MANUFACTURING METRICS REVIEW REPORT

A paper by the Manufacturing Metrics Expert Group

FEBRUARY 2016

This report has been prepared for the Department for Business, Innovation and Skills.

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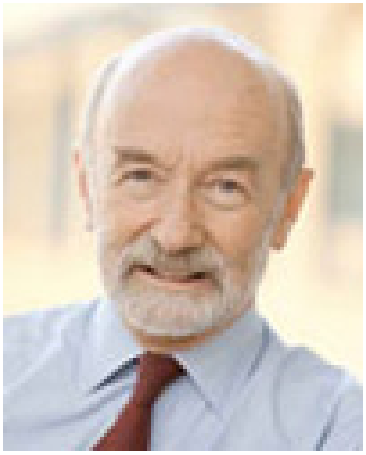
Executive Summary



Manufacturing is moving rapidly up the agenda of developed and developing countries. After a period when it was felt to be less important, particularly for advanced countries, there is now a serious re-evaluation of the role which manufacturing could or should play. In part this reflects the changing balance of capability around the world but also the rapid development of technologies which are opening up new possibilities for the rapid design, delivery and customisation of products.

It is now widely accepted that modern views of manufacturing need to include, to varying degrees, R&D, design, distribution, service and sustainability as well as physical production. These rapidly evolving views of manufacturing have raised questions about the appropriateness of current manufacturing metrics. The Government Office for Science's recent Manufacturing Foresight Report highlighted this concern and its recommendation that a review be undertaken was the starting point for the work reported here.

A small group with expertise in economics, statistics, operations, technology and industry was assembled to review the current arrangements and explore new approaches where appropriate. Their broad conclusion was that whilst current data collection and analysis of manufacturing by ONS faithfully and professionally follow international standards, more could be done to reflect the changing nature of manufacturing and provide a clearer picture of the structure and dynamics of modern manufacturing.

The review was asked to look at three key areas:

- How present metrics are used to capture manufacturing activity
- Whether existing data or metrics can be used more effectively.
- The potential for additional metrics to significantly add to how manufacturing activity is captured, reported and understood.

The group enjoyed wholehearted support from the ONS and ready access to BIS officials who provided a very capable secretariat. The key findings include observations about current practices but also several proposals for enhancing current arrangements. Some of the new ideas could be implemented relatively quickly, others will require a period of experimentation. Those involving internationally comparable measures will of necessity take longer but it is important that the UK remains at the forefront of such developments.

A key observation of the Metrics Group, echoing the Foresight findings, is that it is essential to consider activities upstream and downstream of physical transformation in order to understand the impact as well as the activity of manufacturing industries. These activities may include R&D, design, supply, distribution and service. Considering only activities conventionally defined as 'manufacturing' is likely to miss key elements of contemporary manufacturing related economic activity.

Key findings are as follows:

- Current arrangements for data collection and analysis reflect international agreements and are robust and widely respected. Many bodies use ONS data as a basis for their commentary on manufacturing trends.

- Current ONS, and indeed international, data and analyses do not facilitate detailed reporting of trends in the structure and dynamics of manufacturing particularly the 'value added' within and between activities along the value chain.

- New analyses of existing data to reflect a value chain approach might be used to indicate the reach and impact of transformation activities related to manufacturing more effectively. An illustrative example of this approach in Chapter 4 suggests that jobs associated with manufacturing might number 5.1 million compared with the 2.6 million directly classified to manufacturing using conventional interpretations.

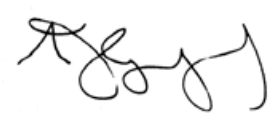
- New descriptors of manufacturing related activities including Factoryless Goods Producers, Production Centred, Service Plus and Services for Manufacturing could serve to identify the different business models associated with manufacturing more clearly. Initial findings suggest that progress could be made towards quantifying these descriptors.

- There may be significant opportunities to supplement national statistics through the development of new data sources and analyses to provide novel insights into modern manufacturing using for example 'big data' techniques. Experiments to be conducted include:

i. Mapping Alternative Sources of Data for Manufacturing Analytics
ii. Exploration of Company Reports as Alternative Data Sources
iii. Exploration of Company Created Data as Alternative Data Sources

- International developments requiring multi-national agreements are of necessity longer term. It is important however that the UK remains closely engaged with international developments to ensure the UK takes a leading role with latest international manufacturing initiatives to ensure continuing visibility in leading industrial countries. In doing so, ONS should continue to access the extended network of expertise identified for this review to support informed engagement in the international arena.

In summary, the group found that, while manufacturing as currently defined in national and international statistics is being effectively and reliably reported, there are substantial opportunities to capture and reflect the influence of manufacturing activities within the economy more comprehensively.



Professor Sir Mike Gregory

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1. Terms of Reference and Approach

The review was initiated as a result of a recommendation in the Foresight report on "The Future of Manufacturing" which highlighted a concern about the appropriateness of current metrics of manufacturing in official statistics. The review Terms of Reference can be summarised as:

- How present metrics are used to capture manufacturing activity.
- Where existing data or metrics can be used more effectively.
- The potential for additional metrics to add significantly to how manufacturing is captured, reported and understood.

Key stages of the approach were as follows:

a. A summary of modern definitions and perceptions of manufacturing.

Definitions and perceptions of the scope of manufacturing vary substantially but there has been a trend to consider a broader range of activities along the value chain rather than simply physical productions. The argument is that many activities along the value chain from R&D through design to distribution and service are essential to the delivery of products from ideas to meeting the needs of customers. This view of the scope of manufacturing was adopted by the Foresight Manufacturing Report and is taken as a starting point for this review, together with an initial identification of alternative representations where these might provide additional insights.

The official definition (UK Standard Industrial Classification of economic activities – UK SIC) of manufacturing is currently:

> The physical and/or chemical transformation of materials, substances or components into new products. The material, substances or components are raw materials which are products of agriculture, forestry, fishing or mining as well as products and semi-finished products of other manufacturing activities.

This highlights that the current classification (that is aligned to internationally agreed definitions) of manufacturing focuses more on physical production rather than the range of activities that can be part of the value chain.

b. Review of current metrics as prepared by the ONS and their implications for manufacturing.

The ONS provides substantial data on manufacturing activities across the economy. In order to maintain comparability with other countries the principles used to prepare data reflect international agreements. This part of the review sets out in some detail the current arrangements for the measurement of manufacturing together with summary example data to provide an indication of the scale of various activities. The implications of current measurement practice for understanding manufacturing are briefly reviewed concluding with a note on the need for new analyses and metrics. More detailed technical

explanations of current practice and classification structures are included in Annexes B and D.

c. Development of new analyses, frameworks and metrics

Opportunities for further analysis and interpretation of existing data are explored resulting in a novel representation of manufacturing related activities along the value chain using jobs as an illustrative example. Further work is then described which proposes new frameworks for the representation of manufacturing activities first at a more granular level and then by offering a new classification of types of manufacturing related activity. Finally experiments are proposed to explore the potential of novel approaches to the measurement of aspects of manufacturing at the company level including performance, benchmarking and particularly ‘big data’.

d. Recommendations

A series of conclusions and recommendations are set out which confirm the robustness of current measurement arrangements within international norms but indicate short, medium and longer term opportunities for enhancing the detailed understanding of modern manufacturing activity and its contribution to wider economic performance.

2. What is Modern Manufacturing?

Modern manufacturing reflects changes in markets, organisations, technologies and capabilities. In this section we introduce some of the key characteristics of modern manufacturing and their potential influence on measurement.

a. Definitions

Definitions of manufacturing are evolving. The original use of the term referred to the physical act of shaping materials. For many people this is still what they mean when they use the word. In modern industries however the term has taken on a broader meaning including activities upstream and downstream of physical production.

This change reflects the growing complexity of industries concerned with the production of goods and indeed services. It also reflects the growing complexity of the goods themselves and the ways they are used. This definitional evolution can easily lead to misunderstandings particularly around issues of measurement.

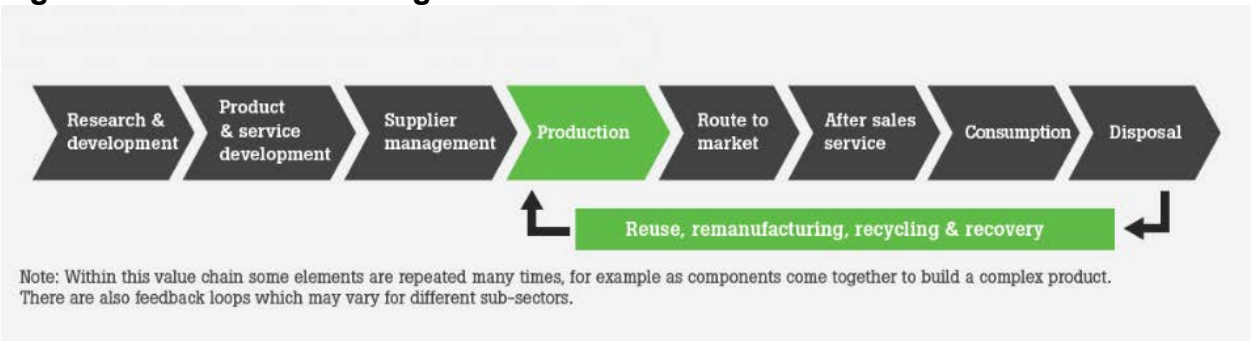
Value Chains

In this report we have chosen to address the 'value chains' which have a physical production component or which influence or are influenced by production. A manufacturing value chain is the full series of activities (inputs) that create and build value at every step of the creation and delivery of a good or service (outputs). This approach is consistent with the view taken in the Manufacturing Foresight report which argued:

> *"….physical production is at the centre of a wider manufacturing value chain.*
>
> *Manufacturers are increasingly using this wider value chain to generate new and additional revenue, with production playing a central role in allowing other value creating activities to occur."*

To illustrate this, the Foresight project developed the following representation of the manufacturing value chain.

Figure 1: The Manufacturing Value Chain



Source: Foresight 'The Future of Manufacturing' Report[1]

[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/255922/13-809-future-manufacturing-project-report.pdf

The adoption of this approach more accurately reflects the realities of modern manufacturing. It also poses measurement challenges not only in assessing the scale of activities within the various stages of the value chain but also in the transitions between them.

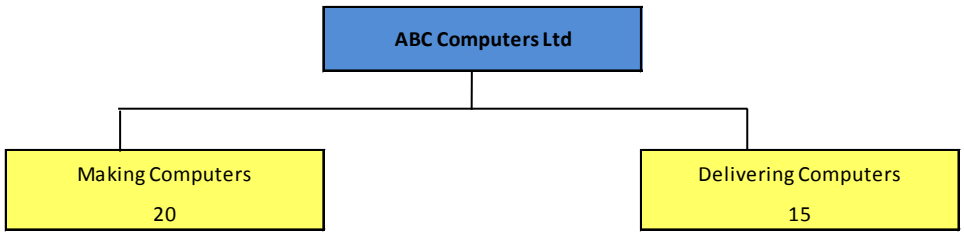
Classifying Manufacturing – the current practice

To better understand these measurement challenges it is important to recognise that there can be great variation in value chain structures. At the one end a single company may be engaged in all activities along the value chain. At the other there may be a complex arrangement in which many companies are providing inputs that contribute to the delivery of a final output. Within national statistics companies are classified to the activity in which their largest number of their employees is engaged. It is possible therefore that, for example, transport services conducted within a simple value chain comprising a single company will be classified differently to the transport services undertaken within a complex value chain where the activity has been contracted out to a specialist supplier.

The following hypothetical example is used to show how apparently similar activities might be counted in different ways depending upon the business arrangements along the value chain.

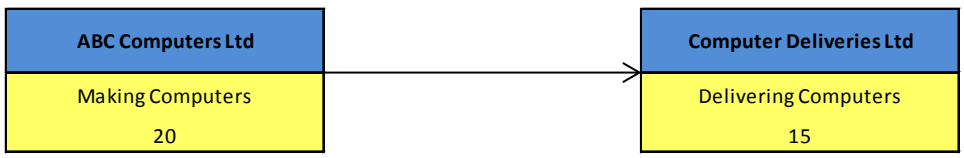
Figure 2: Classifying Manufacturing – 'ABC Computers Ltd' an illustrative example

i. 'ABC Computers Ltd' employ 35 people. 20 are employed to make the computers, 15 are employed to deliver the finished product. All operations are managed and based at a single location.



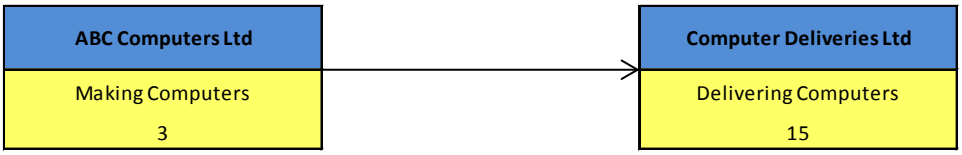
Total employed = 35
Total classified to Manufacturing = 35
Total classified to services = 0

ii. In an effort to boost their competitive position in the market, ABC Computers Ltd have chosen to outsource the delivery of their products to another company, again employing 15 workers.



Total employed = 35
Total classified to manufacturing = 20
Total classified to services = 15

iii. Finally, taking advantage of new technology, ABC Computers Ltd have decided to move to a capital intensive production technology. This automated production provides greater flexibility and productivity to their production processes. They also decide to bring the delivery service back in-house to enable them to be more responsive to customer needs and to further reduce lead times.



Total employed = 18
Total classified to manufacturing = 3
Total classified to services = 15

b. Characteristics

In contrast to traditional manufacturing where much of the conversion of materials to products was done in a single factory, modern manufacturing involves complex global webs of suppliers. This can make it increasingly difficult for the final 'assembler' of a product to manage the timely and efficient supply of inputs. A range of new capabilities are required from the identification and sourcing of inputs to the management of complex logistic chains. Understanding and measuring the performance of such chains and networks presents a major challenge as critical manufacturing activities can lie outside the factory and within a more fluid 'ecosystem' over which the assembler may have limited control.

The challenge is even greater for emerging industries. In these cases there may be few established suppliers and little expertise or experience available to support the fledgling industry. Innovation may require ready access to production capability development where novel processes are required to build to novel products.

At the national level, opportunities for economic growth based upon manufacturing increasingly depend upon effective supply capabilities. Assessing such capabilities again requires new approaches to measurement.

c. Trends

i. Servitisation

As figure 1 (page 9) shows, service is increasingly recognised as being part of a broadly defined manufacturing value chain. Many traditional manufacturing businesses now seek to extend their scope to capture value from service activities. There is clearly no 'right answer' to the appropriate level of manufacturing or services. Indeed attempts to differentiate between them may be unhelpful given their increasing interdependence. Nevertheless the current measurement systems distinguish sharply between manufacturing and services and this is an area where new approaches are necessary.

At the highest level industrial enterprises need to create and capture value if they are to succeed and endure. The challenges here lie in identifying value and then assessing its

degree. The concept is elusive not least because it goes to the heart of the business models of companies, the associated data for which they may choose to keep confidential. Understanding concepts and measurement of value creation and capture however may be substantially more important than fine distinctions between manufacturing and services.

ii. Jobs and Skills

As the structure of manufacturing has changed over time the composition of manufacturing employment has become more specialised. For instance, some activities previously undertaken within a manufacturing business such as accounting and transportation are now often outsourced to service companies. It can be argued that some at least of the growth of service business comes from the outsourcing of services provided to manufacturing.

In addition to the specialisation of manufacturing employment, technological advances and the need to raise competitiveness in the global market mean that manufacturing tasks in developed economies have also changed, including the level of education required, skill sets needed and the importance of through-life education. Better training for instance may be required to enable the use of more sophisticated equipment and systems.

For policy makers, the need for higher levels of education, more intense vocational training and improved matching on the labour market will require appropriate education and labour market policies. The planning and development of infrastructure, including transport, communications and energy, will also need to reflect changing industrial contexts while industrial policies will need to address trends towards service activities noting that manufacturing jobs are typically better rewarded and have higher productivity growth potential compared with service jobs.

iii. Investment

Effective manufacturing typically requires significant capital investment particularly in the early stages of a new product or indeed industry. The most obvious demands for investment include facilities, particularly factory and business premises, machinery and equipment to support and, where appropriate, to automate production.

Careful judgements need to be made about the level of investment that anticipated market demand will support. Too much investment may not be recoverable through sales, too little may mean that necessary levels of efficiency cannot be obtained. The need for accurate assessment of appropriate investment, little of which may be recoverable if sales fail to meet expectation, is a particular feature of manufacturing industries.

Iv. Intangible Assets/Inputs

Evolving company business models and increasingly complex relationships along the value chain can also include a significant proportion of ‘intangible’ content and assets. Intangible assets are knowledge-based assets resulting from “know-how” investment by firms in, for example, R&D, software, training, reputation and business processes. Some of this investment might be bought-in from other sectors e.g. contracted out R&D or cloud-based software services, but much might be performed in-house on their own account.

Statistical authorities have measured tangible investment for many years and have well-established protocols for doing so based on investment surveys that ask firms about their spending on long-lived capital assets (purchases of machines for example). Assets made in-house (such as in-house R&D or software), will be missed if based on conventional investment surveys that ask for purchases from outside the organisation. Thus statistical authorities have generated new types of inquiries to deal with this: special questionnaires to the R&D department for example.

The intangible nature of these new assets presents particular problems: know-how can be often transferred across international borders for example without a monetary transaction. In addition, further intangible spending, currently not measured, might be considered for surveys: spending on design, branding and business processes for example.

v. Factoryless Goods Production

The term factoryless goods production (FGP) has emerged in recent years to describe companies that, while having manufactured goods as an important part of their portfolio, do not own production facilities. Companies such as Apple and ARM are good examples. Both play a major part in the design, distribution and services associated with their products but neither company owns significant production capacity. Current statistical treatments mean that such companies may not be treated within manufacturing despite the fact that they are intimately concerned with the delivery of advanced products to consumers. The subject of factoryless goods producers and their treatment in national statistics is currently being addressed by OECD committees among others.

d. Performance and Productivity

i. Performance

Ultimately companies are focussed on the strategic and operational and financial performance of their businesses and within that the performance of the production activities. Here measurement of performance across a range of indicators is vital to enable businesses to assess their position relative to other providers. For larger businesses with multiple sites there is also a need to compare the performance of similar activities within their corporation. Strategic, operational and underlying technological measures of manufacturing may be of less interest to policymakers but vital for companies seeking to compete internationally

ii. Productivity

Productivity has received increasing attention in the UK where national economic performance in this respect is seen to be lagging behind competitors. According to ONS International Comparisons of Productivity the UK trails behind all of the G7 countries barring Japan and is 20% behind the G7 average productivity level. Data is not available to directly compare the productivity of UK manufacturing with manufacturing productivity in other G7 countries.

Nevertheless it is worth noting that UK manufacturing has delivered a productivity revolution showing a 125% increase in labour productivity since 1985. This has been

driven by a shift to automated production, offshoring of low-skilled labour intensive activity and the adoption of lean practices. These have been essential to ensure the ongoing competiveness of successful businesses though productivity as a measure is not one which is routinely used by manufacturers.

In the past 10 years UK manufacturing's labour productivity has increased by 20% compared with nearly 6% for the whole UK economy.

e. Summary

Traditional views of manufacturing which focussed on the processing and shaping of materials have evolved significantly over recent decades. The migration from large factory based production systems to globally distributed networks is reflected in the increasing use of supply chain representations to describe manufacturing activities from R&D through design and production to service. This section has set out some of the characteristics of these more distributed manufacturing systems.

3. Measuring Manufacturing – the current arrangements

The complexity of modern manufacturing is reflected in the challenges facing measurement. This section, prepared in close collaboration with ONS explores how these challenges are currently tackled including the gathering, classification and analysis of data – particularly which metrics are currently available to measure manufacturing activity. It concludes with a summary of the need for new approaches and metrics.

A more detailed explanation can be found in the separate paper “How Manufacturing is Classified” which is included as annex B to this report.

a. Statistical Classification of Economic Activity

i. International Classification

All National Statistics Institutes within the European Union are bound by legislation to classify economic activity according to the ‘Statistical Classification of Economic Activities in the European Community’ (NACE). This brings consistency to practices across nations and facilitates the collation, comparison and understanding of macro-economic activity.

ii. National Classification

The UK Standard Industrial Classification of economic activities (UK SIC) mirrors that of NACE, however in some instances, further granulation of specific classes has taken place, to create national subclasses.

Within the SIC structure ‘Manufacture' is defined as:

> The physical and/or chemical transformation of materials, substances or components into new products. The material, substances or components are raw materials which are products of agriculture, forestry, fishing or mining as well as products and semi-finished products of other manufacturing activities.

This description of manufacturing is consistent with that used across the international statistical community.

iii. Revision of classification systems

To ensure the classifications are up to date and fit for purpose, NACE and by association UK SIC, is subject to periodic revision. This can take major or minor form. The former will result in a complete review of the system, requiring the introduction of a new European NACE legislation. A minor revision will allow for limited change to the classification and may result in some amendment to an existing ‘NACE’ legislation.

iv. The Inter Departmental Business Register

The Inter-Departmental Business Register (IDBR) is a comprehensive list of UK businesses that is used by government for statistical purposes. It consists of 2.2 million

businesses in all sectors of the economy and is the place where the industry classification for each business is stored along with other key information such as employment and turnover size. The register provides a sampling frame for the majority of surveys of businesses carried out by the ONS and by other government departments. It is also a key data source for analyses of business activity.

Categorisation of business

Table 1 provides a high level breakdown showing how the 2.2 million businesses listed on the IDBR are categorised.

Table 1: Number of enterprises on the IDBR by broad industry

Category	Number of Enterprises
Manufacturing	126,355
Other	422,615
Services	1,714,670
Total	**2,263,640**

Source: IDBR March 2014

How companies are classified

ONS collect records of businesses primarily through administrative information from the UK tax office, plus company registration and ownership data.

There are three key levels of classification:

- Economic activity is generated at the **local unit (LU)**: a physical location representing an economic entity's place of activity, for example, a factory, shop, office building etc. In other countries and economics literature, the LU is often referred to as the plant or establishment.

- Local units are grouped into **enterprises**¸ which is normally the smallest unit that can meaningfully report on economic variables. For limited companies, this will often be the level of legally registered status.

- Several enterprises under common ownership will form an **enterprise group**.

A detailed explanation of how businesses are categorised within the IDBR can be found in Annex B to this report.

Classification of simple and complex organisation structures are also set out in further detail in annexes B and D.

v. Value Added

It is also interesting to consider value added.

Approximate Value Added

A detailed breakdown of approximate Gross Value Added (aGVA) data is provided in annex B to this report. aGVA is a measure of the income generated by businesses, less their expenditure as estimated by the Annual Business Survey. It differs, though, from the National Accounts concept of Value Added. One example is in terms of coverage and number of data sources used. Value added in the National Accounts is estimated using a number of different data sources and covers the whole UK economy whereas aGVA does not cover farming or the financial and public sectors (this means aGVA covers around two thirds on the UK economy).

Gross Value Added (GVA)

GVA may be measured as output minus intermediate inputs consumed, where output is measured at the prices received by the producer (net of any tax on the product plus any subsidy on the product) and intermediate inputs are measured at the prices paid by the producer. It corresponds to the income (profits plus wages) earned by the producing business[2]. Summing gross value added gives the Gross Domestic Product (GDP) of a country's businesses as a whole. By only counting the value added in each firm it avoids the double counting which would arise if all firms outputs were measured, for example, by their total sales value without subtracting the inputs purchased by them from other firms. By subtracting consumption of fixed capital from GVA the corresponding net value added (NVA) is obtained.

b. Other Classifications

Over 70 statistical classifications are approved by Eurostat, for use with National Statistics Institutes.[3] While the majority of business statistics are produced and presented based on UK SIC, alternative classifications may be used for specific statistical purposes. One example which is useful for understanding the activity being undertaken by businesses is the Statistical Classification of Products by Activity (CPA).

i. Statistical Classification of Products by Activity, Version 2.1

CPA constitutes a comprehensive classification of goods and services, presenting categories for all products that can be the object of domestic or international transactions or that can be entered into stocks. It includes products that are an output of economic activity, including transportable goods, non-transportable goods and services.

ii. Use of CPA

CPA, as a product classification, serves as an instrument for assembling and tabulating all kinds of statistics requiring product detail, including production, intermediate and final

[2] This is more formally called gross value added at basic prices. Other definitions are also used for the purpose of calculating GDP and vary mainly in the way that the data to calculate them are collected.
[3] A list of the international and allied classifications used by ONS can be found on the ONS Classifications webpage.

consumption, capital formation, foreign trade or prices. These statistics may refer to commodity flows, stocks or balances and may be compiled in the context of input-output tables, balance of payments and other analytical presentations. The CPA classifies products based on the physical characteristics of goods or on the nature of the services rendered.

CPA has direct links to other classification systems and its main applications are for national and regional accounts; input-output analysis; other analyses requiring product data. It is helpful as businesses classified to one industry may produce, sell or trade products that are linked to a range of different industries.

c. What metrics are currently available on the manufacturing industry?

i. Existing sources

There are well over 20 existing sources of official statistics which provide a wealth of information to allow investigation into the UK manufacturing industry, largely defined by the industry classification. Using these sources, it is possible to construct a picture of UK manufacturing both now and in the past, and how it is adapting to changing global markets and technological developments, as well as identifying areas of the industry that could improve.

Some of the main official statistics sources which provide information on the manufacturing sector are shown in Table 2.

Table 2: Key official data sources which provide data on manufacturing activity in the UK

Source	Theme
Annual Business Survey	Financial
International Trade in Services	Financial
Foreign Direct Investment	Financial
UK trade in goods & services	Financial
UK manufactures sales by product (ProdCom)	Financial
Business Demography	Business Activity
Annual Survey of Hours & Earnings	Labour
Business Register Employment Survey	Labour
Business Enterprise Research & Development	Research & Development
E-commerce	Research & Development
Innovation Survey	Research & Development
Index of Production	Economy
Supply and Use Tables	Economy
Gross Domestic Product	Economy

Annex C to this Report provides specific details on the coverage, strengths and limitations of each of these official data sources together with other additional data sources that provide further detail on the manufacturing sector.

The sources, whether used in isolation or in combination, can be used to answer the following questions. This can be for manufacturing as a whole or specific industries within it; for example, there are 44 industry groupings in the Supply and Use Tables.

What is the structure and value of the manufacturing industry?

Which products are driving manufacturing industry growth?

What proportion of overall production (this includes mining & quarrying, electricity & supply and water supply & waste management as well as manufacturing) Gross Value Added is contributed by manufacturing?

Which manufacturing product group undertook the most Research and development?

How does manufacturing's use of e-commerce compare with other industries/countries?

This highlights only a tiny proportion of the potential uses of the various data sources.

The following sections illustrate the type of the data that exist. Examples are included for the manufacturing sector as a whole and where possible for aerospace as one of the country's leading manufacturing sectors (one exception to this is for 'Investment' where transport equipment has been used due to data availability). After each key concept is introduced, numbers are provided to illustrate the types of data available.

ii. Examples of input and output data sources

With such a wide range of statistics available it is not possible to summarise them all here. Instead a range of examples of the types of input and output statistics available are provided below considering inputs that manufacturers use such as capital, labour, raw materials and knowledge and then moving to outputs such as turnover and sales.

iii. How big is the manufacturing industry?

A useful place to start to understand the size of the manufacturing sector in the UK is to consider the number of businesses classified to manufacturing and how the stock of businesses is changing over time in terms of start-ups and closures. This information is available from the IDBR.

An enterprise is defined as the smallest combination of legal units (generally based on VAT and/or PAYE records) that produces goods or services with a certain degree of autonomy in decision making.

An enterprise often engages in productive activity at more than one location and for some purposes it may be useful to partition it accordingly. A local unit is therefore defined as an enterprise, or part of an enterprise, which engages in productive activity at or from one location.

Example 1: Enterprises – Manufacturing and Aerospace[4] [5]

In 2013:

- 126,365 enterprises were classified to 'Manufacturing' (Section C); 5.8% of all registered enterprises.
- 11,985 enterprises that were classified to 'Manufacturing' ceased trading, compared with 237,660 enterprises that ceased trading in total.
- 15,310 enterprises that starting trading were classified to 'Manufacturing', compared with 346,485 enterprises that started trading in total.
- 137,310 local units were classified to 'Manufacturing'.

In 2013:

- 690 enterprises were classified to 'Manufacture of air and space craft and related activity' (Group 30.3); 0.5% of all registered manufacturing enterprises.
- 80 enterprises that were classified to 'Air and space craft manufacture' ceased trading.
- 150 enterprises that starting trading were classified to 'Air and space craft manufacture'.
- 840 local units were classified to 'Air and space craft manufacture'.

Source: ONS UK Business: Activity, Size and Location (enterprise and local unit counts) and Business demography (births & deaths) [6]

iv. Supply and use tables

The input-output (I-O) framework brings together components of GVA, industry inputs and outputs, product supply and demand and the composition of uses and resources across institutional sectors for the economy. This framework breaks the economy down to display transactions of all goods and services between industries and final consumers for a single period. Information is presented in supply and use tables (SUTs) and five-yearly Input-Output Analytical Tables (IOATs).

The SUTs show the whole economy by industry (e.g. aerospace industry) and products (e.g. machinery). The tables show links between components of GVA, industry inputs and outputs and product supply and demand. The SUTs link different sectors of the economy (for example, public corporations) together with detail of imports and exports of goods and services, government expenditure, household expenditure and capital expenditure.

[4] Covers only enterprises registered for VAT and/or PAYE.
[5] Enterprise counts should not be compared directly with those for purchases and turnover due to differences in methodology.
[6] Demography counts all units that were live at any point over the year so include units that are dead by the end of the year. UK Business only counts those units that were live on the IDBR at the time of the extract (March each year). The demography universe includes all businesses on the IDBR whilst UK business is restricted to the standard ONS survey universe. More information on the differences can be found on the ONS website.

The UK supply and use tables show the:

- composition and value of goods and services entering into final demand
- outputs and incomes generated in the production process
- intermediate transactions that form inputs into these processes

The main part of the supply table shows estimates of domestic industries' output (in aggregate to prevent disclosure) by product. Since 2011 the SUTs have been produced consistent with SIC 2007 and CPA2008. For example for Product group 30.3 (Air and spacecraft and related machinery) the total supply of products is £36,398 million for 2012; the breakdown of which can be seen in Table 4.

Table 3 – Extract from Supply table for 2012

	Supply table 2012							£ million
	Product	Total domestic output of products at basic prices	Imports of Goods	Imports of Services	Total imports of goods and services	Distributors' Trading Margins	Taxes less subsidies on products	Total supply of products at purchasers' prices
30.3	Air and spacecraft and related machinery	18 365	16 507	-	16 507	450	1 076	36 398

Source: ONS Supply-Use Tables

The use table shows the input structure of each industry, the product composition of final demand and the intermediate purchases for each industry. Table 4 shows the intermediate consumption for Product 30.3 for a subset of the 112 industries that are detailed within the table (the industrial breakdown of intermediate consumption is not disclosive so is shown explicitly). The total intermediate demand was £4,328 million in 2012, with 76% of this coming from the 'Manufacture of air and spacecraft and related machinery' industry.

Table 4 – Extract from Use table for 2012

	Use table 2012	Industries' intermediate consumption							£million
	Product	30.3 Manufacture of air and spacecraft and related	30OTHER Manufacture of other transport equipment - 30.2/4/9	31 Manufacture Of Furniture	32 Other Manufacturing	33.15 Repair and maintenance of ships and boats	33.16 Repair and maintenance of aircraft and spacecraft	33OTHER Rest of repair; Installation - 33.11-14/17/19/20	Total intermediate demand
30.3	Air and spacecraft and related machinery	3 294	-	9	-	-	188	1	4 328

Source: ONS Supply-Use Tables

The total demand for products is then produced as the sum of the total intermediate demand and total final demand (Table 5).

Table 5 – Extract from Demand for products table for 2012

						£million
	Demand for products in 2012 The 'Combined Use' matrix	Final demand				
	Product	Final consumption expenditure	Gross capital formation	Total exports of goods and services	Total final demand	Total demand for products
30.3	Air and spacecraft and related machinery	885	8 530	22 655	32 070	**36 398**

Source: ONS Supply-Use Tables

The full tables contain 112 industry groups and 112 product groups, allowing users to study and analyse the detail and see which products are consumed in each industry.

Intermediate consumption by products										
Product	Agriculture [1-3]	Production [5-39]	Construction [41-43]	Distribution, transport, hotels and restaurants [45-56]	Information and communication [58-63]	Financial and insurance [64-66]	Real estate [68.1-2-68.3]	Professional and support activities [69.1-82]	Government, health & education [84-88]	Other services [90-97]
Production	0.318	1.419	0.226	0.145	0.088	0.054	0.045	0.073	0.087	0.070

Source: ONS Supply-Use Tables

Producing SUTs allows an examination of consistency and coherence of national accounts components within a single detailed framework. By incorporating the components of the three approaches to measuring GDP (i.e. production, income and expenditure), it enables a single estimate of GDP to be determined in current prices, which form essential weights within quarterly and annual volume estimates of GDP. As a corollary, the IOATs provide further insight into the UK production process via its reliance on international trade and provide analysts and policy-makers with important multiplier estimates by delineating key supply chain linkage.

v. Purchases of goods, materials and services

Information on the amount of goods, materials and services purchased by businesses is collected and published. Components of the total purchases for a business are captured which can provide a more in-depth analysis of how the business operates, for example:

- energy and materials used in the running of the business;
- cost of goods bought for re-sale#;
- services used for the business.

Data provided are available at detailed industry levels (down to 5-digit SIC in some places) which allows in depth analysis of the manufacturing sector.

Example 2: Purchases – Manufacturing and Aerospace

In 2013 businesses classified to 'Manufacturing' spent:

- £347.3 billion on purchases of goods, materials and services; 13.8% of all purchases made by businesses in the non-financial business economy.
- 68.2% of their purchases were goods and materials, 16.6% were services and 3.2% were energy and water products for own consumption.[7]

In 2013 businesses classified to 'Manufacture of Air and Space craft and other related activity' spent:

- £15.6 billion on purchases of goods, materials and services; 4.5% of all purchases made by businesses in the manufacturing sector.
- 73.8% of their purchases were goods and materials, 19.4% were on services and 1.0% were energy and water products for own consumption.[7]

Source: ONS Annual Business Survey

[7] Services include computer and related services, industrial services, road transport services, telecommunication services, advertising and marketing services, subcontractors and other services purchased. Total purchases also include goods bought for resale, hiring, leasing or renting plant, machinery & vehicles and commercial insurance premiums. A full breakdown of purchases is freely available on request from abs@ons.gsi.gov.uk .

vi. Research and Development

Research and Development (R&D) is defined as “creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications”. R&D data are used to help assess policy impact and inform debate and are a key indicator for measuring the performance of the economy in the UK as well as to monitor and develop R&D policies which seek to increase R&D investment.

Information on R&D undertaken by businesses is available on a product group basis with a limited industry breakdown also available. A product group breakdown describes the different types of R&D work taking place irrespective of the industry classification of the business undertaking the R&D, while an industry breakdown provides the amount of R&D being undertaken by an industry irrespective of the type of R&D work being performed.

It should be noted that not all R&D activity leads to recordable new Intellectual Property Rights (IPR), protected knowledge. It can also lead to the generation of in-house ‘know-how’ which may be a significant factor in business competitiveness but which is difficult to capture statistically.

Example 3: Research and Development – Manufacturing and Aerospace

In 2013:

- Businesses classified to ‘Manufacturing’ performed £7.2 billion of R&D; 39.1% of all R&D performed by businesses in the UK.
- £12.8 billion R&D on manufactured products was undertaken; 69.5% of all R&D performed by businesses in the UK.

In 2013:

- Businesses classified to ‘Manufacture of other transport equipment’ (Division 30 which includes Manufacture of Air and Space craft) performed £1.5 billion of R&D; 20.2% of all R&D undertaken by manufacturers in the UK.
- £1.7 billion R&D on Aerospace products was undertaken; 12.9% of all R&D undertaken on manufactured products.

Source: ONS Business Enterprise Research and Development Survey

vii. Labour

The labour market covers all aspects of people's work, including the education and training needed to equip them for work, the jobs themselves, job-search for those out of work, and income from work and benefits. Information on the labour market is important as labour is a key business input and changes in the labour market can be an indication of economic performance or business behaviour.

Data are available at varying industrial and geographical levels dependent on the variable of interest and the source. Some of the key variables and sources within the labour market are:

- Employee and employment estimates are available at detailed geographical and industrial levels. There are various sources for employment but the Business Register and Employment Survey (BRES) is regarded as the definitive source of official employee and employment statistics by industry. One of the strengths is that estimates are provided at detailed geographical and industrial levels allowing for detailed analysis.
- The most comprehensive source of earnings information in the United Kingdom is the Annual Survey of Hours and Earnings (ASHE). Information is available on the levels, distribution and make-up of earnings and hours paid for employees by gender and full-time/part-time working. Estimates are available for various breakdowns including industries, occupations, geographies and age-groups within the UK.
- Labour productivity measures the amount of adjusted economic output that is produced by a unit of labour input (in terms of workers, jobs and hours worked) and is a key indicator of economic performance. Information is available for manufacturing as a whole and sub-divisions of manufacturing.

Example 4: Labour Market – Manufacturing and Aerospace

In 2013:

- Total employment in 'Manufacturing' (Section C) was 2.6 million; 8.3% of total employment for the UK economy.
- The median gross annual pay for full-time employee jobs in 'Manufacturing' was £27,433 (an annual increase of 1.6%) compared with a median of £27,011 for all UK full-time employee jobs.[8]

In 2013:

- Total employment in 'Manufacture of air and spacecraft and related machinery' (Group 30.3) was 0.09 million; 3.8% of total manufacturing employment.
- The median gross annual pay for full-time employee jobs in 'Manufacture of air and spacecraft and related machinery' was £37,211; an annual increase of 3.7%.

Source: ONS Business Register and Employment Survey, and Annual Survey of Hours and Earnings

[8] Employees on adult rate who have been in the same job for more than a year. Estimates for the tax year ending 5 April 2013.

viii Productivity

Labour productivity is output (value added) per unit of labour input. Labour input may be measured as person employed, person-hours or skill-adjusted person-hours (note that persons employed includes both the employed and self-employed, persons engaged are just the employed).

Total factor productivity is output per unit of labour and capital input.

Labour productivity growth is that part of output growth that cannot be accounted for by the growth of labour input alone. Total factor productivity growth is that residual part of output growth that cannot be accounted for by inputs of capital and labour combined. It can be calculated by subtracting the growth of the capital and labour inputs (weighted by their respective shares in output) from the growth of output. Further measures of total factor productivity and total factor productivity growth may also be calculated for example by including other inputs that create value added such as R&D services used.

ix. Foreign Direct Investment

Foreign Direct Investment (FDI) refers to investment that adds to, deducts from or acquires a lasting interest in an enterprise operating in an economy other than that of the investor, where the investor's purpose is to have an effective voice in the management of the enterprise. Direct investment is a financial concept and is not the same as capital expenditure on fixed assets. It covers only the money invested in a related enterprise by the parent company with the enterprise having the discretion on how to use it.

FDI makes an important contribution to flows, earnings and positions for the UK balance of payments. It is also used as a factor in measuring gross national income, which determines contributions to the EU. FDI statistics can be used to measure the international investment patterns between the UK and the rest of the world, either by country or groups of countries. Inward FDI data indicates which sectors of the economy are of interest to foreign competitors and where long-term growth is expected to be. Outward FDI indicates which countries of the world are expected to be growth areas and where a company might wish to invest.

FDI data are collected both annually and quarterly and data are available on a country and industry basis. Direct investment in the UK by enterprises located abroad (inward FDI) and direct investment abroad by enterprises located in the UK (outward FDI) are both available. Among the variables measured are share purchases, holdings and the income received from share investments.

Example 5: Investment – Manufacturing and Transport Equipment In 2013

- The total international investment position (IIP) in UK manufacturing businesses was £175.1 billion; 18% of the UK's IIP.
- The total IIP in UK transport equipment businesses (Group 30) was £10.0 billion (£3.6 billion from Netherlands and £2.2 billion from USA); 5.7% of the UK's manufacturing IIP.
- The total IIP abroad from UK manufacturing businesses was £165.9 billion; 16% of the UK's IIP.
- The total IIP abroad from UK transport equipment businesses was £6.4billion (£2.8 billion in the Americas and £1.4 billion in Italy); 3.9% of the UK's manufacturing IIP.

Source: ONS Foreign Direct Investment Survey

x. Capital Expenditure

Capital expenditure is when a business spends money either to buy fixed assets or to add to the value of an existing fixed asset with a useful life extending beyond the taxable year.[9] Fixed assets are those which are not used up in the businesses processes, for example, it would include the acquisition or upgrade of physical assets such as property, industrial buildings or equipment. The majority of the investment captured is tangible but there are exceptions e.g. software, research and development and intellectual property products. Capital expenditure by businesses provides an indication of business plans or future performance, for example, businesses may be less likely to undertake capital expenditure in times of economic uncertainty and more likely to do so if they are planning to maintain or expand production. Some components of the capital expenditure estimates are used in the compilation of gross fixed capital formation; a major component of the expenditure measure of gross domestic product(GDP), which shows the total economic activity taking place in the country.

Information is collected on capital expenditure with some information available on the manufacturing sector. Some of the main variables collected are:

- Total net capital expenditure **–** for example, value of new building work, acquisitions less disposals of land and existing buildings, transport equipment and plant and machinery;
- Acquisitions **–** value of new building work, acquisitions of land and existing buildings, vehicles and plant and machinery;
- Disposals **–** value of disposals of land and existing buildings, vehicles and plant and machinery.

[9] This is the definition of capital expenditure collected on the Annual Business Survey. Capital expenditure information is also collected on the Quarterly Acquisitions and Disposals of Capital Assets Survey (QCAS). Business Spend will become the Annual Acquisitions and Disposals of Capital Assets Survey (ACAS). More information on these is available on the ONS website.

Example 6: Capital Expenditure – Manufacturing and Aerospace

In 2013:

- Businesses classified to 'Manufacturing' had a total net capital expenditure of £12.1 billion; 10% of net capital expenditure in the non-financial business economy.

- Businesses classified to the 'Manufacture of Air and Space craft and other related activity' had a total net capital expenditure of £0.7 billion; 5.9% of net capital expenditure in the manufacturing sector.

Source: ONS Annual Business Survey

xi. Turnover and sales

When considered alongside purchases, turnover can give a useful indication of business performance.

Information on the total value of turnover by businesses is collected and published at a detailed industry level. Components of the total turnover for a business are also captured which can provide a more in-depth analysis of how the business operates, for example:

- sales of goods produced;
- goods purchased and resold without further processing;
- work done and industrial services rendered;
- non-industrial services rendered.

Example 7: Turnover – Manufacturing and Aerospace

In 2008 businesses classified to:

- 'Manufacturing' generated turnover of £500.2 billion; 16.3% of all turnover made by businesses in the non-financial business economy.
- 'Manufacture of Air and Space craft and other related activity' generated turnover of £17.6 billion; 3.5% of all turnover of businesses in the manufacturing sector.

In 2013 businesses classified to:

- 'Manufacturing' generated £522.1 billion of turnover; 15% of all turnover made by businesses in the non-financial business economy.
- 'Manufacture of Air and Space craft and other related activity' generated £24.7 billion turnover; 4.7% of all purchases made by businesses in the manufacturing sector.

Source: ONS Annual Business Survey

As well as this, data are available at product level showing the total turnover of businesses classified to industries. In addition data are available for merchanted goods, work done,

sales of waste products and all other income at an industry level. This allows users to distinguish what level of turnover comes from what aspect of businesses in the manufacturing industry. The product sales information provides some insight into the activity of businesses classified to manufacturing (Table 3).

Although products are classified under an industry classification, businesses outside these industry classifications can produce these products. In the same vein, businesses within an industry classification can manufacture products outside the industry. Each business can therefore span a variety of products depending on its diversity.

Table 6: Components of turnover for Manufacture of air and spacecraft and related machinery, 2013[10]

	2013 Sales
Total UK manufacturer sales of products in this product group	80.0%
Merchanted goods	1.7%
Work done	0.1%
Waste Products	0.1%
Non production income	13.5%
Net carry in/carry out	4.4%
Total turnover of businesses classified to this industry	25,334,987

Source: ONS UK Manufacturers' Sales by Product (PRODCOM)

xii. Output

The measures of turnover and sales are from structural surveys which give the best estimates of the level of activity available at a point in time. However, to understand business performance it is important to measure performance over time.

The monthly UK Index of Production (IoP) provides a timely indicator of growth in the output of production industries in volume terms, in other words, the effects of price changes have been removed. The IoP is a key economic indicator and one of the earliest short-term measures. Industry coverage is the same as the corresponding quarterly series within UK GDP.[11]

Data are available as a seasonally adjusted estimate of total production and at broad sector groupings for mining & quarrying, manufacturing, energy and water supply & sewerage. Output estimates are calculated by taking value estimates and adjusting them to remove the impact of price changes, or by using direct volume estimates.

[10] Data from PRODCOM should not be directly compared with that from ABS due to differences in methodology.
Output as measured by IoP differs from Turnover from the ABS as IoP measures the volume of production at base year prices whereas ABS measures the sales value (revenue) at current prices.

[11] Output as measured by IoP differs from Turnover from the ABS as IoP measures the volume of production at base year prices whereas ABS measures the sales value (revenue) at current prices.

Example 8: Output – Manufacturing

In 2014,

- Output in 'Manufacturing' was 2.7% higher in Q4 2014 compared with Q4 2013.

  Comparing data from December 2013 and December 2014 shows that UK experienced the strongest total manufacturing growth in the euro area at 2.6%, compared with total euro area manufacturing growth of 0.4%. Italy experienced manufacturing growth of 1.0%, while growth in France and Germany was lower, at 0.3% and 0.2% respectively.

Source: ONS Index of Production

Output here is also used as a proxy for value added in the short term output indicators.

xiii. Trade

Trade information provides another important insight into the way businesses operate. Trade information is identified through a business reporting if they import or export goods and/or services. Data are available on both the values of UK trade, and counts of businesses trading.

Data on values of UK trade are collected through surveys and administrative sources, and are published on both a monthly and quarterly basis. Monthly information on Trade provides industrial breakdown of changes to key commodities with quarterly information allocating UK imports and exports data to the CPA08 for both imports and exports. Values of trade are available annually in relation to the Standard International Trade Classification (SITC) through the Pink Book. Data are available by product, geographical breakdown of trade, as well as the top fifty UK trading partners for the imports and exports of goods.

Counts of businesses engaging in trade in Great Britain are also available together with proportions, of businesses that trade in goods, services, or both, available on an annual basis. This is broken down by size band, turnover, industry and ownership. Further work is currently taking place to assess the feasibility of producing additional information by multiple aggregations, such as size band and industry section.

d. Examples of summary data sources

The manufacturing data that are available from many of the detailed sources mentioned above, with the addition of other administrative sources, are collated to produce supply and use tables and in turn calculate GDP.

i. GDP

Gross domestic product (GDP) is the primary indicator of economic activity within the UK. It should be noted that there are not three different versions of GDP, just three different ways of estimating the same thing.

Data are available at a broad industry level for the Production approach and also for some lower level industries, including manufacturing.

Example 9: GDP – Manufacturing

- GDP at chained volume measures, within the Manufacturing industry grew by 0.1% between Q3 and Q4 2014; a year on year increase of 2.7%

In 2014 GDP at current prices in:

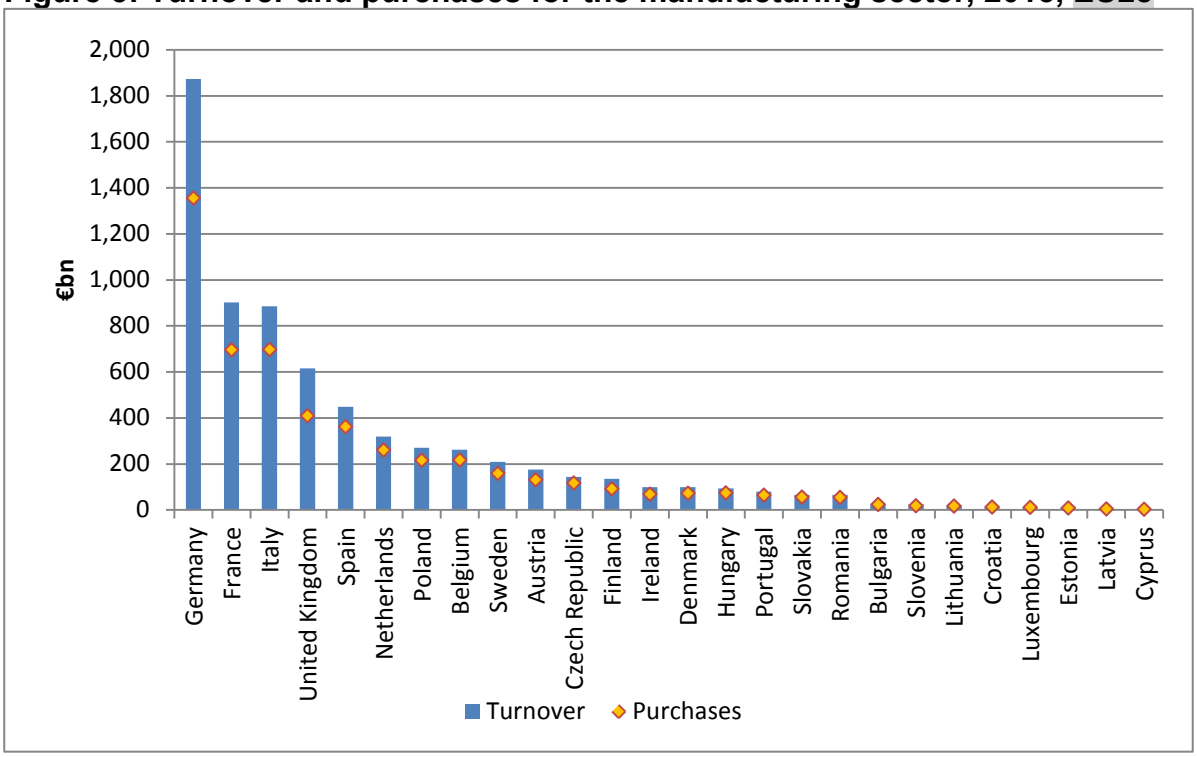
- 'Manufacturing' was £171.21 billion
- 'Manufacture of Air and spacecraft and related machinery' was £7.0 billion

Source: ONS Quarterly National Accounts Q 2015

ii. International comparisons

Many of the official statistics produced nationally are required under international legislation. This, along with the international rules for industrial classification, means that many of the statistics highlighted in this chapter are also available for other countries on an internationally comparable basis. This enables comparison between the UK and other countries, showing how UK manufacturing compares on a global scale. An example of such a comparison is shown in Figure 3, where in 2013 the UK Manufacturing industry had the fourth largest turnover and purchases of all EU28 countries.

Figure 3: Turnover and purchases for the manufacturing sector, 2013, EU28



Source: Eurostat

e. Future developments

As well as the existing data that are available there are a number of developments taking place to existing surveys and the introduction of new surveys to further improve the wide ranging set of statistics that are available to understand manufacturing activity in the UK.

i. International sourcing

One key development is a proposal to improve the information required to understand how businesses operate globally. The UK has been part of a European Task Force to develop the proposal and it is likely that the requirements being proposed will require a new multi-annual survey. The proposed survey will be similar to one ONS piloted in 2007 which has since been piloted a further two times by certain other countries within the EU.

As part of the development of this survey a new classification is being proposed on business functions which includes breakdowns of activity for example by, primary activity, R&D, marketing and after sales service provision.

Some of the likely variables to be collected and produced will be drawn from the following list of subjects:

- General information about the group structure of the enterprise
- Employment in the enterprise by business function
- Domestic sourcing of business functions
- International sourcing of business functions
- Motivations and barriers for sourcing
- Back sourcing of business functions
- International organisation of activities in the foreign affiliates of the reporting enterprise

This will provide useful information on the range of activity taking place within businesses and therefore within the manufacturing sector. It will also allow more detailed analysis of global businesses, specifically highlighting which functions are being retained within businesses, which are being outsourced domestically and which are being outsourced internationally.

The regulation requiring this information is likely to be introduced in 2018 with the first publication of data expected to be 2021 covering the reference period 2018-2020, however, there may be an opportunity for Member States to pilot the collection of the data in advance of this.

ii. Purchases Survey

In order to produce the SUTs data on businesses, purchases for intermediate consumption are required. Intermediate consumption consists of goods and services consumed as inputs by a process of production. The goods and services are either transformed or used up by the production process. This includes raw materials, power and fuel, rental on buildings and business services such as advertising, recruitment consultancy and cleaning. It specifically excludes fixed assets or capital investment, staff costs and goods bought for resale without further processing.

Currently information on business purchases is available from the ABS and this is used to compile the SUTs. However, breakdowns provided on the types of purchases being made are limited. As such ONS is developing a new Purchases Survey to collect and produce information on businesses' intermediate consumption by product

This is an important development in understanding better one aspect of the value chain described earlier in the report as the new survey will provide detailed information on what types of goods and services are being purchased by the manufacturing industry in order for their respective business to operate.

The survey is due to be dispatched for the first time in 2016, with the first publication of the data likely to be in Spring 2017.

f. The need for new metrics

The need for new metrics arises from concerns among policy-makers, industrialists and institutions that conventional ways of representing manufacturing activity may be incomplete, inaccurate or at worse misleading indications about manufacturing activity.

In practice, as the review in this Chapter has shown, robust and wide-ranging measures are already in place for many aspects of manufacturing performance and the major concern is to ensure that they reflect the changing structures and dynamics of manufacturing. The major changes concern the emergence of value chain representations as providing a fuller exposition of manufacturing activities. New approaches to representing and describing manufacturing value chains are set out in the following Chapters. They address key concerns including:

- Whether existing data or metrics can be used more effectively.
- The potential for additional metrics to significantly add to how manufacturing activity is captured, reported and understood.

g. Summary

This section has set out in some detail the current arrangements for the measurement of manufacturing at the national level. It provides an authoritative reference for current arrangements showing how international frameworks are carefully followed with local amendments aligned with these frameworks where appropriate. The section concludes with a restatement of the need to explore additional uses of current data and opportunities for data collection and analysis methods.

4. The Manufacturing Value Chain

The manufacturing 'value chain' introduced in Chapter 2 has found increasing acceptance as providing a more comprehensive representation of modern manufacturing related activity Recent publications adopting this approach include:

- The 2013 Foresight report representation of the Manufacturing value chain (see figure 1, page 9).
- The 2015 Brookings Institution consultation paper "Innovation and manufacturing labor: a value chain perspective" proposing a model for the US manufacturing value chain based on US employment figures[12].
- OECD papers reviewing definitions and contribution of manufacturing activity.

A value chain perspective on manufacturing shows more clearly the activities upstream and downstream of physical production, which are not always considered as part of the manufacturing sector. It offers not only a greater understanding of where value is being added, but can reveal dependencies between different activities, the performance of different parts of the value chain. It also provides a route to understanding required skill profiles and employment levels. Value chain concepts are not currently embedded in models used by national statistical agencies but in the UK and some other G7 economies, the potential for using published analytical input-output tables to identify and measure upstream and downstream activities is being explored. The following are three examples what can be derived from these data sets

- Purchase of intermediate goods and services by manufacturing from other sectors of the economy – of particular interest are specialised services which to a large extent are bespoke for the manufacturing sector (for example research and development, design services and technical testing); the purchase of raw materials such as food produce for processing; and water, gas and electricity, including for the production activity;
- Support services which manufacturing firms use and which are generally not bespoke or tailored for the manufacturing sector, for example accountancy, transport and cleaning services. Some of these activities may have traditionally been undertaken in-house, but may now increasingly be contracted out to specialised service companies;
- Post-production services such as retail sales and repair and maintenance. It is noted, however, that repair and maintenance activities outside the manufacturing sector as traditionally measured are relatively small and include items such as repair of household goods and computers. Within the existing agreed international classification framework, the repair and maintenance of large capital items such as aeroplanes, trains and ships are still recorded as part of the manufacturing sector, even though some may view these as a service activity.

[12] Innovation and manufacturing labor: a value chain perspective http://www.brookings.edu/~/media/research/files/papers/2015/03/06-innovation-manufacturing-labor-value-chain-whitefoot-valdivia/valdiviafinal.pdf

a. Developing new representations

i. Brookings Institution Research

In exploring new representations the Group drew on exploratory work by the US Brookings Institution to develop a representation of employment across the US manufacturing value chain. The Brookings team used US labour force data to capture manufacturing related employment that covered not only people employed directly by companies classified to manufacturing but also people engaged in the delivery of pre-production and post-production services to manufacturing.

The analysis used comparative data for 2002 and 2010 indicate the extent of the overall manufacturing value chain, and also which parts had seen the most change in terms of employment decline or growth. The findings included:

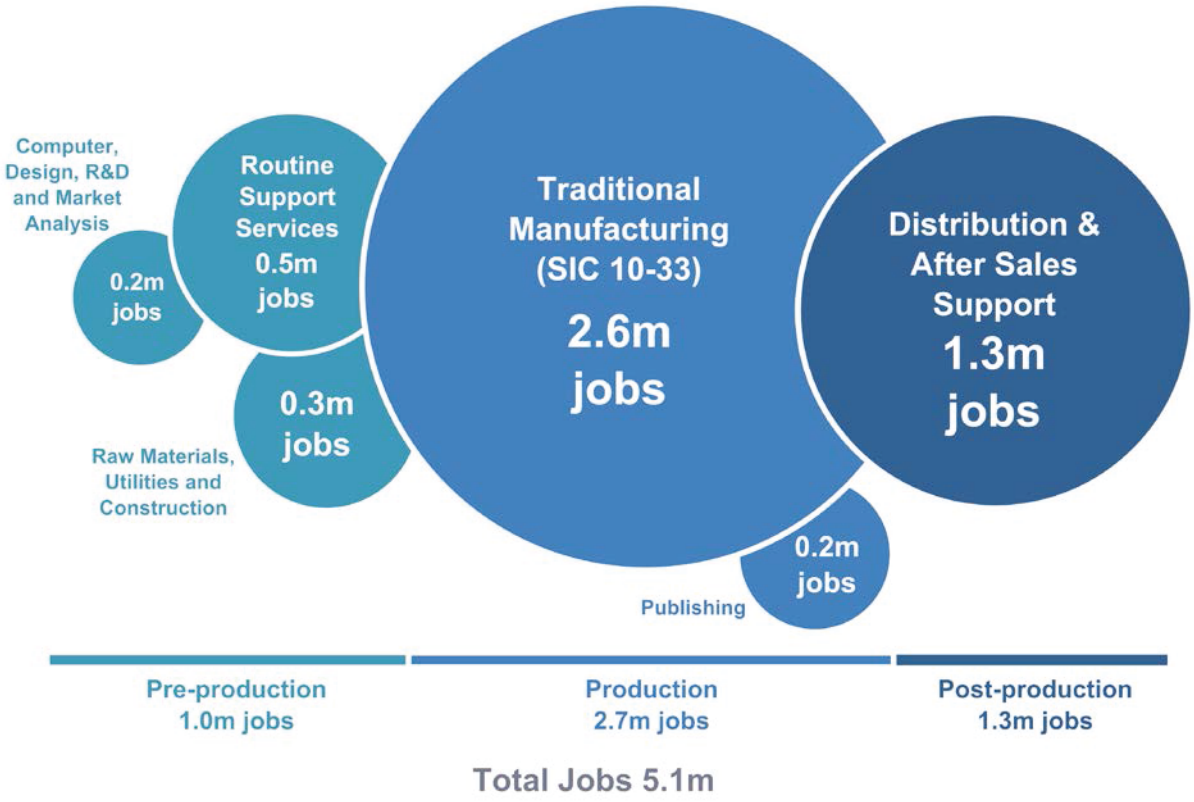
- The number of people employed across the US manufacturing value chain (on their definition) was significantly larger than for the narrow definition of manufacturing used for national economic statistics e.g. in 2010 the number employed across the broader value chain totalled 32.9 million, compared with 11.5 million in 'production'.
- There was a 4 million fall in the number of people employed across the value chain between 2002 and 2010, with
- Factories engaged in physical production saw the most significant job losses
- Upstream activities, i.e. pre-production services, saw employment growth.

ii. Representing the UK manufacturing value chain

The Brookings work is a helpful attempt at providing a new and innovative representation of manufacturing which the Group was keen to develop further. Figure 4 provides an illustration of the way new insights can be obtained using currently available data – in particular the UK Analytical Input-Output (IO) tables which are available for the reference year 2010. As discussed in Annex D, this approach differs significantly from the Brookings work for the USA since IO tables are not available.

However, similar to the Brookings work, the BIS method estimates the number of jobs associated with manufacturing across the UK economy. The assumptions are set out below and discussed in more detail in Annex E. The 2010 estimates should be seen as indicative rather than definitive measures.

Figure 4: Estimate of number of jobs supported by the manufacturing sector across the value chain, 2010 (N.B. There is no overlap in the job numbers shown across the different parts of the value chain in this figure. Due to rounding, the sum of all components of the manufacturing value chain does not equal the total jobs figure)



Source: Provisional estimates produced by BIS using ONS Input-Output Analytical tables ***(the method may be subject to further review / improvements)***

Starting from the internationally accepted Standard Industrial Classification framework, there were 2.56 million jobs in the manufacturing sector in 2010. Publishing activities were previously reported as a manufacturing activity but from 2007 under the new SIC2007, this has been re-classified as a service activity because of the increasing use of electronic means to disseminate books, journals and computer games. However, 'goods' continues to feature substantially in this sector and so for this study is considered to be part of the wider value chain, accounting for a further 170,000 jobs.

Pre-production jobs support the purchase of domestic goods and services by the manufacturing sector, with imports being excluded (an important departure from the methodology of the Brookings study). These data are sourced using estimates derived from the ONS analytical input-output tables and published employment multipliers for the manufacturing sectors. Full details of the assumptions and methods used to estimate the number of jobs associated with these purchases, are given in Annex E.

Jobs supported by the purchase of domestic goods and services have been grouped into three categories:

- Raw materials, utilities and construction 'goods';
- Specialised design, R&D, marketing services and computer services which to some extent are likely to be bespoke or adapted for the manufacturing sector;
- More routine support services including transport, legal, accountancy and administrative services – for example catering, cleaning and other site maintenance services.

This represents a key difference to the methodology of the Brookings team where there was no account taken of the purchase of raw materials, utilities and support services.

Raw materials are dominated by the purchase of food products for processing and utilities including water, gas and electricity for energy. It is known that a number of manufacturing processes require the heavy use of energy and water. There are also a small number of purchases from the mining and quarrying and construction sectors. It is estimated that the purchase of these 'goods' from outside the manufacturing sector supported 0.3m jobs in 2010.

Design, R&D, marketing and computer services purchases were estimated to support 0.2m jobs. The rationale behind the separation of this grouping from "routine support services" below is that while the service activity is also purchased by other sectors of the economy, more than likely there will be some 'bespoke' tailoring for the manufacturing sector based on the specific products being manufactured.

Routine support services, which cover for example transport, telecommunications, other professional and administration services are estimated to account for 0.5m jobs. These service activities are of a more 'routine' nature in that there is unlikely to be a lot of specialism specific to the manufacturing sector.

In addition, **post production activities,** including the wholesale and retail of manufactured goods and the renting of vehicles, machinery and other goods and the repair of household goods and computers, are estimated to support 1.3m jobs, with the majority being in the distribution sector. The methodology includes an estimate of the domestic content of these goods, so that imported goods are not represented and the jobs reflect the support to the domestic and not the world-wide value chain. As discussed in Annex E this is a major difference in approach to the Brookings method which represents the world-wide value chain for after sales activities, rather than just the domestic content.

In summary, it is estimated that the total number of domestic jobs associated with the UK manufacturing sector in 2010 was 5.1 million which is 16.2% of all UK jobs. This is split into:

- 2.56m in the traditional manufacturing sector defined by SIC 10-33, section C, accounting for 8.2% of UK jobs (this compares with the manufacturing sector accounting for 10% of the UK economy on a value added GVA basis),
- 2.51m additional jobs supported by the manufacturing sector through the purchase of goods and services, after-sales services (mainly distribution of domestic goods) and publishing, accounting for a further 8.0% of UK jobs.

b. Potential for further developing this approach

The approach set out in this chapter offers a number of advantages:

- It offers new insights from current data without the need to modify or extend current data collection routines, although there may be some opportunities for improving some of the estimates in consultation with the ONS;
- It explicitly recognises that manufacturing activities directly influence and support jobs in other 'sectors';

At present this analysis has only been undertaken for a single year, 2010. Consistent data and estimates are not available for previous years, although some approximations for 1995 and 2005 may be possible. However, ONS are now planning to publish analytical input-output tables on an annual basis.

While it should be possible to repeat the analysis annually on a routine basis, it is expected that any significant insights from this approach will be seen only over a longer time-scale. For example, the approach could cast light on the changing shape of the manufacturing sector, in terms of use of purchased intermediate goods and services and sources of productivity changes. It might also illuminate the discussion of such as offshoring and reshoring, in terms of the balance between domestic purchases and imports.

5. New Approaches to the Measurement of Manufacturing

Having established that opportunities exist for additional insights to be gained from currently available statistics the group identified opportunities for more radical approaches to the classification and measurement of manufacturing.

Classifying manufacturing – by business model

Value chain representations at different levels of granularity can reveal manufacturing related activities and the relationships between them. Further insights can be gained from a better understanding of the business models that companies adopt – particularly the different degrees of dependence upon physical production or the role of service in a company's business proposition.

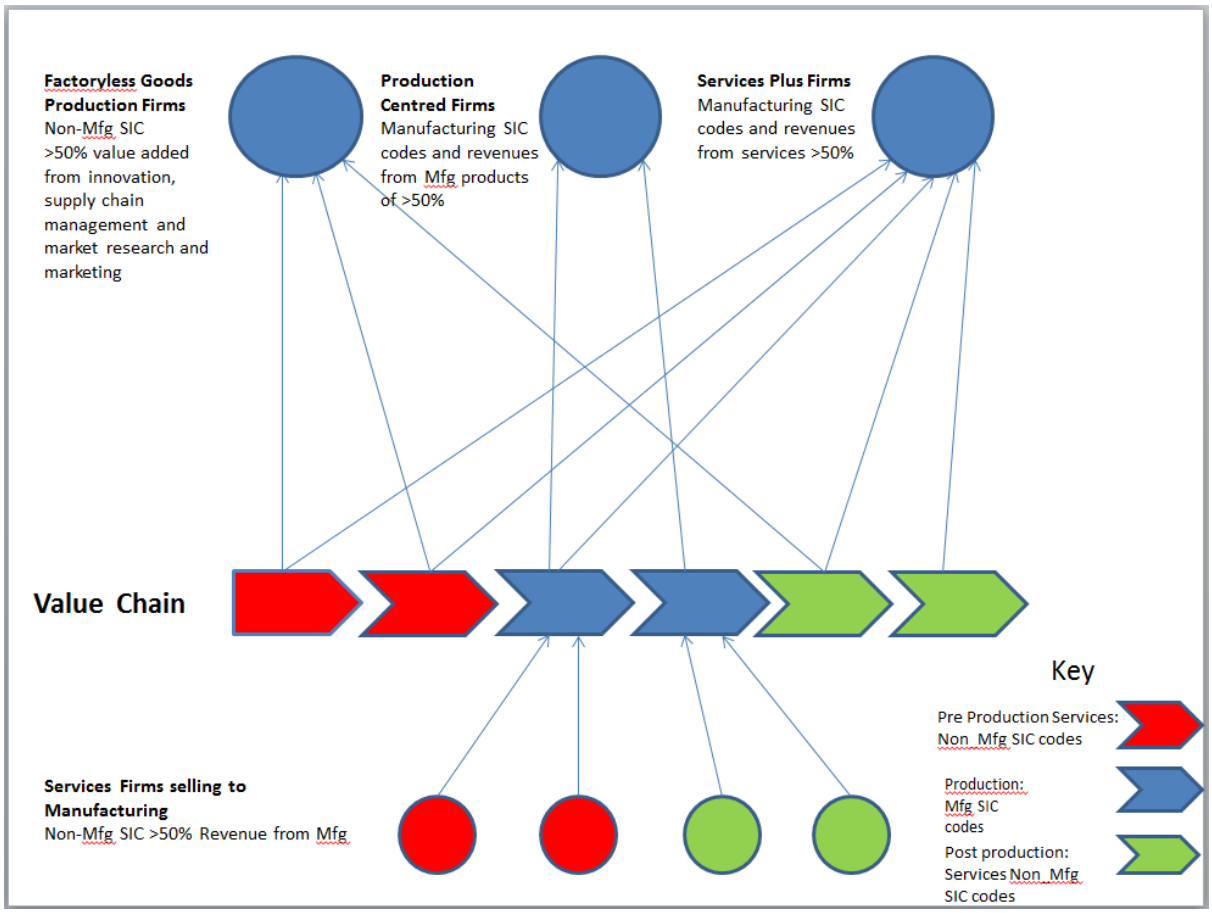
Table 7 shows a first attempt at identifying key 'families' of business model followed by descriptions of each category. Figure 5 shows how these business models in turn may be mapped onto the various components of the value chain. This reveals how each business model represents different combinations of manufacturing and pre-manufacturing service activities (e.g. R&D, Design IPR) and post-manufacturing services (e.g. post-sales service) , all as defined by the UK Standard Industrial Classification.

Table 7: Business Model descriptors

Business Model	Definition	Indicative Stages of Value Chain
Factoryless Goods Producers	Non-manufacturing SIC codes but Intellectual Property investors and more than 50% of value added[13] originates from activities such as innovation, supply chain management and market research and marketing	R&D, Design, IPR, Supply Chain Co-ordination
Production Centred	Manufacturing SIC codes and revenues from products of >50%	R&D, Design, Production
Service Plus	Manufacturing SIC codes and revenues from services >50%	R&D, Design, Production, Post Sales Service
Services for Manufacturing	Non-manufacturing SIC codes, but who receive >50% of revenues from manufacturing firms for the services they provide.	Services

[13] Sales (less cost of bought-in materials, components and services) and Operating Profit (plus Employee costs, depreciation, amortization, impairment)

Figure 5: Mapping Business Models to the Manufacturing Value Chain



a. Factoryless goods producers

One of the most intriguing but - from a measurement perspective - challenging business models is that of the so-called “factoryless goods producer” (FGP). FGPs design the products they sell and coordinate the production activities, typically through the purchase of contract production services. Firms like Apple and ARM are prominent examples of FGP-type organizations. Understanding the circumstances of these firms has potentially significant policy implications. In a recent National Bureau of Economic Research (NBER) working paper (NBER WP. No. 19396, 2013) for example, Bernard and Fort use 2002-7 US Wholesale Trade census data to conclude that that reclassifying FGP establishments to the manufacturing sector would have shifted significant numbers of workers from wholesale to manufacturing (i.e. 595,000-1,311,000 workers in 2002 and 431,000-1,934,000 workers in 2007). The merits of reclassifying FGPs are currently being debated by national and international agencies.

Potential for UK measures

The NBER authors were able to use a new set of "Establishment Activities"[14] questions asked in the 2002 and 2007 wholesale censuses. The majority of UK ONS business surveys, however, are sampled from the Inter-Departmental Business Register (IDBR). An identifier on the IDBR indicating the type of business would enable subsequent survey data to be split by the groups defined in the framework.

b. Production Centred

Production centred manufacturing reflects the 'traditional' view of manufacturing businesses. These are typically focussed primarily on the transformation of materials from one form to another. This would include conventional engineering activities such as the production of cars and aircraft but also food and pharmaceuticals. The conventions mean that companies categorised as production centred may engage in other types of activity but at least 50% will be involved in core manufacturing.

Potential for UK measures

This category contains the manufacturing firms as conventionally measured under manufacturing in ONS statistics

c. Service Plus

Manufacturers are increasingly using production to allow other value creating activities to occur, typically supporting or complementing products in use and/or offering outcome or availability based contracts. In 2011, 39% of UK manufacturers with more than 100 employees derived value from services related to their products, compared with 24% in 2007. This change in the structure of manufacturing businesses should be reflected in the national statistics and so this new category is proposed to include manufacturing companies for which more than 50% of revenues are generated from services

Potential for UK measures

Two approaches have been identified to define a manufacturing business as either 'Production Centred Manufacturer' or as 'Service Plus'. The details of these approaches together with the relevant data are given at Annex F. The first assumes that if the turnover generated from 'Value of sales of goods of own production' is greater than 50% of the total turnover of that business, then it is classified as a 'Production Centred Manufacturer', if it is less than 50%, then it is a 'Service +' business. The second approach combines both the turnover generated from 'Value of sales of goods of own production' and 'Value of work done on customers materials' and if this is greater than 50% of total turnover, then it is a 'Production Centred Manufacturer', if it is less than 50%, then it is a 'Service +' business.

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[14] In 2002, each establishment was asked whether i) Product design/engineering, and ii) Materials fabrication/processing/assembly/blending were a) performed by the establishment; b) performed for the establishment by another company; or c) not provided by the establishment. In 2007, the survey asked each establishment whether i) it designed, engineered, or formulated the manufactured product it sold, produced, or shipped; ii) its primary activity was to provide contract manufacturing services for other establishments, manufacture its own goods, resell goods produced by others, or other; and iii) it purchased contract manufacturing services from another establishment (within or outside the firm) to process its inputs.

Based on these two approaches table 8 shows the counts of businesses that fall into 'Service +' or 'Production Centred' manufacturer for 2008 to 2013. Both approaches identify more 'Production Centred Manufacturers', with approach 2 allocating more businesses into this category in all periods.

Table 8: Numbers of businesses categorised as Service+ and Production Centred

	Number of Businesses			
	Approach 1		Approach 2	
Section	Service+	Production Centred	Service+	Production Centred
2008	10,380	121,401	4,814	126,967
2009	9,886	118,540	8,976	119,450
2010	15,807	108,172	11,809	112,170
2011	14,611	107,980	10,509	112,082
2012	17,970	106,562	14,593	109,939
2013	19,255	108,650	15,059	112,846

Whilst there are differences in absolute numbers both approaches show a similar movement and magnitude of change over time with a shift from 'Production Centred Manufacturers' towards 'Service+' since 2008.

It should also be noted that for some businesses the value of sales of goods of own production may include service activity required alongside the production to produce the product though this simply divides existing measures into two categories rather than expanding definitions.

d. Services for manufacturing

The benefit of manufacturing to adjacent professional and technical services (i.e. lawyers, accountants, consultants, etc.) has a number of significant implications for the 'value' of manufacturing to the broader economy. A specific category of service for manufacturing might therefore be useful. This would include firms with non-manufacturing SIC codes, but which receive more than 50% of their revenues from manufacturing firms for the services they provide.

Potential for UK measures

While it is not possible to identify services for manufacturing firms at an individual business level, some information is collected on purchases across all industries on the ABS. It would therefore be possible to identify the manufacturing businesses making large purchases of services. The types of services could be assessed to establish the industry sectors that are most strongly linked to the manufacturing sector as indicated in Annex F.

Similarly, while the Supply and Use Tables do not provide information at an individual business level they do provide information on the types of products being consumed by manufacturing businesses that can help identify links between the manufacturing and service sectors.

e. Summary

The proposals set out in this Chapter offer longer term approaches to the better articulation of the role of manufacturing in the economy. They are not amenable to immediate quantitative analysis but suggest a direction of travel to improve the awareness and understanding of manufacturing.

The proposals for mapping and labelling of activities offer greater clarity about the nature of manufacturing but also a potential basis for the development of future metrics.

Firm level performance measurement and benchmarking might usefully form the basis for further study to explore potential linkages to national measures.

6 New Data Sources

The Big Data Revolution

Recent developments in information capture and processing, including 'big data' have opened up important new opportunities for understanding the nature of manufacturing. The volume, velocity and variety of data have all increased substantially. An oft cited statistic is that over 90% of the world's data was created in the last 2 years and the growing number of devices and systems connected through the internet suggest that these trends are likely to accelerate.

ONS and others gather official statistics through surveys, annual returns from firms and administrative data. These statistics are clearly valuable and wide ranging, but potentially new and alternative forms of data could be used to supplement the official statistics. These might include: (i) intra-firm data; (ii) inter-firm data; (iii) socially created data; (iv) public data; and (v) private data. The sections that follow outline these different sources of data, suggesting both how they might be accessed and how they might be used.

a. Intra-Firm Data

All firms need data to operate. Increasingly, operational data is captured in sophisticated enterprise information management systems. These systems include:

- Product data - data on product design and structures, including associated bills of materials describing the assemblies, sub-assemblies and individual components that go together to create specific products.
- Operational data - data on the general operation of the organization, including factory planning and capacity management, inventory planning and control data, machine and equipment utilization data.
- Human resource data - data on the workforce covering skills and capabilities, employment and education records, salary and benefits data.
- Financial data - general accounting data including information on sales, margins, investments and expenses.
- Non-financial data - general non-financial data including information on customer and employee satisfaction, lead times, quality levels, etc.

The above data are largely structured - contained in formal systems and databases - with varying degrees of comparability both within and across organisations. In addition organisations generate a large amount of unstructured "dark" data - data that are produced, but not always used. The meta-data attached to emails and phone calls, for example, could be used to explore social networks within and between organisations - who communicates with who, with what frequency? Weblogs statistics could be used to explore who interacts with the organization, and for what purpose. Safeguards for confidentiality would of course be vital in such explorations.

b. Inter-Firm Data

Beyond the single organization, structured data also exists regarding how organisations interact. Key sources would include:

- Supply chain data - procurement and inventory records, who buys what from whom at what price.
- Sales and market data - sales order data - who sells what to whom at what price.

As with the intra-firm data, there is also significant “dark” inter-firm data. Meta data associated with email and phone calls could be used to map social networks and interactions between firms and potentially between countries.

c. Socially Created Data

Outside the firm increasing volumes of data are created through social media. Facebook, LinkedIn and Twitter contain significant volumes of data. Some organisations, such as TrendSpottr.com use socially created data to make predictions about emerging trends and key influencers on the web. Gild.com uses data from LinkedIn and open source coding databases to identify skilled coders who might be available for employment or contract work. They review the quality of code individuals submit to open source projects, identifying those who are the best and most respected coders. Coupling this insight with information from LinkedIn allows Gild to create profiles of potential employees or contractors. Meltwater.com tracks social media, such as Facebook, LinkedIn and Twitter, as well as thousands of blogs to determine sentiment about specific firms and organisations.

d. Public Data

Increasingly governmental and other institutional data are being put into the public domain (Google have a public data explorer) and coupled with other data sources to create new, value added insights. Combining weather or population data, for example, allows organisations to make predictions about demand. Retailers have long used temperature forecasts to make predictions about demand for outdoor goods, including barbeques and charcoal for the classic British barbeque season! Ordnance Survey has made much of its map data publically available. This coupled with other data, for example on crime or house prices, has resulted in services such as the police’s crime mapper, which allows you to track crime in different neighbourhoods or RightMove, which allows you to map house prices in different neighbourhoods. There are also numerous ‘open source’ and community data sources (e.g. Sedex, the Supplier Ethical Data Exchange) where adjacent manufacturing related concerns such as ethical and environmental impact can be explored.

e. Private Data

In addition to public data there are numerous private data sources. Organisations that collect and publish benchmarking data across a wide variety of industries and sectors cover everything from customer satisfaction (e.g. JD Power surveys) through to APQC’s open standards benchmarks for manufacturing. These proprietary databases contain potential useful information about both the performance and evolution of manufacturing.

Potential uses of Alternative Data Sources

It is clear that a wide variety of data are available to support development of better measures for manufacturing. Table 9 , below, summarises some of the questions that might be addressed using specific data sources. Clearly some of these questions can be addressed with existing data, but there may be advantages in triangulating measurement using different data sources.

Table 9: Alternative Sources of Data and Potential Uses

Question	***Data Source***	***Data Category***
1. What proportion of a finished product's value added is captured by UK as opposed to international firms?	Company records on purchases, coupled with bill of materials.	Intra and inter-firm data
2. What is the regional spread of value added captured by UK firms?	Company records on purchases, coupled with Ordinance Survey data.	Intra and inter-firm data, plus public data
3. What is the sectoral spread of value added captured by UK firms?	Company records on purchases, coupled with Ordinance Survey data.	Intra and inter-firm data, plus public data
4. To what extent are integrated, data intensive (the so-called Industry 4.0) operating models gaining purchase?	Telecoms usage data, from providers such as Vodafone, could – via analysis of location, data intensity, type and distribution of exchange, etc. - generate useful leading indicators.	Infrastructure firm and inter-firm data.
5. What is the brand perception of UK versus overseas manufacturing firms?	Social media coupled with brand survey data (e.g. InterBrand).	Socially created data coupled with private data.
6. How dependent are UK professional service firms on manufacturing? What proportion of revenues for the large accounting, consulting and legal services firms come from UK manufacturers?	Data from sales order systems of UK largest professional service firms. How much do the top firms sell to UK manufacturers as opposed to UK services firms and/or overseas firms.	Intra and inter-firm data.
7. How prevalent are factoryless goods production, service+ and services for manufacturers (ref. new value chain framework)?	Data from finance and accounting systems of largest firms (not just manufacturers to capture information on factoryless goods producers).	Intra-firm data.

Mapping of potential “alternative sources of data” for manufacturing would systematically identify sources of data that could be used by BIS to gain a deeper understanding of manufacturing. The mapping could cover the five area identified above: (i) intra-firm data; (ii) inter-firm data; (iii) socially created data; (iv) public data; and (v) private data. . Of course, one of the challenges of this approach is that existing approaches to data collection use internationally agreed structures and standards to collect data. The challenge with new sources of data is that they are likely to be messy and “dirty” - hence there will be challenges in using them at an aggregate level.

These maps might usefully be complemented by a series of pilot studies to test the feasibility of using alternative sources of data to better understand manufacturing’s performance. These pilot studies should cover the five sources of data outlined above, but be structured around specific questions of interest (as suggested in Table 3).

7. Conclusions and Recommendations

The review was established in response to the finding of the Manufacturing Foresight programme:

> 'The performance of the manufacturing sector is currently measured by classifying the output of manufacturing firms by the main type of economic activity in which they are engaged with the ONS using the Standard Industrial Classification (SIC) system. This provides a limited and incomplete picture since it captures neither the wider manufacturing value chain nor the incorporation within the firm of pre- and post- production services which are increasingly important in competitive business models for manufacturing firms.'

The review group included expertise in statistics, economics and operations as well as industrial practice.

a. **The review's findings suggest that the Foresight report's observations about the measurement of manufacturing are echoed internationally – particularly the need for a broader definition of manufacturing to include activities upstream and downstream of physical production. Current metrics* are built on internationally recognised standards and provide a high level of consistency and a basis for many other analysts. They do not however fully reflect the broader definitions of manufacturing.**

We conclude that there are significant opportunities for manufacturing activities to be measured more comprehensively and that it will be important for the UK to keep abreast of, if not lead, the international exploration of these opportunities.

We therefore recommend that:

- A panel of experts should be established to provide a point of authoritative reference on manufacturing matters
- The UK Statistical and Economic communities and BIS should look for opportunities to further engage with their respective international communities through the planned review of the International Standard Industrial Classification and to identify good practices in the monitoring of changes in business behaviour.
- ONS should continue, with the involvement of officials from across government, to be an active participant in shaping the proposed European Legislation 'Framework Regulation Integrating Business Statistics', in particular with regard to the proposed International Sourcing Survey which appears to have the potential to bring significantly better understanding of the manufacturing industry.

The review found that data and metrics are captured and deployed in accordance with international agreements and that the results commanded considerable confidence among users. The effective use of data and metrics is partly the responsibility of ONS but other agencies of government have access to and responsibilities for data which is relevant to manufacturing.

*** The methods used are set out in Chapter 3 of the report. A more technical explanation is provided in Annex B.**

b. The review's findings suggest that new approaches to the analysis of current data could serve both industrialists and policymakers. A first step would be to build upon the novel representation of manufacturing related jobs set out in Chapter 4 which estimated that considering manufacturing dependent jobs upstream and downstream of the conventionally measured production activity increased manufacturing related employment from 2.6m to 5.1m.

We recommend that:

- Building on the jobs/value chain representation of manufacturing set out in Chapter 4, BIS should further test the robustness of the approach, and explore if this model provides a template from which it is possible to develop further representations of the manufacturing value chain using other metrics.
- ONS and BIS should continue to pursue improved data sharing between Government departments and the private sector to fully exploit the potential of existing data. ONS experiments in data linking (e.g. linking HMRC trade data with data from the Annual Business Survey and R&D survey) should be joined up with BIS work to develop alternative representations of the manufacturing value chain.
- The new approach to the representation of manufacturing activities set out in Chapter 5 should be further developed with a view to improving data gathering to inform changing business models, particularly against the four following descriptors:
    - Factoryless Goods Producers (FGPs)
    - Production Centred
    - Service Plus
    - Services for Manufacturing

As part of this work, ONS should utilise new relationships established through their participation in this review to help inform their contribution to international discussion on classification of different activities (e.g. creation of FGP as a sub-class).

- It is proposed that these representations form part of a more informal reporting of manufacturing designed to inform BIS policy makers

c. The review identified a number of opportunities for additional frameworks and metrics to capture, report and explain manufacturing activity including new frameworks for measurement, new sources of data and analysis and the use of modern analytical methods

The review found that, while current statistical data collection undertaken by ONS was thorough and professional respecting international standards, there were opportunities to represent manufacturing activities more fully and to explore additional data sources and analyses.

Many industrial, commercial and institutional organizations collect data for their own purposes which might be of value in understanding the nature and dynamics of manufacturing. New techniques, increasingly referred to as 'big data analytics' are emerging which allow such data to be examined in new ways. Such techniques might be of value in eliciting new information from data already collected by ONS as well as data collected by third parties. It is recognised that privately held data may be commercially confidential and therefore not accessible to government but the potential of public and private data to inform manufacturing should be further explored not least through ongoing business level performance and benchmarking experiments being undertaken in BIS.

We recommend that:

- The potential for the use of 'big data' techniques to elicit new information from existing data sources should be explored including:
    - A mapping of potential "alternative sources of data" for manufacturing to systematically seek to identify sources of data that could be used by BIS to gain a deeper understanding of manufacturing. The mapping should cover: (i) intra-firm data; (ii) inter-firm data; (iii) socially created data; (iv) public data; and (v) private data.
    - Ongoing experiments within BIS focussed on business level performance measures and benchmarking be pursued and their findings shared more widely.
    - Commissioning a series of pilot studies to test the feasibility of using alternative sources of data to better understand manufacturing's performance. These pilot studies should cover the five sources of data outlined above structured around specific questions of interest.

To further inform this recommendation and to ensure momentum is maintained in this important new area the review team has designed and will commission three specific experiments in data gathering as an industry led initiative. The results from these experiments will be reported to BIS in spring/summer 2016. The three pilots are:

i. Mapping Alternative Sources of Data for Manufacturing Analytics
ii. Exploration of Company Reports as Alternative Data Sources
iii. Exploration of Company Created Data as Alternative Data Sources

Summary

The review has confirmed the robustness of current national statistics related to manufacturing but shown a number of ways in which new methods might improve the understanding and representation of manufacturing within the economy.

List of Figures and Tables

Annexes

Annex A

Biographies

Professor Sir Mike Gregory (Chair)

Head of the Manufacturing and Management Division of the University Engineering Department and of the Institute for Manufacturing (IfM), University of Cambridge

Following an early career in industry he was the founder member of the team which established the Manufacturing Engineering Tripos, a senior undergraduate programme covering, marketing, design, production, distribution and service with very close industrial engagement. Subsequent developments in research and collaboration with industry reflected this broad view of manufacturing and led to the establishment of the IfM in 1998. Linking science, engineering, management and economics and integrating education, research and practice the IfM now has over 230 staff and research students and a further 100 undergraduate and Masters students.

Mike Gregory's work continues to be closely linked with industry and government. He has published in the areas of manufacturing strategy, technology management, international manufacturing and manufacturing policy.

External activities have included membership of various government and institutional committees. He served as Executive Director of the Cambridge MIT Institute from 2005-2008 and was Springer Visiting Professor at UC Berkeley in 2008/9. He chairs the UK Manufacturing Professors Forum and is a member of the UK Government's Manufacturing Analytical Group on Manufacturing.
He is a Fellow of Churchill College, Cambridge

Heather Bovill

Assistant Deputy Director of Structural and International Statistics at the Office for National Statistics (ONS)

Heather leads the work on international trade and business outputs within the ONS, with a particular focus on the key structural business surveys such as the Annual Business Survey, UK Manufacture Sales by Product (Prodcom), Research and Development and E-Commerce. Heather also oversees the development of the new purchases survey.

Prior to joining ONS in 2012 Heather worked for a range of other Government Departments both as a user and producer of statistics, including the Department of Business, Innovation and Skills (working on regional and employment policy), the Office of Fair Trading, the Low Pay Commission and the New Zealand Treasury (researching the health impacts on the labour market).

Graham Chisnall

Former DCEO and MD Aerospace, ADS

Graham is an Aerospace Engineer by original training and has retained an interest and responsibility for technology through his career.
His management training was obtained at INSEAD, UCLA and with the Cabinet Office. His career has progressed since his early day as an engineer and manager with BAe Military Aircraft Division, with promotions to Chief Engineer and Director -Military Aircraft and Programme Director for Nimrod, before becoming Head of Group Strategy for BAE Systems in 1998. He then moved to become Group Director of Operations at GKN Aerospace, followed by Director of Strategy, Sales & Marketing, and finally Director, Corporate Strategy, GKN Plc. He was until recently DCEO and MD Aerospace for ADS, the Aerospace, Defence, Space & Security trade association. He is a non-executive board member of an Aerospace engineering company and also of the SRA (the main legal regulator) and is currently working as Industrial Advisor to a Department of BIS. He is a Fellow of the Royal Aeronautical Society and a qualified and active pilot.

Professor Jonathan Haskel

Chair in Economics, Imperial College London

Professor of Economics at Imperial College Business School in the Organisation & Management Group. He has just finished eight years as a Member of the UK Competition Commission, including serving on the panel investigation into British Airports Authority.
Jonathan was previously Professor and Head of Department at the Department of Economics, Queen Mary, University of London. He has taught at the University of Bristol and London Business School and been a visiting professor at the Stern School of Business, New York University and the Australian National University. In 2012 he was a visiting Professor of Economics at the Tuck School of Business, Dartmouth College, USA.
Jonathan is a research fellow of the Centre for Economic Policy Research and the IZA, Bonn and an Associate Editor of Economica. He is an elected member of the Council of the Royal Economic Society.

His research interests are productivity, innovation, intangible investment and growth. His research centre is CERIBA, (the Centre for Research into Business Activity).

Lee Hopley

Chief Economist, EEF

Lee is responsible for developing and communicating our policy thinking to our members, the media, the government and other key policy formers. She leads our work on the economy and industrial policy, dealing with macroeconomic issues and matters relating to productivity and manufacturing competitiveness. Lee also co-ordinates our work on policy issues including investment, tax, innovation, and infrastructure, and oversees its economic forecasting. Before joining EEF, Lee worked as an economic adviser to the Scottish National Party in both the Scottish Parliament and the House of Commons.

Professor Alan Hughes

Professor of Innovation, Imperial College Business School, London and Margaret Thatcher Professor Emeritus of Enterprise Studies University of Cambridge

He is a Life Fellow of Sidney Sussex College and a Senior Research Fellow of the National Centre for Universities and Business. He was from 2000 - 2003 Director of the National Competitiveness Network of the Cambridge-MIT Institute. Professor Hughes has held visiting Professorships in the USA, Japan, France and Australia. He is an internationally leading scholar and policy adviser on innovation and industrial policy and was from 2004-2014 a Member of the UK Prime Ministers Council for Science and Technology. He was a member of the Foresight Lead Expert Group on the recent review of the Future of UK Manufacturing. His research interests, on which he has published extensively, include industrial and technology policy; the measurement of innovation; growth, innovation and financial and acquisition characteristics of business enterprise; measurement and evaluation of industrial and business support policy; and the relationship between law and economics in the analysis of corporate organisation and performance.

Professor Michael Lewis

Professor of Operations and Supply Management at the University of Bath School of Management

Mike's current research interests include Redistributed Manufacturing, servitization, the commercialization of innovative (chemical) technologies and (service) productivity. His research has been published in numerous journals including *Journal of Operations Management, British Journal of Management, Organisation Studies, Omega* and *Harvard Business Review and a series of books (e.g. Operations Strategy, 4e, co-authored with Nigel Slack, published in 2015).* Before coming to Bath, Mike was senior lecturer at Warwick Business School. He is currently visiting professor at Danish Technical University and has been a visiting researcher at Harvard Business School and a visiting professor at the McDonough School of Business, Georgetown University.

Ian McCubbin

SVP North America, Japan & Global Pharma Supply, GMS, GlaxoSmithKline

Ian moved into his latest role at GSK in January 2013. Joined GSK in 2006, his second spell with the company, and has responsibility for GSK's in-market supply chain & distribution throughout North America and Japan. This includes overseeing 17 factories and 7,000 employees globally.

Ian is a founding Board Director of ViiV Healthcare, a global specialist HIV company established by GSK and Pfizer in 2009 to deliver advances in treatment and care for people living with HIV. Ian is also on the Board of GlaxoWellcome Manufacturing Pte Ltd and Glaxo Operations UK.

Ian is a pharmacist and a member of the Royal Pharmaceutical Society GB with 30 years experience in the Pharmaceutical industry working for GSK, Merck Generics and IVAX. His core capability is in the field of manufacturing and supply chain leadership in both the generic sector and the branded sector of the industry.

Fabrice Montagne

Chief UK Economist, Barclays

Fabrice Montagné is chief UK economist at Barclays. Previously, he was a senior European economist responsible for French, Greek and euro area macroeconomics. Mr. Montagné joined Barclays in January 2012 from the Dutch Central Bank where he was responsible for balance sheet, asset/liability management and strategic asset allocation decisions in the Financial Market division. Prior to that, he worked at the French Treasury and Fonds de Reserves pour les Retraites. Mr. Montagné graduated from Ecole Polytechnique, has an MSc in Economics and Statistics from ENSAE, and also holds an MSc in Economic Analysis and Policy from the Paris School of Economics.

Darren Morgan

Deputy Director of National Accounts Co-ordination at the Office for National Statistics (ONS).

Darren has led some of the highest profile economic statistics since joining ONS in 1992 such as GDP, Inflation and the Index of Production. He has also worked across most of the economic surveys where he spent the first 7 years of his ONS career. He currently leads the teams responsible for the compilation of the UK's National Accounts, which includes GDP, the Sector & Financial Accounts and the Regional Accounts.

Prior to joining ONS, Darren worked for British Steel has a management accountant before re-training as a statistician and then National Accountant.

Professor Andy Neely

Director, Cambridge Service Alliance

Founding Director of the Cambridge Service Alliance and the Royal Academy of Engineering Professor of Complex Services. Widely recognized for his work on the servitization of manufacturing, as well as his work on performance measurement and management. He has held appointments at Cranfield University, London Business School, Cambridge University, where he was a Fellow of Churchill College, Nottingham University, where he completed his PhD and British Aerospace. He was Deputy Director of AIM Research – the UK's management research initiative – from 2003 until 2012 and was elected a Fellow of the Sunningdale Institute in 2005, a Fellow of the British Academy of Management in 2007, a Fellow of the Academy of Social Sciences in 2008, a Fellow of the European Operations Management Association in 2009 and President of the European Operations Management Association in 2013.

Terry Scuoler

CEO, EEF

Became EEF's Chief Executive Officer in 2010. He was formerly Managing Director of Ferranti Technologies Ltd and with a supportive team returned the company from years of decline and a loss-making situation to one of substantial growth and high profitability.
Prior to this Terry held a number of senior roles at Royal Ordnance and BAE Systems across commercial, procurement project and general management where he worked in the UK, Western Europe, North America and the Middle East.
He has a degree in economics from Glasgow University and attended the Royal Military Academy at Sandhurst.

Ken Warwick

External Economic Consultant

Ken Warwick is an independent economics consultant who has undertaken studies for the Organisation for Economic Co-operation and Development and the World Bank on industrial policy and innovation. From 2007 to 2011 he was Chairman of the OECD Committee on Industry, Innovation and Entrepreneurship.

Until July 2011 Ken was a senior member of the Government Economic Service and the Director of Analysis in the Department for Business, Innovation and Skills. He served as Chief Economist and Acting Director General, Economics there during 2010. He has also worked as a senior economist in the Foreign and Commonwealth Office and the International Monetary Fund in Washington.

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