Macroeconomic and sectoral value added by the production and application of joining technology in Germany and Europe

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Short version

of the expert reports

Macroeconomic and sectoral value added by the production and application of joining technologies in Germany

and

Macroeconomic value added by joining technologies in the EU and selected countries in Europe

on behalf of the

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Preliminary remarks

In the past, DVS has arranged for a series of investigations to be conducted in order to estimate the value added by the production and application of joining technologies. These include the expert report entitled "Macroeconomic and sectoral value added by the production and application of welding technology" from 2001[1] as well as the study entitled *"Macroeconomic and sectoral value added by the production and application of joining technologies"* from 2005[2.]

The study from 2001 was restricted solely to the joining technologies of welding and brazing/soldering. In the study from 2005, the subject of the investigation was extended to other joining technologies – such as structural adhesive bonding, mechanical joining, thermal cutting and, as a coating technology, thermal spraying. In the following studies from 2009 entitled *"Macroeconomic and sectoral value added by the production and application of joining technologies in Germany"* as well as *"Macroeconomic value added by joining technologies in the EU and selected countries in Europe"*, not only was the study from 2005 completely revised and updated[3] but the survey region was also extended to the European level[4].

The studies from 2009 have now been revised and updated into both the latest studies from 2013.

"Macroeconomic and sectoral value added by the production and application of joining technologies in Germany" (2013)[5] and

"Macroeconomic value added by joining technologies in the EU and selected countries in Europe" (2013)[6]*.*

[1] Rhineland-Westphalia Institute of Economic Research (ed.), Macroeconomic and sectoral value added by the production and application of welding technology. Expert report on behalf of the publishing house of the German Welding Society (processed by: H.D. von Loeffelholz, W. Moos (project management) and R. Janßen-Timmen). Essen 2001.

[2] Moos, Waike and Ronald Janßen-Timmen (2005), Macroeconomic and sectoral value added by the production and application of joining technologies. Expert report on behalf of the German Welding Society, Düsseldorf.

[3] Moos, Waike, Ronald Janßen-Timmen and Stefanie Rettig (2009), Macroeconomic and sectoral value added by the production and application of joining technologies in Germany. Expert report on behalf of the German Welding Society, Düsseldorf.

[4] Moos, Waike and Stefanie Rettig (2009), Macroeconomic value added by joining technologies in the EU and selected countries in Europe. Expert report on behalf of the German Welding Society, Düsseldorf.

[5] Moos, Waike and Ronald Janßen-Timmen with the collaboration of Natalya Leonenko and Julia Klöpper (2013), Macroeconomic and sectoral value added by the production and application of joining technologies in Germany. Expert report on behalf of the German Welding Society, Düsseldorf.

[6] Moos, Waike with the collaboration of Natalya Leonenko and Julia Klöpper (2013), Macroeconomic value added by joining technologies in the EU and selected countries in Europe. Expert report on behalf of the German Welding Society, Düsseldorf.

Consideration is once again given not only to Germany but also to other European countries which are important for joining technology. In the latest study, these are France, Italy, the Netherlands, the Czech Republic and the United Kingdom as well as the entire European region (EU27).

The objective of the studies is to evaluate in the form of a summary all the statistical information available on the German and European levels in order to estimate the value added contribution which was made by the manufacture and use of joining, cutting and coating technology (JCC technology) in Germany in 2011 as well as in selected countries in Europe and in the EU as a whole in 2010 – in each case, those were the latest data boundaries at the time when the study was elaborated.

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 € 3.8 billion is specified for Germany in 2011 for the manufacture of machines and devices which can be utilised for joining, cutting and coating. This corresponds to a proportion of just 0.24 % of the manufacturing sector (in 2011: € 1,580 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, then solely the contribution originating from the manufacture of the technology would be recorded. However, this would illustrate the macroeconomic significance of joining, cutting and coating technology only incompletely.

In order to portray the significance of JCC technology in a more complete way, a distinction is made between the **joining, cutting and coating technology goods** (the JCC technology) on the one hand and the joining, cutting and coating technology processes (the JCC processes) as a part of the manufacturing processes in the user sectors on the other hand. In addition to the three direct value added sources of the manufacture of the JCC devices and of the complementary goods for the utilisation of the devices as well as the use of these devices in the joining-intensive sectors, other sectors are also affected by the demand for the intermediate inputs needed for JCC technology. The (indirect) effects arising there[7] are attributed to the value added contribution made by JCC technology since a causality relationship exists: The manufacture of the intermediate inputs needed for this purpose is also induced by the manufacture and use of the JCC devices.

[7] All the effects which do not result directly from the demand for an end product but instead indirectly from the intermediate inputs needed for the creation of the end product are designated as indirect effects.

For the sake of better transparency, the various value added sources of the manufacture and utilisation of JCC devices are systematised as follows:

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.

Effect IVa: The indirect (intermediate input) effects of the manufacture of JCC technology, i.e. the indirect effects belonging to Effect I.

Effect IVb: The indirect (intermediate input) effects of the manufacture of the complementary goods, i.e. the indirect effects belonging to Effect II.

In the latest study for Germany, the resulting overall effect is the total of Effects I, II, III, IVa and IVb.

In the preceding study in 2001 which encompassed welding and brazing/soldering alone, a value added of € 16 billion and 428,000 employees were established for Germany as the overall effect – i.e. the total of all the direct and indirect effects. A value added of € 27 billion and 638,000 employees were quantified in the preceding study for Germany in 2005 in which the subject of the investigation was extended to all the joining technologies. The study for Germany in 2009 indicated a value added of € 24.4 billion and 421,000 employees. The latest study for Germany resulted in a value added of € 22.9 billion and 395,000 employees as the overall effect. In part, the deviations in the results of the various studies are also based on methodological changes.

However, the same data availability as for Germany does not exist on the European level. One example of this is provided by the economic sectors / occupations matrices which are available in Germany as a special evaluation of the microcensus. These represent an evaluation in which the gainfully employed people are assigned to the occupations. Such detailed evaluations do not exist on the European level but this special evaluation is an integral constituent in the studies for Germany in order to estimate the indirect value added contributions made by JCC technology and to quantify Effects IVa and IVb in this way. On the European level, it is therefore not

possible to estimate the indirect Effects IVa and IVb in a form backed up by official data. In any case, the quantification of Effects I, II and III without the relevant indirect effects in the various European countries also constitutes a great increase in knowledge and contributes to the illustration of the significance of JCC technology in Europe.

Effect III can also be estimated on the basis of the employee data from the economic sectors / occupations matrix. Since this is not available for Europe, the value added contribution made by the application of JCC technology must be established using employed joining technologists (Effect III) and data sources other than the economic sectors/occupations matrix. There are various possibilities of estimating the number of employed joining technologists. Three methods were used for the calculations in the expert report for Germany: First of all, the numbers of employees in the economic sectors/occupations matrix were used as the data basis – supplemented by estimations about joining technologists in ancillary activities. Secondly, the number of performed welder qualification tests served as the basis for the estimation of the full-time-equivalent joining technologists. Thirdly, reference was made to a survey conducted by DVS about the number of employees in welding occupations according to countries from 2008. Although this survey could not be repeated for the latest study, the numbers of employees determined at that time were used as the data basis and were extrapolated with the current steel consumptions: The steel consumptions are regarded as an indicator variable for the welding intensity in a country. All three methods led to extremely similar final results for Germany. The robustness of the estimates could be proven in this way. The third method was chosen for the European study in order to establish the number of employed joining technologists as well as their relevant value added contribution made by the application of JCC technology.

Empirical results

Production values of JCC technology and complementary goods

In the studies, the respective national inland production values of the specified JCC technologies of welding, brazing/soldering, structural adhesive bonding, mechanical joining, thermal cutting as well as thermal spraying and coating are evaluated from the production statistics from Prodcom in 2010 (Eurostat in 2012). Lasers and laser technology which are also utilised for cutting and joining as well as, amongst the industrial robots, especially the joining robots are recorded in addition to the JCC devices. The established production values are attributed to **Effect I**. Table 1 gives an overview of these production values for JCC technology in selected countries in Europe. In each case, the production value in every individual field in this table is composed of a large number of individual items of information about various types of goods. For example, the production value of German welding technology is the total of approx. 20 different device types. The detailed tables can be found in both the

original expert reports[8].

Germany is the most important producer of JCC technology in Europe. More than one third of the European production of JCC technology originates from Germany. JCC technology worth € 3.8 billion was manufactured in Germany in 2011 (this figure was still € 2.9 billion in 2010). The amount in Europe (in 2010) was more than € 7.9 billion. In comparison with the preceding study with the data boundary of 2007 (€ 2.6 billion), it was possible to raise the production of JCC technology in Germany by almost half. Other important manufacturers of JCC technology are Italy with a production value of nearly € 0.9 billion and France with € 0.5 billion. However, no information is available about the laser production in these countries. Thus, their actual production of JCC technology might turn out to be even somewhat higher. In Europe, Germany is also the most important producer of welding technology. Precisely one third of the European welding technology production originates from Germany. Only 9 % originates from Italy and nearly 4 % from France. As far as the production of the other JCC devices and machines is concerned, Germany stands out even more strongly in part: For example, 56 % of the European adhesive bonding technology production originates from Germany and 54 % of the JCC robot production. However, Italy has a great significance with regard to the manufacture of mechanical joining technology: 39 % of the European production originates from Italy. With a proportion of one fifth of the European production, France is a significant producer of coating technology.

Table 1a: Production values of JCC technology in Europe (in € million) – selection

	2011	2010			
	D	**D**	**I**	**F**	**EU27**
Welding, brazing/soldering and cutting technology	1.560	1.259	319	137	3.732
Parts and accessories	679	535	255	243	2.202
Adhesive bonding technology	429	309	100	35	548
Mechanical joining technology	143	89	109	39	279
Coating technology	18	17	7	11	59
JCC robots	689	444	87	53	829
Lasers (optical constituents)	41	31	no data	no data	62
Lasers (Infrastructure)	240	197	no data	no data	239
Total	**3.799**	**2.881**	**876**	**518**	**7.951**

[8] Moos, Waike and Ronald Janßen-Timmen with the collaboration of Natalya Leonenko and Julia Klöpper (2013), Macroeconomic and sectoral value added by the production and application of joining technologies in Germany, expert report on behalf of the German Welding Society, Düsseldorf *and* Moos, Waike with the collaboration of Natalya Leonenko and Julia Klöpper (2013), Macroeconomic value added by joining technologies in the EU and selected countries in Europe, expert report on behalf of the German Welding Society, Düsseldorf.

The production values of JCC technology in Europe are compared once again in Table 1b – now for all six countries investigated in greater detail as well as for EU27.

Table 1b: Production values of JCC technology in Europe (in € million) – all the investigated countries

		2011	2010								
		D	**D**	**I**	**NL**	**F**	**UK**	**CZ**	**EU27**	**Other EU states without D, I, NL, F, UK, CZ**	Ratio of the other countries not considered in any greater detail to EU27
Welding, brazing/soldering and cutting technology		1.560	1.259	319	confidential	137	58	21	3.732	1.938	0,52
Parts and accessories		679	535	255	confidential	243	99	43	2.202	1.028	0,47
Adhesive bonding technology	*	429	309	100	15	35	16	5	548	68	0,12
Mechanical joining technology	**	143	89	109	confidential	39	9	confidential	279	34	0,12
Coating technology (thermal spraying)	1	18	16,6	6,7	2,2	11,5	11,8	no data	59	10	0,18
JCC robots (welding, adhesive bonding and cutting robots)											
Quantity in 2010 (D: in 2010 and 2011)		6.890	4.436	866	91	530	199	76	8.289	2.091	0,25
Quantity* production value per unit	100.000	689	444	87	9	53	20	8	829	209	0,25
Lasers (optical constituents)		41	31	no data	no data	no data	no data	no data.	62	-	-
Lasers (infrastructure)	2	240	197	no data	no data	no data	no data	no data	239	-	-
Total		**3.799**	**2.881**	**876**	**27**	**518**	**213**	**76**	**7.951**	**3.360**	**0,42**
Preceding expert report in 2007			2.551	1.169	29	323	160	-	7.504	3.272	0,44

It is necessary to take account not only of the JCC devices but also of the ancillary goods required during the JCC processes – the complementary goods. These are goods and services which are needed additionally in connection with the utilisation of the JCC devices. These include welding and brazing/soldering consumables, welding gases, adhesives, rivets, thermal spraying consumables, protective equipment, venting and testing machines as well as training and further education services. The production values specified here are attributed to Effect II. The production values of the complementary goods are portrayed in Table 2a as a summary.

Table 2a: Production values of complementary goods in Europe (in € million) - selection

	2011	2010			
	D	D	I	F	EU27
Consumables	647	549	193	238	2.027
Adhesives	375	339	164	155	1.860
Rivets	207	182	75	114	552
Gases	536	544	368	298	1.728
Clothing	58	56	22	10	230
Venting	22	18	1	2	37
Testing machines	303	267	56	122	688
Training and further education[1]	179	179	no data	no data	417
Total	**2.327**	**2.135**	**880**	**940**	**7.539**

[1] 2011 value set like 2010

As far as the complementary goods are concerned, Germany is ranked first with production values of € 2.1 billion in 2010 and € 2.3 billion in 2011, followed by France with € 940 million and Italy with € 880 million. Around 28 % of the European production of consumables originates from Germany; in each case, around 12 % originates from France and Italy. Italy stands out because of its above-average significance with regard to gas production. France is conspicuous due to relatively high proportions of the rivet production, the gases and the testing machines. For France and Italy, no information is available about training or further education. Therefore, the actual production value of the complementary goods might turn out to be even greater.

The production values of JCC technology in Europe are compared once again in Table 2b – now for all six countries investigated in greater detail as well as for EU27.

Table 2b: Production values of complementary goods in Europe (in € million) - all the investigated countries

	2011	2010								
	D	**D**	**I**	**NL**	**F**	**UK**	**TSCH**	**EU27**	**Other EU states without D, I, NL, F, UK, CZ**	Ratio of the countries not considered in any greater detail to EU27
Consumables	647	549	193	73	238	137	7	2.027	830	0,41
Adhesives	375	339	164	69	155	167	1	1.860	965	0,52
Rivets	207	182	75	confidential	114	75	9	552	98	0,18
Gases	536	544	368	84	298	69	31	1.728	334	0,19
Clothing	58	56	22	confidential	10	32	2,5	230	106	0,46
Venting	22	18	1,4	0,6	2	2,1	0,3	37	13	0,34
Testing machines	303	267	56	2,2	122	60	0	688	181	0,26
Training and further education[1]	179	179	no data	no data	no data	no data	no data	417	-	-
Total	**2.327**	**2.135**	**880**	**228**	**940**	**541**	**51**	**7.539**	**2.765**	0,37
Preceding expert report in 2007	-	2.106	1.797	382	1.514	1.193	-	12.843	**5.851**	0,46

Not only the **production values of JCC technology** but also the **value added** associated with it as well as the **employment** are indicated in Table 3. These may also be attributed to Effect I specified above. As said by the name, the value added indicates the extra value created by the production. It is calculated by deducting the intermediate inputs needed for the production from the production value. The relevant employment results from dividing the gross value added by the average working productivities in the sectors and the countries.[9] In Germany, a value added of € 1.3 billion and the employment of over 18,000 people are connected with the production of JCC technology. In Europe, the value added amounts to € 2.7 billion and the employment to around 45,000 people.

Table 3: Value added and employment resulting from the production of JCC technology (Effect I) - selection

	2011	**2010**
	D	**EU27**
Production value (in € million)	3.799	7.951
Value added (in € million)	1.332	2.700
Employment	18.332	45.000

[9] The resulting working productivities are the gross value added per gainfully employed person at the respective prices.

Not only the **production values of the complementary goods** but also the corresponding **value added** and **employment** are portrayed in Table 4. In Germany, the production of the complementary goods leads to a value added of almost € 900 million. Over 16,000 employees are associated with this. Thus, the production of the complementary goods once again results in value added and employment similar to those resulting from the production of the actual JCC technology. One job in the production of JCC technology safesguards almost one more whole job in the production of complementary goods.

Table 4: Value added and employment resulting from the production of complementary goods (Effect II) - selection

	2011	2010
	D	EU27
Production value (in € million)	2.327	7.539
Value added (in € million)	898	2.491
Employment	16.419	36.267

In Europe, the production of the complementary goods leads to a value added of € 2.5 billion as well as the employment of over 36,000 people. That is somewhat lower than in the case of the production of JCC technology. Here, one job in the production of JCC technology safeguards 0.8 jobs in the production of complementary goods.

Value added and employment resulting from the application of JCC technology

Value added and employment resulting from JCC technologies arise not only during the production of the devices and the machines as well as during the manufacture of the complementary goods but also in the user sectors (such as vehicle construction, mechanical engineering or the manufacture of metal products) - during the utilisation of JCC technology within the framework of joining processes. However, the total value added occurring in these joining-intensive sectors must not be attributed but instead only the proportion which has resulted directly from the joining processes. From the number of **employees in JCC processes** multiplied by the sectorally specific working productivity or gross value added per gainfully employed person, the proportional **relevant gross value added (Effect III)** by joining, cutting and coating can be estimated in every sector.

However, the number of employed joining technologists must be estimated. The starting point of the estimation procedure is the number of employees in the various occupational groups in welding which is available to DVS from a survey of twelve welding technology institutes and societies in 2008. Since this survey could not be repeated for the present expert reports, reference was made to the steel consumptions as an indicator variable in order to extrapolate the numbers of employees. DVS made the numbers of employees established in this way available to the authors. In this respect, it was possible to make a distinction between welders, welding supervisors, welding inspectors, welding designers, welding instructors and welding planning engineers. Thereafter, it was necessary to extrapolate the welding technology personnel to the joining technology personnel. In this case, the average ratio of the production values of welding and brazing/soldering technology to those of joining technology as a whole was used in order to extrapolate the welders to the joining technologists. On the European level, exactly the same method was applied to the estimation of the employed joining technologists.

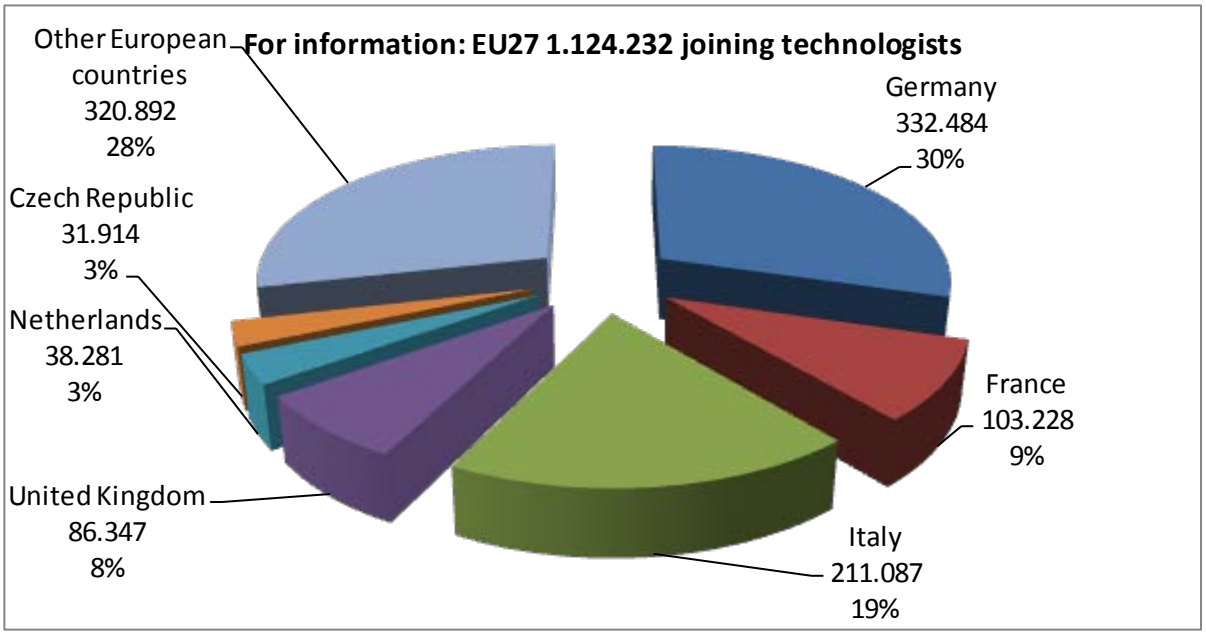
Table 5: Employed full-time-equivalent joining technologists in Europe - selection

	2011			
	D	**I**	**F**	**EU27**
Welders	156.146	112.829	51.068	646.914
Other welding occupations[1]	19.611	19.667	11.357	110.487
Welding robot operators	82.570	23.806	26.052	200.746
Total of welders in the widest sense	258.327	156.302	88.477	958.147
Total of joining technologists	332.484	211.087	103.228	1.124.232

[1] Welding supervisors, (NDT) inspectors, designers, researchers, instructors and planning engineers

The number of people in occupational groups associated with all aspects of welding and joining is portrayed in Table 5. There are over 330,000 joining technologists in Germany. Around 30 % of the 1.1 million European joining technologists are to be found in Germany. All of 210,000 joining technologists work in Italy. No fewer than over 100,000 people working in joining occupations are to be found in France. The numbers of employed joining technologists also for the other EU countries considered in greater detail are portrayed on Fig. 1.

Fig. 1: Employed joining technologists in Europe



If the numbers of employees established in this way are divided by the average working productivity[10] in the joining-intensive sectors, this results in the value added induced by the employed joining technologists.

Table 6: Value added and employment resulting from the application of joining technologies (Effect III) – selection

	2011	
	D	EU
Value added (in € billion)	18,8	60
Employment (in 1,000)	332	1124

In Germany, a value added amounting to € 18.8 billion is associated with the 330,000

[10] Gross value added by gainfully employed people at the respective prices.

joining technologists via the sectorally specific working productivities (Table 6). In comparison with the value added by the production of JCC technology (€ 1.33 billion), the value added by the application of JCC technology is 14 times higher than that resulting from the production of it.

The figure of 1.1 million joining technologists established for Europe is around 3.4 times higher than the corresponding numbers of German employees. Via sectorally specific working productivities, a value added of € 60 billion is computationally associated with this employment in Europe. That conrresponds to no less than three times the German value added. For Europe too, the value added by the application of JCC technology is many times higher than that resulting from the production (€ 2.7 billion).

Indirect intermediate input effects of the production of JCC technology and the complementary goods in Germany

If consideration were given merely to the production of JCC technology and the complementary goods as well as to their application, only the direct effects of their manufacture would be recorded. This would not take account of a significant part of the value added chain or of the employment associated with it: the indirect effects. The indirect effects of the production of JCC technology and the complementary goods are based on the fact that intermediate inputs from other sectors are required for their manufacture. For a comprehensive assessment, it is therefore necessary to add the (indirect) value added and employment arising in connection with this intermediate input production (Effects IVa and IVb) to the direct value added and employment resulting from the production of JCC technology and complementary goods (Effects I and II).

Within the framework of an input-output analysis, indirect effects are calculated with the aid of input-output tables. Since no adequate input-output data or economic sectors / occupations matrices were available for the European countries under consideration or on the level of EU27, the indirect effects of the production of JCC technology and the complementary goods could be determined for Germany alone. The latest input-output tables from the Federal Statistical Office for 2007 were used for this purpose. The results of the executed input-output analysis were linked with the production data from 2011.

The input-output analysis was made in the form of a multiplier analysis. For every individual sector (here, the manufacture of JCC technology as a part of mechanical engineering as well as those sectors in which complementary goods are produced for the utilisation of JCC technology), it supplies multipliers which can be used for the calculation of the macroeconomic effects of a given change in the demand for the goods in one sector. The investigated (change in) demand represents exclusively the

purchases of end products and not of parts of JCC devices or complementary goods. From the macroeconomic effects, the effects on the production, the gross value added and the employment are considered within the framework of this study.

The demand for JCC technology as well as for the complementary goods is needed as the initial variable of the multiplier analysis. Both variables were deduced by evaluating the input-output data from the production data used in this study. The production value for the manufacture of JCC technology in Germany in 2011 amounting to around € 3.8 billion (Table 1) results in a demand of nearly € 3.3 billion for JCC goods (Table 7). The remaining value of approx. € 0.5 billion encompasses the production of parts of JCC goods. These must already be attributed to the indirect effects. In the German national economy as a whole, the direct demand for JCC technology led to a production effect of almost € 6.0 billion (direct and indirect effects together). On the macroeconomic level, this results in indirect effects amounting to more than € 2.7 billion - including the production of parts of JCC goods. The proportion of the indirect effects thus amounts to around 46 %.

Table 7: Production, value added and employment resulting from the manufacture of JCC technology in 2011

	Direct	Indirect	Overall effect
	Production effects in € million		
Demand for JCC technology	3.275		
Production of the JCC technology	3.275	524	3.799
Production of the overall economy[1]	3.275	2.738	6.013
	Gross value added in € million		
JCC technology	1.158	185	1.343
Overall economy[1]	1.158	1.187	2.345
	Employment[2] in person-years		
JCC technology	15.417	2.467	17.884
Overall economy[1]	15.417	18.462	33.879
Our own calculation – [1] Including JCC technology. – [2] On the basis of the average working productivity in 2007.			

The gross value added included in these values is calculated with the aid of value added ratios. For this purpose, the total gross value added earned in one sector is related to the production value of the sector. For the employment effects of the demand for JCC technology, reference is made to average working productivities. Not only the value added ratios but also the working productivities can be calculated

from the data in the input-output tables.

In 2011, the direct demand for JCC devices led to a value added of almost € 1.2 billion (Table 7). An additional figure of € 185 million originated from the indirect demand for intermediate inputs (production of parts). Altogether, this results in a value added of around € 1.3 billion which is included in the production value for the manufacture of JCC technology. On the macroeconomic level, the direct demand for JCC technology even led to a value added of more than € 2.3 billion. In this respect, the indirect value added effect amounted to nearly € 1.2 million and this value also includes the above indirect value added by the production of parts. Thus, the indirect value added effect caused by the demand for JCC goods turned out to be almost as high as the direct value added effect.

In 2011, the demand for JCC goods served to safeguard the employment for 15,417 people (Table 7). Furthermore, 2,467 people worked in the production of parts. In the overall economy, the employment effect resulting from the demand for JCC goods even amounted to 33,879 people in 2011. In addition to the workforce required for the direct production of the demanded JCC goods, 18,462 people were therefore employed due to the indirect demand for intermediate inputs. While the ratio of direct to indirect effects turns out to be extremely well-balanced in the case of the value added, substantially more employment is safeguarded or created indirectly - i.e. on the intermediate input level.

Table 8: Production, value added and employment resulting from the manufacture of complementary goods in 2011

	Direct	Indirect	Overall effect
	Production effects in € million		
Demand for complementary goods	1.741		
Production of complementary goods	1.741	720	2.461
Production of the overall economy[1]	1.741	1.610	3.351
	Gross value added in € million		
Complementary goods	553	171	724
Overall economy[1]	553	622	1.175
	Employment in person-years		
Complementary goods	8.134	1.580	9.714
Overall economy[1]	8.134	9.317	17.451

Our own calculation. – [1] Including complementary goods – [2] On the basis of the average working productivities in the relevant sectors in 2006.

The types of complementary goods listed in Table 2 were assigned to the following sectors: manufacture of clothing, manufacture of chemical products (without pharmaceutical products), manufacture of metal products, mechanical engineering, manufacture of medical, measurement and control technology as well as the field of teaching services. The production value for complementary goods from Table 2 amounting to € 2.3 billion includes a direct demand for these goods amounting to more than € 1.7 billion (Table 8). Because of the intermediate input interlinking of the German national economy, this demand results in a macroeconomic production effect of around € 3.4 billion. At € 1.6 billion, the indirect production effect reaches a level similar to the demand and to the direct production corresponding to it.

At € 553 million, the direct value added by the demand for complementary goods in 2011 also turned out to be only half as high as the direct value added by the demand for JCC goods (Tables 7 and 8). The indirect value added effect amounted to € 622 million in the case of the complementary goods. Altogether, this results in a macroeconomic value added effect of nearly € 1.2 billion.

With regard to the complementary goods, the macroeconomic employment effect with 17,451 people also turned out to be only approximately half as high as in the case of the JCC goods (Tables 24 and 22). In this respect, the effect caused by the direct demand for complementary goods accounted for the employment of 8,134 people. As in the case of the JCC goods, the larger proportion of the macroeconomic employment effects is attributed to the demand for intermediate inputs. In 2011, the indirect employment effect resulting from the manufacture of complementary goods amounted to 9,317 people altogether and corresponded to around 53 % of the macroeconomic employment effect.

Summary

The technologies of joining, cutting and coating (JCC technologies) constitute cross-sectional technologies. These are used in many sectors and for many different fabrication processes and, with regard to the utilised materials and the applied technologies, are closely related to suppliers and customers. The characteristic of JCC technology as a cross-sectional technology hinders the statistical recording and estimation of its macroeconomic significance.

The objective of both studies was to quantify the significance of JCC technology for the German national economy, for selected countries in Europe as well as for Europe as a whole. This should not only be geared to the contribution made by the production of machines and devices for joining, cutting and coating and their relevant value added and employment but should also take account of the production, value added and employment which arise amongst the users of JCC technology. The various investigated sources for production, value added and employment resulting from JCC technology were divided into three direct effects:

Effect I: Direct effects of the manufacture of JCC technology.

Effect II: Direct effects of the manufacture of complementary ancillary materials and consumables as well as the provision of available ranges of training and further education.

Effect III: Those direct effects in joining-intensive sectors which are accounted for proportionally by the JCC processes, i.e. the users of JCC technology.

Furthermore, two indirect value added and employment contributions as a consequence of intermediate input interlinks were established - with the aid of an input-output model:

Effect IVa: Indirect (intermediate input) effects of the manufacture of JCC technology.

Effect IVb: Indirect (intermediate input) effects of the manufacture of complementary goods.

The indirect effects could not be established in the European study since important data (i.e. the European economic sectors / occupations matrices and input-output

matrices) were not available on the European level. However, the indirect effects make up only a small proportion of the overall effect. In spite of the fact that they were ignored, it was thus possible to establish the largest proportion of the overall effect - i.e. well over 90 %.

The study for Germany in 2013 indicated the overall effect, i.e. here, the total of Effects I, II, III, IVa and IVb resulting from the production and application of JCC technology in Germany, at nearly € 23 billion as well as the associated employment of 395,000 people. That is 1 % of the macroeconomic value added (€ 2,317 billion) or nearly 4 % of the value added in the manufacturing sector (without construction) (€ 607 billion). If the direct effects whose counterparts could be established on the European level too are considered for Germany alone, this leads to a value added of € 21 billion with the employment of 366,000 people (Table 9 and Figure 2). Therefore, the indirect effects ignored here make up only approx. 7 - 8 % of the overall effect.

As the total of Effects I, II, III, IVa and IVb, the preceding study came up with a value added contribution of € 24.4 billion with the employment of 421,000 people. However, the differences between both studies should not be overrated since Effect III which contributes the largest proportion of the value added and the employment had to be calculated using a different method in the latest studies. Furthermore, precisely the numbers of employees react to increased working productivities in the individual economic sectors and to technical progress in the form of new or refined technologies.

In summary, it may thus be stated that, for the German economy, the value added contribution made by the production and application of JCC technology has been stable for several years at around € 23 - 24 billion. Around 400,000 employees are associated with this in Germany.

Table 9: Summary: Value added and employment resulting from the production and application of JCC processes in Germany

	Germany in 2011					
Effect	I	II	III	IVa	IVb	Overall affect
Value added (in € billion)	**1,33**	**0,90**	**18,8**	**1,2**	**0,6**	**22,9**
Employment (in 1,000)	**18**	**16**	**332**	**18**	**9,3**	**395**
Proportions of the gross value added (in %)	5,8	3,9	82,3	5,2	2,7	100,0
Proportions of the employment (in %)	4,6	4,2	84,2	4,7	2,4	100,0
Employment standardised	1	0,9	18,1	1,0	0,5	21,5
	Germany in 2007 (preceding study)					
Effect	I	II	III	IVa	IVb	Overall effect
Value added (in € billion)	**0,97**	**0,89**	**20,8**	**0,8**	**0,9**	**24,4**
Employment (in 1,000)	**15**	**15**	**360**	**11,6**	**19,3**	**421**
Proportions of the gross value added (in %)	4,0	3,7	85,4	3,3	3,7	100,0
Proportions oft he employment (in %)	3,6	3,6	85,5	2,8	4,6	100,0
Employment standardised	1	1,0	24	0,8	1,3	28,1
Our own calculations						

Figure 2: Value added and employment resulting from JCC technology in Germany in 2011

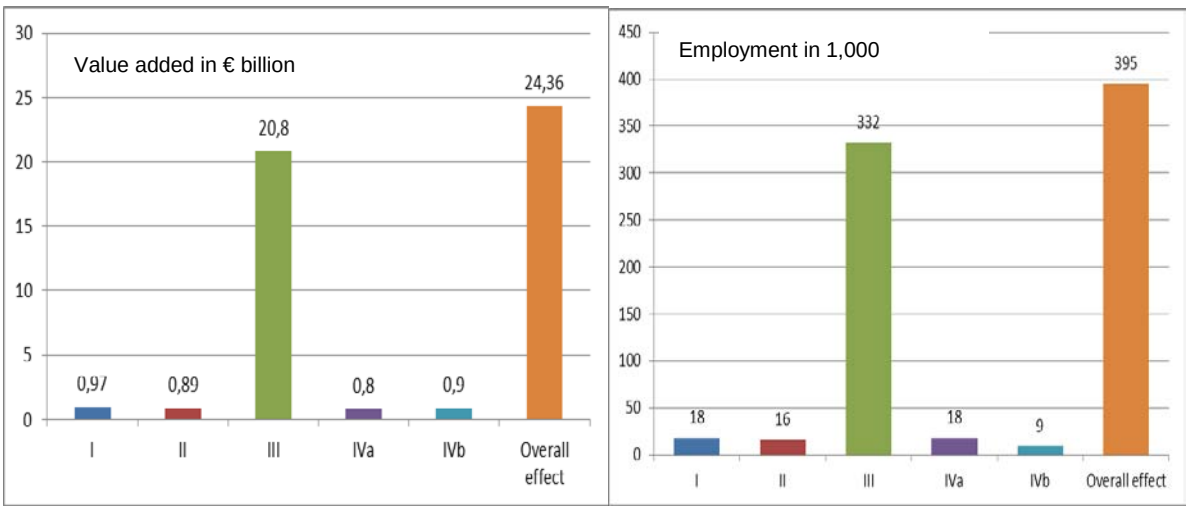
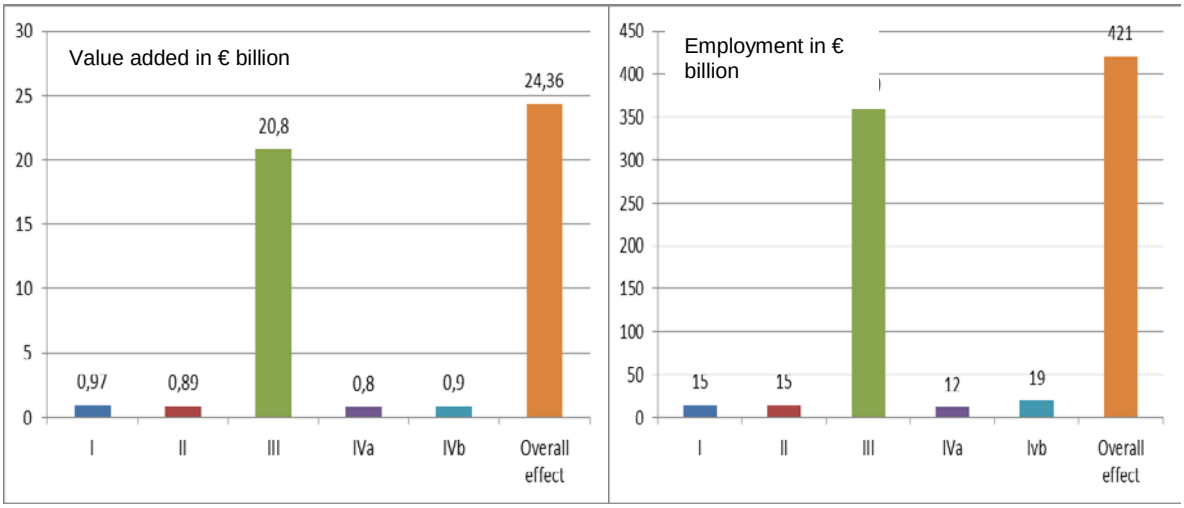


Figure 3: Value added and employment resulting from JCC technology in Germany in 2007 (preceding study)



The value added and employment effects in the studies from 2013 and 2007 are compared directly on Figures 4 and 5 below in order to be able to derive time-related developments. However, it must be taken into consideration in this respect that precisely Effect III was calculated using deviating methods in both studies. The value added and employment results in Effect III turn out to be far more conservative in the latest study than in the preceding study. Thus, the overall effect also turns out to be smaller in the latest study than in the preceding study. The increasing significance of JCC technology can only be assessed in a methodologically accurate way in a comparison of both Effects I from the different years (Figure 6).

Figure 4: Time-related comparison of the value added by JCC technology in Germany

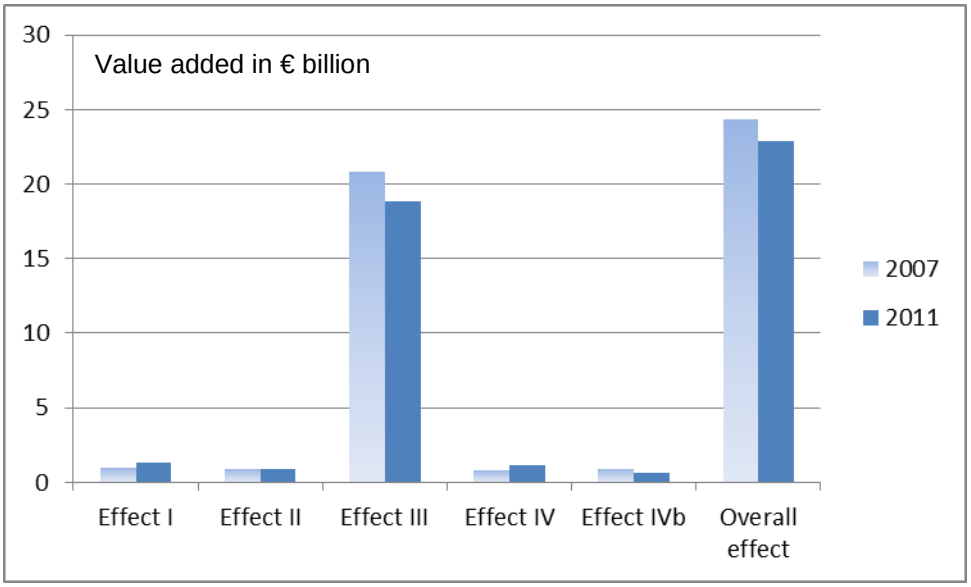


Figure 5: Time-related comparison of the employment resulting from JCC technology in Germany

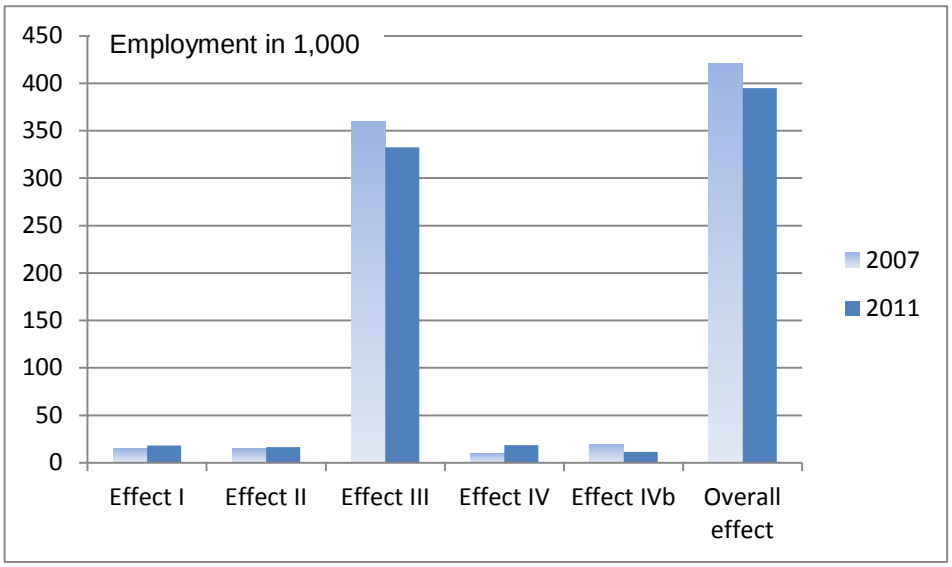
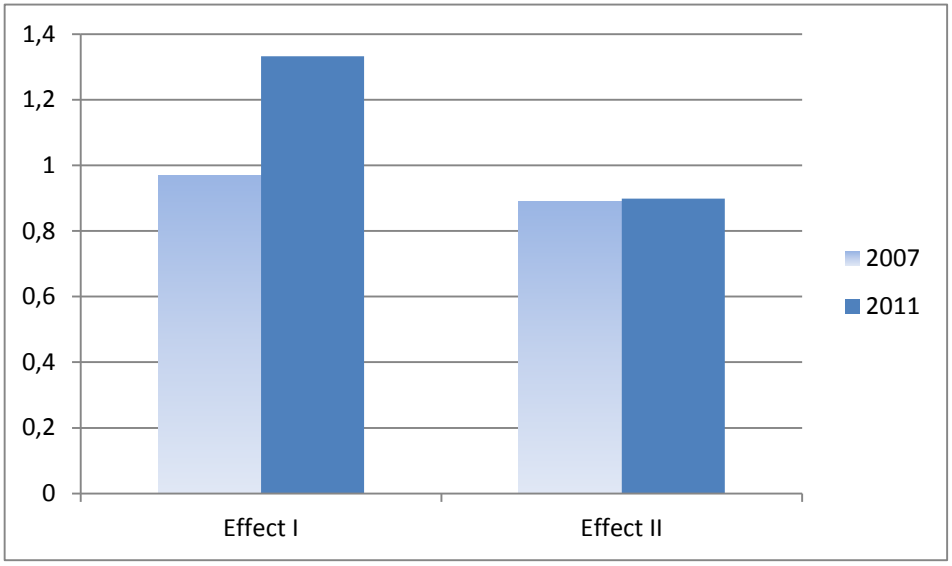


Figure 6: Time-related comparison of the value added in Effects I and II (in € billion)



In 2010, the direct overall effect resulting from the production and application of JCC technology on the value added in Europe amounted to € 65 billion (Table 10 and Figure 7). That is three times more than the corresponding value added for Germany (€ 21 billion)[11] but from 2011 In Europe in 2010, over 1.2 million employees who were directly involved in the manufacture of JCC technology or the complementary goods or as their users were associated with the direct overall effect on the value added. The numbers of employees connected with the production and application of JCC technology in Europe are 3.3 times higher than the corresponding numbers of German employees (total of Effects I to III).

Table 10: Summary: Value added and employment resulting from the production and application of JCC processes in Europe

	Europe 2010			
Effec	I	II	III	Overall effect
Value added(in € billion)	**2,70**	**2,49**	**60,0**	**65,1**
Employment (in 1,000)	**45**	**36**	**1.124**	**1.205**
Proportions of the gross value added (in %)	4,1	3,8	92,0	100,0
Proportions of the employment (in %)	3,7	3,0	93,3	100,0
Employment standardised	1	0,8	25,0	26,8
	Europe 2007 (preceding study)			
Effect	I	II	III	Overall effect
Value added (in € billion)	**2,6**	**4**	**79,1**	**85,7**
Employment (in 1.000)	**55**	**68**	**1.904**	**2.027**
Proportions of the gross value added (in %)	3,0	4,7	92,3	100,0
Proportions of the	2,7	3,4	93,9	100,0

[11] As the total of effects I, II and III.

employment (in %)				
Employment standardised	1	1,2	34,6	36,9
Our own calculations				

In the preceding study, the value added and employment effects in Europe turned out to be substantially greater. This decline has various causes which must be considered effect by effect.

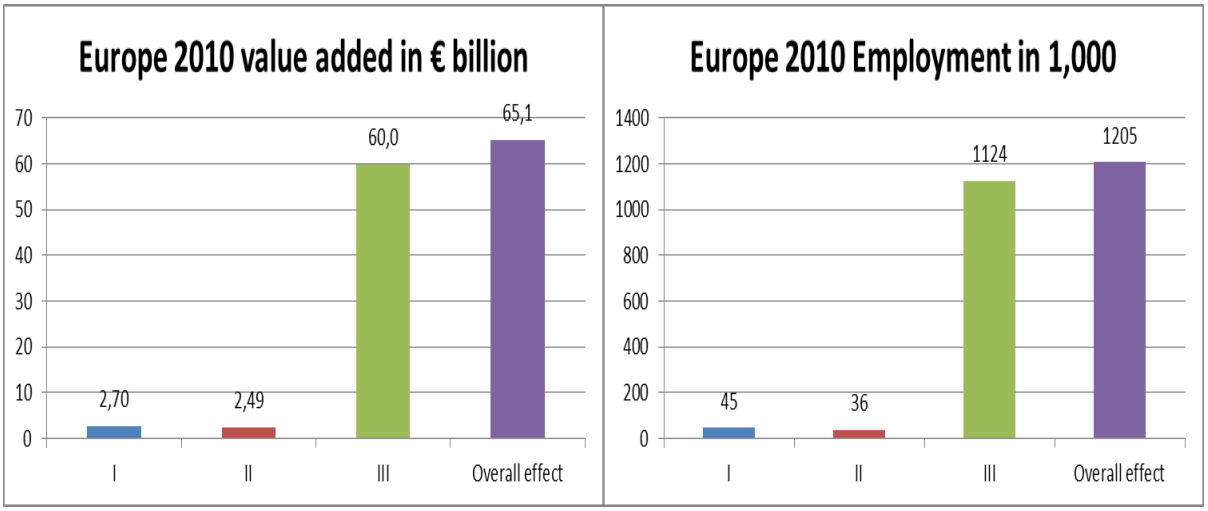
In Effect I, the value added has remained nearly constant in comparison with the preceding study. There were only slight methodological changes by modifying a few proportions to be taken into account. The employment effect has dropped due to the increased working productivities.

In Effect II, the consideration of the adhesives resulted in crucial methodological changes which reduced their production value by almost two thirds. Thus, the total production value of the complementary goods dropped by around 40 % compared with the preceding study. Parallel to this, the value added and the employment have also decreased in Effect II.

In Effect III, the numbers of employees were established using a totally different method to the preceding expert report. At that time, the number of employees was established on the basis of a survey and other estimations (1.9 million) and exceeds the latest result on the basis of the survey at that time with the extrapolation of the numbers of employees using the indicator variable of the steel consumptions (1.2 million) by 58 %.

In the total of Effects I - III, the methodological changes lead to a value added effect which is a quarter below that in the preceding expert report. The employment effect is around 40 % below that in the preceding expert report. Since the calculations were inevitably associated with a lot estimations, methodological changes always occurred whenever it was possible to presume that the new method would lead to a better estimation. In this respect, a conservative estimation with which it may tend to be assumed that the calculated effects constitute a lower limit should always be preferred to any possible overestimation which might have arisen in the preceding expert report.

Figure 7: Value added and employment resulting from JCC technology in Europe in 2010



(1) Out of the total of € 22.9 billion of value added by joining technology in Germany, only a very small proportion of € 1.33 billion or nearly 6 % of the entire resulting value added by joining technology was accounted for by the manufacture of JCC technology (Effect I). Thus, the overall effect is 17 times higher than that value added resulting from the production of JCC technology alone. Around 18,000 people were employed in the manufacture of JCC technology in 2011. That constitutes just 4.6 % of the employment of 395,000 people (overall effect) resulting from the production and application of joining technology altogether. In the preceding study, 15,000 employees belonged to Effect I but the value added (0.97) for Effect I was also lower in the preceding study. The overall effect of the employment in 2011 is 22 times higher than that resulting from the production of JCC technology alone. 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 € 0.9 billion and around 16,000 employees (Effect II) in 2011.

However, the largest proportion of the value added (i.e. around 82 %) did not originate from the manufacture of the JCC devices but instead from their utilisation in joining processes in the user sectors. In the German national economy, a value added of around € 18.8 billion (Effect III) was achieved by the production processes of joining, cutting and coating. This is associated with 332,000 joining technologists and joining robot operators in the joining-intensive sectors. That corresponds to around 84 % of the overall effect of the employment.

If the (rounded) standardised numbers of employees (Table 9) are considered, it is possible to recognise the enormous leverage emanating from JCC technology. One employee in the production of JCC technology is connected with nearly one additional employee in the production of complementary goods. In the joining-intensive sectors, around 18 more jobs are safeguarded by the application of JCC technology. Furthermore, the intermediate input demand as a consequence of the production of JCC technology induces one extra job amongst the suppliers for its

intermediate inputs. As far as the complementary goods are concerned, an additional half an employment relationship in the rest of the economy is safeguarded by their intermediate input demand.

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. In particular, Effect III turned out to be higher there. In any case, the method used for estimating the numbers of employees in Effect III in the latest study was different from that in the preceding study. However, as already in the preceding study, the following core result can 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) Due to the close interlinking of the manufacturers of JCC technology and the joining-intensive sectors, not only do the directly affected sectors profit from the utilisation of JCC technology but the effects also radiate far across the overall national economy: In other sectors, the manufacture of JCC technology caused a rise of € 1.2 billion in the indirect value added (Effect IVa) and thus safeguarded around 18,000 employment relationships. In other sectors, the manufacture of the complementary goods for JCC technology induced a rise of € 0.6 billion in the indirect value added (Effect IVb). This served to safeguard another 9,300 employment relationships.

The leverage of the *demand* for JCC technology as a consequence of the intermediate input interlinks becomes particularly evident when the results are considered in the form of the multipliers introduced in Chapter 6 of the expert report for Germany: Thus, if the value added by the manufacturers of JCC technology increases by one unit, the value added in the overall economy rises by 2.02 units, i.e. 1.02 units of value added are induced via the intermediate input interlinks in all the other sectors. A similar order of magnitude is shown with regard to the employment effect: One additional employee in the manufacture of JCC technology induces 2.2 employees in the overall national economy, i.e. another 1.2 *indirect* jobs in all the other sectors are dependent on one direct job at the manufacturers of JCC technology.

(3) The ratio in which the individual effects contribute to the overall effect on the European level is similar to that in Germany. Out of the total of € 65 billion of value added by joining technology in Europe (Table 10), only a small proportion of € 2.7 billion was accounted for by the manufacture of JCC technology (Effect I). Around 45,000 people were employed in the manufacture of JCC technology in Europe in 2010. 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 € 2.5 billion and 36,000 employees (Effect II) in Europe in 2010. 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 € 60 billion (Effect III) was achieved by the production processes of joining, cutting and coating. In this respect, over 1.1 million full-time-equivalent joining technologists and JCC robot operators were employed in the joining-intensive sectors. With regard to the employment in Europe, the overall effect resulting from the production and application of JCC technology is thus around 27 times higher than that employment originating from the production of JCC technology alone: One employee in the production of JCC technology is associated with 0.8 employees in the production of complementary goods and services as well as with 25 employees in the application of JCC technology.

Also in the other countries under consideration, there are basically similar orders of magnitude for the extent to which the individual effects contribute to the overall effect: A strong leverage emanates from JCC technology: 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.