gainfully employed people in Effect II grew from 36,000 at that time to 62,600 now. However, there were decisive methodological changes in Effect II. Thus, the deviations should not be overinterpreted.

In Germany, the value added in Effect III grew from Euro 18.8 billion to Euro 21.9 billion. In contrast, it dropped from Euro 60 billion to Euro 52.5 billion in Europe. In Germany, the employment in Effect III grew from 332,000 gainfully employed people at that time to 374,000 now, an increase by almost 13 %. In Europe, there was a decline from around 1.1 million gainfully employed people at that time to 951,000. However, in Effect III, the numbers of employees and the value added connected with them were established with deviating data sources and a method different from that in the preceding expert report.

If Table 3 and the figures are considered, it is once more illustrated that, in Germany, the largest proportion of the value added is created by the application of JCC technology. Out of the total of Euro 27.3 billion value added by joining technology, only a very small proportion of Euro 1.4 billion of the total created value added results directly from the production of JCC technology (Effect I). There is also a similar level of indirect effects caused by intermediate input demand amounting to Euro 1.6 billion (Effect IVa). The production of complementary goods leads to another Euro 1.4 billion of direct value added (Effect II) as well as Euro 1 billion of indirect value added (Effect IVb). The largest value added contribution (Euro 21.9 billion) results from the application of JCC technology.

Thus, the overall value added effect as the total of Effects I to IVb exceeds that value added solely by the production of JCC technology by 19 times[1]. Euro 1.00 of value added by the production of JCC technology induces around Euro 1.10 of indirect value added by the intermediate input demand. Furthermore, another Euro 1.00 of value added is triggered by the direct production of complementary goods. This induces a relevant indirect value added of another Euro 0.70. However, the direct production of JCC technology worth Euro 1.00 leads to a value added of Euro 15.20 during the application of JCC technology.

[1] $1.4/27.3 \approx 19$

Table 3: Value added and employment effects in Germany and EU28

Germany in 2015							
Effect	I	II	III	Total of I-III	IVa	IVb	Overall effect
Value added in € billion	1.4	1.4	21.9	24.8	1.6	1.0	27.3
Employment in 1,000	17.4	21.0	374.3	412.7	23.5	14.5	450.6
GVA, standardised (I-III)	1.0	1.0	15.2	17.2	-	-	-
Employment, standardised (I-III)	1.0	1.2	21.6	23.8	-	-	-
GVA, standardised (I-IVb)	1.0	1.0	15.2	-	1.1	0.7	19.0
Employment, standardised (I-IVb)	1.0	1.2	21.6	-	1.4	0.8	26.0
EU28 in 2015							
Effect	I	II	III	Total of I-III	IVa	IVb	Overall effect
Value added in € billion	4.3	4.0	52.5	60.8	-	-	60.8
Employment in 1,000	78.6	62.6	950.7	1,091.9	-	-	1,091.9
GVA, standardised	1.0	0.9	12.1	14.0	-	-	14.0
Employment, standardised	1.0	0.8	12.1	13.9	-	-	13.9

Our own calculations

Around 17,400 people dealt with the manufacture of JCC technology in Germany in 2015. That is just 4 % of the employment of 451,000 (overall effect) resulting from the production and application of joining technology in total. In addition to the 17,400 people involved in the direct production of JCC technology, there are 23,500 indirect gainfully employed people (Effect IVa) resulting from the induced intermediate input demand. 21,000 gainfully employed people are triggered by the production of the complementary goods (Effect II) as well as another 14,500 indirect gainfully employed people by the relevant intermediate input demand. The overall effect of the employment in 2015 exceeds that resulting solely from the production of JCC technology by 26 times[2].

If the (rounded) standardised numbers of employees are considered, then it is possible to recognise the enormous leverage emanating from JCC technology. One gainfully employed person in the production of JCC technology (Effect I) is connected with 1.2 gainfully employed people in the production of complementary goods (Effect II). In addition, there are 1.4+0.8 indirect gainfully employed people induced by intermediate input demand (Effects IVa and IVb). In the joining-intensive sectors, around 21.6 more jobs are safeguarded by the application of JCC technology (Effect III).

In the preceding study, it was already possible to recognise these orders of magnitude of the leverage of the cross-sectional technology of joining, cutting and coating. As already in the preceding study, the following core result can therefore be derived: Only very small proportions of the value added and the employment originate from the *production* of JCC technology and its complementary goods and services. The outstanding proportions of the value added and the employment (actually many times the value added and employment resulting from the production of the technology and the complementary goods as well as the intermediate inputs needed for this purpose) are caused by the *application* of this technology in the joining-intensive sectors.

[2] 451,000/17,400≈26

Figure 1: Value added and employment resulting from JCC technology in Germany in 2015

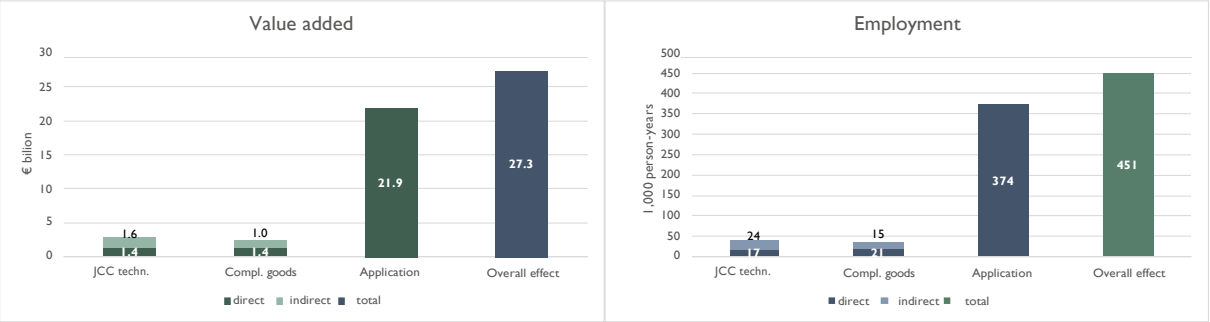
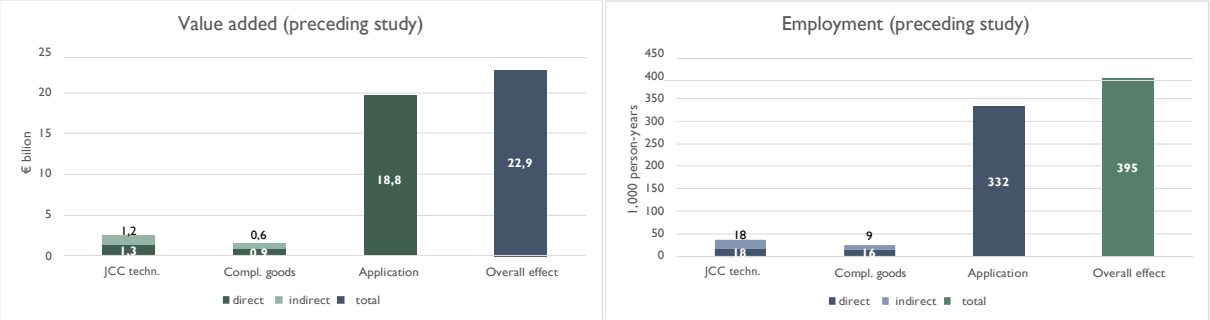


Figure 2: Value added and employment resulting from JCC technology in Germany in 2011 (preceding study)



The contributions made by the individual effects amongst each other in the EU are to be analysed below. Out of the total of nearly Euro 61 billion of value added by joining technology in Europe, only a very small proportion (Euro 4.3 billion) was accounted for by the manufacture of JCC technology (Effect I). Nearly 79,000 people were employed in the manufacture of JCC technology in Europe in 2015. The production of the required complementary ancillary materials and consumables (such as consumables for welding and spraying, rivets, protective equipment and further education services) resulted in a value added of Euro 4 billion by 62,600 employees (Effect II) in Europe in 2015. As already described for Germany, the largest proportion of the value added did not originate from the manufacture of the JCC devices but instead from their utilisation in joining processes in the user sectors. In Europe, a value added of nearly Euro 53 billion (Effect III) was achieved by the production processes of joining, cutting and coating. In this respect, nearly 951,000 joining technologists and JCC robot operators were employed in the joining-intensive sectors. Thus, the total value added by the production and application of JCC technology including its complementary goods and services needed for this purpose in Europe exceeds that value added by the production of pure JCC technology by 14 times[3]. Euro 1.00 of value added by the production of JCC technology entails Euro 0.90 of value added by the production of complementary goods and around Euro 12.00 of value added by the application of the JCC processes.

[3] 60.8/4.3≈14

Figure 3: Value added and employment resulting from JCC technology in Europe in 2015

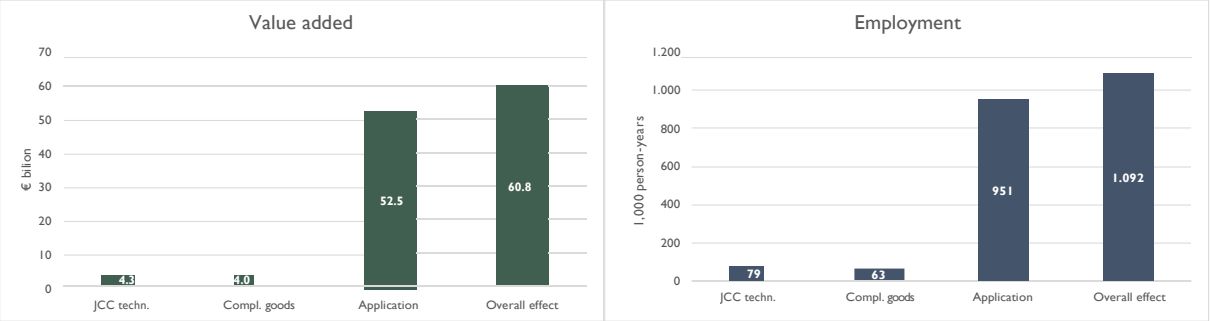
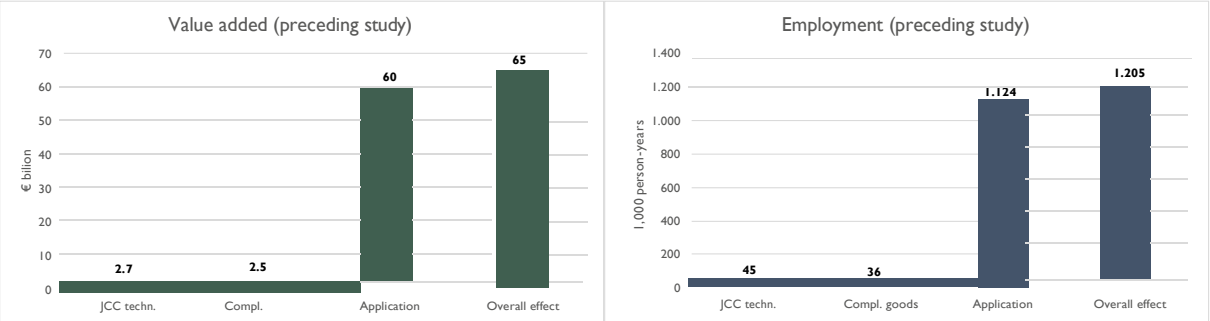


Figure 4: Value added and employment resulting from JCC technology in Europe in 2010 (preceding study)



With regard to the employment in Europe, the overall effect resulting from the production and application of JCC technology also exceeds that employment which is created solely by the production of JCC technology by around 14 times[4]: One gainfully employed person in the production of JCC technology is connected with 0.8 gainfully employed people in the production of complementary goods and services as well as with no fewer than twelve gainfully employed people in the application of JCC technology.

The contributions made by Effects I, II and III to the overall effect deviate between Germany and Europe and must not be overinterpreted. On the one hand, more estimations are included in the European results than in those for Germany. On the other hand, the economic structure as well as the working productivities and the capital intensities in Germany deviate considerably from those on the European average. However, the fundamental orders of magnitude of the extents to which the individual effects contribute to the overall effect coincide: Only very small proportions of the value added and the employment originate from the *production* of JCC technology and its complementary goods and services. The outstanding proportions of the value added and the employment (actually many times the value added and employment resulting from the production of the technology and the complementary goods) are caused by the *application* of this technology in the joining-intensive sectors.

4 1,092/78.6≈14

3.2 Summary of the production values of the various JCC technologies (Effect I)

Table 4 below supplies a summary of the *production values* of the various *JCC technologies* (Effect I) *according to the seven investigated European countries*. For example, the production value of JCC technology in Germany in 2015 amounting to Euro 3.7 billion is composed as follows: By far the largest proportion (over Euro 3 billion) originates from the production of welding, brazing/soldering and cutting technology. German welding technology also accounts for the largest proportion within welding technology in the EU amounting to Euro 6.4 billion in total. Nearly half of the welding technology throughout the EU is produced in Germany. Thus, Germany occupies an outstanding market position with regard to welding technology within Europe. In comparison with the preceding expert report, Germany was able to consolidate its significance considerably. Italian welding technology production amounting to nearly Euro 0.5 billion comes in second place. Italy's share of the European welding technology production amounts to nearly 8 %. It is followed by France with Euro 214 million, the United Kingdom (Euro 170 million) and Poland with Euro 135 million. However, the concentration of the welding technology production in Europe is exceptionally high: Germany, Italy and France produce well over half (59 %) of the entire welding technology in the EU.

Table 4: Summary of the production values of JCC technology according to seven countries and EU28; overview

	Germany	France	Italy	Netherlands	Poland	Romania	United Kingdom	Other EU countries	EU28	Ratio of 7 considered countries to EU28
	In € million in 2015									
Welding, brazing/soldering and cutting technology	3,061	214	499	6	135	3	170	2,349	6,437	63.5%
Adhesive bonding technology	19	39	173	25	5	0	36	616	913	32.5%
Riveting technology	177	9	120	confidential	0	0	24	49	379	87.1%
Thermal spraying	51	11	12	6	-	-	14	-	94	-
Laser (optical constituents)	40	15	9	0	0	0	21	14	99	85.9%
JCC robots	337	51	117	41	56	3	36	294	936	68.6%
Production value of joining technology	**3,685**	**339**	**930**	**78**	**196**	**6**	**301**	**3,322**	**8,858**	62.5%
Preceding study in 2010	2,881	518	876	27	-	-	213	3,360	7,951	-
Value added (in € million)	**1,437**	**112**	**279**	**27**	**63**	**3**	**114**	**2,305**	**4,340**	46.9%
Employment	**17,359**	**1,380**	**3,736**	**243**	**2,646**	**107**	**1,376**	**51,780**	**78,627**	34.1%

Our own calculations

If joining technology is considered as a whole, the German production of nearly Euro 3.7 billion accounts for almost 42 % of the European production (Euro 8.9 billion). Italy follows well behind in second place with an ample figure of Euro 0.9 billion or one tenth of the European production. France produces joining technology worth Euro 339 million - considerably less than still in the preceding expert report. France accounts for nearly 4 % of the European production. The 21 EU countries not considered in any greater detail here produce joining technology worth Euro 3.3 billion in total. That is 37.5 % of the entire EU production of joining technology. Thus, the seven countries investigated in greater detail here account for 62.5 % of the entire joining technology production in Europe. In Europe, almost 79,000 gainfully employed people deal with the production of JCC technology. In Germany, there are around 17,400 or 22 %. Italy follows in second place with over 3,700 gainfully employed people and Poland with over 2,600.

3.3 Summary of the production values of the complementary goods (Effect II)

Table 5 below supplies a summary of the *production values* of the various *complementary goods* and services (Effect II) as well as of the employed joining technologists *according to the seven investigated European countries*. The production value of the complementary goods in Germany amounts to Euro 3.6 billion in total - a value similar to the production value of JCC technology. In the preceding expert report, the production value of the complementary goods reached only Euro 2.1 billion. Anyway, the methodology was changed with regard to the consideration of the testing machines. Thus, they are now registered with far higher weighting. With regard to the complementary goods too, the lion's share of the European production originates from Germany - i.e. 30 %. In this respect, the concentration on Germany turns out to be not quite as strong as in the case of the production of JCC technology.

Table 5: Summary of the production values of the complementary goods according to seven countries and EU28; overview

	D	F	I	NL	POL	ROM	UK	Other countries	**EU28 as a whole**	Proportion of 7 considered countries in EU28 as a whole
Welding, brazing/soldering and thermal spraying consumables	812	55	343	141	51	0	56	1,458	1,952	74.7%
Adhesives	7	375	300	121	74	5	246	1,128	2,093	53.9%
Rivets	223	82	63	0	14	0	88	470	603	77.9%
Welding gases	186	172	128	85	73	13	3	660	1,256	52.5%
Occupational health and safety	66	12	54	0	14	11	41	198	280	70.7%
Venting machines	300	27	30	6	5	0	29	397	562	70.6%
Testing machines	1,871	165	530	16	0	0	937	3,519	4,753	74.0%
Training and further education courses	152	19	21	12	17	9	6	236	465	50.8%
Production value in total (in € million)	**3,617**	**907**	**1,469**	**381**	**248**	**38**	**1,406**	**8,066**	**11,964**	67.4%
Preceding expert report in 2011	2,135	880	228	940	541	-	-	-	7,539	-
Value added (in € million)	**1,492**	**280**	**433**	**104**	**78**	**18**	**527**	**1,047**	**3,978**	73.7%
Employment	**20,978**	**3,001**	**6,731**	**1,095**	**3,467**	**1,280**	**6,348**	**19,712**	**62,610**	68.5%

Our own calculations

With regard to the significance of the production of complementary goods, Italy with a production value of nearly Euro 1.5 billion or a 12 % share of the European production and the United Kingdom with Euro 1.4 billion are almost level in second place. France follows in fourth place with a production value of around Euro 0.9 billion.

It is noteworthy that the production of the complementary goods in Europe (nearly Euro 12 billion) even exceeds the production of the underlying JCC technology (nearly Euro 9 billion). In EU28, one unit of the production of JCC technology entails 1.35 units[5] of the production of complementary goods and services. In Germany, the ratio is nearly balanced: One unit of the production of JCC technology entails one additional unit of the production of complementary goods[6]. Thus, the production of the complementary goods and services is at least just as important as the production of the actual JCC technology. In Europe, almost 63,000 gainfully

5 11,964/8,858≈1.35

[6] $3{,}617/3{,}685 \approx 1$

employed people deal with the production of the complementary goods and services. That is 80 % of the employees in the production of JCC technology (78,600). Most of the gainfully employed people can be found in Germany (nearly 21,000), well ahead of Italy (6,700) and the United Kingdom (6,300).

3.4 Summary of the employment figures for the application of JCC processes (Effect III)

In Germany, over 249,000 full-time joining technologists worked in the joining-intensive sectors (Effect III). If the part-time joining technologists for whom it was possible to make an estimate for Germany are added, this figure even rises up to 374,000 full-time-equivalent joining technologists. In Europe, there are nearly one million full-time joining technologists. For lack of data availability, only the full-time joining technologists were estimated for EU28 and the other European countries.

Table 6: Summary of gainfully employed joining technologists according to seven countries and EU28; overview

	Full-time people in joining occupations	Ratio of country to EU28	Value added in € billion	Ratio of country to EU28
Germany	249,343	26%	17.8	34%
Italy	136,712	14%	8.2	16%
France	84,878	9%	5.9	11%
United Kingdom	69,453	7%	4.5	9%
Netherlands	23,073	2%	1.6	3%
Romania	23,958	3%	0.4	1%
Poland	75,981	8%	1.8	3%
Other EU countries	287,278	30%	12.3	23%
EU28	**950,676**	**100%**	**52.5**	**100%**
For information: preceding study	1,124,000		60.0	

Our own calculations

Germany's full-time joining technologists have a 26 % share of the European joining technologists. With an estimated figure of 137,000 joining technologists and a 14 % share, Italy is less significant than Germany. Nearly 85,000 joining technologists are estimated for France. That is almost one tenth of the European joining technologists. The considered countries all exhibit high joining intensities. Thus, the cross-sectional technology of JCC technologies is applied by a large number of qualified employees in many European countries. 70 % of all the European joining technologists work in the seven countries considered here and merely 30 % of the joining technologists are active in the other 21 EU countries.

3.5 Input-output analysis: Determination of the indirect effects (Effects IVa and IVb)

In addition, a comprehensive input-output analysis was made in order to quantify the indirect effects (IVa and IVb) for Germany. The majority of the final demand for these goods is met not only with the produced goods for JCC technology (Effect I) but also with the complementary goods (Effect II). However, this also partly includes the intermediate inputs of the production area in question which are required for the production itself. Goods from other production areas are utilised in addition. Thus, a macroeconomic consideration is required in order to recognise the overall effect of JCC technology and the complementary goods. This was carried out within the framework of the separately portrayed input-output analysis not only for JCC technology (Effect IVa) but also for the complementary goods (Effect IVb). The effects of the estimated final demand not only on the production, the value added and the employment but also on the sector and the overall economy were considered there.

The instrument is the determination of the relevant multipliers. These indicate to what extent a triggering impulse (increase in the final demand) exerts effects on the overall economy. In the case of the production values of JCC technology (Effect I), the corresponding multiplier is 1.91. Accordingly, a final demand amounting to Euro 3.1 billion leads to a rise of nearly Euro 5.9 billion in the production across all the sectors of the overall economy. In JCC technology, it will be necessary to add Euro 1.8 billion caused by indirect effects (Effect IVa) to the direct effect resulting from the final demand amounting to Euro 1.1 billion with regard to the gross value added. The direct employment effect is approx. 14,000 person-years to which around 23,500 more person-years are added due to indirect effects.

The meeting of the final demand for complementary goods amounting to around Euro 2.8 billion results in additional production effects due to the intermediate inputs amounting to over Euro 2.6 billion (Effect IVb). The value added by the pure final demand production amounts to Euro 990 million to which approx. Euro 970 million more must be added as an indirect effect. The direct employment effect amounts to 13,300 person-years while 14,500 more people are employed in the intermediate input production required for this purpose. One additional employee in JCC technology thus leads to an employment increase of another 1.7 people while additional indirect effects amounting to 1.1 more employees are caused per employee dealing with the manufacture of complementary goods.

3.6 Outlook - Additive manufacturing procedures

In addition to the joining, cutting and coating technology processes considered in this study, there are, in the meantime, newer manufacturing procedures which supplement the JCC processes until now - but are also in competition with them. Additive or generative[7] manufacturing is a procedure which has been gaining significance to an extreme extent for around ten years. The initial precursors had already been developed around the turn of the millennium. In the case of additive manufacturing, a digital 3D model is used in order to apply material in layers until a finished component has been created from these very layers. Thus, the

[7] See the VDI 3404 guideline from 2009 as the first technical rule on the subject of additive manufacturing.

procedure is totally different from the conventional, removing manufacturing procedures.

On the one hand, the advantages of additive manufacturing are of a technical kind. On the other hand, additive manufacturing offers economic efficiency gains due to the individualised production of (single) products adapted to the customer specifications without the high fixed costs per unit which are usually connected with them. The introduction of additive manufacturing procedures leads to retroactive effects on the entire value added chain since decisions about the production location are influenced and the freight volume is lowered by production in situ.

Since additive manufacturing is a still so young technology, it has not yet been input into the production statistics of the Federal Statistical Office. Furthermore, it is questionable whether additively manufactured goods can be recorded in the goods directory of the manufacturing sector in an appropriate way at all. Indeed, a large proportion of their value added originates from the software for controlling the 3D printer. In order to quantify the significance of additive manufacturing, it is thus firstly necessary to make reference to the opinions of experts and to estimates.

The increasing significance of additive manufacturing can also be estimated according to the forecast of the worldwide market volume for additive manufacturing systems, the services associated with them as well as the raw materials to be applied[8]. In 2012, the global turnover in the field of additive manufacturing amounted to around Euro 1.7 billion. A rise in turnover up to Euro 7.7 billion (that is more than four times higher) is forecast until 2023 (Figure 5).

Furthermore, the estimated turnover with products created by additive manufacturing amounted to around Euro 10 billion worldwide in 2016. Germany accounted for one tenth of this turnover, i.e. Euro 1 billion[9]. Expressed in extremely simplified terms, every Euro which is invested in additive manufacturing systems thus causes around three times the turnover with the correspondingly manufactured products[10].

If solely the raw materials (i.e. the basic materials available in powder form) are considered, then it has been possible to observe strong growth in this market segment too since 2008[11]. In 2013 (the latest value in this survey), the worldwide turnover with the materials amounted to nearly Euro 400 million. Thus, the material turnover accounted for around one fifth of the total turnover of the additive manufacturing technologies. In comparison, the production value of the

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8 Statista (n.d.). Forecast for the market volume of "additive manufacturing" worldwide until 2023 (in Euro billions). In Statista - The Statistics Portal. Access on January 30, 2017, from https://de.statista.com/statistik/daten/studie/445066/umfrage/prognose-zum-umsatz-mit-additiver-fertigung-weltweit/.

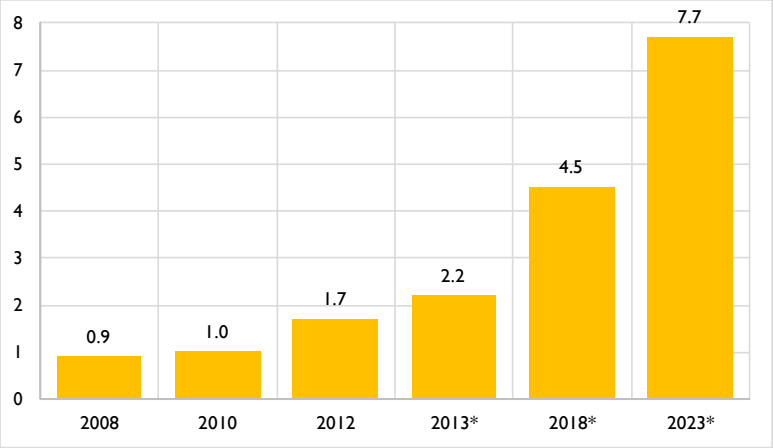
9 Statista. (n.d.). Estimated turnover with 3D printing products in Germany and worldwide in 2016 (in Euro billions). In Statista - The Statistics Portal. Access on January 30, 2017, from https://de.statista.com/statistik/daten/studie/581411/umfrage/umsatz-mit-3d-druck-in-deutschland-und-weltweit/.

10 A worldwide turnover of Euro 3.3 billion with the manufacturing technologies (estimated by trend extrapolation) is connected with the worldwide turnover of Euro 10 billion with products from additive manufacturing estimated for 2016. This results in the factor of three.

11 Statista (n.d.). Turnover with materials for additive manufacturing worldwide from 2008 to 2013 (in US Dollar millions). In Statista - The Statistics Portal. Access on January 30, 2017, from https://de.statista.com/statistik/daten/studie/448153/umfrage/umsatz-mit-materialien-fuer-die-additive-fertigung-weltweit/.

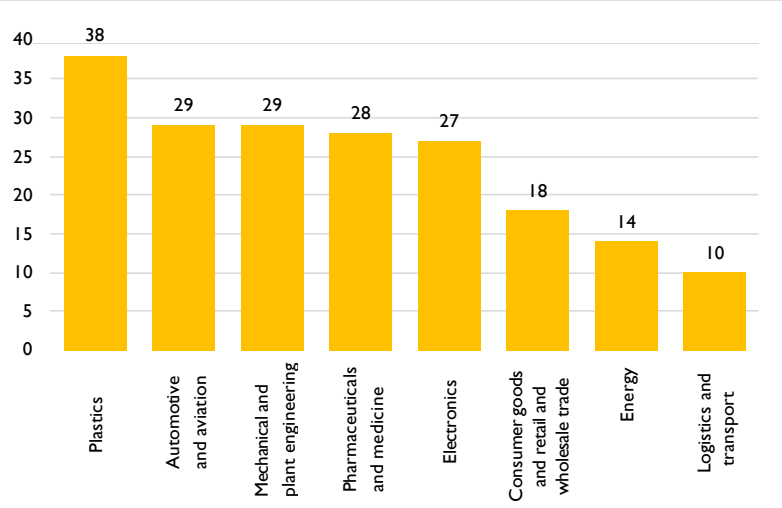
complementary goods for joining technology in Germany (including, in particular, the consumables, the rivets, the adhesives and the gases) amounted to Euro 1,228 million. That is three times the worldwide turnover with the basic materials for additive manufacturing.

Figure 5: Additive manufacturing - Forecast for the global market volume for additive manufacturing systems, relevant services and raw materials



** estimated*
Source: Statista; our own diagram.

Figure 6: 3D printing - Application according to sectors worldwide in 2016 in percent



Source: Statista; our own diagram.

The application of additive manufacturing already plays an important role in quite a lot of sectors (see Figure 6). The sectors specified there are also precisely those sectors in which JCC processes are widespread too. Thus, additive manufacturing is, in part, in competition with the traditional joining procedures. For example, in a survey of around 900 companies from twelve countries in total in April 2016, 38 % of the companies from the plastics sector stated that they were already using additive manufacturing[12].

For future investigations into the significance of JCC technology, additive manufacturing should thus be taken into consideration too. In any case, one prerequisite for the quantitative consideration of additive manufacturing as a new technology within JCC technology is that data about the production values of the 3D printers (Effect I) as well as about the production values of the required consumables (Effect II) is introduced into the production statistics as new BP numbers. The quantification of the contribution made by the software for controlling the 3D printer continues to be problematical. As for JCC technology, it will be applicable that the value added by the application of additive manufacturing (Effect III) will exceed the value added by the production of the 3D printers by far. However, it will be similarly difficult to record the value added by the process of 3D printing itself as it is to record the value added by the JCC processes. Possibly, Effect III of the 3D printing will also have to be quantified via the estimated gainfully employed people dealing with the application of 3D printing. However, one prerequisite for estimating the economic significance of additive manufacturing is the systematic recording of the relevant technology and the gainfully employed people by the Federal Statistical Office.

[12] Statista (n.d.). Application of 3D printing worldwide according to sectors in 2016. In Statista - The Statistics Portal. Access on January 30, 2017, from https://de.statista.com/statistik/daten/studie/581453/umfrage/anwendung-von-3d-druck-weltweit-nach-branchen/.