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Big data driven customer insights for SMEs in redistributed manufacturing

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Abstract

Redistributed manufacturing (RdM) refers to manufacturing business models, strategies, systems and technologies that change the economics and organization of manufacturing, particularly related to location and scale. Small-scale manufacturing has the potential to help tailor products to satisfy the specific needs of consumers different in terms of geographical location, cultural roots, improve sustainability and drive the society towards circular economy. While RdM has the great potential to deliver this, currently, very little has been understood on how RdM could help SMEs for gaining economic benefits due to the constraint of their business model, lack of understanding on customers, limited resource commitment on R&D, marketing and sales, supply chain integration, etc. Similarly user-driven design and customer-insights delivered through 'big data' analytics has the potentially to be highly beneficial for manufacturing SME and little is known of how they can be combined with RdM to benefit SMEs. Hence, they may impose risks on the business and operation of SMEs should poor choices be made or systems be implemented badly. The economic importance of SMEs within the UK and Europe is long established with manufacturing SMEs accounting for 60% of all private sector jobs in the UK. Within the European Union the overwhelming majority of companies (trading in the non-financial sectors) were SMEs (99.8%), employing 89.7 million people (67.1% of the workforce). This paper reports some of the results of an initial exploratory survey of manufacturing SMEs within the United Kingdom. Focusing on their background and status, and their current understanding and interests in RdM, big customer analytics and related topics.

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1. Introduction

The term Redistributed manufacturing (RdM), within the context of the UK Engineering and Physical Science Research Council (EPSRC) RdM Networks program, has been defined as technology, systems and strategies that change the economics and organization of manufacturing, particularly in relation to location and scale[1]. Smaller-scale manufacturing has the potential, if applied appropriately with suitable levels of localization, to drastically reduce supply chain costs, improve sustainability and tailor products to the needs of users and consumers.

Such smaller-scale manufacturing has the potential to help tailor products to satisfy the specific needs of consumers differing in terms of geographical location, cultural roots, improve sustainability as well as drive the society towards circular economy[2].

While RdM has the great potential to improve sustainability, currently, very little has been understood on how RdM could help SMEs for gaining economic benefits due to the constraint of their business model, lack of understanding on customers, limited resource commitment on R&D, marketing and sales, supply chain integration, etc.

Micro enterprises and small and medium-sized enterprises (that for the purposes of this exploratory study will be referred to as SMEs) have an important role to play in the continuing success and growth of national economies. Studies have suggested that the contribution of SMEs in realizing the demands and improving the profitability of their supply chain partners (including large businesses) should not be understated as they have a critical role in modern economies [3, 4].

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A study conducted for the British government's department of business innovation and skills reported that in 2015 99.9% of the total number of enterprises in the UK could be classified as being SMEs. These companies contributed more than 2/3rds of private sector workforce as well as 47% of the annual turnover in the UK.

According to an extensive study of companies conducted by The Data Warehousing Institute (TDWI) in 2009, 38% of organizations surveyed reported that they utilize advanced analytics, whereas 85% said they would be practicing it within three years[5]. According to the study the respondents were spread evenly across a wide spectrum of company sizes. However, only 23% of respondents were from companies whose revenue was less than $100million[5], within the EU this is above the turnover threshold for a medium enterprise. Additionally only 4% of respondents to this study were from non-computer manufacturing companies. As such this and other industry studies may not accurately reflect the opinions of manufacturing SMEs

This exploratory paper specifically focuses upon SMEs based in the South Wales industrial area of the UK and their potential motivations for using and knowledge of big data based customer analytics. Whilst there is much research regarding big data and collaborative design there is comparatively little that examines these from the perspective of SMEs. Two research questions are tackled:

1. What are companies doing with regards to their product and customer data?
2. What position are they in to potentially make use of big data analytics and participate in RdM?

2. Research method

This particular exploratory study takes an inductive approach, this encourages the use of research instruments that are capable of delivering principally qualitative data. The use of qualitative research is suitable in situations where the aims of the researcher is to understand the meaning that participants in the research give to events and situations, and to appreciate the context in which these are made [6].

In total fifteen on-line surveys were undertaken with participants who are in senior roles within several Welsh manufacturing companies. The sector(s) are summarized in Table 1, where it can be seen that a broad spectrum of sectors has been surveyed.

A survey would normally involve questions based on single/multiple selection questions or Likert scale answers. Typically a semi-structured interview would give the respondent the opportunity to discuss the topic in question within their own particular frame of reference, utilizing ideas and concepts that they are familiar with [7].

This online survey incorporated some aspects of semi-structured interviews by allowing the respondents to enter free form text (appropriate as well as offering pre-defined options). This was used in order to try and achieve higher levels of participation from those in managerial positions, in order to allow participants to understand how the information they provide will be used (addressing trust issues), and by hybridizing also attempting to negate some of the effort associated with writing (for example in the response to a survey) [8]. A coding schema for the surveys was developed, and the results used as a principal contributor to the research objectives of this paper.

Table 1: Summary of sectors covered.

Company	Percentage of Responses
Aerospace, Defence & Security	33.3%
Automotive	6.7%
Chemical	20.0%
Computer	6.7%
Construction	26.7%
Education	6.7%
Energy	20.0%
Health Care	20.0%
Manufacturing	73.3%
Medical devices	6.7%
Oil & Gas	6.7%
Photonics	6.7%
Renewables	6.7%
Steel	6.7%
Transport	6.7%
Water	6.7%

3. Background

3.1. Big data analytics

Big data analytics is a broad term given to the application of advanced data analysis techniques are applied to big data sets. Therefore it can be considered that big data analytics (often referred to as 'big data') is about two things. Firstly big data – the gigabytes or terabytes of data that a company can hold. Secondly analytics – the tools and techniques that are used to analyze the data.

A 21st century business will potentially have data from many streams such as emails, electronic business records, website logs, social media, production monitoring systems etc, According to [9] in the period up until 2003 a total of 5 exabytes (10^{18} bytes) of data were created by human beings, yet in the now it takes only two days to create this amount.

The McKinsey Global Institute [10] listed the potential of big data analytics in five main domains, of which two can be considered as being relevant to manufacturing SMEs:

Manufacturing: improved demand forecasting, supply chain planning, sales support, developed production operations, web search based applications

Retail: in store behavior analysis, variety and price optimization, product placement design, improve performance, labor inputs optimization, distribution and logistics optimization, web based markets.

However, as shown in [11] big data within manufacturing companies isn't necessarily just about products and customers, a single machine tool monitoring system could easily generate nearly 0.5TB of data a year. Also network based control systems will potentially generate potentially large quantities of

data [12]. With both of these sources containing potentially useful information.

The rapid growth of the internet when combined with the growth in user generated content – i.e. internet forums, social media and review sites created a great deal of content that is of interest to researchers. However, there is one significant difference between the data gathered by legacy systems from the 1980's and 90's and that of web-based and e-commerce systems. Namely that the data is less structured and often contain rich customer opinion and behavioral information (in particular user reviews at e-commerce sites for example)[13]. Such rich information could be of particular use to the manufacturers of consumer goods, in particular SMEs who may not be in the position of large companies who are able to conduct extensive market research.

In a review of big data analysis Chen and Zhang [14] stated that a large number of techniques and technologies to capture, curate, analyze and visualize big data have been developed by scientists (from fields such as computer science, mathematics and statistics). Despite this they are some distance away from being able to meet a variety of needs.

As well as the fields mentioned above big data analysis also encompasses data mining, machine learning, neural networks, social network analysis, signal processing, pattern recognition, optimization methods and visualization[14] the inter-relationships are illustrated in Fig. 1.

This wide variety of tools, techniques and disciplines could make it difficult if not impossible for a manufacturing (non-IT) SME to implement without expert guidance. As stated in Chen and Zhang "Big Data also means big systems, big challenges and big profits, so more research works in these sub-fields are necessary to resolve it."

3.2. SME challenges big data analytics

Whilst it is reasonable to say that it is incorrect to assume that all SMEs cannot afford sophisticated computer systems, cost and in particular value for money often plays a critical role (and hence potential barrier) when a company is considering purchasing software. There is a natural cost – functionality trade-off, systems may have the desirable functionality but the addition costs outweigh any benefits. Perhaps equally important consideration is that SMEs often do not have in-house capabilities for the selection, installation, configuration and maintenance of complex IT systems. Such factors are a potential barrier to big data analytics in SMEs [15].

However the emergence of cloud computing, could provide a means to access complex IT systems. Studies have suggested that cloud computing will become attractive option for many SMEs due to its flexible cost structure and scalability[16]. Although interoperability between cloud computing platforms / applications as well as cloud and 'desktop' systems may present challenges [17].

As stated in [15] the application of cloud computing technologies to big data analytics has the potential to be very cost effective. In particular for SMEs where cloud computing can reduce the cost of implementing big data analytics and make it feasible for them to use it.

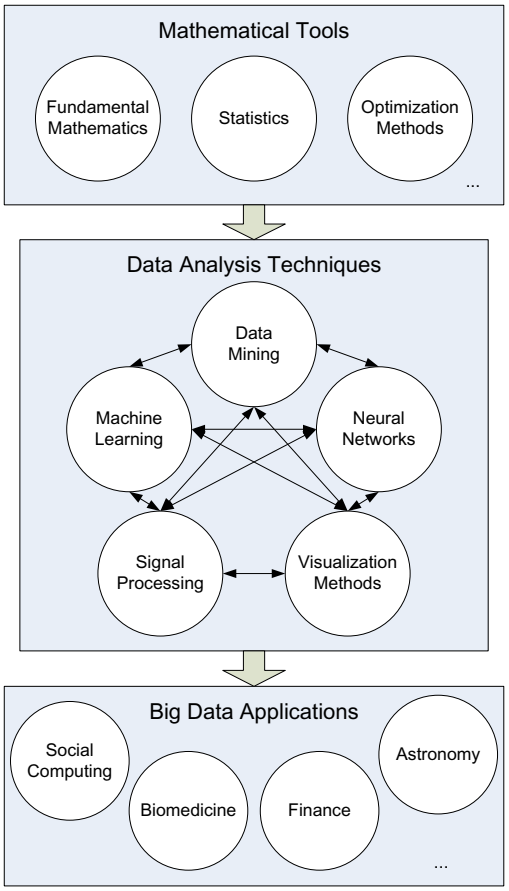

Fig. 1. Big data techniques. Source: Chen and Zhang [14]

4. Results and discussion

This exploratory study takes a snapshot of how manufacturers in South Wales engage with their customers, the data they have available to them, how they use it and what benefits they feel they can obtain from big data analytics. The following sections examine different elements of a company's interaction with its data and RdM. The outcomes are examined from both a general perspective and from the perspective of the companies and the use of big data analytics.

4.1. Perception of Redistributed Manufacturing

Because RdM has been defined around smaller scale manufacturing SMEs stand to potentially gain the most from the proliferation of RdM. In order to gauge the perception of RdM amongst SMEs they were asked three questions. 1) Have they heard of RdM (awareness); 2) Would RdM be helpful in their company (usefulness); 3) Do they have any plans to get involved in RdM (involvement). As Table 2 shows the majority of respondents had not previously heard of RdM and only a

minority think it could be important for them or have any plans to become involved.

The fact that 66% of respondents were unsure how useful RdM could be suggests that the RdM research community and policymakers still have a lot of work to do to raise awareness amongst SMEs. This is concerning as theoretically it is SMEs who could stand to benefit from RdM.

The alternative to this could be large manufacturers establishing smaller, distributed manufacturing, assembly or finishing centers. The automotive sector provides an example of this, although not common in Europe it is normal for dealerships to fit optional extras in cars in emerging economies. This lowers the product variety levels offered by the car plant which in turn keeps production costs low [18].

Table 2. Perception of redistributed manufacturing.

	Unsure	Yes	No
Aware	-	40%	60%
Useful	66.7%	6.7%	26.7%
Involvement	-	6.7%	93.3%

4.2. Availability of customer data

A company, depending on the products it makes and the IT systems it uses can carry varying types of information. The bare minimum most companies will have is sales and order information, some will carry product specification data especially when bespoke products are frequently manufactured. Other forms of data that companies may hold include CAD data from customers, returns data and potentially feedback as well.

For the purposes of the survey the different types of data were grouped into several broad categories: Supplier Data; Manufacturing Data; Product Data; Sales Data; Customer Data; Financial Data. The respondents were then asked to indicate what type(s) of data they had (they were also given a free text field to indicate any other types of data they have).

In the results shown in Table 3 below it can be seen that all of the respondents in the survey maintain product data and that the majority keep customer and sales data. With hindsight the universal maintenance of product data could be considered to be unsurprising as it is sufficiently broad that this would incorporate CAD data, product specification, product datasheets etc. Such data could for example include what is necessary for a “CE” mark within the EU that shows that the manufacturer has checked that these products meet EU safety, health or environmental requirements. Additionally one respondent indicated that they also kept research / IP related data and another kept regulatory compliance data.

Based on the results from this preliminary question there is an indication that the majority of companies could be in some sort of position to apply some form of big data analysis techniques. However, this would of course be contingent on the type of data being stored and its format, for example a sales spreadsheet would be considerably easier to analyze than a scanned document.

Table 3: Types of data held by the companies.

Type of data held	Percentage of respondents
Supplier Data	80.0%
Manufacturing Data	93.3%
Product Data	100.0%
Sales Data	86.7%
Customer Data	73.3%
Financial Data	93.3%
Other	13.3%

Despite the fact that companies may maintain a lot of data those figures would not indicate how much customer specific data is kept. The companies were asked if they maintain data about their customers, from Table 4 it can be seen that 80% said that they do and 20% responded that they do not.

Table 4: Is data regarding customers stored.

	Yes	No
Maintain customer data	80%	20%

Based on this the respondents answering Yes were asked to provide information regarding how they currently use data (in whatever way it is stored) as shown in Table 5. Of those that responded the majority indicated that they use it to improve their products, market and customer service. This raises an interesting question, that would perhaps be worthy of future study, regarding how many companies use or keep records of their product reviews. Specifically those from websites such as Amazon where customers leave feedback and Which? an organization that conducts formal product tests. Such websites, as mentioned earlier, can contain a great deal of information that might be of use to product manufacturers.

Table 5: Current uses of customer data.

Current use of data	Percentage of respondents
Personalizing Customer Experience	16.7%
Improve Products or Services	66.7%
Improve Marketing	75.0%
Improve Customer Service	75.0%
Reduce Risk & Fraud	16.7%
Other	8.3%

As some of the analyses mentioned in Table 5 are provided within Customer Relationship Management (CRM) systems the respondents were asked to confirm whether the used CRM systems of not. The results if Table 6 show that the overall response was that 73.3% of the respondents did not use CRM and only 26.7% did use CRM systems. This could be a matter of concern, if a company isn’t in the position to use CRM it raises a question mark regarding how able they would be to make full use of big data analytics.

Table 6: Use of Customer Relationship Management systems.

	Yes	No
Use customer relationship management	26.7%	73.3%

4.3. Data storage

Studies have suggested that cloud computing could be an enabler for SMEs wishing to use big data analysis [15]. However, in order to make this achievable there is some is necessity for the use of cloud storage. Therefore the respondents were asked what storage methods they used. As can be seen from Table 7 53.3% of respondents use cloud storage for some if not all of their data. This is broadly positive as it implies there is some familiarity with cloud computing at some level. The majority of respondents use Network Attached Storage which suggests a degree of familiarity with the idea of not just storing data on the hard drive of the PC they use.

Table 7: Storage methods.

Storage mediums	Percentage of respondents
Flash Drives	20.0%
Hard Drives	53.3%
Hard Drive Arrays	20.0%
Network Attached Storage	66.7%
Cloud Storage	53.3%

4.4. Data volume

In order to gauge how much data companies actually store they were asked to estimate how much data their company actually has. The results of this are illustrated in Figure 2, as can be seen the majority of respondents have less than 2TB of data. Though this amount may seem comparatively small (within the context of big data) but taking a historical perspective 500GB of data is over 100 times the capacity of a typical hard drive used in a fileserver's RAID array in 1996 (c. 4.3GB) and would have been unimaginable for SMEs.

The respondents were asked whether they had any difficulties managing the volumes of data they have and 93.3% responded that they do not have a problem. However, 6.7% have indicated that do have a problem and a cross-tabulation between this and the results in Figure 2 shows that it is the respondents with >10TB of data that experience problems.

This is broadly positive as it shows that at the very least most are able to manage the data that they already have, but it does seem to suggest that as volumes increase companies begin to encounter problems.

4.5. Awareness of big data

The survey respondents were asked if they were aware of big data analytics as a yes / no question. As the table below shows less than half of them were aware of big data analytics. When compared to the 85% figure for companies that would be using it within three year from the TDWI [5] this suggests that there is a possible discrepancy between what businesses as a whole and what manufacturing SMEs think about big data and potentially their ability to gain meaningful results.

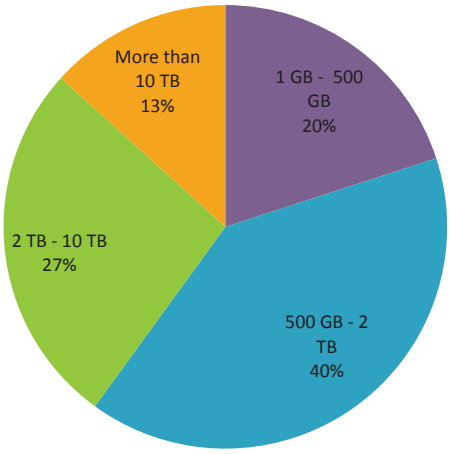

Fig. 2. Amount of data stored by SMEs

Also of note is that 75% of companies surveyed by TDWI were non SME and only 4% were non-IT manufacturers, this also suggests that larger enterprises are more aware of big data than SMEs (especially manufacturing companies outside of computing / IT sectors).

Further analysis of the survey data showed that the respondents from the previous section who had >10TB data and were experiencing problems indicated an awareness of big data analytics.

Table 8: Awareness of big data analytics.

	Yes	No
Aware of big data	46.7%	53.3%

Table 9 shows what companies would hope to garner from big data analysis, the responses when comparing to the lists provided in [10] it shows that the overall awareness of all that could be achieved through the application of big data analytics is perhaps not as good as it could. Additionally this suggests that perhaps there is a possibility that companies have heard of big data analysis but are in reality unaware of what it can offer, this would have to be investigated through further studies. In total of the companies who had heard of big data analytics three quarters of them actually had a vision of what they'd hope to achieve through big data analytics.

Table 9: Insights that companies wish to gain through analytics.

Type of insight	Percentage of respondents
Market Understanding	28.6%
Increase in Productivity	28.6%
Understanding Customer Patterns and Char	42.9%
Sales Predictions	57.1%
Other	42.9%

Based on this initial data it could be concluded that there is a need to further inform SMEs about big data analytics, what it

can do and how to overcome the real or imaginary barriers to entry that SMEs might face.

5. Conclusions

With regards to the two research questions posed the following conclusions can be drawn.

RQ1 - What are companies doing with regards to their product and customer data? It is clear that although companies are storing data, not all companies are actively using customer data. The survey also showed that only a few companies are actively using CRM systems, which could provide answers to some of the queries they have.

RQ2 - What position are they in to potentially make use of big data analytics and participate in RdM? The majority of respondents have not heard of big data analytics, of those who did there were some ideas regarding what they hope to achieve. However, as mentioned above a small proportion of companies actively used any form CRM which could perhaps provide some of the insights they wish to obtain. The small number of respondents who had any plans to get involved in RdM is a concern as it suggests that there is a lack of awareness of what it is and how SMEs stand to benefit. The potential consequence of this is that individual SMEs may miss-out or that large manufacturers take it upon themselves to redistribute their manufacturing hence ignoring SMEs. This is something that may require actions from academia, policymakers as well as organizations involved in supporting and nurturing manufacturing.

The results of this exploratory study suggest that although there may be some demand for big data analysis it is possible that the current solutions may not be viable for SMEs and that SMEs are seem to be ill-prepared and ill-equipped to make the most of what big data analytics can offer them.

This initial exploratory survey also shows that there is a necessity to study the needs of manufacturing SMEs and big data analytics and RdM in more detail.

6. Limitations and further work

This exploratory study has limited itself to examining the current situation of a small number of manufacturers with regards to their interactions with data and redistributed manufacturing via a survey (with many of the implicit limitations of this method). In order to provide more deep and meaningful results future analysis will involve conducting full semi-structured interviews with a number of these companies.

Due to the wide variety of SMEs (involved in various tiers of the supply chain) the future study will primarily focus on those companies who are involved in manufacturing consumer goods, in other words SME OEMs. Such SMEs could be operating in a variety of ways for example: supplying major retailers directly, selling directly to consumers, contract manufacture for a customer or selling via a third party (wholesaler).

These studies will examine topics such as: challenges faced when using customer data, customer insight-driven product and service development, user-driven re-distributed manufacturing. This will enable some of the initial findings of this exploratory study to be examined in more detail to obtain a clearer picture of SMEs and their attitudes. As well as to ascertain the challenges that they face when handling and try to “add value” through the analysis of customer data.

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