Follow up study on the economic benefits of ITER and BA projects to EU industry

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Contract details

European Commission – Directorate D - Nuclear energy, safety and ITER

Follow up study on the economic benefits of ITER and BA projects to EU industry

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Abstract

This report studies the economic benefits of ITER and Broader Approach (BA) projects for industry in the EU. It aggregates structured data information about relevant grants and contracts for F4E Member States, entities from Fusion for Energy (F4E), the ITER Organisation (IO), Voluntary Contributors and the European Commission. It also provides a robust sound extrapolation for future payments. The report evaluates and analyses the added value created from these contracts and grants for a number of sectors in the EU through short-, medium- and long-term benefits.

Profiting off the already-existing baseline, which was created by the previous study in 2017, the present study has made number of updates as regards to the underlying data and approach to interpreting that data. This study focuses on the period of 2008 to 2019 while incorporating additional data arising from the IO's payments and commitments to European industry. In order to ensure comparability between the two studies, the same methodology has been used in both.

IHS Markit's Global Link Macro-Industry Model (GLM-IM) has been used to estimate the macroeconomic effects of all spending related to ITER payments on the EU economy in terms of Gross Value Added (GVA) and job-years created. The modelling showed that F4E spending on ITER does not only deliver significant benefits to EU economies but also positively impacts other technological and industrial sectors.

The study also provides a number of relevant stories and case studies related to the examples of spill-overs, spin-offs and synergies from ITER related activities.

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Glossary

A&E	Architecture and Engineering
BA	Broader Approach
DA	Domestic Agency
DEMO	Demonstration Power Plant
EC	European Commission
EU	European Union
European States	United Kingdom, Switzerland and the EU-27
F4E	Fusion for Energy
GLM-IM	Global Link Macro – Industry Model
GVA	Gross Value Added
IO	ITER Organisation
ISIC	International Standard Industrial Classification
NACE	Statistical Classification of Economic Activities in the European Community
SME	Small and Medium-Sized Enterprises
UK	United Kingdom
WBS	Work Breakdown Structure
WP	Work Package

Executive Summary

The consortium consisting of LGI and IHS Markit presents an economic impact analysis that quantifies the contribution of ITER to the European economy. This report discloses the results of this analysis, and also presents new findings for case studies that illustrate the multi-faceted linkages of ITER with the industry landscape and the benefits for research and development in the European Union.

The analysis was carried out using the analysis considered newly available data on spending related to the development and operations of the ITER for the years 2008 to 2019. Data information were provided on in-cash and in-kind payments by the European Domestic Agency Fusion for Energy (F4E), the ITER Organisation (IO), Voluntary Contributors and the European Commission. During 2008 to 2019 total expenses from these entities related to ITER amounted to EUR 5.639 billion (Table 1).

For the years 2008 to 2016, the database was identical with the data used by the previous study. For 2017, the previous study had used an estimated level of payments, while the new study relied on historic data. This was also the case for 2018 and 2019. Moreover, the research consortium of this study delivered an improved industry categorization of the existing data.

The economic impact of ITER on the EU economy has been positive. Incremental gross value added generated due to ITER's activities equalled EUR 1.739 billion during 2008 to 2019 (Figure 8). Cumulatively, the total number of jobs per year directly or indirectly created by ITER reached nearly 29,500 (Figure 12), with a preliminary peak being reached in the last two years of the historic data sample (2018 and 2019).

For every job that was directly created as a result of ITER's activities, the study estimated that another job was indirectly created. Those indirect jobs typically emerged in the supply chains of the ITER, or as a result of ITER-related wages being spent on other products and services.

The consortium also estimated the net impact of the ITER plant on the European economy. This net impact represents the difference of the economic impact described above relative to a hypothetical investment that reflects an identical amount of spending per year on EU member countries' economies.

The net impact has been positive as well. The cumulated net benefit on the EU economy was estimated at EUR 104 million for 2008 to 2019 (Figure 13).

The study also received guidance on the future spending commitments on behalf of ITER. This allowed IHS Markit to project the future net contribution of ITER to the European economy using the Global Link Macro-Industry Model (GLM-IM) comparing a scenario with ITER to a world in which ITER is assumed to not exist for 2020 to 2035.

The quantification revealed a further increase to a peak net impact level around the middle of the current decade (Figure 19). In line with declining investment levels, the net impact level of ITER follows a descent until the end of the forecast period. The net impact remains positive in each year, though. The cumulated net economic impact over the entire period 2020 to 2035 is estimated at EUR 332 million (Figure 20).

Finally, LGI and IHS Markit were commissioned to evaluate the results from the previous study. The consortium found the economic impact to be higher than the estimate run by the previous study. The incremental number of jobs amounted to 3,339 (cumulated job-years) for the timeframe 2008 to 2017 (Figure 15), while the previous study had estimated 3,164.

Résumé Analytique

Le consortium entre LGI et IHS Markit présente une analyse de l'impact économique de la contribution d’ITER à l'économie européenne. Ce rapport détaille les résultats de cette analyse et présente également de nouvelles conclusions pour des études de cas illustrant les liens multiples d’ITER avec le paysage industriel et les avantages pour la recherche et le développement dans l’Union Européenne.

Outre les données sur les contrats de Fusion for Energy (F4E), l'analyse a pris en compte les données nouvellement disponibles de l'organisation ITER (IO) concernant les dépenses liées au développement et à la construction d'ITER pour les années 2008 à 2019. Pour les années 2008 à 2017, la base de données a été à celle utilisée pour une estimation précédente à cette étude, réalisée en 2017, mais le consortium a pu recueillir de nouvelles données. De plus, la présente étude a également permis d'améliorer la catégorisation par type d’industrie des données existantes. Entre 2008 et 2019, les dépenses totales liées à ITER se sont élevées à 5,639 billions d'euros (Table 1).

L'impact économique d'ITER sur l'économie de l'UE a été positif. La valeur ajoutée brute supplémentaire générée par les activités d'ITER s'est élevée à 1,739 billions d'euros entre 2008 et 2019 (Figure 8). Cumulativement, le nombre total d'emplois par an directement ou indirectement créés par ITER a atteint 29.500 (Figure 12), avec un pic prévisible atteint au cours des deux dernières années de la plage étudiée de données historiques (2018 et 2019).

Pour chaque emploi directement créé à la suite des activités d’ITER, l’étude a estimé qu’un autre emploi était indirectement créé. Ces emplois indirects ont généralement émergé dans les chaînes d'approvisionnement de l'usine ITER, ou en raison de la dépense des salaires liés à ITER pour d'autres produits et services.

Le consortium a estimé l'impact net d'ITER sur l'économie européenne. Cet impact net représente la différence de l’impact économique décrit ci-dessus par rapport à un investissement hypothétique qui reflète un montant identique de dépenses par an dans les économies des pays membres de l’UE.

L'impact net a également été positif. Le bénéfice net cumulé pour l'économie de l'UE a été estimé à 104 millions d'euros de 2008 à 2019 (Figure 13).

L'étude a également pris en compte les orientations sur les futurs engagements de dépenses au nom d'ITER. Cela a permis à IHS Markit d’évaluer la future contribution nette d'ITER à l'économie européenne à l'aide de son modèle économétrique (GLM-IM) qui compare un scénario avec ITER à un monde dans lequel ITER est supposé ne pas exister entre 2020 et 2035.

Il est important de noter que les effets de la pandémie de CoVID-19 se reflètent dans les résultats du modèle présentés dans ce rapport. Les prévisions GLM-IM ont été mises à jour avec les dernières perspectives macroéconomiques d'IHS Markit pour l'Union Européenne, qui incluent des hypothèses détaillées sur les effets de la pandémie.

La quantification a révélé une nouvelle augmentation du niveau d'impact net maximal vers le milieu de la décennie en cours (Figure 19). Parallèlement à la baisse des niveaux d'investissement le niveau d'impact net d'ITER suit une baisse jusqu'à la fin de la période de prévision. L'impact net reste cependant positif chaque année. L'impact économique net cumulé sur l'ensemble de la période 2020-2035 est estimé à 332 millions d'euros (Figure 20).

Enfin, LGI et IHS Markit ont été chargés d'évaluer les résultats de l'étude précédente. Le consortium a constaté que l'impact économique était supérieur à l'estimation effectuée par l'étude précédente. Le nombre supplémentaire d'emplois s'élevait à 3.339 (années-emplois cumulées) pour la période de 2008 à 2017 (Figure 15), alors que l'étude précédente avait estimé à 3.164.

1. Introduction

1.1. Background of the study

The ITER Project is one of the most complex big-science projects in human history. Designed to realise the technical and scientific feasibility of fusion energy, the ITER project constructs the world's largest tokamak – a device that confines a hot plasma in the shape of a torus by using a powerful magnetic field. Harnessing the fusion power from this construction, ITER aims to demonstrate safe, non-carbon emitting and sustainable energy. This significant pillar will lay the foundation for the construction of a Demonstration Power Plant (DEMO), which will open the way to the commercial exploitation of fusion energy.

With its seven Parties[1], including the European Union, it is one of the highest-budget international collaboration projects in the research field. This collaboration required each Party to establish a Domestic Agency (DA) in order to make its in-kind components[2] and in-cash contributions[3] available to the ITER Organisation (IO)[4].

Committed to building the ITER facility, Euratom (on behalf of the European Union) set up its Domestic Agency, Fusion for Energy (F4E), in 2007 for a period of 35 years. As it was commissioned to prepare and coordinate the construction activities of ITER, F4E started to deliver the European share of components and contributions in order to successfully complete the construction of ITER in 2008.

In addition to the in-kind contribution and cash contributions from F4E for the construction of ITER, Euratom pays for adjacent activities, which have an ITER-related economic impact within the EU. These include:

- F4E administration costs incurred for work carried out by F4E in Barcelona, Spain;
- F4E's other activities such as payments to Japan regarding the Broader Approach (BA) Agreement activities aimed at facilitating and coordinating fusion-related developments;
- Project administration costs due to the work undertaken by the European Commission (EC) in Brussels, Belgium to manage the ITER project.

For the in-kind contribution, F4E manages procurement procedures with the aim of concluding the contracts with mainly European companies. These contractual activities have been increasing since the beginning of F4E's operations in 2008. A positive side effect of this increase has been fostering innovation in key technologies, which will make the European industry more competitive when fusion energy plants are in commercial operation.

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[1] China, India, Japan, Russia, South Korea, the United States, and Euratom on behalf of the European Union.

[2] High-tech components such as the Magnets, the Vacuum Vessel, heating systems, first wall components and diagnostics necessary for the construction of the ITER which are procured by the Domestic Agencies and delivered to the ITER site.

[3] Paid directly to IO and used for its business operations and design activities for the project components as well as assembly, installation and operation.

[4] The ITER Agreement signed by the seven Parties set the ITER Organisation (IO) which has overall responsibility for the construction, operation, exploitation and decommissioning of the ITER facilities.

1.2. Follow-up Study

In 2017, the European Commission (hereinafter referred to as "the Commission") assigned an external contractor[5] to evaluate the impacts of the European contribution to ITER through F4E's activities described under point 1.1 for the period 2008 to mid-2017. This first study (hereinafter "the previous study") analysed F4E spending on ITER and estimated its economic impact in terms of Gross Value Added (GVA) and job-years created by using the E3ME economic model. The model was used to examine two scenarios: a counterfactual "non-ITER scenario" where ITER would not have existed, and an "alternative spending scenario" assuming the same amount was spent that corresponded to the collected data on F4E spending for ITER. In the alternative scenario, the amounts were allocated to the corresponding economic sectors.

The previous study found that in-kind payments to European contractors totalled EUR 2.245 billion in the period of 2008 to mid-2017 (EUR 2.31 billion in 2017 values[6]). The in-cash contribution of F4E to IO (of the order of EUR 200 million per year) was assumed to be used partly for contracts to EU companies. For confidentiality reasons, the value of the contracts awarded by IO to European contractors could not be accessed, thus, it was estimated that European companies received 10% of the in-cash contribution of F4E to IO. In the absence of the IO's contracts received by European contractors, it was estimated that EU companies received EUR 5.125 billion as F4E's cash and in-kind contributions as well as payments for adjacent services as pointed out in Section 1.1[7].

The modelling results of the previous study showed that F4E spending on ITER, compared to the no-spending scenario, has produced 34,000 job-years and almost EUR 4.8 billion in GVA over the period of 2008-2017[8]. With a positive cumulative impact of EUR 132 million on GVA, the alternative spending scenario calculated that 5,800 job-years in non-business services were created over the similar period. The output[9] of this study also detected that there is a high potential for spin-offs and technology transfer, as ITER is at the cutting edge of fusion research and many of its components are the first of their kind.

By refining the methodology and incorporating additional data, this follow-up study investigates and assesses the accuracy of the previous study's forecasts while extending the analysis to the two years that have elapsed since the first analysis.

1.2.1. Objectives

Starting from the previous study, this follow-up aims to examine the impact of ITER-related spending on the European economy and job creation. The three main objectives of this study are:

- Update the 2017 F4E data, extend it to 2019 and include the payments from IO to the European industry;
- Assess and analyse the economic impact of all Euratom contributions for the periods of 2008-2017 (the scope of the previous study), 2018-2019 and 2008-2019 in terms of value added and jobs created using an econometric model;

[5] The former study was contracted under the framework contract ENER/A4/516-2014. See the link.
[6] Deflators are used in order to calculate the estimated values.
[7] Table 2-1: Summary of model inputs per main category in the previous study.
[8] Part of the 2017 data was forecasted as only part of the data was historic back then.
[9] For the purposes of calculating this contribution, the previous study analysed ten case studies of innovation and new technologies that were created due to ITER.

- Provide wider, non-direct, economic impacts of ITER by considering and completing the previous study's results and highlight the changes that have occurred during the past two years, both positive and negative.

1.2.2. Scope

This study focuses on the assessment of the economic consequences of all contributions made by Euratom to the EU economy, looking at industries ranging from research and high technology companies to construction utilities and SMEs. Each sector involved in the realisation of ITER is included in the scope of this study. Despite not being European Union Member States, Switzerland and the United Kingdom have been included in the scope of the analysis. Therefore, the terms of "Member States" and "EU" in this report cover these countries as well.

The quantification of the economic impacts of ITER is based on the Global Link Macro – Industry Model (GLM-IM) which is proprietary to IHS Markit. It includes national input-output tables with a breakdown of different sectors. The breakdown of sectors is based on the ISIC code; the list of sectors is given in Annex A.

Three periods are considered for the economic analysis: 2008-2017, 2018-2019, and 2008-2019. The first scope enables an understanding of how sensitive the results are to the modelling methodology. Thus, this study also investigates the discrepancies between results of the two models[10]. In order to compare the results, the present study used the inputs collected during the previous study to generate a scenario with IHS Markit's GLM-IM model (see Annex D for a description of the GLM-IM). The results are then set into perspective to the results published in the previous report (see Annex E).

In addition to direct economic effects of ITER on industry in the EU, indirect and induced economic effects (value chain and income effects) on all sectors in the EU are included in the scope of this study. Possible future non-monetary impacts of ITER are provided in a more qualitative way by comparing and analysing the similar effects other big-science projects have on industry. These diverse effects and impacts of ITER-related activities in the EU are assessed by following-up the case studies performed in the previous study. Any changes that have developed in the past two years are highlighted and included in the scope of this report.

1.2.3. Methodological aspects

The study is grounded on a robust dataset supporting the analyses of the corollary effects the investment in the ITER Project has on the relevant European economic sectors. Accounted payments and commitments along with other relevant information since 2008 were provided by the procurement divisions of F4E and IO. These datasets serve as the input to the GLM-IM.

Provided with this report, each dataset includes payment lines for associated contracts accompanied by their values in EUR, quarterly payment date and their contractors. In the F4E's dataset, contracts come along with their Work Breakdown Structure (WBS) – lines which describe the relevant Work Package (WP) category. These lines also provide basic information about the necessary work which should be delivered to the ITER site in the scope of the contract.

The previous study covered the period of 2008 to mid-2017. The present study focuses on the period of 2008 to 2019 while incorporating additional data arising from the IO's payments and commitments to the European industry. In order to ensure the comparability

[10] E3ME model was executed in the previous study. See the details of this model in the previous study's report.

between the two studies, the same methodology has been used, though a number of updates have been made in regard to the underlying data and approach. In particular, the matching exercise of the payment lines (contracts) used to identify their respective NACE sector has been updated to ensure that the selection of corresponding code reflects the real economic activity of the investment. More detailed information regarding how the economic sectors of awarded contracts are allocated and updated is given in Annex B.

The industry module of GLM-IM is based on ISIC classification due to the global scope of the model and covers 57 sectors. ISIC and NACE classifications are compatible. Some ISIC sectors where aggregated in GLM-IM and the matching exercise has accounted for this. This allocation considered several matching assessments amid the previous study's matching exercise for the comparison purposes. Final decision for the sector matching was made by manually reviewing each contract. An ISIC code is allocated to each contract by analysing the contract detail and contractor's sectoral profile. Various websites[11] as well as the company's own internet site were consulted, and cross checked in order to determine the most accurate ISIC code for the corresponding contract. Contracts with a value lower than EUR 1000 were allocated on the basis of the company's industrial activity without looking at the contract details.

The breakdown of NACE and ISIC economic activities can be found in Annex A.

Arranged datasets equipped with requisite inputs have been prepared in order to run the GLM-IM. It will quantify the number of jobs, estimate the gross value added and industry-related benefits from the installation and development of ITER, and activities associated with its administration and management.

Section 3.1 describes the detailed methodology on how the model was executed.

1.2.4. Assumptions

Performing an economic analysis of ITER-related spending in European industry required gathering different data from various sources. Each dataset is unique and must be adapted to serve as input for the GLM-IM. In this regard, datasets obtained from F4E and IO, which are the primary sources for this study, have been aggregated and prepared for the model.

Nevertheless, interpreting data required some assumptions to be made about the accuracy of the data in order to produce accurate quantification of the econometric model. Firstly, some contracts have been awarded to consortia. Secondly, a Tier 1 company, who is the main contractor, can choose to subcontract some of its activities to Tier 2 and Tier 3 companies from different countries. This means that various unknown companies and their States cannot be identified and included in the dataset.

For major contracts, the information about consortium members is accessible. Depending on the contract detail, which can be found through desk research, the payment is distributed either equally or on a basis of weighted calculation (i.e. 60 to 40% or 80 to 20%). As consortium members are known in these major contracts, their country of origin and their economic sectors are minutely allocated to the corresponding payment line.

However, subcontracting details and data for each member of consorted contracts with a relatively low value are scarce. Regarding subcontracting, it is assumed that major contractors tend to choose a "compatriot" subcontractor. In the case of big civil engineering contracts, a contractor may, however, opt for local companies which are close to the work site. Since a large share of the construction activities are already entrusted to French companies, it is not expected that this assumption would induce significant errors.

[11] Depending of the origin country of companies, various sources have been used for FR, D, UK, I, ES.

Under these assumptions, subcontracting does not have an impact on the result of the economic analysis. For other cases where subcontractors and consortium members are located in different countries, the model would not use the real input. However, this effect is negligible as there are some thousands of payment lines of which major contractors (Tier 1 companies) dominate the total amount of the payments. The share of the subcontracting activity can be neglected when the major contractor’s contribution is considered.

Finally, a member of the consortium can be a non-European company. If its headquarters is located outside of the European States, even though it has a registered office in the EU, its payment share has been deduced from the contract value.

2. Analysis of spending on ITER in the EU

The largest contributions to ITER are the F4E's in-kind and in-cash payments to IO. Along with these major payment lines, other monetary contributions with different purposes are presented in Table 1. The key source of these values was the Commission reports [1], [2] and F4E's reports [3].

The value of all European contribution both in-kind and in-cash totalled almost EUR 5.64 billion in the period 2008 and 2019.

As described above, an invaluable contracting dataset has been provided by the procurement departments of F4E and IO. These datasets which have been arranged and adjusted in a way to be executed in the econometric model, were separately supplied as an Excel file.

Annex C – Analysis of the previous data thoroughly explains the variations in payment amount between the present and previous study.

Table 1: Various European contributions for ITER operations

European Contribution (Actual EUR in Million)	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**TOTAL by 2019**	**TOTAL by 2017**
F4E cash to IO[12]	41	46	65	83	98	71	96	86	125	140	144	227	1,221	850
F4E in kind[13]	18	36	96	133	210	274	293	326	457	551	504	427	3,324	2,393
Voluntary contributions[14]	42	42	42	42	42	42	42	42	42	42	42	42	504	420
F4E administration[15]	14	24	29	36	39	40	43	44	48	53	56	56	482	370
EC project administration[16]	9	9	9	9	9	9	9	9	9	9	9	9	108	90
TOTAL	123	157	242	302	398	436	483	507	681	794	755	761	**5,639**	**4,123**

[12] Executed payments up to 2018 (included) and forecast value for 2019 have been obtained from the Annual and Multiannual Programme (2019-23), Table 5.
[13] Executed payments have been obtained from the F4E's contracting dataset.
[14] European voluntary contributions amounted to EUR 339 million as of 2005. This is obtained from the Final Report of Negotiations on the Broader Approach Agreement Tokyo, 20 June 2006. It is estimated that nearly EUR 500 million in 2019 values have been contacted as of 2019 for 12 years. It is assumed that the value of the contracts awarded each year is identical.
[15] Executed payments up to 2017 (included) and forecast values for 2018 and 2019 have been obtained from the Annual and Multiannual Programme (2019-23), ANNEX XVI.
[16] Average value for each year have been obtained from the EC COM (2017) 319 final and EC SWD SWD(2017) 232 final.

The following subsections describe each spending for the ITER project with an economic impact in the EU and briefly explain how each was used.

2.1. IO payments

Along with other Domestic Agencies (DA) of ITER Parties, F4E delivers a substantial cash contribution to IO on a yearly basis to cover its internal operating costs and activities regarding the design and specification of ITER components as well as their assembly and installation.

As given in Table 1, F4E has paid approximately EUR 1.221 billion to IO between 2008 and 2019. In return, some thousands of contracts have been awarded to the European companies by IO.

IO has awarded contracts with a value more than EUR 1.5 billion between 2008 and 2019 to European contractors. Of this amount, nearly EUR 980 million has already been paid to those contractors in European States by 2019. The rest of the payments will be realized by the due dates which are not included in the scope of this study.

The difference in the amounts paid by F4E and the values of the contracts awarded by IO to European contractors can be explained by the fact that other DAs also contribute to IO. It can be said that an excess of EUR 300 million is earnings for the EU.

2.1.1. Geographic distribution

As shown in Figure 1, France being the host State of ITER has received nearly 75% of the IO’s contracts in terms of their value. Other major contractors who benefited from these payment lines are registered in the United Kingdom, Spain, Italy and Germany. In total, contractors from 23 States received payments from IO by the end of December 2019.

Figure 1: Geographical distribution of IO's contracts value in terms of millions of EUR

Table 2 gives the detailed geographical distribution of the IO payments and contributions to European contractors between 2008 and 2019. It should be noted that this table does not consider subcontractors. Some major contractors might have subcontracted some of their activities to other companies which are located in another State. Consequently, there might be an activity in some European States that are presented as having not received any payments. It is assumed that these payments would have been minor if it was the case.

Table 2: Overall distribution of IO contracts value per Member State (Million in EUR)

Country	Contracted value	Paid value by 2019
Austria	0.49	0.35
Belgium	1.32	1.15
Bulgaria	0.06	0.06
Switzerland	25.25	21.80
Czech Republic	1.09	0.94
Germany	85.03	34.46
Denmark	0.52	0.46
Spain	69.62	41.99
Finland	1.35	1.14
France	1,153.63	738.75
United Kingdom	91.67	75.37
Croatia	6.00	1.39
Hungary	0.28	0.25
Ireland	2.13	2.07
Italy	75.99	39.44
Luxemburg	0.45	0.43
Netherlands	9.91	9.39
Poland	1.37	1.28
Portugal	1.57	1.30
Romania	0.13	0.13
Slovakia	0.00	0.00
Slovenia	9.34	8.14
Sweden	0.52	0.42
TOTAL	**1,537.73**	**980.71**

2.1.2. Economic sector distribution

The above analysis has focused on the geographic distribution of the IO's payment lines to European companies and research organisations. In this section, these payments are broken down by economic activities.

Figure 2 shows how these payment lines are distributed across main economic sectors in the EU.

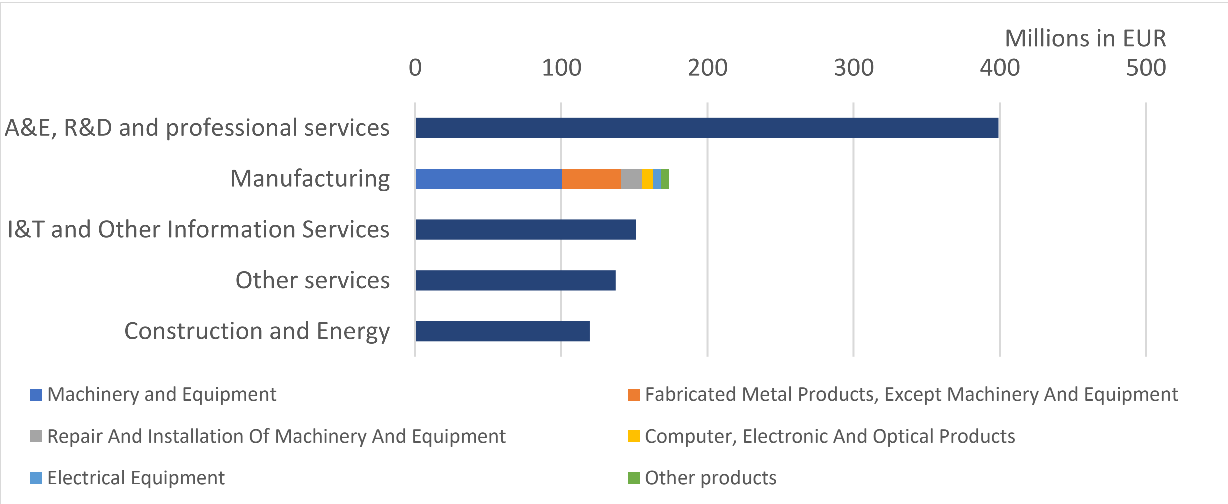


Figure 2: Distribution of the IO's payment lines by economic sector in the EU

2.2. F4E in-kind contribution

F4E's in-kind contribution represents the most significant investment in the construction, manufacturing and A&E activities delivered to ITER. To date, entities in 20 Member States have benefitted from contracts awarded by F4E for the delivery of in-kind contributions to ITER and from grants for supporting research and development actions. Based on data provided by F4E, in-kind payment appropriations amounted to nearly EUR 3.324 billion in the period between 2008 and 2019.

The in-kind payments vary across countries and major economic sectors in Europe.

2.2.1. Geographic distribution

Figure 3 illustrates the geographical distribution of the total amount of F4E's in-kind payments to each Member State.

Figure 3: Geographical distribution of F4E in-kind payments in EUR

France which benefits from being the host country of ITER captures the greatest share of the contract value. Along with France, nearly 98% of the total value of in-kind payments is received by the European largest 5 economies.

Between 2017 and 2019, F4E provided new opportunities to European companies and research institutes to work on ITER project by awarding contracts valuing of nearly EUR 930 million. Figure 4 shows how the amount of the in-kind payments have evolved over the two years in those States which provide a sounds basis for the progress of the project.

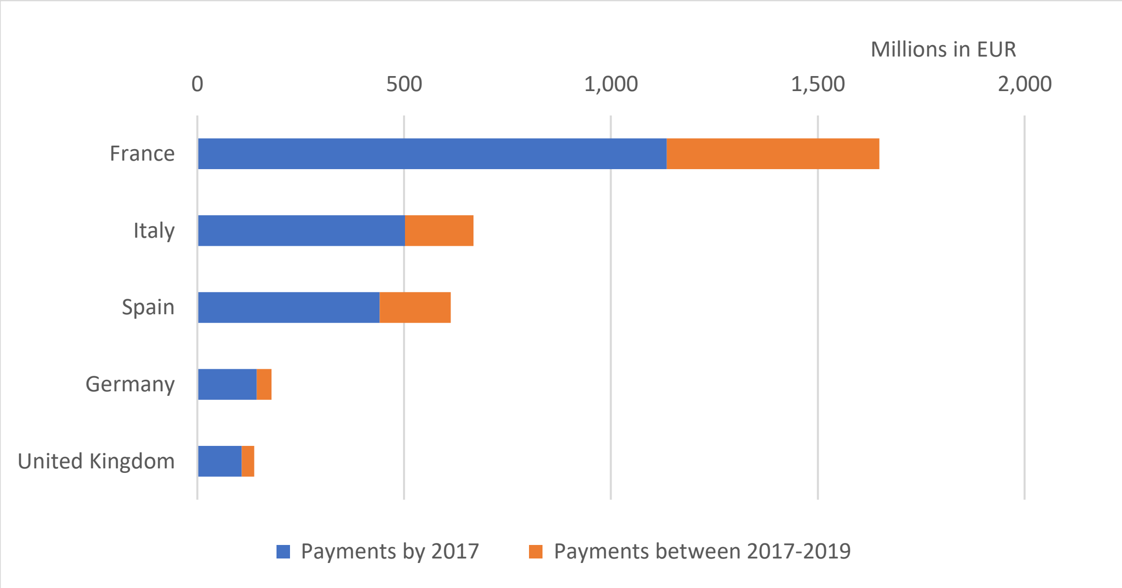


Figure 4: Top five States receiving the greatest proportion of the in-kind contributions

A complete overview of the payments up to 2017 and 2019 for each Member State is given in Table 3.

Table 3: Geographical distribution of F4E in-kind payments (Million in EUR)

Member State	by 2017	by 2019
Austria	5.56	5.64
Belgium	1.74	3.13
Bulgaria	-	-
Croatia	0.01	0.03
Cyprus	-	-
Czech Republic	-	-
Denmark	1.28	2.80
Estonia	-	-
Finland	10.65	12.16
France	1,135.27	1,649.11
Germany	143.68	179.72
Greece	-	-
Hungary	1.51	1.52
Ireland	15.37	17.76
Italy	501.93	667.50
Latvia	0.03	0.03
Lithuania	-	-
Luxembourg	0.02	0.02
Malta	-	-
Netherlands	2.28	2.50
Poland	0.41	0.45
Portugal	7.04	10.62
Romania	0.02	0.02
Slovakia	-	-

Slovenia	-	-
Spain	441.23	612.75
Sweden	3.10	4.25
EU-27 Sub-Total	2,271.15	3,170.02
United Kingdom	107.61	137.43
Switzerland	14.28	16.60
TOTAL	**2,393.04**	**3,324.05**

2.2.2. Economic sector distribution

The above analysis has focused on the geographic distribution of the in-kind payments from F4E to the European companies and research organisations. In this section, these payments are broken down by economic activities.

Figure 5 illustrates how the payments are shared by main economic sectors and also provides the most important manufacturing sub-sectors.

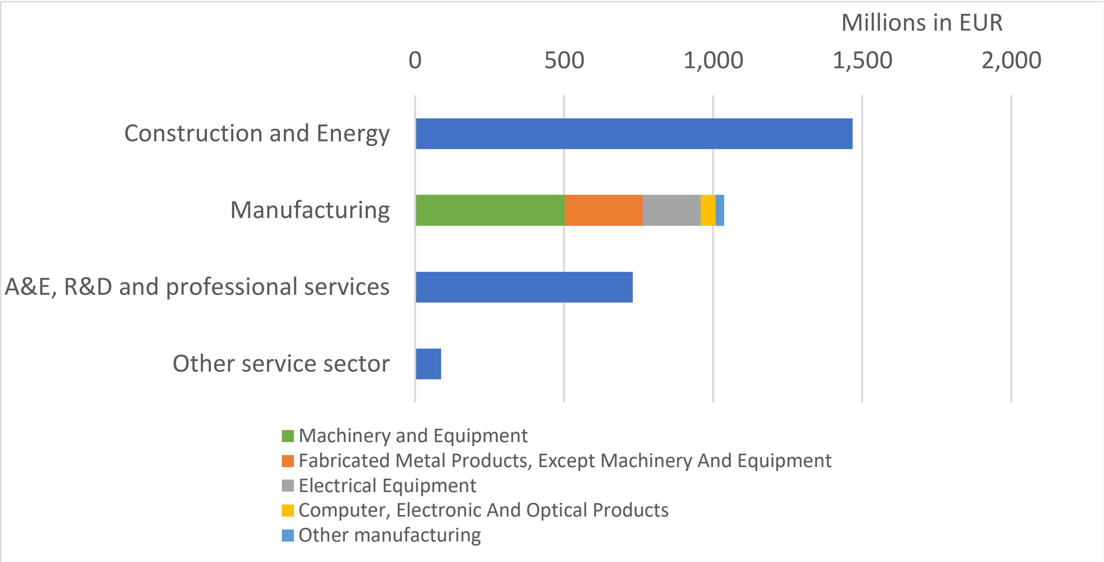


Figure 5: Distribution of F4E in-kind payments by economic sector

The construction sector, which is also entrusted with meeting the nuclear grade fabrication requirement, dominates contract awards with nearly EUR 1.5 billion. Succeeding construction, the manufacturing sector takes the second largest share of payments. The manufacturing of machinery, equipment and fabricated metal products along with electrical equipment account for nearly 30% of all in-kind payments. Architecture & Engineering (A&E) activities along with Research and Development (R&D) and other professional activities such as legal, accounting and inspection work subsequently receive a large portion of payments of about 22%.

It is important to note that financial intensity lies with construction of ITER devices and buildings as well as with its architecture and engineering activities.

Figure 6 illustrates the F4E's payment divided into various industries in these five economically biggest States in the EU which capture the major part of the payment as pointed out previously.

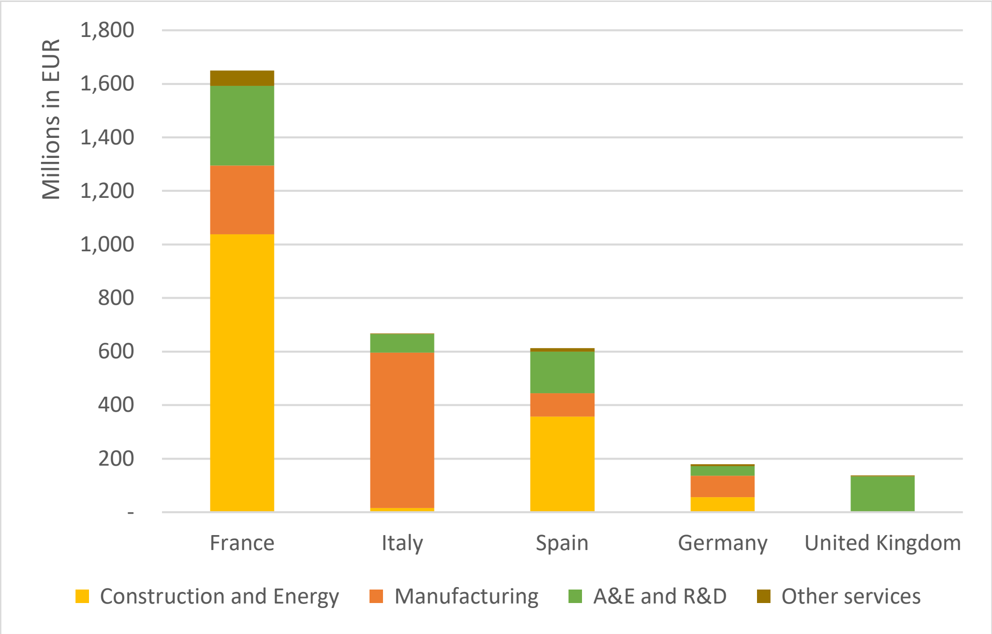


Figure 6: Distribution of F4E in-kind payments by sector and by top 5 contributors

Construction activities in ITER site is dominated by France and Spain while Italy is the major contributor for the manufacturing industry. Germany provides key components in a lesser extent. Almost 100% of the payment made to the United Kingdom is allocated to the A&E and R&D services.

This shows that engineering and manufacturing processes of all key components have also seen significant contracting activity despite the financial intensity of constructing the building.

All other subdivided economic sectors which are targeted by the in-kind payments to the European industry are given in

Table 4. ISIC code represents the description of the nature of the economic activity behind the payment. The reclassification of these ISIC codes shown in the

Table 4 is due to the econometric model that will be used in this study.

Table 4: ISIC distribution of F4E in-kind payments (Million in EUR)

ISIC Code	ISIC Description	by 2017	by 2019
41T43	Construction	943.0008	1,433.9837
69T75	Professional, Scientific And Technical Activities	561.6743	730.8220
28	Machinery And Equipment N.E.C.	387.5751	502.1530
25	Fabricated Metal Products, Except Machinery And Equipment	227.0152	262.8516
27	Electrical Equipment	137.6919	192.9832
26	Computer, Electronic And Optical Products	44.4965	51.7434
35	Electricity, Gas, Steam And Air Conditioning Supply	12.6091	31.7881
52	Warehousing And Support Activities For Transportation	16.7474	24.3983
65	Insurance, Reinsurance And Pension Funding, Except Compulsory Social Security	17.4953	20.8209

62T63	It And Other Information Services	13.7417	18.9604
33	Repair And Installation Of Machinery And Equipment	3.8153	15.0133
78A80T82	Security, Buildings, Employment	7.3640	14.5457
OSTU	Public Administration And Defence; Compulsory Social Security	4.9765	6.7942
303	Air And Spacecraft And Related Machinery	5.3197	5.3197
241A2431	Iron And Steel	4.7154	4.7154
23	Other Non-Metallic Mineral Products	1.9988	2.2515
36	Water Collection, Treatment And Supply	1.0316	1.7484
46	Wholesale Trade, Except Of Motor Vehicles And Motorcycles	0.2980	0.8903
58	Publishing Activities	0.3772	0.7598
242A2432	Non-Ferrous Metals	0.7128	0.7342
66	Activities Auxiliary To Financial Service And Insurance Activities	0.3454	0.4606
77	Rental And Leasing Activities	-	0.1567
85	Education	0.0243	0.1368
47	Retail Trade, Except Of Motor Vehicles And Motorcycles	0.0098	0.0162
19	Coke And Refined Petroleum Products	0.0046	0.0046
49	Land Transport And Transport Via Pipelines	0.0005	0.0005
	TOTAL	**2,393.0411**	**3,324.0523**

2.2.3. WBS distribution

F4E's contracting activity is shaped by achieving the First Plasma in 2025. When divided into the specific F4E's WBS, the data reveals that the contracting activity is concentrated on the Site and Buildings and Magnet activity.

Figure 7 shows the distribution of F4E's in-kind payment on a selection of projects undertaken between 2008 and 2019 on the major systems needed to achieve First Plasma by 2025. Nearly 80% of F4E's in-kind contributions have gone to the activities related to the WP including "Site and Buildings", "Vacuum Vessel" and "Magnets".

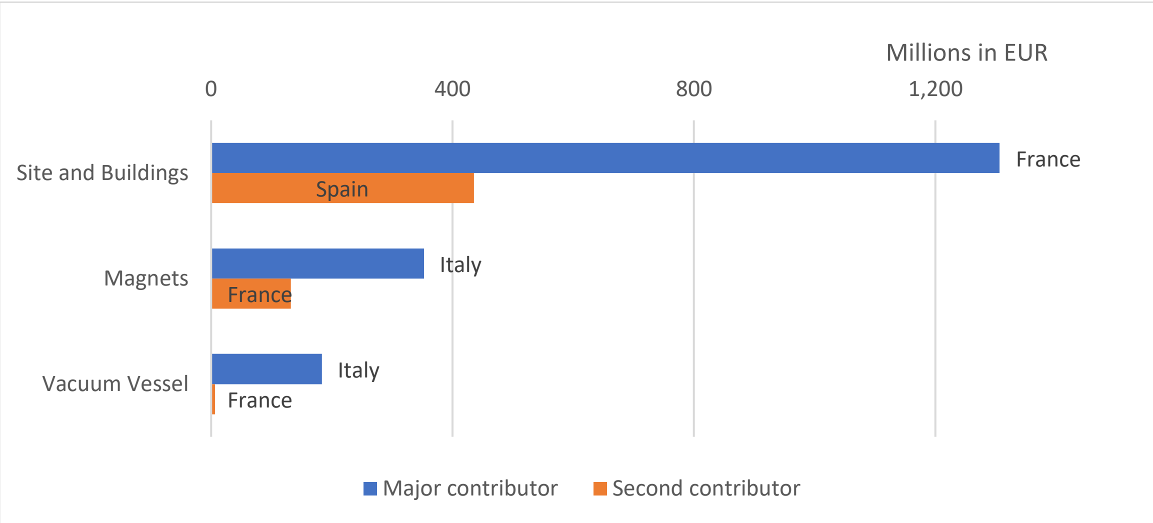


Figure 7: Selected work package distribution of F4E in-kind payments

As noted above in the analysis of economic sector, France and Spain are the major contributors for the construction activities. Along the same line, Italy leads the manufacturing of innovative components such as superconducting magnets and vessel.

Further, it is noted that payments accounted to the WBS "Site and Buildings" are not entirely allocated to the economic sector "Construction" given in Section 2.2.2.

The amounts paid for all other WP elements crucial to achieve the First Plasma are presented in Table 5.

Table 5: Distribution of the in-kind payments among WBS by 2017 and 2019 (Million in EUR)

WP Code	Designation	Paid by Dec 2017	Paid by Dec 2019	Major contributor
62	Buildings Infrastructure and Power Supplies	1,313.2498	,928.7741	France
11	Magnets	547.5935	641.7094	Italy
15	Vacuum Vessel	135.8669	195.9774	Italy
53	Neutral Beam Heating and Current Drive	90.8581	133.3206	Italy
34	Cryo-plant	68.6135	77.3622	France
55	Diagnostics	25.9493	44.4948	Spain
23	Remote Handling	25.9421	40.9172	United Kingdom
16	Blanket	30.9360	40.5807	France
17	Divertor	24.6346	37.0397	Italy
56	Test Blanket	27.6526	30.4958	France
PM	ITER Programme Management	18.8912	30.0738	Spain
52	Electron Cyclotron Heating and Current Drive	23.1445	29.0780	Sweden
BA	Broader Approach	13.1992	26.7201	France
TR	Transportation	15.3393	23.1224	France
31	Vacuum Pumping and Leak Detection	4.0928	10.8116	Germany
ES	Technical Support Services	6.7310	10.1233	Spain
32	Tritium Plant	6.0077	6.6288	Spain
51	Ion Cyclotron Heating and Current Drive	4.7787	6.0672	United Kingdom
PE	Plasma Engineering	2.9145	3.4164	Italy
53	Neutral Beam Heating and Current Drive	2.6670	2.6767	United Kingdom
NS	Nuclear Safety	1.9247	2.3671	Germany
64	Radiological and Environmental Monitoring	0.7571	0.7571	United Kingdom
CE	CE Marking Assessment	0.4765	0.6758	Spain
MF	Materials and Fabrication Technologies	0.5238	0.5652	Sweden
66	Waste Management	0.2835	0.2835	United Kingdom
AD	Administration	0.0134	0.0134	United Kingdom

2.3. Broader Approach and voluntary contributions

In parallel to the ITER Agreement, a separate bilateral agreement between Euratom and Japan was signed in 2005. This agreement, called the "Broader Approach" (BA) Agreement, further facilitates and coordinates three fusion-related projects in Japan which intend to support the development and realisation of ITER and the preparations for DEMO.

It is foreseen that both parties of the BA agreement will equally provide "Voluntary Contributions". The majority of the European contributions are in the form of voluntarily provided in-kind components and staff by some member states of Euratom.

As of 5 May 2005, the complete scope of work covered by the BA Agreement had a value of EUR 678 million of which European voluntary contributions amounted to EUR 339 million (nearly EUR 500 million in 2019 values) [4].

Procurement Arrangements (PAs) between the two members of the BA agreement describe the scope of the procurement and service, including its technical specifications, estimated cost and schedule. According to the PAs, an indicative sectoral allocation of the estimated value of the voluntary contributions from Member States is set out in Table 6[17].

Table 6: Economic sector allocation of voluntary contributions from Member States

Economic sector allocation of voluntary contributions (EUR in Million)	France	Italy	Spain	Germany	Switzerland
Computer, Electronic and Optical Products	85	0	0	3	0
Electrical Equipment	95	90	35	5	10
Professional, Scientific and Technical Activities	60	45	45	25	2

2.4. F4E administration

F4E administrative spending is dedicated to its operating activities including wages, salaries and other related expenses as well as maintenance and community cost of the headquarters building in Barcelona. For convenience, the spending on administration is assumed as 25% of the total F4E spending.

2.4.1. Staff expenditures

This category includes internal and external staffs' salaries, their duty, travel and training. It is assumed that 85% of the F4E administration spending is accounted for staff expenditures: Of this amount, 25% is related to the external staff expenditures and is allocated to "Professional, Scientific And Technical Activities (69T75)". Internal staffs' expenditure is allocated to the economic sector for "Public Administration and Defence; Compulsory Social Security (OSTU)".

Since this line represents the work carried out by F4E in Barcelona and at the ITER site in France, 80% and 20% of this spending is allocated to Spain and France, respectively.

2.4.2. Buildings and miscellaneous operating expenditure

This category is intended to cover the expenses linked to community services including electricity, gas, water; and maintenance costs such as cleaning, security and the fitting-out of the premises.

As explained above, this appropriation is assumed to cost 15% of the F4E administration spending. While all payments are allocated to Spain, selection of economic sectors for these varied payments includes:

- 40% is allocated to "IT And Other Information Services (62T63)";

[17] European Commission, EU contributions to BA activities (personal communication, March 2020)

- 25% is allocated to “Security, Buildings, Employment (78A80T82)”;
- 10% is allocated to “Hotels and Restaurants and Travel Agency and Tours (55T56A79)”;
- 25% is allocated to miscellaneous service sectors.

2.5. F4E other activities

This appropriation is intended to cover miscellaneous expenditure, in particular of the Broader Approach activities in coordination with Japan which are intended to accelerate the realisation of fusion energy and develop advanced technologies for future demonstration fusion power reactors such as DEMO.

In this regard, all high-level scientific and technological activities which are performed in the EU have been allocated to the corresponding State and the economic sector “Professional, Scientific and Technical Activities (69T75)”. Payments made to Japan have been excluded from the scope of this study.

As included in the separate dataset of in-kind payments provided by F4E, spending of nearly EUR 26.7 million indicated by the WP code of BA – Broader Approach in Table 5 attributes to the expenditure accounted for “F4E other activities”.

2.6. EC project administration

This category represents the work undertaken by the European Commission in order to manage the project from a policy perspective. In this regard, European Commission average annual administration costs of the project is considered to be EUR 9 million as given in Table 1. These payments are allocated to Belgium under the economic sector for “Public Administration and Defence; Compulsory Social Security (OSTU)”.

3. Impact analysis

ITER has been and will continue to bring an important contribution to the economic and scientific landscape in the European Union. The purpose of this chapter is to quantify the economic contribution and explain the results. The research team consisting of LGI and IHS Markit benefited from data on spending which were received from entities from F4E, IO and the European Commission for the time frame 2008-2019.

3.1. Methodology

This section describes the results of IHS Markit's Global Link Macro-Industry Model (GLM-IM) for the implementation of ITER on EU economies. Compared to the previous study, this report is based on an updated database including:

- F4E contracts up to 2019;
- IO contracts up to 2019;
- BA contracts up to 2019;
- Project administration expenditure, e.g. by the European Commission.

In addition, this study also provides an outlook of how ITER could impact EU economies in the future by analysing the additional impact of future F4E and IO contracts.

The collected contract data has been aggregated in two dimensions: countries and sectors. So that for each year of the analysis one number for each country and sector was taken into account. The sectors covered correspond to the sectors available in the GLM-IM and amount to 57 comprising agriculture, industry, construction and service sectors. For a complete list of the GLM-IM sectors please refer to Annex A - NACE and ISIC Table

The aggregated contract data is used to change sector-specific investments. As the historic data already ingested the impacts of ITER activities, a counterfactual scenario was calculated. The counterfactual scenario tries to answer the question what if ITER would not have been implemented and no investment into ITER would have taken place. Thus, the investments into ITER enter our model negatively. The team then compares the results to our baseline, the status quo, hence, a world in which ITER investments have been made.

The model takes the changed investment figures and runs it through a module which is based on Input-Output Tables for each country. Input-Output Tables describe the sale and purchase relationships between producers and consumers within an economy. One section depicts the producer-consumer interlinkages between sectors. This part provides the information on supply chains within the sectoral space and is used in the GLM-IM to calculate the industrial impact of ITER including the supply chain (direct and indirect economic impact).

From the changes in investment figures, output and GVA numbers are calculated taking the supply chains impacts into account. These effects drive the employment impacts which are captured by the number of jobs and the resulting change in wage bills. A share of the additional wages is then used to increase consumption, i.e. industries serving consumers benefit from this cycle and create additional value added in these sectors and adjacent supply chain sectors.

For a description of the model and how it works, please refer to Annex D: Global Link Macro Industry Model.

3.2. Impact of ITER: Results for 2008-2019

The impact analysis assessed the economic contribution for both in-kind and in-cash as detailed in Table 1 of the report and broke the economic contribution down in values as described in the previous chapter. The total value of all contributions for ITER development and operations during 2008 to 2019 amounted to nearly EUR 5.64 billion.

All data on gross value added is given in millions of euros (2015 prices). All data on jobs is given in number of full-time jobs per year.

Gross value added is defined according to Eurostat as follows: 'Gross Value Added (GVA) (ESA 2010, 9.31) is defined as output value at basic prices less intermediate consumption valued at purchasers' prices. GVA[18] is calculated before consumption of fixed capital.'. Basically spoken, gross value added equals the value of a product less all inputs that are needed to produce the product. The producer margin that is generated when a product is sold may be regarded as a proxy for gross value added.

Gross value added as a concept differs from the total value of European contributions to ITER both in-kind and in-cash. While the European contributions include purchases of goods which serve as supplies to the production and development process of ITER, the concept of gross of gross value added explicitly subtracts supplies from the final value of the produced good. Both concepts are expressed in monetary values but should be regarded as separate from each other.

The first order effects, which is equivalent to the gross value added from spending on ITER based on in-kind and in-cash contributions for ITER, are shown as direct effects in Figure 8. The direct effects are cumulated over the entire time horizon of the data history, i.e. for the period from 2008 until 2019.

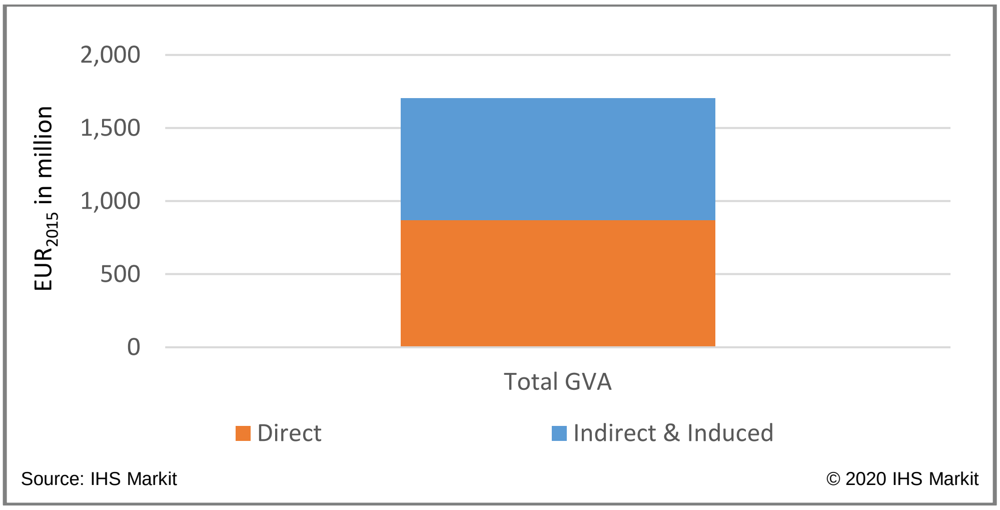


Figure 8: Cumulative economic impact of ITER compared to a world without ITER

The cumulated first order impact of ITER for 2008 to 2019 has been estimated at EUR 868 million.

The indirect and induced effects, meanwhile, are those impacts which result from activities that are generated among suppliers of ITER and which would not have been generated had ITER activities not taken place. Moreover, these effects also include further-reaching impacts beyond the supply chain and include all effects which result from the share of wages and profits, which are earned in connection with these activities, and are spent and recycled in the economy.

[18] Please see Link to Eurostat

For example, a worker at a plant that supplies ITER will earn an incremental amount of the wage bill that can directly be linked to ITER activities and will partially be spent and partially be saved. Only the part of the incremental income that is spent within the local economy is counted as an impact of ITER.

However, the part of the income that is spent includes expenses for all sorts of goods from across all sectors, including agriculture, industry, construction, and services. The sectoral breakdown of the economic impact will thus reveal contributions for all the four sectors above (see for example Figure 10).

Furthermore, all incremental taxes that are generated in connection with ITER activities and all activities in the supply chain of ITER are assumed to be spent by the government and hence count as impact on the economy. Again, all sectors are potentially involved.

These indirect and induced effects taken together amounted to a cumulated EUR 871 million in the twelve years from 2008 through 2019. The total contribution from ITER direct, indirect, and induced effects combined – is estimated at EUR 1,739 million as shown in Figure 8.

Moreover, this means that for every euro spent on ITER, one additional euro has been generated by resulting ITER activities between 2008 and 2019 on average. To be precise, the multiplier for ITER is identical to the ratio between the direct effects and the indirect/induced effects, i.e. EUR 871 million/EUR 868 million = 1.002.

In line with ITER funding becoming available, the economic impact of ITER has been steadily increasing over time and eventually plateaued in 2019 when the total impact edged down from EUR 255 million in 2018 to EUR 253 million in 2019 (see Figure 9).

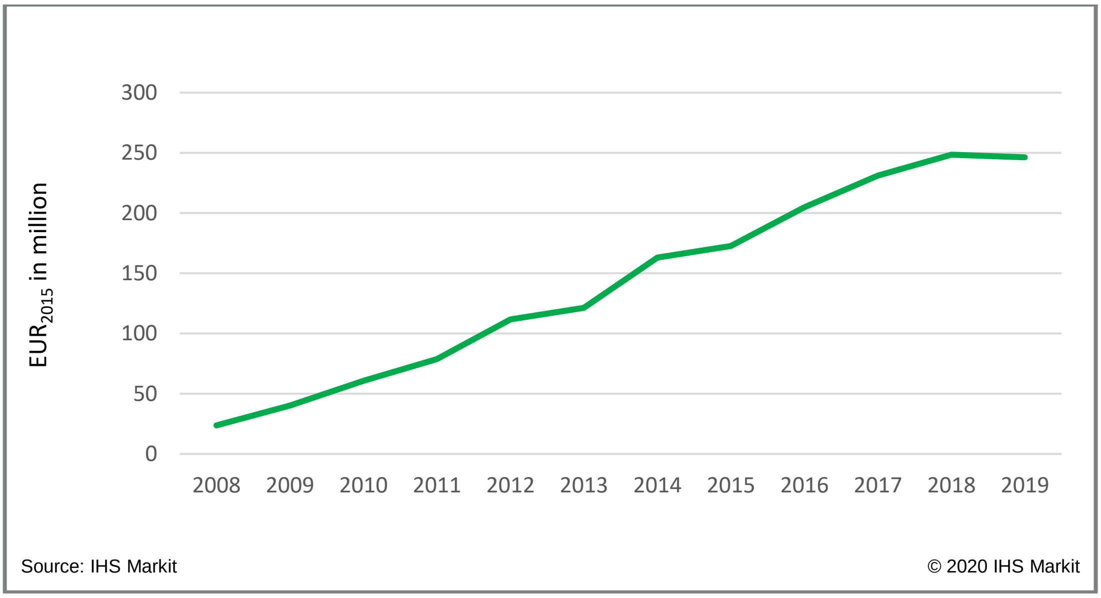


Figure 9: Economic impact of ITER compared to a world with no ITER

It is interesting to note though that the impact of ITER has been increasing over time. The ITER multiplier (the ratio of the direct impact versus the indirect and induced impact) is estimated at 0.51 in the year 2008 when ITER operations started. By 2019, ITER activities generated more than one euro (1.20) for every incremental euro spent directly on ITER operations.

This means that while the impact of spending for ITER had been dominated by funding for ITER itself in the earlier years of ITER, the economic benefits of ITER spending has spread from the ITER plant into the wider economy and the supply chain as operations progressed and became more entrenched in the economic and industry structure of the European Union and member countries of ITER.

The economic impact of ITER is distributed across the four main sectors of the economy, including agriculture, industry, construction, and services. The latter sector, services, benefits most, with the total impact over the entire historical timeframe accumulating to EUR 1,185 million, or 68.2%.

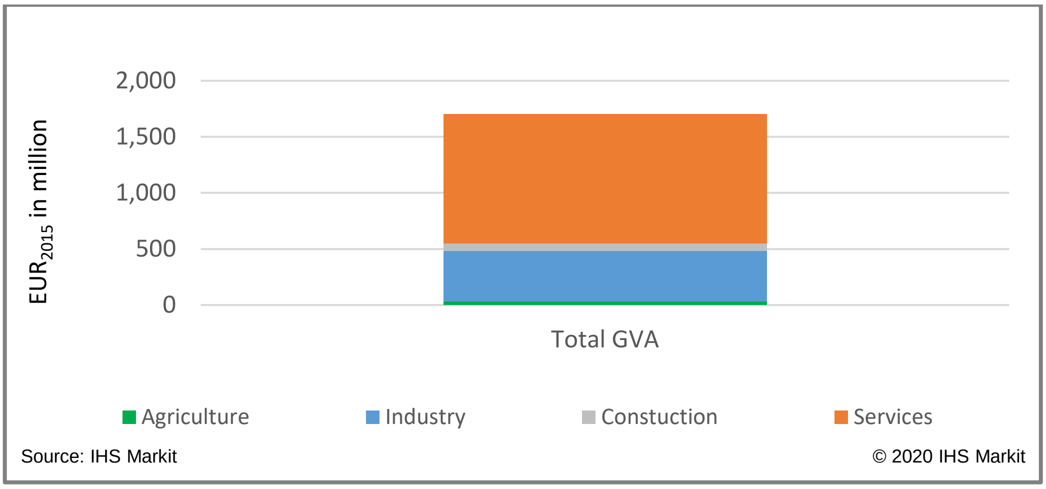


Figure 10: Cumulative economic impact of ITER by sector compared to a world with no ITER

It is not surprising that industry's benefits outsize the industry's share in the European economy, since ITER operations are strongly influenced by industry supplies. Total benefits for the industry from ITER operations equalled EUR 460 million or 26.4%.

A relatively small share of total benefits is allocated to construction and agriculture, with construction accounting for EUR 63 million and agriculture for EUR 31 million, or 3.6% and 1.8% of the total.

The number of jobs per year created because of ITER activities follows a similar pattern. The average number of jobs created per year during the timeframe 2008 to 2019 is estimated at 2,454 persons, with services accounting for the bulk share (1,724). Industry follows second, construction and agriculture follow in third and fourth place, respectively (see Figure 11).

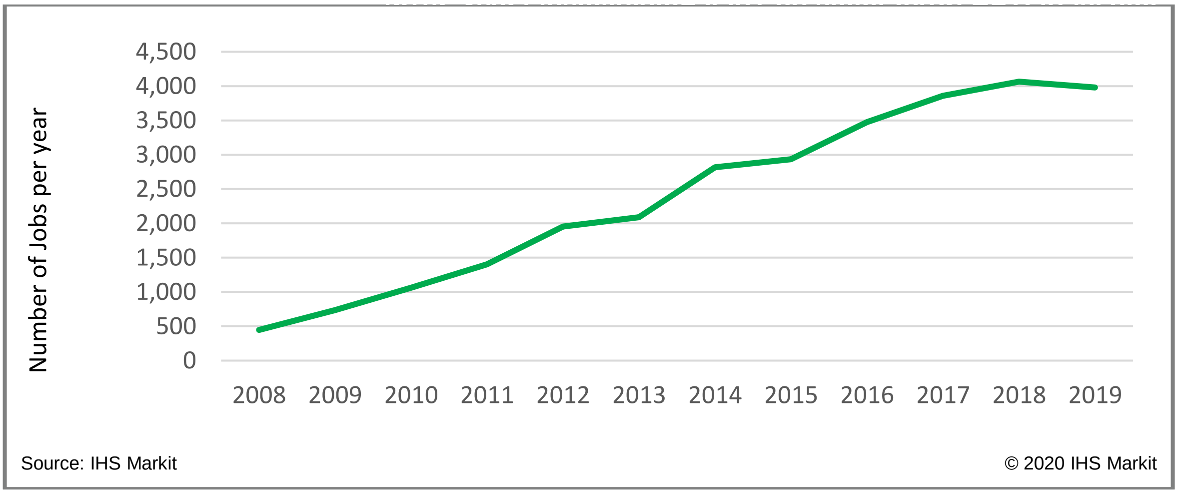


Figure 11: Employment impact of ITER compared to a world without ITER

The performance of the jobs multiplier as a result of the activities surrounding ITER tracks a similar pattern compared to the multiplier for gross value added. The longer ITER operations are in place, the more jobs are created.

The jobs multiplier is estimated to have equalled 0.55 in 2008, which means that for approximately every second job created at the ITER plant, another job is created in the supply chain and the wider economy. By 2019, this multiplier has increased to 1.19, signalling that more than one job is created in the supply chain and the wider economy on top of a job created directly at the ITER plant.

Cumulatively, the economic impact of the number of jobs per year equals 28,822 during 2008 to 2019. Broken down into impact categories, a cumulated total of 14,492 job-years is counted for the direct impact and 14,330 for the indirect and induced impact (see Figure 12).

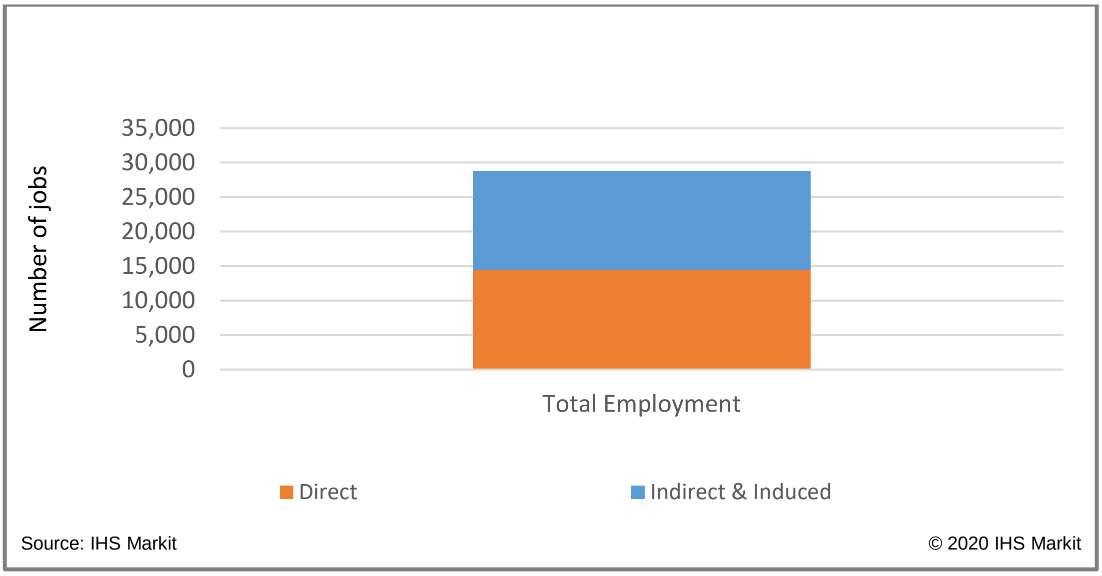


Figure 12: Cumulative Impact of ITER Programme on Employment by Impact

The analysis so far examined the impact of investments on ITER, including direct, indirect and induced impacts, compared to a world in which the ITER project and related investments would not have been executed. However, if investments on ITER had not been spent, funds would have been transferred to alternative investments. These funds would have generated alternative direct impacts, which would have triggered alternative indirect and induced impacts.

The net impact scenario will now quantify the difference between the ITER scenario as discussed in the previous chapter, and an alternative scenario where funds would have been transferred to alternative, non-ITER-related investments and triggered alternative effects in other parts of the economy.

This approach is the basis of the following section. The approach shall demonstrate the net impact of ITER relative to a scenario in which ITER had not been implemented. The analysis is conducted based on historical data (2008-2019) as well as on the forecast (throughout 2035).

In line with the impact assessment of ITER as published in the previous study in 2018, the assumptions for the non-ITER-scenario are as follows: First, the distribution of ITER funds across the member countries of the ITER consortium has been maintained; for example, France gets the same amount of funding in the non-ITER-scenario as it receives in the scenario where ITER is realized.

Second, it is assumed that all sectors benefit from ITER funding on the national level according to their share of output in total sectoral output. There are 57 individual sectors in our industry model, which means that 57 sectoral ratios exist for which funds are allocated proportionately. For example, a sector that produces a fifth of total output in a country would get fifth of total spending of ITER-related funds. These ratios vary slightly from year to year in accordance with the sectoral output share.

This investment for a sector constitutes the direct impact of spending in this non-ITER scenario. The indirect and induced effects are then calculated in the same way as in the ITER scenario presented above.

It is reckoned that these assumptions represent an objective and efficient way to calculate the impact of a non-ITER-scenario on the economy of the ITER consortium member countries.

Based on these assumptions, the total net benefit of all ITER spending, both in-cash and in-kind, on gross value added (GVA) in the EU member countries for the historic time frame 2008-2019 is estimated at EUR 104 million. This includes direct, indirect, and induced net benefits. The overall impact of ITER on the ITER member countries' economy is thus **positive**.

Figure 13 shows how each sector contributes to the overall net impact assessment. Service's and agriculture's net impact is positive, while construction and industry's net impact are negative. The strong positive net impact of services can be explained by the dominant positive effect of ITER investments into research & development, which accounts for a large share of the services category. Europe's R&D-landscape clearly benefits from the development of ITER.

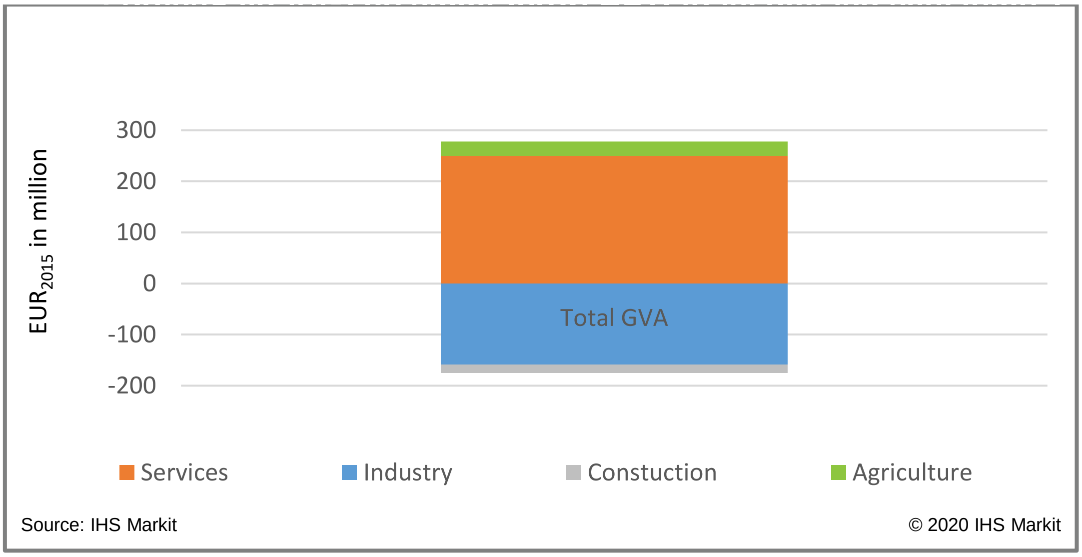


Figure 13: Cumulative net impact of ITER Programme on GVA by Sectors: 2008-2019

Industries' gross value added has a negative impact in the net scenario, although direct spending for ITER is related to Europe's industry for a significant part. However, the output share of Europe's industry and, as a consequence, the spending on industry in the non-ITER scenario is just so much larger, that a negative effect could not be compensated.

Construction, finally, reflects an outsize impact in the ITER scenario in the earlier years and a declining impact with the works at the ITER site making further progress. Hence the net positive impact of the earlier years converts to a net negative impact from 2014 onwards.

The breakdown of the impact reveals that indirect and induced effects dominate the positive impact on gross value added in the net scenario, while the direct impact of the ITER scenario and the non-ITER scenario nearly compensate each other. The cumulated positive direct impact is estimated at EUR 0.03 million, while the cumulated indirect and induced impact is estimated at EUR 104 million.

The performance of the net impact over time reveals a pattern that has been evident already in the previous chapter. Spending for ITER takes a while to have an impact. Supply chains need to be set up, communication channels are established, business networks created.

These effects are captured by a dynamic model that ensures that effects are carried over from one quarter to the next. Some impact is happening in the time period where the investment is taking place, but some impact is happening with a lagged effect that takes place in the following periods. Once spending has taken root in the economy, the impact is clearly positive and growing.

A first, small net positive effect is estimated for gross value added in 2011. This positive impact is growing steadily from 2014 onward (see Figure 14).

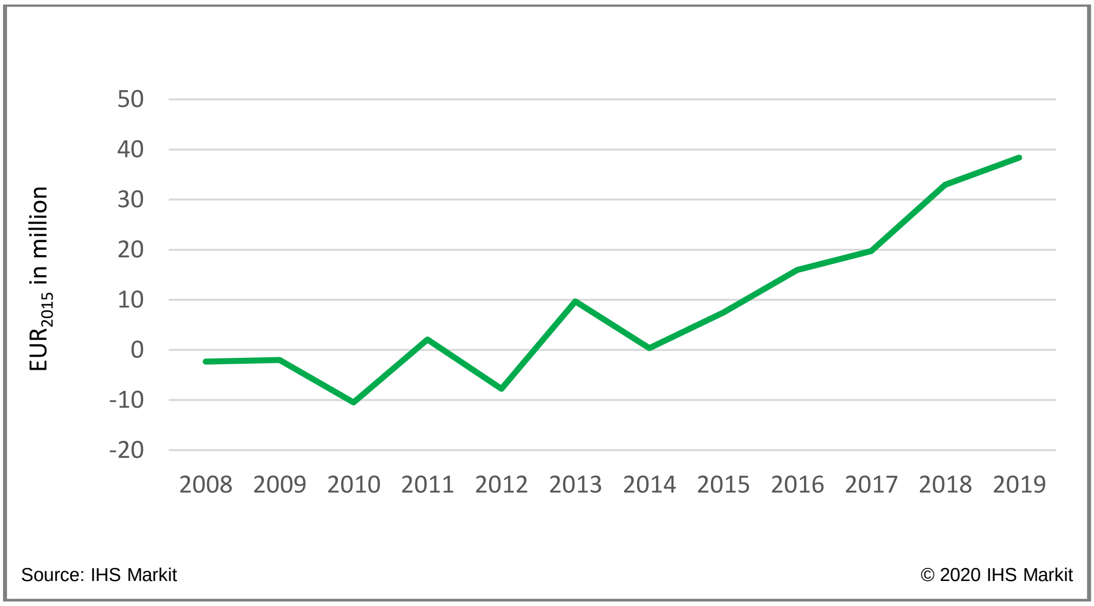


Figure 14: Net impact of ITER Programme on Total GVA: 2008-2019

Employment follows a similar pattern. Hovering around the zero line in the earlier years, the total number of jobs turns positive in 2013 and keeps growing from then on, counting the total impact including direct, indirect and induced effects. The number of jobs created on a net basis peaks at the end of the observed timeframe in 2019 at 792, with most of jobs generated in the supply chain from indirect effects (770). The services sector is responsible for the bulk share of jobs created in that year on a net basis (1,058) (see Figure 15).

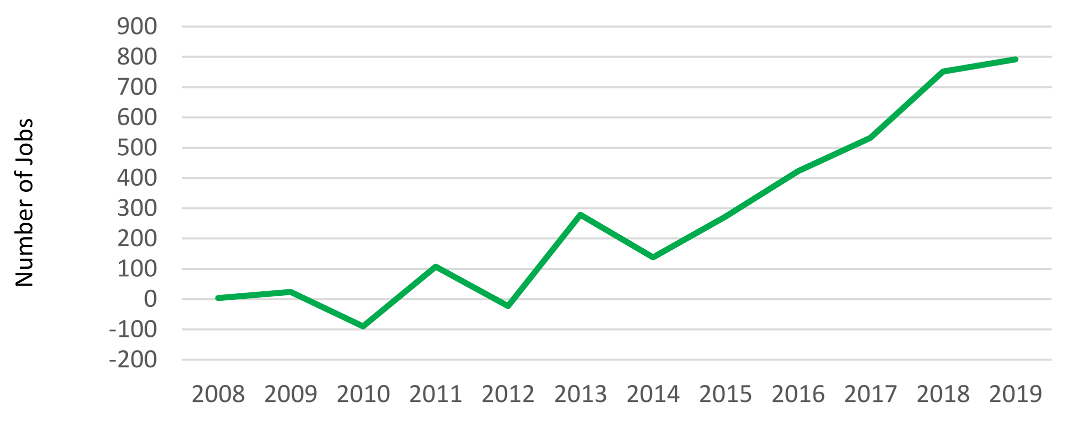


Figure 15: Net Impact of ITER Programme on Total Employment: 2008-2019

3.3. Impact of ITER: Future scenario

The outlook quantifies the impact of ITER on the European economy for the period 2020 until 2035. A set of assumptions are made in order to quantify the impact. These assumptions are consistent with IHS Markit's main economic outlook and industry outlook for the European Union. One of these assumptions include the recovery from the CoVID-19 pandemic that is assumed over the next couple of years and will deliver changes to the industry landscape. These effects are implicitly reflected in the results of the impact analysis.

Cumulatively, the incremental impact on gross value added is estimated at EUR 6,704 million for the future timeframe, while the cumulated impact on the number of jobs per year is estimated at 77,902 in 2020-2035 (see Figure 16 and Figure 17).

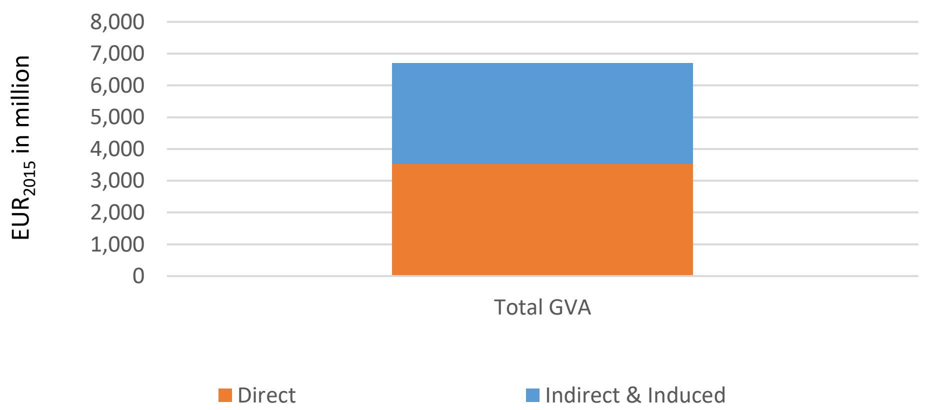


Figure 16: Cumulative Impact of ITER Programme on GVA by Impact: 2020-2035

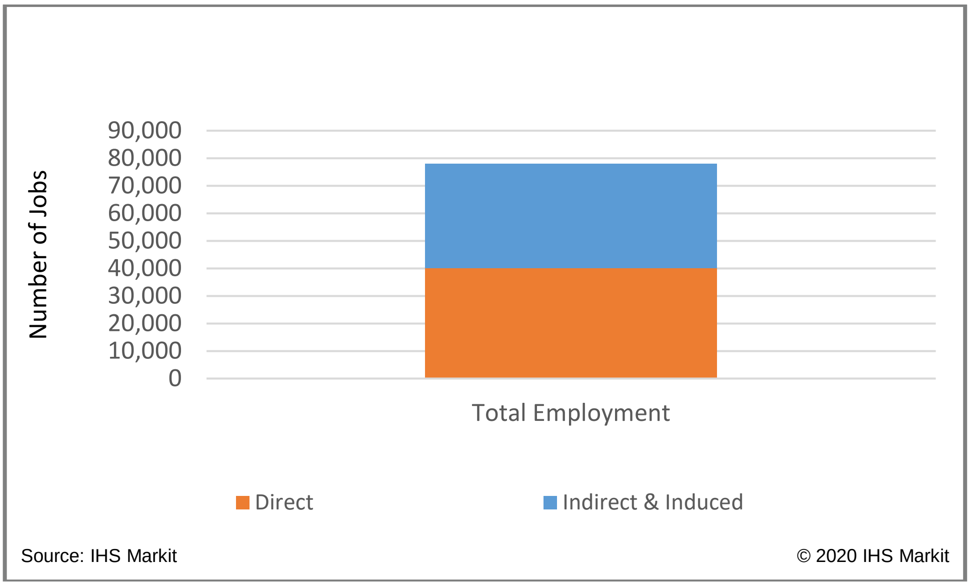


Figure 17: Cumulative Impact of ITER Programme on Employment by Impact: 2020-2035

The annual performance pattern of the incremental impact reveals a peak for the total impact in the year 2027, after which the actual impact starts a descend. Peaking at an incremental impact of EUR 511 million in terms of gross value added or 7,550 additional jobs in the entire economy in 2024, the total impact declines until 2035 to EUR 336 million in terms of incremental gross value added and 3,764 additional jobs. This is hardly surprising, though, since the incremental direct impact and the actual spending on ITER-related activities from F4E follows a similar pattern (see Figure 18 and Figure 19).

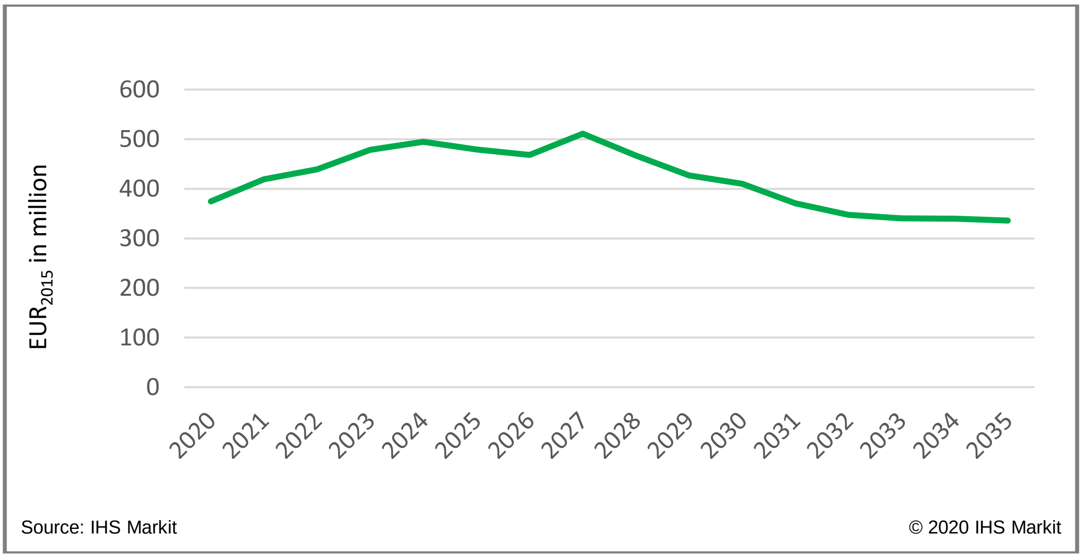


Figure 18: Impact of ITER Programme on Total GVA: 2020-2035

The impact multiplier for gross value added, which had increased to more than one in 2019, drops in 2020 to less than one (0.96) and stays close to that level until 2025 after which a slow descend takes the multiplier down to 0.81. The jobs multiplier follows a similar pattern for the 2020-2035 timeframe.

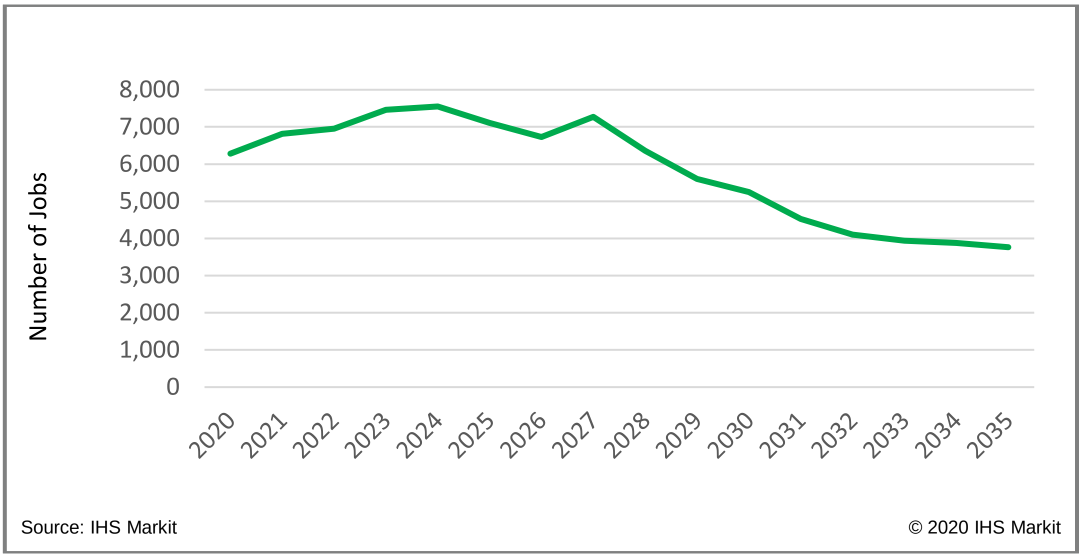


Figure 19: Impact of ITER Programme on Total Employment: 2020-2035

A breakdown of the multiplier by sector reveals that the multiplier for industry alone continued to rise, though. The ratio of indirect and induced effects on the one hand and direct effects on the industry value added on the other increased from 1.22 in 2020 to 2.35 in 2035.

Meanwhile the multiplier for industry jobs edged up from 1.09 in 2020 to 2.94 in 2035. This signals that, for every job created in direct relation to ITER's industrial activities, almost three more jobs are created in the supply chain of ITER and the wider industry of Europe's economy.

The overall decline of the total multiplier is caused exclusively by the services multiplier, which showed the steepest descend between 2020 and 2035 of all four sectors covered. The multiplier for construction, in contrast, showed a slowly ascending trend.

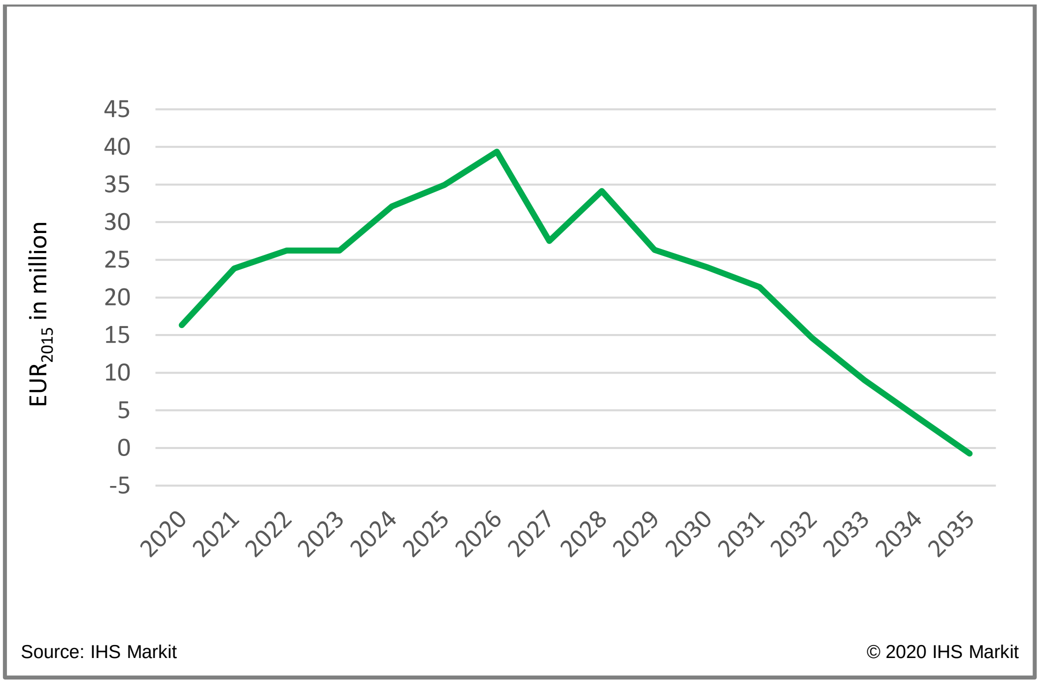


Figure 19: Net Impact of ITER Programme on Total GVA: 2020-2035

The estimated net impact results – the difference of the economic effects between a scenario with ITER and a scenario where ITER funds are channelled toward other sectoral spending not related to ITER – presents a similar pattern over the forecast period 2020 to 2035. The positive economic impact grows further but eventually peaks in 2026 at EUR 39 million and declines further out. By the end of the time horizon, in 2035, the impact of the ITER and non-ITER scenarios are almost exactly balanced (see Figure 19).

The cumulated total economic impact over the entire period 2020 to 2035 is estimated at EUR 332 million. Indirect and induced effects dominate again, while both second-order effects are in declining mode after hitting a peak in 2026.

A breakdown according to sectors reveals that the largest sectoral impact – on services – reaches a plateau around the middle of the current decade before trending down again. Net impact of the industry sector and the construction sector, though, move in the other direction. Both sectoral impacts improve in an annual perspective, which suggests an increasing weight of industry and construction spending on ITER among diminishing overall funds from the ITER project consortium toward the end of the forecast horizon (see Figure 20).

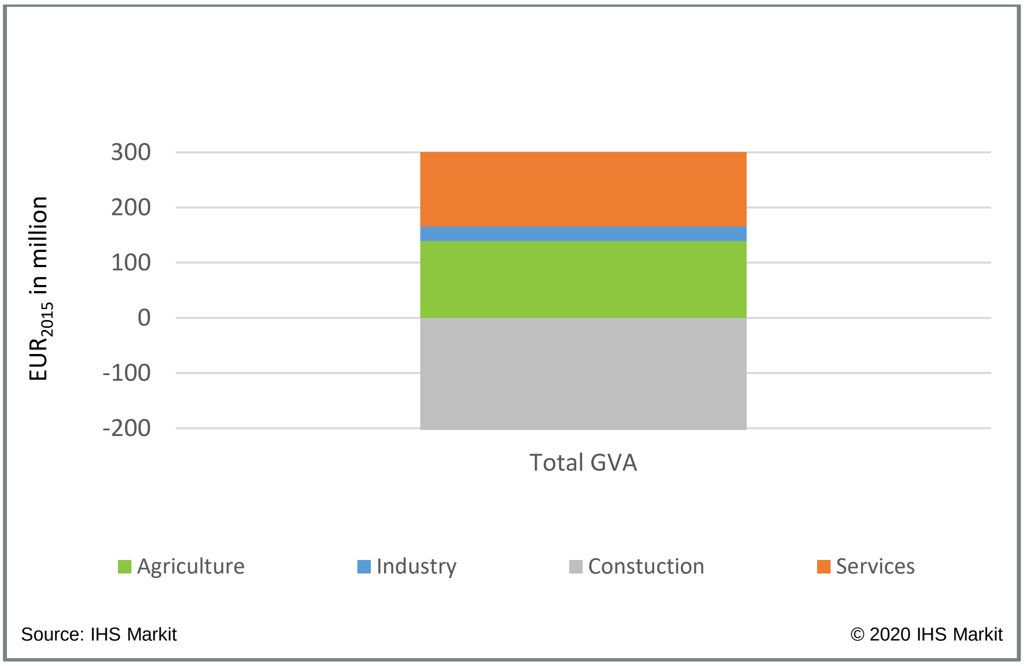
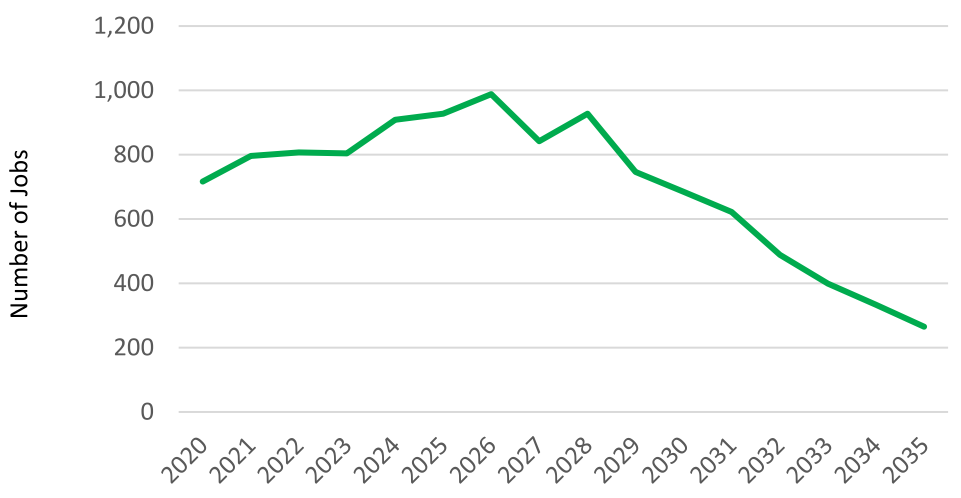


Figure 20: Cumulative Net Impact of ITER Programme on GVA by Sectors: 2020-2035

The net impact of ITER on the number of jobs is different from the corresponding results for gross value added insofar as the estimated number of jobs stays positive throughout the end of the forecast horizon in 2035. A declining trend is observed nonetheless from the end of the current decade onward.

The number of jobs per year peaks at 988 in 2026 on a net basis (see: Figure 21). This suggests that almost 1,000 jobs have been created in a future scenario that includes ITER versus a scenario that does not include ITER but is spending related funds elsewhere on the economy of the ITER member states.



Source: IHS Markit

Figure 21: Net Impact of ITER Programme on Total Employment: 2020-2035

4. Wider impact of ITER

Big science projects have a far wider impact than just their research mission. For instance:

- a researcher invented the World Wide Web (WWW) while working in CERN;
- a team of radio astronomers paved the way for today's wireless internet (WiFi) technology while developing a by-product in a research project, "a failed experiment to detect exploding mini black holes the size of an atomic particle[19]".

There is an impressive appetite to innovate, succeed and deliver high quality service and products by Euratom through F4E contracting activates to ITER. Contracts awarded to European companies are helping them gain new competences and know-how which are enhancing competitiveness and business growth, not only in fusion domain but also in various applications through spill-over effects.

ITER will transfer knowledge and technology to the industry through different means. Some of which would market game-changing technologies as new products and services with high economic impact for society:

- **Spin-offs:** ITER has made unprecedented technologies available to entrepreneurs, nurturing them to develop a wide range of new products and services resulting in further economic benefits through qualified jobs and revenue generated;
- **Outflow of highly skilled staff:** ITER has introduced highly educated employees into the private sector where they can switch various enterprises and allow them to contribute to the absorption of the knowledge by another industry or their related domain;
- **Amelioration in competition and organisational framework:** ITER promotes economy-strengthening collaboration with international partners, domestic companies, academia, and foreign agencies which constantly emerge new ideas and intensify the competition while creating high societal impacts.

In this regard, it is of note that the present study has identified a number of case studies which qualitatively illustrate the diversity of positive impacts of the ITER activities in the EU.

4.1. ITER spurs innovation and business growth

The fusion technology is still far from commercialisation; thus, fusion related contracts in private industry are limited. However, ITER procures multiple pathways to commercialize its technological development. While many industrialists have made its innovative products and services available to other domains, some entrepreneurs have generated spin-offs to further develop and differentiate new products.

Many of them have developed a comprehensive portfolio of various technologies that it now provides to domestic and international clients from public and private sectors. Superconducting electromagnets are one of the most notable examples which have advanced the state of the art in other than fusion fields such as medical diagnostics, semiconductors, electronics, and defence applications.

[19] https://sites.google.com/site/relyonwifi/history-of-wifi

4.1.1. Case study N°1: ASG Superconductors

Confining and suspending the ITER's plasma soaring to between 150 and 300 million °C requires the world's most sophisticated superconducting magnet system, a system more complex than anything that exists today. In order to achieve this mission, F4E awarded ASG Superconductors contracts to deliver ITER toroidal field coils and the poloidal field coils because of the Italian company's experience with the design and production of superconductive and resistive magnetic system in work performed for CERN.

Succeeding the work performed for ITER, ASG Superconductors could secure a significant international contract in 2016 which was awarded by South Korean Gachon University Gil Medical Center. The objective of the project is to develop a powerful and experimental 11.7-tesla magnetic resonance imaging (MRI) magnet, whose plane resolution is far better than existing equipment, to diagnose brain diseases. The same technology which has been developed during the construction of ITER is now expected to treat humans and to produce new findings about brain disorders, such as Parkinson's disease and Alzheimer's.

In times of global crisis as of today, the industry benefits from existing knowledge. In this regard, technology transfer from ITER activities boosts European economic development. The more spin-offs are created, the more probable the economic crisis can be tackled.

There is currently no study which has advanced to gather data showing revenues generated from ITER's spin-offs. Given the schedule of ITER, there is also a commercialisation lag that would allow sales revenues that will occur in the future. However, it is widely expected that ITER is likely to continue commercialising new innovative products, services, and processes in the future while many of these spin-offs create new jobs and revenues.

4.1.2. Case study N°2: MAGICS Instruments

Standard digital circuits cannot operate reliably in environments with high levels of ionizing radiation. MAGICS Instruments[20] (MAGICS) was entrusted by F4E to develop electronic chips for remote handling robotics which can be sustainable under the ITER's harsh radioactive environment. After the license of this technology enabled the design of these chips, MAGICS became the only commercial company in the world that offers semiconductor chips which survive accumulated radiation doses 1000 times higher than any other commercially available electronic devices.

While this starting point has evolved to a bigger mission since 2015, MAGICS increased its revenues to nearly EUR 1.5 million in 2019 and EUR 3 million (expected) in 2020. Having started with the two founders, the company aims to reach twenty-two employees by the end of 2020.

The company's core mission is to develop platforms for reliable machines that support mankind in creating a sustainable future by creating access to new resources such as energy and key materials. The company achieves this goal by leveraging MAGICS' expertise in semiconductor chip design, machine learning, and radiation-hardening. Apart from the ITER contracts, the company obtained the first contracts related to harsh environment and critical applications from European Space Agency in 2018.

Moreover, the company created a new business line, Intelligent Sensing, by selling smart and scalable sensing solutions and creating unique selling propositions by combining their expertise in machine learning and chip design. This led to smart microphone platforms that translate what machines or productions lines need in order to maintain operations. It has the potential to grow to a whole ecosystem, allowing to

[20] a spin-off company created by two researchers from KU Leuven and SCK•CEN (the Belgium Nuclear Research Centre) which started its activities in 2015.

build machine-knowledge of employees in models. While exploring business cases with this platform, MAGICS is developing a chip that will allow further differentiation by enabling local self-learning, low power anomaly detection, and enabling sensors nodes that consume at least 10 times less power than the competition.

In 2020, an opportunity was landed to start a development trajectory for machine learning-based smart sensors. Working with a unique Belgian consortium, the project aims at producing food on Mars through underground ecosystems. MAGICS role is to develop a Nanodrone that can detect blossoms and fly autonomous from flower to flower to make production of fruits possible. This opportunity created a way for an intelligent vision chip where algorithms can run efficiently to detect certain objects in its environments. This final item allows MAGICS to provide a platform for reliable, autonomous operation of machines (motion control, ears and eyes for diagnosis) in the long term.

4.2. ITER promotes collaboration

Engaging research institutions, large industrial companies and SMEs is an important component of the ITER's positive impact in the EU. Collaboration on new technologies has allowed many SMEs forming new consortiums to bid for new contracts. This competition has further multiplied the synergies and networking activities.

Many of the developments for ITER have been made in collaboration with other European industries either through consortia or through the supplier chain, showing that the effort for fusion is really framed inside a wide European dimension.

The subcontracting activities between larger- and smaller-scale industries lead newly established firms to access more resources. This relationship does not only contribute to enhance their reputation and recognition in the market, but also to allow them to innovate in the area of product and services. Consequently, this translates into better economic performance of SMEs.

4.2.1. Case study N°3: ASE Optics

ASE Optics[21] is a good example showing how a micro SME can access ITER contracts.

Despite the size of the company, ASE Optics secured a subcontract for the design, mock-up and testing of an in-vessel viewing and metrology system in 2015. Since then, the company has quadrupled the number of employees to 8 while it has increased its technical capabilities in the medical and the aerospace industry as well as its turnover. On the one hand, participating in such a big science project enabled greater visibility and helped the company win contracts outside of nuclear fusion.

Moreover, the company has become familiar with the complex procurement procedures because of ITER's complicated specifications. Through the collaboration with F4E, ASE Optics has perfect confidence in its ability to overcome a range of barriers in accessing procurement opportunities and in winning contracts.

With its expertise in opto-mechanical engineering, ASE Optics continues to enhance its technical ability to develop new projects and make key design recommendations that should offset some major technical risks in custom optical design and development services.

[21] ASE Optics develops custom optoelectronic and optomechanical systems, precision optics, and prototypes, and provides optical engineering support for companies and research facilities.

While ITER-awarded contracts lead SMEs to obtain advanced corporate vision and increased awareness of its ability to compete with other corporates, larger companies working on the project positively change the way of thinking and commercial development aspects. For instance, Ferrovial[22], as a part of the major consortium of ITER, has adapted its quality processes to design and construct facilities which are in classification of nuclear grade.

4.2.2. Case study N°4: Ferrovial

ITER is a unique research project in every aspect and its construction is nevertheless subject to stringent French nuclear regulations. Every parameter is recalculated, reverified, questioned and restarted. This is why Ferrovial used all sorts of toolsearly on to monitor, control, and manage each detail and change that could have an impact on nuclear safety.

As a first nuclear project, the work that Ferrovial has been performing for ITER represents one of the most exciting challenges engaging the company’s knowledge and focus on quality assurances, processes, safety and the environment. ITER as a project whose technical prescriptions were not defined in advance led the Spanish company to innovate its managerial and organisational procedures and systems to ensure quality standards on nuclear projects.

4.3. ITER improves organizational management and business development

Obtaining contracts not only stipulates competence and skills in nuclear and ITER specific design requirements, but also knowledge in industrial codes, standards and F4E’s conditions, obliges companies to acquire different management procedures and adopt critical decision-making models.

ITER initiates those businesses to become part of such an intense and complex project which requires a very structured process of pre-qualification of suppliers and subcontractors as well as a lot of qualifications and documentation to be supplied.

4.3.1. Case study N°5: Cosylab

Since 2008, Cosylab[23] has been ITER’s trusted partner for substantial and continued delivery of ITER’s basic control programme, CODAC Core System, (Control, Data Access and Communication) which organically grows the company’s expertise in control-systems technology for complex physics machines. Cosylab’s specialised knowledge in integrating the right software into specialised devices, like ANKA and similar projects, came in handy when ITER constructions began. And it formed the groundwork for further developing ITER’s system. Today, the Slovenian company continues to support regular updates of CODAC and carries out training and support for ITER developers.

Although the company was rich in innovation and quick in learning technical expertise from its beginning, it did lack the organisational aspects and the procedural prowess of a larger specialised company. It is the Cosylab's belief that had it not collaborated with ITER in its formative years, its growth would have been significantly slower, with its annual revenue and added value being at most half of what it is now. This is because

[22] One of the world’s largest infrastructure and city operators which employs 70,000 people and operates in over 15 countries.

[23] a spin-off from EUROfusion’s Slovenian Research Unit, began its journey in 2001 after successfully implementing a very complex bespoke control system for ANKA - German national synchrotron light source at the Karlsruhe Institute of Technology. The company employs 217 people and has more than a hundred customers across – Europe, the United States and China. The group has a consolidated annual revenue of EUR 17 million.

the company gained critical management and processes skills in its early stage while working on demanding contracts for ITER, gaining essential confidence and practices for accomplishing work on other complex projects in science, medical and high-tech sectors.

Working for ITER helped Cosylab understand the community, the market, the physics, the development cycle and the specifications of large physics facilities. Since Cosylab realised that it was not so different working to provide engineering for a proton-therapy machine than for a tokamak, the company has become one of the global market-leaders in systems engineering for big science, radiotherapy machines and medical products and devices.

The company's knowledge of how to systematically prove in a documented manner that a machine, device or subsystem works safely and effectively, as required by standards and regulations, was useful for developing medical solutions. The company has branched out into delivering medical products for radiation therapy that include accelerator and treatment control systems and dose delivery systems. Cosylab is now looking forward towards new frontiers such as healthcare solutions, med-tech devices, space applications and supporting high-tech innovations of start-ups in concordance with regulatory frameworks.

4.4. ITER invests in skills, training and education

While ITER has allowed more than a hundred future scientists to study for master's and PhDs in various fields, it indirectly gives many companies the unique opportunity to generate and build on the competence and talent that this kind of project requires. The ground-breaking engineering skills which have been delivered by ITER have been transferred to major projects across the EU.

4.4.1. Case study N°6: IDOM NS

Along with its partners, IDOM NS has secured a range of F4E contracts totalling EUR 58 million since 2008. While these contracts resulted in new international partnerships and a boost to the company's reputation, twenty-five new-highly skilled jobs were created since these contracts were performed. Of this number, seven PhD students attracted by the ITER project have joined IDOM because of IDOM's talent attraction programme. It is also essential to note that the company aims to recruit technicians at the end of their apprenticeships.

Currently, 22 IDOM NS employees are working on ITER site and 3 on-site in F4E premises to execute the F4E contracts.

4.5. ITER pushes the limit of science and technology

Meticulous engineering works took place in ITER site. The project not only yields advances in innovation but also leads companies to improve their infrastructure and capacity for different component manufacturing.

On the other hand, ITER is still in the construction phase which means that ITER has gradually created new technologies that would help advance other industries and big science projects. One of the examples of developing cutting-edge technologies that carried out for ITER is the manufacture of ultra-high precision measurement tools.

4.5.1. Case study N°7: Tekniker

Since technical parameters of ITER's procurement procedure is complex (or not defined in advance) as is its unprecedented nature, F4E in collaboration with Tekniker[24] successfully defined technical prescriptions for a non-existent metrology tool which was specifically developed for ITER. Within 18 months, the Spanish company was able to invent the high accuracy tool which is capable of measuring with a tolerance of 20-micron, or a measure25 times thinner than A4 paper.

Through this project, Tekniker improved its skills and knowledge in the development of high-precision mechatronic systems as well as the ability to customize solutions. Currently, the company applies its expertise in metrology solutions for ultra-precise measurements to non-nuclear energy projects such as particle accelerators, neutron sources, robots and telescopes used in aerospace industry. Tekniker will likely continue to push technological boundaries to make inspection tools faster and more accurate.

4.6. ITER paves the way for DEMO

ITER is the biggest scientific international initiation in the field of energy research, as it brings together seven partners which accounts for half of the world's population and 80% of global GDP[25]. It is both multinational and multi-disciplinary in technology.

Combined with technological constraints of clean and sustainable power generation through nuclear fusion, political challenges, such as delays in harnessing fusion power and cost overrun of the project, add a new level of complexity to the overall process.

While an amalgam of cultures, the intensity of the innovation, and collaborative efforts contribute to make ITER happen, DEMO will benefit from the use of both its construction and operation experience. Resolution of the technological, political and economic issues which exist for ITER will be achieved by DEMO. Though DEMO will be bigger in size than ITER, it will not be as costly.

Firstly, ITER's purpose is to deliver various experiments and research the possibilities to increase the Q[26] factor while DEMO aims to produce large amounts of electricity. In this regard, ITER has been designed in a way to study different plasma configurations making the device itself complex and complicated. As a research reactor, it will be equipped by a glut (and redundant) of safety sensors and I&C (diagnostic) devices to monitor and control reactions and un-postulated events.

Secondly, seven parties with more than 30 nations which are geographically located all around the World are obliged to contribute their expertise and components. Depending on their work share, some had to specially construct various facilities in which manufacturing of pioneering components takes place. Moreover, oversea freighting of these fragile components is both time consuming and expensive. Indeed, when examining contracts awarded by IO and F4E, the logistics sector and employing international experts (bringing them to France with families and sending back) accounts for a considerable amount of contracting value. Involving many oversea nations requires complex project management. In case of DEMO, only Europe will be involved in providing these components and most of aforementioned cost could be eliminated.

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[24] a private not-for-profit technological centre specialised in advanced manufacturing, surface and product engineering. The Spanish company focuses on developing intelligent robotic applications able to interpret the environment through multimodal sensors.

[25]https://fusionforenergy.europa.eu/downloads/mediacorner/publications/Highlights/Highlights_2016_light.pdf

[26] Ratio of « power out » to « power in ».

Europe has well developed the necessary manufacturing capabilities, especially for those challenging superconducting technologies. Having such capabilities would allow Europe to benefit from employing existing facilities and not having to build new ones.

Without a doubt, a lot will be learned from ITER implementation. Bottlenecks and opportunities will be identified during construction and operation of ITER and result in cost reduction in manufacturing of DEMO.

5. Conclusions

The impacts of ITER's investment in technologies and discoveries for the future ripple throughout the economy by supporting cutting-edge technologies in critical industries, creating new business and jobs, and attracting more students to science while laying the foundation for the commercial electricity generation from fusion energy.

ITER as a research reactor alone supports some thousand job opportunities and has already had a positive economic impact on the European economy.

It is widely acknowledged that the hefty investment in ITER does not only contribute to the economic growth in terms of GVA and employment but also contributes to the intellectual, human and industrial capital to indirectly harness the European industry and progress the European society.

Apart from the mere commercial benefits, construction of ITER presents a number of opportunities for businesses: entering new markets, developing new skills and stimulating innovation, transferring know-how and generating applications, building international collaboration and commercial partnerships, and setting a new benchmark for fusion technology.

Most of European companies have been encouraged to build international partnership collaborations. This translated into accessing to new markets and leads most SMEs to grow in size and expertise.

A substantial know-how and a number of special technologies have been created during the construction of ITER. This knowledge is transferred to other domains through a variety of channels including staff outflow, research and industrial networking, industrial partnerships, apprenticeships, training and overall education.

While ITER is the backbone of the fusion energy development, there should be analogous R&D programmes to solve technological issues unleashed by ITER. By exploiting the experiences delivered by ITER, R&D programmes might focus on achieving the competitiveness with other low-carbon energy sources.

Aiming at gridding fusion power in the second half of the century in Europe requires early engineering and design activities of DEMO even before ITER completes its high-performance activities. While some outcomes delivered and lessons learnt from ITER experiments are mandatory to advance the design of DEMO, others can be obtained at earlier phases which could sustain the fusion industry.

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[5] Department of Economic and Social Affairs, "International Standard Industrial Classification of All Economic Activities Revision 4," United Nations, New York , 2008.

Annex A - NACE and ISIC Table

Basic type	NACE Sector	Description	ISIC Code used in model	ISIC Description
Primary production	A01	Crops, animals, etc	01T03	Agriculture, Hunting, Forestry And Fishing
Primary production	A02	Forestry & logging	01T03	Agriculture, Hunting, Forestry And Fishing
Primary production	A03	Fishing	01T03	Agriculture, Hunting, Forestry And Fishing
Primary production	B05	Coal	05T06	Mining And Quarrying Of Energy Producing Materials
Primary production	B06	Oil and Gas	05T06	Mining And Quarrying Of Energy Producing Materials
Primary production	B07-09	Other mining	07T09	Mining And Quarrying Except Energy Producing Materials
Manufacturing	C10	Food	10	Food Products
Manufacturing	C11	Drink	11	Beverages
Manufacturing	C12	Tobacco	12	Tobacco Products
Manufacturing	C13	Textiles & leather	13	Textiles
Manufacturing	C14	Wearing	14	Wearing Apparel
Manufacturing	C15	Leather	15	Leather And Related Products
Manufacturing	C16	Wood & wood prods	16	Wood And Products Of Wood And Cork, Except Furniture
Manufacturing	C17	Paper & paper prods	17	Paper And Paper Products
Manufacturing	C18	Printing & reproduction	18	Printing And Reproduction Of Recorded Media
Manufacturing	C19	Coke & ref petroleum	19	Coke And Refined Petroleum Products
Manufacturing	C20	Other chemicals	20	Chemicals And Chemical Products
Manufacturing	C21	Pharmaceuticals	21	Pharmaceutical Products And Pharmaceutical Preparations
Manufacturing	C22	Rubber & plastic products	22	Rubber And Plastics Products
Manufacturing	C23	Non-metallic mineral prods	23	Other Non-Metallic Mineral Products
Manufacturing	C24	Basic metals	241A2431	Iron And Steel
Manufacturing			242A2432	Non-Ferrous Metals
Manufacturing	C25	Fabricated metal prods	25	Fabricated Metal Products, Except Machinery And Equipment
Manufacturing	C26	Computers etc	26	Computer, Electronic And Optical Products
Manufacturing	C27	Electrical equipment	27	Electrical Equipment
Manufacturing	C28	Other machinery/equipment	28	Machinery And Equipment N.E.C. Not Elsewhere Classified
Manufacturing	C29	Motor vehicles	29	Motor Vehicles, Trailers And Semi-Trailers
Manufacturing	C30	Other transport equipment	301	Building Of Ships And Boats
Manufacturing			303	Air And Spacecraft And Related Machinery
Manufacturing	C31-32	Furniture; other manufacture	31T32	Furniture, Other Manufacturing
Manufacturing	C33	Machinery repair/installation	33	Repair And Installation Of Machinery And Equipment
Energy & Utilities	D351	Electricity	35	Electricity, Gas, Steam And Air Conditioning Supply
Energy & Utilities	D352-353	Gas, steam & air cond.	35	Electricity, Gas, Steam And Air Conditioning Supply
Energy & Utilities	E36	Water, treatment & supply	36	Water Collection, Treatment And Supply

Energy & Utilities	E37-39	Sewerage & waste	37T39	Sewerage, Remediation Activities And Waste Management
Construction	F41-43	Construction	41T43	Construction
Services	G45	Wholesale & retail MV	45	Wholesale And Retail Trade And Repair Of Motor Vehicles And Motorcycles
Services	G46	Wholesale excl MV	46	Wholesale Trade, Except Of Motor Vehicles And Motorcycles
Services	G47	Retail excl MV	47	Retail Trade, Except Of Motor Vehicles And Motorcycles
Services	H49	Land transport, pipelines	49	Land Transport And Transport Via Pipelines
Services	H50	Water transport	50	Water Transport
Services	H51	Air transport	51	Air Transport
Services	H52	Warehousing	52	Warehousing And Support Activities For Transportation
Services	H53	Postal & courier activities	53	Postal And Courier Activities
Services	I55-56	Accommodation & food serv	55T56A79	Hotels And Restaurants And Travel Agency And Tours
Services	J58	Publishing activities	58	Publishing Activities
Services	J59-60	Motion pic, video, television	59T60	Audiovisual And Broadcasting Activities
Services	J61	Telecommunications	61	Telecommunications
Services	J62-63	Computer programming etc.	62T63	It And Other Information Services
Services	K64	Financial services	64	Financial Service Activities, Except Insurance And Pension Funding
Services	K65	Insurance	65	Insurance, Reinsurance And Pension Funding, Except Compulsory Social Security
Services	K66	Aux to financial services	66	Activities Auxiliary To Financial Service And Insurance Activities
Services	L681-682	Real estate	68	Real Estate
Services	L683	Imputed rents	68	Real Estate
Services	M69-70	Legal, account, consult	69T75	Professional, Scientific And Technical Activities
Services	M71	Architectural & engineering	69T75	Professional, Scientific And Technical Activities
Services	M72	R&D	69T75	Professional, Scientific And Technical Activities
Services	M73	Advertising	69T75	Professional, Scientific And Technical Activities
Services	M74-75	Other professional	69T75	Professional, Scientific And Technical Activities
Services	N77	Rental & leasing	77	Rental And Leasing Activities
Services	N78	Employment activities	78A80T82	Security, Buildings, Employment
Services	N79	Travel agency	78A80T82	Security, Buildings, Employment
Services	N80-82	Security & investigation, etc	78A80T82	Security, Buildings, Employment
Services	O84	Public admin & defence	OSTU	Public Administration And Defence; Compulsory Social Security
Services	P85	Education	85	Education
Services	Q86	Human health activities	86T88	Human Health And Social Work Activities
Services	Q87-88	Residential care	86T88	Human Health And Social Work Activities
Services	R90-92	Creative, arts, recreational	90T93	Arts, Entertainment And Recreation
Services	R93	Sports activities	90T93	Arts, Entertainment And Recreation
Services	S94	Membership orgs	94	Activities of membership organizations

Services	S95	Repair comp. & pers. goods	95	Repair of computers and personal and household goods
Services	S96	Other personal serv.	96	Other personal service activities
Services	T97	Hholds as employers	97	Activities of households as employers of domestic personnel
Services	T98	Unallocated/Dwellings	98	Undifferentiated goods- and services-producing activities of private households for own use
Services	U99	Extraterritorial orgs	99	Activities of extraterritorial organizations and bodies

Annex B – Matching economic activities

In the previous study, the in-kind contracts awarded by F4E were allocated to specific NACE codes by considering some matching assessments. During the matching exercise of newly collected data beyond 2017 obtained from F4E, some inaccurate economic activity selections in the previous dataset have been recognized. The following table indicates some concrete sampled errors.

Firstly, all payments lines, which are below EUR 500K, have been allocated on the basis of their WBS code and correspond to matching in the previous report. This is not an accurate approach as the WBS of the payment lines does not give their economic sector activity but provides a minimum basis to understand contract activity. For instance, in cases where the payment lines' WBS is related to "Vacuum Vessel" or "Magnet Section", the economic sector was assigned to "Other Machinery Equipment (C28)" or "Fabricated Metal products (C25)", respectively. Another example is that a contract's WBS is related to "radioactive waste" was assigned to the economic activity "Waste, treatment and supply (E36)". However, the contract is indeed pertinent to the consultancy services which should have been allocated to the "Architecture and Engineering services (M71)".

It should be noted that the total value of the payment lines which are below EUR 500K is nearly EUR 160 million. Therefore, the matching exercise for the payment lines which is based on the WBS description has led to erroneous selection of the sector. This could have resulted in unsound economic analysis of these payment lines since the economic model considers the sectoral classifications as a significant input.

Secondly, it is true that identifying some of the contracts' economic activity is not an easy task which sometimes requires some technical details of the contract other than "its name". Also, the previous study indicates that matching activity was validated by independent fusion experts who were part of the team. The judgement of fusion experts on the system and components are not exclusively crucial in order to decide the subdivided economic sectors for these payment lines. A sound knowledge about the definitions and content of each economic activity as well as how to analyse and use the classification structure of economic activities are also dire needs to allocate the relevant economic activities to the payment line. For instance, a payment line with a WBS of "Building and Infrastructure" was allocated to the economic sector of "Construction". However, the contract, the value of which is nearly EUR 30 million, is to design and manufacture a lifting equipment (a crane) which is used for construction. This should have been allocated to the economic sector of C28 (see the example in table).

In this report, the reference papers [4] and [5] about statistical classification of economic activities have been thoroughly examined in order to understand how the economic activities should be allocated.

Finally, it is worth to note that ITER is a scientific project in which disruptive technologies, components and advanced materials are being widely used. All these are translated from technical research and development programme in collaboration with industry, research institutes and universities. Moreover, some key components are manufactured as prototypes and mock-ups which are not industrialised or manufactured products. Therefore, some important activities in terms of economic value which were performed by research centres or by universities are allocated to the economic sector for "Professional, Scientific and Technical Activities (69T75)". In the previous study, these were allocated to sectors covering manufacture industrialized products.

Contract	Contractor	Country	Assigned sector by the previous contractor	Comment
OPE-058 ARCHITECT/ENGINEER	CONSORTIUM ENGAGE (ASSYSTEM FRANCE SAS, WS ATKINS INTERNATIONAL LTD, IOSIS INDUSTRIES, EMPRESARIOS	UK	F41-43	All other consortium members are assigned to A&E sector, but Atkins is assigned to Construction sector.
Various	BUREAU VERITAS	Various	Various	IF WP is in Vacuum Vessel, it is assigned to C28, if it is in Magnet section, it is assigned to C25. Bureau Veritas is an inspector company.
HCLL AND HCPB TBS MODELS DEVELOPMENT AND QUALIFICATION, EXECUTION OF THE FIRST SET OF ACCIDENT ANALYSES	AMEC FOSTER WHEELER NUCLEAR UK LIMI	UK	C23	An example of over EUR 1 million contract. Since the payment line is in the WP of "TBM and Materials Development Project Team", it is assigned to wrong sector. AMEC should be in A&E services.
PRELIMINARY DESIGN OF THE DRHS-PHASE 2_AMD1-DACC10491-AMD2-DACC10668	AMEC FOSTER WHEELER NUCLEAR UK LIMI	UK	C26	An example of over EUR 1 million contract. Since the payment line is in the WP of "Remote Handling Project Team", it is assigned to C26, electronic manufacturing sector. AMEC should be in A&E services.
Design, Certification, Manufacturing, Testing, Installation and Commissioning of a Tokamak Cargo Lift and Tokamak Assemble Hall Cranes And The Design And Construction of Associated Infrastructure on The ITER Facilities	NKM NOELL SPECIAL CRANES GMBH*NNCS	Germany	F41-43	Lifting equipment manufacture should be in sector C28. This is allocated to construction sector because the WBS is Building and infrastructure. The contract’s value is nearly EUR 30 Million.
POLICY N°740001934_GLOBAL INSURANCE_CONSTR.+ERECT. OF ITER DEVICE	ZURICH INSURANCE PUBLIC LIMITED COM	IRELAND	F41-43	In another payment line with the same contracts, the sector was correct. Selection the sector according to WBS is not good assessment; this mistake was probable due to that the corresponding WBS was related to Site, Buildings and Power Supplies Project team
Various	ASSYSTEM	France	Various	All payment lines of Assystem, a major company for ITER, are below EUR 300K is wrongly assigned.
Various	APAVE	France	Various	Same as Assystem, all payments lines below EUR 500K is wrong. There are many payment lines.
TRITIATED WATER HOLDING AND EMERGENCY TANKS OF THE WATER DETRITIATION SYSTEM	EQUIPOS NUCLEARES SA	SPAIN	C28	Both company and the contract refer to the sector of 25.
SUPPLY OF THE JT-60SA TF COILS PROTOTYPE DOUBLE PANCAKE FOR DEMO PURPOSES	ASG SUPERCONDUCTORS SPA	ITALY	M71	Example of a payment line lower than EUR 500K is wrongly assigned. ASG is a major Italian contributor to ITER. His contribution is in the field of electric equipment.
ANALYSIS OF TYPE-A RADWASTE PROCESSES	SERCO LTD*	UK	E37-39	Analysis of radioactive waste process is a consulting service, not an Energy and Utility service

BABCOCK NOELL_OPE-142_ENGINEERING STUDY OF COLD TEST AND COIL INSERT.PROCESS	BABCOCK NOELL GMBH	GERMANY	C25	Consultancy services should not be assigned to C25
preliminary activities in preparation of the preliminary design review	IDOM CONSULTING, ENGINEERING, ARCHI	SPAIN	C23	There are various payment lines for this company. It provides engineering and consulting services. Since the payment line is in the WP of "TBM and Materials Development Project Team", it is assigned to C23

Annex C – Analysis of the previous dataset

Each contribution used in the present study has been cross checked with those of the previous study. This section explains the investigated differences and estimates the underlying reasons for these variations.

The table below gives the summary data used in the previous study.

Current Euros (billions)	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Sub-total 2008-2017
F4E cash to IO	0.130	0.051	0.101	0.124	0.104	0.094	0.217	0.217	0.217	0.217	**1.471**
Of which:											
Construction	*0.130*	*0.051*	*0.101*	*0.124*	*0.104*	*0.094*	*0.217*	*0.217*	*0.217*	*0.217*	***1.471***
Operations	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	***0.000***
Upgrades& operational spares	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	***0.000***
Decommissioning/deactivation	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	***0.000***
F4E in kind	0.079	0.049	0.099	0.143	0.219	0.287	0.289	0.323	0.448	0.776	**2.711**
F4E admin	0.015	0.024	0.029	0.036	0.039	0.040	0.055	0.055	0.055	0.055	**0.402**
F4E other	0.004	0.017	0.009	0.009	0.003	0.011	0.011	0.011	0.011	0.011	**0.099**
Cash to Japan	0.006	0.018	0.009	0.010	0.204	0.080	0.006	0.006	0.006	0.006	**0.352**
EC project admin	0.008	0.008	0.008	0.008	0.008	0.008	0.010	0.010	0.010	0.010	**0.090**
Total	**0.242**	**0.167**	**0.255**	**0.330**	**0.577**	**0.520**	**0.589**	**0.623**	**0.748**	**1.075**	**5.125**

F4E cash to IO

It is believed that the data in the previous study originates from the estimated contributions in the EC reports given in the references. It is important to note that the precise data for each payment between 2007 and 2013 is not available in these reports. It is not known how the cash payments for each year in this period had been obtained in the table above. Compared the data given in the table above, the present study considered the realized cash payments by F4E. The amount paid for each year has been obtained from the corresponding report given in the reference. Only the value 2019 is the forecast obtained from the related F4E's report.

F4E in Kind

When analysed the datasheet prepared during the first study, in-kind payments yield to nearly EUR 2.245 billion as given below excerpted from the previous study.

Analysis of payments to mid-2017 (in-kind contributions only)

Based on data from F4E in kind payments totalled €2.245 billion in the period 2008-mid-2017 (€2.309 billion in 2017 values if deflators are applied). The following section analyses where this money was spent.

Firstly, this amount includes the contracts awarded to other States including contracts with Japan due to the BA agreement. The present study considered only those contracts awarded to the European contractors. This resulted in relatively less in-kind payments for each year except 2017. Secondly, F4E's contracting dataset in the previous study shows that in-kind payments in 2017 (partially or mid-2017) totalled nearly EUR 309 million. Since the scope of the previous study covers the payments up to mid-2017, it was assumed by the previous study that the same amount would be paid for the other half of the 2017. Therefore, in-kind payments in 2017 had been estimated as EUR 776 million (multiplied by 2 and then deflators were applied) as shown in the table above. The present dataset provided by F4E unveils that in-kind payments totalled EUR 551 million in 2017.

F4E admin

There is a slight difference between the two study's input which can be neglected. The present study considered the realized payments. Additionally, the spending in the present study is not only allocated to the economic sector for Public Administration but also to other economic sectors as this appropriation also covers building, equipment and miscellaneous expenditures.

F4E others

This appropriation includes “TBM, DEMO, DONES, JT60-SA operation, cash to Japan and other minor horizontal activities”. It is believed that these payments have already been accounted in F4E’s contracting dataset. It is therefore probable that some payments in the previous study were repeated under different category i.e. “F4E in-kind payments”, “Cash to Japan”, “F4E others”.
Payments for “F4E others” has not been shown in Table 1 in the present study. Spending nearly EUR 26.7 million has already been accounted for the Broader Approach which is included in the dataset of in-kind payments provided by F4E: For those paid to Japan have been disregarded. Others which remained in the EU has been considered under the “F4E in-kind contribution” (section 2.2).

Cash to Japan

Same as above. Data for “Cash to Japan” is given in the F4E dataset. In this study, cash payments to Japan have been removed from the present dataset.

EC Project admin

Both studies consider the same payments.

Annex D: Global Link Macro Industry Model

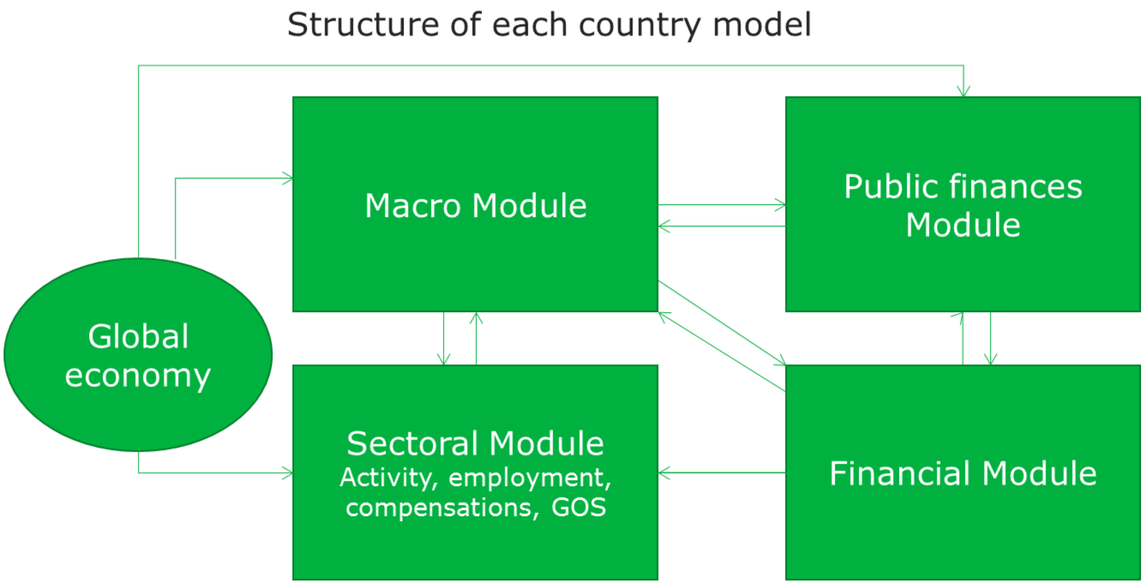
The Global Link Macro Industry Model (GLM-IM) is designed to quantify the impacts of a large range of shocks on the macroeconomy and on industries. It covers all current EU member states, the US, Canada, Mexico, Australia, New Zealand and the largest non-EU economies in Latin America, Middle East, Asia and Europe in full sectoral detail.

The GLM-IM integrates the original macroeconomic Global Link Model (GLM) with an industry module fully consistent with the IHS Markit's proprietary Comparative Industry Service (CIS) framework. The combined GLM-IM model is a quarterly frequency model covering 68 countries representing 96% of the world GDP, plus several regional aggregates. The model makes it possible to provide the impact of changes on multiple dimensions in a fully consistent way, across sectors and regions. Its quarterly frequency makes it possible to assess not only the magnitude of shocks but also the time that it takes for these to diffuse through the economy.

The GLM-IM is organised in country models. Each country model comprises four modules, fully linked to the rest of the world. These four modules describe:

- In the **macro module** – the trends in GDP and final demand components, nominal and real, along with all prices and deflators, potential output, employment and labour market, trade and balance of payments flows and stocks, and exchange rates;
- In the **public finances module** – the different constituents of public sector revenue and expenditures, along with the relevant tax rates, public sector debt and the servicing of the debt;
- In the **financial module** – all variables relating to monetary policy, along with detailed flows of funds for all the major economies, in order to see how changes in credit conditions or unconventional monetary policy impacts the economy;
- In the **sectoral module**[27], covering 57 industrial and service sectors as given in XXX, the trends in production, value added, prices, exports, imports, employment, compensations, capital expenditures (CAPEX), operating expenditures (OPEX) as well as gross operating surplus for each industry.

[27] The sectoral module is a complete re-design and enhancement of the former, annual-frequency, Comparative Industry Service model. The enhancements include the shift to the quarterly frequency to better track business cycles; the shift to ISIC-Rev 4 data; and, expanded – both top-down and bottom-up – linkages between the macro economy and the sectoral modules designed to broaden the range of simulation possibilities.



Structure of a country model in the GLM-IM

The sectoral performance naturally impacts the macro-economy, since the sum of sectoral value added at factor cost evolves in line with real GDP at market prices. Indeed, GDP at factor cost is equal to total value added at basic prices, itself equal to real GDP at market prices minus indirect taxes, trade and transport costs, plus subsidies.

The model can be used both in "top-down" and in "bottom-up" simulation exercises. The consistency between national accounts on the expenditure and production side is ensured in both top-down and bottom-up simulations. In top-down simulations, the changes in final demand components filter through the model to impact all sectors, leading to consistent changes across both the macro and sector parts of the economy.

In bottom-up scenarios, the changes in sectoral value added is carried into the macro model through changes in final demand components, via an allocation of the sectoral value added which were modified to the final demand components that each sector traditionally serves: for example, a fall in value added in the food industry will filter through to real GDP via household consumption and exports, since the food sector mainly services domestic consumption and export markets. If the change occurs at the level of production or output – for example a fall in those variables – they will filter through all sectors in the economy to eventually alter value added in all sectors, but also imports.

The changes in value added are similarly carried through to final demand components, pro-rata to which demand component the sector typically serves. Imports at macro level are then defined based on sectoral imports. Hence, if final demand did not change, the fall in production would trigger an increase in imports.

Activity by sector also drives employment by sector, which sums up to total employment. A convergence rule is applied to ensure that macro employment and total sectoral employment evolve in a consistent way, so that a change in sector employment will impact total (macro) employment, hence incomes, unemployment rates, labour costs etc. Finally, the gross operating surplus derived at sectoral level influences the economy's ability to invest, creating another bottom-up link to the macro-economy via total fixed investment. The top-down, macro/sectoral approach makes it possible to quantify the impacts of change originating in the macro-economy – such as fiscal and monetary policy changes, or changes in the pattern of growth or in the rate of development of certain countries - onto industries and service sectors in all countries. The bottom-up approach consists in analysing the impact at macroeconomic level of shocks originating at the sectoral level, such as disruptions to the value chain, specific regulations, public investment schemes for specific sectors. The bottom-up approach will be mainly used for the purpose of this study. GLM-IM is based on econometric estimations over the longest possible time horizon (which varies across countries), using ECM (error-correction model) specifications in order to capture both short term trends and cycles, and structural, longer term relationships between variables. The forecast horizon of the GLM-IM currently is 2050.

Approach for the use of model in the present study

The use of the GLM-IM will have several benefits for the estimation of the economic impact of ITER. Specifically, we are able to quantify the economic impact not only for one year – as would be the case if we worked with an Input Output (I/O) model – but over time and ensure that the economic effects of an investment into ITER are quantified in a dynamic way over several years.

The economic benefits can be categorized in direct, indirect and induced impacts:

- **The direct impact** is the immediate benefit that the installation and development of ITER brings for the development of the industry in question. That benefit will be quantified as a larger use of resources to produce a larger amount of output. That increase – in terms of gross value added, output, jobs and tax revenues – can be expressed in operational expenditures which is the direct impact or benefit of ITER in the respective industry.
- **Indirect impact:** The change in purchasing activities of an industry and immediate impact on their supplier industries is expressed as indirect effects on output, employment, and income that are attributable to those sectors, their suppliers, and suppliers' inter-industry linkages. The incremental increase of supplies is called the indirect impact of ITER.
- **Induced impact:** Finally, because workers and their families in both the direct and indirect industries spend their income on food, housing, autos, household appliances, furniture, clothing, and other consumer items, additional output, employment, and income effects are part of the expenditure-induced impact.

The use of an Input-Output table, which captures all inter-industry linkages of an economy, allows to quantify these direct and indirect impacts. The GLM-IM model uses input-output tables for the breakdown of all 27 EU economies plus UK into 57 industry sectors.

The quantification of the economic impact will include specifically:

- **Jobs:** The number of new jobs generated due to the installation and development of the ITER fusion reactor and the Broader Approach with the nuclear fusion cooperation with Japan. The breakdown of skill demand on the labour market will be available according to the industry breakdown of the GLM-IM (see sector breakdown above) and include a breakdown into lower skill-sector like construction and services as well as potentially higher skill sectors in the manufacturing, engineering and research areas.
- **Employment history and outlook:** The GLM-IM allows to quantify the number of jobs as a result of ITER activities for the historical periods 2008 to 2017 and 2019, respectively. Moreover, we are able to quantify the impact of ITER and BA activities for the near, medium- and long-term future. The time horizon of the GLM-IM currently is 2049.
- **Gross value added:** Similar to the quantification of jobs, we will estimate the incremental gross value added that occurs as activities for ITER take place in the European Union and its member states.
- **Counterfactual analysis:** Since the GLM-IM has been conceptualized as a scenario model, we are able to quantify the impact of what happened if ITER were abandoned as of now, or at any time in history or future within the model's time horizon. We will provide a forecast based on the assumption that ITER was abandoned.

Annex E: Comparison with the previous study

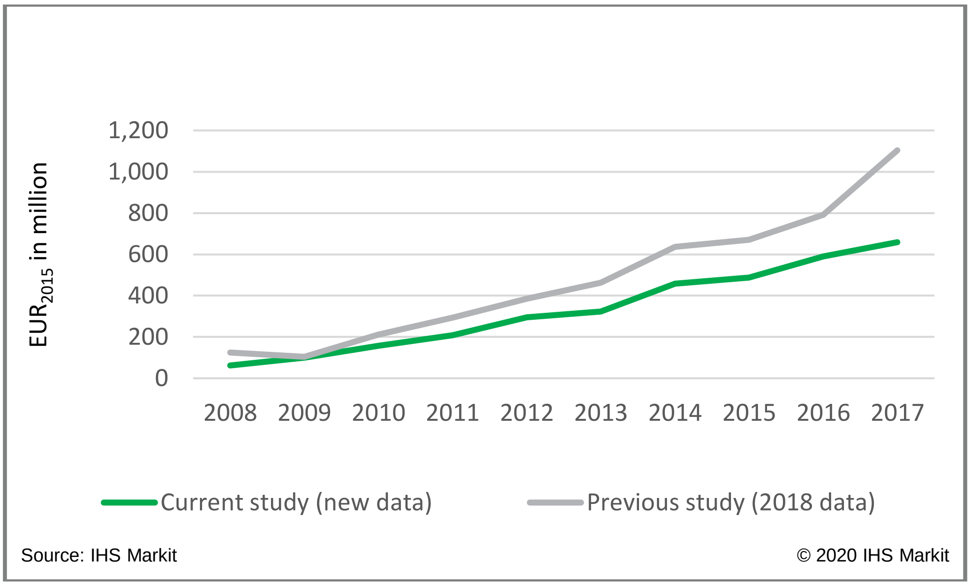
It has been important for the European Commission to validate the results of the previous study published in 2018 and compare it with the current study's results. LGI and IHS Markit have thus been assigned with two tasks in this respect.

First, to compare the results of the previous study with the results of the current study. Second, to re-create the database of the previous study to the extent possible, run that database with the IHS Markit model, and compare the results with the estimates obtained from the new database and the IHS Markit model (ie this study's main results).

The comparison between the results on the total economic impact of the ITER project published in the previous study and compared the results present in this study yields significant differences for both gross output and the number of jobs.

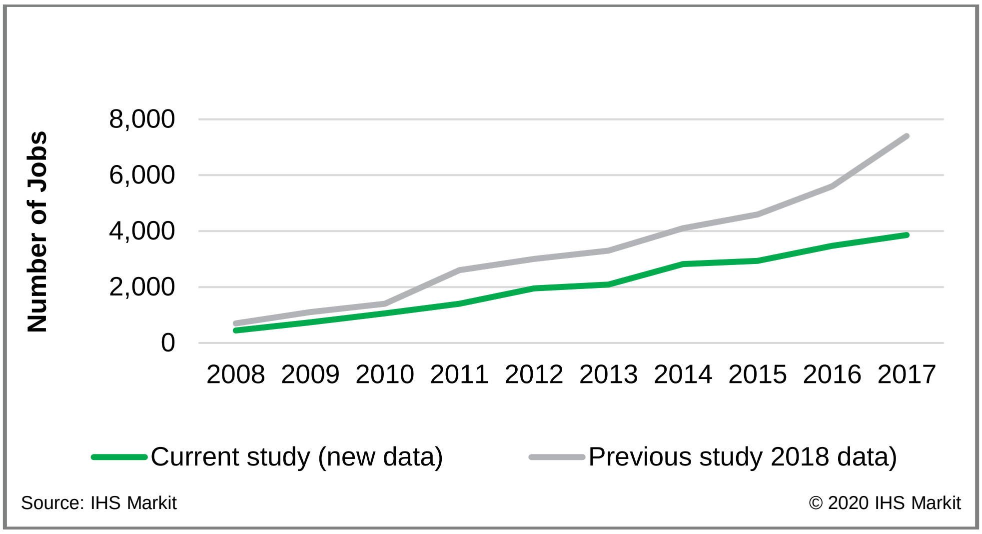
We chose gross output over gross value added to display the differences of the two studies. Gross value added is part of gross output, the main difference between the two metrics is that gross output implicitly includes intermediate consumption (eg supplies to produce a product), whereas that metric is explicitly subtracted in gross value added.

The results of the two studies are displayed in Annex E - Figure 22. With the exception of 2009, when the estimates from the previous study are only 5% higher compared to the current study, the results from the previous study are approximately 40% above the results of this study on average. The year 2017 is an exception again as the results are 68% higher compared to the current study.



Annex E - Figure 22: Impact of ITER Programme on Gross Output: Result from Current vs. Previous Study

A similar pattern is apparent when comparing the results for employment (Annex E - Figure 23). Again, the number of jobs is higher by approximately 60% on average. The difference for the year 2017 is once again particular large (91%).



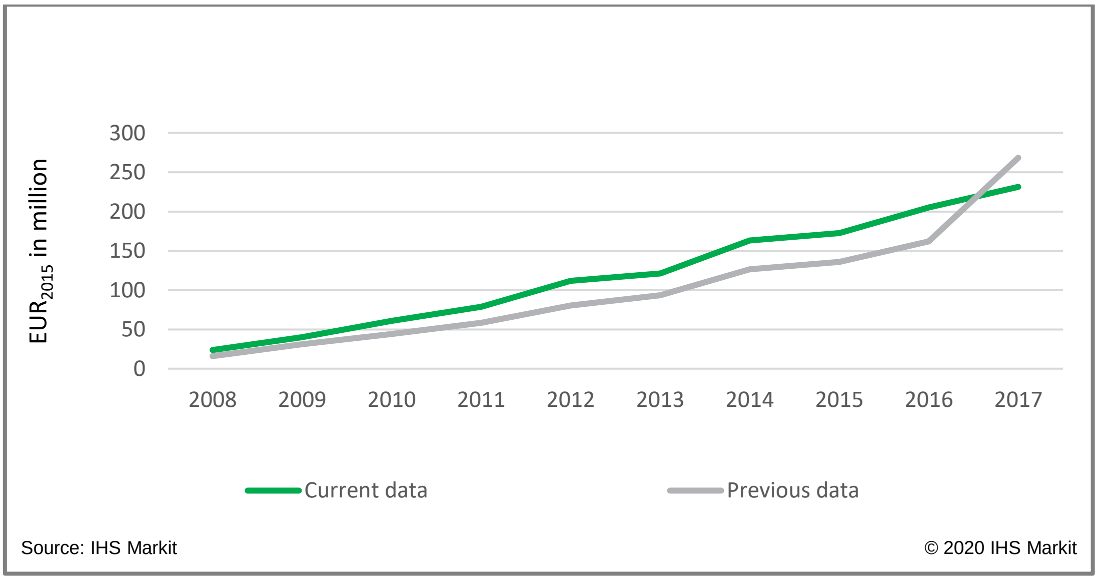
Annex E - Figure 23: Impact of ITER Programme on Employment: Result from Current vs. Previous Study

We think the differences can be explained. The previous study had access only to data from F4E but relied on own estimates for the expenses from IO. The new study benefitted from access to both data from F4E and IO and was thus able to deliver a more accurate assessment of the economic impact of ITER.

The previous study also had to rely on own estimates for the second half of 2017 for nearly all expenses. The actual spending results were overestimated, as our analysis shows.

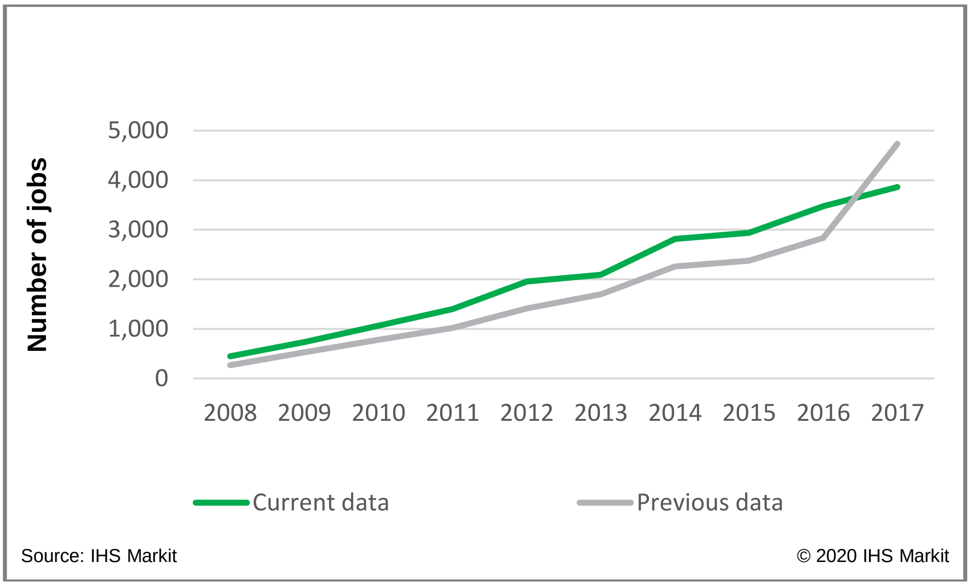
Finally, the previous report might have considered the entire value of voluntary contributions for the impact analysis. The current study only included expenses related to voluntary contributions if these related to contracts executed in the European Union.

The second task illustrates this explanation. We ran the model of the current study with the data compiled by the previous study and again compared the results with the current study’s main results. The results are shown in Annex E - Figure 245.



Annex E - Figure 245: Impact on Total GVA Estimated by LGI/IHS Markit Model - Current and Previous Dataset Compared: 2008-2017

In each year, the impact is higher when using the current data with the current model, while the estimate from our model using the previous study's dataset is lower. Only in 2017, when the previous dataset had to rely on estimates for the second half of the year, the economic impact is higher. This holds for both GVA (Figure 25) and employment (Figure 26).



Annex E - Figure 256: Impact on Total GVA Estimated by LGI/IHS Markit Model - Current and Previous Dataset Compared: 2008-2017

The differences between both results might be explained by different assignments of contract values to individual sectors. Moreover, a different country allocation of the ITER-related expenses might also have played a role. The country and sector allocation of the expenses related to ITER was not apparent from the previous report, however.

European Commission

Publications Office
of the European Union