The Institution of Engineering and Technology

Written evidence submitted to BEIS by the Institution of Engineering and Technology (The IET)

Business Productivity Review

INTRODUCTION

The Institution of Engineering and Technology (IET) is a charitable professional engineering body representing 170,000 members worldwide, over 80% live and work here in the UK. We seek to inspire, inform and influence the global engineering community **for the benefit of society**, working to engineer a better world.

The IET's Manufacturing Policy Panel, a member-led expert group of industry leaders, technology practitioners and world-leading manufacturing academics, welcomes this opportunity to contribute advice and evidence to BEIS. Productivity is **a topic which has inspired our thoughts** over the last year or so and is an **on-going passion** for our Panel.

BEIS QUESTIONS

The UK's Productivity Challenge

1. Do you agree with our working definition of low-productivity businesses?

1.1 There are many different definitions and interpretations of **what productivity is** (including that applied in paragraph 2.1). How it is applied and measured. The particular definition we apply determines which firms are identified as 'low-productivity'.

1.2 We believe a deeper understanding and national conversation about productivity is needed. Adopting **a view of productivity that firms themselves embrace** is the key. This has to be at a level which is set by them, which they understand and which is meaningful to them.

1.3 Our deliberations have, in part, been inspired by a paper written by one of our Panel experts. The paper – 'Review of Productivity in terms of **wealth generation and competitiveness in terms of manufacturing**' - is incorporated as part of this response and can be found as Appendix One. We commend it to you.

1.4 We understand the definition of 'low-productivity' as set out in paragraph 2.1 but respectfully question how helpful this is, in informing policy. Close examination of the firms classified as being 'low-productivity' reveals **a rich and highly diverse set of factors**. By way of example: firms which are at different stages in their lifecycle (e.g. start-ups, scale-ups, established enterprises); firms which have different ownership models and drivers (e.g. family-run firms which provide lifestyle choices for the owners); firms operating in different sectors (including some sectors which, by their very nature, may have limited scope to increase existing levels of productivity or profitability e.g. some in the food sector); firms which, for whatever reason, may lack ambition.

1.5 We recognise (a) that it would be a mistake to consider such 'low-productivity' firms as a single homogeneous grouping and (b) that firms are 'in the tail' for a reason. A thorough examination of **their profiles, drivers, needs and wants** would be hugely beneficial. Once we know why they are 'in the tail' decisions can be made. However, not all firms will be capable of change.

2. Is there further evidence to compare the UK's productivity distribution of firms to that of other countries?

2.1 We commend the **Cranfield University** white paper 'Industrial Strategy and UK Manufacturing' (May 2018) which compares the UK with seven main manufacturing competitor countries. https://www.cranfield.ac.uk/events/national-manufacturing-debate/national-manufacturing-debate-2018/national-manufacturing-debate-white-paper-reports

3. Is there further evidence on how the UK's firm-level productivity distribution has changed over time?

3.1 The **EEF** report 'Unpacking the puzzle: Getting UK manufacturing productivity growth back on trend' provides some useful evidence. https://www.eef.org.uk/resources-and-knowledge/research-and-intelligence/industry-reports/unpacking-the-productivity-puzzle-2018

4. Is the long tail of low productivity firms being driven by weaker competition in UK markets?

4.1 Consistent with our response in points 1.4 and 1.5, we acknowledge that the drivers behind the 'long-tail of low-productivity firms', is complex, with no one single over-riding factor responsible. There are many other contributing factors worthy of further examination. Leadership, communication and management all **have a significant role to play**, to influence and help deliver continuous growth and improvement.

Understanding high and low productivity businesses, and the firm-level characteristics driving the performance of each

5. Is there further evidence from the UK or internationally, on what drives the distribution of business productivity?

5.1 Nothing to add.

6. What do you think are the most important firm-level factors that impact productivity?

6.1 We **applaud and concur** with the firm-level factors set out in paragraph 3.9.

7. Would you add any further characteristics of high productivity businesses as set out in paragraph 3.9?

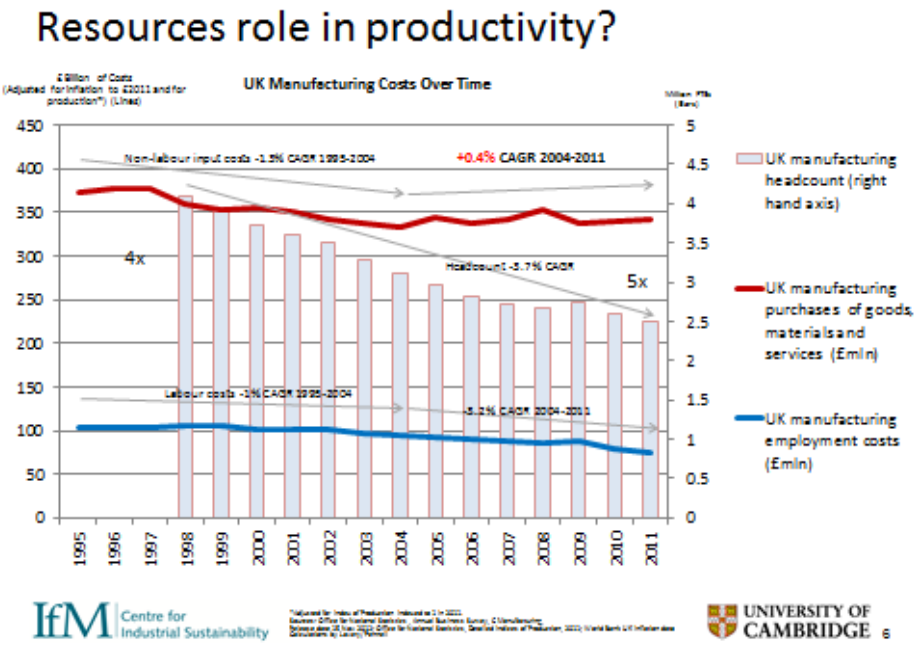
7.1 We place a high premium on those factors which address the human capital within a firm. Meaningful and embedded employee engagement, **where staff feel empowered to inform, determine and deliver productivity outcomes**. We recognise trade unions can provide an effective vehicle for real employee engagement rather than management-controlled engagement practices which can amount to little more than lip service. A commitment to

continuous professional development for all employees within a business can have a profoundly positive impact on personal and collective performance.

7.2 Positive terms and conditions of employment together with wage levels are also important factors. Sadly, for some businesses, improved productivity has, in part, been about reducing headcount, or taking on temporary workers on zero-hours contracts paying minimum wage. Higher productivity does not necessarily result in higher wages for workers. Yet **UK working hours are among the highest** in Europe, according to figures published by Eurostat. http://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20180125-1?inheritRedirect=true

7.3 Commitment **to invest in productivity** on a planned, year-on-year rather than ad hoc basis.

7.4 Commitment to **wider consideration of productivity measures beyond direct labour productivity** e.g. resource efficiency. The background rate of resource productivity in the service sector has been in the order of 1-2% per annum in recent years yet a much higher figure of 3-4% has consistently been achieved in the industrial sector.



Leadership and Management

8. Is there further evidence on the links between management practices and productivity? If so, which management practices have the biggest impact on productivity?

8.1 Nothing to add.

9. What are the main reasons for businesses adopting or not adopting management best practice?

9.1 Once again, the reasons for adoption or non-adoption will be many and varied. These cannot be aggregated and turned into policy. Is the firm's leadership aware of these 'best practices'?

Do they feel such practices are capable of having a 'fit' within their particular firm? Do they have the time, resource and commitment in order to benefit? **Is the fear of inaction greater than the fear of action?** Why change unless there's sufficient danger in not making a change? Most people fear change. However, demonstration and understanding of the new does not reduce the fear of it.

10. Are there further examples, from the UK or internationally, of approaches that have worked to increase the adoption of management best practice?

10.1 Nothing to add.

11. What actions by the public or private sector would be most effective to facilitate effective adoption and embedding of management practice?

11.1 Target and direct support where it will have the greatest impact. Such calculation can best be drawn up, once the segmentation and profiling identified earlier in points 1.4 and 1.5 is complete. This is likely to include a combination of factors such as highest growth potential, development stage, sector etc.

Technology and innovation adoption and diffusion

12. Is there further evidence to demonstrate the link between technology or innovation adoption and a business' productivity growth?

12.1 The IET conducts a regular survey of UK engineering employers. In 2017, we took the opportunity to ask employers about the Fourth Industrial Revolution also known as Industry 4.0. Only 7% of the 800 employers (*) surveyed had actually heard of the term Industry 4.0. It is likely that the 93% who hadn't heard the term will include 'low-productivity'. Understanding the mind-set, trials and tribulations of such firms is crucial.

12.2 In our survey, 78% of businesses believed that digital technologies and automation will advance rapidly in the next five to ten years and yet **only 30% of firms had plans** to introduce or extend their use of digital technologies in the next three years. Please note (*) of the 800 firms surveyed 129 were micro, 285 were small, and 356 were medium-sized businesses.

13. What are the main reasons for businesses adopting or not adopting new to firm technologies?

13.1 The response to adoption or non-adoption varies from company to company and for a myriad of reasons including:

- Too busy with the day-to-day / getting product out of the door
- Denial or failure to recognise investment is needed
- 'Doing things the present way has always served us well'
- Lack of technology knowledge and know-how amongst the senior management team
- Lack of skills and training within the rest of the workforce and on the shop floor
- Limited funds to invest coupled with concerns over return on investment.

14. How important are the seven identified 'best practice' technologies (identified in paragraph 5.14) to enhancing productivity at the firm-level, and which offers the greatest return? Are there other technologies which offer greater potential?

14.1 The seven technologies listed, whilst invaluable for sound business and financial management, may have a limited impact on future productivity and manufacturing improvement. Firms making products and competing nationally and internationally are likely to have to invest in a much richer suite of digital technologies in order to survive and thrive, in the future. Ultimately, such 'Industry 4.0' technologies will connect a firm's legacy systems, bringing in data created and collected from finance, sales, marketing and other systems to enable the firm to have better intelligence of its operations, to identify key performance indicators and secure continuous improvement.

14.2 This suite of new technologies may include:

- Internet of things
- Data analytics
- Robotics and automation
- Artificial intelligence
- Virtual and augmented reality
- Additive /3D printing
- Blockchain

15. Do you have any examples, from the UK or internationally, of public or private sector approaches that have increased the adoption of best practice technologies or new to firm technologies?

15.1 There are several user cases which firms considering adoption may well find beneficial and inspiring via:

- Sharing in Growth UK https://www.sig-uk.org/
- The High Value Manufacturing Catapult https://hvm.catapult.org.uk/

16. What actions by the public or private sector would be most effective in driving effective adoption of new to firm technologies?

16.1 The 'Made Smarter' review published in November 2017 outlines a set of actions targeted to drive innovation and technology adoption. Such digital transformation, properly funded and implemented, would provide a significant boost to UK manufacturing and the pursuit of future gains in productivity. https://www.gov.uk/government/publications/made-smarter-review

The UK market for business support and advice services

17. What are the main reasons for businesses utilising or not utilising public and private business support?

17.1 Business support, whether delivered by the public or private sector, needs to clearly identify, anticipate and satisfy a firm's needs. 'What's in for me?' How will the support provided benefit the business?

17.8 An IET survey exploring the needs of 333 SMEs (March 2018) identified several innovation-related areas for support (excluding financial matters):

Skills and Training

- **Assistance in the training and development of existing employee skills** including: Upskilling managers with skills to develop strong business plans for their Innovation ideas. Low cost online training for individual engineers to help dispel myths, reinforce what Innovation is and exemplify how subtle it can be.
- **Support engaging with both skilled graduates and other candidates**: Engagement between universities and local SMEs to help identify young talent and encourage graduates to join SMEs rather than larger firms.
- **Encouraging and promoting incentives and initiatives to take internships at SMEs**: Improve early training of graduates to learn how to apply their skills and acquire the experience they need to contribute effectively to meeting business goals.

Mentoring and Advice

- **From people who are active in the industry** and possess both the knowledge and experience to guide SMEs in their sector.
- **Support from trusted advisors to inventors** in start-ups to develop sensible, flexible business plans.
- **Easy to access and either free or at a minimal cost**: Access to external expertise, for example from universities and manufacturers. Access to community-driven mentoring/support and smart money. More specific guidance on areas such as the protection of IPR whilst discussing with potential clients / partners and the impact of the GDPR regulation.
- **Networking**: Support finding partners and customers.

18. How effectively is private and public business support provided in the UK?

18.1 In recent years, the level of business support in the UK has been in decline e.g. the loss of Industry Forums across the country, Business Links, the Manufacturing Advisory Service (MAS). This has been compounded by a **lack of effective communication and promotion** of present day schemes and pockets of assistance. This, in part, explains relatively low levels of take-up.

18.2 In May 2018, the IET convened a workshop for SMEs on innovation and entrepreneurship. One of the key findings was a lack of awareness of such support schemes. Many of the firms which had some level of awareness were concerned at sheer **plethora of schemes and initiatives**, albeit intermittent and perceived to be not wholly successful, and seemingly delivered by an array of agencies with different drivers, terms and conditions. The net result was confusion.

19. Do you have any examples, from the UK or internationally, of approaches that have worked to increase the uptake of business support?

19.1 Nothing to add.

20. What actions by the public and private sector would be most effective to facilitate uptake of business support?

20.1 A national strategy for such support which, whilst respecting local conditions, choice and decision- making, creates **targeted resource to those businesses** and sectors deemed to provide the greatest opportunities and propensity for success.

21. Do you have further evidence of what forms of business support are more effective at improving firm level productivity?

21.1 The examples provided in Section 6 of the document clearly **demonstrate that intensity** of support, regular consultation on a regular weekly / monthly basis over a protracted timescale is both powerful and effective.

22. What is the role of public sector in ensuring the uptake of private sector business support?

22.1 Sustainable clusters which **bring sector and or cross-sectoral firms together** provide an effective and appropriate way of working for many firms, helping to promote Place-based solutions and strategies. By way of example, the IET has been pleased to promote the work of the North East Maintenance Forum in recent months.
http://www.northeastmaintenanceforum.org.uk/events/

22.2 Where public funds are applied, there needs to be measurement and accountability. Success breeds success and should result in future funding to **sustain and help such clusters grow** and become more successful.

23. How can Government promote self-sustaining business support ecosystems, where firms seek and access information, advice and tools that improve their performance?

23.1 No specific comment.

SUMMARY

24. Do you agree that we are focusing on the right set of businesses? Do you agree that there are opportunities to increase productivity in the long tail?

24.1 There are opportunities to increase productivity across the entire spectrum of UK businesses. Whether it is right and proper to target Government support for those businesses deemed to be in the category of low-productivity, as opposed to helping existing success stories reach even higher ground, is a matter for debate. As suggested in points 1.4. and 1.5, low-productivity businesses come in all shapes and sizes and a more targeted strategy is essential.

25. Are there any other firm-level factors that we should be focusing on, that are not covered in this call for evidence?

25.1 In the IET's 2017 Skills Survey, 46% of the 800 employers surveyed reported **difficulties in the skills supply in the external labour market** when recruiting; with 71% reporting that many candidates had academic knowledge but lacked workplace skills. Such findings are consistent with previous IET surveys (and similar studies commissioned by other organisations).

25.2 UK success, albeit unsung, in labour productivity needs now to be complemented, maximised and augmented by a greater focus on resource efficiency – reducing energy, water and raw materials in manufacturing and production processes, making more with less. Firms which incorporate resource efficiency at the same time as they digitally transform could provide huge dividends for the future.

26. Where do you think the main opportunities are for the UK to drive business productivity growth?

26.1 A thriving high-skill, high-value manufacturing sector which offers flexible, high-wage jobs for engaged and empowered workers and creates the products, wealth and sustainable future our country needs.

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The Institution of Engineering and Technology
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APPENDIX ONE

Review of Productivity in terms of wealth generation and competitiveness in terms of manufacturing

Prepared for the IET by: Dr Colin Herron CBE, MIET, MD: Zero Carbon Futures and Newcastle University

The IET Manufacturing Policy Panel has commissioned this paper on what has been called the 'Productivity Puzzle'. The following sets out to define what productivity is in terms of wealth generation and increased manufacturing performance, and moves on to discusses the conflict/confusion caused by how the term Productivity is applied/reported. A summary includes proposals for a way forward. A report from the eef; manufacturing a solution to the productivity crisis (June 2016) is acknowledged and considered in the context of this paper.

Abstract

This paper challenges the understanding of the meaning/perception of productivity, how it is measured and reported by government/industry, and how this then influences policy, it then moves on to address the competences/strategies that drive productivity. The contextual problem of the use of the work productivity is highlighted in the extensive report; Made Smarter Review, Headed by Professor Juergen Maier, which in 231 pages the word productivity appears 224 times using 22 different adjectives to preface it. The actual term productivity is clarified only as output per worker.

This paper does not consider directly productivity gained through technology development such as; miniaturisation and data transfer but focuses on manufacturing activity. Sustainable manufacturing will deliver direct improvements and must be included as a factor in any productivity improvement strategies. Manufacturing has access to funding and support based on an established scale of product and process development namely; Manufacturing Readiness Level (MRL) and Technology Readiness Level (TRL) which have a scale of 1 to 10, with 10 being the most advanced. There is a need to maximise the operator, machine and the process ecosystem to increase efficiency at the Point of Adding Value (POAV). Using productivity in terms of economic growth and in relation to production efficiencies is not conducive to developing targeted industrial strategies with applicable measures. This paper presents a rational for a new MRL/TRL or even a Process Readiness Level (PRL).

1.0 Productivity (the suggested problem and the solution)

Introduction to productivity

First is a look at a recent press covering the productivity problem, an article from the Guardian will be used to show some of the confusion and lack of understanding.

Why is UK's productivity still behind that of other major economies? Dismal trade, growth of low-level service jobs with low-level pay, and a chronic lack of investment only partly explain the gap Phillip Inman Economics correspondent, The Guardian, Thursday 24 November 2016 19.27 GMT

The piece opens with a photograph of a German car worker in a car on a production line. The title is: Mercedes-Benz factory in Rastatt. German workers produce the same in four days as UK workers do in five. This would suggest, even though it does not say it that German car workers produce more cars in 4 days than UK car workers do in 5. The irony is that the UK car industry measured on a like for like basis is more efficient than the German car industry (SMMT). The UK Chancellor also used the same words in his Autumn Statement.

The article also comments that: There are generally two ways to improve productivity. One is the purchase of better machinery. The second involves a new process, which allows a worker to increase the speed or quality of what they are doing. Quality matters as much as quantity when firms can charge more for higher grade goods. Without starting a discussion on the meaning of 'Quality' it is important to state that in manufacturing terms the quality of an object is its adherence to specification. To charge more for a product it requires a higher specification. Quality is the adherence to the specification so a company cannot charge more for doing what it is supposed to do. Sales price to a car maker included adherence to specification as a given with no rewards for exceeding the specification.

Productivity is referred by both government and reporters as instrumental to raising revenue for the treasury and is defined both as Gross Domestic Product (GDP) and Gross Value Added (GVA). The logic being the more productive we are as a nation, the more options that are available to the chancellor when forming a budget. Productivity as applied in manufacturing is understood as maintaining outputs, with reduced inputs or increasing outputs, with the same inputs. This paper will demonstrate the conflict of reporting manufacturing productivity with government productivity. For instance, maintaining the output with a reduced input can reduce GDP, if there is a straight labour reduction. Reporters often illustrate productivity as 'widgets per person', which is applicable to certain industries, but not the whole economy and suggests (wrongly) that it is manufacturing, which is failing the economy.

Bill Martin, a former City economist who is now at Cambridge University's Judge business school, has argued that the UK's poor productivity is "more plausibly interpreted as a symptom of a largely demand constrained, cheaper-labour economy". This will be discussed later in the section on regional productivity.

GDP is an estimation of the 'wealth generation' of a geographic area or country and is an amalgam of economic data. It is estimation because, collecting accurate information with regard to every item of value added within a region, is an impossible task. Because it is a measure of the wealth of a region the whole population is involved in calculations. Data with regard to the region's population comes from the Census; this data may contain errors, as the assumption is that people filled in the data in a true and honest way. The collection of GDP data includes factors that do not generate wealth directly but contribute to wealth in a general sense, for example increase in house prices. The calculations are derived by ONS and they recognise demographic areas can skew information because of regional factors. Because of the factors involved it is suggested that GDP is a very poor

measure of manufacturing and should be removed, improved or added to, as it is not sensitive enough to measure changes in a production line within a manufacturing unit. Regions within the UK are very diverse and as such have limits on wealth generation.

Productivity is accepted and used as a measure of wealth generation and as a comparator between regions and countries. It is interesting looking at figure 1, that productivity in Japan is seen as not performing as they have been held up as a benchmark for manufacturing productivity through publications such as the Toyota Production System (TPS), which has been copied world-wide. This graph uses GDP to show productivity.

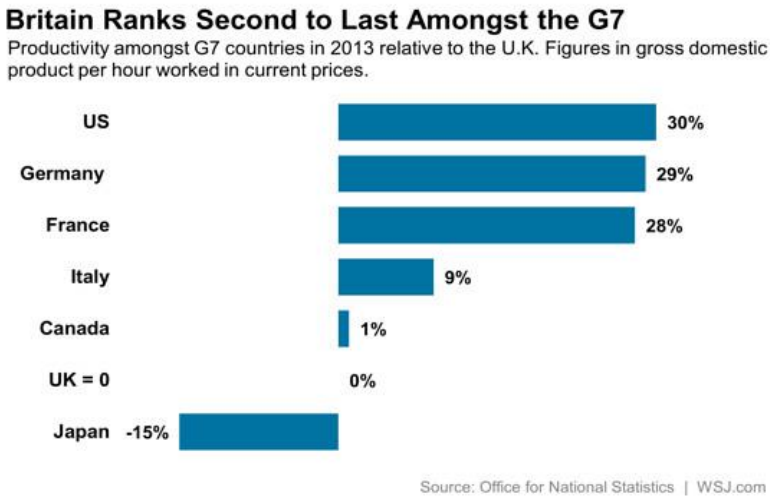


Figure 1

Productivity is also used to compare sectors with the same sector in other countries for example the automotive sector. Traditional plant to plant comparators remove none related manufacturing activities such as design and marketing, however; GDP will include them and in doing so, the French and German automotive sector will appear more productive than the UK even if the plant to plant productivity figures are the reverse. Another consideration is that, it is possible to have a highly productive sector in a low productivity region due to using different comparators under one heading. Looking at regional productivity there is a tendency to measure using London as the datum (Figure 2) which, when house prices are included results in a not expected gap as a the average price of a house on Grosvenor Crescent the most expensive street in London is £17m and the equivalent street in the North East averages £1.1m. All these points will be addressed in this paper.

The UK has a productivity problem. The size of the problem is well understood, even if the exact causes are not. If output across the economy per hour worked had stayed on its pre-recession path productivity would have been 16% in 2014. Data from the Office of National Statistics also point to a widening gulf in the UK's productivity performance compared with our competitors in the developed world. If the UK's productivity growth in the next decade looks anything like the lacklustre growth rates achieved since 2008, then the UK will face slower long-term growth, depressed wage growth and slower than hoped for improvements in living standards (eef 2015). The eef have produced a report; Manufacturing a solution to the productivity crisis (June 16) and have set out the following key messages:

1. The UK will not achieve sustainable growth and improvements in living standards without an improvement in productivity over the next five years.

2. Short term gains will be most easily achieved from the firms and sectors with a good track record of strong productivity growth – this includes manufacturing, which could account for 40% of productivity gains over the next 10 years.
3. Government policy can be an enabler of stronger productivity growth by prioritising resources towards improving skills, raising innovation levels and creating a competitive tax system for investment in new technologies. Barriers to securing greater productivity gains can also be dismantled.
4. Businesses must also play their part by investing strategically, collaborating with supply chains and developing the skills and capabilities of their workforce.
5. Some areas of government spending are critical to improving the productivity of all businesses. Infrastructure investment must not suffer in forthcoming spending reviews. Longer term productivity gains will also need to come from spreading best practice from the private sector to public services.

The above points are all correct but use the word 'productivity' without defining it and point (2) will be tested in this paper as to how productivity is a complex subject with different meanings which confuse when used incorrectly. The following comment in the same report highlights the problem:

In the post-war period manufacturing productivity, as measured by output hour, has increased almost twice as fast as in the whole economy – 2.8% compared to 1.5%. Levels of output per job are also around a fifth higher, according to official data.

The above statement apart from using multiples, fractions and percentages in the same sentence also uses output per hour and output per job in the same sentence. Units are not included i.e. is it volume or value which is being measured. The points raised here will be discussed further.

2.0 Analysis of UK public sector measures

2.1 Gross value added (GVA)

A measure of the contribution to the economy of each individual producer, industry or sector in the UK. It is used in the estimation of Gross Domestic Product (GDP). In the UK, three different theoretical approaches are used in the estimation of one GDP estimate. When using the production or income approaches, the contribution to the economy of each industry or sector is measured using GVA. The following is a review of the respective GDP and GVA measurement methodologies.

2.2 GDP

GDP from the output or production approach – GPP (O)
This looks at the contribution of each economic unit by estimating the value of an output (goods or services), less the value of inputs used in that output's production process. This approach provides the first estimate of GDP and can be used to show how much different industries contribute within the economy.

GDP from the income approach –GDP (I)
This measures the incomes earned by individuals (e.g. wages) and corporations (e.g. profits) in the production of outputs (goods or services).

GDP from the expenditure approach – GDP (E)
This measures the total expenditures on all finished goods and services produced within the economy.

Balancing GDP

All three approaches to estimating GDP are balanced annually using the Input-Output Supply and use accounting framework.

2.3 GVA

The definition of GVA for this paper = (Profit before tax + Total payroll + Total depreciation), this type of calculation is wealth generation and not value added in the manufacturing sense. The formula to be proposed will reflect the following:

Gross Value Added (GVA) = Value added to raw materials in transforming them into an output.

$$\text{GVA per person} = \frac{\text{Value of produced part (manufacture)} - \text{cost of raw materials}}{\text{Number of people to produce the product}}$$

$$\text{GVA per hour} = \frac{\text{Value of produced part (manufacture)} - \text{cost of raw materials}}{\text{Number of hours worked to produce the product}}$$

$$\text{UK output per job} = \frac{\text{GVA}}{\text{Productivity jobs}} \qquad \text{UK output per hour} = \frac{\text{GVA}}{\text{Productivity hours}}$$

Value is normally considered in monetary terms; however, it could be considered a produced unit with a monetary value. For example, a widely reported measure of productivity in the automotive industry is the number of cars produced per employee per annum.

The value added in this case would be:

$$\text{GVA per person} = \frac{\text{Value of produced part} - \text{cost of raw materials}}{\text{Number of people to produce the product}}$$

The discussion point in this case will apply to all participants in the research. That is, how is an employee classified as being involved in producing the product? It is intended to specify clearly who can be included in the calculation. For the purpose of this paper the more sensitive version of GVA will be considered i.e.

$$\text{GVA per hour} = \frac{\text{Value of produced part (a)} - \text{cost of raw materials (b)}}{\text{Number of hours worked to produce the product (c)}}$$

The assumption will be that (a) and (b) will remain constant and productivity will be achieved by the reduction of (c). This measure will be applied to manufacturing units, production lines and individuals.

A discussion point has arisen which considers the market trend to reduce the selling price of products. Examples given are: washing machines, micro-waves and computers where the current price is considerably less in real terms than it was 10 or 20 yrs ago. Even with a matched reduction in purchased parts the efficiency of the process must also compensate to maintain the margins. The effect of market forces is real but out of the control of the manufacturing department so ideally sales price should be excluded from any proposed productivity calculation.

Relating GVA to GDP
GVA + taxes on products – subsidies on products = GDP
Methodology applied to ONS figures for productivity looking first at (GDP):

$$\text{GDP per worker} = \frac{(GDP/PPP)}{\text{Employment}}$$

$$\text{GDP per hour worked} = \frac{(GDP/PPP)}{\text{Employment x hours}}$$

For both the above methodologies the GDP figure is converted to dollars using a Purchase Power Parity (PPP) to give international comparisons of productivity. An alternative is Gross Value Added (GVA), which could be used if it can be applied at a micro level as well as a national or regional level. GVA measures the contribution to the economy of each individual producer, industry or sector in the UK.

3.0 Regional productivity reporting

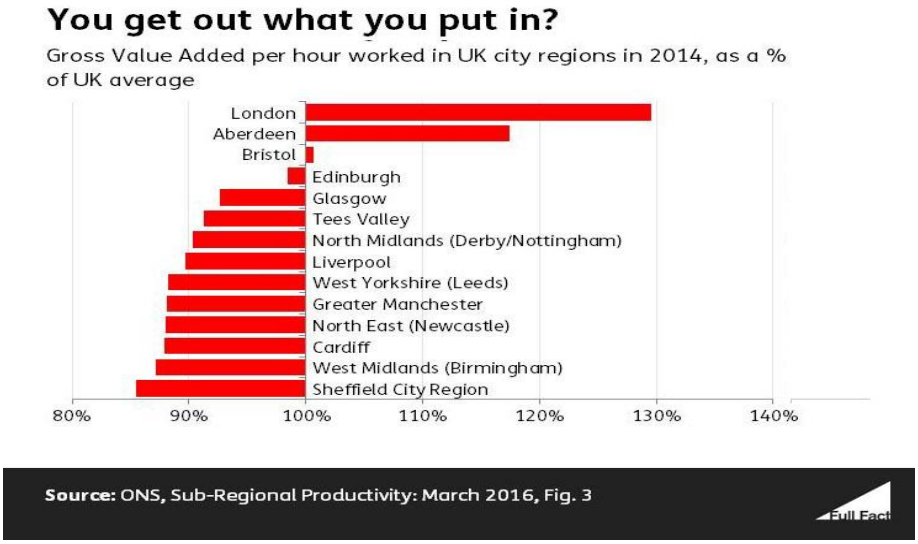


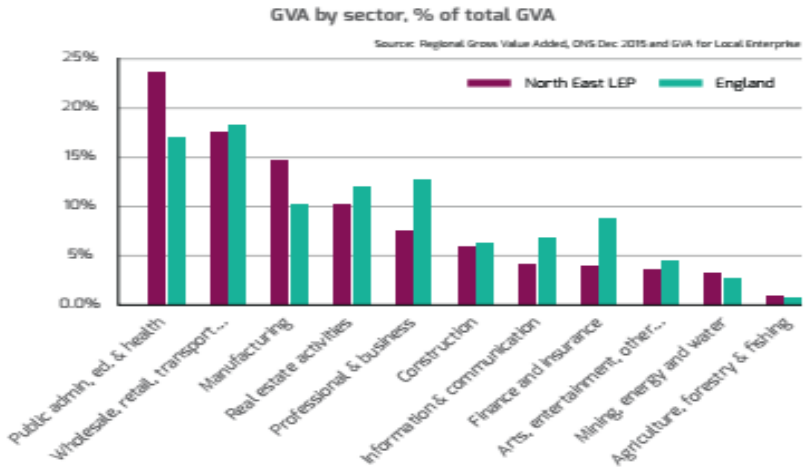
Figure 2

The North East of England has been used as an example of history and circumstance have defined the current level of GDP and how the same constraints limit growth. The above chart is typical of publications of regional productivity and uses GVA but both are referred to as productivity when searched for. The picture is totally distorted by the city of London and the oil industry in Aberdeen. A proposal would be to report average productivity with extremes removed. The authors suggest that using a biased comparator will produce a negative reaction due to the fact that it showing a pictured so skewed that it is not worth trying to 'compete'. Edinburgh is Scotland's finance centre.

The EU used the North East of England as a case study as part of an ex post evaluation cohesion policy programmes 2000-2006. Work package 4 "Structural Change and Globalisation". The authors

identified that; individual sectors may be internationally competitive but the region just has a concentration of those sectors which have a relatively low productivity compared to other sectors. *Note: the term competitiveness has been introduced*. Comparing GVA/employee levels for sectors in the region and nationally, the nature of the problem is clear. For a small number of sectors, amounting to around 10% of employment, the region had productivity levels that are higher than those in the same sectors nationally. For the rest productivity was low, and in many cases very low. The problem was not the mix of sectors so much as the low levels of value added, which was mainly due to the emphasis on production and low skill tasks rather than the high value added and strategic functions within firms. Thus the policy response should be to strengthen the productivity of the existing sectors and focus on stimulating innovation within existing firms (Hodgson. C and Goldman D). The report; however, does not characterise the sector as this paper attempts to do in terms of scope to add value using existing measures.

Again using the North East as an example we have an interesting but not unique situation where the output of satellite companies is reported through a head office located somewhere else in the UK. This situation is possibly due to the history of the automotive sector in the UK in that, the midlands automotive sector has evolved, however; the sector in the North East was mostly created around the arrival of Nissan in 1985. Two of the regions OEM's report their output via their registered office which in the case of one removes 2,400 staff at £1bn from the regional figure. This will have no impact on the national GDP but on a regional basis it does. A survey found 3,970 jobs and £2.1bn not reported as North Eastern added value, and this is not believed to be the whole picture. The scale of the problem can also be demonstrated by ONS figures showing 11,000 people in the NE auto sector and the NEAA reports 30,000. The makeup of a region in terms of sectors and employers also determines GDP. Taking the NE as an example the service sector makes up 80% of the economy. This is influenced by the lower wage sectors such as; tourism, retail and hospitality and government control of the public sector. So for a large sector of the working population the government sets a key element of the GDP, in other words the region has little scope to increase GDP other than to try to re-train and redeploy the working population.



The manufacturing side of the economy at 14.6% (nationally 10.3%) is largely foreign owned and operates via competitiveness measures. The main employer (Nissan) has to compete on a unit cost basis with its rival plants in Europe for business. The extensive first tier supplier base is also in the same position which results in a focus to deliver at the lowest unit cost.

- Part development is centralised;
- Part piece price is set; and
- Overheads in terms of energy and labour are the only real variable.

The scope for increased wealth generation in a region such as the North East is limited as manufacturing when combined with the service sector is an economy of minimising labour content and labour cost. So Value Added per operator becomes a key measure together with process efficiency. The net result is an objective to produce/sell a unit at a competitive cost as the sales price is determined elsewhere. The trading margins are defined and as such so are salaries and consequently house prices which impact on GDP figures. There is little research and development carried out in the NE auto sector and as such the salaries paid reflect the piece part competitiveness pressures.

The authors suggest that any government support mechanism and associated measurement needs to reflect the diversity and constraints of regions and sectors within regions. Any measure needs to show that a sector or region is performing against a set of measures which give a fair comparison with factors built in for circumstances.

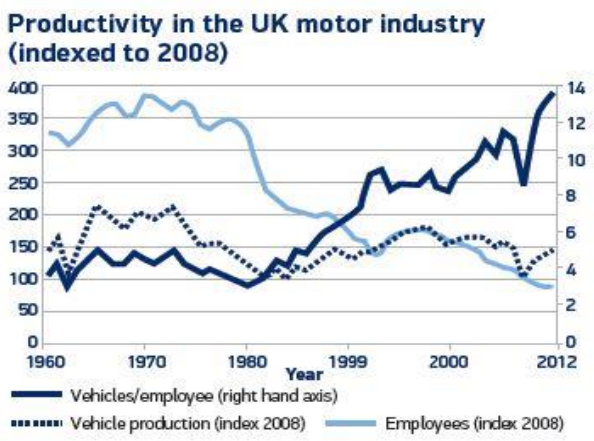


Figure 3; source SMMT 2017

UK Automotive Industry	1984	2011	2016
Vehicles Produced	1.1m	1.3m	1.8m
People employed	298,000	124,000	151,000
Productivity (vehicles/person)	3,700	10,500	11,900

Table 1; source Made Smarter Review 2017

Workforce productivity at a record high (Table 1) in the UK automotive sector with 11,900 vehicles produced per employee (SMMT 20th June 2017). Productivity has increased considerably with average gross value added (GVA) per job in the sector up from an average of £40,000 in the late 1990s to an average of over £75,000 between 2010 and 2013. According to Eurostat data, the UK now has the most productive automotive sector in the EU in terms of GVA per job. (Eurostat, accessed on 17 March 2014). Both Figure 3 and Table 1 show the impact of productivity activity but while vehicle output is relatively constant (Figure 3) labour levels have dropped dramatically which will impact regional wealth.

The challenge is to separate the overall wealth measures from the competitive measures used in manufacturing. The current trend to use GDP as a measure of performance is important to the Treasury but of little interest to the UK manufacturing base, and the way it is used currently by government and press results in the debate on productivity being the author suggests being de-valued and de-motivational. Government support mechanisms also need to reflect the different needs of regions, and how support could grow or maintain a regional GDP. The SME (manufacturing) base needs different support to corporations as they have more scope to create higher value new jobs.

5.0 Options to classify productivity

Investigation into categories of performance measurement (Jayaram *et al.,* 1999; Barker, 1998) highlighted two basic groupings of measurement, these are time based and performance based.

Time-based measures	**Performance-based measurements**
• New model development time	• Pre-tax return on assets
• New product introduction time	• After-tax return on assets
• Manufacturing lead time	• Return on investment (ROI)
• Delivery speed	• Market share
• Delivery reliability/dependability	• Growth in ROI
• Customer responsiveness	• Growth in market share

Examples of time based and performance based measures

The Organisation for Economic Co-operation and Development (OECD) Productivity Manual (2001) provides a good opening point to the discussion as it becomes apparent from the literature search and interviews that the key points made seem valid. The key point being that:

- Productivity is commonly defined as a ratio of a volume measure of output to a volume measure of input use. While there is no disagreement on this general notion, a look at the productivity literature and its various applications reveals very quickly that there is neither a unique purpose for *nor, a single measure of, productivity.* The manual goes on to state the following purposes of productivity measurement: -

- Technology: A frequently stated objective of measuring productivity growth is to trace technical change, however; in spite of the frequent explicit or implicit association of productivity measures with technological change, the link is not straightforward.

- Efficiency: Technical efficiency gains are a movement towards 'best practice', or the elimination of technical and organisational inefficiencies. When productivity measurement concerns the industry level, efficiency gains can either be due to improved efficiency in individual establishments that make up the industry, or to a shift of production towards more efficient establishments.

- Real cost savings: a pragmatic way to describe the essence of *measured* productivity change. Productivity measurement in practice could be seen as a quest to *identify real cost* savings in production.

- Benchmarking production processes: in the field of business economics, comparisons of productivity measures for specific production processes can help identify inefficiencies. Typically, the relevant productivity measures are expressed in physical units (e.g. cars per day, passenger miles per person) and highly specific.

- Living standards: A simple example is per capita income, probably the most common measure of living standards: income per person in an economy varies directly with one measure of labour productivity, value added per hour worked. In this sense, measuring labour productivity helps understanding the development of living standards.

5.1 Glossary of Industry standard measures
Originated by the old DTI (now BEIS), these are basic measures of manufacturing performance that a company should have in place.

5.11 Value Added per Operator (GVA per operator)
A measure of how people add value to the finished product, it is calculated by subtracting from the sales value of the component the raw materials value. The product of this calculation is then divided by the number of directs involved in that process to give a V.A. per direct employee figure. This can be improved by extending the role of any cell or process by absorbing more work into that process.

5.12 Workforce Productivity (parts per operator hour)
The measure of how effectively direct hours is being used to produce good components. This figure is affected by the 'Right First Time' performance of the process as this measure uses 'Good Components' in its calculation. The total number of hours used must include production overtime and any time spent waiting in the process for materials or machine breakdown.

5.13 Not Right First Time (NRFT)
The effectiveness of processes to produce parts 'Right First Time'. A defect whilst not necessarily a scrap part as rework may be possible was not produced correctly the first time of asking. This is important because a high not right first time percentage will have an impact upon the performance of a process especially if rework is performed on line. NRA is calculated as the ratio of all components produced in a given period, and the number of defective components produced during the same period.

5.14 Schedule Achievement (to the warehouse)
A measure of delivery to customer requirement measured at individual process level and at plant level. A delivery in this context is the scheduled requirement from a particular process and how much of this was completed on time. If the process handles batches of work as in machining companies it will be the number of batches produced against the scheduled number of batches for that period. As with the Not Right First Time data a low Schedule Achievement percentage figure may be symptomatic of a problem that will require investigation to establish root cause.

5.15 Stock turns (per year)
A company's effectiveness in converting raw material to finished components. A lean process carries little stock due to control of manufacturing eliminating the need to carry stock as a buffer. Stock levels can be measured by value and quantity. Whilst a high stock turn figure is good for assessing the processes ability to convert material to finished product it is also extremely important from the liquidity of the company perspective. The longer cash is tied up in un-saleable stock the more exposed the company will be until the cash is returned from the sale of finished goods.

5.16 Overall Equipment Effectiveness (O.E.E.)
Overall Equipment Effectiveness measures output effectiveness and how well the company is utilising its resources whilst providing the quality the customer requires. The calculation uses three distinct different elements: availability, performance & quality. Analysis of the areas of worst performance allowing the focusing of initiatives.

5.17 Utilisation of Floor space (£ m^2)
The effective use of factory floor space in generating sales. Therefore, by reducing the amount of floor space used by a cell or process this can reduce the fixed overhead aspect of overhead allocation. Better utilisation of floor space could remove the need to extend to accommodate the new work hence saving on capital investment. A recent project supported by the Advanced Propulsion Centre has resulted in an increase in capacity, which also reflects in VA per operator and GDP from the plant within the same footprint.

6.0 Summary of measures

Value added is the preferred measure by industry, as it relates to GVA; however, it will be measured as value added per hour. Workforce productivity measures the effective utilisation of time, which will maximise output (value) as an input ratio of time. Not right first time will reduce the output and reflect in productivity through time spent reworking, or replacing, defective parts. Failure with regard to schedule achievement may result in additional hours worked to rectify a situation with no increase in output (reflected in the productivity figure). In the case of a process industry, OEE will be the accepted measure of performance. In a processing environment we are looking at the performance of a machine (or series of machines) as opposed to the performance of an operator. The overall effectiveness of a machine will reflect in the hours worked to achieve schedule. All of the above measures are complimentary. Following the gathering of performance data relevant to a company, a more detailed study of the production is required. The diagnostic phase quantifies the potential for productivity improvement. To do this, each operation in the chosen areas should be subjected to a study to determine how much of the current work being carried out is actually adding value to the product. It is at this point that the measures applied must be relevant, not only to the company involved, but also to the stakeholders of the overall research. The level and location of the potential will shape the plan to realise it. The objective of the above is to support the proposed equation for measuring the project:

$$\text{GVA per hour} = \frac{\text{Value of produced part (a)} - \text{cost of raw materials (b)}}{\text{Value adding hours worked to produce the product (c)} + \text{non value adding hours (d)}}$$

Also to: Quantify (d) non value adding hours, or waste.

The reason for using value added as a measure of productivity improvement is the possibly that it could bridge the gap between the measurements applied by the private and public sectors. Additional potential for using value added is that it is a measure, which forms part of companies' accounts; therefore, current and historical data should be readily available.

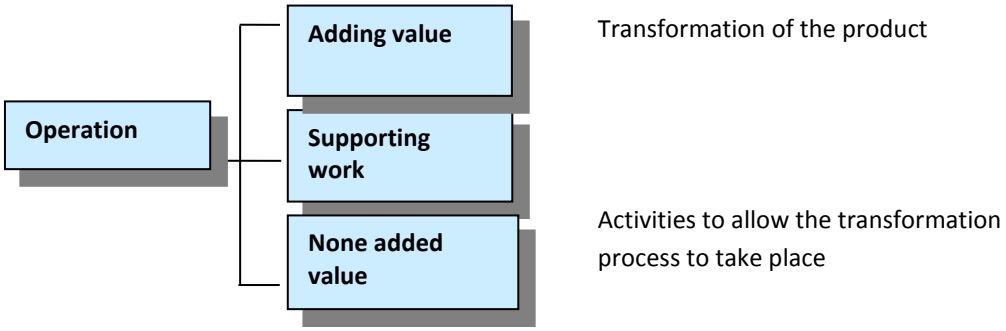
By reducing manufacturing costs through increased efficiencies, profit will increase but value added could *reduce* because of inefficiencies, such as overtime or excessive labour, increase the value of the product. The desired outcome resulting from the application of lean manufacturing principles will be to reduce inefficiencies such as overtime or excessive manning. This type of strategy may put the programme in conflict with the expected outcome for the Treasury. Looking again at the proposed measure for value added:

$$\text{GVA} = \text{Profit before tax} + \text{Total payroll} + \text{Total depreciation}$$

If reduction in the overall cost of the payroll simply transfers to the profit part of the equation, then the project will be deemed as failing, regardless of increases in manufacturing efficiencies.

7.0 Proposal for manufacturing productivity reporting:

Productivity as applied in manufacturing is understood as maintaining outputs, with reduced inputs or increasing outputs, with the same inputs and not monetary. The measure will be: Components produced per operator or process hour worked. For a process OEE will be used. Added value of a process is the tasks which increase the sales value of the component i.e. welding, painting, forming. None value adding are tasks such as inspection, carrying, reworking.



Value added ranking

It is important to distinguish between the added value to the product and the value added by the operator in the process of adding value to the product. The process of transforming the product is adding value, anything else is adding cost.

Examples where a process returned to profitability can reduce GVA

The base assumption is that any intervention in a company will increase GVA. However, there is an assumption that the company is in profit, staff numbers remain constant (or increase) and salaries will increase. Marginal profitability maintained by staff reduction and no investment is a productivity improvement but will reduce GVA and subsequently GDP through reduction in salaries. With regard to GVA, this paper suggests that it should become the measure for productivity, but the picture is obscured by what economists, civil servants and politicians on one side and industrialists on the other side class as value added. We again enter the arena of wealth-generated vs. manufacturing efficiency as a measure of value added. It is important that a meaningful measure of productivity is selected for each ecosystem being measured. Manufacturing cost is a prime consideration but not in the value added context, as the objective of an intervention is to increase manufacturing efficiency, through the elimination of waste and therefore reduce the cost of manufacture. It will have to be accepted that reducing the *cost of manufacturing* may impact *the manufacturing cost* and therefore value added. Consideration should be given to considering productivity as the improvement in manufacturing cost related to three elements: labour, materials and overheads. These three elements will vary in proportion dependant on the product being produced.

Any measure developed or agreed must be sensitive enough to allow for the measurement of a single operator or machine right up to a sector. A relevant question is the actual requirement for the productivity measure, or simply what is it to be used for needs to be asked. If there is more than one use, is there a requirement for more than one measure? The final question to ask is if one productivity measure can be applied to all companies even within the same sector? A Government and its agencies may have to recognise the fact that; productivity as a concept, requires clarification in its reports/strategies. A start point will be the premise that productivity in an economic sense will refer to wealth generation as measured by GDP/GVA. Productivity in a manufacturing sense will refer to manufacturing competitiveness.

Using competitiveness as a category complements the fact that HM Treasury has identified 5 factors that underline productivity. These points are supported by the eef (June 2015).

1. Skill
2. Investment
3. Innovation
4. Enterprise
5. Competitiveness

Any intervention should deliver; skill through workforce development, innovation via change and competitiveness by action considering company culture. The objective will therefore be to increase competitiveness utilising innovative techniques, which will increase the skill of participating companies and their staff. In order to measure competitiveness, the measures of manufacturing performance should be adopted (Value Added per Operator, Workforce Productivity, Not Right First Time (NRA), Schedule Achievement, Overall Equipment Effectiveness (O.E.E.), Floor Space Utilisation and Stock Turns). The measure most suited to the needs of a company/sector should be selected as the prime measure of competitiveness and then reported as 100% to define a start point. The reporting of performance is confined to a regional level (wealth) or manufacturing sector (performance). The term 'value' can be interpreted as the monetary value. GDP is a reflection not only of market trends but of societal trends as well.

We need to test any proposals in actual trials to confirm suitability, as they must satisfy the following basic criteria:

- Comparable: the data/measurement indicator reflecting any changes in productivity levels must be capable of being placed in a comparative context.
- Consistent: the data/measurement indicator should allow any changes in manufacturing productivity levels to be analysed over a given time frame, using consistent data series.
- Strategic focus: the chosen data must reflect the underlying purpose of the intervention.
- Data should be methodological, robust and easily available, in a format that does not require unnecessary research effort.

By increasing the competitiveness of manufacturing there should be a causal link between the identified measures and GDP/GVA.

8.0 Summary of productivity

This paper suggests based on the current reporting mechanisms that there is a common purpose to generate wealth, but in doing so the reporting of national and specifically regional productivity in terms of GDP is of little interest to the manufacturing sector. A regional figure correctly reports a total for wealth generation, but it does not recognise large elements of excellence or the specific circumstances in play. The authors (as do others) suggest that manufacturing is key to the wealth generation of the nation however; manufacturing changes by sector and by region depending on circumstance related to the history of the sector.

The eef state in the same report that: We need to break with recent trends if the UK is to enter a new decade of sustained growth, good jobs and improving living standards. This will require a three-pronged attack from government and businesses.

1. Levelling up – securing further productivity improvements from manufacturers and reducing the gap between the weakest and the strongest performing businesses.

2. A greater focus on the most productive sectors – reducing barriers to growth for manufacturers and supporting stronger expansion of this higher-productivity sector.

3. Getting the basics right and sharing best practice – some areas of government spending are proven productivity props for all sectors and can support the spread of good practice.

Longer term there will inevitably be further gains to be had from a greater emphasis on encouraging new business start-ups, many of which will have low levels of productivity initially, and supporting the dispersion of productivity enhancing business models and practices to the public sector. Achieving the potential gains from this route will take a long time, however; the difference between outputs per hour across different firms in the same sector is as significant for overall productivity

levels as is the difference between sectors. Action by firms and support by existing policy levers can help reduce firm level disparities. Moreover, as manufacturers strive to make productivity gains, government support can amplify the benefits to the economy.

The sentiments here are correct however addressing the points above;

(1) Increasing units per operator can make a business competitive but not increase productivity in terms of wealth generation.
(2) Some of the most productive (competitive) plants need support to grow, as many are not UK owned and are 'competing' against EU plants for new business to just maintain the current facility and better gain new business.
(3) The third point should be promoted via clusters as the companies will gain more in terms of knowledge if they are in control. The competitiveness aspect of manufacturing is applicable to many sectors.

The final thought on improving productivity comes from the previously quoted Guardian article: In France, and to a lesser extent Germany, restrictions on working hours are other factors at play. For instance, widespread industrial pay bargaining and limits on redundancies make hiring workers a more costly proposition than in the UK. This encourages French and German firms to invest in the latest machinery and limit employment (Guardian 2016). Productivity may be seen to increase by one government department but the impact on society may not be acceptable to another department or constituency MP's. The question of a fully automated plant, with an overseas owner using land in a deprived area of the UK, to produce parts at low cost with no visible benefit to the local community may not be challenged?

9.0 Proposal

Manufacturing is still important to the UK economy and as such vital to the UK for not just economic reasons. The sector contributes over £6.7 trillion to the global economy. And, while the UK's manufacturing contribution has declined over the past 20 years, it still produces 3 percent of the world's manufacturing output (compared with Germany at 9 percent and the USA and China at 19 percent each). It accounts for 9.8 percent of the UK economy (£162 billion GVA in 2015). The UK is still one of the top ten manufacturing nations in the world (the eighth largest in 2017) and is the third largest in the EU. It employs 2.6 million people directly, and something like 5.1 million across the whole manufacturing value chain. UK exports of manufactured goods totalled £257 billion in 2015 (50 percent of all UK exports). The sector accounts for 70 percent of business R&D and 14 percent of business investment.20 EY's 2016 UK Attractiveness Survey found that, for every foreign direct investment project in a manufacturing plant, there was a matching investment across the supply chain in areas such as logistics, R&D and sales and marketing. (Maier 2017)

Ultimately, the private sector will deliver the lion's share of the UK's productivity improvements. Manufacturers must maximise the investment in research and innovation by working with the science base and engaging with Catapult Centres and their supply chain. Plans to investment more in management capabilities in response to the growing complexity of modern, globally focussed businesses must be sustained. And manufacturers must be fully involved with developing apprenticeships and engaging with young people about industrial career opportunities. (eef 2016).

The above is correct but the UK funds and supports frameworks which can be aligned to funding. If we are to focus on manufacturing with a development of the established product development cycle, we have to examine that development cycle. The product development cycle is set out via MRL and TRL levels which are defined and accepted as a guide by UK funding bodies but the emphasis is on TRL. Levels 1, 2 and 3 being the research area and 8, 9 and 10 being the production

ready area. The MRL and TRL level 10 suggests a current state of the art with an enabler such as lean manufacturing and 6 sigma to make improvements. This paper will now propose that: if the individual elements in a process have been optimised in terms of lean and design for manufacture then we need to move the connected process to a new level which creates a maximum state of optimisation. This maximum state must be considered as temporary with a mechanism to introduce any technology or methodology which would introduce a new state-of-the-art condition.
To move forward the concepts and technology associated with:

- Artificial Intelligence.
- Additive Manufacturing.
- ERP.
- IOT.
- Advanced robotics. and
- Industry 4.0

All need to be evaluated and adopted as appropriate, but with a defined return on investment and efficiency increased in terms of increased value added. We also have to codify and disseminate the skills associated with the new techniques via both the Higher and Further Education system.

This paper is will now address:

1. What is an appropriate productivity measure(s) for manufacturing; and
2. What is needed to develop the current state of the art; (MRL/TRL 10)

Considerations are that any new activities must be:

- Digitally inclusive;
- Operator inclusive;
- Equipment optimisation;
- Supply chain inclusive;
- Customer inclusive; and
- Best in class.

For example, the role of resource productivity is often ignored, while resource costs are 50% of total costs and labour is about 10% of total manufacturing costs.

9.1 Looking specifically at readiness levels

TRL10: The technology is successfully in service in multiple application forms, vehicle platforms and geographic regions. In-service and life-time warranty data is available, confirming actual market life, time performance and reliability

MRL10: Full Rate Production is demonstrated

- Lean production practices are in place and continuous process improvements are on-going.
- Engineering/design changes are limited to quality and cost improvements.
- System, components or other items are in rate production and meet all engineering, performance, quality and reliability requirements.
- All materials, manufacturing processes and procedures, inspection and test equipment are in production and controlled to six-sigma or some other appropriate quality level.
- Unit costs are at target levels and are applicable to multiple markets.
- The manufacturing capability is globally deployable.

Moving forward the interface of products already at high TRL and MRL is becoming a key area for development and moves into process interface levels. An example being a human, a robot, a part and an assembly operation. All items could be at level 10, however; the interface and outputs of the interface are at a past state of the art. To move into advanced manufacturing, we need to be operating in terms of process integration level 10, which is not defined, as the focus is on the individual elements and not the whole. Developing process integration in terms of industry 4 would allow funding and set new targets for engineers to work to. The author is aware of the work being undertaken by the Catapult system to further digital use whilst developing advanced manufacturing. This work should not stop but requires a lot more contextualising in terms of what productivity is and how different people interpret it. Manufacturing productivity is not the same as regional/national productivity even though they are intrinsically linked.

A simple brochure needs to be produced which explains the nuances of productivity and possibly introduce new terms such as:

1. Economic productivity: The overall wealth generation of the country
2. Manufacturing productivity: The performance of a plant within its sector
3. Sectoral productivity: The productivity of a UK sector within the world

It is also suggested that balancing factors are also introduced as was the case when comparting car plant efficiencies. The impact of this type of reporting would be to engage more people as the terms used will have relevance.

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