THE IMPACT OF PHYSICS ON THE ITALIAN ECONOMY

Executive Summary of a report by Deloitte for

SIF Società Italiana di Fisica

together with

Centro Fermi Museo Storico della Fisica e Centro Studi e Ricerche Enrico Fermi

CNR Consiglio Nazionale delle Ricerche

INAF Istituto Nazionale di Astrofisica

INFN Istituto Nazionale di Fisica Nucleare

INRIM Istituto Nazionale di Ricerca Metrologica

January 2014

DISCLAIMER

This document summarises the results of a detailed study carried out by the professional services company Deloitte which was commissioned by the Italian Physical Society (Società Italiana di Fisica – SIF) to assess the economic contribution of physics-based sectors to the Italian economy. The study is based entirely on data available in the public domain, mostly through the Italian National Statistical Service (Istituto Nazionale di Statistica – Istat). Whilst every effort has been made to ensure the accuracy of the material in this document, neither Deloitte nor the SIF will be liable for any loss or damages incurred through its use.

FOREWORD

The aim of the Italian Physical Society (Società Italiana di Fisica – SIF) is to promote, favour and safeguard the study and the progress of physics in Italy and worldwide. SIF represents the Italian scientific community, in the research, educational and professional fields, both public and private, relevant to all areas of physics and its applications. The Society was founded in 1897 in connection with the renowned scientific journal "Il Nuovo Cimento". Since then, the Society has undoubtedly expanded and acquired an international dimension concerning its scientific, societal and publishing activities. This expansion was accompanied by the foundation in 1953, of the International School of Physics in Varenna, Lake of Como, a School later named after Enrico Fermi, which has then acquired a worldwide fame. Since 1968, SIF is a Member Society of the European Physical Society (EPS).

Italy, by itself and as part of Europe, has a long tradition of excellence in science and technology, which altogether are the lever for progress, research and innovation. Italy hosts outstanding physics institutions, centres and laboratories, and also contributes, on an international scale, to the existence of many of these establishments in Europe. The connection between basic physics and technological applications is very tight and brings directly to the question of the appropriate level of support to physics as a whole, a discipline which impacts on the lives of all of us.

In 2012 EPS took the initiative to address the issue of how important is physics to the economies of nearly 30 European states, including Italy, and of how crucial is the maintenance or even the increase of investment in physics. The result was the EPS-Cebr report on "The importance of physics to the economies of Europe", published at the beginning of 2013 (see www.eps.org/?page=policy_economy). On the heels of the EPS initiative, in 2013 SIF has commissioned from Deloitte an independent and quantitative study concerning – for the first time – Italy alone. This study, referring to an analysis performed on data from the Italian National Statistical Service (Istituto Nazionale di Statistica – Istat), spanning the 4-year period 2008-2011 (2011 being the most recent year for which public data for Italy are available), was concluded by December 2013.

The approach adopted in this study by Deloitte, especially the definition of the so-called "physics-based" sectors of the Italian economy, was the result of a lively collaboration of SIF with a number of stakeholders, i.e. of national research institutions broadly involving the physics community in Italy:
Centro Fermi – Museo Storico della Fisica e Centro Studi e Ricerche Enrico Fermi
CNR – Consiglio Nazionale delle Ricerche
INAF – Istituto Nazionale di Astrofisica
INFN – Istituto Nazionale di Fisica Nucleare
INRIM – Istituto Nazionale di Ricerca Metrologica.

The detailed study carried out is available in a Final Report issued by Deloitte which can be integrally downloaded from www.sif.it/attivita/physics_economy. The main and most relevant results of this study are highlighted in the present Executive Summary, also downloadable from the same web page.

Across this recent 4-year period, physics-based sectors have given a major contribution to the Italian economy. Although they have suffered a severe contraction in terms of employment from 2008 to 2011 (by 7%, more than the all-sector Italian average of 2%), physics-based sectors have shown a markedly higher than average (by more than 20%) productivity per worker, a parameter significantly contributing to a multiplier benefit to the whole economy. This productivity per worker even increased by 2.5% between 2008 and 2011 and outperformed Italian productivity which instead decreased by 1.5% over the same period. Just to give some reference numbers, in 2011 physics-based sectors have directly produced 1.51 million jobs (about 6% of total employment in Italy) and €118 billion of Gross Added Value output (more than 7% of Gross Domestic Product), with a productivity per worker exceeding €78,000.

The thorough and detailed analysis of Italian data contained in the Final Report by Deloitte can deliver a deeper insight of the many achievements and drawbacks within the physics-based sectors in Italy in the recent, difficult past.

Our hope is that this study, which refers to a definitely delicate phase for the Italian economy where physics-based sectors have badly suffered, will target the right audience of decision makers and will be highly inspiring for the future, providing a convincing case for a comprehensive support of physics in our Country, from education to research, from business to industry.

Luisa Cifarelli
SIF President

1. PHYSICS AND PHYSICS-BASED SECTORS OF THE ECONOMY

Physics is the branch of science that deals with the nature, structure, properties and interactions of matter, ranging from the smallest scale of elementary particles up to the immense one of the Universe. Of course such definition cannot completely express the detailed role of physics with respect to other disciplines and with respect to technology.

Physics has many facets, from theory to experiment, from knowledge-driven research to applications. The study of physics topics, in an academic environment or in research establishments, and the subsequent innovation and commercialisation of ideas to develop tangible goods and services, has shaped the world we live in today.

Physics-derived technology and innovation are a driving force in a wide range of sectors of the industry and in a large number of activities and services of the economy and the society. How effectively physics affects our daily lives can be seen, for instance, in the internet, mobile telephony, medical tools and instruments, global positioning systems, transportation, etc.

Physics-based sectors in this study are those sectors of the economy where the use of physics – in terms of technologies or expertise – is critical to their existence. In other words, without physics and physics-derived technology these sectors would simply not exist.

The choice of which sectors constitute the physics-based sample to examine was carefully agreed with stakeholders and reflects previous definitions used across the EU as well as Italy-specific factors. The list of physics-based industrial and business sectors analysed herein was obtained using the international **NACE** code nomenclature standard (Rev. 2). This list of the 78 NACE codes chosen over a total of over 600 can be found at the end of this Executive Summary and in the Final Report by Deloitte. Statistical data from publicly available sources were used, mainly from **Istat**. The analysis procedure was based on a tailored "input-output model" of the Italian economy. Details on the methodology used can be found in the Final Report by Deloitte.

2. THE STUDY

The language of science, in particular of physics, is difficult. Many people in Italy (and elsewhere) are unaware of the importance of physics, of its scientific and technological achievements, of its implications and applications in generating economic growth, progress and prosperity.

To address the issue of **the importance of physics in Italy**, this study by Deloitte uses a realistic and concrete approach. It considers the ways in which physics-based sectors influence economic performance in Italy and quantifies the economic value of physics in terms of direct employment supported and output generated over the period 2008 to 2011.

To this purpose, those sectors that can be defined as physics-based were identified according to the NACE classification and publicly available Istat data were correspondingly used. Insights on direct employment in the many different physics-based sectors were then introduced into an "input-output model" which was specifically conceived and applied to Italy to produce the desired estimates. The focus of the present study was limited to the assessment of: **employment, turnover** (i.e. revenue), **GVA** (Gross Value Added) and **productivity per worker**. Four types of impacts or effects on the Italian economy were considered, namely:

- **direct impacts** of physics-based sectors;
- **indirect effects** of physics-based sectors (due to business-to-business supply-chain purchasing within the Italian economy);
- **induced effects** of physics-based sectors (due to consumer spending of wages throughout the Italian economy);
- **total impacts** (the three above effects aggregated together so as to estimate a "footprint" contribution).

An attempt to distinguish among the three major geographical regions of Italy, namely **North, Centre** and **South**, including the Islands, was also made.

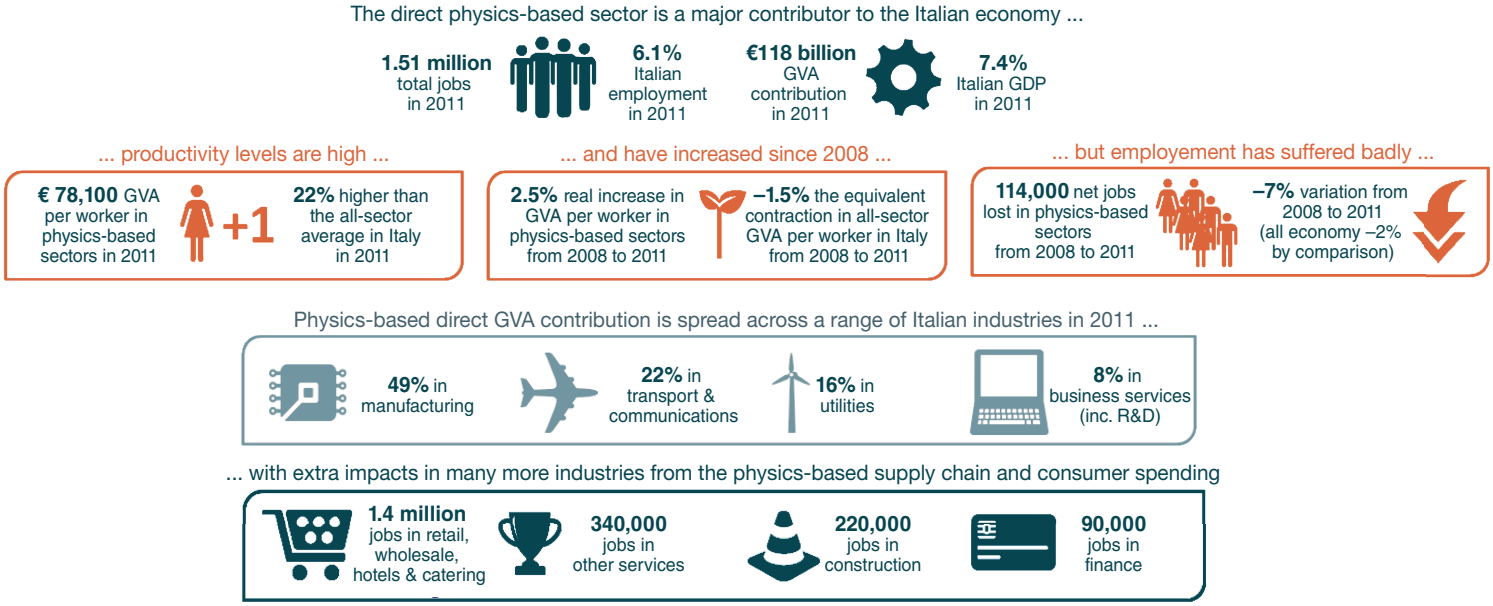
Although projections after 2011 for physics-based sectors were beyond the reach of this study, the issue of the evolution trend of the Italian economy as a whole up to 2014 was briefly commented.

Some evaluation of **output per enterprise** was included and some significant **case studies** of Italian enterprises were introduced, illustrating the way in which physics-based sectors can start and flourish, as well as the way in which leading-edge physics **R&D** is crucial to commercialise emergent technology.

This is the first time such a detailed quantitative analysis has been applied to Italy alone and, as such, the estimates represent a step in a hopefully longer process of impact evaluation for the physics-based sectors of Italy.

3. AT A GLANCE

THE QUANTIFIABLE IMPACTS OF PHYSICS-BASED SECTORS IN ITALY, 2011: 60-SECOND SUMMARY



Source: Deloitte

Note: All figures refer to 2011 apart from growth rates which show change between 2008 and 2011. Concerning physics-based direct GVA contribution, 7% comes in other sectors including government activities and extractive industries.

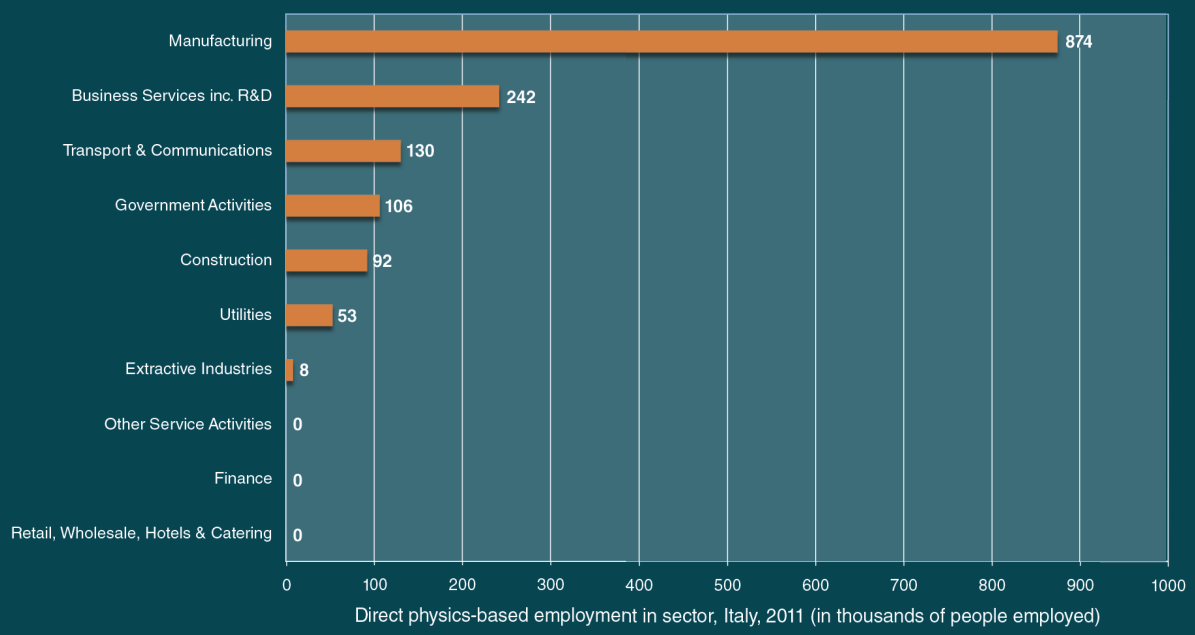
Physics-based sectors are a major contributor to the Italian economy, as can be clearly seen from the schematic chart presented here, which gives at a glance the most significant figures of this study: in 2011 physics-based sectors contributed directly to employment in Italy with more than **1.5 million jobs, 6.1% of total employment**, and accounted a Gross Added Value (GVA) contribution of **€118 billion, 7.4% of national Gross Domestic Product (GDP)**.

Nevertheless **physics-based sectors have suffered more than many other areas of the Italian economy through the recession** from 2008 to 2011, mostly due to the strong links of these sectors with manufacturing activities. The number of jobs lost (114,000 from 2008 to 2011) is significant: it corresponds to a fall of 7%, well in excess of the overall contraction in Italy of 2%.

At the same time, however, **jobs in physics-based sectors are much more productive than the Italian average.** Each worker in physics-based sectors produced about €79,000 in GVA in 2011, which is 22% higher than the all-sector average in Italy. Moreover this physics-based productivity in Italy has increased (by 2.5% in GVA per worker from 2008 to 2011) while the equivalent all-sector average productivity has decreased by a comparable amount.

Also because of their high productivity level, physics-based sectors have an extra impact in many more industrial and business sectors of the whole Italian economy, deriving from the physics-based supply-chain and consumer spending. This extra impact translates into a **multiplier benefit** to the Italian economy. Hence the **total footprint** of physics-based sectors in 2011, i.e. their reach across the Italian economy, is: **6.5 million jobs, 25% of all employment** in Italy, and correspondingly in terms of GVA: **€341 billion, 22% of national GDP**.

4. EMPLOYMENT



Source: Deloitte Analysis, Istat

Note: Business services including R&D stands for all non-financial businesses providing services (as examples: management consultancies, services by architects, accountants, PR people, etc.). Utilities stands for electricity, gas and water supplies. Government activities are predominantly defence.

Altogether, physics-based sectors accounted for 1.51 million jobs in 2011, representing 6.1% of the total 24.7 million jobs in Italy.

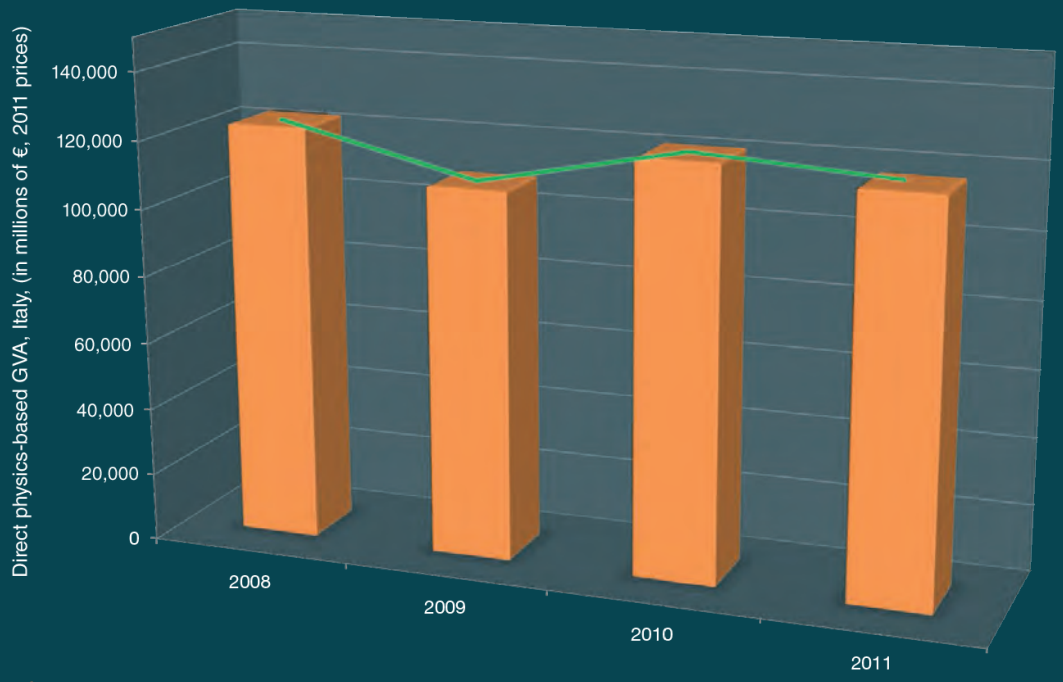
When compared with the Italian economy as a whole, where manufacturing absorbs nearly 19% of all jobs, manufacturing in physics-based sectors accounts for a much higher proportion: 58% of all jobs. This means that **around 20% of all Italian manufacturing jobs can be classed as physics-based.**

Since 2008 the direct employment in Italy supported by physics-based sectors has fallen markedly. Between 2008 and 2011, physics-based sectors lost 114,000 net jobs, a reduction of 7%. More than 80% of these jobs were in the manufacturing sector.

Over the same period the Italian economy lost over 500,000 net jobs, a reduction of 2%. This means that more than 1 in 5 net jobs lost were in physics-based sectors, thus that **the recession hit physics-based sectors to a greater extent** than the Italian economy as a whole.

5. GROSS VALUE ADDED AND PRODUCTIVITY

DIRECT PHYSICS-BASED GVA CONTRIBUTION, ITALY, 2008-2011



Source: Deloitte, Istat

Physics-based sectors accounted for €118 billion in Gross Value Added (GVA) contribution to the Italian economy in 2011, representing 7.4% of Italy's Gross Domestic Product (GDP).

For comparison, more or less around the same year, physics-based sectors accounted for 8% of GDP in the UK and slightly more than 9%, on average, across the EU27 states. The share of physics-based sectors in Italy is therefore marginally lower than across EU as a whole and the UK. However, the percentage contribution is the same as in other major countries in Europe such as France[1].

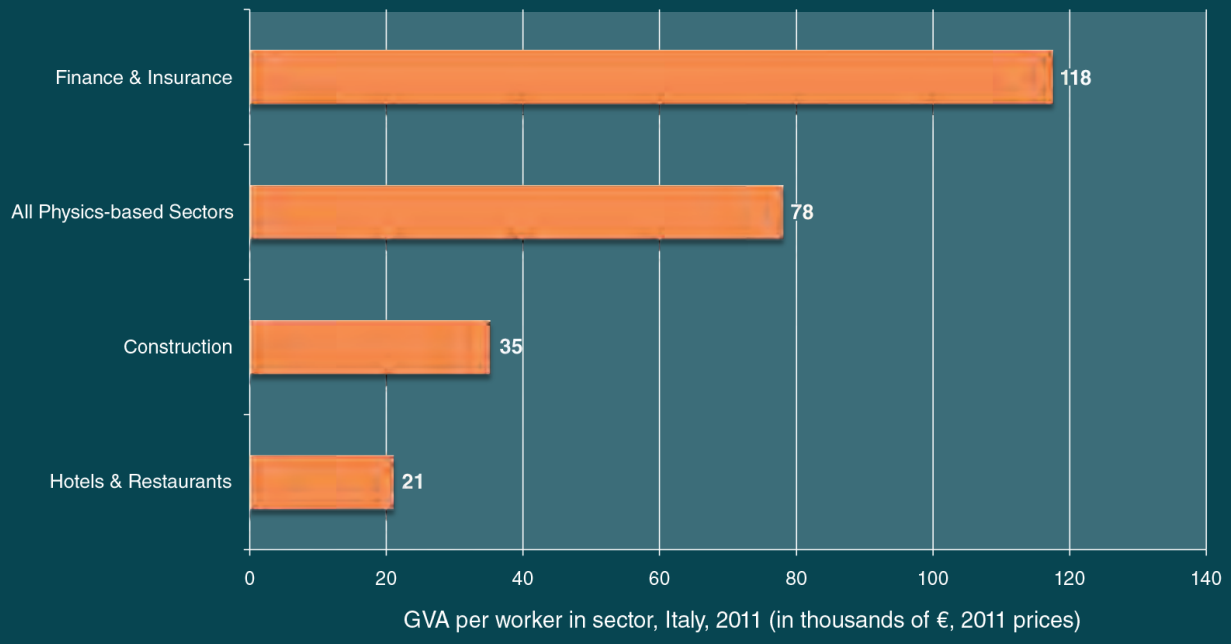
It is worth noting that physics-based sectors have a greater share of national economic output (7.4%) than the equivalent share of national employment (6.1%), which is due to the relevant productivity level in physics-based sectors, as discussed later on.

Concerning the distribution of GVA, as already seen for employment, manufacturing accounts for the largest share of physics-based activity: some €57 billion or 49% of total physics-based GVA in Italy in 2011.

Considering the direct GVA contribution of physics-based sectors over time, there was an effective rebound in output in 2010 after the 2008-2009 decline. By 2010 output levels had almost recovered to levels seen in 2008 (only 1.4% lower), after being as much as 11% lower in 2009.

[1] From previous and analogous studies by Deloitte for the UK Institute of Physics (IoP) and by Cebr for the European Physical Society (EPS), and from public Eurostat data.

PHYSICS-BASED PRODUCTIVITY PER WORKER (GVA) VERSUS PRODUCTIVITY IN OTHER SECTORS, ITALY, 2011



Source: Deloitte, Istat

In 2011 there was a further stall in physics-based GVA contribution, with a contraction from 2010 to 2011 of 3.4%, while the Italian economy as a whole grew by approximately 0.5% in real terms.

Productivity per worker refers to the amount of output produced each year by a worker. All-economy productivity per worker for Italy in 2011 was €64,000, only 82% of the physics-based sector average of €78,100. In other words, **industries defined as physics-based are significantly more productive than other industries**, on average.

Within the tightly defined parameters of physics-based sectors, productivity per worker is highest in utilities, transport & telecommunications, and extractive industries. Specifically these three sectors have productivity per worker above the physics-based sector average, while all other sectors have it below. Although this productivity in physics-based manufacturing sectors is below average relative to other physics-based sectors, it is still in excess of the all-economy average by around 2%.

When confronted with other specific sectors in Italy in 2011, physics-based productivity per worker performs well. Three particular non-physics-based sectors (i.e. with either no, or very little overlap with physics-based sectors) have been chosen for comparison, namely finance & insurance, construction, and hotels & restaurants.

Workers in physics-based sectors in Italy in 2011 are much more productive than their equivalents in hotels & restaurants

DIRECT PHYSICS-BASED PRODUCTIVITY PER WORKER (GVA), ITALY, 2008-2011

Source: Deloitte, Istat

or in construction, but they trail finance & insurance employees by about 50% (which is comparable with an analogous differential of 35% in the UK in 2012[2]).

As far as time evolution is concerned, between 2008 and 2009 productivity per worker in physics-based sectors fell significantly, by about 9%. However in 2010 this trend was reversed and GVA per worker increased to €79,000 besides a further fall in employment, thus signalling a significant increase in output.

In 2011 productivity per worker in physics-based sectors slightly dropped again, and was marginally lower than 2010, falling to just over €78,100 in real terms.

This behaviour, with a dip and then an effective flattening off in 2010-2011, is consistent with productivity for the Italian economy as a whole, which in turn appears to be part of a wider trend amongst many western economies. In 2011, productivity per worker in Italy was 1.5% lower than in 2008.

In physics-based sectors productivity per worker increased by 2.5% between 2008 and 2011 and outperformed Italian productivity.

[2] From an analogous study by Deloitte for the UK Institute of Physics (IoP).

6. REGIONAL BREAKDOWN

PHYSICS-BASED SECTORS CONTRIBUTION ACROSS ITALIAN REGIONS, 2011

Region	All Economy		Physics-based Sectors				
	GVA (at production factor cost, in billions of €)	Number of people employed	GVA (at production factor cost, in billions of €)	Number of people employed	Relative productivity	% Regional GVA	% Regional employment
North	457.8	9,513,000	67.5	929,000	96	14.7	9.8
Central	149.4	3,376,000	21.7	261,000	110	14.5	7.7
South	130.1	3,729,000	16.8	216,000	103	12.9	5.8
Italy	737.3	16,618,000	105.9	1,406,000	100	14.4	8.5

Source: Deloitte, Istat

Note: Here the quoted GVA figures are lower than elsewhere in this study because of: a) the use of production factor cost instead of market price; b) missing regional data for both physics-based and non-physics-based sectors (predominatly in defence and finance).

In absolute terms, data from Istat confirms that in 2011 **physics-based activity is concentrated in the North of Italy**. The bulk of jobs in physics-based sectors are located in the North: 66% of all physics-based jobs in Italy. Across the whole Italian economy, the North accounts for nearly 60% of economic activity.

Physics-based activity accounts for a greater share of regional economic activity in the North (approaching 10% of regional employment and 15% of regional GVA), while in the South this accounts for the lowest proportion (less than 6% of regional employment and 13% of regional GVA).

However, it is interesting to note that **relative productivity per worker in the South of Italy is higher than in the North, and higher still in Central Italy**. An explanation for this may be that the bulk of lower productivity jobs in physics-based sectors are located in the North, or that there are a number of major institutions operating in Central and Southern Italy responsible for the higher productivity[#].

[#] By the time this document was printed, a further analysis of the North-Centre-South data actually favours the second interpretation. Much of the difference of Central and Southern Italy with respect to Northern Italy comes from a concentration of activities in physics-based sectors which tend to be very capital intensive, such as extractive industries, utilities (electricity, gas and water supplies) and also manufactures of computer, electronic and optical products.

7. ENTERPRISES

Physics is responsible for the creation and support of enterprises in the Italian economy, from the generation of ideas, to the research and development (R&D) and to the commercialisation process.

In 2010[3] there were around 262,000 enterprises or business units operating in physics-based sectors throughout Italy. Between 2008 and 2010, over 5,600 physics-based enterprises were lost (almost all of them from 2008 to 2009): a 2% fall.

Adjusting for missing data[4], the **output per enterprise** in physics-based sectors can be estimated in terms of GVA. Despite the recession, the output per enterprise rised from about €420,000 in 2008 to over €450,000 in 2010, corresponding to a 7% increase (with a 9% jump from 2008 to 2009, then a slight fall from 2009 to 2010). This seems to indicate that **physics-based enterprises are to a certain extent resilient to the crisis** since enterprises numbers did not fall as much as GVA or employment. Nevertheless it remains to be seen how physics-based enterprise creation/destruction has evolved in more recent times.

The sectoral coverage of **R&D** statistics in Italy did not allow at this stage to undertake an analysis on how physics-based sectors contribute to R&D in Italy through government and/or business enterprise funding mechanisms.

Some concise qualitative analyses in the form of **case studies** of Italian enterprises operating in physics-based sectors are presented here to show how these enterprises can start and flourish, how physics R&D in Italy has been commercialised for economic benefit, and how emergent technologies may be in the process of being commercialised.

[3] 2011 Istat data in terms of business units were not yet available when this study was performed.
[4] Some 4-digit NACE sector codes are suppressed in Istat data in terms of business units.

AN EXAMPLE OF A PROMISING SPIN-OFF ON CONCENTRATED PHOTOVOLTAICS

A technology transfer project on concentrated photovoltaics (CPV) was started in 2010 by **Centro Fermi***, an institution focusing on interdisciplinary research activities. The resulting University-participated spin-off, **AtemEnergia**, succeeded in involving three private companies of the manufacturing sector (mainly in the automotive sector): **Unitek, Unica and PiazzaRosa**. All these companies provide their know-how in different production technologies (production of moulds for plastic components and of high performance mirrors) for the development of a special CPV module. Thanks to the use of triple junction solar cells with 40% efficiency, the ongoing physic-based R&D allowed to sensibly increase the capabilities of CPV up to twice with respect to the current existing technology. So far, the trial production has been developed and needs to be tested before being marketed.

* Museo Storico della Fisica e
Centro Studi e Ricerche "Enrico Fermi"

Unitek Cad Cam Moulds Design

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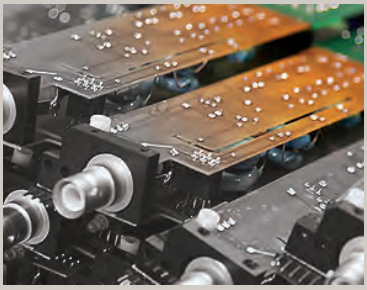
PIAZZAROSA the new world



CAEN
Tools for Discovery
Costruzioni Apparecchiature Elettroniche Nucleari

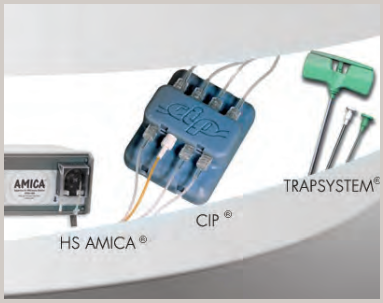
A SUCCESSFUL WORLDWIDE LEADING COMPANY IN ELECTRONIC TOOLS FOR DISCOVERY

CAEN was established in 1979 and is today one of the most important industrial players in the nuclear physics research market. Its products are currently used in the most prestigious laboratories, research centers, and universities worldwide. Throughout the years CAEN has strengthened by inserting a "massive" number of young physicists in all of its business activities: today 10% of the total employees are physicists. CAEN operates in a highly specialized international market: the design, production and supply of electronic instrumentation for radiation and low light sensors. The company targets two main areas: nuclear physics research (both at high and medium-low energies) and its fall-out applications. CAEN is involved in several leading-edge R&D collaboration projects and has also been involved in R&D projects in the fields of security and environment.

ThunderNIL
NANOSTRUCTURES IN MICROSECONDS

A TECH STARTUP SHOWING HOW PHYSICS AIDS ENTERPRISE CREATION

ThunderNIL, created in 2009, is a young startup company which provides services and produces equipment to imprint macro, micro and nano structures onto surfaces of goods using the pulsed-NIL (pulsed-Nano Imprint Lithography) proprietary technology, with an imprint time of 100 microseconds. This outperforms the popular Nano Imprint Lithography (NIL) technology, considered nowadays an ideal tool except for insufficient throughput for mass production. ThunderNIL's technology fits to a large class of applications, but the markets of prime interest are the personalized luxury goods, with products such as glasses, watches; plastic disposables for medical analysis; plastic packages for food industry; high-tech applications, etc. Currently ThunderNIL invests 40% of its annual budget in R&D activities.



HS
FUTUREMADEPRESENT
Hospital Services

35 YEARS OF SIGNIFICANT AND CONTINUED CONTRIBUTION THROUGH PHYSICS

HS was founded in 1980 with the objective to promote and make available new methods and tools for minimally invasive interventional and diagnostic technologies, introducing on the Italian market a new generation of ultrasound-guided biopsy tools. Over the years, HS has consolidated its leadership on the worldwide markets of interventional radiology, critical care, interstitial therapies, minimally invasive surgery (patent licensing by **CNR***) and, today, also in oncologic therapies. The R&D unit of HS hosts multidisciplinary competences and skills, in order to generate top-level innovation and drive the change in minimally invasive medicine. Products development is carried out side by side with clinical key leaders in the fields of surgery, anesthesiology, interventional radiology and oncology. A wide network of technical, industrial and academic consultants provides an enlarged and multidisciplinary team of experts, covering all the critical areas, from the initial concept to the final manufacturing and clinical use of innovative medical devices.

* Consiglio Nazionale delle Ricerche

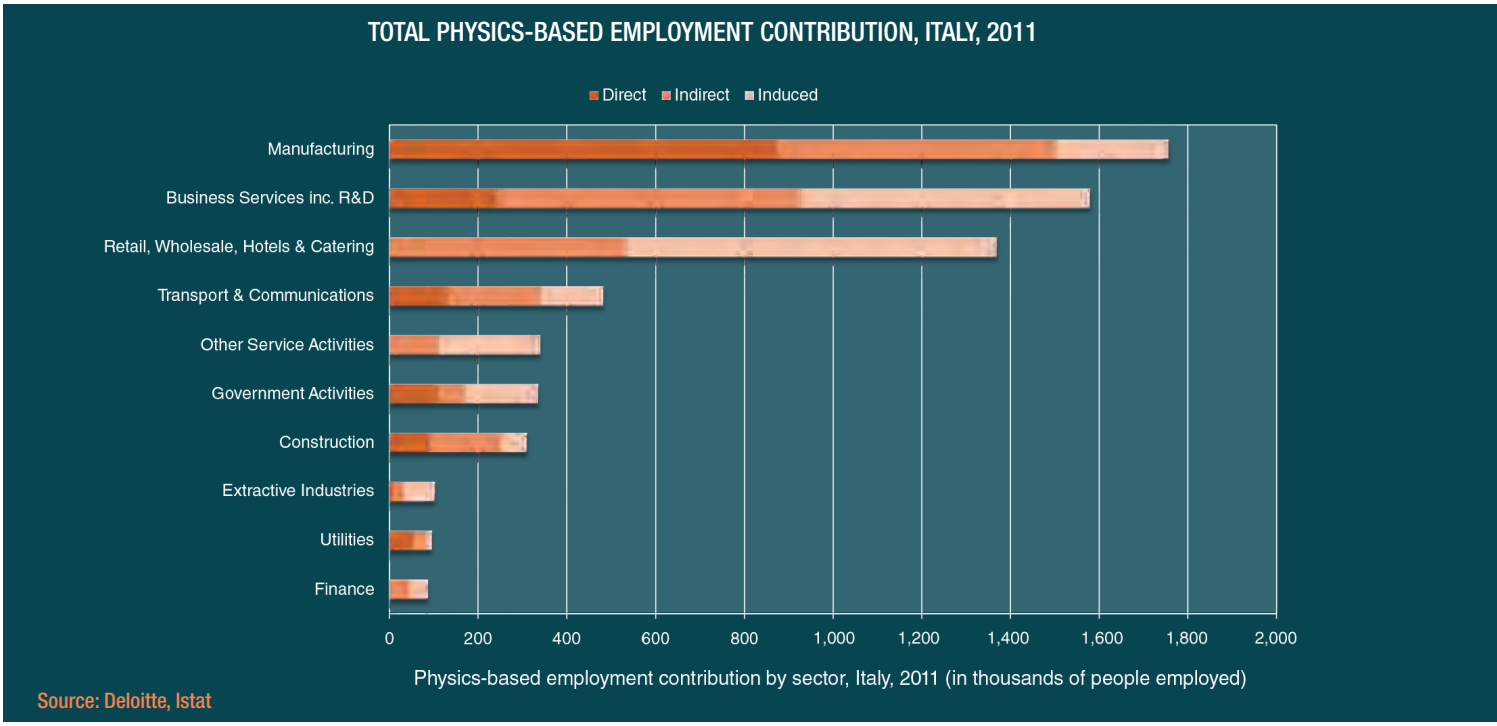
Media Lario Technologies
Media Lario **Technologies**

A HIGH-TECH, HIGH-PRECISION COMPONENT SUPPLIER

Media Lario Technologies is a leading supplier of cost effective high-precision reflective optical components and systems, serving the desired radiation spectrum from X-ray to millimeter waves.These products target a variety of advanced applications: in semiconductor lithography, semiconductor processing capital equipment, space & terrestrial science, and medical & life science devices. Media Lario Technologies builds on more than 10 years of experience and success in space & terrestrial precision optics due to the company's longstanding cooperation with renowned astrophysical institutions and it has been a key contributor to the success of the XMM-Newton mission of ESA*, the most powerful X-ray telescope ever built. Media Lario Technologies is a privately held company owned by its management and a group of leading international venture capital organizations.

* European Space Agency

8. TOTAL IMPACT AND MULTIPLIERS



To quantify the reach and impact of physics-based sectors across the whole Italian economy, the direct physics-based contribution has been aggregated together with indirect (business-to-business spending) and induced (consumer spending) contributions.

In terms of employment, 77% of the employment contribution of physics-based sectors is non-direct, i.e. either indirect or induced. **The total footprint of physics-based sectors in Italy in 2011 is 6.5 million employees, roughly 25% of all employment in Italy.**

Manufacturing again accounts for the main contribution to employment due to physics-based sectors: more than 1.75 million jobs, with 600,000 of these in other manufacturing organisations supplying the physics-based sectors (i.e. as indirect contribution).

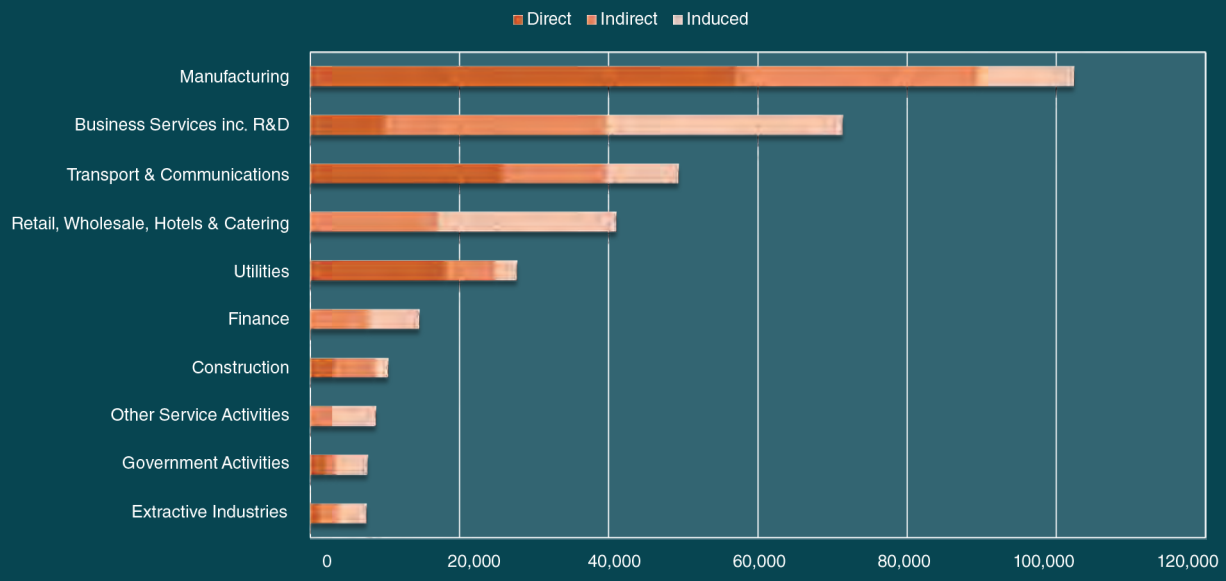
Physics-based sectors are big buyers of business services including R&D, which means that the supply chain and consumer spending effects on jobs are particularly strong: 85% of the total employment footprint of nearly 1.6 million jobs is generated through the supply chain and consumer spending.

The third most significant sector in job terms is retail, wholesale, hotels & catering. Despite having zero jobs based on physics according to the definition adopted in this study (i.e. no direct contribution), business organisations and individuals in this sector spend a significant fraction of income on physics-based services. This is why almost 1.4 million jobs are supported through the physics-based sector.

The picture is similar in terms of GVA. **The total GVA footprint of physics-based sectors in Italy in 2011 equals €341 billion, roughly 22% of Italian GDP**: 65% of this contribution is non-direct and comes from the way in which physics-based sectors interact with the wider economy.

Manufacturing accounts for over 30% of physics-based sector total contribution to the Italian economy in 2011. Business services including R&D, and transport & communications account for 21% and 14% of the total GVA contribution respectively, meaning that the three major sectors

TOTAL PHYSICS-BASED GVA CONTRIBUTION, ITALY, 2011



Physics-based GVA contribution by sector, Italy, 2011 (in millions of €, 2011 prices)

Source: Deloitte, Istat

together account for 65% of the sum.

Across the whole economy, these three sectors account for 27% of GVA, which illustrates how important they are for the economy, but also how much activity is generated in these sectors through physics-based activity.

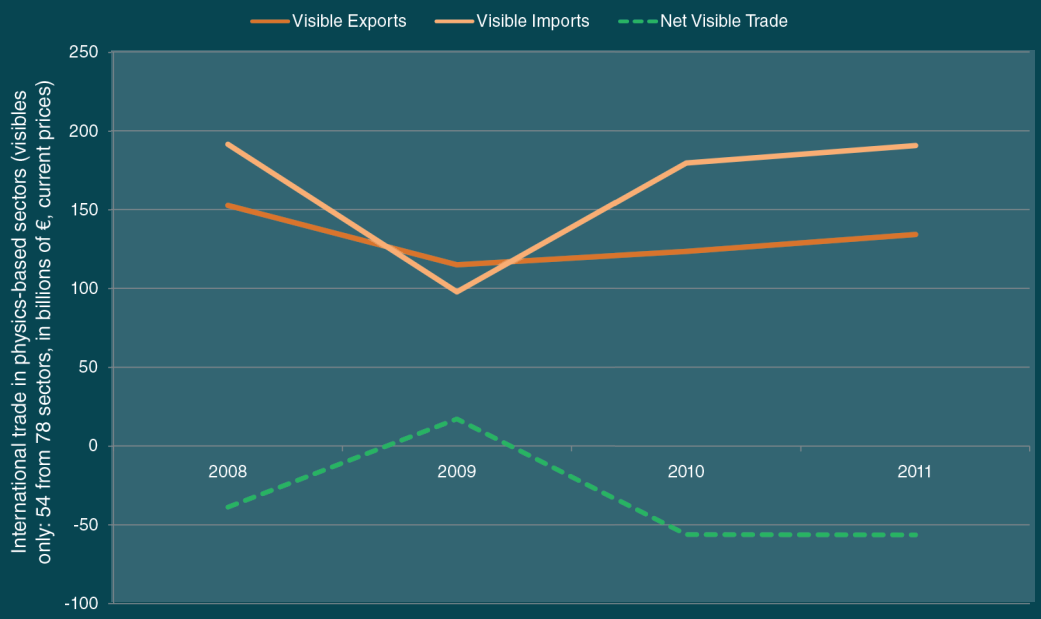
Considering the total employment and GVA contribution on a time-series basis from 2008 to 2011, the overall effects are broadly similar to the direct physics-based contribution (see p. 6). In particular, the total employment contribution from physics-based sectors across the economy has flattened at the level of 6.5 million jobs between 2010 and 2011. This is in spite of a contraction in the number of direct physics-based jobs between 2010 and 2011, implying that **physics can contribute to the Italian economy even when elements of the sector contract in employment terms.**

In 2011 the **employment multipliers** are, respectively, 2.67 for direct + indirect impact, and 4.29 for direct + indirect + induced impact. In other words, **for every job in direct physics-based sectors (1.5 million jobs in 2011), another 1.67 jobs** are supported because of business-to-business supply-chain purchases by physics-based sectors; **and another 1.64** jobs are supported because of consumer spending from the employees of physics-based sectors. These relatively high employment multipliers are typical for high productivity sectors such as the physics-based ones, because their spending supports more jobs per unit of expenditure in the rest of the economy.

As for **GVA multipliers**, the estimates for 2011 are 0.33 for direct, 0.67 for direct + indirect, and 0.97 for direct + indirect + induced impacts, respectively. In other words, **for every €1 of direct turnover in physics-based sectors (accounting a GVA contribution of €118 billion in 2011), another €0.34 of GVA** is generated because of business-to-business purchases by physics-based sectors; and **another €0.30 of GVA** because of consumer spending from the employees of physics-based sectors.

9. INTERNATIONAL TRADE

INTERNATIONAL TRADE IN PHYSICS-BASED SECTORS (VISIBLES ONLY) ITALY, 2008-2011, CURRENT PRICES



Source: Deloitte, Istat

Note: Only physics-based sectors where that data exists are included. Current prices (non-inflation adjusted) are considered due to issues with deflating imports and exports at a disaggregate level.

Estimates of imports, exports and net international trade balance for physics-based sectors (only those producing manufactured goods, i.e. 54 sectors out the 78 considered here) have been made over the period 2008-2011. The effect of the recession and the downturn of 2009 show up very clearly.

Between 2008 and 2009 exports only fell by 25% (much slower than imports), likely thanks to Italian exports tied into long-term contracts or, more likely, thanks to exports towards countries (for instance, China) less or not affected by the recession. The result was a significantly positive "visible balance of trade" in Italian physics-based sectors in 2009. Subsequently however, as from 2010, as the demand for imports increased faster than the one for exports, the visible balance of trade in physics-based sectors turned negative.

Italy generally returns a visible trade surplus in most sectors apart from energy where it is a net importer. **In 2008-2011, €130 billion of physics-based exports on average accounted for about 35% of all Italian physical goods exports.**

Just to give some context to these numbers, a similar percentage for physics-based exports applies also to the UK and the trade deficit in UK physics-based sectors is of a similar magnitude to that seen in Italy.[5]

[5] From an analogous study by Deloitte for the UK Institute of Physics (IoP) over a similar period of time.

10. CONCLUSION

The detailed study by Deloitte examines the contribution of physics to the Italian economy over the 2008-2011 period (2011 being the latest year of publicly available data) and highlights how physics-based sectors can play an important role in Italy in generating economic growth and prosperity. This study is based on a model, on a specific choice of parameters and indicators, and represents an independent economic analysis of the Italian case.

The results obtained in terms of measures such as turnover, employment, productivity and multiplier impacts, show that across these difficult recent years of still ongoing crisis in Italy, **physics-based sectors significantly contributed to the Italian economy and performed well, especially on metrics such as productivity**. The message is therefore that investing in physics today in Italy through education, research, business and industry is the right thing to do, and is likely to yield economic benefits in years to come, such as employment growth and productivity enhancements.

ACKNOWLEDGEMENTS

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GLOSSARY

Gross Value Added (GVA)
A measure of the value of goods and services produced by a business, industry, sector or region of the economy. The Organisation for Economic Cooperation and Development (OECD) defines Gross Value Added (GVA) as the value of output less the value of intermediate consumption, though it can also be thought of as the sum of profits, employee remuneration and attributable taxes. It is analogous to Gross Domestic Product (GDP), which also measures economic output but additionally includes items that can only be included at aggregate level across all sectors such as taxes and subsidies on products. At aggregate level, GVA usually differs from GDP by less than 1%.

Impacts
Direct impacts: Those initial and immediate economic activities (jobs and GVA) attributable to the activities of organisations and employees in physics-based sectors, as defined in this study. These effects are often referred to as "first-round" impacts as they coincide with the first round of spending in the economy.
Indirect impacts: Changes in the number of jobs and GVA in associated industries that supply inputs to physics-based organisations (sometimes referred to as "supply-chain" impacts).
Induced impacts: The spending by households that result in changes to the number of jobs and GVA due to direct and indirect impacts. Indirect and induced effects are sometimes collectively referred to as "downstream effects".

NACE
Nomenclature statistique des Activités économiques dans la Communauté Européenne, commonly referred to as NACE, is a European industry standard classification analogous to the UK's Standard Industrial Classification (CIS) and the North American Industrial Classification Systems (NAICS). NACE is used here to define physics-based sectors, with data provided at the 4-digit NACE level by Istat.

Physics
The pervasiveness of physics makes it hard to reach a single conclusive definition. A general definition is: the branch of science that deals with the nature, structure, properties and interactions of matter, ranging from the smallest scale of elementary particles up to the immense one of the Universe. Such definition does not adequately capture the detailed role of physics with respect to other disciplines and with respect to technology. The definition used here uses sectors which are deemed likely to be physics-based, in total or in part.

Physics-based sectors
Those sectors of the economy where the use of physics – in terms of technologies or expertise – is critical to their existence. The choice of which sectors constitute physics-based sectors reflects previous definitions used across the EU as well as Italy-specific factors. A list of sectors that make up the list of physics-based sectors can be found at the end of this Executive Summary.

Prices
2011 prices: Constant prices (see below), where 2011 is the base year.
Constant prices: Prices given with reference to some base year, so that the estimates are inflation-adjusted (i.e. with inflation removed) to give "real" values.
Current prices: Prices given as "outturn" prices in each year, so that estimates represent the actual price paid in that year unadjusted for inflation. Also called "nominal terms".
Real terms: Adjusted for inflation. GDP growth is often given in real terms, showing growth after inflation has been considered. The opposite is nominal terms, where inflation is included.

Visibles
Trade in items that are physical or visible, i.e. all trade excluding trade in services.

DIRECT PHYSICS-BASED EMPLOYMENT BY NACE 4-DIGIT INDUSTRY, ITALY, 2011 (% Attributable refers to proportion of all sector activity counted as physics-based)

NACE Code	% Attributable	Direct Physics-based Employment
0910 : Support activities for petroleum and natural gas extraction	100%	8,100
2011 : Manufacture of industrial gases	2%	100
2013 : Manufacture of other inorganic basic chemicals	100%	6,000
2059 : Manufacture of other chemical products n.e.c.	2%	300
2110 : Manufacture of basic pharmaceutical products	1%	100
2120 : Manufacture of pharmaceutical preparations	100%	51,000
2229 : Manufacture of other plastic products	2%	1,800
2319 : Manufacture and processing of other glass, including technical glassware	2%	200
2344 : Manufacture of other technical ceramic products	100%	500
2452 : Casting of steel	8%	200
2521 : Manufacture of central heating radiators and boilers	100%	4,200
2530 : Manufacture of steam generators, except central heating hot water boilers	100%	2,700
2540 : Manufacture of weapons and ammunition	100%	7,000
2561 : Treatment and coating of metals	2%	700
2593 : Manufacture of wire products, chain and springs	2%	200
2599 : Manufacture of other fabricated metal products n.e.c.	100%	79,300
2611 : Manufacture of electronic components	100%	29,200
2612 : Manufacture of loaded electronic boards	100%	9,000
2620 : Manufacture of computers and peripheral equipment	100%	6,800
2630 : Manufacture of communication equipment	100%	26,800
2640 : Manufacture of consumer electronics	100%	2,500
2651 : Manufacture of instruments and appliances for measuring, testing and navigation	100%	22,400
2660 : Manufacture of irradiation, electromedical and electrotherapeutic equipment	100%	12,700
2670 : Manufacture of optical instruments and photographic equipment	100%	2,100
2680 : Manufacture of magnetic and optical media	100%	100
2711 : Manufacture of electric motors, generators and transformers	100%	29,700
2712 : Manufacture of electricity distribution and control apparatus	100%	23,900
2720 : Manufacture of batteries and accumulators	100%	2,900
2731 : Manufacture of fibre optic cables	100%	1,300
2732 : Manufacture of other electronic and electric wires and cables	100%	11,000
2733 : Manufacture of wiring devices	100%	6,600
2740 : Manufacture of electric lighting equipment	100%	17,100
2751 : Manufacture of electric domestic appliances	100%	38,400
2790 : Manufacture of other electrical equipment	100%	34,600
2811 : Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	100%	17,300
2821 : Manufacture of ovens, furnaces and furnace burners	100%	12,000
2823 : Manufacture of office machinery and equipment (except computers and peripheral equipment)	100%	2,100
2825 : Manufacture of non-domestic cooling and ventilation equipment	100%	31,300
2829 : Manufacture of other general-purpose machinery n.e.c.	100%	72,400
2841 : Manufacture of metal forming machinery	100%	17,200
2849 : Manufacture of other machine tools	100%	21,500
2892 : Manufacture of machinery for mining, quarrying and construction	100%	21,700
2899 : Manufacture of other special-purpose machinery n.e.c.	100%	21,700
2910 : Manufacture of motor vehicles	47%	30,000
2931 : Manufacture of electrical and electronic equipment for motor vehicles	100%	11,200
3011 : Building of ships and floating structures	100%	16,200
3020 : Manufacture of railway locomotives and rolling stock	100%	10,400
3030 : Manufacture of air and spacecraft and related machinery	100%	31,900
3040 : Manufacture of military fighting vehicles	100%	1,300
3250 : Manufacture of medical and dental instruments and supplies	100%	61,800
3299 : Other manufacturing n.e.c.	25%	4,500
3320 : Installation of industrial machinery and equipment	100%	52,700
3511 : Production of electricity	100%	25,200
3512 : Transmission of electricity	100%	3,500
3513 : Distribution of electricity	100%	23,600
3514 : Trade of electricity	10%	700
3812 : Collection of hazardous waste	100%	2,600
3822 : Treatment and disposal of hazardous waste	100%	3,000
4222 : Construction of utility projects for electricity and telecommunications	1%	200
4321 : Electrical installation	23%	54,800
4322 : Plumbing, heat and air-conditioning installation	19%	37,200
5221 : Service activities incidental to land transportation	11%	8,800
5222 : Service activities incidental to water transportation	100%	12,200
5223 : Service activities incidental to air transportation	100%	26,900
6110 : Wired telecommunications activities	100%	60,000
6120 : Wireless telecommunications activities	100%	22,100
6130 : Satellite telecommunications activities	10%	-
6190 : Other telecommunications activities	2%	300
6209 : Other information technology and computer service activities	2%	500
7022 : Business and other management consultancy activities	10%	9,600
7111 : Architectural activities	6%	4,500
7112 : Engineering activities and related technical consultancy	42%	81,900
7120 : Technical testing and analysis	32%	10,400
7211 : Research and experimental development on biotechnology	100%	3,100
7219 : Other research and experimental development on natural sciences and engineering	100%	17,000
7420 : Photographic activities	10%	1,900
7490 : Other professional, scientific and technical activities n.e.c.	100%	112,900
8422 : Defence activities	33%	106,400

Note: Figures round to nearest 100 for disclosure purposes. May not sum to estimates presented in the remainder of the document due to rounding.

Source: Deloitte


Società Italiana
di Fisica


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Consiglio
Nazionale delle
RIcerche


INAF ISTITUTO NAZIONALE DI ASTROFISICA


INFN
Istituto Nazionale
di Fisica Nucleare


INRiM
ISTITUTO
NAZIONALE
DI RICERCA
METROLOGICA