DIW ECON

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Economic impact of public contracts awarded to the aerospace industry in Spain

The macroeconomic impact of public contracts awarded to the defence sector of the aerospace industry in Spain

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Executive Summary

This study provides an assessment of the **economic impact of public procurement contracts awarded to defence sector of the aerospace industry in Spain.** For this purpose, DIW Econ created a model of the Spanish defence aerospace industry and its complex supply chain. The model is based on the Spanish input-output table. It is adjusted to capture the aerospace industry in detail and to estimate the economic effects on value added, employment and returns to public funds. Moreover, the model captures additional economic activity induced by consumption spending of workers, entrepreneurs and shareholders of involved companies.

The analysis shows exemplary effects of procurement contracts **per 100 million euro net contract volume[1] in each of the relevant segments of the defence sector of the aerospace industry** on value added, employment and returns to public funds in Spain:

Table 0-1:
Total effects (direct, indirect and induced) on value added per 100 million euro net contract volume in each of the relevant segments

Segments of the defence sector of the aerospace industry	Unit	Contract volume (net)	Gross value added
Research and development	Million euro	100.0	**160.6**
Manufacture of air and spacecraft	Million euro	100.0	**122.9**
Repair and maintenance of aircraft and spacecraft	Million euro	100.0	**146.2**

Results per 100 million euro procurement net contract volume in the three segments are generally valid for public procurements in the defence sector in the aerospace industry in Spain.

Source: DIW Econ.

[1] Net contract value at basic prices according to the System of National Accounts, excluding value added tax.

Additionally, as shown in Table 0-2, employment effects are caused in all three segments of the defence sector of the aerospace industry.

Table 0-2:
Total effects (direct, indirect and induced) on employment per 100 million euro net contract volume in each of the relevant segments

Segments of the defence sector of the aerospace industry	Unit	Contract volume (net, in million. euro)	Persons employed
Research and development	Persons	100.0	**2,503**
Manufacture of air and spacecraft	Persons	100.0	**2,168**
Repair and maintenance of aircraft and spacecraft	Persons	100.0	**2,176**

Results per 100 million euro net contract volume in the three segments are generally valid for public contracts in the defence sector of the aerospace industry in Spain.

Source: DIW Econ.

Moreover, the production effectuated per 100 million euro net contract volume in the three segments generates public revenue in the form of taxes and social security contributions:

Table 0-3:
Generated tax and social security returns (direct, indirect, and induced) per 100 million euro net contract volume in three segments

Segments of the defence sector of the aerospace industry	Unit	Contract volume (net)	Returns to public funds (taxes and social contributions)
Research and development	Million euro	100.0	**36.1**
Manufacture of air and spacecraft	Million euro	100.0	**33.2**
Repair and maintenance of aircraft and spacecraft	Million euro	100.0	**36.2**

Results per 100 million euro net contract volume in the three segments are generally valid for public contracts in the defence sector of the aerospace industry in Spain.

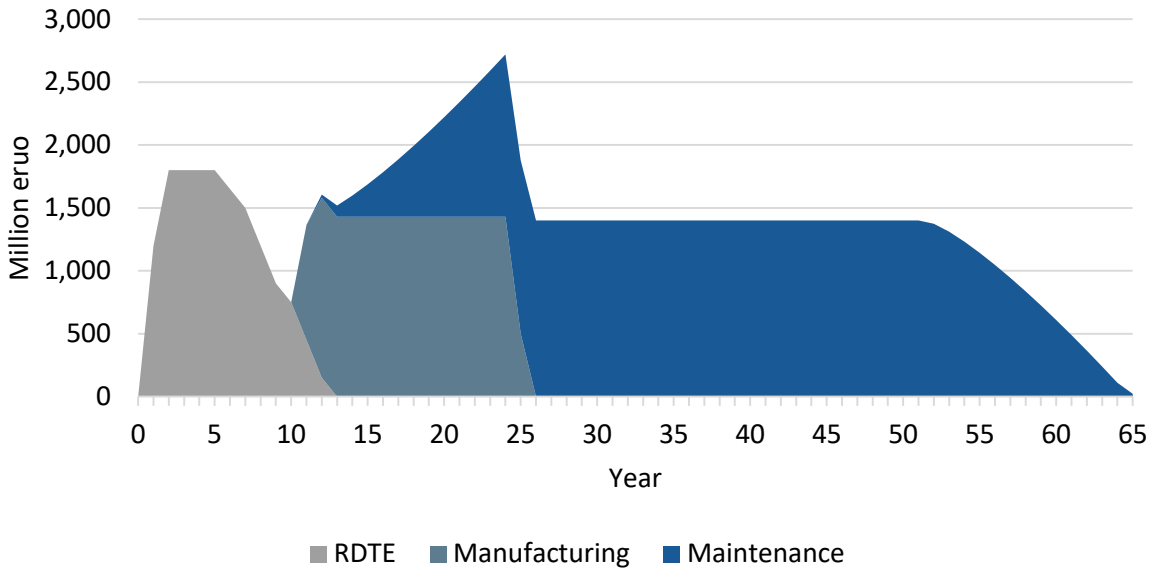
Source: DIW Econ.

In addition, this study quantifies the effects of an exemplary European long-term cooperative project over 65 years. It involves research, development, testing and evaluation (RDTE), manufacturing, as well as repair and maintenance of 200 military aircraft with an average annual net expenditure[2] of

[2] Expenditure at basic prices, i.e. excluding value added tax.

1.4 billion euro. Over the entire project the expenses are divided between the three involved segments of the defence sector of the aerospace industry as shown in Figure 0-1.

Figure 0-1:
Net expenditure by segment (Research, Manufacturing, and Maintenance) and year, stacked



Source: DIW Econ.

On average, the project is associated with an **annual total gross value added of 2 billion euro** and **employment** of about **31,200 persons per year.** It raises **about 500 million euro annual tax returns and social security contributions per year.**

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1. Introduction

The Spanish aerospace industry is a high-tech sector and a driver of economic growth featuring high paying jobs and strong technological innovation activity. In addition to the development, production, and maintenance of commercial aircraft, the Spanish aerospace industry also develops cutting-edge technologies and produces and operates products for the defence sector. Such research and knowledge-intensive activities have spill-over effects on the wider economy and thus positively affect overall economic output, employment and competitiveness.

This study focuses on quantifying the immediate economic effects that are caused by public demand for products of the defence sector of the aerospace industry.

- First, companies in the defence sector of the aerospace industry directly add to Spanish gross value added and employment.
- Second, many other industries supply intermediate inputs to the defence sector of the aerospace industry, adding indirectly to Spanish value added and employment.
- Third, these economic activities generate additional income and in turn the associated consumption spurs additional economic activity in many sectors of the economy.
- Finally, in addition to effects on economic output and employment, all involved companies and persons employed generate returns to public funds in terms of tax payments and social contributions.

With regard to public "make-or-buy decisions" in the defence sector of the aerospace industry, these effects matter. Commissioned by Airbus, this report quantifies and assesses the macroeconomic impact of a public contract awarded to the defence sector of the aerospace industry in Spain.

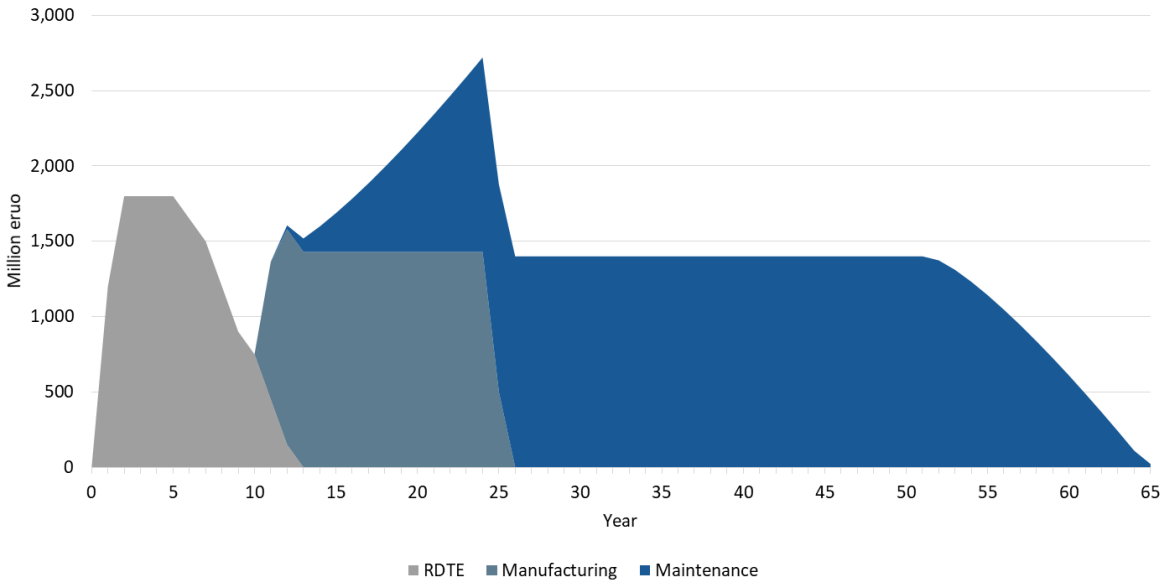
The structure of this report is as follows: Chapter two describe an exemplary project in the defence sector of the aerospace industry. Chapter three introduces economic impact analysis, explains different types of effects, and defines the core metrics used to assess the macroeconomic impact. Readers familiar with sectoral specificities and economic concepts can directly continue with the results (chapter four). Methodological details are presented in chapter five.

2. Exemplary Long-term Project

The starting point of the analysis is an exemplary, fictitious long-term project in the defence sector of the aerospace industry. While the project is a joint European partnership programme, this study focuses on the Spanish share of the overall net contract volume and the effects on the Spanish economy. In the following, we assume that the project involves the development, production and maintenance of 200 military aircraft in Spain. The underlying project timeline consists of 12 years of research, development, testing and evaluation (RDTE) and 15 years of production. Repair and maintenance of aircraft starts in the second year of production once the costumer has accepted the first series aircraft and lasts for the entire life-span of the produced aircraft. The overall project duration is 65 years. Based on industry expertise we make the following assumptions and show the following parameters at basic prices (net), i.e. excluding value added tax, of the project:

- Production of 200 aircraft (Spanish share of total production)
- Manufacturing costs (net) of 100 million euro per series-built aircraft
- Spanish share of total development costs (net): 15,000 million euro
- Operating time of 8,000 flying hours per aircraft
- Repair and maintenance costs (net) of 35,000 euro per flying hour

Figure 2-1:
Net expenditure by segment (Research, Manufacturing, and Maintenance) and year, stacked



Source: DIW Econ.

Furthermore, we assume that the defence project is carried out among European cooperation partners, in our case in close cooperation with Germany. For details on typical European cooperation programmes see section 5.6.

Based on the assumed project, the following total net expenditures result in Spain, where all monetary terms are real values, i.e. at the price level of the year of this study (2018):

- Total net expenditure for RDTE: 15,000 million euro (16 percent of total net contract volume)
- Total net expenditure for manufacturing of aircraft: 20,000 million euro (22 percent of total net contract volume)
- Total net expenditure for repair and maintenance: 56,000 million euro (62 percent of total net contract volume)
- Average total net expenditure per year: 1,400 million euro

In the case of long-term projects such as the one assessed in this study, it can reasonably be assumed that the principal makes regular – for instance annual – payments instead of paying large sums up front. It is assumed that taxes are paid immediately, even though parts of tax payments might occur with slight delay.

3. Analytical Approach: Economic Impact Analysis

This study analyses the economic impact of public contracts awarded to the defence sector of the aerospace industry in Spain. The main activities related to this sector take place in three segments:

- RDTE (research, development, test and evaluation),
- Manufacture of air and spacecraft and related machinery, and
- Repair and maintenance of aircraft and spacecraft.

In order to estimate the economic impact of such contracts, DIW Econ used a series of matrix algebra calculations and adjusted the most recent Spanish input-output table[3] to the specifics of the defence sector of the aerospace industry. The bespoke input-output table provides the framework for studying the interconnections between the above specified relevant segments of the defence sector of the Spanish aerospace industry and other industries within the Spanish economy. On this basis, DIW Econ calculated the total economic impact of a public contract awarded to the aerospace industry, accounting for its complex and global supply chain.

3.1 Quantifying Economic Impact: Core Metrics

This economic-statistical analysis measures the economic impact of public contracts awarded to the aerospace industry on the Spanish economy, using indicators of increased level of economic activity. Economic activity in turn is expressed using three core metrics: gross value added (hence also value added), employment, and returns to public funds.

- **Gross value added** is the most important indicator for economic performance; it measures the value of goods and services produced less intermediate inputs. Throughout the report, we refer to gross value added, which includes depreciation.[4] It corresponds to the incomes received by entrepreneurs, shareholders, and workers in the sector.
- **Employment** is measured according to the internationally agreed labour force concept of the International Labour Organization (ILO). It is the number of persons employed,

[3] Instituto Nacional de Estadística (2016): Spanish National Accounts. Input Output Table 2010.

[4] In contrast, net value added equals the value of gross value added less depreciation.

comprising all persons in employment covering employees, self-employed, civil servants etc., regardless of the hours worked.

- Finally, this study estimates **returns to public funds** associated with the economic activity in the aerospace industry and all upstream stages. This study considers tax revenues from income tax, value added tax, corporate tax and economic activity tax[5] as well as social security contributions (compulsory employers' social contributions plus compulsory actual social contributions by employees and the self-employed). It is important to note that value added tax is only relevant regarding induced spending (see induced effects, 3.2).Value added tax revenues generated through public consumption, however, will not result in any direct or indirect returns to public funds since taxes are both directly paid and collected by the government.

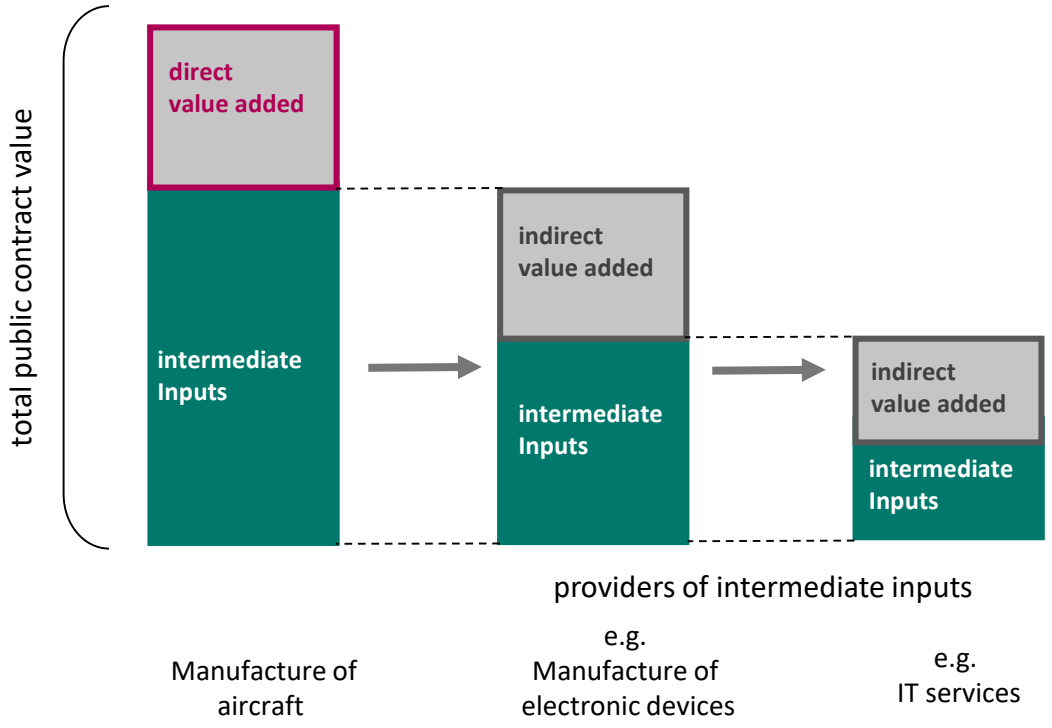
3.2 Economic Effects along the Value Chain

The total economic impact of a public contract awarded to the aerospace industry in a given area is the sum of *direct*, *indirect*, and *induced effects*.

- The first component of the total effect is the **direct effect.** An award of a public contract to the aerospace industry is associated with production activities in the core fields of the aerospace industry, i.e. in research and development, manufacturing, repair and maintenance of air- and spacecraft. Thus, direct economic effects are generated by companies that are directly involved in the production of the final products (i.e. aircraft) as illustrated on the left-hand side of Figure 3-1.
- The second component goes beyond the direct production activities in the core fields of the aerospace industry. **Indirect effects** consider the production of intermediate goods and services of suppliers that are critical inputs for the production of the final product. Thus, indirect effects account for all stages of the supply chain of the aerospace industry. The generation of indirect effects is exemplarily illustrated on the right-hand side of Figure 3-1.

[5] In Spanish: *Impuesto sobre la Renta de las Personas Físicas*, *Impuesto al Valor Añadido*, *Impuesto de Sociedades,* and *Impuesto sobre Actividades Económicas*.

Figure 3-1:
Direct and indirect effects generated through a public contract awarded to the aerospace industry

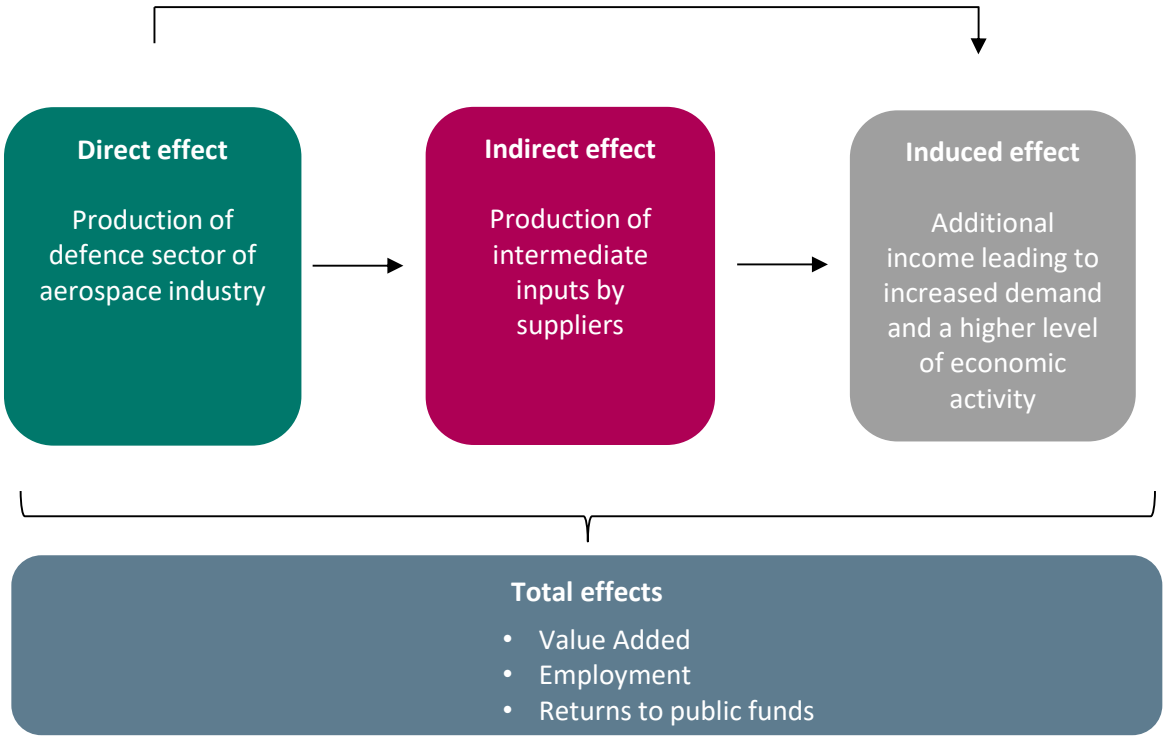


Source: DIW Econ.

- Finally, this study not only quantifies direct and indirect, but also estimates **induced effects.** Direct and indirect value added generated in production processes of the aerospace industry constitute income (both profits and labour income). Workers, shareholders and entrepreneurs spend these incomes (to some extent), which leads to increased demand and – in turn – a higher level of economic activity in the total economy. This higher economic activity translates into higher levels of value added, employment, tax revenues and social contributions, captured by induced effects. Due to induced effects, total effects on value added can potentially exceed the contract volume (see section 5.2 for a more detailed discussion of induced effects).

Figure 3-2 provides an overview of the total effects as sum of direct, indirect, and induced effects.

Figure 3-2:
Total effects as sum of direct, indirect and induced effects



Source: DIW Econ.

4. Economic Impact: Results

4.1 Economic Impact of an Exemplary Project

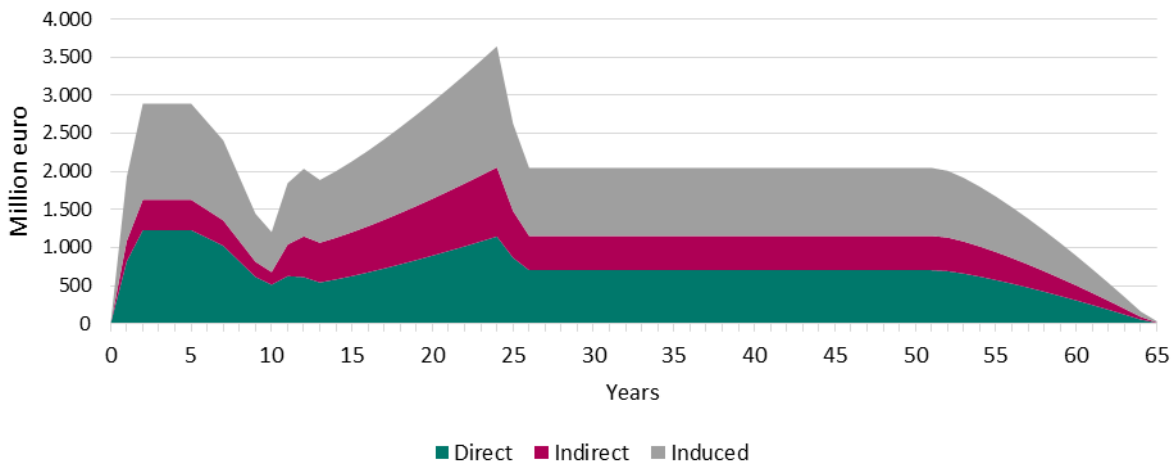
This section presents the economic effects of the exemplary public procurement project over 65 years (see section 2) on the Spanish economy. The companies involved in the development, manufacturing, and maintenance of aircraft directly add to GDP and employment, and they pay taxes (direct effect). Companies in all three segments rely on an extensive supply chain in Spain, which delivers crucial inputs for their production. The companies in the supply chain also contribute to value added, employment and public tax revenues (indirect effect).[6] Finally, people working at the directly involved companies and the entire supply chain as well as entrepreneurs and shareholders spend their income on consumption which stimulates demand and thus further economic activity (induced effect).

[6] Note that intermediate goods procured from firms abroad do not affect value added in Spain. Production of these inputs and thus value added occur abroad. The share of imported inputs – including potential partner countries – in the total production value is 30 percent in the manufacturing of other transportation vehicles, including aircraft, 10 percent in maintenance and repair, and 6 percent in research and development of the production value at basic prices (i.e. excluding value added tax).

4.1.1 Gross Value Added

Figure 4-1 shows a stacked area graph of the annual impact the exemplary 65-year project would have on value added. Research and development rely to a lower extent on supply from other sectors than aircraft manufacturing and maintenance and repair. Therefore, the indirect effect is about one third of the direct effect during the first phase of the project, i.e., when the aircraft are developed. Consequently, in Figure 4-1 in the first 12 years the area representing indirect value added is substantially smaller than the area representing direct value added. This changes in the manufacturing phase, where value added by suppliers is closer to the value added generated directly by the firms that produce the aircraft. Additionally, induced effects play an important role throughout the entire project. We estimate the project's **average total annual impact on value added** to be **2 billion euro** for the project's life span of **65 years.** The annual contribution to value added is strongest at the end of the manufacturing phase (year 24), 3.6 billion euro, about 0.3 percent of Spain's annual GDP (of 2016).

Figure 4-1:
Annual impact on gross value added

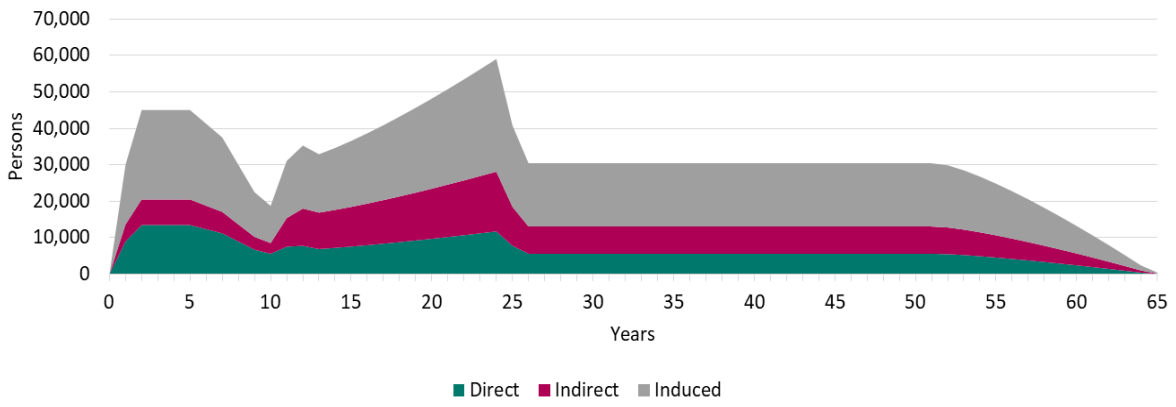


Source: DIW Econ.

4.1.2 Persons Employed

Figure 4-2 shows a stacked area graph of the annual employment effects. As is the case for value added, the role of the supply chain gains importance starting in the eleventh year of the project. On average, the project **sustains** about **31,200 jobs** throughout its duration of **65 years**. Roughly, one fifth of these jobs are created directly at the commissioned companies, and more than half are ascribed to the induced effect. At the peak of the project at the end of the manufacturing phase (year 24), almost 60,000 jobs are created.

Figure 4-2:
Annual impact on persons employed



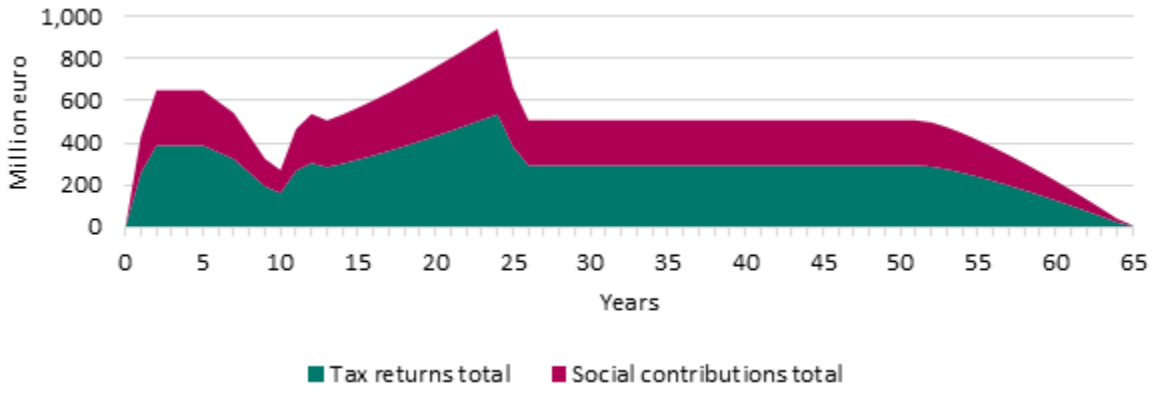
Source: DIW Econ.

4.1.3 Returns to Public Funds

The commissioning of the development, manufacturing, and maintenance and repair of 200 aircraft in Spain triggers substantial returns to public funds. Companies and workers involved in the value chain as well as those involved in induced economic activity pay taxes. In particular, we model trade tax (IS), economic activity tax (IAE), value added tax (IVA) that is generated through induced consumption, and income tax (IRPF). The latter is paid by the additional persons employed. The jobs created also lead to substantial payments of social security contributions.

Figure 4-3 shows a stacked area graph of the returns to public funds. These include returns due to direct, indirect, and induced effects. The project raises on average **about 300 million euro additional annual tax returns** and 200 million euro additional social security contributions per year. This amounts to an annual 500 million euro additional return to public funds.

Figure 4-3:
Total annual returns to public funds



Source: DIW Econ.

4.1.4 Average Annual Effects in Three Project Phases

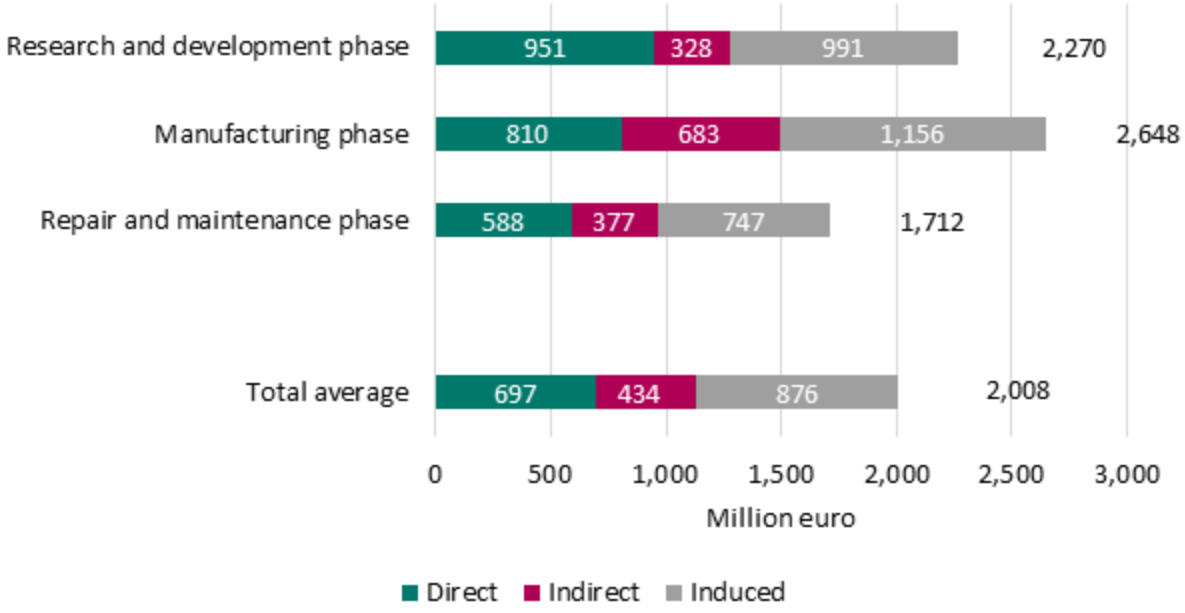
This section presents average annual effects of the entire project. For this purpose the 65 year life-span is split into three characteristic phases (according to their main activities, but also accounting for overlapping activities, see Figure 2-1):

- **Research and development phase**: years 1-10
- **Manufacturing phase:** years 11-25
- **Repair and maintenance phase:** years 26-65

As illustrated in Figure 2-1, the entire manufacturing process takes place in the manufacturing phase. Research and development is phased out at the beginning of this phase and the demand for maintenance and repair increases during the manufacturing phase as soon as the first aircraft is in operation in year 12.

Figure 4-4 shows the average annual value-added effect in the three phases of the project as well as the total average. Value-added effects are broken down into direct, indirect, and induced effects. We estimate an average of 2.6 billion euro value added during the manufacturing phase. Of these, about 810 million euro are generated directly by the commissioned firms and 680 million euro are supported by the commissioned companies' demand for intermediate inputs (indirect effects). The value-added effects in the development and operating phase are 2.3 and 1.7 billion euro, respectively.

Figure 4-4:
Average Annual Value Added

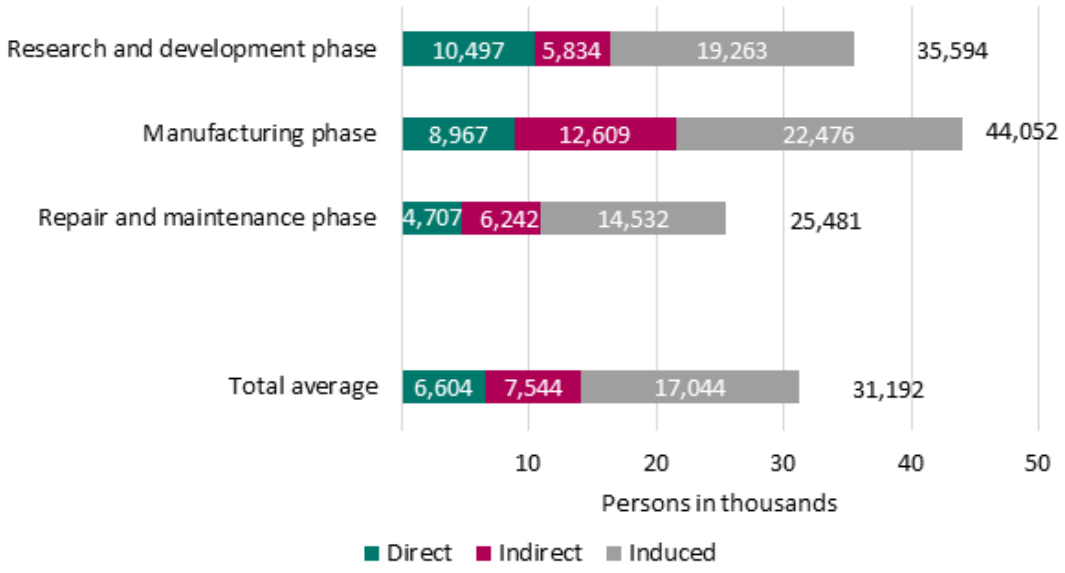


Source: DIW Econ.

Figure 4-5 shows the average annual employment effects during the three phases of the project. Again, the effects are strongest during the manufacturing phase. Compared to value added, the demand for intermediate inputs from suppliers along the value chain plays an even more important role during this phase. The reason is that the sectors involved in the supply chain of the manufacturing phase are characterized by higher labour intensity, i.e. they employ more persons to generate a fixed amount of value added than the commissioned firms (aircraft-manufacturing and maintenance) in the manufacturing phase.

While labour intensity of the firms directly involved in the research and development phase is similar to the labour intensity of the firms directly involved in the manufacturing phase, it is lower during the repair and maintenance phase. Moreover, among all phases, the suppliers along the value chain are of least importance in the research and development phase. The direct employment effect is almost twice as large as the indirect effect during the research and development phase.

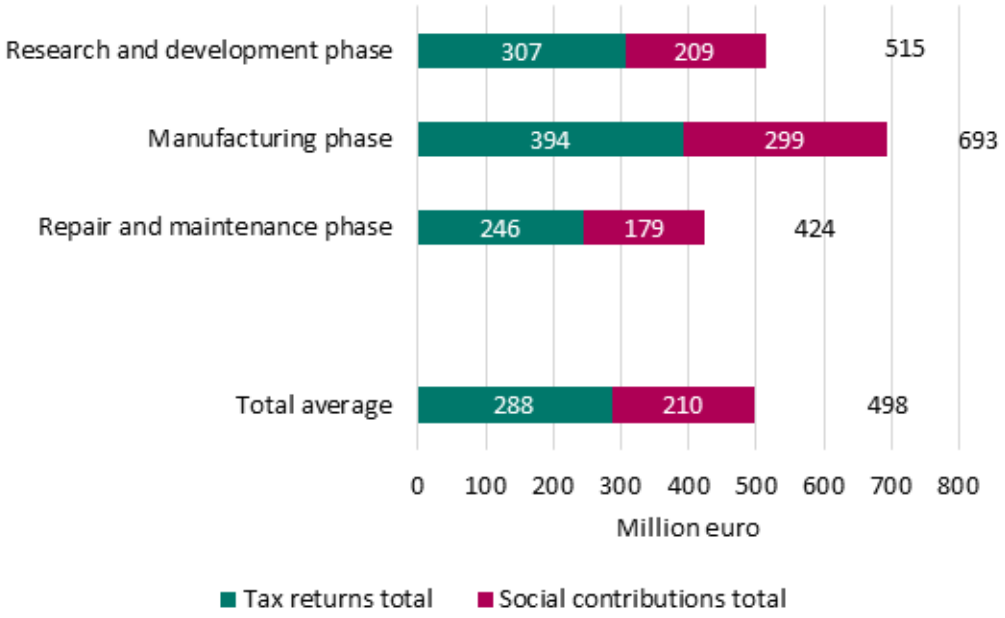
Figure 4-5:
Average annual employment effects



Source: DIW Econ.

Figure 4-6 shows average annual returns to public funds in the form of taxes and social security contributions. Due to the highest contract volume in this phase, average annual returns to public funds are highest during the manufacturing phase.

Figure 4-6:
Average annual returns to public funds



Source: DIW Econ.

4.2 Economic Effects per 100 Million Euro Public Net Contract Value

This section presents estimates for the economic impact of public net spending (at basic prices according to the System of National Accounts, i.e. excluding value added tax) in the defence sector of the aerospace industry. The effects are presented per 100 million euro public procurement net contract volume in the three segments of the sector.

Within the modelling framework of the input-output model, the effects are linearly scalable as far as the contract value to be modelled is within the range of valid volumes (see section 5.4). This means that the impact of a contract volume of 200 million euro is twice the impact of a contract volume of 100 million euro.

4.2.1 Gross Value Added

Overall, a **public procurement contract of 100 million euro (net) leads to value added effects in Spain of 161 million euro if invested in research and development, to 123 million euro if invested in manufacture of aircraft and spacecraft, and to 146 million euro if invested in repair and maintenance**, see Table 4-1.

Per 100 million euro contract volume (net), 68 million euro direct value added are generated by the commissioned firms in research and development, 35 million euro by the commissioned firms in manufacturing of aircraft, and 50 million euro in repair and maintenance. Thus, direct value added per net contract volume is highest in the research and development sector with 68 percent, substantially more than the economy wide average.

The effects generated in the supply chain (indirect effect) per 100 million euro contract value amount to 22 million euro (research and development), 35 million euro (manufacturing) and 32 million euro (repair and maintenance), respectively. Again, it becomes apparent that research and development relies less on the supply chain than the other two segments.

Finally, consumption of directly and indirectly generated income induces additional 70 million euro (research and development), 54 million euro (manufacturing), and 64 million euro (repair and maintenance) in the three segments of the defence sector of the aerospace industry.

Table 4-1:
Value added effects in Spain per 100 million euro public procurement contract value (net) per segment

Gross value added in million euro		Research and development	Manufacture of air and spacecraft	Repair and maintenance of aircraft and spacecraft
Net contract volume		100.0	100.0	100.0
Gross value added	Total effect	**160.6**	**122.9**	**146.2**
	direct	68.3	34.8	50.2
	indirect	22.2	34.5	32.2
	induced	70.1	53.6	63.8

Source: DIW Econ.

4.2.2 Persons Employed

In addition to value added, public procurement contracts lead to employment effects. Overall, a **public procurement net contract value of 100 million euro leads to total employment effects of 2,500 persons employed if invested in research and development, of 2,200 persons employed if invested in manufacture of aircraft and spacecraft, and of 2,200 persons employed if invested in repair and maintenance**, see Table 4-2.

Per 100 million euro contract volume (net) in each segment, direct employment effects of 750 persons employed are generated by the commissioned firms in research and development, 460 persons employed by the commissioned firms in manufacturing of aircraft, and 400 persons employed in repair and maintenance. This outlines the relatively high productivity, measured as gross value added per person employed, in the segment repair and maintenance compared with the other two segments. It is also apparent that direct labour productivity in all three segments is higher than in the respective supplying industries.

Table 4-2:
Employment effects in Spain per 100 million euro public procurement contract value (net) per segment

Persons employed in persons		Research and development	Manufacture of air and spacecraft	Repair and maintenance of aircraft and spacecraft
Net contract volume in mio.euro		**100.0**	**100.0**	**100.0**
Persons employed	**Total effect**	**2,503**	**2,168**	**2,176**
	direct	749	459	402
	indirect	391	666	533
	induced	1,363	1,043	1,241

Source: DIW Econ.

4.2.3 Returns to Public Funds

Finally, the additional production activity caused by public procurement contracts leads to public revenue through taxes and social security contributions. Overall, **public procurement contracts of 100 million euro net contract value result in public revenue of 36 million euro if invested in research and development, in 33 million euro if invested in manufacture of aircraft and spacecraft, and to 36 million euro if invested in repair and maintenance**, see Table 4-3. In all three segments total tax revenues account for more than half of total returns to public funds.

Table 4-3:
Public revenue in Spain per 100 million euro public procurement contract value (net) per segment

Returns in million euro		Research and development	Manufacture of air and spacecraft	Repair and maintenance of aircraft and spacecraft
Net contract volume		100.0	100.0	100.0
Taxes	Total effect	**21.6**	**18.7**	**21.0**
	direct	5.7	4.4	5.2
	indirect	2.3	3.9	3.5
	induced	13.5	10.3	12.3
Social security contributions	Total effect	**14.6**	**14.5**	**15.3**
	direct	4.6	4.5	4.8
	indirect	2.4	4.2	3.6
	induced	7.5	5.8	6.9
Taxes and social security contributions	Total effect	**36.1**	**33.2**	**36.2**
	direct	10.3	8.9	10.0
	indirect	4.7	8.2	7.0
	induced	21.0	16.1	19.2

Source: DIW Econ.

Table 4-4 shows tax revenues broken down by type of tax. For contracts awarded to all three segments, the income tax is the most important type of taxes in terms of its share of generated public revenue. It accounts for more than 50 percent of total generated tax revenues. It is important to note that in contrast to the other taxes value added tax is only generated through induced effects, i.e. through increased incomes as a consequence of higher economic activity that in turn lead to increased spending and therefore value added tax.

Table 4-4:
Tax revenues in Spain per 100 million euro public procurement contract value (net) per segment

Taxes in million euro		Research and development	Manufacture of air and spacecraft	Repair and maintenance of aircraft and spacecraft
Net contract volume		**100.0**	**100.0**	**100.0**
Corporation tax	Total effect	**4.0**	**3.1**	**3.7**
	direct	1.7	0.9	1.3
	indirect	0.6	0.9	0.8
	induced	1.8	1.4	1.6
Income tax	Total effect	**11.2**	**10.7**	**11.5**
	direct	3.9	3.4	3.8
	indirect	1.7	3.0	2.6
	induced	5.6	4.3	5.1
Economic activity tax	Total effect	**0.3**	**0.2**	**0.3**
	direct	0.1	0.0	0.1
	indirect	0.0	0.1	0.1
	induced	0.1	0.1	0.1
Value added tax	*induced*	6.1	4.6	5.5
Total taxes	Total effect	**21.6**	**18.7**	**21.0**
	direct	5.7	4.4	5.2
	indirect	2.3	3.9	3.5
	induced	13.5	10.3	12.3

Source: DIW Econ.

4.2.4 The Value Chain of the Defence Sector of the Aerospace Industry

Due to the complex value chain of the aerospace industry, indirect economic effects occur in numerous sectors of the economy. The results for indirect effects presented in sections 4.1.1 and 4.1.2 already indicate that the share of the production volume sourced from the value chain differs between the three segments of the defence sector of the aerospace industry. For instance, indirect value-added effects per 100 million euro public procurement net contract volume are substantially larger in manufacturing than in research and development. This section presents the value chains, i.e. the ten key sectors in the value chain of the three segments in more in detail.

Table 4-5 displays the most important supplying branches for the research and development segment in terms of value added and employment. Per 100 million euro net contract volume, the commissioned firms set off substantial production activities at supplying firms. In terms of value added, other firms in the scientific research and development sector play the largest role in the supply chain with an indirect value added of 2.0 million euro. Companies engaging in security and administrative services or real estate service are of similar importance. Regarding employment effects, the biggest indirect effect occurs in the security and administrative services sector, where 68 additional jobs are generated.

Table 4-5:
The ten most important sectors in terms of indirect value added and indirect employment in Spain per 100 million euro contract volume (net) for the segment research and development

Supplying branches	Gross value added (in million euro)
Scientific research and development	2.0
Security and administrative services	1.8
Real estate services	1.7
Electricity, gas, steam and air conditioning	1.2
Legal and accounting services	1.0
Architectural and engineering services	0.9
Financial services, except insurance and pension funding	0.9
Constructions and construction works	0.9
Computer programming, consultancy and related services; information services	0.7
Education services	0.7
Supplying branches	**Persons employed (in persons)**
Security and administrative services	68
Legal and accounting services	26
Scientific research and development	21
Architectural and engineering services	19
Education services	16
Wholesale and retail trade and repair services of motor vehicles and motorcycles	15
Wholesale trade services, except of motor vehicles and motorcycles	14
Fabricated metal products, except machinery and equipment	13
Computer programming, consultancy and related services; information services	11
Land transport services and transport services via pipelines	11

Source: DIW Econ.

Table 4-6 displays the most important suppliers of commissioned firms in the manufacturing segment. Regarding value added, security and administrative services (2.5 million euro), wholesale trade services (2.2 million euro), and financial services (2.2. million euro) generate the largest indirect effects, while security and administrative services, metal products, and wholesale trade services account for the biggest employment effects contributing 95, 76, and 50 persons employed, respectively.

Table 4-6:
The ten most important sectors in terms of indirect value added and indirect employment in Spain per 100 million euro contract volume (net) for the segment manufacturing of aircraft and spacecraft

Supplying branches	Gross value added (in million euro)
Security and administrative services	2.5
Wholesale trade services, except of motor vehicles and motorcycles	2.2
Financial services, except insurance and pension funding	2.2
Repair and installation services of machinery and equipment	2.0
Basic metals	1.9
Warehousing and support services for transportation	1.9
Fabricated metal products, except machinery and equipment	1.9
Rubber and plastics products	1.8
Electricity, gas, steam and air conditioning	1.6
Land transport services and transport services via pipelines	1.5
Supplying branches	**Persons employed (in persons)**
Security and administrative services	95
Fabricated metal products, except machinery and equipment	76
Wholesale trade services, except of motor vehicles and motorcycles	50
Rubber and plastics products	37
Legal and accounting services	31
Warehousing and support services for transportation	31
Land transport services and transport services via pipelines	31
Basic metals	25
Employment services	21
Financial services, except insurance and pension funding	17

Source: DIW Econ.

Table 4-7 displays the most important suppliers of the repair and maintenance segment. In terms of value added, other firms in this sector (but outside the aerospace industry) account for 6.1 million euro indirect value added, followed by wholesale trade services (3.1 million euro) and electricity and gas (1.9 million euro). The most important sectors in terms of employment are wholesale trade services, security and administrative services, and repair and installation services, which generate employment effects of 70, 54, and 46 persons employed, respectively.

Table 4-7:
The ten most important sectors in terms of indirect value added and indirect employment in Spain per 100 million euro contract volume (net) for the segment repair and maintenance of aircraft and spacecraft

Supplying branches	Gross value added (in million euro)
Repair and installation services of machinery and equipment	6.1
Wholesale trade services, except of motor vehicles and motorcycles	3.1
Electricity, gas, steam and air conditioning	1.9
Real estate services	1.9
Financial services, except insurance and pension funding	1.5
Security and administrative services	1.4
Architectural and engineering services	1.0
Basic metals	1.0
Rental and leasing services	1.0
Land transport services and transport services via pipelines	1.0
Supplying branches	**Persons employed (in persons)**
Wholesale trade services, except of motor vehicles and motorcycles	70
Security and administrative services	54
Repair and installation services of machinery and equipment	46
Fabricated metal products, except machinery and equipment	40
Wholesale trade services, except of motor vehicles and motorcycles	28
Security and administrative services	24
Architectural and engineering services	22
Land transport services and transport services via pipelines	21
Employment services	17
Warehousing and support services for transportation	15

Source: DIW Econ.

In summary, research and development, manufacturing, and repair and maintenance of military aircraft in Spain is associated with substantial effects on domestic value added and employment as well as returns to public funds. These effects would not be realized if the respective project was commissioned to companies producing in foreign countries. Nonetheless, the government expenditures would have to be financed – e.g. through taxes or debts.

5. Methodological Details

This section outlines the key methodological techniques used for estimating the economy-wide effects of a public contract that is awarded to the defence sector of the aerospace industry.

5.1 Economic Impact Model

The economic impact model compiled by DIW Econ is based on detailed input-output tables (IO tables) provided by the Spanish Statistics Institute (INE).[7] These tables capture the interconnections within the national economy as well as the product flows between the national economy and the rest of the world. With his article "Quantitative Input and Output Relations in the Economic System of the United States", the economist Wassilly Leontief developed the basis for future research using this technique.[8] In 1973, this research and numerous publications building on it resulted in the award of a Nobel Prize in Economics for the development of the input-output method and for its application to important economic problems. For an in-depth description of input-output analysis, see Miller and Blair (2009).[9] Fletcher (1989)[10] provides a gentle introduction of the methodology using the example of the economic impact of tourism.

Today the basic concept introduced by Leontief is frequently used for the analysis of the economic impact of specific industries and the impact of public policies. For instance, input-output analysis is routinely used to estimate total greenhouse gas emissions associated with specific economic activities.[11] The application of IO tables is also internationally widespread, IO tables have been consolidated in global frameworks (e.g. OECD, WIOD).[12]

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[7] INE Contabilidad Nacional de España (2016). Base 2010. Tabla 1. Tabla input-output a precios básicos.

[8] Leontief, W. (1936): Quantitative Input and Output Relations in the Economic System of the United States. The Review of Economics and Statistics, Volume 18, Issue 3, Pages 105-125.

[9] Miller, R. and P. Blair (2009): Input-Output Analysis: Foundations and Extensions. 2nd Edition, Cambridge University Press.

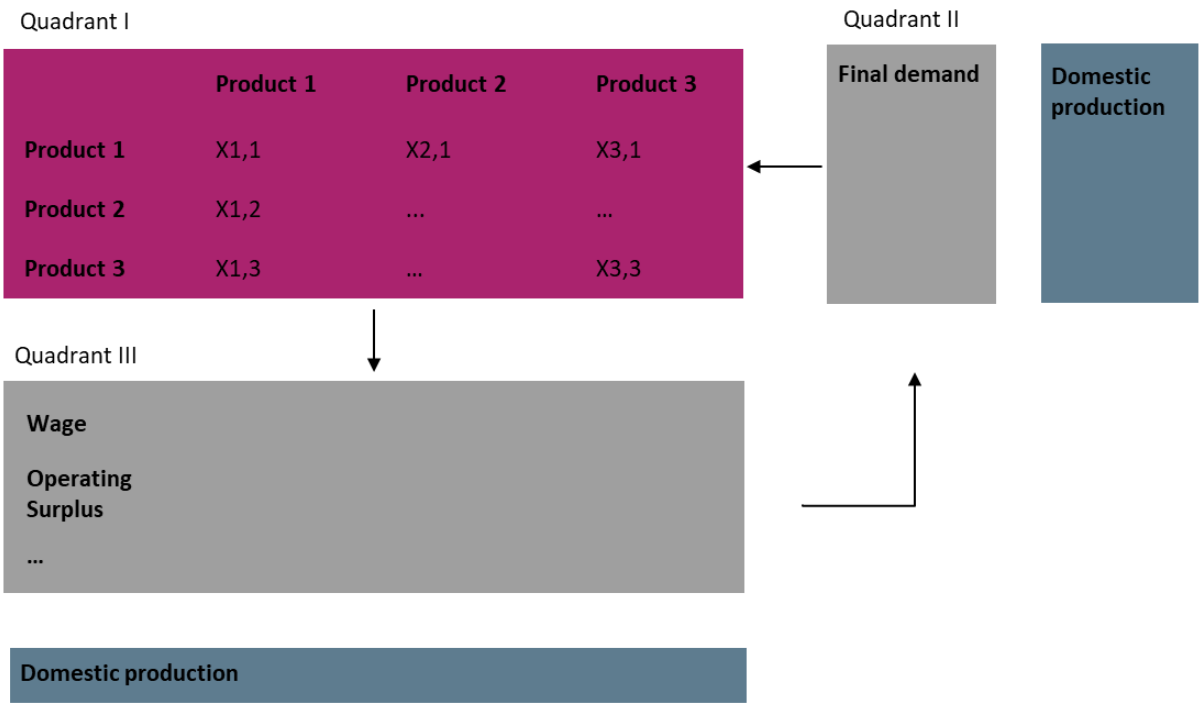
[10] Fletcher, J. (1989): Input-output analysis and tourism impact studies. Annals of Tourism Research, Volume 16, Issue 4, Pages 514-529.

[11] See Wiedmann, T. (2009): A review of recent multi-region input–output models used for consumption-based emission and resource accounting. Ecological Economics, Volume 69, Issue 2, Pages 211-222.

[12] See http://www.oecd.org/trade/input-outputtables.htm or http://www.wiod.org/project, the official WIOD Project, for example, was funded by the European Commission as part of the 7th Framework Programme and launched in 2012.

IO tables are constructed from observed economic data for a country or region. In Spain, IO accounts are compiled centrally at the National Statistics Institute. The underlying data of the latest officially published IO tables by the National Statistics Institute are based on the year 2010. Since compiling IO tables requires large amounts of data and time, IO tables are usually published with a considerable time lag. However, the year-to-year changes of the underlying economic and technological structure are not large, because structural change usually takes place in periods of decades and not in a few years. Therefore, using the 2010 IO table is a viable approach. Figure 5-1 provides a simplified picture of the structure of IO tables.

Figure 5-1:
Simplified structure of IO tables



Source: DIW Econ.

IO tables specify production processes and interlinkages within an economy in a given year. The heart of the table is Quadrant I showing the simplified three-by-three matrix. It represents the intermediate good flows between producers. Quadrant II represents final demand by households, governments or export. Domestic production is located to Quadrant I or Quadrant II, i.e. to intermediate demand or to final demand. Total domestic production is given by the sum of both quadrants.

Primary inputs are displayed in Quadrant III. The input of primary production factors is measured by the components of value added. These are wages, operating surplus, depreciation and indirect taxes less subsidies.

Based on these IO tables, we calculate the economic activity that is stimulated by a given amount of final demand (e.g. a public contract of 100 million euro) while accounting for the entire supply chain.

In matrix notation, the following equation represents the starting point

$$\boldsymbol{X} - \boldsymbol{AX} = \boldsymbol{Y},$$

where $\boldsymbol{X}$ is a gross output vector, $\boldsymbol{A}$ is the technical coefficient matrix, which is calculated using the official IO tables, and Y is the final demand vector.

Using a series of algebraic matrix operations, the system yields

$$(\boldsymbol{I} - \boldsymbol{A})\boldsymbol{X} = \boldsymbol{Y}$$

$$(\boldsymbol{I} - \boldsymbol{A})^{-1}(\boldsymbol{I} - \boldsymbol{A})\boldsymbol{X} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{Y}$$

$$\boldsymbol{X} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{Y}.$$

(I-A)$^{-1}$ matrix is called Leontief inverse and is central for calculating direct and indirect effects. It can be derived as follows. If final demand for the product category 1 increases by one unit ($\Delta \mathrm{Y}_1 = 1$), then production in sector 1 directly increases by one unit ($\Delta \mathrm{Y}$). This requires intermediate inputs from supplying sectors of sector 1 where economic activity is stimulated ($\mathrm{A}\Delta \mathrm{Y}$). Supplying sectors of sector 1 in turn require inputs from other sectors ($\mathrm{A}^2\Delta \mathrm{Y}$) and so forth,

$$\boldsymbol{\Delta X} = \boldsymbol{\Delta Y} + \boldsymbol{A\Delta Y} + \boldsymbol{A}^2\boldsymbol{\Delta Y} + \boldsymbol{A}^3\boldsymbol{\Delta Y} + \ \ldots$$

$$\boldsymbol{\Delta X} = (\mathbf{I} + \boldsymbol{A} + \boldsymbol{A}^2 + \boldsymbol{A}^3 + \ \ldots)\boldsymbol{\Delta Y}$$

$$\boldsymbol{\Delta X} = (\mathbf{I} - \boldsymbol{A}\ )^{-1}\boldsymbol{\Delta Y}.$$

Hence, the total change in production can be divided into a direct (ΔY) and an indirect effect $(A + A^2 + A^3 + \ \ldots)\Delta Y$ (see Miller, R. and P. Blair, 2009).[13]

In addition to the effects on production and value added, the employment effect can be calculated. Basis for this calculation is employment data from the IO table published by the Spanish Statistics Institute.[14] The data contains the number of persons employed whose place of work is in Spain in accordance with the European System of Accounts and in line with the standards set up by the International Labour Organization (ILO).

[13] Miller, R. and P. Blair (2009): Input-Output Analysis: Foundations and Extensions. 2nd Edition, Cambridge University Press.

[14] INE Contabilidad Nacional de España (2016). Base 2010. Tabla input-output 2010.

Keep in mind that the model rests upon several assumptions. Important assumptions include the absence of supply constraints, the emphasis on short-term effects or the assumption of fixed prices.[15]

- Supply-side constraints: The model assumes that the production capacity can sufficiently accommodate the additional workload, implying that extra output can be produced without taking away resources from other activities.
- Constant returns to scale and fixed prices: Relative price changes play no role in the allocation of scarce resources between activities that would actually affect the economic impact.
- Short-term consideration: The analysis is based on characteristics of an economy at a single point in time and does not account for long-term adjustments within an economy.

These assumptions are implicit in the linear structure of the model. For relatively small changes in demand, relative prices and production structures can reasonably be assumed to be constant, see section 5.4.

5.2 Keynesian Multiplier Analysis

In addition to direct and indirect effects, this study quantifies induced effects. Directly and indirectly generated value added constitutes profits and labour income. This income stimulates additional demand, which in turn translates into a higher level of economic activity in the total economy (induced effects). To quantify these effects, the study makes use of a Keynesian **multiplier analysis**. The multiplier analysis takes into account that consumers can spend only a fraction of their income as leakages occur through saving, taxes or spending outside the local economy.

[15] Coughlin and Mandelbaum (1991): A Consumer's Guide to Regional Economic Multipliers, ABS (2012) Australian System of National Accounts: Concepts, Sources and Methods or Gretton (2013): On input-output tables: uses and abuses.

The country-specific multiplier *m* can be calculated based on an approach, well documented in the economic literature, and is smaller when there are more leakages in an economy:[16]

$$m = \frac{1}{1-[(1-s)(1-t)(1-k)]}$$

with *s* as savings rate, *t* tax ratio on incomes, *k* import quota.

Despite the common use of the multiplier, suggesting that economists, governments and firms have found them useful, there is an ongoing debate regarding their suitability stemming from the theoretical basis and from measurement problems.[17] In frameworks analysing an exogenous stimulus, e.g. increased government demand, in contrast to analysing the importance of an entire sectors, it is conceded, that models concentrating exclusively on direct and indirect effects underestimate the economic impact. However, there is less consensus about the size of the multiplier. Because of the rigid assumptions about labour incomes and associated consumer spending, the multiplier for induced effects might be overestimated.[18] Miller and Blair (2009) state that the theoretical induced effect can be interpreted as an upper bound for the empirical one.

To understand the potential limitations of the theoretical Keynesian multiplier, consider a change in final demand, like a change in government demand for aircraft, which causes an increase in the number of persons employed and associated income. This increase translates into higher household spending. However, if the newly employed persons previously received unemployment benefits, the gain in spending is smaller than the theoretical induced effect. Moreover, additional spending must be financed, e.g. through taxes or borrowing. Tax increases lead to decreases in disposable income, government borrowing leads to increased interest rates, both of which result in decreased demand. This will to some extent offset of the additional spending. Thus the multiplier would overstate the effect.

Despite the uncertainty in the correct size of the multiplier, the extension of the standard input output analysis by the Keynesian multiplier allows for a more comprehensive representation of the expected economic effects.

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[16] See, e.g. Armstrong and Taylor (2000): Regional Economics and Policy (3rd edition), Oxford: Blackwell.

[17] Bess and Ambargis (2011): Input-Output Models for Impact Analysis: Suggestions for Practitioners Using RIMS II Multipliers.

[18] Miller, R. and P. Blair (2009): Input-Output Analysis: Foundations and Extensions. 2nd Edition, Cambridge University Press.

5.3 Taxation and Social Security Contributions

The economic activity supported by a hypothetical public programme generates substantial returns to public funds. The production activity by businesses in the value chain directly leads to increases in trade tax, corporate tax, and value added tax. Moreover, people employed in these companies pay income tax and social contributions. Further cash flow to public funds is generated through the induced economic activity. Based on several primary administrative data sources, DIW Econ expanded the input-output model in order to quantify these effects.

- **Income tax (IRPF)**: For every sector, the average compensation per person employed is calculated. Multiplied with the economy-wide average income tax rate, we obtain a sector-specific income tax coefficient. To obtain the income tax effect generated in a particular sector, the income tax coefficient is multiplied by the estimated additional employment.[19]
- **Social security contributions:** The social contributions coefficients are available on sector-level. They are calculated dividing the social contributions within a sector by the number of persons employed in that sector. To obtain the overall additional social contributions, firstly the coefficient of each sector is multiplied with the correspondent additional employees. The resulting, sector-specific additional social contributions are then added together.[20]
- **Value added tax (IVA):** In a first step, the economy-wide average value added tax per gross value added sourced from domestically used products is calculated based on official tax data.[21] This coefficient is then multiplied by the induced value added that is associated with the public contract.
- **Corporation tax (IS):** For the entire Spanish economy, the average corporation tax per gross value added is calculated based on official data. [22] Multiplying this coefficient by the gross value added that is associated with the public contract yields the corresponding corporation tax returns.

[19] Source: Eurostat (2017): Questionnaire NTL - Detailed list of taxes and social contributions according to national classification (1995-2016).

[20] INE Contabilidad Nacional de España. Base 2010. Tabla 1. Tabla input-output a precios básicos and Eurostat: http://ec.europa.eu/eurostat/statistics-explained/index.php/Tax_revenue_statistics.

[21] Source: Eurostat (2017): Questionnaire NTL - Detailed list of taxes and social contributions according to national classification (1995-2016).

[22] Source: Eurostat (2017): Questionnaire NTL - Detailed list of taxes and social contributions according to national classification (1995-2016).

- **Economic activities tax (IAE):** The economic activity tax coefficient is calculated similarly to the corporation tax coefficient. However, the economic activities tax coefficient is calculated per person employed and is based on official data.[23] Multiplying this coefficient by employment that is associated with the public contract yields the corresponding trade tax returns.

5.4 Range of Valid Contract Volumes

IO analysis is a linear modelling framework, which is scalable. However, it is based on statistical averages and a linear homogenous production function with constant returns to scale. The latter implies a constant relationship between input and output. Suppose that the value of aircraft production in a given year is 50 million euro and the producing industry purchased 10 million euro of metal as intermediate inputs. If aircraft production were to double to 100 million euro, the input-output model then assumes that the intermediate inputs of metal that the aircraft producer purchases would double as well to 20 million euro. The upper limit of scalability is reached if the contract volumes reach a magnitude in which the productive capacity of the defence sector in the aerospace industry and its suppliers are exhausted and cannot be expanded for technical reasons in the short run. Contract volumes exceeding the productive capacity would involve significant price adjustments. In this case, the defence sector would for example need to recruit workers from abroad at much higher costs. The IO model does not account for price changes that may result from the shortage of the workforce or intermediate inputs. In this case, the assumption of linear production function does not hold.

It is therefore reasonable to apply contract volumes that do not exceed actual capacities of the defence sector of the aerospace industry. The annual contract volume of the exemplary project is 1,400 million euro annually on average, which amounts to just a small share of the total annual production in the sector. Based on this expertise of industry experts, the estimation of economic effects of public procurement contracts of this magnitude seems plausible.

[23] Source: Eurostat (2017): Questionnaire NTL - Detailed list of taxes and social contributions according to national classification (1995-2016).

5.5 Classification of the Defence Sector of the Aerospace Industry and Data Availability

The defence sector of the aerospace industry involves different production activities. The relevant activities and corresponding statistical classification of products by activity, abbreviated as CPA (2008)[24], are listed below:

- manufacture of air and spacecraft and related machinery (CPA 30.3)
- repair and maintenance of aircraft and spacecraft (CPA 33.16)
- RDTE (research, development, test and evaluation) (CPA 72.1)

However, the underlying data of IO tables of the National Statistics Institute – consequently, also the information on input structure, employment intensity and the share of value added – are not available in such detail. Instead, information is only available for CPA divisions (two-digit numerical codes) of product categories: CPA 30, CPA 33 and CPA 72. This information can be used to approximate the input structure, employment intensity and share of value added of the corresponding, more detailed three-digit or four-digit CPA levels.

DIW Econ adjusted the aggregate information to the specificities of the defence sector of the aerospace industry as far as additional detailed data is available. Based on different sources, adjustments were made especially with respect to the input structure, employment intensity and the share of value added of CPA 30.[25] For example, value added relative to production value for CPA 30.3 is higher than for the average of the aggregate CPA 30. Similarly, labour productivity is slightly higher in the subsector.

5.6 European Armament Cooperation Programmes

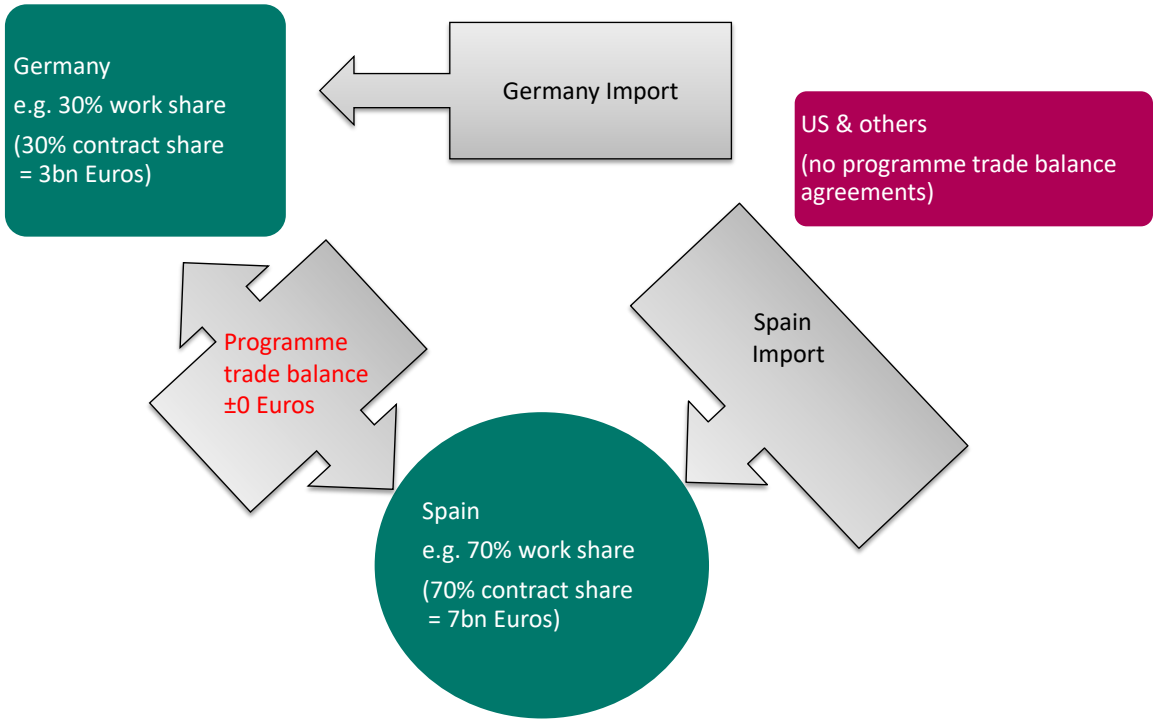
Impact studies usually asses the economic impact of an activity within the geographic area of interest, in this case Spain. Correspondingly, economic activity will only take effect on the economy if goods and services are produced domestically. Thus, any import from other countries will not contribute to domestic value added, employment or returns to public funds (*standard approach*).

[24] Eurostat CPA 2008– Statistical classification of product by activity.

[25] VDI (2015): Analyse der strukturellen Lage der Verteidigungsindustrie in Deutschland, Study commissioned by the Federal Ministry of Economic Affairs and Energy, detailed supply and use tables of the Federal Statistical Office, Employment statistics 2015 of the Federal Employment Agency.

This study however goes further. It takes into account the specific structure of European cooperation programmes in the defence sector of the aerospace industry. Cooperative programmes in Europe have a long tradition and history for spreading the supply chain over Europe. However, cross-country subcontracting among participating countries usually balances within the project phase or over several projects.[26] This means that a public contract awarded to Spanish aerospace firms obliges the Spanish firms to purchase intermediate inputs from participating countries, for example from Germany. The cooperation programme also ensures that, within the programme framework or related procurement programmes, German firms are in turn required to purchase inputs from Spain (*adjustment of imports*). The subcontracts are supposed to involve imports of equal value as illustrated in Figure 5-2. This implies that within the procurement programme or over several projects the value of inputs imported from the partner country is the same in the two participating countries.

Figure 5-2:
European programme subcontracting balance



Source: DIW Econ.

[26] CSIS (2017): Designing and managing successful international joint development programs or Institute for security studies: Armaments cooperation in Europe.

To account for this, imported intermediate goods used for the direct additional production of the three involved sectors are added to the domestic production. As imports of intermediate products from the other participating country lead to exports of intermediate goods of the same value, they are directly treated as domestic production. This results in slightly higher estimates regarding value added, employment, and public revenue. Throughout the study, results with adjusted imports are shown.

Table 5-1 shows that the treatment of imports from participating countries has **no substantial impact on results**. For instance, 100 million euro programme contract value (net) for the manufacturing sector lead to an additional employment of 2,168 persons using the method with *adjustment of imports* compared to 2,087 persons estimated using the *standard approach*.

Table 5-1:
Total economic effects under different treatments of imports and exports

Overview of Economic effects	Unit	Economic effects: standard approach	Economic effects: adjustment of imports
Net contract volume for manufacture of air and spacecraft	Million euro	100.0	100.0
Gross value added	Million euro	118.8	122.9
Persons employed	Persons	2,087	2,168
Taxes	Million euro	18.0	18.7
Taxes and Social security contributions	Million euro	32.1	33.2

Source: DIW Econ.

6. Tabular Appendix

Table 6-1:
Average annual effects of the exemplary project by project phase

		Unit	Total average	Research and development phase	Manufacturing phase	Repair and maintenance phase
				(acc. to phase definition in section 4.1.4)		
Net contract volume[27]		Million euro	**1,400.0**	**1,433.2**	**2,027.9**	**1,171.1**
Corresponding gross value		*Million euro*	*1.694,0*	*1.734,2*	*2.453,8*	*1.417,0*
Gross value added	Total effect	Million euro	**2,008.3**	**2,269.8**	**2,648.3**	**1,712.3**
	direct	Million euro	697.5	950.8	810.0	588.4
	indirect	Million euro	434.3	328.4	682.5	376.6
	induced	Million euro	876.5	990.6	1,155.8	747.3
Persons employed	Total effect	Persons	**31,192**	**35,594.0**	**44,052**	**25,480.7**
	direct	Persons	6,604	10,496.6	8,967	4,706.6
	indirect	Persons	7,544	5,834.1	12,609	6,242.1
	induced	Persons	17,044	19,263.3	22,476	14,532.0
Taxes	Total effect	Million euro	**287.8**	**306.5**	**393.7**	**245.6**
	direct	Million euro	71.5	80.7	94.2	61.0
	indirect	Million euro	47.2	34.7	76.5	40.4
	induced	Million euro	169.1	191.1	223.0	144.2
Social security contributions	Total effect	Million euro	**209.8**	**208.7**	**299.5**	**178.7**
	direct	Million euro	66.2	66.4	93.7	56.5
	indirect	Million euro	49.4	35.9	81.6	41.9
	induced	Million euro	94.2	106.4	124.2	80.3
Taxes and social security contributions	Total effect	Million euro	**497.6**	**515.2**	**693.2**	**424.3**
	direct	Million euro	137.7	147.1	187.9	117.5
	indirect	Million euro	96.7	70.6	158.1	82.3
	induced	Million euro	263.2	297.5	347.1	224.4

Source: DIW Econ.

[27] Net contract value at basic prices according to the System of National Accounts, i.e. excluding value added tax.

Table 6-2:
Effects per 100 million euro net contract volume for each segment of the defence sector of the aerospace industry

Indicator		Unit	Research and development	Manufacture of air and spacecraft	Repair and maintenance of aircraft and spacecraft
Net contract volume[28]		Million euro	100.0	100.0	100.0
Corresponding gross value		*Million euro*	*121.0*	*121.0*	*121.0*
Gross value added	Total effect	Million euro	**160.6**	**122.9**	**146.2**
	Direct	Million euro	68.3	34.8	50.2
	Indirect	Million euro	22.2	34.5	32.2
	Induced	Million euro	70.1	53.6	63.8
Persons employed	Total effect	Persons	**2,503**	**2,168**	**2,176**
	Direct	Persons	749	459	402
	Indirect	Persons	391	666	533
	Induced	Persons	1,363	1,043	1,241
Corporation tax	Total effect	Million euro	**4.0**	**3.1**	**3.7**
	Direct	Million euro	1.7	0.9	1.3
	Indirect	Million euro	0.6	0.9	0.8
	Induced	Million euro	1.8	1.4	1.6
Income tax	Total effect	Million euro	**11.2**	**10.7**	**11.5**
	Direct	Million euro	3.9	3.4	3.8
	Indirect	Million euro	1.7	3.0	2.6
	Induced	Million euro	5.6	4.3	5.1
Economic activity tax	Total effect	Million euro	**0.3**	**0.2**	**0.3**
	Direct	Million euro	0.1	0.0	0.1
	Indirect	Million euro	0.0	0.1	0.1
	Induced	Million euro	0.1	0.1	0.1
Value added tax	*Induced effect*	Million euro	6.1	4.6	5.5
Total taxes	Total effect	Million euro	**21.6**	**18.7**	**21.0**
	Direct	Million euro	5.7	4.4	5.2
	Indirect	Million euro	2.3	3.9	3.5
	Induced	Million euro	13.5	10.3	12.3
Social security contributions	Total effect	Million euro	**14.6**	**14.5**	**15.3**
	Direct	Million euro	4.6	4.5	4.8
	Indirect	Million euro	2.4	4.2	3.6
	Induced	Million euro	7.5	5.8	6.9
Taxes and social security contributions	Total effect	Million euro	**36.1**	**33.2**	**36.2**
	Direct	Million euro	10.3	8.9	10.0
	Indirect	Million euro	4.7	8.2	7.0
	Induced	Million euro	21.0	16.1	19.2

Source: DIW Econ.

[28] Net contract value at basic prices according to the System of National Accounts, i.e. excluding value added tax.