

# Industry 4.0 readiness in west of Ireland small and medium and micro enterprises – an exploratory study

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## ABSTRACT

This study looks to understand the uptake of Industry 4.0 and digital technologies by Small and Medium Enterprises and Micro Enterprises in the West of Ireland with a focus on the challenges of Industry 4.0 as well as current integration levels of Industry 4.0. This study finds that there is a high level of awareness of Industry 4.0 and digitalization and its benefits within West of Ireland SME's and Micro enterprises. However, a sizeable majority are not implementing any Industry 4.0 projects currently, nor is it a part of their strategy. 53% of participant organizations had implemented Lean, with 97% of those only implementing within the last 2 years. The challenges to Industry 4.0 were high costs, lack of state support and fear of choosing the wrong equipment/solution. This is the first empirical study on Industry 4.0 readiness within the West of Ireland Small, Medium and Micro Enterprise space which investigates the understanding of and the readiness for Industry 4.0 as well as the motivation and support required by these enterprises for Industry 4.0. Organizations, including government bodies, can use this study to understand the readiness for digitalization and Industry 4.0 in smaller enterprises as opposed to larger enterprises.

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## KEYWORDS

digitalization; Industry 4.0; Ireland; small and medium enterprises; SME's micro enterprises

## 1 Introduction

There are just under 250,000 Small & Medium Enterprises (SMEs) active in Ireland, with almost 970,000 employees (Irish SME Association 2022). Over a quarter of a million micro-businesses employ almost 400,000 people (Central Statistics Office 2018a). The West of Ireland's regional enterprises, in particular, have 20% of Irish gross industrial output for Irish owned enterprises, with just under 14000 employees employed in the SME sectors (Central Statistics Office 2018b)

Industry 4.0, or the fourth Industrial Revolution, is changing how companies manufacture, improve and distribute their products (Antony, McDermott, et al. 2021). Manufacturers are integrating new technologies, including the Internet of Things (IoT), cloud computing and analytics, Artificial intelligence (AI) and machine learning, into their production facilities and throughout their operations (Sony et al. 2021). Digitalization has the potential to improve resource efficiency, help address supply constraints, and make production processes safer. Other terms which have been used interchangeably with

Industry 4.0 are “smart manufacturing” and “digital manufacturing” (Aithal and Sony 2020).

Ireland's Department of Business, Enterprise and Innovation (DBEI) recently put forward a strategy and vision for Industry 4.0 for 2020–2025. In this report, the DBEI put forward its vision underpinning that by 2025, Ireland will be a competitive, innovation-driven manufacturing hub at the frontier of the fourth industrial revolution and at the forefront of Industry 4.0 development and adoption (Naughton 2019). The European Union (EU) have also established a ‘Digitalization of European Industry’ (DEI) initiative (EUR-Lex 2021). The aim is to reinforce the EU's competitiveness in digital technologies and ensure that industry can fully benefit from digital innovations.

Many reports have highlighted a slower rate of Industry 4.0 digitalization for SMEs across both developed and developing regions (Horváth and Szabó 2019). However, Industry 4.0 and digitalization present challenges to all enterprises. Upskilling, training, attraction and retention of qualified staff, and an understanding of digitalization, are key concerns

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(Sony 2020; Sony et al. 2021). To this end, the Irish government and Enterprise Ireland has put forward many strategies and supports to aid Irish enterprises in their digitalization journey (Enterprise Ireland, 2022). The success of previous Irish government strategies to promote enterprise competitiveness and success via Lean deployment has been deemed a success (Keegan 2014; O'Reilly, Freeman, and Dooley 2021; Trubetskaya, Manto, and McDermott 2022).

There is yet to be an empirical study that captures Irish SME's and Micro enterprises' perceptions of the motivation & barriers to implementing Industry 4.0. Such a study is crucial because it will seek to fill the knowledge base on Industry 4.0 and set the future direction for this particular location. Therefore, the West of Ireland region was chosen as a representative region within Ireland. Therefore, the authors ask the following research questions related to Irish West of Ireland SME's and Micro Enterprises.

1. What are the levels of awareness, understanding and integration into the strategy of Industry 4.0?
2. What are the top motivators, critical success factors, and challenges for implementing Industry 4.0?
3. What is the level of Lean implementation in these enterprises?
4. What supports are required for Irish SME's and Micro Enterprises to deploy Industry 4.0?

This study is basically grounded in the theory of socio-technical systems (Ceconi 2016; Cooper and Foster 1971). This theory suggests that organizational development is possible through interaction between social and technical systems in an organization. A neglect of one aspect leads to organizations not meeting the intended performance. Socio-technical systems theory in organizational development have been used in complex organizational work design (Walker et al. 2008), and few authors have suggested this approach in Industry 4.0 (Davies, Coole, and Smith 2017; Sony and Naik 2020). Our fundamental line of thought is that for Industry 4.0 to be a success we need to consider both these aspects; hence our study contributes to the literature of Socio-technical systems theory by explaining its importance in Small and Medium & Micro Enterprises. The rest of the article is organized as follows: Section 2 outlines the literature review; Section 3 outlines the methodology. Sections 4 and 5 elucidate the results and discussion. Finally, Section 6 is the conclusion.

## 2 Literature review

In this section, the literature was reviewed predominantly using two broad themes. First literature on based

on the nature of SME & MEs in Ireland – the changing environment and current skills gaps were reviewed, followed by a short discussion on Industry 4.0.

### 2.1. The nature of SME & ME's in Ireland – the changing environment and current skills gaps

Micro enterprises account for 92.2% of all enterprises in Ireland, while Small and Medium enterprises account for 7.5% of the total number of enterprises (Central Statistics Office 2019). Micro enterprises accounted for almost 28% of persons engaged and had the highest number of enterprises, while Small and Medium enterprises combined accounted for 41.5% of total persons engaged in enterprises. Despite continued uncertainty surrounding the COVID-19 pandemic, the Irish Economic and Social Research Institute (ESRI) expect overall strong growth post-COVID-19, with Irish Gross Domestic Product (GDP) set to increase by 13.6 per cent (Economic & Social Research Institute 2021).

The Irish government has recognized the importance of embracing Industry 4.0 in the success and expansion of Irish industry. The Future Jobs Report Ireland 2019 acknowledges the impact that advanced digital technologies, such as artificial intelligence, robotics, big data, and analytics will have on Ireland's economy and manufacturing base (Government of Ireland 2019).

With technology so ingrained in organizations and their strategy, personal and skills shortages affect digitalization and innovation. In a recent survey, 62% of Irish smaller organizations reported having difficulty retaining tech talent, according to a recent report (Business Transformation Index 2022).

Infrastructural constraints, skills deficits and labor availability, and concentrations in some sectors and markets could affect enterprise progress (Antony, McDermott, et al. 2021). Technology continues to herald new ways of doing business and new economic opportunities. This presents challenges but also new possibilities – certain job roles will disappear or be redefined, and emerging job roles will require new and different skillsets (Government of Ireland 2019).

### 2.2. Industry 4.0 defined

Industry 4.0 has attracted exponentially increasing attention among organizations and governments because its successful implementation will lead to competitive advantages for companies and national economies (Sony et al. 2021). Industry 4.0 is defined by various authors in different contexts. One definition of Industry 4.0 has

been "I4.0 facilitates interconnection and computerisation into the traditional industry" (Masood and Sonntag 2020). The goals of I4.0 are many and wide – to provide IT-enabled mass customization of manufactured products; to make an automatic and flexible adaptation of the production chain; to track parts and products; to facilitate communication among parts, products, and machines; to achieve IoT-enabled production optimization in smart factories; and to provide new types of services and business models of interaction in the value chain" (Shafiq et al. 2015). There are many benefits to implementing Industry 4.0; improving customer satisfaction, maximizing operational efficiency, reducing costs, and increasing competitiveness (Antony, McDermott, et al. 2021). However, the benefits and challenges in the manufacturing and service sector are different when implementing Industry 4.0 (Sony et al. 2021). The quality of the products manufactured are improved, and increased automation can reduce operational costs and lead times with increased digitization and connectivity (Kiel et al. 2017). Customer satisfaction can also be improved by the technology and changed business models associated with Industry 4.0 (Oesterreich and Teuteberg 2016).

It is estimated that 70% of digital transformations fail (Sony et al. 2021). One of the main reasons for failing is that these technologies provide means of productivity, efficiency, or better customer management; however, nothing works if there is no alignment with management strategy (Tabrizi et al. 2019). Another point of view is that Industry 4.0 is a joint optimization of Social and technical systems to meet the objectives of the organization (Davis et al. 2014). Thus, for a successful implementation of Industry 4.0, the social and technical aspects must be given equal importance. Many challenges to implementing Industry 4.0 have been cited, including ensuring the high initial investment to digitalize the organization, data security concerns, employees resistance to change and lack of employee skillset and training in the technologies (Sony et al. 2021). In addition, SMEs significantly lag behind large organizations in benefiting from disruptive Industry 4.0 technologies (Ghobakhloo et al. 2022). Early adopters of Industry 4.0 tend to be larger enterprises and therefore have higher operational, and implementation costs, but smaller enterprises will benefit from late adoption as business models may be improved (Antony, McDermott, et al. 2021b). Aligning Industry 4.0 with organizational strategy or the lack of an implementation model or road map can be another challenge to digitalization (Chiarini 2020).

Many authors have discussed the synergistic relationship between Lean and Industry 4.0 (Tortorella and Fettermann 2018; Antony, McDermott, et al. 2021a). Companies with a strong LSS culture can ease the transition to Industry 4.0, while Industry 4.0 technologies can provide superior performance for companies using LSS methodology (Antony, McDermott, et al. 2021b, 2022). The synergistic effect between Lean and Industry 4.0 aids operational excellence by improving process flows and reducing bottlenecks (Moeuf et al. 2018). Implementing Industry 4.0 technologies makes factories smart and supports organizations in overcoming the Lean implementation barriers. The reduction of product and process complexity through the Lean approach enables the economical and efficient use of Industry 4.0 technologies (Rosin et al. 2020).

There are many CSFs for implementing Industry 4.0 within organizations; these include ensuring the alignment of Industry 4.0 technology or plan with the organizational strategy, employee involvement in making your products or services smart, and digitalization of the organization (Antony, McDermott, et al. 2021). Readiness dimensions for Industry 4.0 can differ in criticality depending on the size of the enterprise, whether large or small (Brozzi et al. 2018).

The CSFs for implementing Industry 4.0 are aligning the Industry 4.0 initiative with organizational strategy, ensuring top management support of the Industry 4.0 initiative, employee involvement and engagement for Industry 4.0, making products and services smart, digitization of the supply chain and the organization, effective change management processes, and good project management (Sony and Naik 2019). Leadership and top management support for Industry 4.0 implementation are required to digitally transform the organization (Antony, Sony, and McDermott 2021). Industry 4.0 needs to be embraced by leadership to be successful in organizations and aligned with strategy (Chiarini 2020). In a recent study ten critical failure factors were elucidated. They were (a) lack of I4.0 strategy, (b) absence of well-designed smart product/service systems, (c) lack of digital supply chains, (d) leadership is not supportive for I4.0, (e) poor human resource management for I4.0, (f) absence of I4.0 technology transformation management plan, (g) I4.0 is not implemented totally, (h) lack of top management support for I4.0, (i) poor change management strategies in place, and (j) inadequate consideration of sustainability in I4.0 initiative (Sony et al. 2022). Thus, it is evident that Industry 4.0 implementation has a high failure rate if it is not implemented appropriately, thus there is a need for a

study which investigates the nature of readiness of Small and Medium & Micro Enterprises in West Ireland.

### 3. Research methodology

The authors utilized both an online quantitative survey and qualitative interviews. The study was conducted in two phases: Phase 1 Qualitative Study and Phase 2 Quantitative Study using survey. Qualitative interviews were carried out prior to the survey. Senior managers/owners working in a wide range and diversity of industries were chosen in this study. A purposive sampling study was carried out (Charmaz and Belgrave 2007). An exploratory qualitative design was used to capture the views of the SME and ME enterprises within the West of Ireland to ascertain their practical understanding and their views of Industry 4.0. This study included participants from 10 different Small, Medium and Micro Enterprises in different sector types across the West of Ireland. This selection was chosen to establish a wide range of viewpoints and concepts concerning Industry 4.0 outside large enterprises. The participant enterprise organization details and sectors are elucidated in Table 1.

Participant enterprise details were found from West of Ireland business directories and the Enterprise Ireland LEOs. In addition, online interviews using Zoom or MS teams were conducted. The interviews consisted of general demographic information about the enterprises, followed by eleven open-ended questions specific to the research objectives. The same questions were intended to be asked of all respondents to ensure consistency and comparability of the qualitative study. The themes of the questions were centered around definition, *benefits, motivations, current Industry 4.0 initiatives, alignment with strategy; government supports, implementation of a Lean program, CSFs, challenges and readiness factors* for Industry 4.0 implementation. In addition, knowledge of what Industry 4.0 tools can aid the organizations was asked.

**Table 1.** Interview organizations.

Participant organization	Organization size	Sector
#1	Micro (<10 employees)	Manufacturing
#2	Small (10–50 employees)	Manufacturing
#3	Medium (51–249 employees)	Manufacturing
#4	Micro (<10 employees)	Craft
#5	Micro (<10 employees)	Engineering services
#6	Medium (51–249 employees)	Engineering
#7	Small (10–50 employees)	Construction
#8	Micro (<10 employees)	Food
#9	Small (10–50 employees)	Manufacturing
#10	Micro (<10 employees)	Engineering

Other more in-depth questions were subsequently asked concerning Industry 4.0 depending on the information and opinions expressed by the respondents during the study. Interview results, once completed, were transcribed from the recordings, documented and uploaded to ATLAS.Ti9 software using participant numbers (P numbers) to maintain anonymity. A sample size of eleven was judged appropriate as saturation was achieved and no new themes emerged (Saunders et al. 2018). Participants in the interview process were either senior managers or owners of the enterprises with responsibility for strategy.

Coding was utilized to identify similar thematic statements (Cascio et al. 2019). Axial coding was utilized for categorization or sub-categorization and linked to the research master themes (Charmaz and Belgrave 2007). Memoing was used for data verification, verifying the data, and tracking the research themes. Coding was carried out by multiple research team members (Creswell 1999). The qualitative research requires the authors to epoche or ‘bracket’ previous views about the topic (Moustakas 1994). This is done so that we can identify prejudices, biases and prior knowledge (Rathbone et al. 2021). Further it also helps to critique the analysis, against their prejudices. Such an approach adds rigor to their analysis. This is because due to this process, authors will now interrogate codes and themes, so that they can be sure that analysis is inductive and based on data (Baxter and Jack 2008). This was done by the authors holding regular meetings, where in we discussed and explored codes, and discussed past and present views to make sure that inductive analysis is carried out based on data, rather than views and perceptions.

An online survey was designed to obtain a large amount of information on Industry 4.0 from the respondents in the shortest possible time. Participant enterprises were contacted with the survey link via local county Enterprise Ireland offices to aid responsiveness and assure enterprises of the study’s legitimacy. As these enterprises can be smaller in nature and have fewer resources, the researchers designed a relatively short questionnaire to scaffold respondents in answering the survey in a short period of time. A pilot study was conducted during the survey development process (Boynton and Greenhalgh 2004). The online survey was piloted before dissemination to the enterprises. Participants from 10 SME and Micro enterprises were chosen to pilot the survey, and a further 5 academics expert in Industry 4.0. Piloting ensured validation of the survey instrument and ensured that the questions aligned with the research

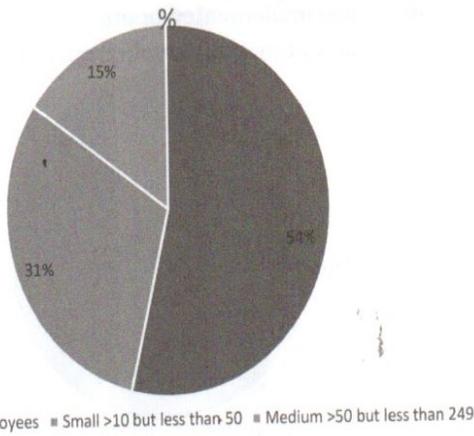


Figure 1. Participating SME's & ME's by their primary business sector.

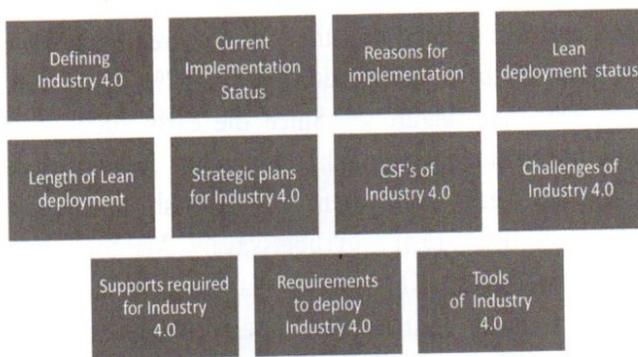


Figure 2. Analysis plan.

questions set by the researchers (Couper and Miller 2008). Most of the comments were positive, and hence the survey questionnaire was deemed suitable for research. The revised online survey link was sent out to 300 SME's and Micro enterprises managers or owners. This research methodology was adopted in previous studies (Antony et al. 2019, Antony, Sony, and Gutierrez 2020). A total of 70 responses were collated over 12 weeks yielding a response rate of 23%. Easterby-Smith, Thorpe, and Jackson (2012) argue that a 20% survey response rate is considered sufficient. The sample characteristics are given in Figure 1. Of the 70 respondent enterprises, 54% were micro-enterprises, 31% were small enterprises, and 15% were medium-sized enterprises, as in Figure 2.

## 4 Results

The analysis plan is depicted in Figure 2.

### 4.1. Current state of Industry 4.0

In this section we discuss the understanding and definition of the Industry 4.0 concept as understood by the SME's & ME's, as well as their current implementation of Industry 4.0 (if any) and their reasons for adopting Industry 4.0.

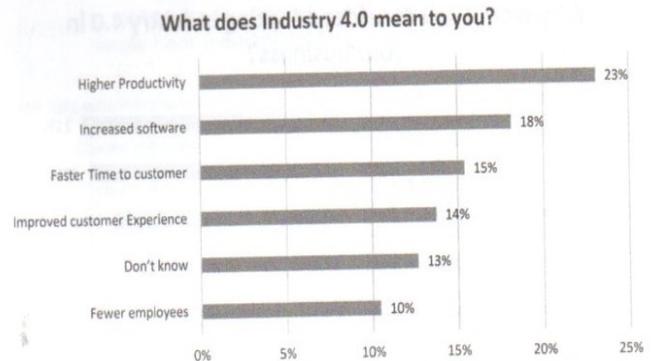


Figure 3. What does Industry 4.0 mean to SME and ME businesses of West of Ireland?

### Are you currently implementing any Industry 4.0 projects or initiatives?

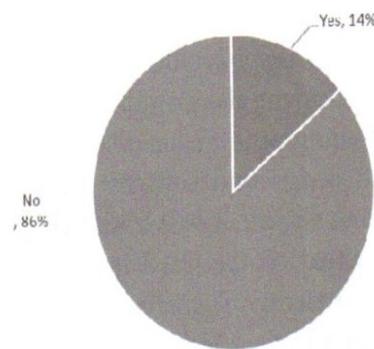


Figure 4. Current implementation status of Industry 4.0 in West of Ireland SME's and ME's.

#### 4.1.1. Defining Industry 4.0

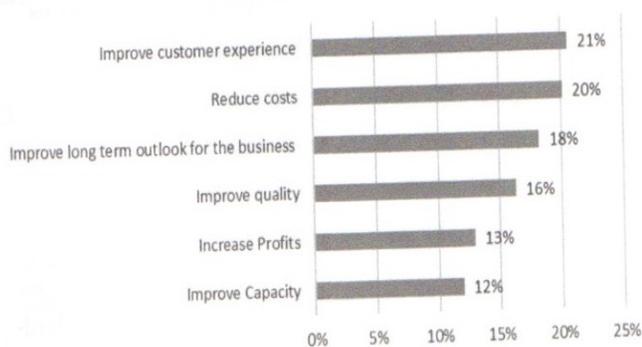
One of the first questions asked in relation to Industry 4.0 was, "What does Industry 4.0 mean to your business in layman's terms?". Participants were asked to choose from a range of options. Higher productivity (23%) was deemed to be the highest motivating factor, followed by increased software (18%), faster time to the customer (15%) and improved customer experience (14%) (Figure 3). Only 13% of SME's and ME's felt that they "did not know" what Industry 4.0 might mean for their businesses. This suggests some awareness, if not a high awareness, of Industry 4.0 within the West of Ireland SME and ME community.

#### 4.1.2. Current implementation of Industry 4.0 initiatives

In response to the question "Are you currently implementing any Industry 4.0 initiatives in your businesses?" 86% of SME and ME's stated that they were not currently implementing Industry 4.0 initiatives, whilst 14% stated that they were (Figure 4).

One participant commented that "Obviously we manufacture, design, manufacture equipment, and we do know about industry 4.0, but like it is not key to how our business runs, so we are not implementing it

### Why would you consider adopting Industry 4.0 in your business?



**Figure 5.** Reasons for adoption of Industry 4.0 in West of Ireland SME's & ME's.

now ..." (P9), while another participant stated, "We started out just out doing some conversions, small, simple solutions into bespoke automation equipment" (P8). Another participant also commented, "we would have developed equipment for measuring, and integrated electronic design and software design, but at that, I do not think we are at I4.0 levels?" (P5).

Interestingly none of the participants mentioned the Enterprise Ireland Digitalization (Enterprise Ireland, 2022) program, which offers support and grants to get enterprises started on their innovation and digitalization journey.

#### 4.1.3. Reasons for adopting Industry 4.0

A question on "Why would you consider adopting Industry 4.0 in your business?" yielded the following responses (Figure 5). Just over one-fifth of the respondents stated improved customer experience and reduced costs (21% and 20%, respectively) as their top reasons for implementing Industry 4.0. Improved customer experience would be in alignment as the top reason for implementing Industry 4.0 in many other studies on Industry 4.0 in multi-national corporations (MNC's) and large enterprises (LE's) (Sony 2020b; Sony et al. 2021).

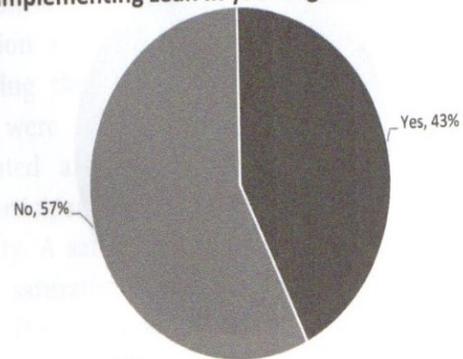
#### 4.2. Lean in relation to Industry 4.0

This section summarizes the status of lean implementation and the length of the duration of lean programs in the West of Ireland SME's & ME's

##### 4.2.1. Lean implementation

Many researchers have linked Lean as an enabler for Industry 4.0. Indeed Lean and Industry 4.0 have been found to have a synergistic relationship (Tortorella and Fettermann 2018) (Antony, McDermott, et al. 2021), (Rosin et al. 2020). Thus, a question was asked for the SME and ME participants as to whether they

### Have you implemented or are you currently implementing Lean in your organisation?



**Figure 6.** Percentage of Irish West of Ireland SME & ME businesses currently implementing lean.

had a Lean program within their organization. 43% of SME and ME's stated that they were currently deploying Lean in their organizations, while 57% stated that they were not (Figure 6). Since the early 2000s, the Irish government, through Enterprise Ireland, has supported Lean deployment in all Irish businesses (MEs, SMEs, LEs) (Trubetskaya, Manto, and McDermott 2022). This support has been via funding, grants, training courses, and access to Lean consultants to help train, mentor and implement Lean management.

##### 4.2.2. Length of lean program deployment

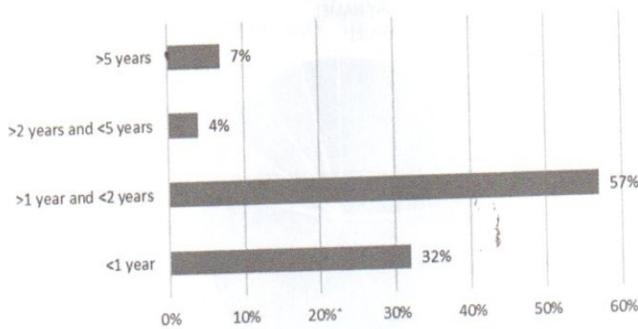
For those SME's & ME's that stated they were implementing Lean (43% of overall participants), these SME's & ME's were asked a subsequent question on the length of time they have had a Lean program. A lean program and Lean practices are seen as a precursor or enable for Industry 4.0 deployment and increased digitalization (Antony et al. 2022; Antony, McDermott, et al. 2021).

Only a small % of SME's and ME's had deployed Lean for over 2 and over 5 years. However, 57% of SME's and ME's were deploying Lean for over 1 year and under 2 years, while 32% were starting to implement it in the 12 months preceding the survey (Figure 7). Ireland and Irish SME and ME businesses are well placed in that the state assists and recognizes the need and competitive benefit of Lean and funds its deployment (Brennan 2018; Keegan 2014).

#### 4.3. The organizational aspects (strategy, critical success factors and challenges and tools used) to implementing Industry 4.0

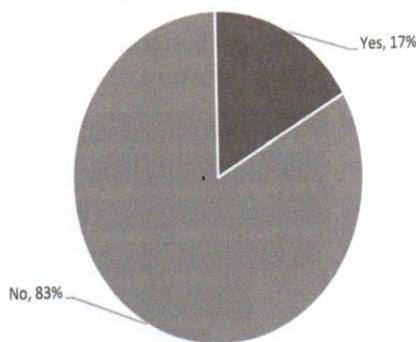
The following section analyses the responses in relation to the organizational aspects of Industry 4.0 readiness; the alignment of Industry 4.0 with strategy,

**If you have a Lean program how long have you been deploying Lean?**



**Figure 7.** Length of duration of lean programs in Irish West of Ireland SME's & ME's.

**As a leader in your organisation has Industry 4.0 featured in your strategic plans?**



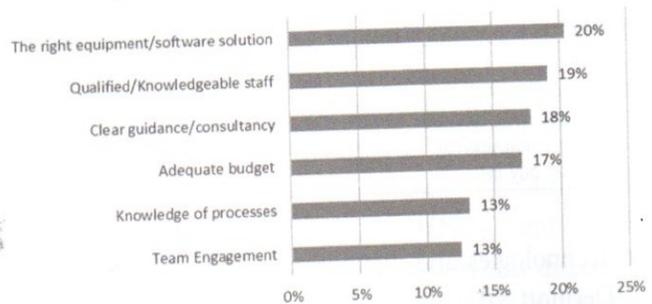
**Figure 8.** Percentage inclusion of Industry 4.0 in West of Ireland SME's & ME's strategic plans.

the critical success factors for Industry 4.0 implementation and the challenges involved in Industry 4.0 implementation. We also analyze the types of digitalization tools considered as being valuable to the SME's & ME's.

**4.3.1. Industry 4.0 as part of strategy**

A question was asked to ascertain if Industry 4.0 featured in SME and ME participant organizations' strategic plans. Aligning Industry 4.0 with strategy is a key success factor for the success of Industry 4.0 implementation (Sony 2020b). 17% of SME's and ME's stated that Industry 4.0 had featured in their strategic plans, while 83% stated that it did not (Figure 8). One participant stated that "In the west of Ireland, all of these delays and shortage of supplies due to Brexit have had an impact on what we can produce and the timelines we can give, and thus this is consuming our focus -this means many will be looking at what they can afford money and time-wise in terms of Industry 4.0 and for their business" (P1). Another participant commented, "Maybe it is something we need to be talking about, but it is not something that is vital when you are looking at a company of our size, and we are flat out - we have been busy

**What are the Critical Success Factors for you to implement Industry 4.0 (at present or in the future)?**



**Figure 9.** Critical Success Factors for Industry 4.0 implementation in West of Ireland SME's & ME's.

since before COVID and even more so now and it (Industry 4.0) is not something we are thinking of right now" (P2).

Aside from Brexit and COVID-19, the busy operational nature of the day to day running of SME's and ME's and the difficulty in concentrating on strategy featured. One SME commented, " I think the SME industry, possibly because they tend to be organically grown ... they tend to be time-poor in terms of where we have to work in the present, we have to work in the immediate. There is nobody giving any serious thought as to tomorrow" (P3).

**4.3.2. Critical Success Factors (CSF's) for implementation of Industry 4.0**

There were 4 key CSF's for Industry 4.0 identified: (1) Having the right equipment/software solution (20%), (2) having a qualified/knowledgeable staff (19%), (3) having guidance or consultancy support, and (4) an adequate budget to implement (17%) (Figure 9). In terms of having the right equipment/software solution, one participant elaborated, "You have to have a strategized and planned out and thought out framework before you finance and buy certain solutions .otherwise you will be designing faults into products and inefficient processes, uncompetitive processes"(P7). As per Sony and Naik (2019) and Tortorella et al. (2021), these key CSF's aligned very much with the literature in terms of the factors required for deploying and implementing Industry 4.0 technology. Notably, as this survey was completed by senior management representatives or owners of enterprises, leadership support did not feature as a key CSF.

**4.3.3. Challenges to Industry 4.0 implementation in SME's and ME's**

The main challenges cited by West of Ireland SME's and ME's to Industry 4.0 were implementation costs (Table 2). Costs of Industry 4.0 have been cited as a major factor in early versus late adoption of Industry

**Table 2.** Challenges for West of Ireland's SME's & ME's in the deployment of Industry 4.0.

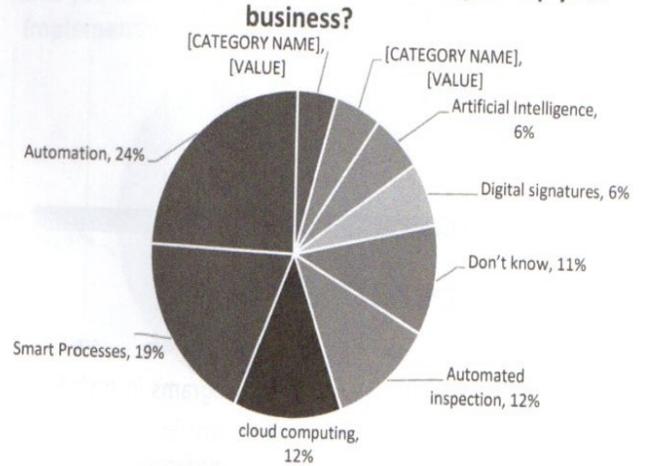
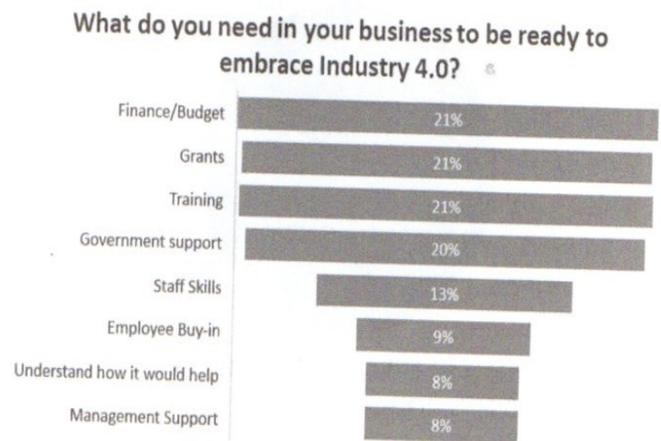
Challenges to Industry 4.0 deployment	%
Costs	36%
Lack of state support	25%
Wrong equipment/solution	20%
Leadership vision unclear	12%
Lack of staff buy in	7%

4.0 technologies and digitalization (Antony, Sony, and McDermott 2021) as well as an obstacle to adoption in general (Sony 2020b). More than one-third of respondents stated that costs were the main challenge (36%), while lack of state support (25%) and the wrong equipment/solution (20%) were also ranked highly. Leadership vision being unclear is often cited as an impediment to Industry 4.0 by organizations (Sony and Naik 2019), but in the ME situation, where the ME's are very much owner/managed, this was not seen as a challenge. However, bearing in mind that many of the participants were on the management team or were the senior manager or owner -caution must be taken. The fact that a previous question had demonstrated that a high % of enterprises were not aligning I4.0 with strategy and were not currently implementing it suggests a lack of leadership vision. Also, given the "micro" and "small" nature of ME's and SE's, lack of staff buy-in was not a concern as teamwork is considered higher within these organizations (Achanga et al. 2006). However, recent studies suggest that implementation of Industry 4.0 will result in employees requiring a new skill set; therefore, buy-in will be critical for the success of Industry 4.0 (Hecklau et al. 2016)

Some SME and ME participants commented on staff shortages and stated, for example, "it will be a while before many commit to making any serious changes when they cannot rely on the workforce and they are the key at the minute to work" (P5).

#### 4.3.4 Tools of Industry 4.0

To assess awareness of Industry 4.0 and digitalization tool types, the question "What tools of Industry 4.0 do you think might help your business?". Automation (24%), Smart processes (19%) were ranked as the most valuable tools of Industry 4.0, followed by automated inspection (12%) and cloud computing (12%) (Figure 10). Not surprisingly, the more technical elements of Industry 4.0, such as biometrics, sensors, artificial intelligence and digital signatures, were ranked lower, with 11% stating they "did not know" what tools were useful. Despite the fact that 83% of SME's & ME's had previously stated that Industry 4.0 did not feature in their strategic plans, there was still

**Figure 10.** Tools of Industry 4.0 that can help West of Ireland SME's & ME's.**Figure 11.** Requirements of Irish West of Ireland SME's & ME's to embrace Industry 4.0.**Figure 11.** Requirements of Irish West of Ireland SME's & ME's to embrace Industry 4.0.

a strong understanding of what types of Industry 4.0 tools could help their businesses based on the answers.

#### 4.4. The needs of the West of Ireland's SME's & ME's

In this section, the requirements and supports required by the West of Ireland SME's and ME's are discussed.

##### 4.4.1. Requirements for SME's and ME's to implement Industry 4.0

Four main "needs" were cited by the surveyed SME's, and ME's as being a requirement to embrace Industry 4.0. These were having appropriate finance/budget, grant aid, training and government support (Figure 11). The lowest percentage requirements were having management support and understanding how Industry 4.0 can help. Given that ME's and SME's can be primarily owner-managed, they may not see a lack of management support which is a factor in Industry 4.0

deployment in LE's and ME's, as an obstacle. The participants in this study were primarily owner-managers and preoccupied with day to day running of their businesses. Understanding how Industry 4.0 can help did not seem an important factor for embracing Industry 4.0 among the survey participants. This finding correlates with the findings in a previous question on Industry 4.0 understanding, where only 13% of SME's & ME's stated they didn't know or understand what Industry 4.0 would mean for their business.

Within the participant interviews, training was reiterated as a key need. However, there were mixed views on the value of training and the time required for training. Many echoed the value of "Further investment in apprenticeships and a big change of attitude around the whole apprenticeship program and embracing of it"(P4).

**4.4.2. Supports required by West of Ireland MEs for Industry 4.0**

The top-ranking supports required by West of Ireland MEs were stated as training and education on Industry 4.0 (25%) and Grants (24%) (Figure 12). A participant commented that "one area that would benefit SMEs overall is strengthening grants on the whole use and focus of digitalisation in sales and marketing" (P4). Also, "in terms of education, currently it is an employee's market. We are finding it very difficult to find people such as programmers and they can ask for huge salaries"(P5).

The sharing of best practice stories (16%), networking with other businesses (15%) and mentoring (11%) were the next cited supports required. Having opportunities to benchmark others and digital transformation roadmaps were deemed to be the least required supports. However, a recent report (University of Cambridge & Policy Links, 2019) commissioned by the Irish government on the digitization of the Irish manufacturing sector cited the importance of

collaboration between multi-national corporations (MNCs) or LE's and SMEs as required to fully exploit the benefits that digital capability offers. The report recommended that, in particular, support from MNCs (foreign-owned and indigenous) to SMEs in their digitalization journey can lead to positive outcomes for both types of firms and exploiting clustering, and the strong linkages between MNCs and SMEs throughout Ireland is thus a key step in this direction.

Thus, despite networking, sharing of best practice stories, mentoring and benchmarking being ranked not as high as other supports by the participants, they are instrumental in helping enterprises along the digitalization route. Also, it should be noted that Enterprise Ireland has a Digitalization program specially targeted at SME's which involves grants, support and mentoring for enterprises on their innovation and digitalization journeys (Enterprise Ireland, 2022). However, there was a lack of awareness of these programs among the study participants, as "lack of supports" was cited in several interviews. It is suggested that also there is a lack of time and resources to engage directly in these programs amongst smaller sized enterprises.

**5. Discussion**

This study highlighted that there is a level of awareness of Industry 4.0 amongst West of Ireland SME and ME businesses (RQ1). However, despite a level of awareness and implied understanding of the benefits of Industry 4.0, the majority of SME's and ME's surveyed have no plans to implement Industry 4.0 or increase digitalization, nor does the former feature in their strategic plans. Without the alignment of digitalization to strategic plans, the status quo will be maintained in terms of increased digitalization (Antony, Sony, and McDermott 2021). While there may be some levels of implementing of automation or other

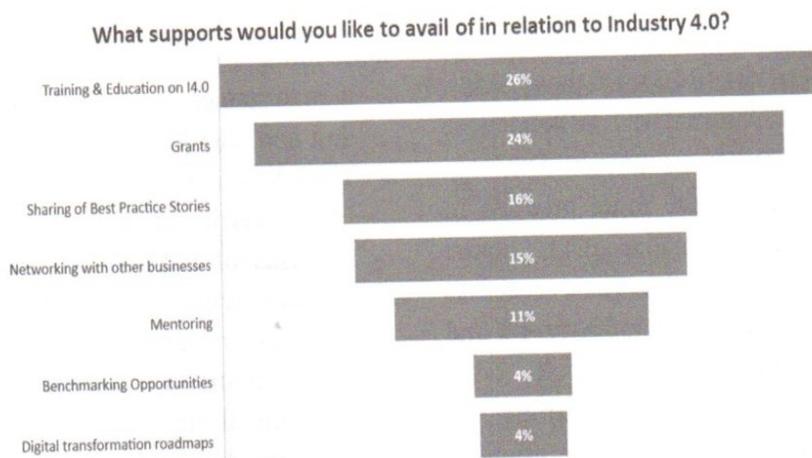


Figure 12. Supports required by West of Ireland SME's & ME's in order to deploy Industry 4.0.

technologies in these enterprises, especially within manufacturing environments, there will be limited benefits if other functional systems within the business were not integrated also (Fatorachian and Kazemi 2018). The integration is unlikely without alignment to strategy. There was a strong understanding and awareness of what types of technologies of Industry 4.0 could help SMEs & ME's. Automation (24%) and smart processes (19%) were ranked as the most valuable tools of Industry 4.0, followed by automated inspection (12%) and cloud computing (12%), with biometrics, sensors, artificial intelligence and digital signatures ranked as lower. Thus, despite the fact that 83% of SME's & ME's had previously stated that Industry 4.0 did not feature in their strategic plans, there was still a strong understanding of what types of Industry 4.0 tools could help their businesses based on the answers. The challenges to Industry 4.0 deployment amongst West of Ireland SME's & ME's included the costs of implementation, lack of state support and selecting the wrong equipment/solution ranked as the key challenges (RQ2a). There were also 4 key critical success factors (RQ2b) for Industry 4.0 identified amongst West of Ireland SME's and ME's, including having the right equipment/software solution, having a qualified/knowledgeable staff, having guidance or consultancy support and an adequate budget to implement Industry 4.0 technology.

The costs of digitalization can be prohibitive for smaller sized enterprises, and there is a need to understand the technology and its benefits before investing. However, Stentoft et al. (2020) found in a study of Danish SME's that SMEs seem to engage positively with Industry 4.0 barriers and costs when there is perceived a business case to do so.

A Lean program is an enabler for Industry 4.0 deployment (Kamble, Gunasekaran, and Dhone 2020) and just 43% of West of Ireland SME's and ME's who participated in this study stated that they were currently deploying Lean in their organizations, while 57% stated that they were not (RQ3). Of those SME's and ME's deploying Lean, the majority (<90%) were only starting to deploy in the last 1–2 years. This suggests that these organizations have more progress in improving their operations management before embarking on a digitalization journey. Lean is seen as a precursor for and synergistic with Industry 4.0 and an enabler for digitalization ((Rosin et al. 2020; Tortorella et al. 2021). Companies with a strong LSS culture and the program can ease the transition to Industry 4.0, while Industry 4.0 technologies can

provide superior performance for companies using LSS methodology (Antony et al. 2022).

A combined 50% of the West of Ireland SME's and ME's who participated in this study stated that training and education in Industry 4.0 as well as government grants were the primary supports they would like to see in terms of preparing for Industry 4.0 (RQ4). Enterprise Ireland and the Irish government have a number of supports in place to promote digitalization and aid enterprises in their Industry 4.0 journeys; however, these supports were not well known amongst many enterprises who participated. However, given the size of some of these enterprises and their current priorities in light of COVID-19 and Brexit, it will take time to embark on Industry 4.0 type initiatives. This study thus highlights the importance of technical elements such as automation and smart processes, in addition to social aspects such as qualified/knowledgeable staff etc for the SMEs and MEs being ready for Industry 4.0 in West Ireland. The theoretical basis of this argument stems from socio-technical systems theory, which argues that tangible (technical) and intangible (social) elements interrelate in a complex manner for successful organizational development initiatives (Walker et al. 2008). The socio-technical systems theory suggests that social and technical elements should be designed and improved together, and there are multiple ways to attain joint optimization (Davis et al. 2014). Therefore, we feel that the social and technical aspects of Industry 4.0 should be considered by SMEs and MEs in West Ireland while implementing Industry 4.0.

## 6. Conclusions

As the majority of participants stated that they were not currently implementing Industry 4.0 technology, nor did they feature it in their strategic plans, the authors conclude the following:

- Training & Upskilling, while valuable, will be futile if management is not on board with implementation and aligning I4.0 with strategy.
- That these enterprises be made more aware by the Irish government of the support available to them in terms of Industry 4.0 government grants and available training and upskilling programs (both academic and apprenticeship based).
- While technology, software, IT and digitalization skills are all important to Industry 4.0 deployment, Industry 4.0 integration with strategy is key. Communication and awareness will facilitate

progress and digitization, understanding Industry 4.0 benefits, training and upskilling, and inform strategy.

This study is one of the first on Industry 4.0 readiness, awareness and status in the west of Ireland, Ireland, and globally amongst the SME and ME population. This study should inform both enterprises and governments of the challenges facing these enterprises and inform government support and policy to enhance readiness for Industry 4.0.

A limitation of the survey is that the response rate was low as a percentage of the SME's and ME's in the West of Ireland that the survey was disseminated to. As a result, the researchers plan to extend the study across other provinces in Ireland as well as in other countries and also carry out a phase 2 longitudinal study. These future studies will ascertain more information on the status of Industry 4.0 deployment and the skills gaps and challenges within individual SME & ME businesses.

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