The importance of physics to the economies of Europe

Executive summary of an analysis prepared by Cebr - Centre for Economics and Business Research for the European Physical Society

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European Physical Society

DISCLAIMER

FOREWORD

Since its establishment in 1968, the European Physical Society (EPS) has held a dual role of learned society and federation of national member societies. After 45 years, the EPS has 41 member societies and represents a very large and varied community of physicists. One of the main objectives of the EPS is to give them a coherent voice despite the existence of many educational, scientific, social and geographic diversities.

Europe has a long lasting tradition of strength in science and technology, and today hosts many of the most important national and international physics research laboratories. Physics is vital to European culture. The new European research program Horizon 2020 is being launched to reinforce the intimate link between basic science and technological applications to favour Europe's progress in research and innovation, a major challenge for the future.

Along this line, key questions arise: how important is physics to the economies of European countries? And how worthwhile is it to maintain and increase investment in physics? To address these issues the EPS has commissioned an independent economic analysis from the Centre for Economics and Business Research (Cebr), using statistics available in the public domain through Eurostat. It is the first time that such a study has been performed on this scale and it covers 29 European countries – the EU27 countries, plus Norway and Switzerland. Under examination is the 4-year period 2007-2010, 2010 being the most recent year for which official data are simultaneously available for all these countries. The Cebr analysis is contained in a detailed report which was completed in December 2012, while the most important results are highlighted here in this Executive Summary. Please see www.eps.org/physicsandeconomy for further details and downloads.

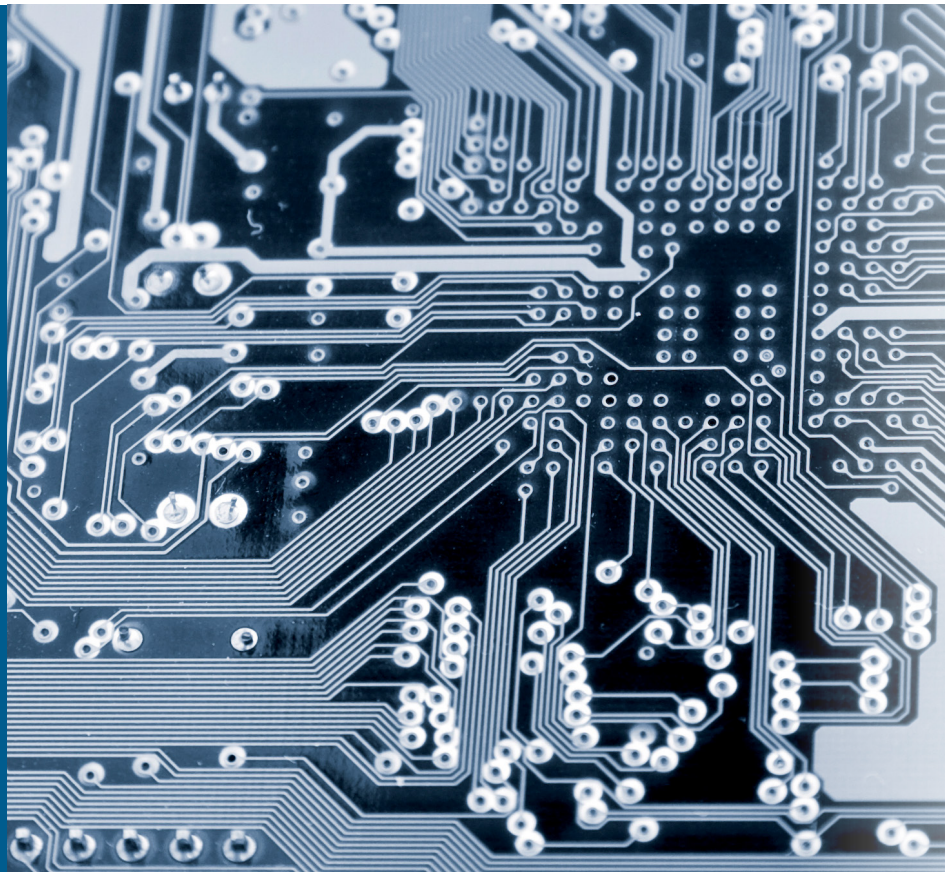
This 4-year snap-shot of the European economy shows that the physics-based industrial sector generated over 15% of total turnover and over 13% of overall employment within Europe's business economy. To give some context to these numbers, the turnover per person employed in the physics-based sector substantially outperforms the construction and retail sectors, and physics-based labour productivity (expressed as gross value added per employee) was significantly higher than in many other broad industrial and business sectors, including manufacturing. The European physics-based sector was also highly R&D intensive and despite the effects of the global economic downturn on enterprise birth and failure rates, physics-based industries and enterprises were more resilient in comparison with the wider economy. The thorough analysis of European data, contained in the full Cebr report, can provide us with a deeper understanding of the many achievements and drawbacks within the physics-based sector in the recent past.

Our hope is that the message conveyed by the EPS through the study performed by Cebr will be inspiring for the future, both at the European and national levels, making a convincing case for the support for physics in all of its facets, from education to research, to business and industry.

Luisa Cifarelli
President of the European Physical Society

WHAT IS PHYSICS?

Physics is the branch of science concerned with the nature, structure and properties of matter, ranging from the smallest scale of elementary particles, to the Universe as a whole. Physics includes experiment and theory and involves both fundamental research driven by curiosity, as well as applied research linked to technology. Physics often provides the foundations for other disciplines, and plays a central role in many different sectors of industry.



WHAT ARE PHYSICS-BASED INDUSTRIES?

Physics-based industries are defined as those sectors of the European economy where the use of physics – in terms of technologies and expertise – is critical to their existence. This means that the industries considered are those where workers with some training in physics would be expected to be employed and where the activities would be expected to rely heavily on the theories and results of physics to achieve their commercial goals. The list of physics-based industries analysed in this report was obtained from the statistical nomenclature standard NACE (Rev. 2) that is used to classify the different economic activities of the European Union. The analysis here was based on a subset of 77 NACE codes amongst a total of over 700. Those activities considered include to varying degrees the sectors of electrical, civil, and mechanical engineering, energy, information technology and communications, design and manufacturing, transportation, medicine and related life-science fields, and technologies used in space. These are listed on the inside back cover of this Summary. Depending on the particular datasets analysed in different parts of this study, the size and importance of physics-based industries to the wider European economy were estimated using different comparators of 'business economy' and 'whole economy'. The latter represents a larger comparator than the former which does not include, for example, agriculture, financial, public administration and other non-market services. Under NACE (Rev. 2), there are 65 broad industry categories in the 'whole economy', 49 of which are covered by the 'business economy'. Complete details of methodology are provided in the full Cebr report.

AT A GLANCE

€3.8 trillion

In 2010, physics-based industries generated €3.8 trillion of turnover, representing over 15% of total turnover within Europe's business economy. Turnover per person employed in the physics-based sector substantially outperforms the construction and retail sectors.

€47 billion

The European physics-based sector is highly R&D intensive. Physics-based sector expenditure on R&D exceeded €47 billion every year over the period 2007-2010. R&D investment levels in 2010 exceeded those in 2007.

15.4 million

In 2010, physics- based industries employed 15.4 million people. This is over 13% of total employment within Europe's business economy. Moreover, for every job created in physics-based industries, a total of 2.73 jobs are supported in the whole economy by these industries.

44.9%

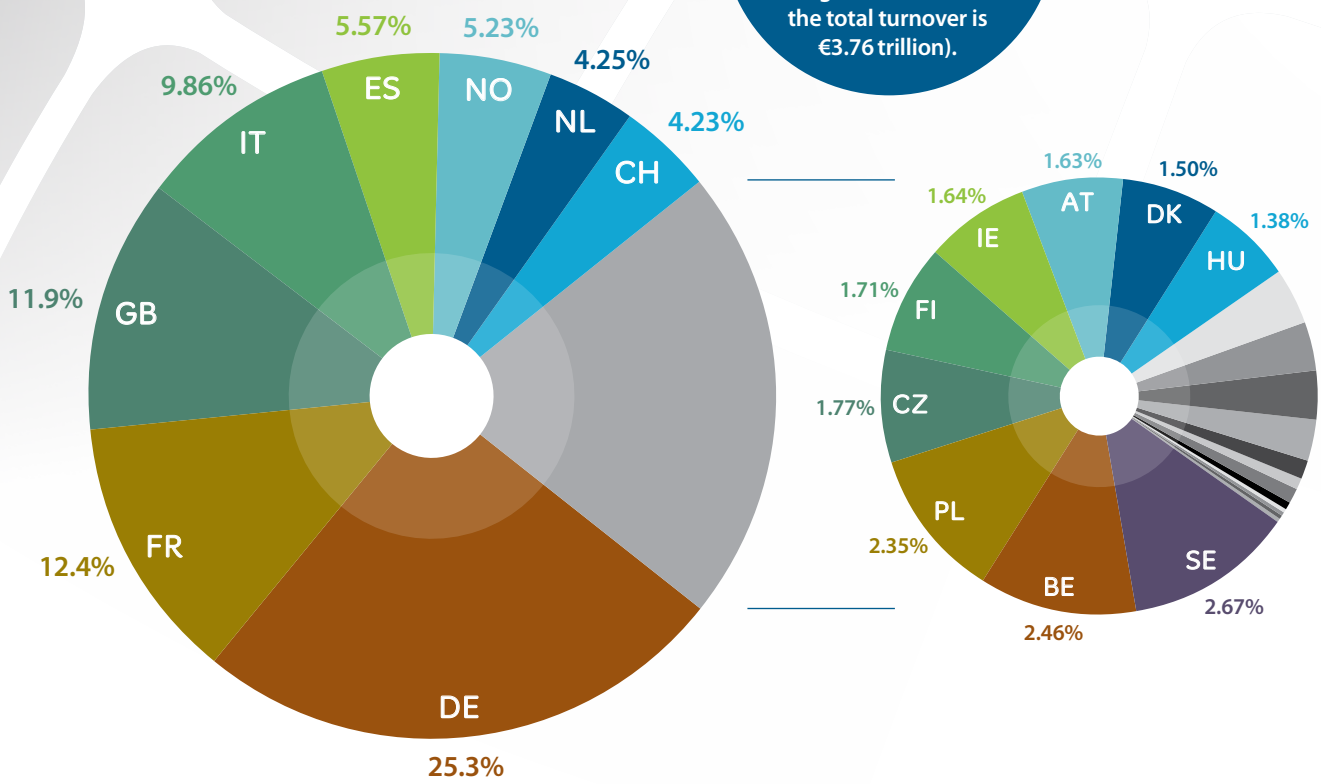
Gross Value Added (GVA) measures the value produced by a sector of the economy. Physics-based GVA is diverse. 44.9% comes from manufacturing, but more than 50% is spread between information & communication, professional, scientific & technical activities, oil & gas activities, and energy production.

INTRODUCTION

This Summary describes an analysis of the contribution of the scientific discipline of physics to the economies of Europe over the four year period 2007-2010 inclusive. The analysis has been prepared by the Centre for Economics and Business Research (Cebr) in order to provide the European Physical Society with an assessment of the importance of physics to the economies of Europe.

The focus of this report is the 27 countries of the European Union (EU27), together with Norway and Switzerland, two of the four members of the European Free Trade Association (EFTA). Unless otherwise indicated, the term **Europe** will be used throughout this Summary to refer to these 29 countries. The report examines the economic contributions of physics using many different measures of economic growth and prosperity, and is based entirely on data that is in the public domain, primarily through Eurostat, the European Union's Statistical Service. The research highlights the value generated by **physics-based industries** to the economic prosperity of Europe.

FIGURE 1
Contribution of the different countries in Europe to turnover from physics-based industries (using 2010 data where the total turnover is €3.76 trillion).



PT	0.85%
RO	0.80%
SK	0.77%
GR	0.61%
SI	0.30%
BG	0.22%
LU	0.20%
EE	0.11%
LT	0.08%
LV	0.06%
CY	0.06%
MT	0.02%

PHYSICS CONTRIBUTES SIGNIFICANTLY TO THE ECONOMIES OF EUROPEAN COUNTRIES AND TO THE EUROPEAN ECONOMY AS A WHOLE

The turnover (or revenue) of the physics-based industries within Europe has exceeded €3.40 trillion in every year of the period 2007-2010. The maximum turnover of nearly €4 trillion was in 2008, falling to €3.48 trillion in 2009 as the effects of the global economic downturn were felt, but recovering healthily by 8% to €3.76 trillion in 2010.

The physics-based sector typically accounts for over 15% of the total turnover of the EU27 business economy, which is more than the gross turnover contribution of the entire retail sector. Figure 1 shows the percentage distribution of physics-based turnover between the different countries of Europe for the year 2010. The major economies of Western Europe clearly dominate. Similar geographical distributions are observed for all other years in the period of study.

Gross Value Added (GVA) is a measure of the value generated in the production of goods by particular sectors of the economy, analogous to GDP. The GVA of the physics-based sector within Europe has sizably exceeded €1.25 trillion in each year of the period 2007-2010, except for 2009 during the economic downturn when GVA contracted to just under €1.16 trillion. The physics-based sector contributes about 11% of the total GVA of the EU27 economies, a greater fraction than either the construction, financial or retail sectors.

PHYSICS CREATES OVER 15 MILLION HIGHLY PRODUCTIVE JOBS IN EUROPE

Employment of people in physics-based sector within Europe exceeded 15.3 million people in every year of the period 2007-2010. Maximum employment of 15.9 million was in 2008, falling to 15.3 million in 2009 following global trends and remaining at a similar level in 2010.

This level of employment represents more than 13% of Europe's total business economy employment.

Employment and GVA data can be combined to estimate **workforce productivity** in the physics-based sector compared with other sectors within Europe. The period 2007-2010 saw an average GVA per employee of €81,600 per annum. This level is higher than for the manufacturing sector and substantially outperforms the construction and retail sectors. Figure 2 compares the GVA per employee contribution of physics with other sectors of the European economy.

Turnover per employee in the physics-based sector over the same period averaged €240,000 per annum. This also compares very favourably to other sectors and is almost twice the equivalent figure for the construction industry. The physics-based sector can therefore be viewed as a highly productive part of the European economy.

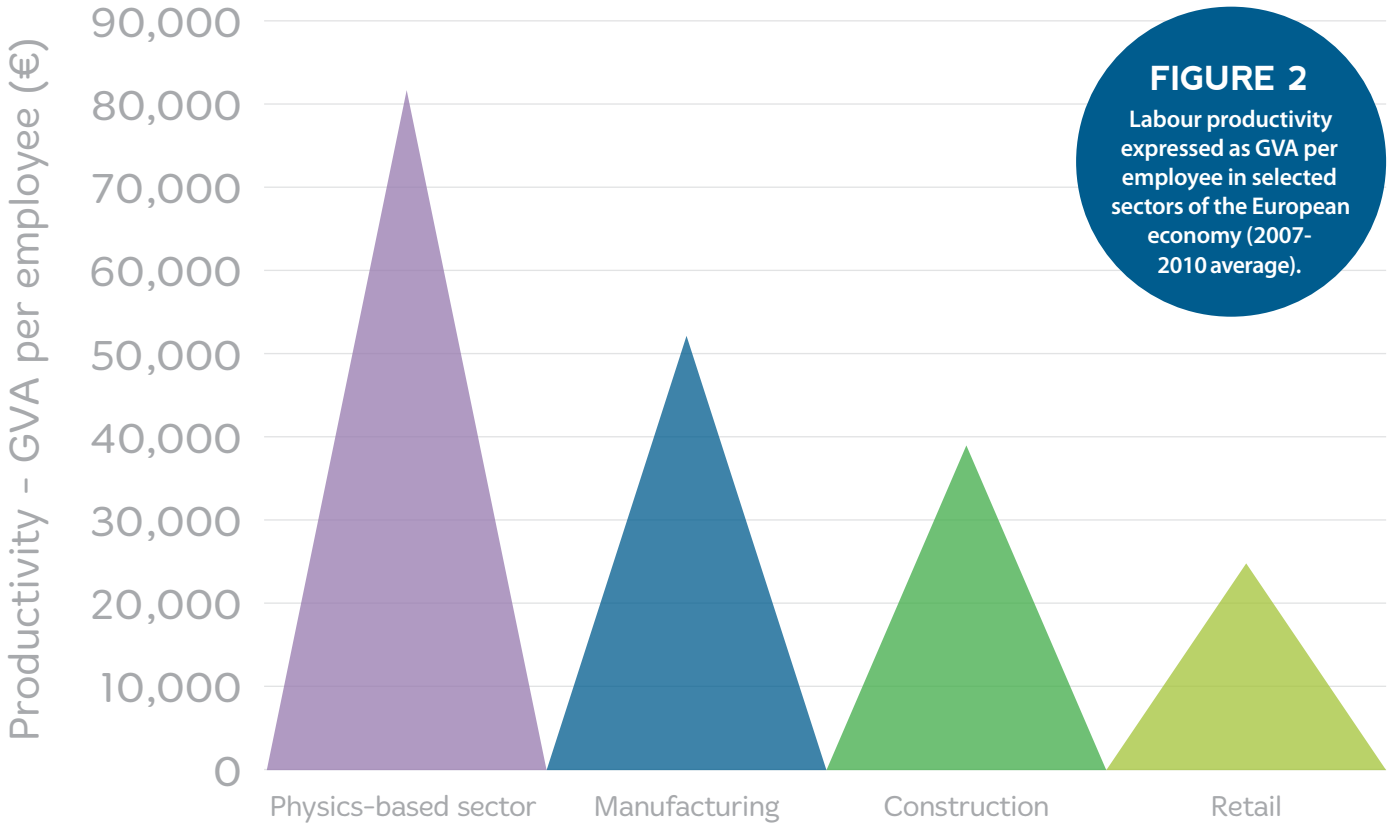


FIGURE 2
Labour productivity expressed as GVA per employee in selected sectors of the European economy (2007-2010 average).

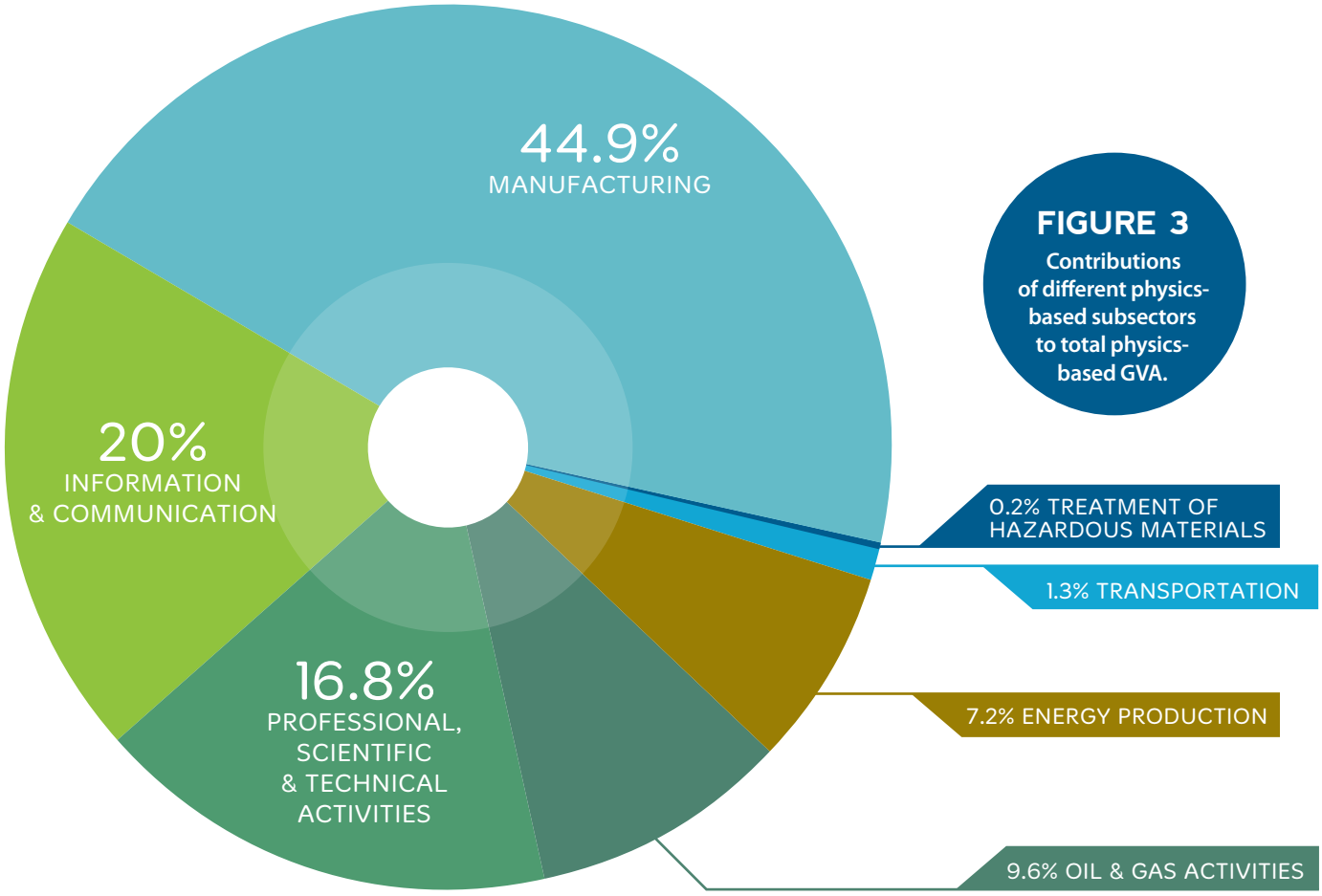


FIGURE 3
Contributions of different physics-based subsectors to total physics-based GVA.

PHYSICS CONTRIBUTES TO A DIVERSE RANGE OF ACTIVITIES

It is important to understand that **different sub-sectors of physics-based industry** contribute different levels of added value. Averaged over the 2007-2010 period, the three major contributions to physics-based GVA in Europe were from manufacturing (44.9%), information & communication (20.0%), followed by professional, scientific & technical activities in physics-based fields such as architecture, engineering and R&D (16.8%). This distribution can be seen in Figure 3.

Similar distributions are observed in employment data. Averaged over the period 2007-2010, the dominant areas of physics-based employment were manufacturing (55%), information & communication (12%), and professional, scientific & technical activities in fields where physics is important such as architecture, engineering and R&D (27%). In the years 2007-2010, the variation in physics-based employment in manufacturing suggests that manufacturing activities utilising some degree of physics are becoming more important in the overall manufacturing sector within Europe.

Other physics-based sub-sectors contributing to GVA and employment are transportation, energy production, oil & gas activities, and the treatment of hazardous materials.

MULTIPLIER IMPACTS

The activities of physics-based sectors also impact on the wider economy. For example, the production of physics-based goods and services can have a significant knock-on 'upstream' effect throughout the supply chain when, for example, a physics-based enterprise purchases other goods and services as inputs for their own business. This and other effects are summarised by a **multiplier on output, GVA and employment**.

In the case of output, this means that for every €1 increase in physics-based output, the economy-wide increase in output is €2.28 within the EU27. For GVA, the multiplier effect is greater: for every €1 increase in physics-based GVA, the economy-wide GVA increase is €2.49. The employment multiplier is higher again at 2.73, which means that for every job created in physics-based industries, a total of 2.73 jobs are supported in the economy as a whole by these industries.

BUSINESS STARTUPS AND FAILURES

Analysis of business startup (birth) and failure (death) rates within the EU27 show a slight decline in physics-based enterprise creation over the period 2007-2009. In 2007, **new physics-based enterprises** were created at a rate of 10.1%, implying around 10 new startups for every 100 existing physics-based enterprises. By 2009 however, this rate had declined to 9.4%. Note that this latter figure is slightly lower than the 9.9% birth rate across all sectors of the European economy, and may suggest greater entry barriers (*e.g.* the need for higher initial investment) than for other sectors in the wider economy. The observed trend in the creation of physics-based enterprises over the period 2007-2009 was also accompanied by an increase in physics-based enterprise insolvency rates over the same period from 7.9% to 9.7%.

However, it is important to note that insolvency rates amongst physics-based enterprises remains markedly lower than in the total European economy which was approaching a 10.5% rate in 2009 for example. This suggests that physics-based industries are more resilient in comparison to the wider economy.

INVESTMENT AND R&D

Research and development (R&D) activities are an important investment function in the economy, leading to innovation in new technologies and products and generating economy-wide growth. Unsurprisingly, the European physics-based sector is highly R&D intensive. Physics-based sector **expenditure on R&D** within the EU27 exceeded €47 billion in every year of the period 2007-2010. The maximum R&D expenditure of €48.8 billion was in 2008, falling to €47.4 billion in 2009 and recovering to €48.2 billion in 2010 and, therefore, recovering to above the 2007 level. Note also that in fact, these numbers most likely underestimate the full R&D intensity of the sector as they do not include internal (in-house) R&D costs.

INTERNATIONAL EXPORTS

It is interesting to compare how the contribution of physics-based goods and services to total exports in Europe compares with similar data for other major international economies. Figure 4 compares the EU27's **physics-based exports** with those of selected other countries, illustrating the proportion of overall exports that physics-based products and services account for. Note that the estimates do not all refer to the same year due to constraints of data availability.

From a European perspective, the key information is that physics-based goods and services contributed over 35% of all exports from the EU27 in 2008.

CONCLUDING REMARKS

The detailed analysis performed by Cebr over the 2007-2010 period allows the role that physics makes to the European economy to be meaningfully compared to other sectors such as manufacturing, construction and retail. Using analysis of measures such as turnover, GVA, employment and multiplier impacts, the summary presented above clearly highlights the **importance of physics to the European economy**. It is clear that businesses in physics-based sectors contribute significantly to employment, innovation and growth in Europe.

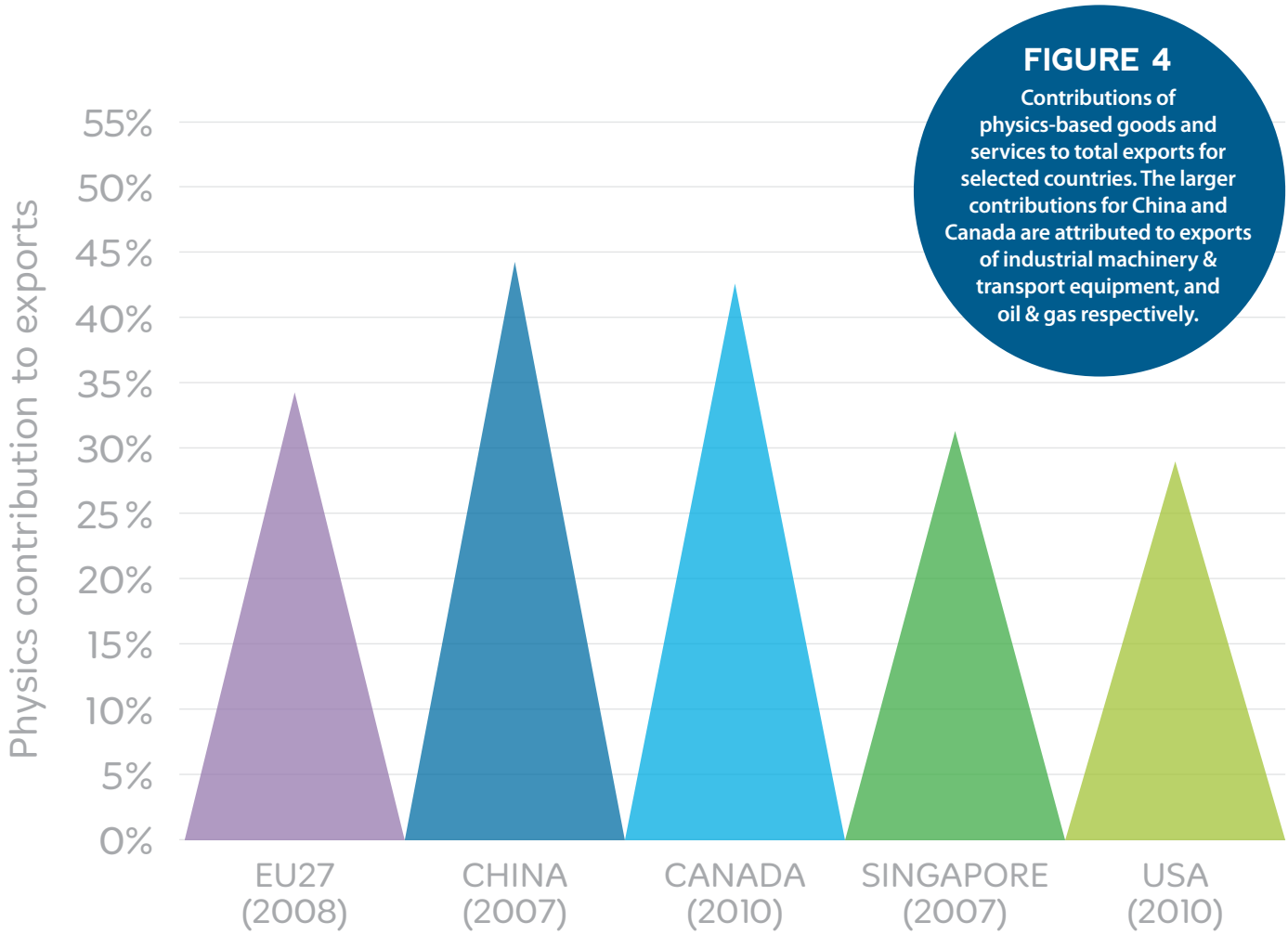


FIGURE 4
Contributions of physics-based goods and services to total exports for selected countries. The larger contributions for China and Canada are attributed to exports of industrial machinery & transport equipment, and oil & gas respectively.

NACE (REV. 2)-BASED DEFINITION OF PHYSICS-BASED ACTIVITIES USED IN THIS STUDY

CODE	DESCRIPTON	CODE	DESCRIPTON
6.1	Extraction of crude petroleum	30.11	Building of ships and floating structures
6.2	Extraction of natural gas	30.2	Manufacture of railway locomotives and rolling stock
9.1	Support activities for petroleum and natural gas extraction	30.3	Manufacture of air and spacecraft and related machinery
20.13	Manufacture of other inorganic basic chemicals	30.4	Manufacture of military fighting vehicles
21.2	Manufacture of pharmaceutical preparations	30.91	Manufacture of motorcycles
23.44	Manufacture of other technical ceramic products	32.5	Manufacture of medical and dental instruments and supplies
24.46	Processing of nuclear fuel	32.99	Other manufacturing n.e.c.
25.21	Manufacture of central heating radiators and boilers	33.11	Repair of fabricated metal products
25.3	Manufacture of steam generators, except central heating hot water boilers	33.12	Repair of machinery
25.4	Manufacture of weapons and ammunition	33.13	Repair of electronic and optical equipment
25.99	Manufacture of other fabricated metal products n.e.c.	33.14	Repair of electrical equipment
26.11	Manufacture of electronic components	33.15	Repair and maintenance of ships and boats
26.12	Manufacture of loaded electronic boards	33.16	Repair and maintenance of aircraft and spacecraft
26.2	Manufacture of computers and peripheral equipment	33.17	Repair and maintenance of other transport equipment
26.3	Manufacture of communication equipment	33.2	Installation of industrial machinery and equipment
26.4	Manufacture of consumer electronics	35.11	Production of electricity
26.51	Manufacture of instruments and appliances for measuring, testing and navigation	38.12	Collection of hazardous waste
26.6	Manufacture of irradiation, electromedical and electrotherapeutic equipment	38.22	Treatment and disposal of hazardous waste
26.7	Manufacture of optical instruments and photographic equipment	51.22	Space transport
26.8	Manufacture of magnetic and optical media	52.21	Service activities incidental to land transportation
27.11	Manufacture of electric motors, generators and transformers	52.22	Service activities incidental to water transportation
27.12	Manufacture of electricity distribution and control apparatus	52.23	Service activities incidental to air transportation
27.2	Manufacture of batteries and accumulators	60.1	Radio broadcasting
27.31	Manufacture of fibre optic cables	60.2	Television programming and broadcasting activities
27.32	Manufacture of other electronic and electric wires and cables	61.1	Wired telecommunications activities
27.33	Manufacture of wiring devices	61.2	Wireless telecommunications activities
27.4	Manufacture of electric lighting equipment	61.3	Satellite telecommunications activities
27.51	Manufacture of electric domestic appliances	61.9	Other telecommunications activities
27.9	Manufacture of other electrical equipment	62.09	Other information technology and computer service activities
28.11	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	71.11	Architectural activities
28.21	Manufacture of ovens, furnaces and furnace burners	71.12	Engineering activities and related technical consultancy
28.23	Manufacture of office machinery and equipment (except computers and peripheral equipment)	71.2	Technical testing and analysis
28.25	Manufacture of non-domestic cooling and ventilation equipment	72.11	Research and experimental development on biotechnology
28.29	Manufacture of other general-purpose machinery n.e.c.	72.19	Other research and experimental development on natural sciences and engineering
28.49	Manufacture of other machine tools	72.2	Research and experimental development on social sciences and humanities
28.92	Manufacture of machinery for mining, quarrying and construction	74.2	Photographic activities
28.99	Manufacture of other special-purpose machinery n.e.c.	74.9	Other professional, scientific and technical activities n.e.c.
29.1	Manufacture of motor vehicles	95.12	Repair of communication equipment
29.31	Manufacture of electrical and electronic equipment for motor vehicles		

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