Network //
Praxis

New Digital Methods for Mapping and Measuring the Digital Economy

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"**The stakes are high**, not only because SMEs make most of the business and industrial fabric in most countries and regions, but also because they are strategic actors in large firms' supply chains and play a key role in building inclusive and resilient societies. At an aggregate level, the SME digital gap has proved to weigh down on a country's productivity performance and to contribute to increasing inequalities among individuals, firms, communities and places."

The Digital Transformation of SMEs, OECD, (2021) page. 17

Executive Summary

This document presents the results of a project to demonstrate the feasibility of using entirely new digital metrics to measure, monitor and understand the business economy of Wales. For the first time we apply AI and Big Data analytics alongside other contemporary information technologies to the task using a platform that has been under development over the last two years.

The results below show that we can now quantify key aspects of the modern business economy that previously could only be exposed by expensive surveys, if at all. As we report below, governments, international bodies, investors and business support agencies around the world are looking for modern alternative sources of data to help address the requirement for frequent, granular information with which to understand and intervene during this period of massive change. This report describes a Welsh initiative to address these demands.

We constructed a sample of 48,000 companies to represent the distribution of businesses across Wales and England. Using this we created a dataset containing three metrics we have developed; Digital Growth Index, Innovation Index and Digital Maturity Index. Each of these provides quantitative data enabling us to build a comprehensive picture of business investment and innovation and progress at both national and individual business levels.

The Digital Growth Index has proven useful at the macro level by demonstrating, in great detail, the impact of significant events such as elections, the Brexit referendum and now the Covid-19 emergency on company behaviour. A real time quantitative measure of the impact of uncertainty upon business behaviour is now available. Given that economic downturn usually reduces investment in small companies and leads to an uptick in larger companies it would be interesting to see what more can be learned from its application at this difficult time. At the micro level the trajectory of individual companies can be described and tracked, providing data to complement financial or other information required for a variety of decisions.

The Innovation Index, another unique tool, shows the distribution of innovative companies within and between the different parts of Wales. Revealing interesting details about the concentration of innovation businesses in boroughs outside of the capital and how Cardiff performs in comparison with similar sized cities in England.

The data demonstrates the relationship between innovation and company size, showing that perhaps the highest levels of innovation are concentrated in large SMEs and companies with more than a thousand employees. However this data signposts that thousands of innovation SMEs exist outside of the start-up economy here in Wales. More important we now know where many of them are and indeed, who they are. Feasibly, we could find all such companies operating in Wales if required.

The Digital Maturity Index is very revealing showing that England and Wales are essentially alike once variation in make-up of the cohort of companies within the two countries is accounted for. Wales has exhibited a steady increase in digital maturity as measured by us over the last six years but this progress is uneven.

Large differences exist between sectors and although these tend to reflect the difference between the behaviours of B2B and B2C companies, other factors are at work. Retail in particular and other direct to the public selling businesses have increased their digital sophistication faster and to higher levels than other sectors. But this is not true of all B2C sectors or companies, we therefore have a measure of those businesses that are becoming more exposed over time.

It would seem likely that digital maturity is driven by an awareness of and immersion in a competitive situation with all the consequences that follow from failure to respond. It is also probable that those sectors with low levels of digital maturity will face competition from afar or from companies adding value by taking a part or all of their business with digital alternatives. We are thinking here for example of low performing accountancy practices and underinvested real estate businesses which appear particularly vulnerable. The Digital Maturity Index is a tool that can be used to explore the potential impact of competition within and between sectors.

These new metrics can all be collected regularly, with retrospective data if required, they are robust and they scale readily. In contrast to survey data alone they are **cost-effective** with a **high degree of granularity** and potential **source of near continuous data** for oversight, policy, business-support and programme impact evaluation. Using these tools it is possible create new products and services to support innovation and the digitalisation of the economy. For the first time we are in a position to ask and answer new questions around investment and innovation quickly. Most important of all we can find and characterise the behaviour of most companies, opening up an opportunity for interventions never previously possible.

Project Overview

This project will demonstrate the availability and utility of a new digital method to map and measure the SME sector of the economy developed by Network Praxis.

Network Praxis has developed a digital platform to profile key aspects of the Welsh population of SMEs. In this document we discuss opportunities that derive from the application of this new technology in the drive to improve innovation and competitiveness in the Welsh economy.

Our digital platform, called *Foresight SI* is designed to help address the urgent requirement within the public and private sector for new tools that monitor the rapidly unfolding changes in the economy and measure their impact, in this case on SMEs. It is becoming widely understood that, as economies respond to the pandemic and climate emergencies, the conventional armoury of public statistics and surveys is proving slow and inadequate.

The tools, practices and structures that are used to support business innovation are also coming under increasing scrutiny.

Alternative and highly focussed data is urgently required to provide insight into the scale, location and timing of changes in company behaviour as they respond to disruption and new developments. Additionally, there is a pressing need to monitor changes occurring in the context of the 4th Industrial Revolution; the digitalisation of the global economy as it rapidly unfolds over the coming years. This change alone is creating a complex set of requirements that the public and private sector are at only the beginning of understanding. More than ever, new tools are required to monitor and support intervention in this transformative global economic dynamic.

Network Praxis has developed a solution for quantifying and understanding the development of businesses across time periods, geographies and sectors. The platform we have built can systematically acquire data at scale, process metrics and store multiple sources of structured and unstructured data concerning the behaviour of UK businesses. Using the platform we have developed and tested a suite of new data products designed to quantify key concepts in the context of the SME economy.

In this project we demonstrate that our new digital platform has a role to play in any modern effort to support innovation at scale in the SME economy. We offer a new type of data to help address the task of both helping to create change and managing and monitoring its consequences.

To do this we will show that the data we have engineered reflect the level and distribution of key attributes of SMEs within the Welsh economy. Our target has been to quantify and profile companies with respect to the extent they engage with four key issues that determine their success:

1. Digital Growth
2. Digital Maturity
3. Innovation
4. Environmental, Sustainability and Governance (ESG)

We then demonstrate how these data can help understand the importance of geography, sectoral differences and developments that occur over time. At each stage we have collected and arranged data from England as well as Wales to place our data in context with respect to geography and trends over time.

Introduction

Network Praxis was founded to deliver digital tools and strategic services to help our clients understand the twenty-first century economy. Our research and development effort over the last two years has focussed entirely on the task of developing innovative approaches to measuring and mapping the development of the business economy, particularly with respect to SMEs that have progressed beyond the start-up stage.

Foresight SI is a product that provides a core of metrics with further metrics under development. This is currently the **most comprehensive set of digital economic indicators applied to a SMEs available anywhere**.

A number of recent events such as; the publication of Professor Brown's report; the statements made in the Senedd in December 2020 by Lee Walters MS; the Conference convened and addressed by the Minister to discuss the two recent reports on a Welsh Innovation strategy (May 2021) on scoping a future innovation policy for Wales; and the early outputs from the reformed IACW form the background to this work. More recently we have engaged with the task of mapping the Welsh business community for our commercial clients and consequently have a very large and unique dataset covering many aspects of the business network in Wales.

The Welsh Government has described a requirement to accelerate industrial transformation and notes that the 'challenges facing Wales in nurturing an innovation ecosystem that is fit for the future are such that radical, rather than incremental, developments that embrace both institutional and cultural change will be needed.'. It is also stated in the same report that the new innovation policy should be expected to 'include a suite of innovation support programmes for SMEs, increased availability of venture capital, and investments in unlocking data resources and enabling digital technologies.'

Network Praxis has chosen to highlight innovations that are data driven, can support a local agenda within a national programme and provide tailored support to the Welsh situation for the growth and diffusion of innovation.

This report also sets out some initial ideas on ways new technologies can enhance the work of business development, especially in the context of promoting innovation. Innovation is a particularly important facet of business development in any economy, but one which has been

highlighted as representing a considerable deficit here in Wales on a number of occasions (BEIS, 2020).

We were particularly struck by the inclusion in the Scoping Future Innovation Policy of the following:

' ...data from the UK Innovation survey suggests that Welsh businesses draw ideas primarily from their supply chain (customer base). In contrast, comparatively few report either government research or higher education institutes as highly important.'

and

'It has recently been argued that innovation represents a cross-cutting thematic area that has the potential to support multiple clusters. That views the key ingredients of innovation as a common asset that can ultimately support the capability of a wide range of firms to innovate.'

Our target has been to quantify and profile companies with respect to the extent they engage with four key issues that determine their success:

• Digital Growth
• Digital Maturity
• Innovation
• Sustainability

Network Praxis offers robust, regular and above all comprehensive data concerning the level of investment in and maturity of digital properties and the propensity for innovation across the SME sector at a national level. We have restricted ourselves to accessing only those data which a company has placed in the public domain – **we do not acquire, process or deliver any information that is not publicly visible.**

We set out below some examples of our approach to highlight how we can help support business development activities by providing the tools and systems that will give advisors and businesses timely, detailed and comprehensive data concerning the behaviour of companies across the economy.

The goal we have chosen to address is to design tools and services that promote change by driving innovation and competition at scale.

References

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BEIS. (2020) *UK innovation survey 2019: Main report covering the survey period 2016 – 2018*. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/903582/UK_Innovation_Survey_2019_Main_Report.pdf [Accessed: 29th March 2021].

New Digital Economic Measures

Background to our approach

Just over 85% of UK companies with 10 or more employees operate a website(s) for the purpose of selling products and services, attracting investment or advertising their capabilities and achievements (Arora et al., 2016). Over the last five years researchers across Europe have been exploring the potential of Big Data retrieved by accessing the data contained in public facing business websites to inform financial decision making in the investment economy, monitoring the behaviour of multi-national companies, modelling economic developments, measuring the impact of events upon the behaviour of businesses and predicting company performance.

Projects have been undertaken or are underway sponsored by the OECD, German, Italian and Danish government agencies to develop and understand new digital metrics of business behaviour based on their websites. In France, Spain, Sweden and Belgium research groups have similarly explored the application of Big Data techniques to the collection and processing of data retrieved from firms' websites. This work has usually focussed on a single metric or topic of concern (see below for a list). Apart from the OECD project, these projects have never led to a production grade software tool. They remain academic systems designed for research purposes and with a limited capacity (if any) for acquiring novel data. Nevertheless they have clearly demonstrated the great potential and current utility of these metrics for monitoring, measuring and predicting the behaviour of businesses.

Especially important is the ability to use these methods to explore the otherwise opaque (in data terms) population of SME's. A cohort of companies that is both immensely important to the economy and about which too little is known as they report in less detail, about fewer topics and less frequently than large companies. For example, research has frequently shown that available financial data alone cannot be used to predict the success or otherwise of smaller companies as it is with larger firms. There is too little financial data and it is too opaque for external analysis to create much insight. Additionally, smaller businesses are far more likely to be stressed by external events than larger companies meaning different factors are at play when predicting their success or failure.

#	Topic Areas
1	Predicting Business Default
2	Identifying Long-term impacts of early adoption
3	Predicting Long-term survivability of businesses
4	Predicting High Performing Universities/companies
5	Predicting the likelihood of exporting
6	General economic activity predictor
7	Monitoring E-Commerce adoption
8	Predicting/measuring Innovation in businesses
9	Predicting engagement with ESG issues

Every member of the European Union has to undertake a regular review of the level of innovation within its economy as a fundamental requirement of community membership.

In the UK, this is, or was, based upon a large survey of businesses undertaken every two years and reported within six months of the survey being completed. Research undertaken in Germany after the last survey identified a high correlation between the German innovation survey and a much larger survey undertaken by measuring the websites of German businesses. This opened up the possibility for more frequent and granular digital innovation surveys using a new approach. Subsequent industrial research by Network Praxis has led to the point where we can now **describe the results of the first digital survey of Welsh business innovation.**

The significance of this body of research has been further underlined by economic research into the long-term consequences of companies developing and maintaining their websites. Here the evidence of impact is extremely compelling. For example Tranos et al.(2020) were able to demonstrate an effect upon business profitability and survival that lasted more than a decade after (early) adoption of a website. After controlling for size of company and business sector, they were able to demonstrate positive impacts in 2015 of changes made in 2000 by companies that were early adopters of web technology in the English regions.

A second area of activity underpinning our approach has been the rapid development of technologies and companies dedicated to providing what has come to be called alternative

data sources for the business intelligence market. The acquisition of unstructured textual data from many sources, including but not limited to company websites, and the application of Natural Language processing techniques to create novel quantitive and qualitative data, has become a central plank in a business sector that is now worth many £10's of billions a year.

Fig. 1 Metrics currently provided by Foresight SI Platform

Metric	Topic	Available Now	Under Development
Digital Maintenance	Overall Level of economic activity	Yes	
Digital Maturity	Progress & Digitalisation	Yes	
Innovation Potential	Innovation	Yes	
Business Sustainability	Business survival/high growth	Yes	
SME failure	Business failure/default		Yes
ESG Engagement	Environmental & Social Contribution	Yes	
Export Orientation	Probability of export activity		Yes
Languages supported	Use of Welsh & Other Languages for export	Yes	
E-Commerce Rating	Use of up-to-date e-commerce tools		Yes

Innovation Policy and the Significance of Place

In 2019 the then the UK Government Science Minister Jo Johnson called upon "local areas to develop 'audits' mapping local research and innovation strengths and infrastructure. These deep dives will provide a new way to identify and build on areas of greatest potential in every region". This was to form part of the Government's One Nation Science agenda which would "take a more thoughtful approach to place". More recently this approach has been strongly recommended in research commissioned by the UK government. (Page.1 Goddard, 2021)

The experience of the last 20 years, especially within the EU suggests that a place based innovation strategy cannot take the form of a one size fits all approach. This is particularly apparent in terms of policies premised upon the expectation that knowledge generation from research will lead to downstream local innovation. Numerous studies have shown that lagging regions (within the EU) lack both the absorptive capacity in local businesses, collaborative

networks, leadership capacity and perhaps most important in Wales – they follow different innovation pathways (Herva´s-Oliver et al., 2021).

Research published by the ONS and other actors underlines the fact that spatial issues are highly important in understanding innovation and growth. Local concentrations of businesses are important but this is tempered by the fact that ultimately businesses grow in the context of sectoral dynamics – intensity of competition and the growth trajectory for a given sector as a whole being key drivers of growth for example.

Place-based interventions require regional/sub-regional granularity to identify and support a variety of clusters of activity and differing models of innovation and this is not always available in time or with sufficient detail. Time series data such as that provided by the UK National Innovation survey lack sufficient granularity to support a (more) localised innovation support strategy. These data are far too infrequent to be of use for project evaluation and planning under current circumstances. Essentially, most of the empirical research findings available to guide policy and planning such as those referenced below are provided at the macro level, often without explicit mention of Welsh government priorities or Welsh data. Such research outputs are always retrospective, sometimes so much so in the context of the current rate of change as to be of limited utility. When solving problems, local data that is recent and granular is almost impossible to obtain.

For example, there is an absence of any scalable research data to support the evaluation of business support interventions and this has hampered the development and enhancement of strategies to diffuse innovation in the Welsh economy. Answering questions about project reach, impact and effectiveness is hard to do especially when the answers are needed more often and in greater detail than previously.

Given all of the above, we have sought to create data with sufficient coverage and granularity such that issues of geography can be addressed as they arise using all of our different measures as required.

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[Measuring Innovation in the SME Economy of Wales](#)

Why we focussed upon SME's in general and not technology start-ups

Our focus is primarily upon the innovation performance of SME's in Wales because these companies by their very nature are central to any project that seeks to improve the performance of the economy.

It is important to stress that our aim was not to measure the start-up or scale-up economy.

We have instead developed this technology with an operational definition of innovation that suits a particular purpose. In future it will be possible, and perhaps even necessary, to extend these measures to the start-up economy, but the main concern in Wales, as with most advanced economies, is to enhance the competitive efficiency of SMEs in general. Trends in terms of the sectors involved, technologies employed and business models of these companies are central to the evolution of the Welsh economy in a way that start-ups, particularly those that attract venture capital, cannot be because they do not represent the wider economy.

This is the case because the cohort of innovative SME's located in Wales has a different distribution both by geography, size and sector than start-ups. Technology start-ups represent slightly less than 1% of the active companies in Wales. Recent research indicates **a population in Wales of start-ups and scale-ups of around 1,300 companies**. The last national Innovation survey suggests that we can expect between 10 and 20 times as many innovative SME's in the wider Welsh business economy.

How do SME's differ from larger companies when it comes to measuring and predicting innovation and growth?

It is widely understood that despite a very large literature on predicting defaults in larger companies it remains very much harder to accurately predict failure of SMEs. In particular, trends, values and ratios in financial predictors are simply ineffective below certain business size thresholds (Ciampi, 2015). Similarly, with SME's the impact of external events (e.g. sudden loss of major client, a key member of staff or a mistaken decision) is much higher in that it may

be sufficient to weaken a previously strong position. For these and other reasons quantitative variables and financial ratios (for example debt to earnings) are very poor at predicting outcomes for SMEs compared to larger companies. These findings have a direct bearing upon the task of identifying and predicting innovation behaviour of SMEs. Local and particular circumstances feature more largely with SMEs, and their behaviours will not necessarily be captured by conventional attempts at measuring innovation potential which are heavily skewed, for good reason, by what is known or can be known about larger companies.

The research literature concerning SME innovation also highlights another difference in measuring innovation capabilities between SMEs and large companies. While the amount of expenditure devoted to R&D activities is a reliable and easy-to-measure variable in the case of large companies, it does not seem to be a robust measure in the case of SMEs (Wolff 2007). In contrast, diligence and the use of appropriate internal management tools (such as ISO quality certifications) suitable for adequately formalising structured innovation development process seem to be more effective antecedents of SMEs innovation performance (Howell et al. 2005). Rosenbusch et al. (2011) also stressed that SMEs innovation performance is significantly associated with the strategic innovation focus of the company that ultimately results in for example, higher brand reputation, more effective collaboration from partners, and attracting highly-competent employees.

A meta-analysis by Rosenbusch et al. (2011) found that the use of variables such as the number of new products or patents is not particularly useful when it comes to measuring innovation performance in SME's properly. Contextual factors such as the category of innovation, the cultural context, the age of the firm, and network ties affect SMEs innovation performance much more than the number of new products or patents. Indeed some very recent work suggests that a focus upon IP registration and its defence may have a negative impact upon outcomes for some innovative companies.

How we define & measure innovation

The definition of innovation we work to views Innovation as the development and implementation of a product or service that either offers a completely new approach to meeting customer requirements, or significantly improves on existing products or services. This significant improvement could take the form of, though need not be limited to, areas such

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as increased efficiencies and effectiveness, reduced costs, improved ease-of-use and new business models.

It is clear from this perspective on innovation that no single measure, however sophisticated, can capture all that is required to predict innovation capability. Consequently, we developed a neural net that was capable of using all of the multiple items of information we could capture from the digital signature of companies and then used this to predict the innovative potential of a company.

It is important to remember that we do not use this measure in isolation, our Innovation Score is not independent of our measure of digital maturity or the measured level of investment by companies in their digital properties (Digital Growth Index). Each of these metrics contribute to creating a rounded picture of what is being done by companies alone or in aggregate, whether or not it is 'working' in some sense and indeed what trends there might be in these measures and in combination with other measures such as GDP and GVA.

Reference

https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation/datasets/ukbusinessactivitysizeandlocation ONS, UK business: activity, size and location (04/20/2021)

Results – Digital Growth

Our Digital Growth Index is useful firstly at a macro level, loosely this represents the volume of changes made by Welsh companies to their digital properties every month between January 2010 and January 2022. This measure is complicated to interpret but essentially the business community is constantly working to maintain their digital properties and this effort unsurprisingly, has steadily increased over time. Individual companies vary in their approach to this task as we will discuss below, but taken in the round, this is a massive and continuous operation. What this gives us is a window into the predominant business sentiment across the economy; positive, normal or negative that is driving changes in this commercial behaviour. Almost exactly as movements in the value of the FTSE 100 reflect the cumulative effect of millions of buy and sell decisions and the impact of real world events, so too do changes in this measure reflect the impact of external events on decision making. These events can be short-term or long term in their impact but over time this metric most closely reflects the strength of the underlying economy.

As can be seen from the graph comparing the the mean Digital Growth Index for our sample of Welsh and English businesses the two countries would appear to track one another very closely over time. This of course reflects the intrinsic level of connection between these two regions of the UK. Two other interesting features of this dataset need to be looked at. The first is the fact that we can see the overall level of activity recovering from the 2008 recession albeit with two secondary recessions. Followed by the huge impact of Brexit upon this metric, first depressing activity and then driving it to new highs in late 2019 early 2020. Clearly demonstrating the extent to which business uncertainty drives decisions such as investment in their digital presence. The second interesting feature is the fact that for the very first time in these data, starting in the summer of 2020 the trajectory of the DG metric for England and Wales, is beginning to diverge.

We can get a better picture of what is happening by looking at the graph of Digital Growth using the delta of the Mean, roughly a measure which reflects the scale of the increase or decrease in activity from month to month. The graph of the mean changes or delta of Digital Growth scores shows more detail of the impact of external events upon confidence and hence continuity of investment in maintaining commercial digital properties. It is this measure which shows greatest detail with regard to the impact of Brexit and now Covid-19.

Using the mean change score shows the short term volatility of the overall level of activity and the scale of the impact of uncertainty around Brexit and now Covid. Interestingly it is possible to see how the different strategies followed in England and Wales is reflected in the data, across lock-down and particularly the impact of the 'opening-up' in England in 2021. What this explains, we suggest, is the way in which for the first time in this series, the two economies are beginning to diverge as the impact of different policies for managing Covid-19 become apparent in their influence on the scale of change in Digital Growth scores. The two early discontinuities in the overall trend in the mean change data in 2011 and 2013 for example, occurred at moments of great uncertainty. The impact of the EU membership Referendum and subsequent events are all too clear. Given that these data are available at high frequency e.g. monthly and can be accessed almost immediately, they are of great value in helping to understanding aspects of major events such as policy changes, that influence business sentiment.

One final health warning with respect to interpreting this metric and country level data; it does not show the relative level of digital growth when comparing English and Welsh companies. Rather it reflects the level of change exhibited by the different mix of companies within in the two countries. Obviously the make-up of the business community in Wales is entirely distinct from that of England.

Fig 1. **Mean Digital Growth scores for England and Wales (2010 – 2022)**
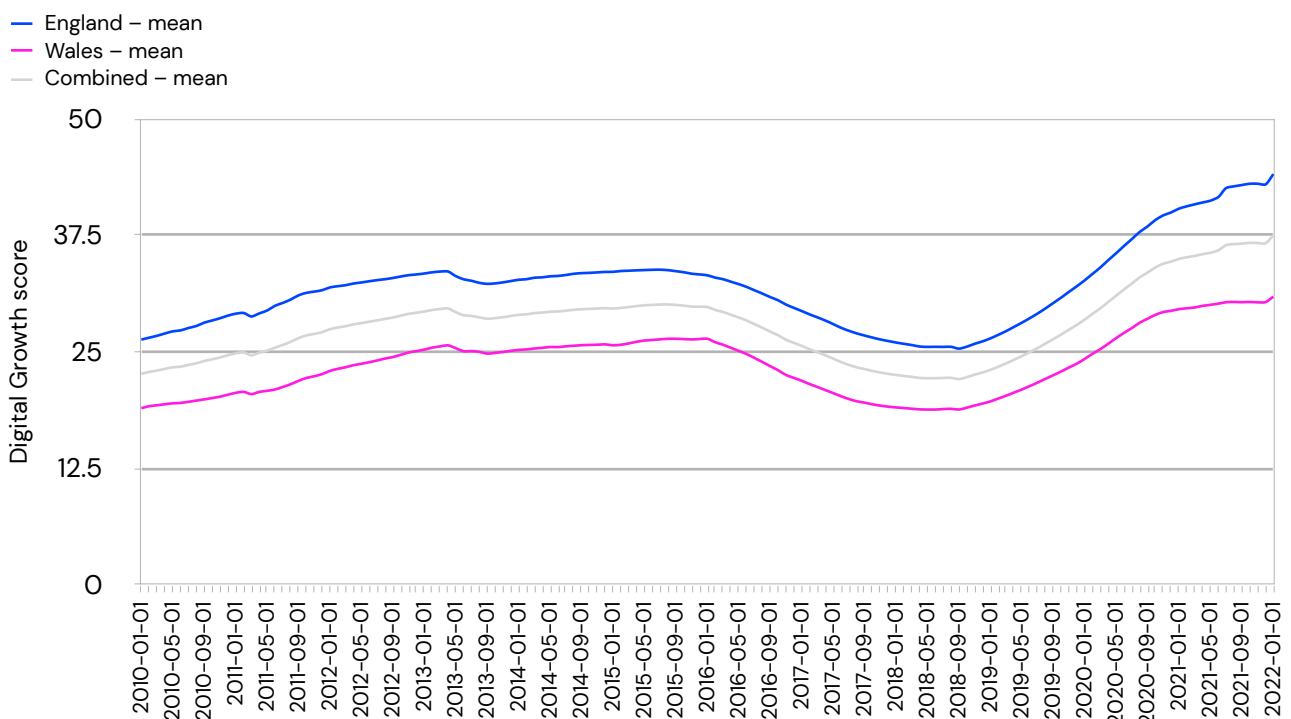
Fig 2. **Changes in mean Digital Growth score in England and Wales (2010 – 2022)**
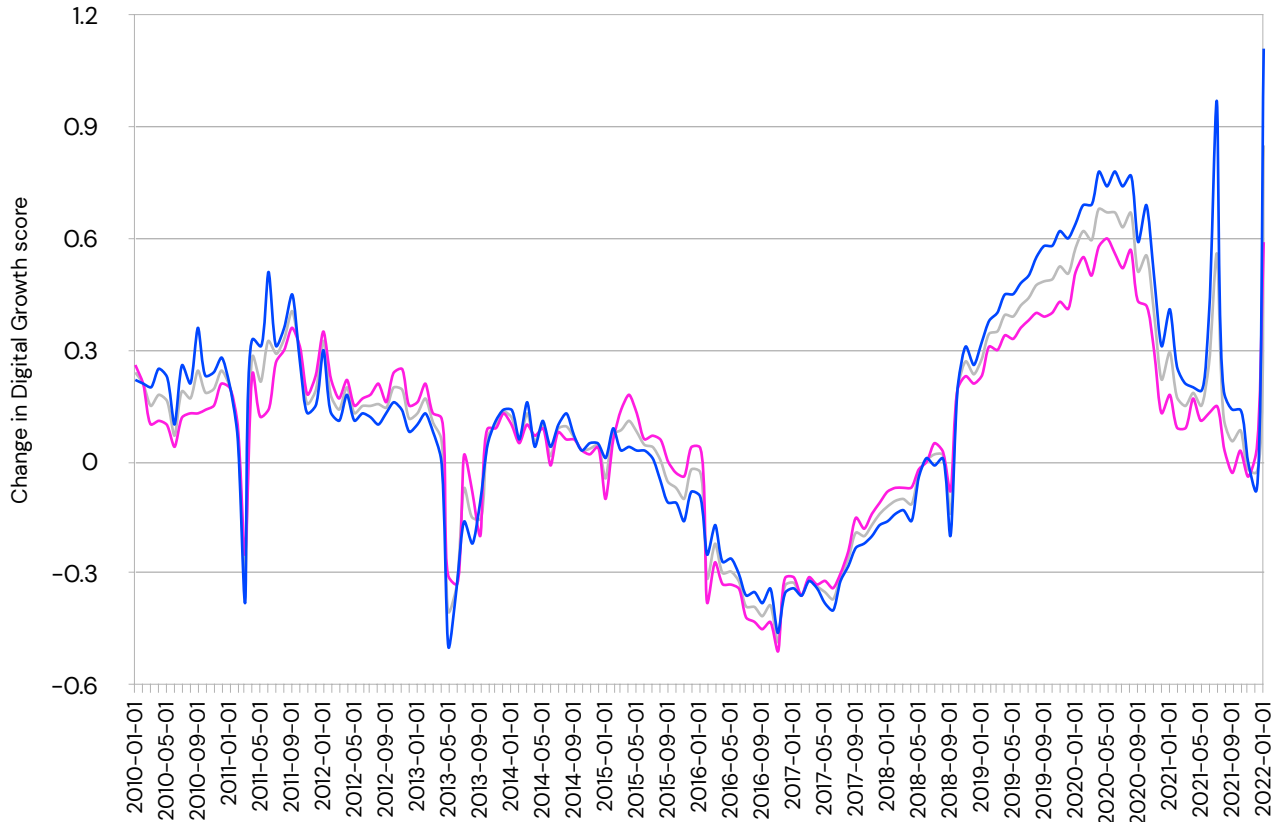
Results – Digital Maturity

The Digital Maturity metric is a comprehensive tool that provides a robust comparison between businesses with respect to the sophistication and scope of their digital presence. This has a number of uses at both macro and particularly micro levels of analysis. Our data show that this is a very stable measure that reveals a steady increase over time at the national level. Interestingly there is little or no difference between our Welsh and English samples either at the national level in terms of the trend over time or digging down, in terms of differences between business sectors.

What we can see are differences between different geographical locations; cities and counties vary somewhat as a result of the make-up of the local economy. A table of English and Welsh locations is provided below to show the very narrow range of Digital Maturity when aggregated in terms of geographical location. Wrexham was included because it is an interesting test case for our approach and its high Digital Maturity score was intriguing. Given the high score we drilled down into data to examine the trend data for Wrexham within our sample.

The aggregated trend in Wrexham is a steady increase over the last 5 years. We looked at those companies which contributed to this trend and discovered a number of companies that have exceptional Digital Maturity scores and reflect a number of features of this measure. The two companies are Ragazzi: ragazziclothing.co.uk. with a score of 67 and Cable services group cableservices.co.uk. with a Digital Maturity score of 66.2. The range and sophistication of the digital tools used in their websites is very impressive. This is as it should be, given that they stand out within both their sectors and the locality. Interestingly these companies reflect two other factors exposed by this metric.

First that the level of Digital Maturity varies significantly between sectors, particularly favouring as here, companies that are public facing. The second feature of these companies is the extent to which our Digital Maturity score reflects their internal organisation and overall level of digitalisation. In order to support the tools and facilities that make a website so digitally mature, they require high levels of internal sophistication with regard to inventory management and logistics for example.

One conclusion that we can draw with respect to this metric is that it is not measuring Innovation, at least not as measured by our Innovation Index. Rather, it is measuring the impact of competition on digitalisation and in particular the difference between the impact of

competition in B2B and B2C businesses. It is evident from these data that Digital Maturity is driven by competition in public facing businesses such as retail, consumer goods, real estate and the public facing sector properties. By contrast and perhaps surprisingly, B2B services businesses such as Architecture and Planning and Design have very much lower levels of Digital Maturity.

Fig 1. Trend in Digital Maturity – Wales & England
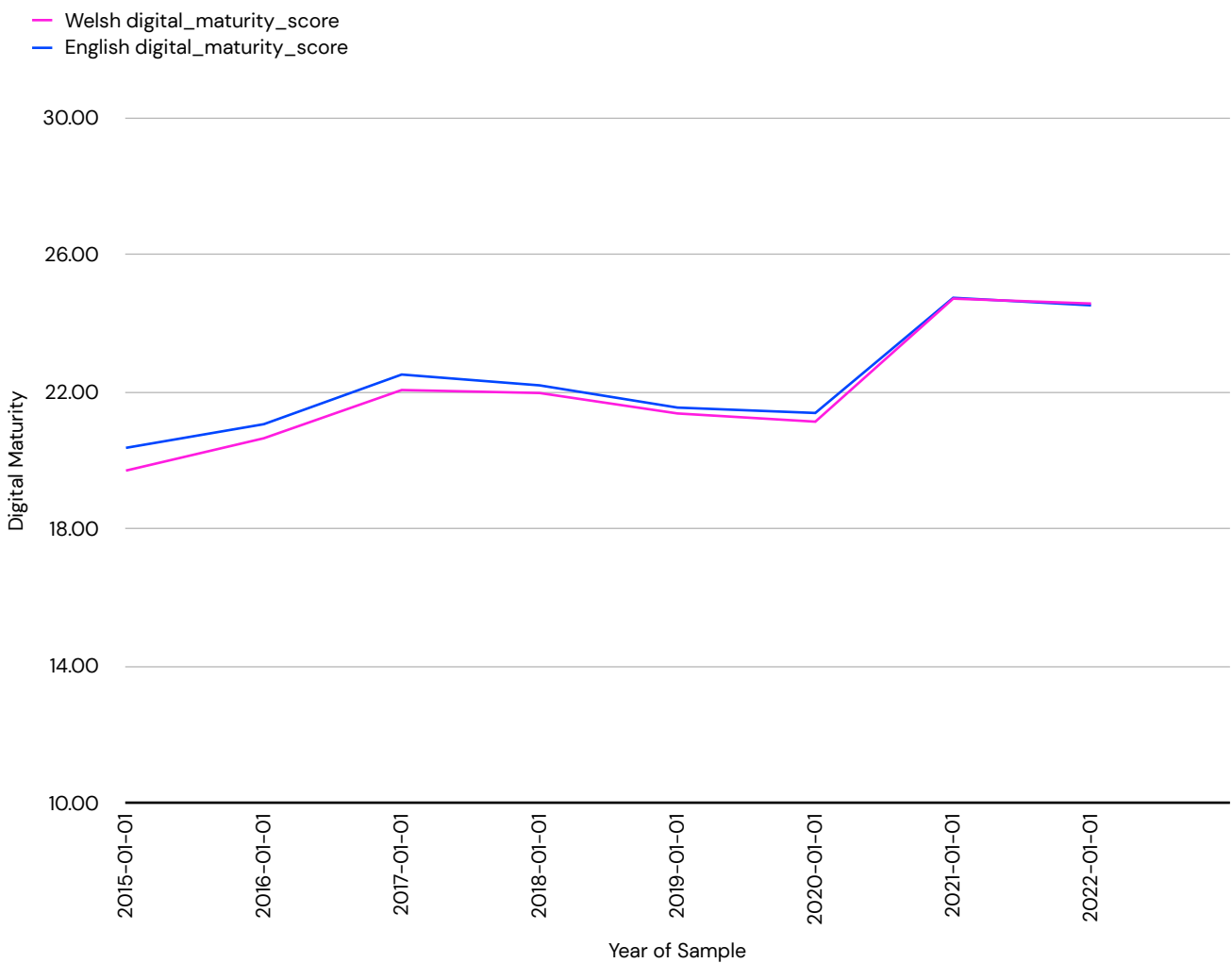
Fig 2. **Table of locations ranked by Digital Maturity**

Digital Maturity with weighted proportion of innovation companies for comparison purposes

NUTS3	avg_dm	Adjusted Proportion of all 'A's found in the region
Birmingham	25.91	1.35
Wrexham	25.76	0.58
Bristol	25.68	5.22
Manchester	25.13	6.45
Cardiff	25.00	2.12
Liverpool	24.93	1.98
Swansea	24.70	0.93
Leeds	24.58	1.06
Tyneside	23.64	1.64
London	23.53	3.89
Bradford	23.33	0.84
Sheffield	23.16	1.68
Newport	23.12	0.81
Milton Keynes	22.87	1.68
Chester	22.82	0.65
Sunderland	21.70	0.58
Wolverhampton	19.05	0.31

The sector level breakdown we offer here can be refined, as can be seen Music, Events services and publishing are not included in the list of large Welsh sectors because they were not as numerous (in our sample) as other sectors. They may however be of be of interest and the data could be acquired to provide a better picture of the impact of the size and dispersion of a sector upon digital maturity.

The power of this metric lies in the ability to support an analysis, in conjunction with our other measures, of how a company is performing in respect to its competitors, locally and nationally. One powerful opportunity now available as result of this tool is a capability to demonstrate to a company, advisor or agency what 'good' looks like in a particular sector. Indeed it would be possible to provide the data as to how any given company compares with nominated competitors wherever they might be located. It is at this micro level that the metric will be most useful. It also shows the benefit of being able to draw upon comparative data from outside Wales in order to inform what is done in Wales.

Fig 3. Largest 40 Sectors by Digital Maturity in Wales and England

WALES industrial_classification_industry	avg_dm
non-profit organization management	37.66
retail	**34.04**
consumer goods	31.42
education management	30.64
real estate	30.37
law practice	30.09
professional training & coaching	29.54
sports	29.28
legal services	29.00
hospital & health care	28.87
automotive	28.16
food & beverages	26.89
accounting	**26.44**
events services	26.25
internet	25.92
environmental services	25.55
hospitality	25.06
staffing and recruiting	24.98
building materials	24.95
entertainment	24.92
renewables & environment	24.82
financial services	24.81
machinery	24.66
printing	23.57
electrical/electronic manufacturing	23.24
transportation/trucking/railroad	23.05
facilities services	22.19
telecommunications	21.78
mechanical or industrial engineering	21.72
oil & energy	21.36
computer software	21.32
media production	21.15
information technology and services	21.12
design	20.64
marketing and advertising	20.57
management consulting	19.06
construction	**18.89**
civil engineering	18.67
architecture & planning	16.44

ENGLAND industrial_classification_industry	avg_dm
non-profit organization management	37.89
retail	**34.61**
education management	30.03
sports	29.98
hospital & health care	29.88
law practice	29.81
food & beverages	29.75
building materials	29.62
publishing	28.60
legal services	28.39
accounting	**27.56**
automotive	27.17
real estate	26.22
professional training & coaching	26.03
business supplies and equipment	26.00
environmental services	25.94
printing	25.57
music	24.96
hospitality	24.95
telecommunications	24.87
electrical/electronic manufacturing	24.83
staffing and recruiting	24.20
internet	23.70
financial services	23.39
insurance	23.15
events services	22.93
transportation/trucking/railroad	22.22
mechanical or industrial engineering	22.14
entertainment	21.92
computer software	21.54
marketing and advertising	21.28
information technology and services	21.24
facilities services	21.23
security and investigations	20.06
design	19.83
construction	**19.21**
media production	18.93
management consulting	18.48
architecture & planning	16.67

Results – Innovation Companies In Wales

The innovation metric we have developed is based upon a neural net that allocates target companies into one of five classifications A to E, with category A companies looking the most like innovative companies and E the least like an innovative company. In order to avoid confusion we do not describe companies in terms of their being innovative or otherwise, but instead describe them as innovation companies or not innovation companies. Because what we are measuring is the extent to which they look like companies we do know to be innovative. For the purposes of this discussion we have collapsed these categories further into two classes; treating category A and B as innovation companies whilst collapsing the D and E category companies together as they look most unlike an innovative company and we call these not innovation companies. Finally, we have discarding the C category companies from the discussion.

For the purpose of understanding the distribution of innovation companies the table below shows the number of companies, from our sample, with innovation and not innovation classifications in each of the 22 boroughs in Wales.

[See Overleaf for Table]

Fig. 1 Location of Innovation Companies

location_region	Percentage of all Welsh A and B's found in this region
Cardiff	22.77
Swansea	8.18
Monmouthshire	6.54
Rhondda cynon taf	5.05
Carmarthenshire	4.92
Vale of Glamorgan	4.88
Pembrokeshire	4.62
Powys	4.42
Flintshire	4.36
Wrexham	3.94
Newport	3.67
Denbighshire	3.54
Neath Port Talbot	3.47
Bridgend	3.45
Conwy	3.33
Caerphilly	3.10
Gwynedd	2.96
Ceredigion	2.20
Anglesey	2.03
Torfaen	1.31
Blaenau Gwent	0.67
Merthyr Tydfil	0.56

The proportion of companies identified in our data that look like an innovation company roughly aligns with the UK Innovation survey data, where 36% of UK businesses were recognised as 'Innovation active'. The more restricted definition used here, suggests 25% of the total number of companies in our survey data look innovative.

As was expected, the highest number of such companies are located in the Cardiff region, having more than twice as many Innovation companies as the next best performing location.

Importantly though, when we look at each borough in terms of the proportion of innovation companies in the cohort of companies at that location, Cardiff does not come out on top. Rather, Denbighshire, Gwynned, and Conwy all have a larger proportion of local businesses that are classified as being an innovation company than does Cardiff. Torfaen appears to be on a par with Cardiff. Blaenau Gwent has an above average proportion of innovation companies albeit from a much lower base.

In terms of the location of companies that do not look like an innovation company there are a number of points to be made. First, the overall picture shows less variability in terms of the proportion of not innovation companies than is the case for innovation companies. Suggesting that the underlying reasons for the distribution of innovation companies is somewhat different and needs more analysis. Second, Wrexham and Vale of Glamorgan both have a high proportion of not innovation companies compared with the average for Wales, they stand out, not least because they also has a lower than average level of innovation companies. By way of illustration in Chester and Cheshire West 30% of companies are innovation companies and the comparable figure for nearby Wrexham is 18.63%. Overall this suggests that Wrexham and Vale of Glamorgan perhaps should be looked at more closely.

Third, Conwy in particular also has the lowest proportion of companies that we designate low or no innovation companies in Wales which in combination with its high proportion of innovation companies is notable.

Finally, because its size and the fact that it is the second most important contributor to the total number of innovation companies in Wales, the high proportion of not innovation companies in Swansea is notable.

Of course, it may well be that if we break down these results further within the boroughs for example, interpreting this pattern of findings would be easier. One notable result that underlines the difference between innovation and growth is the finding that Flintshire and Wrexham have enjoyed above average growth in their GVA for some time and have one of the highest GVA per capita in Wales (ONS, 2020). In terms of Innovation companies and non-innovation companies nether stand out, in fact Flintshire has an average score in both.

Looking at the comparative data for Wales and England in the graph below, we can see that in line with expectations and prior research, the proportion of Innovation companies increases with company size. The two distributions do differ, but it must be pointed out that the small number of companies at the largest size bands in our sample of Welsh businesses means we should not make too much of these data points. That said, it is reasonable to infer that the relationship between company size and the proportion of innovation companies is not the same in the two countries. Nor should we expect it to be so given the different make-up of the two cohorts of companies in Wales and England.

Turning to the table comparing Wales and England and the proportion of innovation businesses in each, here we have chosen a range of different NUTS3 locations in order to put our Welsh sample in context. Cardiff although ranked lower than Bristol or Manchester bears comparison with many of the other large cities in England. Of course we could provide any comparison required at the NUTS3 output level. It is interesting that Bristol at this level of resolution appears to stand out in England, with its high proportion of innovation companies.

Key Findings

If we extrapolate from our sample to predict the overall number of innovation companies in Wales then we can expect between 5,000 and 10,000 micro businesses that will be classed as either A or B. Turning to SME's with between 10 and 500 employees, we would predict a population of between 3,000 and 6,000 with an A or B classification. (We have used a range up to 500 employees, rather than 250 because of variations in publicly reported definitions of medium sized enterprises). The point of this calculation is that we can offer to find these companies. To provide a detailed picture of each, as provided by our metrics along with their location. This data can be provided for Boroughs, Government business support purposes as well as policy making. Of course this also applies to the companies we have described as not innovation companies.

[See Overleaf for Tables]

Fig 2. Concentration of Innovation Companies

location_region	Percentage of this region that is graded A or B
Conwy	33.46
Gwynedd	30.99
Denbighshire	29.41
Blaenau Gwent	29.09
Torfaen	28.97
Cardiff	28.35
Merthyr Tydfil	28.26
Newport	27.33
Ceredigion	27.22
Bridgend	26.95
Powys	26.32
Monmouthshire	26.03
Pembrokeshire	25.73
Caerphilly	25.69
Flintshire	25.28
Carmarthenshire	24.63
Rhondda Cynon Taf	24.03
Swansea	22.31
Neath Port Talbot	20.49
Vale of Glamorgan	19.10
Wrexham	18.63
Anglesey	18.07
Average	**25.74**

Fig 3. Concentration of 'Not' Innovation

| location_region	Percentage of this region that is graded D or E
Vale of Glamorgan	72.11
Anglesey	71.08
Swansea	70.51
Wrexham	70.50
Neath Port Talbot	70.32
Rhondda Cynon Taf	67.48
Carmarthenshire	67.16
Monmouthshire	65.73
Powys	65.65
Newport	65.33
Caerphilly	65.22
Pembrokeshire	64.99
Ceredigion	64.44
Flintshire	64.04
Bridgend	63.83
Gwynedd	62.81
Denbighshire	62.63
Blaenau Gwent	61.82
Torfaen	61.68
Cardiff	61.54
Conwy	59.93
Merthyr Tydfil	56.52
Average	**65.24**

Fig 4. Table of Locations Ranked by Proportion of Innovation Companies

These data were created from two different samples. The English and Welsh derived population modifiers reflect this.

NUTS3	Population	Population Modifier	Adjusted Proportion of all 'A's found in the region
Manchester	555741	1.16	6.45
Bristol	465866	0.97	5.22
London	9002488	18.76	3.89
Cardiff	369202	11.6	2.12
Liverpool	500474	1.04	1.98
Milton Keynes	270203	0.56	1.68
Sheffield	589214	1.23	1.68
Tyneside	868778	1.81	1.64
Birmingham	1140525	2.38	1.35
Leeds	798786	1.66	1.06
Swansea	246563	7.8	0.93
Bradford	542128	1.13	0.84
Newport	156447	4.94	0.81
Chester	473582	0.99	0.65
Sunderland	277846	0.58	0.58
Wrexham	136055	4.3	0.58
Wolverhampton	264407	0.55	0.31

Fig 5. Proportion of innovation by size of company – measuring Digital Maturity
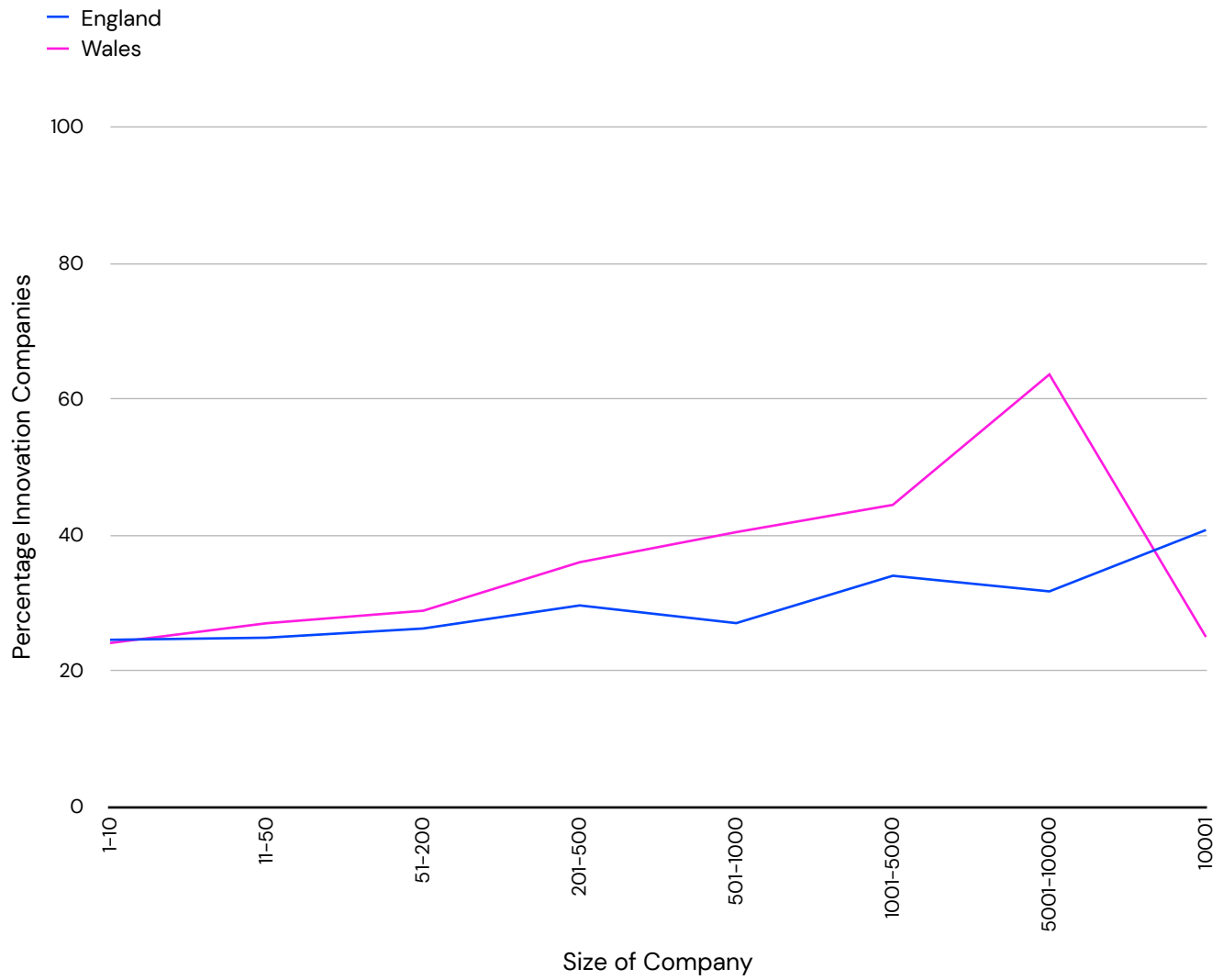
The updated digital strategy for Wales (2021) underlines the economic significance of digitalisation and as we already know, most countries and relevant international bodies are aware of the importance of the 4th industrial revolution and in particular its impact upon SMEs and developing tools to measure it.

There exists a large body of academic research showing the overall quality of a business website is predictive of the underlying economic performance of the business itself. In much the same way that we have direct evidence of a relationship between web materials and innovation within a company. Studies of businesses as diverse as hotel chains and universities have confirmed this basic finding.

What we offer with this metric is an alternative tool, complementing existing data sources, when assessing the level and direction of travel exhibited by companies with respect to the progress of digitalisation. As we are aware, survey data touching on this is already available; the Digital Maturity Survey for Wales (Cardiff, 2020) assesses much the same topic. Indeed amongst the items in our Index are behaviours measured to directly address questions similar to those posed in that survey.

Our digital maturity index builds on prior research by systematically measuring a comprehensive set of attributes common to business websites, providing the ability to quantify and profile the level of maturity exhibited at a given point in time including from years in the past. The features intrinsic to the Digital Maturity Index range from scoring the accessibility of the site, measuring the complexity of language present, number of social media accounts, to quantifying the use of specific technologies deployed in the website. In order to exploit these data we first aggregate them and provide suitable comparative data allowing us to place a particular company in context; **comparing a company's level of digital maturity with its competitors, across an entire sector or within the wider economy**.

The key feature of this approach is that we can ask more questions, **with much more detail than can ever be included in a survey.** Similarly, it is easy to quantify responses and have that data reflect the real world behaviour of the company. Asking of a respondent, 'How often did your company invest in digital?' becomes how many times did we register a change in content on web properties owned by the company, how large a change took place and did this achieve a higher level of digital maturity than was the case before? Perhaps just as important a benefit is the sample of companies we can access using this technology. For the purposes of this demonstration, we built a sample of Welsh companies 10 times larger than that achieved in the

last Welsh Digital Maturity Survey. We also include data from 40,000 English companies to provide context. The intrinsic scaleability of our solution and its inherent replicability is a key advantage of the approach as a source of complementary data

Given the importance of the digital domain for the development and maintenance of a companies brand, the acquisition of customers and the delivery of services in the modern economy it is not surprising that this metric has predictive utility with respect to performance. Significantly, it is perhaps most relevant as an indirect measure of the overall level of digital sophistication of a business. Based upon the assumption that the publicly visible digital presence a company will reflect its internal stage of adoption and strategy with respect to digitalisation. It follows therefore that this metric will sit alongside our other measures to provide a comprehensive picture that could not be created from existing data sets alone.

<u>Overview of the Methodology and Metrics</u>

Methodology

In order to conduct this piece of research we first constructed a sample of English and Welsh currently trading registered companies to meet the following criteria:

- Large enough numbers to afford a meaningful regional analysis within Wales.

- A sample weighted by the known population of companies in each relevant jurisdiction, for this purpose we used the ONS population of companies survey data.

- A sufficiently large sample in comparison to existing surveys. For this purpose we matched the overall sample size of the last UK innovation survey (UKIS) published by ONS in 2019.

In total we identified 40,000 companies from the English regions and 8,000 from Wales, which means that Welsh companies were, by design over-sampled in order to support a more detailed break-down of these data.

Having built our sample we then identified the websites associated with these companies and visited these sites to retrieve the data. Similarly, we retrieved where possible, archived images of these web sites as they existed in each of the last four years. Once this body of data had been acquired and checked we applied our toolset to create the metrics described below. The metrics were then aggregated in order to produce analytical outputs at national, regional and sectoral levels.

Data volumes associated with this process

- We analysed historical data for 49k websites going back to 2015 - total of 350k snapshots

- These contained 15m documents/pages which equated 1.5TB of data.

- We used around 60 CPU cores and 120GB RAM to analyse the data – equivalent to 10–15 powerful workstations running at full capacity 24/7

- Our systems viewed and analysed about 100 webpages per second (~10 websites per second)

- If a human analyst could look at 250 websites per day, it would take them 1400 days (~3.8 years) to look at the same amount of data we have retrieved.

Measuring Digital Growth

Given that we can measure the degree to which a company looks like it can and perhaps will engage in innovation and we can also provide a comparative measure of Digital Maturity, the next task is to see wether or not these are shrinking, stable or growing business.

We have developed a further measure; the Digital Growth Index that seeks to inform answers to these key questions. As discussed above, there are a lot of reasons why financial data is usually insufficient, even if it is available, to answer such questions when considering SMEs.

The route we have followed is to repurpose the data we collect concerning Digital Maturity in order to create an index of the rate of change of digital content associated with a company, sector or economy. At the macro level this gives us a tool to measure the global level of digital investment activity in that we can measure the volume of changes over many thousands of companies every quarter, or more frequently if required. As we have seen from a number of projects, this measure is particularly sensitive to major events such as Brexit and Lockdown, events can create both a down-turn in activity (the aftermath of the Brexit vote for example), or a growth in activity (Lockdown and opening up in 2021). Because these data are available in advance of and are complementary to more usual data sources, they can help with planning and understanding what is happening during major events and more enduring changes.

At the micro level of analysis this metric can be used to help profile companies, especially alongside the other metrics and understand there future prospects. To put matters simply, a company that intermittently or regularly updates its materials at a low rate (in relation to its competitors or the industry as whole) will be deemed to have a lower index of growth than a company that updates (regularly or intermittently) more frequently than comparison businesses.

More specifically, a company that moves upwards from one level of digital growth to a higher level is probably signalling the start of significant growth. At this micro level, we have seen in our consultancy practice how this metric can find those companies that have changed the level of investment they are making in the business. So much so that we have been able detect for some companies the point that they have attracted new investment and started to put it to use – using the Digital Growth measure alone.

Measuring Environmental and Sustainability Engagement

The incorporation of environmental, social and governance (ESG) factors into investment decisions has grown massively in recent years, particularly since the UN–backed Principles for Responsible Investment (PRI) introduced the term "ESG integration" in 2006. Asset managers in particular now strive to better understand how companies and organisations address ESG issues.

This has led to an ever–growing proliferation of ESG assessment instruments including 'alternative' data sources seeking to capitalise upon the many thousands of documents usually from larger companies, that are available from the web. Network Praxis has made it a priority to create and incorporate a robust measure of the prevalence of ESG concerns within the population of companies we seek to understand. In order to do so we have refined the approach taken with innovation measurement, combining Big Data and AI techniques to create a measure that confers the ability to create some indication of the prevalence and scope of ESG concerns both within and between companies. Our focus is placed upon the text contained within the publicly available materials, the output of any one company being 'scored' with reference to a target derived from the data of a reference group.

These data are not an attempt to create an absolute measure of the level of ESG observance by any one company. Our goal is to be able to quantify the prevalence of these issues within and between sectors and/or geographies over time.

Given the expressed policy goals of Welsh Government, some measure of the breadth and depth of representation that ESG issues have across the economy would seem appropriate. Just as important is the ability to locate this metric alongside data for Innovation and Digital Maturity in support of analysis and policy making.

References

Welsh Economy Research Unit, (2020) Digital Maturity Survey for Wales 2020
Welsh Economic Contract, https://businesswales.gov.wales/economic-contract

Our Metrics

Digital Growth Index

This metric is designed to allow us to create a usable measure of the rate and volume of website maintenance activity over time. Digital Growth Index, is a measure of digital business activity which gives a predicted direction of travel (growth) for businesses. We create seasonally adjusted trend lines from a catalogue of changes to company websites over time.

Digital Maturity Index

This metric is designed to allow us to create a measure of the overall level of sophistication and to track its development over time. Digital Maturity Index, a measure of the digital sophistication of a company websites:

- The technologies in use on company websites are analysed and scored
- Score range from 0 – 50
- Calculated using the mean of a target group of companies

Innovation Capacity Index

This metric is designed to allow us to provide an indication of the active innovation potential of a company. Innovation Capacity Index, a measure of the innovation level exhibited by the contents of company websites:

- A neural network is used to predict whether or not a company is innovative
- Grade range from E – A
- Grades A and B are pooled together as HIGH innovation capacity
- Grades D and E are pooled together as LOW innovation capacity
- Final counts are normalised

ESG Posture Index

This metric is a sophisticated abstraction of the reported ESG Posture Index, a measure of interest in and engagement with Environmental and sustainability issues exhibited by the contents of company websites.

- Company website text is parsed using a neural network
- The result is checked against known ESG topics
- Scores are 0 centred between –1 and 1
- Calculated relative to a target group of companies

Ethical Considerations

The following principles are applied when reading and structuring text from the public open web or accessing public open data sets. They form our web scraping policy on how we read open web data.

- We only access the open web and public information maintained in the public domain by responsible bodies e.g. Companies House

- We seek to use recognised and supported API's where available

- We seek to minimise any burden on company website owners by limiting the depth to which we read their properties

- Honour any potential requests made by website owners to refrain from reading their public website

- Protect all personal data of potential users and will refrain from publishing any open web data which may identify individuals;

- Abide by all applicable legislation and monitor the evolving legal situation (especially with regards to GDPR)

- We maintain our registration with the ICO as a data processor

- We maintain our professional liability insurance for these activities

- We do not provide our customers with personal identifying data e.g. Managing Directors' names and contact numbers.

New Tools & Opportunities for the Welsh Government

The ability to monitor the prevalence of innovative and high growth potential SME's within and between different sectors and geographies over time both regularly and at scale is obviously useful as we hope to have shown. The greater value of this new data resource, lies in the ability to support change; principally change in the way businesses are engaged in order to enhance their competitiveness either by their own efforts or in combination with an extensive repertoire of publicly funded interventions.

Research

This project is designed only to illustrate the capabilities of the technology, as such a number of opportunities for research into the dynamics of the innovation economy in Wales have now opened up. Especially, we would argue with respect to novel lines of enquiry which fold these data into existing sources available to the government. However a number of other concrete examples for exploitation of this facility are set out below.

Horizon Scanning

We can search through the digital properties within target sectors, locations or both to perform a part of the horizon scanning function. Using our toolset we can show what technologies, products and services are emerging, growing or declining in numbers, interest and exposure. Such a method is perhaps not as accurate as industrial surveys but the process can be conducted in near real time and as often as questions need to be asked. A key asset is the facility to locate particular businesses with a innovation/growth profile. This last feature feeds into a benchmarking capability.

Benchmarking

The essence of a modern and digital innovation policy will probably involve benchmarking in some form or another. Foresight SI can be used to acquire signals associated with innovation for example, for discrete areas such as Greater Manchester or Scotland or in specific sectors. The point is that monitoring and reacting to the rate of change elsewhere in the economy of

which Wales is a part, will necessarily influence both the what and how of interventions as they evolve. We can also offer the facility to create trend data retrospectively.

Programme Evaluation

We used Foresight SI to profile two cohorts of companies that entered the Astute and Made Smarter business support programmes in England and Wales and a control group. Using a small number of measures from Foresight SI the system revealed a number of facts quickly:

- The companies recruited to the two programmes were frequently dissimilar in respect to age, size and sectors represented.

- The two groups exhibited a growth in the relevant measures of innovation and digital maturity

- The Welsh group tended to be higher scoring but experienced greater attrition due to business failure.

- The impact of the Astute intervention on the digital maturity of the cohort was especially notable.

- The research to create a control group for comparison purposes showed how rare the profile of companies in the Astute group is in Wales. It took a systematic examination fo more than 20,000 companies to find 300 companies with a similar profile for innovation and digital maturity.

The research revealed a significant number of companies that have transferred ownership and/ or moved overseas since the Astute programme began. This effect was notable in the wider sample of Welsh companies reviewed for this project. Company website domains have been transferred to Hungary, Norway, Poland and etc. during the period in question.

The system can be used to find, profile and monitor individual companies or groups of companies with respect to their interest in and capacity for innovation as well as location and continuing operations. Perhaps most important is the ability to create dataset from the time

before the intervention. This helps with identifying impact and relating outcomes to prior conditions.

Business Support

Because we can identify which companies are and are not likely to exhibit innovative behaviours and a higher than average growth trajectory, we can increase the accessibility of interventions designed to improve business performance. Firstly we can, and indeed already have increased efficiency in locating suitable targets for help and support. Our customer in North Wales, BIC Innovation, used our data to help meet its demanding targets for contacting and acquiring companies in order to deliver its business support services. Both the rate at which they gained an initial response to their offer and ultimately a business engagement were considerably enhanced by using our data.

10KSB UK is a partnership between Goldman Sachs, the Goldman Sachs Foundation, leading UK universities and with government support, it was launched as 10KSB UK in early 2011. Since then, over 1,900 entrepreneurs from across the country have graduated from the programme. This programme of training and support for entrepreneurs is designed to target high growth businesses from amongst the 1.4 million SME's in the UK. Attracting the attention of likely applicants is perhaps the single most difficult task they face in operating this programme. Our technology can obviously be of help to those operating such programmes. But the more important point is finding solutions to the problem of creating an offering or offerings that can match the scale of the task. Less than two thousand businesses, from a pool of 1.4 million, have engaged with a programme which is both highly successful and very largely subsidised by government – in a decade.

The problem of improving coverage and with that the opportunity to have impact that matches the scale of the problem can only be achieved with digital offerings. Here our new technology can be of use in multiple ways. The chief amongst which is the ability to create and deliver value to businesses by providing access to valuable information and knowledge which they would not, indeed could not otherwise have access. This confers the opportunity to create an engagement 'funnel' directing users to other products and services that might further enhance their ability to compete and grow. Here we discuss three concrete examples of the kind of service we have in mind and which are directly derived from the ability to find individual companies and profile them with respect to their (digital) behaviour. Our goal is to

illustrate that it is possible to provide modern tools that can add value to the process of driving innovation.

Client Discovery

As already discussed above, our tool can and is already being used to locate and provide valuable background information not elsewhere available concerning target companies. Greatly reducing the workload associated with traditional methods and vastly improving the quality of contacts.

Fig 1. Using Foresight SI for Client Discovery
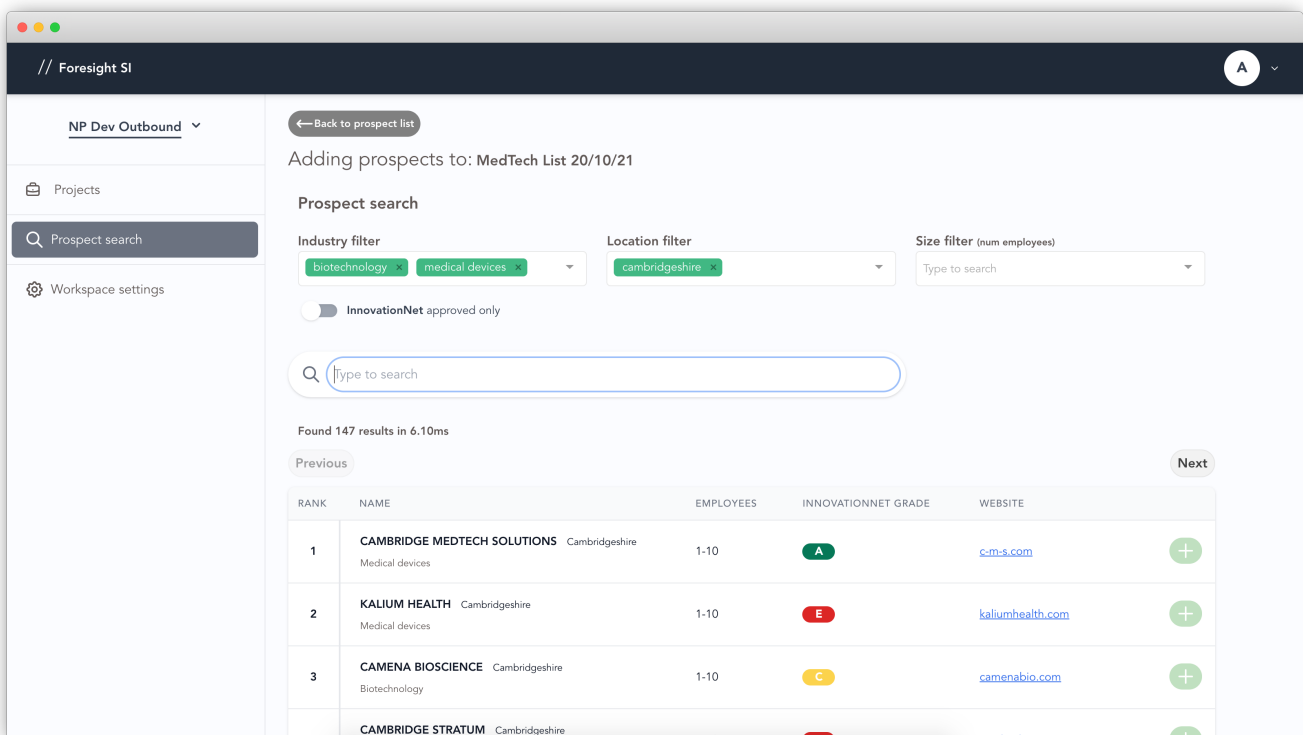
Funding Finder

We have developed using the Foresight SI toolset a database of Venture Capital companies along with a comprehensive search facility. Users can locate funding actors by their interests, such as particular technologies or markets, stage of funding offered, location and more. This could be provided to businesses in Wales as an on-line self-service tool, the branding and ownership of which would represent a highly visible and useful contribution to innovation.

Company Comparison Tool

We have begun work on the prototype of a digital tool based upon Foresight SI that allows a company to create a series of scorecards for itself; measuring the quality and growth of its digital presence and comparing their own results with up to five competitors that they might nominate. Most important is the ability to automatically provide concrete, in-depth guidance as to what a business might do to improve their position. Again this could be delivered as a remote self-service tool, but one which could be enhanced by and indeed lead to - business support agencies.

These are only some examples of the possibilities opened up by the availability of the Foresight SI platform, we offer these because the tools already exist or have been demonstrated in proof-of-concept.

Cooperation opportunities

Foresight SI can identify organisations who would benefit from cooperation or collaboration due to their profile according to several metrics. For example, joint bids for grants or tenders that would be stronger with both parties than it would be as individual organisations.

Fig 1. Foresight SI 'Comparative Opportunity' Results Visualisation

Rank	Digital Maturity	Rank	Innovation
01	https://www.c2cbusiness.org.uk	01	https://www.c2cbusiness.org.uk
02	https://www.bcgrowthhub.com	02	My Company
03	My Company	03	https://bbf.uk.com
04	https://www.d3n2growthhub.co.uk	04	cheshireandwarrington.com
05	cheshireandwarrington.com	05	https://www.d3n2growthhub.co.uk
06	https://bbf.uk.com	06	https://bbf.uk.com

The case of High Growth, Small and Medium Sized Enterprises

Being able to predict whether a business has the potential to show high growth – or alternatively low performance – can be used to target where and how much investment to offer, what support structures and policies to develop and deliver, and much more. As a result of the very large investment over recent years in research into this problem by academia, public bodies and the private sector much is known about the characteristics of SME's that might generate high growth. As yet however, so far as we are aware no tools exist that are capable of identifying at the level of the individual company, SMEs that are or likely to be high growth candidates.

The huge impact that high growth (SME) companies have on employment growth is evidenced by a study covering the period 2002 to 2008, that found that high growth companies represented around 6% of the total number of firms in the UK economy and created 54% of all net new jobs in the UK. Most of these high growth companies are small businesses consisting of fewer than 50 employees and are over five years old. Subsequent research has replicated these findings, demonstrating that these companies are important both in periods of economic recession and growth (ONS, 2019).

The most commonly used definition of such companies is that of the Organisation for Economic Cooperation and Development (OECD)-Eurostat (2007); which identifies high growth firms as 'enterprises with average annualised growth in employees or turnover greater than 20 percent per annum, over a three-year period, and with more than 10 employees in the beginning of the observation period'.

The main and most important source of information for research is the Interdepartmental Business Register (IDBR) which is a list of UK businesses with two main sources of input: Value Added Tax (VAT) system from HM Revenue and Customs (HMRC) (Customs) and Pay As You Earn (PAYE) from HMRC (Revenue). Research carried out in the public sector or in public private partnership has not yet involved predicting which particular organisations are likely to achieve high growth. ONS for example is legally obliged to not identify individuals or individual companies in their outputs. A recent blog post from the ONS Data Science Campus looking at the characteristics of high growth companies put the position like this; **'The scope for the Campus does not include predicting which organisations are likely to achieve high growth. ONS is legally obliged not to identify individuals or individual companies in our outputs, so this work looks only at group characteristics.'**

Consequently this has led to research focussed upon understanding the group characteristics of high growth SME's; such as geographical clustering, the impact of different business sectors, management quality and similar characteristics.

Our product is distinctive in that we are able to identify relevant companies at the individual level and then aggregate these data to explore the impact of geography, sector and other factors. For the first time the requirement to understand the behaviour of high growth SMEs and subsequently design interventions and assess and monitor change can be driven by a comprehensive source of granular data – data that is accessible.

It is understood that regions differ in terms the number and growth rate of such companies, but the underlying need is to be able to identify clusters of like businesses – within and between regions. Similarly, growth rates vary by sector, but we also need to understand which sectors are themselves growing or declining because this trend greatly impacts the success of individual companies. In short we need to be able to make both longitudinal and cross-section comparisons at both the individual and aggregate level something that Network Praxis is uniquely capable of providing.

References

https://datasciencecampus.ons.gov.uk/projects/understanding-the-characteristics-of-high-growth-companies-using-non-traditional-data-sources/

www.oecd.org/sdd/business-stats/eurostat-oecdmanualonbusinessdemographystatistics.htm