March 2019

The Global Chemical Industry: Catalyzing Growth and Addressing Our World's Sustainability Challenges

Report for ICCA

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March 2019

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Executive summary

The chemical industry has been an integral part of the global economic landscape for many centuries.[1] The first chemical plants were built in Europe during the industrial revolution, when chemical processes for making concrete and waterproof clothing were devised. Since then, the industry has evolved to become a bastion of productivity that permeates through nearly every good-producing sector.

Today, the chemical industry plays a crucial role in regional economies in every corner of the world—and in most sectors of those economies. As the manufacturer of innovative, life-enhancing products and technologies, it is also central to achieving the global targets expressed in many of the United Nations' 17 Sustainable Development Goals (SDGs). The industry produces a huge range of finished products for general consumption, including:

- fertilizers, pesticides, and other agrochemical products that play a crucial role in feeding a growing global population;
- LED lighting which results in substantial power savings; and
- roof and window coatings, used to improve insulation levels as part of climate change mitigation efforts.

The industry also produces key inputs, and enables processes, for other manufacturing activities that benefit living standards and consumers around the world. These include:

- water chemistry, enabling the treatment, delivery, and conservation of clean drinking water that is critical to a number of SDGs;
- plastics used for packaging, which plays a major role in protecting fresh, processed and prepared food, extending its shelf life; and
- man-made fibers, such as nylon and polyester.

In addition to these products and processes, the chemical industry is committed to the sound management of chemical substances—as encapsulated by the adoption of the Strategic Approach to International Chemicals Management (SAICM) in 2006. Sound management of chemical substances represents another way in which the industry is contributing to sustainable development around the world. Moreover, through "circular" initiatives, the chemical sector can more effectively recycle and reuse molecules to produce consumable products, while reducing waste and creating new value to society.

$5.7 trillion

The chemical industry's total contribution to global GDP in 2017.

Equivalent to seven percent of the world's GDP that year.

The International Council of Chemical Associations (ICCA) commissioned Oxford Economics to provide a detailed assessment of the chemical industry's activities across the globe, and to quantify their total economic impact. The findings outlined in this report paint an important picture of the industry's contribution to the global economy, and in so many aspects of people's daily lives. While our modeling framework covers 34 industries and 58 countries worldwide, the final results are scaled up to account for the entire world, using each country's GDP share within its region.

1 This report identifies the chemical industry according to the European Community definition in NACE Rev. 2 Division 20: i.e. "Manufacture of chemicals and chemical products". This excludes the manufacture of coke and refined petroleum products (Division 19) and the manufacture of pharmaceutical products (Division 21). However, the manufacture of petrochemicals from refined petroleum is classified in Division 20.

Our analysis focuses on two key measures of economic value: the number of jobs sustained each year by the global chemical industry, and its contribution to the amount of gross domestic product (GDP) that different nations generate. These metrics are at the heart of SDG 8, which targets inclusive and sustainable economic growth, full and productive employment, and decent work for all.

As well as directly creating jobs and economic activity in virtually every country of the world, the chemical industry sustains further employment and growth via "multiplier effects" in the countries' wider economies. To quantify these contributions, we conducted an economic impact assessment, which takes into account the industry's impact across three channels of influence:

- **Direct impact**—the chemical industry's own activities, such as the GDP it generates and the number of people it directly employs each year;
- **Indirect impact**—the activity and employment supported in the industry's broad supply chain, through its procurement of goods and services;
- **Induced impact**—the wider economic benefits that arise when workers within the global chemical industry and its supply chain spend their earnings—for example, in local retail and leisure establishments.[2]

120 million

Total number of jobs supported by all aspects of the global chemical industry in 2017.

This almost equates to the population of Mexico.

The economic value of the global chemical industry

Our global analysis finds that the chemical industry, its supply chain and payroll-induced impacts, made an estimated $5.7 trillion contribution to world GDP in 2017, and supported 120 million jobs. Its economic contribution was therefore equivalent to seven percent of the world's total GDP that year, while its employment contribution was broadly on a par with the population of Mexico.

Of this total, the chemical industry itself is found to have directly added $1.1 trillion to global GDP in 2017, while directly employing 15 million people. This makes it the fifth-largest global manufacturing sector, in terms of its direct annual contribution to GDP (making up 8.3 percent of global manufacturing's total economic value). Comparing the chemical industry's direct and total employment impacts implies that, for every person directly employed in the industry, seven jobs are supported elsewhere in the global economy. In terms of GDP, we find that for every $1 generated by the industry itself, a further $4.20 is generated elsewhere in the global economy.

We estimate that companies in the chemical industry spent $3.0 trillion with their suppliers in 2017, buying goods and services used in the manufacture of their products. Almost two-thirds of this amount was spent by chemical companies in the Asia-Pacific region. This supply chain spending (indirect impact) supported an estimated $2.6 trillion contribution to global GDP in 2017, and 60 million jobs—spread across goods and services providers in a wide range of industries, from mining to wholesale trade.

In addition, staff employed by the sector and in its supply chain earn wages that are spent in the consumer economy, thus supporting further economic activity. The chemical industry paid an estimated $313 billion in gross wages globally in 2017. After paying taxes, employees in the chemical industry are estimated to have earned $239 billion

2 The indirect and induced contributions were estimated using Oxford Economics' Global Economic Impact Model (GEIM), which captures both within-country and cross-country impacts of supply chain and wage-financed expenditure. In other words, our modeling takes a comprehensive view, ensuring that none of the impact of cross-border trade is lost, and that "feedback effects" from complex cross-country trade patterns are captured.

in net wages. When the spending of workers in its supply chain and the consumer economy is added to this, we estimate that a $2.0 trillion GDP contribution was sustained through all wage-consumption channels in 2017 (the chemical industry's induced impact). This spending is estimated to have supported 45 million jobs globally that year.

Dividing our analysis into five global regions, we find that the Asia-Pacific chemical industry made the largest annual contribution to GDP and jobs in 2017. Our model shows it generated 45 percent of the industry's total annual economic value, and 69 percent of all jobs supported (see Fig. 1). Europe made the next most important contribution globally, followed by North America.

Finally, chemical manufacturers also invest heavily in research and development (R&D) throughout the world. The global chemical industry invested an estimated $51 billion in R&D in 2017, and we calculate that this spending supported 1.7 million jobs and $92 billion in economic activity in that year alone.

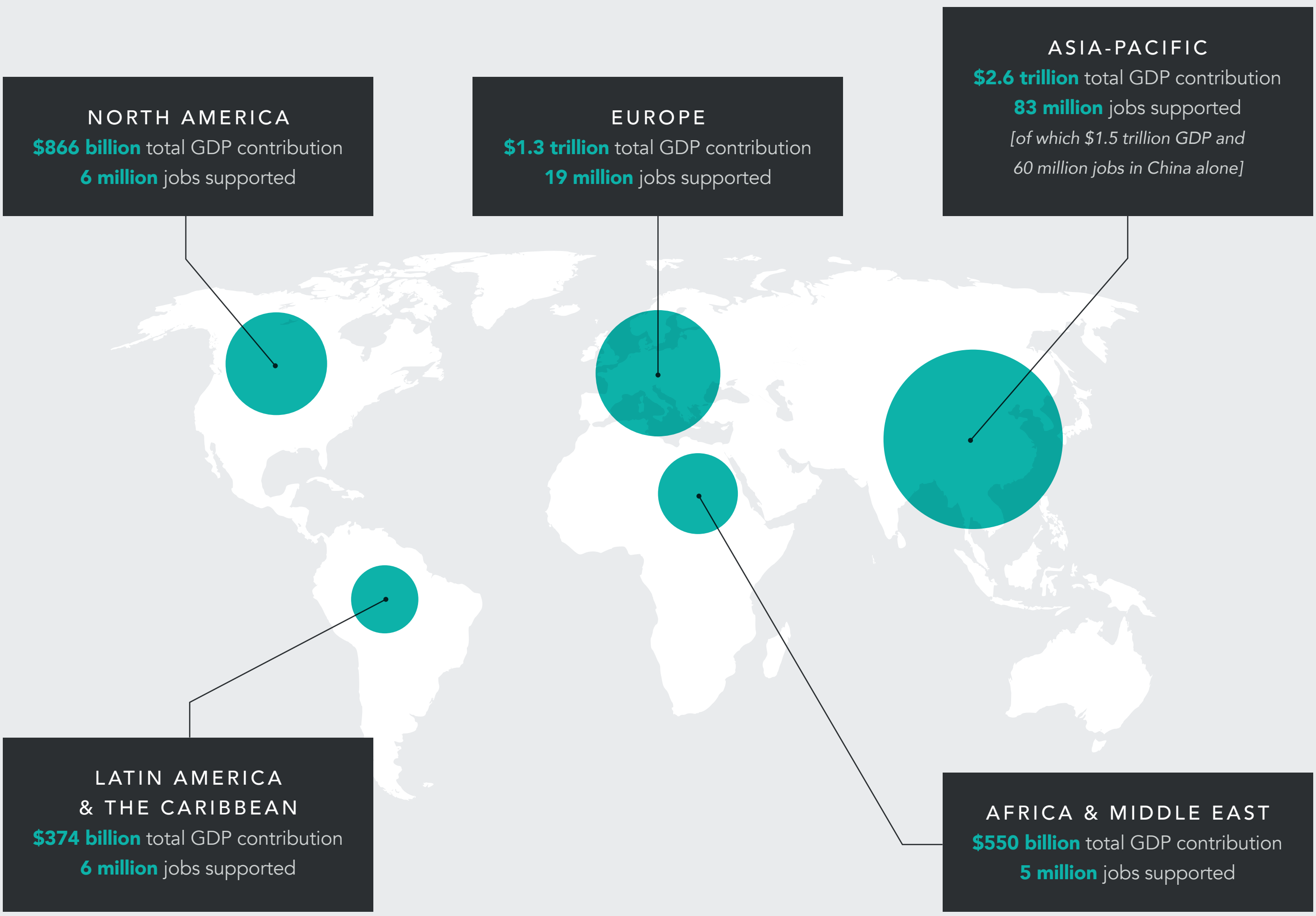
$51 billion

Total amount spent on R&D by the global chemical industry in 2017.

This spending supported a $92 billion GDP contribution, and 1.7 million jobs.

FIG. 1.

Total global economic impact by region, 2017



Introduction

The chemical industry has had a longstanding presence worldwide, providing inputs into manufacturing activities that benefit living standards across the globe, while also contributing to addressing a variety of global sustainability challenges.

The International Council of Chemical Associations (ICCA) estimates that over 95 percent of all manufactured goods rely on some form of industrial chemical process. Most industry sectors make use of chemical products, from energy generation and transportation, to ICT and construction. From developing ammonia-based fertilizers to providing clean drinking water, some innovations have turned the tide of human history.

The industry is an important source of skilled employment. It also supports a significant amount of activity and jobs in the wider global economy, as a result of all the money spent on materials and services used in chemical production processes. These inputs range from the natural gas that is needed to produce fertilizers, to the transportation equipment to move raw materials and products, to consultancy services which assess chemical companies' returns and audit books.

This report, commissioned by the ICCA, aims to examine the full extent of this "economic footprint"—whereby production of chemical products supports activity not just in the industry itself (direct impact), but in a wide range of other sectors through knock-on supply chain (indirect impact supported through procurement of intermediate goods) and wage-financed effects (payroll-induced impact sustained via consumption spending of workers employed by the industry and its suppliers). These three channels of impact are described in more detail in the Methodology box at the end of this chapter.

What do we mean by the chemical industry?

We use the definition as outlined in Division 20 of Eurostat's NACE Rev. 2; i.e. "Manufacture of chemicals and chemical products". This includes the following sub-sectors:

- Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms;
- Manufacture of pesticides and other agrochemical products;
- Manufacture of paints, varnishes and similar coatings, printing ink and mastics;
- Manufacture of soap, detergents, cleaning, polishing, perfumes and toilet preparations;
- Manufacture of other chemical products, including explosives and pyrotechnic products, glues, essential oils and chemical products not elsewhere classified (e.g. photographic chemical material, composite diagnostic preparations, etc);
- Manufacture of man-made fibers.

The chemical industry's contribution to sustainable development*

The 2030 Agenda for Sustainable Development, and its 17 associated Sustainable Development Goals (SDGs), were adopted by the General Assembly of the United Nations in September 2015. The goals aspire to overcome poverty while protecting the planet, stressing a vision of sustainable growth that encompasses economic, social, and environmental aspects.

Sound management of chemical substances is a specific focus under SDG 12 on sustainable consumption and production—and this is also the mission of the Strategic Approach to International Chemicals Management (SAICM), a policy framework to promote chemical safety around the world that was adopted by the industry in 2006.

SDG 12 requires a systematic approach throughout the lifecycle of chemicals, and hence demands cooperation across actors throughout the supply chain, from producers to final consumers. Target 12.4 calls for achieving the "environmentally sound management of chemicals and all wastes throughout their lifecycle, in accordance with agreed international frameworks, and for significantly reducing their release to air, water and soil". This goal is set for achievement by 2020, in keeping with the overall SAICM target year.

Since chemicals touch each aspect of development, their sound management supports the completion of many other SDGs. Indeed, chemicals, waste and air quality are also referred to under: SDG 3 (good health and well-being); SDG 6 (clean water and sanitation); SDG 7 (affordable and clean energy); SDG 11 (sustainable cities and communities); and SDG 14 ("life below water").

Sound chemicals management represents only a fraction of the industry's contribution to achieving the 17 SDGs. Many of the products and processes developed by the industry have substantial positive impacts on global development. Examples include:

- Fertilizers, pesticides, and other agrochemical products that play a crucial role in feeding the global population, while also contributing to SDG 15 to promote sustainable use of terrestrial ecosystems;
- LED lighting, resulting in substantial power savings and supporting SDG 9, to "build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation";
- Roof and window coatings, used to improve insulation levels as part of climate change mitigation efforts, and also contributing to the achievement of SDG 9;
- Water chemistry, enabling the treatment, delivery and conservation of clean drinking water, and therefore contributing to several SDGs including Goal 1 ("end poverty in all its forms everywhere"), and Goal 6 ("ensure availability and sustainable management of water and sanitation for all"); and
- Plastics used for packaging, which plays a major role in protecting fresh, processed and prepared food, extending its shelf life and contributing to SDG 2 (zero hunger).

* While the chemical sector improves lives and health of communities—in part through its attention to SDGs and its adoption of SAICM—the measurable and tangible economic benefits of these improvements are not quantified in this study. Subsequent economic modeling that quantifies key areas of social and community benefits would provide deeper context of the social value of the chemical sector.

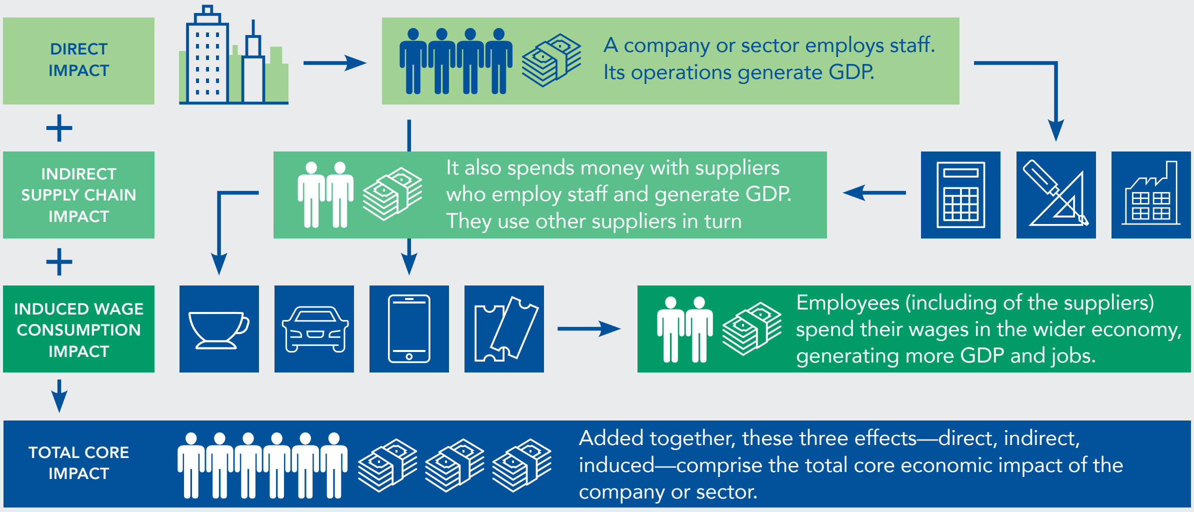
Economic impact modeling: methodology

Economic impact modeling is a standard tool used to quantify the economic contribution of an industrial sector, company, or investment project. Impact analysis traces the economic impact of a sector's activities through three separate channels:

- **Direct impact**—the activity of the global chemical industry itself.
- **Indirect impact**—the activity across the globe that is supported as a result of the procurement of goods and services by the chemical industry.
- **Induced impact**—the activity across the world supported by the spending of the chemical industry's workforce, and by the spending of workers in the sector's supply chain.

FIG. 2.

The three channels of economic impact



The sum of these channels makes up the industry's total economic impact. The sector's economic footprint is presented and quantified with three key metrics:

- **GDP**, or more specifically, the chemical sector's gross value added (GVA) contribution to GDP. This can be understood as either: 1) the value of output (goods or services) less the value of all inputs used in the production process; or 2) the sum of compensation of employees plus gross operating surplus (profits).
- **Employment**, the number of people employed, measured on a headcount basis.
- **Income**, the compensation paid to workers within the industry, the industry's supply chain and induced wages paid to workers in consumer industries.

The modeling is conducted using an Input-Output (I-O) based model of the global economy, and its countries and regions. This model was constructed by Oxford Economics, using national accounts' data published by the OECD. Further detail about the economic impact methodology is included in Appendix 2, at the end of this report.

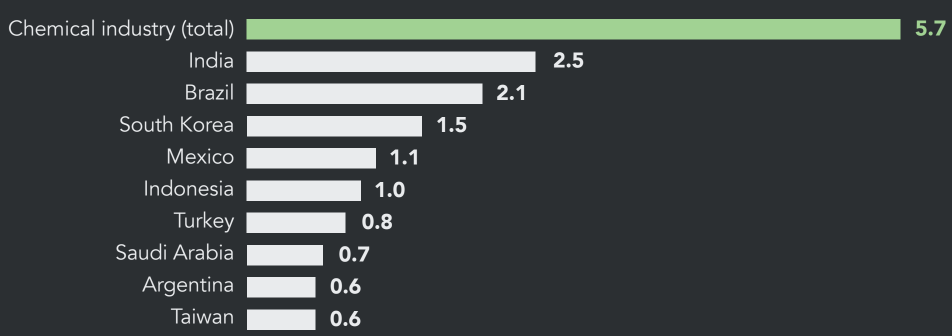
The total economic impact of the global chemical industry

This chapter describes the chemical industry's total economic footprint across the world. To estimate this, we take into account not only the size of the industry itself (its direct impact), but also its indirect and induced impacts, which relate to economic activity in its supply chain—including complex international linkages—and wage-funded staff spending, respectively.

The chemical industry's global economic impact in 2017 was substantial. We estimate its total annual contribution to global GDP was $5.7 trillion, sustained through a combination of its direct, indirect, and induced economic channels. This equates to 7.1 percent of the world's GDP in 2017. To give a sense of scale, this impact was roughly equivalent to the combined annual GDPs of India, Brazil, and Mexico—three of the largest developing economies in the world (see Fig. 3).

FIG. 3.

The global chemical industry's economic footprint in context, 2017 ($ trillion)



Source: Oxford Economics

7.1 percent

Proportion of global GDP supported by the chemical industry across the three channels of impact in 2017.

Equivalent to the combined annual GDPs of India, Brazil, and Mexico.

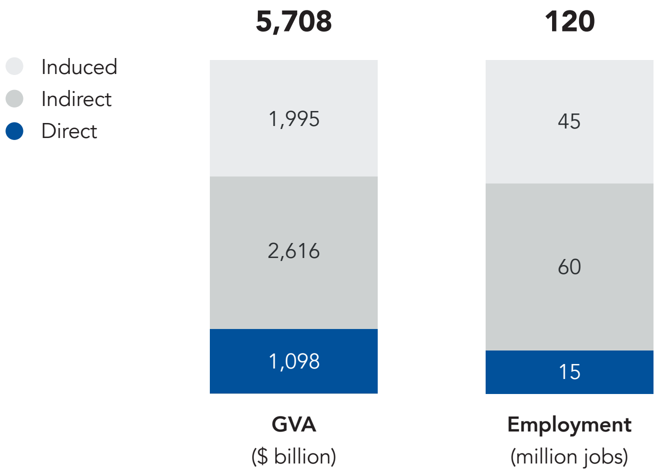
We find the global chemical industry supported a total of 120 million jobs both directly and through its "multiplier channels" in 2017. This is almost equivalent to the entire population of Mexico.

On average, we calculate that every $1 of gross value added (GVA) created directly by the chemical industry supported an additional $4.20 contribution elsewhere in the global economy in 2017 (see Fig. 4). Furthermore, due to the industry's high levels of productivity, the sector's employment multiplier is even greater. For every employee in the industry itself, we find that seven jobs are supported elsewhere in the global economy.

Each and every sector of the global economy benefits from the existence of the chemical industry, as is shown in Fig. 5, below. When all three channels of impact are accounted for, chemicals manufacturing generates the largest proportion of the industry's total annual GDP ($1.1 trillion), with mining

FIG. 4.

The global chemical industry's economic footprint across the world, by channel of impact, 2017



Source: Oxford Economics

FIG. 5.

The global chemical industry's total GDP contribution by industry, 2017 ($ billion)

and quarrying (including oil and gas extraction), and wholesale and retail trade, generating $0.8 and $0.7 trillion respectively. The remainder is spread across the rest of the economy, with R&D, real estate, financial services, and agriculture all playing important roles.

Direct impacts

Not only do chemical manufacturers transform raw materials into some of the final products consumers use every day, the industry also provides inputs to a broad range of sectors, from agriculture to transportation. In 2017, the chemical industry generated sales (gross output) worth some $4.1 trillion, of which $1.1 trillion represented GVA.

Given that the chemical industry supplies inputs to almost all sectors of the economy, its prosperity also has important implications for downstream chemicals users (i.e., the users and buyers of its products). Beyond chemical manufacturers themselves, the biggest industrial users of chemicals are the rubber & plastics, textiles, construction, computer production, and pulp & paper sectors (see Fig. 6, below). In all, nearly 58 percent of the global chemicals sold to downstream users go to other industrial sectors. The remainder goes to other branches of the global economy such as health and social work, agriculture, and services.

Combining all these revenues, we estimate the chemical industry directly made a $1.1 trillion gross value added contribution to global GDP in 2017. This direct GVA accounted for 27 percent of the industry's total sales.[3] Chemicals are thus the fifth-largest component of the manufacturing sector's total value added, after machinery & equipment, high-tech goods, motor vehicles, and food products (see Fig. 7). To put it in context, this value was equivalent to 1.4 percent of the world's

$1.1 trillion

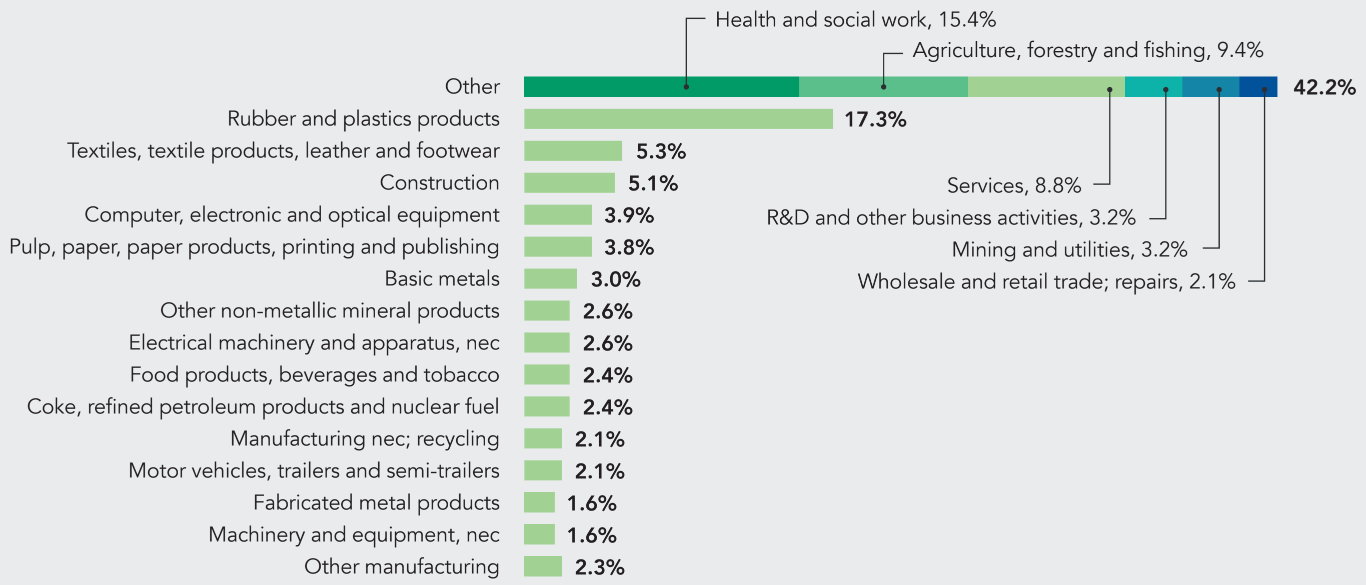
The chemical industry's direct gross value added contribution to global GDP in 2017.

Some 15 million people were directly employed in the industry worldwide.

3 As explained in the modeling methodology box, direct GVA is equal the value of output (sales) less the value of all inputs used in the production process. This implies that the difference between sales ($4.1 trillion) and GVA ($1.1 trillion) was used to procure inputs into the production process. These purchases form the driving force behind the sector's indirect contribution to GVA and jobs, as discussed in the next section.

FIG. 6.

Customer sectors of the global chemical industry (excl. chemical manufacturers)



total GDP in 2017, or roughly the entire GDP of Indonesia that year.

By region, Asia Pacific (APAC) lead the way here, creating 51 percent of the worldwide chemical industry's GVA in 2017. In this region, the industry represented 2.1 percent of total GDP. North America and Europe follow, with 21 and 17 percent of the total, respectively. In both regions, however, the size of the industry is just above one percent of total annual GDP.

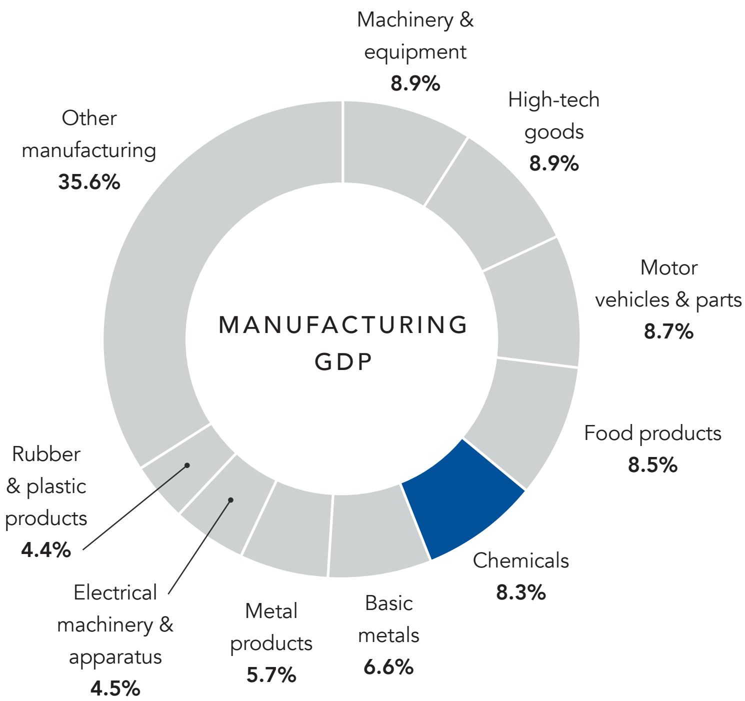
The chemical industry directly employed 15 million people worldwide in 2017—equivalent to the population of Kolkata in India (the 14th largest city in the world).[4] This included over 11 million people in APAC (77 percent of the total), almost 2 million in Europe (11 percent), and over 600,000 in North America (four percent). Indeed, it is estimated that 0.7 percent of all employment in APAC is directly created by the chemical industry.

The global chemical industry's productivity—i.e. the average amount of GVA generated by each

4 World Economic Forum, "These Are the World's Most Populous Cities" <https://www.weforum.org/agenda/2017/10/these-are-the-world-s-most-crowded-cities-a93dbbdf-fa9a-41b7-a215-65b5da9bc21e> [accessed 14 December 2018]

FIG. 7.

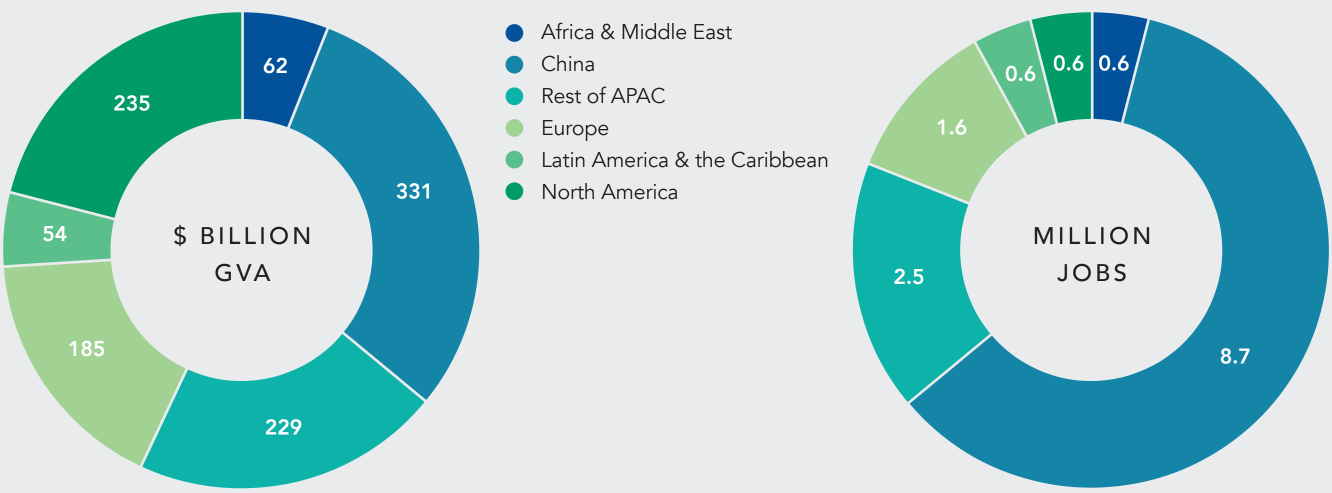
Sectors' direct contributions to GDP as percentages of total global manufacturing, 2017



Source: Oxford Economics

FIG. 8.

Size of the chemical industry by region, 2017



Source: ACC, CEFIC, Oxford Economics

FIG. 9.

The chemical industry's productivity levels by region, 2017*

Region	GVA per worker	Index
Africa & Middle East	108,800	1.45
Asia-Pacific (APAC)	50,000	0.67
Europe	112,600	1.50
Latin America & the Caribbean	92,300	1.23
North America	386,000	5.15
World	75,000	1.00

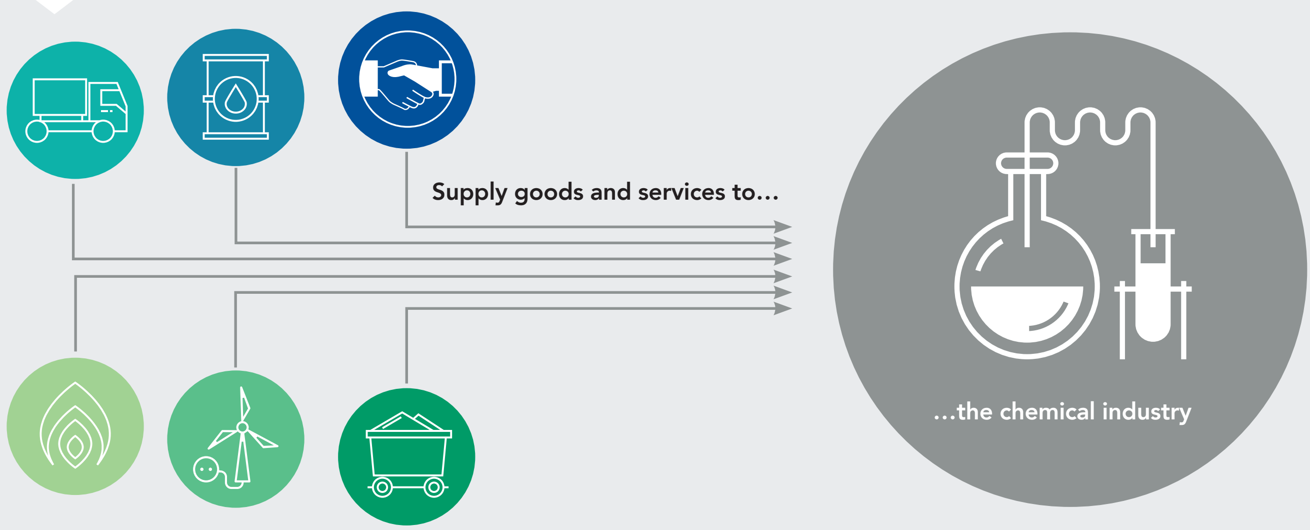
* The Index column benchmarks each region's productivity levels to the world's productivity for the chemical industry. For example, European chemical manufacturers are 1.5 times as productive as the global average.

worker in the industry—was more than $75,000 in 2017. This is some 23 percent above the average for manufacturing as a whole ($61,000 in 2017). Productivity varies widely by region, however, with the average North American chemical worker producing almost eight times as much (in GVA terms) as the average APAC worker.[5]

Indirect and induced impacts

The economic impact of the chemical industry extends much further than just its direct impact. Supply chain and wage-spending economic benefits must also be considered, and these impacts

5 It should be noted that the US uses relatively more contract labor than other regions within chemical manufacture. As this labor is not captured in the employment data, GVA per worker in North America might be artificially inflated. On the other hand, this employment is likely to be included in the indirect impact.



$3.0 trillion

Global supply-chain spend of the chemical industry in 2017.

This spending supported a $2.6 trillion GDP contribution and 60 million jobs globally.

demonstrate the breadth of the industry's upstream economic reach.

The chemical sector spent $3.0 trillion on goods and services from suppliers worldwide in 2017. A third of this spending goes back into the chemical industry (e.g. as chemical firms purchase chemical inputs from other companies to include in their production process), as expected.[6] Other major beneficiaries of the chemical industry's supply-chain spending are mining, including oil and gas extraction (14 percent of the total), and wholesale & retail trade (11 percent).

In regional terms, the Asian chemical industry accounted for $1.9 trillion of these supply-chain purchases, followed by the European industry ($0.6 trillion) and North America ($0.4 trillion).

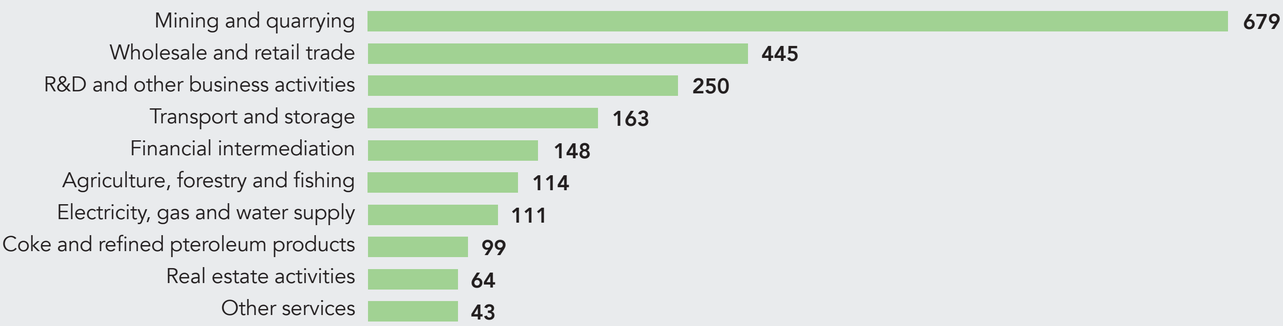
Oxford Economics' global Input-Output model was used to work out the GDP contribution supported through this supply-chain spending. Our model captures both the within-country and cross-country impacts of this expenditure, as it stimulates economic activity across the globe. We find that this supply-chain spending had the greatest impact in the mining, and wholesale & retail sectors, supporting $679 and $445 billion of GVA respectively in 2017 (see Fig. 10). The chemical sector supported a further $250 billion in the R&D & other business activities sector. **Across all non-chemical sectors, we find the supply-chain spending of the chemical industry supported a $2.6 trillion contribution to global GDP in 2017—of which roughly half was in the Asia-Pacific region.**

The industry's supply-chain spending also stimulates high levels of employment. An estimated 60 million jobs were supported through the purchase of goods and services by chemical companies in 2017—three-quarters in Asia-Pacific alone. But the pattern of indirect employment

6 The economic impact generated through indirect and induced channels within the chemical industry itself is not included in our total economic impact calculation, to avoid double counting. The entire value stemming from the chemical industry is accounted for in our direct impact calculation.

FIG. 10.

GDP contribution supported through chemical industry's global supply-chain spending, top 10 industries, 2017 ($ billion)



Source: Oxford Economics

is somewhat different to the pattern of GVA, reflecting the significant variation in labor productivity by industrial sector. For example, the role of the R&D sector (a relatively high-productivity sector) is significantly reduced, while that of wholesale & retail trade (a relatively low-productivity sector) is boosted.

In addition to the indirect channel, payroll-induced impacts reflect the additional GVA and jobs that are supported by the wage-funded expenditure of global chemical industry employees, together with that of workers in the industry's worldwide supply chain. As workers are paid wages, they go out and spend that income on consumer goods and services in the wider economy. **Oxford Economics estimates that the total induced impact amounted to $2.0 trillion in 2017, supporting 45 million jobs.**

The chemical industry paid an estimated $313 billion in gross wages globally in 2017 (see Fig. 11). Average annual labor costs per head ranged from an estimated $144,000 in Belgium, to an estimated $5,000 in Vietnam. In total, after paying taxes, employees in the chemical industry are estimated to have earned $239 billion in net (after tax) wages in 2017—of which they are estimated to have spent $196 billion in the consumer economy, with the remainder being saved.

Note: the pattern of induced GVA (in terms of its impact on different sectors) is heavily influenced by the pattern of household expenditure, and bears no systematic relationship with the sectoral split we saw for the chemical industry's supply-chain (indirect) activity. The mining sector's share of induced GVA is therefore very modest compared with its share of indirect GVA, while the induced shares of real estate activities and agriculture are comparatively higher. The pattern of induced employment is different again, with relative productivity effects boosting the share of agriculture at the expense of real estate services.

In addition to the income received by workers employed directly by chemical companies, the industry also sustains labor income in its supply chain and in the consumer-facing global economy, through the induced channel. **In 2017, we estimate that a further $939 billion and $779 billion in labor income was supported by the chemical industry through its indirect and payroll-induced channels, respectively.**

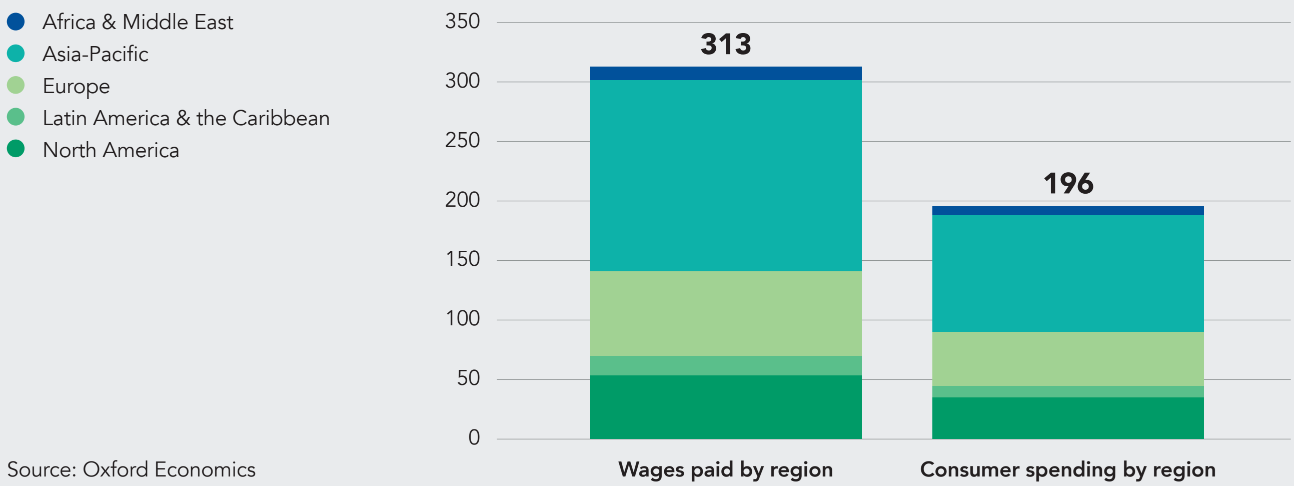
$313 billion

Total gross wages paid by the chemical industry in 2017.

These wages (and those paid in its supply chain) supported a $2.0 trillion GDP contribution and 45 million jobs.

FIG. 11.

The chemical industry's gross wages and consumer spending by region, 2017 ($ billion)



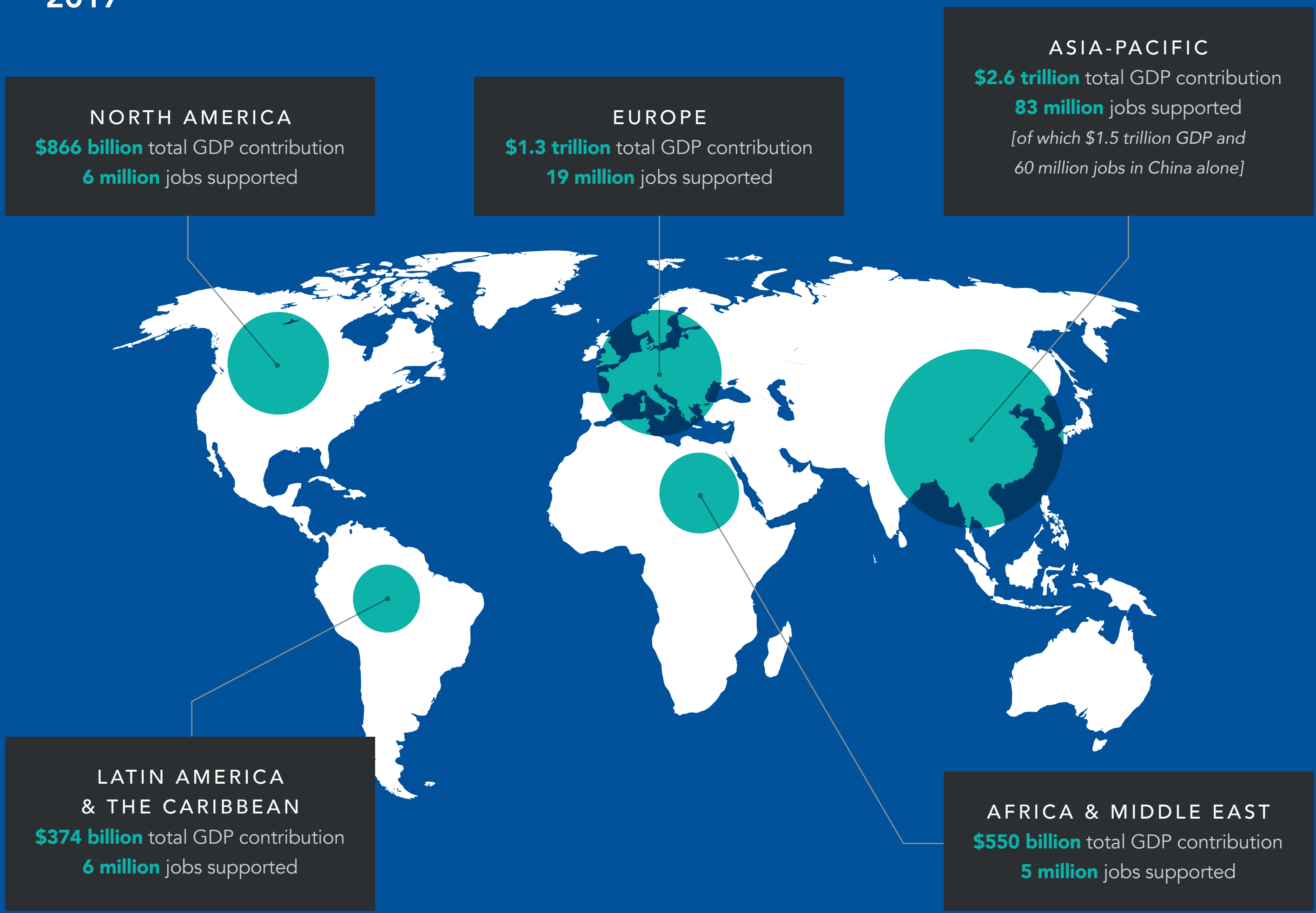
Source: Oxford Economics

Regional analysis

This chapter describes the total economic impacts of the global chemical industry on a region-by-region basis. In terms of contributions to the annual global economy, Oxford Economics estimates that the largest GDP contribution comes from the Asia-Pacific region (45 percent of the world total), followed by Europe (23 percent), and North America (15 percent).

FIG. 12.

Map of the chemical industry's total global economic impact by region, 2017



In value terms, the chemical sector's total GDP contribution ranged from $2.6 trillion in APAC (a greater value than the entire GDP of India) to $374 million in Latin America & the Caribbean (roughly equivalent to the GDP of the Metropolitan Region of São Paulo)—see Fig. 12, overleaf.

As a share of each continent's GVA, the total impact is highest in Africa & the Middle East (where it made up 13 percent of the economy), APAC (10 percent), and Latin America & the Caribbean (eight percent).

The greatest number of jobs supported by the global chemical industry is again in APAC (at 69 percent of the world total, or 83 million jobs), followed by Europe (16 percent, or 19 million jobs) and North America (five percent, or six million jobs).

Thanks to its broad supply chain and vast workforce, the chemical industry is characterized by substantial GVA and employment multipliers. These measure the number of jobs and amount of economic activity supported elsewhere in the region, for every direct job or $1 of direct GVA contribution that is generated by the chemical industry in that region.

We find that employment multipliers for the chemical industry range from six in APAC to 11 in Europe. In GVA terms, the multipliers range from 2.7 in North America to 7.8 in Africa & Middle East.[7]

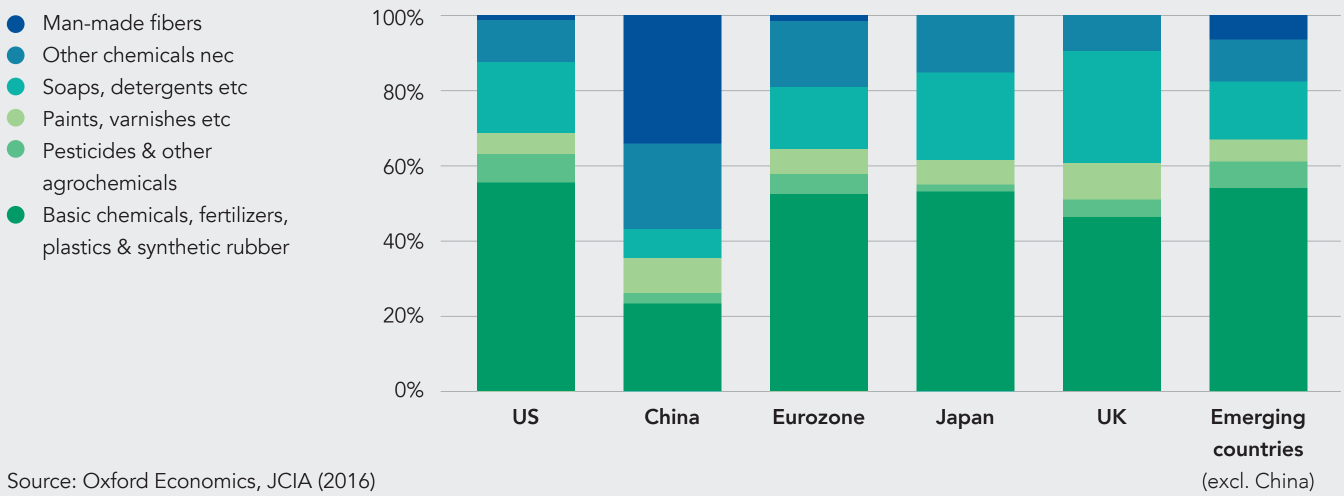
The size of these multipliers depends on a number of factors. For example, if a region has a relatively well-developed supply chain, then chemical firms will not need to import much from other regions, thereby keeping money and intermediate inputs in circulation in the "local" economy for a longer period of time—resulting in larger multipliers for that region.

Other factors include the size of the economy (smaller economies tend to have smaller multipliers); the industry's reliance on intermediate goods (a large supply chain implies large multipliers); average productivity levels;[8] and the mix of chemical products produced in each region (Fig. 13).

7 Note that our results for employment multipliers tend to be larger than for GVA multipliers, as a direct consequence of the chemical industry's high productivity levels in comparison to the rest of the economy.
8 This factor relates to average GVA levels per worker, both within the chemical industry and across the wider economy. High productivity industries tend to display relatively large employment multipliers. In addition, more productive workers are paid more, and therefore have more resources to spend in the particular regional economy, further boosting multiplier effects.

FIG. 13.

Mix of chemical products in selected countries and regions, % of chemical industry's GDP



Source: Oxford Economics, JCIA (2016)

Africa & Middle East

$550 billion

The chemical industry's total contribution to the Africa and Middle East region's GDP in 2017.

This is equivalent to the GDP of Egypt and UAE combined.

The Middle East's chemical industry has grown significantly over the past two decades. Its share of global production virtually doubled between 2000 and 2014, before the drop in oil prices led to a slowdown in economic activity.

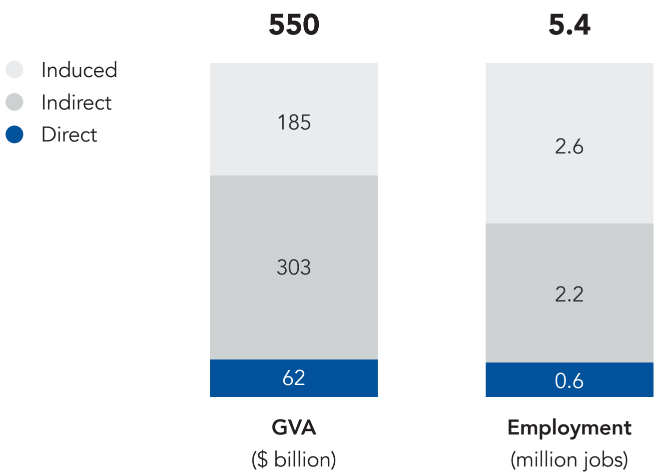
Industrial output in the Middle East is largely focused on the production of refined petroleum (not included in our analysis, but important to highlight) and basic chemicals, particularly petrochemicals, given the easy access to low-cost oil and gas. However, the decline in global oil prices plus stronger competition from countries such as the US, which is benefitting from its shale gas boom, have contributed to efforts to diversify away from purely supplying crude oil, and more towards developing the downstream supply chain. The recently completed Sadara chemicals complex, a joint-venture between Saudi Aramco and Dow Chemical, is a good example of large scale investments which aim to develop the region's downstream chemical sector.

Africa's chemical industry is concentrated in South Africa and Morocco. While upstream activities are concentrated (and well-developed) in South Africa, the downstream sector remains relatively under-developed.[9] The production of synthetic coal and natural gas-based liquid fuels and petrochemicals is prominent, with South Africa being the world leader in coal-based synthesis and gas-to-liquids (GTL) technologies. In Morocco, meanwhile, the presence of the Office Cherifien des Phosphates (OCP), a leader in the phosphates industry (used in agriculture as fertilizer), drives that sector's footprint in the country. The easy access to phosphate at low prices, and the transfer of know-how from OCP, give the country a comparative advantage in this particular chemical sub-sector.[10]

Including its supply chain and wage-spending channels, we find that the chemical industry supported a $550 billion contribution to GDP, and 5.4 million jobs, throughout Africa and Middle East in 2017 (see Fig. 14).[11] This implies that 13 percent of this region's economy is in some way related to the chemical sector.[12]

FIG. 14.

Total GDP and employment supported in Africa and Middle East region, 2017



Source: Oxford Economics

9 Upstream activities generally include the manufacture of basic chemicals as raw materials, while downstream activities turn these raw materials into intermediate and final products. Brand South Africa, "South Africa's economy: key sectors" <https://www.brandsouthafrica.com/investments-immigration/economynews/south-africa-economy-key-sectors> [accessed 14 December 2018]

10 Royaume du Maroc Ministere de l'Industrie, de l'Investissement, du Commerce et de l'Economie Numerique, "Chemical and para-chemical" <http://www.mcinet.gov.ma/en/content/chemical-para-chemical> [accessed 14 December 2018]

11 Oxford Economics' model covers the impact of the chemical industry in three African countries (Morocco, South Africa, and Tunisia) and two Middle Eastern countries (Israel and Saudi Arabia). These countries make up a third of the region's GDP, making this region the least well-represented in our model. Results for the five countries are scaled up to cover the entire region.

12 This is the largest relative impact across the five regions and is partly driven by the low model coverage characterizing this geography. Indeed, given our model only explicitly covers 32 percent of the region's GDP, we allocate a large share of the "Rest of the world" indirect and induced impact to this region. This might also be driving the large multipliers found for both GVA and employment.

To give a sense of scale, the total gross value added contribution of the chemical industry in the region is equivalent to the GDP of Egypt and UAE combined. The employment contribution supported through the three channels of impact is roughly equivalent to the population of the city of Alexandria in Egypt.

The largest share of GDP contribution sustained in the region stemmed from the indirect channel, i.e. the supply-chain economic effects. In employment terms, however, the induced (wage-consumption) channel constituted the major component of the total impact in 2017. This is explained by the fact that consumer-facing sectors in the region tend to be relatively more labor-intensive than sectors involved in the chemical industry's supply chain.

Oxford Economics estimates that each worker in the chemical sector supported another eight jobs elsewhere in Africa and Middle East in 2017. In GVA terms, we find that $7.80 of economic activity was supported elsewhere in the region for every $1 of gross value added that was directly created by the chemical industry.

Asia Pacific

Fueling Asia's textile and apparel industry, the manufacture of man-made fibers is the largest component of the APAC region's chemical industry. Over 2018, the implementation of policies aimed at improving energy efficiency and reducing pollution has dampened growth, especially in the pesticides industry. However, other sub-components such as soaps/detergents and cosmetics are driving the growth of the chemical sector, as the region moves towards a consumer-led economy amid the rising influence of its middle class. The paints industry's outlook also looks healthy, with support from the motor vehicles and construction sectors.

When supply-chain and wage-spending channels are included, we find that the chemical industry supported $2.6 trillion in GDP and 83.1 million jobs in APAC in 2017.[13] This implies that 10 percent of the local economy is estimated to be in some way related to the chemical sector (see Fig. 15).

To give a sense of scale, the total gross value added contribution of the chemical industry in the region is greater than the entire GDP of India. The employment contribution supported through the region's three channels of impact is roughly equivalent to the combined populations of South Korea and Malaysia.

The largest share of GDP and employment contribution sustained in the region stemmed from the indirect channel, i.e. the supply-chain economic effects. This contribution was supported through nearly $1.8 trillion in procurement spending with Asia-Pacific suppliers. The vast majority of this spending was

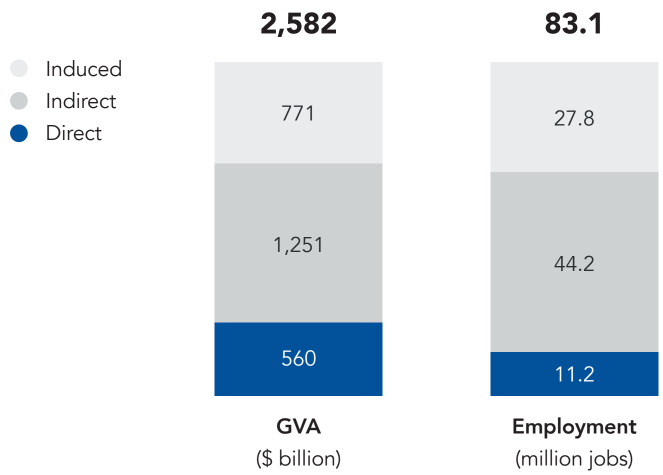
$2.6 trillion

The chemical industry's total contribution to the Asia-Pacific region's GDP in 2017.

This is greater than the entire GDP of India.

FIG. 15.

Total GDP and employment supported in APAC region, 2017



Source: Oxford Economics

13 Oxford Economics' model covers the impact of the chemical industry in 12 Asian countries (China, Japan, South Korea, Indonesia, India, Taiwan, Singapore, Malaysia, Thailand, Philippines, Vietnam, and Hong Kong), Australia and New Zealand. These countries make up almost 97 percent of the region's GDP. Results for these 14 countries are then scaled up to cover the entire region.

with Chinese suppliers, followed by Japanese and South Korean companies.

Oxford Economics estimates that each worker in the chemical sector supported another six jobs elsewhere in APAC in 2017. In GVA terms, we find that $3.60 of economic activity was generated elsewhere in the region for every $1 of gross value added directly created by the chemical industry.

Europe

Basic chemicals and fertilizers dominate the European chemical presence. Recent relatively low oil prices have had a positive impact on this subsector, along with global trade upswings. With global trade slowing, the European chemical industry is expected to also grow more modestly—an effect probably to be captured in 2018 and 2019.

2018 was also characterized by supply-chain issues, especially in Germany, where, due to severe drought in parts of the country, barge deliveries of raw materials were postponed, leading to some chemical plants being temporarily shut down. Though not captured in our data for this research, this will certainly have had an impact on the output of European chemicals in 2018, as Germany accounts for a considerable proportion of the region's total production.

Another major challenge for the European chemical industry stems from consumer activism against single-use plastics. A cross-EU ban is due to be implemented in 2021, with consequences on future demand for chemical products, but also bringing with it potential opportunities related to technical developments and R&D.

When supply-chain and wage-spending channels are included, we find that Europe's chemical industry supported a $1.3 trillion contribution to GDP and 19.1 million jobs in 2017.[14] This implies that seven percent of the region's economy is in some way related to the chemical sector.

To give a sense of scale, the total gross value added contribution of Europe's chemical industry in 2017 was greater than the entire annual GDP of Spain. The employment contribution supported through the three channels of impact was roughly equivalent to the combined population of Greece and Switzerland.

The largest shares of both GDP and employment contributions in Europe stemmed from the indirect channel, i.e. the supply-chain economic effects. This contribution was supported through nearly $665 billion in procurement spending with European suppliers.

Oxford Economics estimates that each worker in the chemical sector supported another 11 jobs elsewhere in Europe in 2017. High employment multipliers are very common for highly capital intensive and productive industries such as the

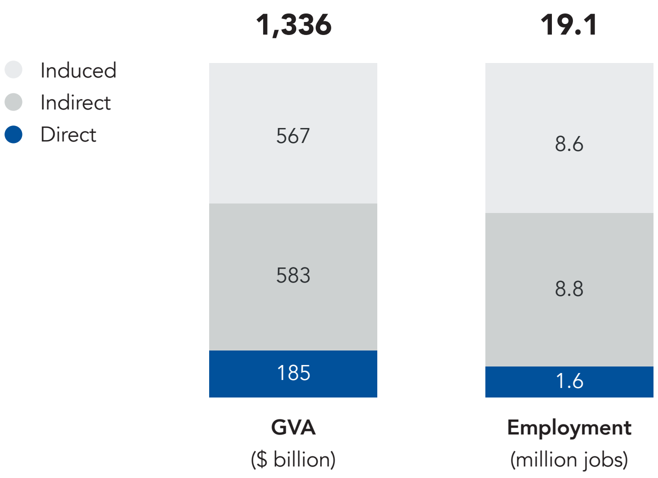
$1.3 trillion

The chemical industry's total contribution to European GDP in 2017.

This is equivalent to the annual GDP of Spain.

FIG. 16.

Total GDP and employment supported in Europe, 2017



Source: Oxford Economics

14 Oxford Economics' model covers the impact of the chemical industry in the EU28, Russia, Switzerland, Turkey, and Norway. These countries make up almost 97 percent of the region's GDP. Results for these 32 countries are then scaled up to cover the entire region.

chemical sector. The industry employs relatively few people and has a relatively large supply chain, which tends to be less productive than the industry itself. These two factors both contribute to the large employment multiplier. In GVA terms, we find that $6.20 of economic activity was supported elsewhere in the region for every $1 of gross value added that was directly created by Europe's chemical industry in 2017.

Latin America & the Caribbean

Brazil is by far the largest chemical producer in the Latin America & Caribbean region. The country's chemical sector is unique due to strengths in areas such as renewable chemicals, agrochemicals, and cosmetics.

Since 2010, Braskem—the largest petrochemical company in Latin America— has been operating a bio-based ethylene plant in Brazil, and is now a leader in this field. Fertilizers, which are vital for the country's booming agricultural sector, make up 12.6 percent of its net chemical sales, with more specialized chemicals across a wide range of industrial applications making up the rest. Despite these success stories, the region's chemical sector is characterized by trade deficit and idle capacity, due to competitiveness issues. The relatively high costs of oil and gas feedstocks are a major impediment to the industry's success, alongside with poor infrastructure.[15]

When all three channels of impact are included, we find that the chemical industry supported $374 billion in GDP and 5.9 million jobs in Latin America and the Caribbean (LAC) in 2017.[16] This implies that eight percent of the region's economy is in some way related to the chemical sector.

To give a sense of scale, the total gross value added contribution of the chemical industry in the region is greater than the GDP of the metropolitan region of São Paulo in Brazil. The employment contribution supported through the three channels of impact is almost equivalent to the entire population of El Salvador.

Once again, the largest shares of both GDP and employment contributions sustained in the region stemmed from the indirect channel, i.e. supply-chain economic effects. This contribution was supported through nearly $118 billion in procurement spending with Latin American suppliers.

Oxford Economics estimates that each worker in the chemical sector supported another nine jobs elsewhere in Latin America and the Caribbean. In GVA terms, $5.90 of economic activity was supported elsewhere in the region for every $1 of gross value added directly that was created by the chemical sector in 2017.

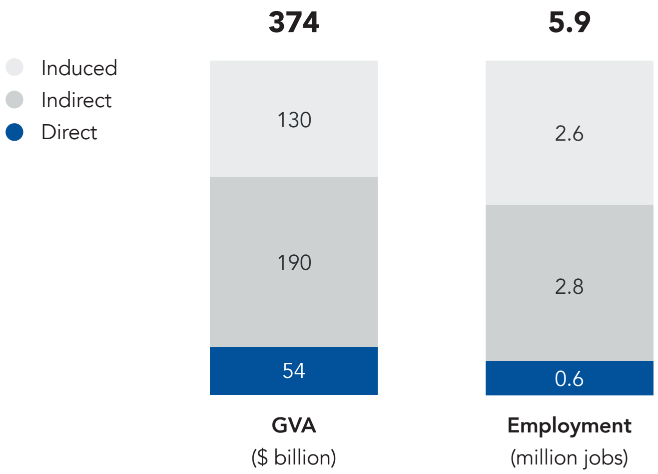
$374 billion

The chemical industry's total contribution to the LAC region's GDP in 2017.

This is equivalent to the GDP of the metropolitan region of São Paulo in Brazil.

FIG. 17.

Total GDP and employment supported in Latin America & the Caribbean, 2017



Source: Oxford Economics

15 Global Business Reports, "Introducing Brazil's Chemical Sector" <https://www.gbreports.com/article/introducing-brazils-chemical-sector> [accessed 14 December 2018]

16 Oxford Economics' model covers the impact of the chemical industry in five Latin American countries (Brazil, Mexico, Argentina, Colombia, and Chile). These countries make up almost 79 percent of the region's GDP. Results for these five countries are then scaled up to cover the entire region.

North America

The North American chemical industry is dominated by the manufacture of basic chemicals and fertilizers. For this reason, 2017 was not as buoyant as it could have been as a consequence of Hurricane Harvey, which affected the basic chemicals sector the most among all chemicals sub-sectors.

However, the shale gas boom led to a near five-fold rise in investment in new chemical plants in the US between 2010 and 2015, and these are becoming operational in 2018-19—maintaining the chemical sector as one of the fastest-growing US industries. In addition to this, a strong construction sector and healthy consumer spending are supporting increased regional production of paints/coatings and soaps/detergents, respectively.

On a less-optimistic note, the future of the industry will inevitably be affected by trade tariffs. Chemical products, particularly basic chemicals which are higher up the supply chain, rely heavily on exports, and tariffs will therefore affect their global demand.

When the impact of supply-chain and wage-spending channels are included, we find that the North American chemical industry supported $866 billion in GDP and 6.1 million jobs in 2017[17] (see Fig. 18). This implies that four percent of the region's economy is in some way related to the chemical sector.

To give a sense of scale, the total gross value added contribution of North America's chemical industry is equivalent to over half of Canada's total annual GDP. The employment contribution supported through the three channels of impact is equivalent to the combined populations of Miami, Fort Lauderdale, and West Palm Beach, Florida.

The largest shares of both GDP and employment contributions sustained in the region stemmed from the payroll-induced channel, i.e. the wage-consumption effect. This feature is unique to the North American region, and is explained by the fact that this region is characterized by a relatively large "gross value added-to-output" ratio. While at the global level, the industry produces 27 cents of GVA for every $1 sold, in the US, 43 cents are generated in value added for every $1 of sales. This stems from the fact that the US chemical industry has a relatively thinner supply chain than other countries in the world, and hence it retains a greater share of its sales as value added, as either pre-tax profits or employee compensation. This also explains why the indirect impact is relatively smaller in this region than elsewhere in the world.

Oxford Economics estimates that each worker in the chemical sector supported another nine jobs elsewhere in North America in 2017. In GVA terms, we find that $2.70 of economic activity was supported elsewhere in the region for every $1 of gross value added directly created by the chemical sector that year.

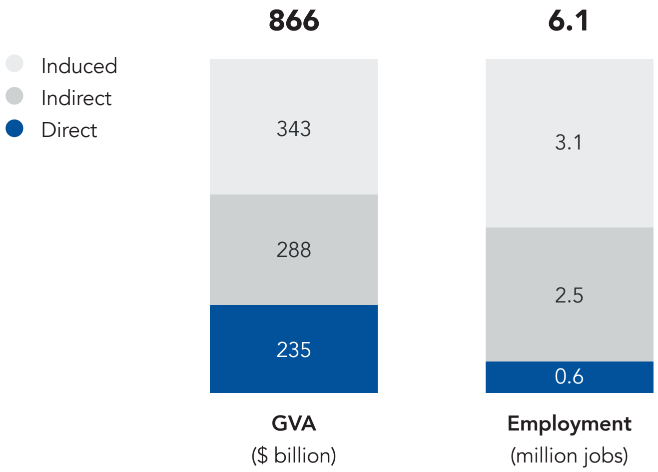
$866 billion

The chemical industry's total contribution to North American GDP in 2017.

Equivalent to over half of Canada's annual GDP.

FIG. 18.

Total GDP and employment supported in North America, 2017



Source: Oxford Economics

17 Oxford Economics' model covers the impact of the chemical industry in the United States and Canada, which make up the totality of North American GDP. Hence, results for these two countries do not require to be scaled up to cover the entire region.

The R&D footprint of the chemical industry

Since the dawn of chemicals production, the industry has been at the forefront of technological innovation, researching and developing ground-breaking chemical products employed for a variety of purposes.

This capability, combined with the industry's global presence, imply that chemical companies are positively contributing toward a variety of SDGs, with a particular focus on SDG 9: to promote sustainable industrialization and foster innovation.

The chemical sector invested an estimated $51 billion in research and development in 2017. That investment spanned from agronomic models for weather and plant growth to support farmers, to research into minimizing noise through innovative material design.

Oxford Economics calculates that this R&D spending supported 1.7 million jobs and $92 billion in economic activity.[18] A geographical analysis of these impacts suggests that:

- $40 billion GDP and 1.1 million jobs were supported in the APAC region;
- $23 billion GDP and 335,000 jobs were supported in Europe;
- $25 billion GDP and 202,000 jobs were supported in North America;

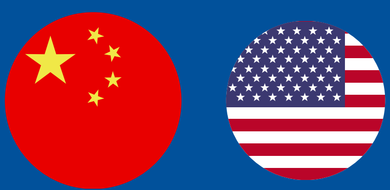
18 It is important to note that these R&D impact figures should not be added to the overall impact results presented in Section 2, as they would already be included in either the direct impact (if the R&D activity is carried out in-house) or the indirect impact (if the activity is outsourced).

$51 billion

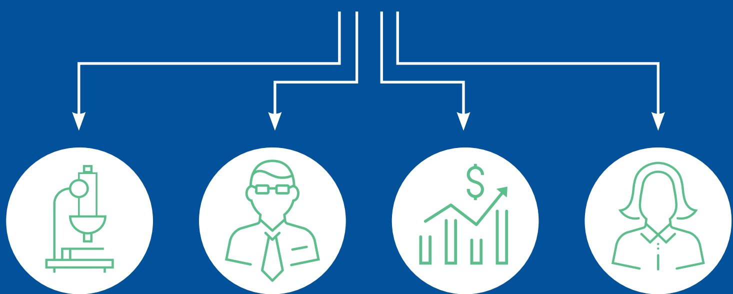
Total R&D spend by the global chemical industry in 2017.

$92 billion GDP
1.7 million jobs

were supported by this spending in 2017.



$15 billion was spent by Chinese chemical companies, vs. $12 billion by US companies.



- $2.3 billion GDP and 26,000 jobs were sustained in Africa & Middle East; and
- $2.2 billion GDP and 41,000 jobs were supported in Latin America and the Caribbean.

The benefits to society of research and development spending, however, are much broader than these jobs and GDP contribution. R&D spending generates long-term benefits for society at large. The chemical sector's research boosts the global economy through the development of new technology, processes, and products that enhance efficiency and productivity, and can have wider social benefits.

While the industry's R&D efforts are obviously aimed at commercialization of research results, societal benefits by far outweigh the private financial returns from innovation. Patents are a formal channel of dissemination of knowledge, processes, and products, as they encourage innovation, and the publication of any invention. In the US, the basic chemicals industry is characterized by above-average patent intensity.

Global impact

The chemical sector invested $51 billion in R&D in 2017. China was home to the largest chemical R&D spend, with an investment of $14.6 billion, followed by the US and Japan, with a $12.1 and a $6.9 billion investment, respectively (Fig. 19).

In total, accounting for all the channels of impact, we estimate that this R&D investment supported 1.7 million jobs and a $92 billion contribution to worldwide GDP in 2017. To give a sense of scale, this GDP contribution was roughly equivalent to the total GDP of Calgary in Canada. In employment terms, the total jobs supported are broadly on a par with the population of Helsinki, the capital city of Finland.

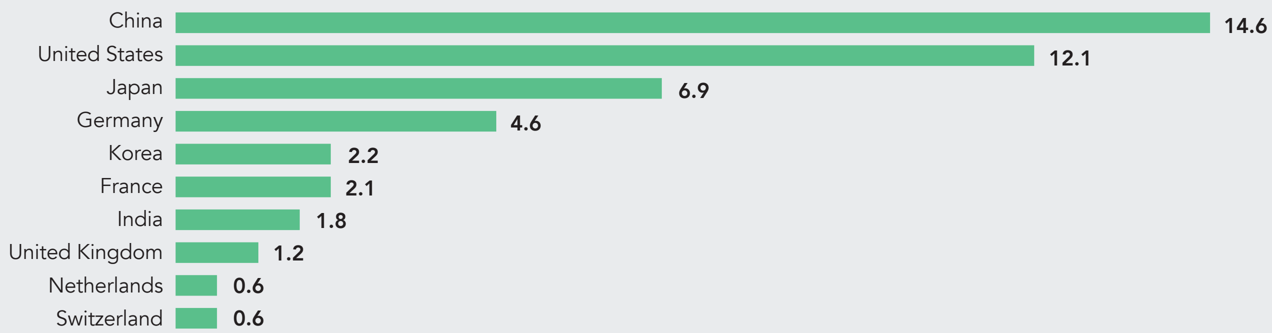
Furthermore, the innovations that emerge from such R&D activity invariably offer "spillover" benefits that spread far wider than the chemical sector itself, raising productivity levels across the global economy. The chemical industry's innovation and R&D activities often lead to the development of new products and processes, and (as explained above) patents are a formal channel for the dissemination of such innovation. Some notable examples of chemical patents with wide societal benefits include:

- synthetic nitrogen used in fertilizers—it is estimated this kind of fertilizer now supports approximately half the world's population;[19]
- organic LED (OLED), used as digital display components in mobile devices;

19 "How many people does synthetic fertilizer feed? ", in *Our World in Data* <https://ourworldindata.org/how-many-people-does-synthetic-fertilizer-feed> [accessed 10 January 2019]

FIG. 19.

Top 10 chemical R&D spenders, 2017 ($ billion)



Source: CEFIC, ACC, Oxford Economics

- a newly developed blood testing technology used to detect infectious diseases using nucleic acid testing; and
- a fog collector technology, used to produce clean drinking water from fog.[20]

In the US, the chemical sector is one of the most patent-intensive sectors, alongside electronics.[21] US patent data are readily available and therefore frequently used to construct a measure of patent intensity. The patent intensity of the basic chemical industry was recorded to be 0.027—roughly in line with medical appliances and electric motors, generators and transformers.[22]

0.027

patent intensity of the US basic chemicals industry

This compares to an overall average patent intensity of 0.018 in the wider US economy

It should be noted that chemical products also fuel innovations and patents in other industries, i.e. photovoltaic cells for electricity production, lightweight vehicle parts, germ-resistant coatings for medical instruments, etc.

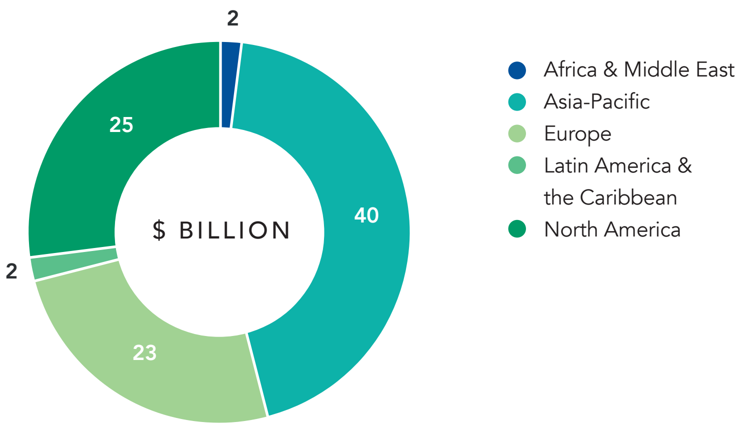
Regional profile

The chemical industry's R&D spend generates extensive economic benefits throughout the world. These benefits, including sizeable GDP contributions and employment impacts, are particularly concentrated within the APAC and North America regions. **Oxford Economics' analysis reveals that in these regions, the industry added $40 billion and $25 billion respectively to GDP through its R&D spend in 2017** (Fig. 20).

We also investigated the employment impact of the chemical industry's R&D investment on each of the world's regions in 2017. The APAC region had by far the largest number of jobs supported by chemical manufacturers' R&D spending, at almost 1.1 million (Fig. 21). The next largest was Europe, where some 335,000 jobs were supported—around one-fifth of the total global employment supported through the chemical industry's R&D investments.

FIG. 20.

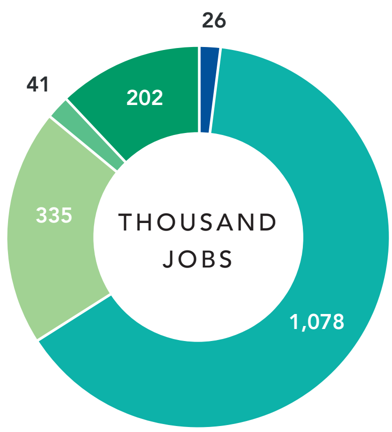
Total GDP supported by the chemical industry's R&D spending, by region, 2017



Source: Oxford Economics

FIG. 21.

Total employment supported by R&D spending by region, 2017



Source: Oxford Economics

20 World Intellectual Property Organization, "WIPO and the Sustainable Development Goals", 2018.
21 Autor D., et al., "Foreign Competition and Domestic Innovation: Evidence from U.S. Patents", December 2017.
22 Patent intensity is measured as the number of US patents awarded to an industry relative to total industry sales in the United States. The variable was developed in Hu, A.G.Z., Png, I.P.L., "Patent rights and economic growth: evidence from cross-country panels of manufacturing industries", Oxford Economic Papers, 65 (2013): 675–98.

Appendix 1: data sources

The **direct contribution** was calculated using output, value added and employment data provided by the American Chemistry Council's (ACC) and the European Chemical Industry Council (CEFIC). Missing values were estimated by the Oxford Economics' industry team, taking into account relevant ratios and information from other official sources.

Building on the extensive data collection efforts undertaken by ACC and CEFIC, Oxford Economics collected and/or estimated financial and employment data points for a total of 58 countries globally. The collected country-level data account for 92 percent of the global gross value added in the chemical sector in 2017. CEFIC generously provided detailed data on jobs, revenues, and value added for the vast majority of the countries, and ACC complemented with its revenue data to validate the former source. Oxford Economics used its own estimates of output, value added and employment, based on national accounts ratios and productivity data.

Starting from these data points provided by ACC and CEFIC, we then used secondary sources to estimate other useful metrics to be used in our model:

- Intermediate consumption (supply chain spending) was estimated as the difference between sales and value added and its sectorial and geographical composition was drawn from Oxford Economics' Global Economic Impact Model (further detail can be found in Appendix 2).[23] This variable constituted the key input for the calculation of the **indirect GDP and employment contributions.**
- The labor and capital shares of value added were estimated on a country-by-country basis using OECD Input-Output Tables. From total labor costs, we were able to estimate gross salaries using OECD Stan Industrial Analysis. Net salaries were calculated using OECD's Taxing Wages Comparative Tables. This variable constituted the input for the calculation of the **induced GDP and employment contributions.**

FIG. 22.

Data sources and coverage

Data series	Source	Coverage (% world)
Sales	CEFIC (Europe), ACC (US & Canada), average of the two (elsewhere), OE (when both missing)	92%
Value Added	CEFIC, ACC (US), OE (when both missing)	92%
R&D spend	CEFIC, ACC (US), OE estimate	99%

23 The economic impact sustained in the agricultural sector was adjusted to exclude subsistence farming in developing economies (such as India and China). The reason for doing this is that, failing to adjust would imply unrealistically large employment contributions within these country's agricultural sectors.

Appendix 2: the Global Model

Indirect and induced impacts were estimated using Oxford Economics' Global Economic Impact Model. Indirect impacts were worked out in three steps:

- For each country, total procurement from other sectors was taken to be the difference between the sector's total value of production and its own GVA, as sourced from ACC/ CEFIC/ Oxford Economics.
- The pattern of procurement for each purchasing country was estimated, by type of product and country of supplier, taking into account ratios in the Input-Output Tables sourced from the OECD.
- This pattern of procurement was then combined with ratios from the same set of Input-Output Tables, to arrive at the indirect GVA impact by country of supplier.

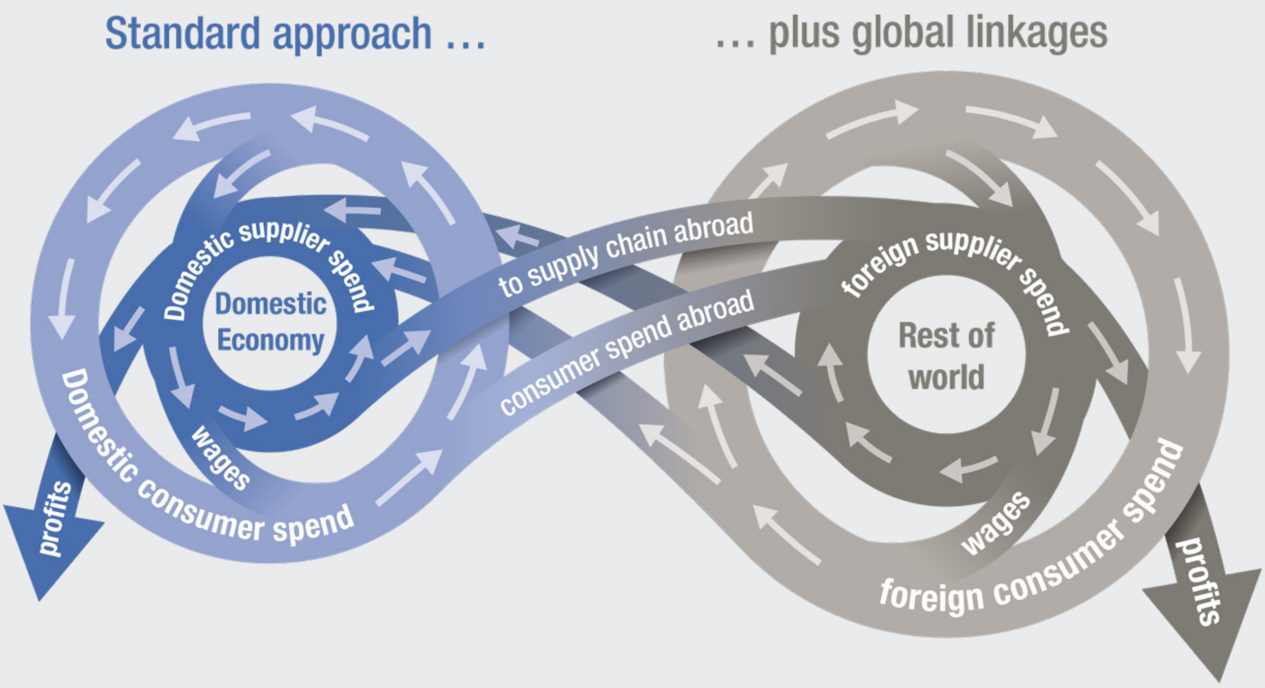
The induced GVA impact was then estimated in two stages. The impact relating to staff in the supply chain was worked out alongside the indirect impact, using further ratios from the Input-Output Tables. Induced impacts relating to the chemical industry's own employees were added to that, using estimates of chemical industry employment costs (one of the two components of GVA, alongside profits) as the starting point.

Employment impacts were worked out from the GVA impacts, taking into account official data for GVA per head, separately for each country in the model and on an industry-by-industry basis.

The Global Economic Impact Model captures the full range of impacts, including cross-border "feedback" effects that would be missed by a more traditional economic impact modeling approach.

FIG. 23.

The Oxford Economics' Global Economic Impact Model



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