

# **Manufacturing Renaissance in Industrial Regions? Advanced Manufacturing in Scotland's Central Belt – Case Study**

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## **1. Introduction**

This case study contributes to the project's aim of investigating the evolution of advanced manufacturing (AM) across Britain and identifying its potential contributions to sectoral and spatial rebalancing. Scotland's Central Belt was selected because of its history as a traditional manufacturing heartland. The area has experienced prolonged deindustrialisation and uneven transition towards a service-based economy, contains a geographical concentration of AM in the British context, and its institutional and policy approaches and framework is different from

England and the other project case studies in the East Midlands and North West regions.

For this case study, the Central Belt is comprised of the following 14 local authority areas, from west to east: Inverclyde; Renfrewshire; West Dunbartonshire; East Renfrewshire; Glasgow City; East Dunbartonshire; South Lanarkshire; North Lanarkshire; Falkirk; West Lothian; Fife; City of Edinburgh; Midlothian; and, East Lothian (Figure 1).

**Figure 1: Scotland's Central Belt**



**Source: Ordnance Survey © Crown Copyright**

The case study research is based on analysis of quantitative data, a firm survey, secondary sources, and primary interviews with key public and private sector actors. For this research, AM comprises the Standard Industrial Classification (SIC) sectors: Chemicals; Pharmaceuticals; Weapons and ammunition; Computer, Electronics and Optics; Electrical equipment; Machinery and Equipment n.e.c.; Motor vehicles; Air- and spacecraft; Other transport equipment (excl. Ship and Air); and, Medical and dental instruments and supplies. The research was undertaken in late 2019 and early 2020 before the COVID-19 pandemic.

While sitting at a lower level in terms of its geographical concentration of employment than Britain as a whole, AM in Scotland remains important and relatively

stable in the national context. There are marked localised concentrations of AM in the Central Belt and they form a strategic part of Scotland's economy and its future development given AM's high value-added output, higher quality jobs, R&D investment, and exports. Contrasting the picture of geographical dispersal of AM nationally, the localised concentrations of AM employment in the Central Belt have increased since the early 1990s while those experiencing deindustrialisation in traditional sectors have continued their decline. GVA production has diverged amongst these local areas with the cities leading growth and recovery due to their more service-oriented and higher value-added AM functions and activities.

The Central Belt provides a range of advantages and disadvantages as a location for AM, many of which reflect Scotland and UK-wide issues such as weak productivity, innovation capacity, skills shortages, and access to finance. Concerns also exist about the relatively limited scale of the Central Belt and Scotland compared to other UK and international AM hubs. There is differentiation amongst the sectors within AM in the Central Belt, each with varying specialisms, relations with wider internationalised production networks, and prospects. Many are, however, facing common future challenges including external foreign ownership, interfacing with policy support and funding, research and innovation especially adaptation to industry 4.0, skills, supply chain reorganisation resulting from Brexit, and upgrading their activities and functions. Specific issues identified by the AM sectors for further support comprised identifying new high-growth potential niches and SME access to supply chains.

Guided by national economic strategy in Scotland, there is a specific strategy for manufacturing with a particular emphasis on its definition of AM – 'high value manufacturing'. This strategy has guided the evolution of an extensive framework of support organised around key investments in leading institutes and geographical concentration around an advanced manufacturing hub and priority programmes addressing many of key cross-cutting issues for AM across the Central Belt and more widely within Scotland. Institutional and policy issues identified for the current approach include linking approaches in Scotland into UK policy and funding, addressing weak productivity and increasing internationalisation, reconciling cross-sectoral technological and sectoral approaches, managing the tension between

geographical concentration and national Scotland-wide reach, addressing skills gaps and workforce renewal, supporting adaptation to industry 4.0, and mitigating Brexit uncertainty.

Potential changes for approaches, institutions and policies are based upon further developing and refining the existing support framework for AM in the Central Belt and across Scotland. Specifically, these areas comprise strengthening the connections and flow of university research and innovation into AM sectors and especially SMEs, embedding inclusive growth into business cases for public sector intervention, creating STEM ambassadors to promote engineering and science careers in schools, incentivising further and higher education institutions to widen and deepen the skills pipeline into AM, securing flexibility to tailor national apprenticeships policy and funding to Scotland-specific issues, enhancing support for Industry 4.0 adaptation, increasing the policy focus on technology absorption and readiness especially amongst AM SMEs, and strengthening monitoring and evaluation of AM support strategy and initiatives.

## **2. The geography of AM in Scotland's Central Belt**

Overall, Scotland's Central Belt has a relatively lower geographical concentration of AM employment than Britain as a whole and it has remained stable since the early 1990s (Table 1). Within the Central Belt, Renfrewshire, Fife, West Lothian, Falkirk, Inverclyde, and West Dunbartonshire have concentrations above the national British level. All of which areas have seen increases in their relative concentrations of employment since the early 1990s, suggesting apparent local benefits to the geographical co-location of AM activities. Renfrewshire in particular has a particularly high concentration, more than doubling since the early 1990s. This increased geographical concentration of AM jobs in the Central Belt contrasts the national picture of spatial dispersal<sup>1</sup>. Three areas which had relatively higher location quotients (LQs) compared to Britain in the early 1990s – North and South

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<sup>1</sup> Sunley, P., Evenhuis, E., Harris, J., Harris, R., Martin, R., Moffat, J. and Pike, A. (2020) *Renewing Industrial Regions? Advanced Manufacturing and Industrial Policy in Britain*, Working Paper, Available at [http://www.manufacturing-regions.org.uk/working\\_papers\\_&\\_downloads/](http://www.manufacturing-regions.org.uk/working_papers_&_downloads/)

Lanarkshire and East Lothian – have experienced declines and are now below British levels. East Dunbartonshire in particular has had a sharp decline in its concentration of AM jobs. East Renfrewshire has experienced growth, resulting from its proximity and overspill from the high concentration of employment in neighbouring Renfrewshire. Edinburgh, Glasgow and Midlothian had relatively low LQs in the early 1990s and all declined further up to 2015. This geography of AM beyond the major cities matches the national picture emerging from this research project, reflecting transition of the cities to more service-oriented urban economies. The emergence of semi-urban hubs outside but adjacent to the major cities is a key feature of the new geography of AM in the Central Belt.

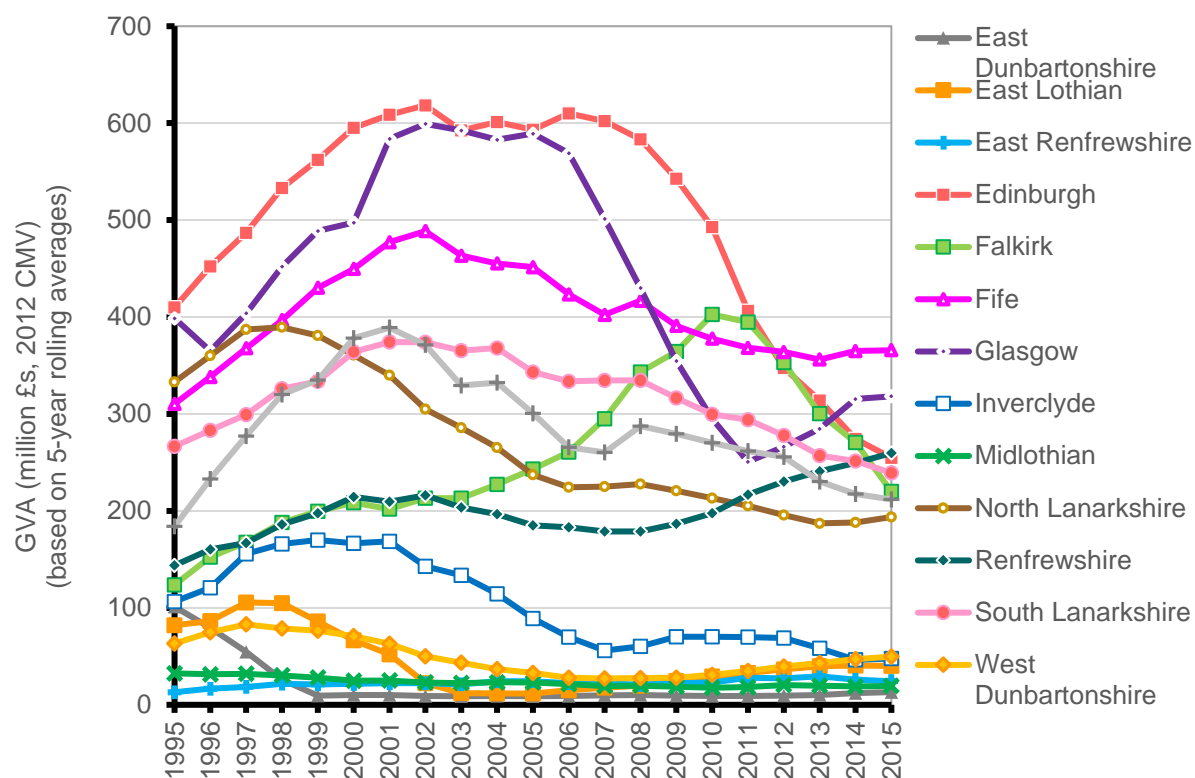
**Table 1: Location quotients for AM employment, Scotland Central Belt and LADs, 1991 and 2015**

	1991	2015
Britain	1.00	1.00
Scotland Central Belt	0.84	0.84
Renfrewshire	1.08	2.23
Fife	1.10	1.74
West Lothian	1.26	1.66
Falkirk	0.88	1.31
Inverclyde	0.98	1.11
West Dunbartonshire	0.65	1.07
North Lanarkshire	1.45	0.89
South Lanarkshire	1.23	0.88
East Lothian	1.18	0.83
East Renfrewshire	0.36	0.48
Edinburgh	0.54	0.45
Glasgow	0.52	0.35
Midlothian	0.62	0.34
East Dunbartonshire	1.57	0.27

**Source: Data from Cambridge Econometrics**

From the mid-1990s to 2015, the local authority areas exhibited divergent trajectories in their Gross Value Added (GVA) production in AM (Figure 2). Reflecting their service-oriented and higher value-added AM functions and activities, Edinburgh and Glasgow grew strongly until the early 2000s, plateaued and then sharply declined following the 2008 crisis. Only Glasgow has recovered more strongly since the early 2010s. Fife, South Lanarkshire and West Lothian share similar trajectories of growth with slower declines since the early 2000s. North Lanarkshire peaked earlier and has declined since the late 1990s. Falkirk experienced sustained growth but has since declined from 2010. Reflecting its growing geographical concentration of AM employment, Renfrewshire has exhibited sustained growth with only a minor dip through the mid-2000s and 2008 crisis. Matching the wider research's finding of AM contraction in traditional industrial areas, Inverclyde grew in the mid-1990s but has experienced prolonged decline since. East Lothian and West Dunbartonshire were producing at lower levels, declined since the late 1990s, but have rallied slightly since the 2008 crisis. Reflecting their limited AM activities, Midlothian and East Renfrewshire have both operated at much lower levels throughout this period.

**Figure 2: GVA in AM by LAD, 1995-2015**



**Source: Data from Cambridge Econometrics**

Employment decline in AM in Scotland’s Central Belt broadly reflects the experience in Britain as a whole, losing over 40% of its jobs between 1991 and 2015 (Table 2). Scotland’s Central Belt mirrors the national picture of employment decline as a result of the transition to ‘lean’ manufacturing, productivity improvements, ‘servitisation’ and the blurring of production and service activities, and the reclassification of formerly production tasks out of manufacturing sectors<sup>2</sup>. Reflecting its growing geographical concentration and GVA, Renfrewshire stands out as having broadly sustained AM employment since the early 1990s. West Lothian and Fife have held up relatively well too, losing around 10% of their AM jobs. East Renfrewshire and Falkirk sit together in experiencing a less than 20% contraction in employment. West Dunbartonshire lost nearly a third of its jobs. The remaining areas all experienced declines of over 50%, reinforcing the picture of traditional industrial local economies

<sup>2</sup> Foresight (2013) *The Future of Manufacturing: A new era of opportunity and challenge for the UK*, Summary Report, The Government Office for Science, London.

losing AM employment. Underpinning its sharp decline in the geography of AM jobs, East Dunbartonshire faced the largest decline of all the Central Belt areas.

**Table 2: Employment change in AM by LAD, 1991-2015**

	1991	2015	Change 1991-2015	% change 1991-2015
Britain	1,437,110	831,078	-606,032	-42.17
Scotland Central Belt	63,271	34,665	-28,606	-45.21
Renfrewshire	5,131	5,117	-14	-0.27
West Lothian	3,809	3,508	-301	-7.90
Fife	7,312	6,580	-732	-10.01
East Renfrewshire	371	315	-56	-15.09
Falkirk	2,760	2,259	-501	-18.15
West Dunbartonshire	1,328	904	-424	-31.93
Inverclyde	1,980	920	-1,060	-53.54
Edinburgh	8,583	3,880	-4,703	-54.79
East Lothian	1,711	742	-969	-56.63
South Lanarkshire	7,565	2,935	-4,630	-61.20
Midlothian	816	300	-516	-63.24
North Lanarkshire	8,741	3,205	-5,536	-63.33
Glasgow	10,450	3,786	-6,664	-63.77
East Dunbartonshire	2,714	214	-2,500	-92.11

**Source: Data from Cambridge Econometrics**

### **3. Key AM sectors in Scotland's Central Belt**

The main advantages of Scotland's Central Belt as a location for AM are:

- Existing AM firms, strong industrial sectors, and their openness as industrial partners
- Geography especially the accessibility to national UK and international markets as well as Glasgow and Edinburgh as two different and complementary city-region economies in relatively close proximity



- Available sites for existing firm expansion and greenfield investments
- Openness to markets given Scotland's position as a historically relatively small and open economy linked into UK and international trade. Although this advantage is influenced by uncertainty related to Brexit and the UK's future external trading relationships and arrangements
- Universities' research capacity as central to the innovation system through their commercialisation and start-ups and specialist service provision, strong links to business, especially Strathclyde University, and supply of graduates
- People with their history and legacy of engineering talent and skills, especially in engineering design consultancy
- Infrastructure especially connectivity with two international airports within 40 miles, rail, and major and minor road networks. A Scottish business association noted the importance of "logistics – easy to get things and people in and out, airport nearby, advantage over the rest of Scotland" (Chief Executive, author's interview, 2019). This advantage will be further developed by future investment plans especially the Glasgow City Region Deal
- Public policy and institutional support "on your doorstep" (Chief Executive, business association, author's interview, 2019) including regional grants and R&D incentives
- Governance – Scotland-level government and key institutions especially Scottish Enterprise and relationships with local authorities, for example on planning and parking rules which "all hits the bottom line if you're wanting to invest in a site" (Director, trade association, author's interview, 2019).

The disadvantages of the Central Belt for AM include:

- Relatively weak productivity
- Aged and ageing stock of plant and equipment requiring investment
- Skills shortages magnified by relatively limited geographical extent of the labour market enabling staff mobility, leading in some cases to "staff moving around the hub, pushing salaries up" (Director, trade association, author's interview, 2019), declining population, and history of outmigration especially of the young and skilled

- Access to investment capital
- Sites and premises that are dated in some cases and in need of investment or relocation
- Duplication, overlap and silos between institutions and policies. Business and trade associations noted concerns about co-ordination, whether support is sufficiently specialised and distinct, and the “complexity of support [is] unbelievably difficult for most businesses to understand” which means it is time consuming and costly for firms to engage especially SMEs (Chief Executive and Director, author’s interviews, 2019). Business associations provide a key role in “focusing down things going on from government and Scottish Enterprise to member firms” (Chief Executive, business association, author’s interview, 2019)
- Need for continued infrastructure investment including roads and rail electrification between Edinburgh and Glasgow
- Limited scale relative to other AM hubs and centres of excellence in the UK and internationally.

Amongst the geography of the key AM sectors in the Central Belt there is evidence of localised agglomerations interconnected with external corporate control and supply chains extending beyond Scotland and the UK. The importance was noted of “other advanced manufacturing companies nearby in Scotland” that provide some “buzz, vibrancy, community” (Director, trade association, author’s interview, 2019) and the “grouping of good high value manufacturing companies”, “skills benefits, cross-pollination of staff” and the “hub approach” of “geographical concentration of investments” (Chief Executive, business association, author’s interview, 2019). Although for many of the largest companies, for example in aerospace, the headquarters tend to be located in London and the “supply chains are UK-wide and international rather than geographically clustered” (Director, trade Association, author’s interview, 2019).

For the case study AM sectors, aerospace is a significant and internationally visible strength in Scotland dominated by large firms, especially prime contractors for the defence industry. These firms include BAE Systems, Betis, Boeing, General Electric,

Leonardo, Raytheon, Rolls-Royce, Thales as well as some tier 1 suppliers. Spirit is also located at Prestwick Airport in nearby South Ayrshire. As a capital intensive and high-technology sector, activities located in the Central Belt are specialised parts of larger and geographically dispersed production systems operated by internationalised UK and foreign-owned firms. Aerospace is considered a key sector nationally in Scotland and promoted for investment from within the UK and beyond. The sector also benefits from the support of the regional branch of a national trade organisation, ADS Scotland, that links into national firm networks. Future issues for the sector reflect those of AM across the Central Belt and Scotland. They include skills shortages especially for engineers and the impacts of Brexit uncertainties on recruitment, talent attraction and retention, international collaboration and supply chain trade<sup>3</sup>. Specific concerns exist about the preparedness and internationalisation of aerospace SMEs in the Central Belt that were “too reactive, unstrategic” and struggling to “grasp opportunities” that was leaving them a “bit exposed” (Director, trade association, author’s interview, 2019).

The automotive sector is less strong and high profile in Scotland and the Central Belt than in other UK regions. Historic passenger car production was introduced by Rootes Group in the 1960s, established with regional policy support at Linwood west of Glasgow, but closed in 1976. Since then relative strengths have developed in commercial vehicles, especially bus and coach production for public transport, component manufacture in lower tiers of the supply chain and, more recently, emergent activities related to electric vehicles. Leading firms including Alexander Dennis, Allied Vehicles and Johnson Matthey Battery Systems. Most activities are focused on traditional assembly for large international own-brand manufacturers in which it is hard to identify productivity improvements and they often have ageing workforces. Scottish Enterprise is leading a strategic initiative aiming to link the sector into low carbon transport innovation and capturing the associated manufacturing jobs, for example in production activities arising from future mobility systems and battery manufacturing.

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<sup>3</sup> Scottish Government (2019) Scotland: A Trading Nation, Scottish Government: Edinburgh.

From the heyday of ‘Silicon Glen’ in the 1990s, electronics in the Central Belt has undergone substantial transformation. The geographical concentration in ‘Silicon Glen’ reached its peak of output and employment in the late 1990s, stretching across the towns of the Central Belt including Greenock, Erskine and Cumbernauld. Silicon Glen was a key centre for especially semiconductors (microchip) and Personal Computer (PC) assembly by US, Japanese, South Korean and Taiwanese companies – including Chunghwa, IBM, National Semiconductor – for the UK and wider European and international markets<sup>4</sup>. Wider trends towards digitisation, the internet and mobile devices, software production and the rise of US-based ‘Big Tech’ companies following the ‘dot com’ crash of the early 2000s left the Central Belt’s specialisation exposed. Production further internationalised especially to central and eastern Europe and China and manufacturing-service integration became more important<sup>5</sup>. The legacy of external control and reliance upon FDI was unevenly embedded in local supply chains and fostered relatively few home-grown electronics activities given its size and history. Higher value-added semiconductor design activity has remained with some foreign-owned companies including Freescale, Texas Instruments and ST Microelectronics. Further and future development is focused upon more digital economy-oriented electronics sector activities framed as technology, digital and media<sup>6</sup>. These include opportunities with global demand in sensor systems and data analytics, ‘mobility as a service’, fintech, gaming, analogue semiconductors, and cyber security. The emergent geographies of AM in this sector are more concentrated in the cities of Glasgow and Edinburgh, building upon links to their universities and further education colleges. Future challenges are ensuring continued growth and addressing future skills needs (especially in STEM and at postgraduate levels).

Pharmaceuticals has developed into a substantial contributor to AM in Scotland in output, employment, exports, and R&D investment<sup>7</sup>. It is based upon operations by

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<sup>4</sup> O’Connor, A. (2019) Evolution and dilution in devolution: economic policy in Scotland, Scottish Parliament Information Centre (SPICe) blog, 3 July, <https://spice-spotlight.scot/2019/07/03/evolution-and-dilution-in-devolution-economic-policy-in-scotland/>

<sup>5</sup> Fraser, D. (2016) “Whatever happened to Silicon Glen?”, BBC News, 28 January, <https://www.bbc.co.uk/news/uk-scotland-scotland-business-35428124>

<sup>6</sup> Scottish Government (2019) Scotland: A Trading Nation, Scottish Government: Edinburgh.

<sup>7</sup> Fraser of Allander Institute (2018) The Economic Contribution of the Pharmaceutical Industry in Scotland, Fraser of Allander, Strathclyde University.

large international firms including Astra Zeneca, BASF, Bayer, GlaxoSmithKline, Lilly, Novartis, Pfizer, Roche and Takeda as well as smaller research-based spin-offs and SMEs. Production locations are spread across the Central Belt, including cities, towns and rural areas. Key to the sector's growth has been close links and partnership working between the private sector, NHS Scotland (especially its public procurement and R&D activities), and university research and specialised life science institutes. The Chief Scientist at the Royal Pharmaceutical Society described this geographical configuration as "similar to the so-called 'Golden Triangle' in the South with London, Oxford and Cambridge"<sup>8</sup>. Scottish Enterprise has been leading support focused on a life sciences strategy for Scotland and involving the new Scottish Investment Bank. Key elements include developing manufacturing and services integration through promotion of outsourcing opportunities for 'pharma services' and associated supply chains. The strength of the sector and growth prospects helped underpin the establishment of new Medicines Manufacturing Innovation Centre in Renfrewshire and connections to urban life sciences hubs the Edinburgh Bioquarter and BioCity/MediCity Glasgow. Future challenges include leveraging the life science industry networks for growth and internationalisation, responding to global ageing population demand (e.g. healthcare related AM in med-tech and medical devices), securing opportunities for outsourced life sciences R&D, and building links to manufacturing in Scotland<sup>9</sup>.

Cross-cutting issues for future AM case study sector growth and development comprise, first, identifying and supporting the emergence of high-growth potential niches. Successful recent examples include the emergence of small satellite manufacturing. Business support agencies and universities are actively considering appropriate ways to enable the further development of such break-out activities and to replicate the future emergence of similar embryonic and budding sectors from the wider AM firmament in the Central Belt as well as identifying opportunities more widely across Scotland. For new and emergent AM activities, such as small satellites in the space sector, opportunities may arise for locating the "full chain [here] in

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<sup>8</sup> Quoted in Nawrat, A. (2019) "A health check for Scotland's pharmaceutical industry", *Pharmaceutical Technology*, 20 February, <https://www.pharmaceutical-technology.com/features/health-check-scottish-pharma-industry/>

<sup>9</sup> Scottish Government (2019) *Scotland: A Trading Nation*, Scottish Government: Edinburgh.

Scotland” (Director, aerospace firm, author’s interview, 2020). For example, support is focused on providing intelligence on markets, mapping supply chains, testing and regulation, access to finance, and potential collaboration for sharing capital equipment and helping SMEs with grant applications to Scottish and UK government funding initiatives.

A second issue is supporting SMEs in Scotland to access supply chains. In AM, such SMEs often encounter high barriers to entry. These include, for example, high level precision manufacturing standards in aerospace, automotive, defence and electronics contractors and the timing, bureaucracy and costs of dealing with large transnational companies for start-up businesses and SMEs. Numerous trade associations are facilitating networking and knowledge exchange for supply chain development opportunities within Scotland. Such support is pitched as a way for the larger prime contractors to reduce costs in finding appropriate, high quality and local suppliers in the Central Belt and Scotland.

#### **4. Institutional and policy support for AM**

The Scottish Government’s (2015) economic strategy for Scotland is focused on competitiveness *and* inclusion both spatial and social<sup>10</sup>. It has evolved from the earlier ‘Smart, Successful Scotland’ (2004) strategy’s narrower focus on GVA growth and key companies<sup>11</sup>. The current strategy has an explicit focus on manufacturing. The sector is considered of strategic and long-term economic importance to the Scottish economy because of its relatively high proportion of R&D and exports, potential for productivity growth, internationalisation, and higher quality and better paid employment. Manufacturing is recognised as a continued source of jobs, albeit at lower than historic levels due to productivity improvements and changes in the sectoral and functional mix of activities in Scotland.

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<sup>10</sup> Scottish Government (2015) Scotland’s Economic Strategy, Scottish Government: Edinburgh.

<sup>11</sup> Scottish Government (2004) A Smart, Successful Scotland, Scottish Government: Edinburgh.

The Scottish Government's strategy 'Manufacturing Future for Scotland' (2016) aims to support the sector's development and its 'Manufacturing Action Plan' (MAP) (2016) is focused on thematic areas<sup>12</sup>. Currently in development is the 'Making Scotland's Future' initiative which, when launched, will have a wider breadth and scope than the MAP. It will focus on priority programmes on supply chain competitiveness, the National Manufacturing Institute for Scotland (NMIS), skills and leadership, industrial partnerships and collaborations, networks and alliance, communication, and engagement. The strategy and initiatives for manufacturing are led by the Minister for Business, Fair Work and Skills in the Scottish Government and sit within the Business, Industry and Innovation team within the Economic Development Directorate. The lead agencies are Scottish Enterprise and Skills Development Scotland working together with local authorities. While the Manufacturing Advisory Service was withdrawn in England since 2015-16, the Scottish Manufacturing Advisory Service (SMAS) continues across Scotland providing business support through regional hubs in the west, east and north.

AM is defined in the Scottish policy setting as 'high value manufacturing' (HVM) meaning technology and innovation-based manufacturing. For HVM, "more knowledge is wrapped around the physical good" and there's "lots of value in the design" (Director, research institute, author's interview, 2019). Evolving from a "vertical sector view of the world to think about cross-cutting capabilities", HVM spans multiple sectors and is seen as a "real area of competence" in Scotland with "clear capabilities" for future development based on its "value propositions" (Managing Director, economic development agency, author's interview, 2019). Drawing upon some project and programme level evaluations of specific interventions, purely sectoral approaches were interpreted as overly narrow and unable to reach across wider groups of firms of various sizes involved in different kinds of AM activities. Overall, strategy for HVM is taking a "long-term, focused approach" based on "cutting-edge innovation and R&D" rather than "revitalising manufacturing history" or "rekindling traditional sectors" (Policy lead, economic development agency, author's interview, 2019). Reflecting the national economic

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<sup>12</sup> Scottish Government (2016) Manufacturing Future for Scotland and Manufacturing Action Plan Scottish Government: Edinburgh.

strategy focusing on competitiveness and inclusion, the aims are twofold: to “nurture the highest end to international competitiveness” and to “take every company forward on the innovation journey” (Policy lead, economic development agency, author’s interview, 2019). This strategy has evolved from the 1990s approach focused on increased commercialisation from research, increasing business expenditure on R&D, higher start-up rates, and growth in the firm base especially creating larger scale businesses and attracting and embedding foreign direct investment (FDI).

Informed by a review of international policy approaches<sup>13</sup>, the approach to supporting HVM is underpinned by the ‘innovation district’ model and anchor role of universities<sup>14</sup>. Funding is from the UK and Scottish governments and universities. The aim is to build geographical co-location spatially to concentrate and “get an agglomeration around that place” with interaction amongst specialised goods and service suppliers, knowledge spill-overs and thick labour markets of skilled people (Managing Director, economic development agency, author’s interview, 2019). Strategy delivery is based upon cross-cutting, technology-based research and innovation institutes. This approach has evolved from the earlier Scottish Enterprise-funded intermediate technology institutions focused on specific sectors such as electronics and life sciences. It seeks to reflect international policy approaches that work across sectors because industry boundaries are breaking down and innovations are emerging in the novel overlaps and cross-fertilisation between AM activities. The aim has changed towards investing in institutes and buildings as “physical build, shared to cut across sectors, then map back into specific sectors” and having a wider reach across manufacturing activities rather than more narrowly sectoral organisations catering to specific industrial sectors (Principal, university, author’s interview, 2019).

The Advanced Forming Research Centre (AFRC) was established in 2010 as the “sister institution” to the Advanced Manufacturing Research Centre (AMRC) linked to University of Sheffield in Rotherham, South Yorkshire (Principal, university, author’s

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<sup>13</sup> Upper Quartile (2014) Scottish Manufacturing Research Study, Upper Quartile: Edinburgh.

<sup>14</sup> Technopolis (2017) Advanced Manufacturing Innovation Districts: Lessons for Scotland, Technopolis: Amsterdam.



interview, 2019). The strategic partnership in Scotland was with Strathclyde University which is playing a leading and catalyst role aiming for “all round upgrading of the manufacturing base in Scotland” (Business Development Manager, university, author’s interview, 2019), building upon its capabilities in manufacturing engineering, technology and management. The AFRC sought strategically to connect with national UK institutions and funding because it needed Scottish Enterprise and Strathclyde University co-investment to be a “credible partner” for the UK High-value Manufacturing Catapult and its wider network and aimed to “magnetise the location” to attract other AM activities from Scotland, the UK and internationally (Principal, university, author’s interview, 2019). The AFRC proved the viability of the tiered membership subscription business model. The experience of this centre has since supported the development of the Lightweight Manufacturing Centre in 2017 which became the first stage of the NMIS. These investments have been followed in 2018 by the Medicines Manufacturing Innovation Centre (MMIC) in partnership with lead firm Glaxo Smith Kline with the aim to “force up tech readiness” and “industrial scale demonstration” in the pharmaceutical sector (Principal, university, author’s interview, 2019).

This institute-based strategy is central to the Scottish Government-supported geographical and cumulative concentration of investments to create the NMIS as the core of a new ‘Advanced Manufacturing Innovation District for Scotland’ (AMIDS). The AMIDS is located at Inchinnan which was “in Renfrewshire but for the benefit of all of Scotland” (Managing Director, economic development agency, author’s interview, 2019). NMIS is seen as “a strategic national investment and the main centre” and hub to “foster and encourage development of other centres” (Policy manager, Scottish government, author’s interview, 2019). Technology-based centres were to “co-locate with NMIS” with the ambition of building a “research and innovation ecosystem” and the “cluster became the way to critical mass” (Principal, university, author’s interview, 2019). NMIS also includes engineering capability for specialist support and training and outreach.

Matching key elements of the ‘innovation district’ model and following a shortlisting process, the location at Inchinnan was selected because of its abundant land and space for future expansion, link into the wider Glasgow city-region labour market,

access to university expertise, close proximity to Glasgow airport as well as road and rail connections, co-location with lead firms (e.g. Rolls-Royce) and existing local business base, and historic position and role as Scotland's technology park. In addition, Renfrewshire Council owned the site and its development fitted with wider local and regional economic regeneration ambitions for this historically disadvantaged area and aim to improve connections from south of the Clyde into Glasgow and the north. Fundamentally, the geographical setting was vital:

Place was important...If all distributed fine but bringing in Chief Technology Officers from large international companies they want to see scale, credibility, connectivity, infrastructure. They want to build into what's already going on (Principal, university, author's interview, 2019).

The establishment of AMIDS has been supported by other public policy interventions including a £39m investment in site assembly and access roads as part Renfrewshire Council's involvement in the Glasgow City Region Deal and its infrastructure investments to support growth and employment creation. NMIS also includes the Manufacturing Skills Academy providing apprenticeships, technical education and links to universities. From its location at Inchinnan, NMIS is complemented by supporting networks reaching across Scotland. These initiatives include university-industry research consortia and NMIS industry doctorates delivered through the cross-university Scottish Research Partnership in Engineering, with the aim to "connect broader academic community to opportunity" (Principal, university, author's interview, 2019). Also informed by the 'innovation district' model and currently in development are the Glasgow City Innovation District (GCID) led by Strathclyde University around its campus east of the city centre and the Glasgow Riverside Innovation District (GRID) led by the University of Glasgow in the city's west end.

## **5. Institutional and policy issues**

There are a number of priorities and issues with the current approaches, institutional arrangements and policies for HVM in Scotland and the case study AM sectors in the

Central Belt. First is developing from the National (Scotland) Manufacturing Action Plan and linking to and translating UK Government policy and funding opportunities for Scotland. This effort has included trying to raise awareness and encourage further involvement by Scottish firms, especially SMEs, and institutions in UK Industrial Strategy funding initiatives including the Strength in Places and Industrial Strategy Challenge Funds and specifically UK-wide sector deals, for example in aerospace, artificial intelligence, automotive, and life sciences. Such programmes are currently seen as a “centralised, big ticket, London-based enterprise” and, apart from the Strength in Places Fund, “none of them have that geographical issue baked into them...so again the perception is that the money is being sucked into regions already ahead of the game...London and South East and midlands” (Policy manager, economic policy organisation, author’s interview, 2019). Activities have included enabling and supporting close relationships with key UK-level institutions and funders for co-investment including the UK Department for Business, Energy and Industrial Strategy (BEIS), Innovate UK and UKRI. Connected into linking to UK initiatives is the replacement of formerly EU-funded manufacturing support initiatives in Scotland following Brexit, especially for SMEs, including the Advanced Manufacturing Challenge Fund and Low Carbon Challenge Fund, and accessing the funding potential of the new Scottish Investment Bank aiming at “crowding in patient capital” (Managing Director, economic development agency, author’s interview, 2019).

Further developing HVM, second, is a priority to address weak productivity and bolster internationalisation in Scotland’s relatively small open economy, especially in the context of Brexit. HVM is considered uniquely placed to contribute to this ambition because it contributes over 50% of R&D expenditure and exports and, while accounting for 10-20% of employment, its jobs tend to be higher quality and better paid. Support aims to help firms in “moving up the value chain” (Director, trade association, author’s interview, 2019), connecting “to where the knowledge base is strongest” in Scotland (Director, research institute, author’s interview, 2019), improving and upgrading their activities, and connecting manufacturing to services to capitalise upon new opportunities from ‘servitisation’. There is recognition that while there is “political attraction to the manufacturing label because it harks back to a past that was understood”, too narrow and outdated a view of manufacturing “may get in

the way of the value is being added” given its increasing integration with services (Director, research institute, author’s interview, 2019). Mirroring the national situation<sup>15</sup>, HVM in Scotland has “superstar firms” that are active and then a “long tail” with “less knowledge and engagement” but “great potential to grow and improve” (Director, trade association, author’s interview, 2019). Reflecting international debates<sup>16</sup>, the key issue is whether to focus available support and resources on the top end for further productivity growth, the middle with greater potential for productivity growth or the bottom end given its potential for employment creation and inclusion. Or, rather than prioritise, attempt to cover the whole range of firms simultaneously. The Scottish Government approach aims to “bridge that gap between regular and advanced manufacturing and bring in a wider tail of companies” (Policy manager, author’s interview, 2019). SMAS is key in leading on productivity improvement for SMEs and ensuring clarity in the system on where they can go to access specialist support and services. The Scottish Government and Scottish Council for Development and Industry ‘Productivity Club Scotland’ also aims to improve productivity through SME peer-to-peer learning to encourage and support workplace innovation and fair work. Related to the national economic strategy’s emphasis upon competitiveness and inclusion, the ‘Fair Work’ agenda aims to boost productivity, mobilise untapped potential and stimulate innovation<sup>17</sup>. A specific concern is the difficulty of seeding and embedding R&D activities in firms without such functions and staff since “easiest to engage are the high achievers who understand the innovation conversation” (Business development manager, university, author’s interview, 2019). Again, reflecting the inclusion agenda, the priority of improving productivity and competitiveness is married to the concern with creating ‘better jobs’ since there is already a relatively high employment rate in Scotland but the jobs are often not high enough quality and paying high enough wages. There is a spatial dimension to this ambition to improve productivity and wage levels through business development and investment as there is a “geography

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<sup>15</sup> Haldane, A. G. (2018) The UK’s Productivity Problem: Hub No Spokes, Academy of Social Sciences Lecture, 28 June, London, <https://www.bankofengland.co.uk/-/media/boe/files/speech/2018/the-uks-productivity-problem-hub-no-spokes-speech-by-andy-haldane>

<sup>16</sup> Andres, D., Criscuolo, C. and Gal, P. (2015) Frontier Firms, Technology Diffusion and Public Policy: Micro Evidence from OECD Countries, OECD: Paris.

<sup>17</sup> Scottish Government (2019) Fair Work Action Plan, Scottish Government: Edinburgh.

to that...some places need everything they can get, others not” (Policy lead, economic development agency, author’s interview, 2019).

A third issue is reconciling cross-sectoral technology (e.g. advanced forming) *and* sectoral (e.g. aerospace) approaches to supporting HVM. There appear to be different approaches amongst partners trying to articulate and manage these relationships: a “matrix approach” (Business development manager, university, author’s interview, 2019); “network” (Policy manager, Scottish Government, author’s interview, 2019); and, a “vertical lens [sectoral] and cluster lens” intersecting sectors in place (Policy lead, economic development agency, author’s interview, 2019). Expressing the approach is challenging given the need to understand particular firm, sectoral and technological issues in specific AM activities. Traditional ‘sectors’ are also changing and reconfiguring, especially through manufacturing and service integration and the emphasis on “bespoke, designed solutions to address [market] needs” (Director, research institute, author’s interview, 2019). In addition, there are some differences in the locational needs and general industrial dynamics amongst specific AM sectors. A key challenge is connecting the innovation mission-oriented and cross-sectoral approach with SMEs and translating its higher-level and transformative principles into concrete and practicable actions. Business associations are active in trying to engage SMEs using specific challenges and technologies – for example shifts from metals to composites and laser scanning – and enabling “cross-fertilisation across sectors” to address common issues, work out potential solutions and share good practice as well as using larger firms as the foci for supply chain linkage initiatives for SMEs in Scotland (Chief Executive, business association, author’s interview, 2019). As the new HVM support institutions develop, a key issue is ensuring they are connected to the existing R&D activities being undertaken in the Central Belt and potential R&D and innovation funding programmes.

A fourth issue is managing the tension between “trying to balance co-location and national spread and reach” between the manufacturing hub and two Glasgow urban ‘innovation districts’ at the western end of the Central Belt with Scotland-wide reach social and spatial inclusion. (Policy manager, Scottish government, author’s interview, 2019). Achieving and benefitting from the dynamism of geographical

concentration is connected to the aims of the national Scottish Government and partner strategy and investments “to service [the] whole of Scotland” given the “regional equity agenda” (Policy Lead, economic development agency, author’s interview, 2019). The spatial policy challenge is seen as acute because “geography is more of an element in Scotland because its 5m people are regional size but spread out with many distinct economies” (Director, research institute, author’s interview, 2019). This issue is especially important given the ambition and plan to continue growth in the AMID Scotland hub and acknowledgement that the “manufacturing economy is spread across Scotland” (Policy lead, economic development agency, author’s interview, 2019). Support exists for the strategy of “the long game, build the hub” while recognising that “the most important bit of NMIS is not equipment but the skills thread and workstream – as relevant for companies across Scotland from the borders to Aberdeen” (Chief Executive, business association, author’s interview, 2019) since “firms can use the capacity...but not have to be physically located there” (Managing Director, economic development agency, author’s interview, 2019). While some actors felt there was not much “geographical jealousy about the concentration of investment and institutions in Renfrewshire” (Director, trade association, author’s interview, 2019), others expressed concern that “other parts don’t feel left out” (Chief Executive, business association, author’s interview, 2019).

Accommodating the spatial concentration with the national reach and Scotland-wide geography remains a key issue. It is especially important as places across the Central Belt in particular retain “the culture and identity of...being a manufacturing location” and local authorities and partners “don’t want to lose the manufacturing base” (Policy manager, Scottish government, author’s interview, 2019). Some specific and closely proximate geographical links are being made, for example initiatives in the Central Belt linking to Prestwick airport and aerospace activities in South Ayrshire. Indeed, there is a view that the relatively small size of the Central Belt and Scotland meant the nearby locations of HVM firms “could be exploited more” and concerns whether spending could be further “concentrated” since a sector such as aerospace “likes scale, concentration more bang for buck don’t scatter or achieve nothing” (Director, trade association, author’s interview, 2019). The potential for further urban ‘innovation districts’ in other Scottish cities if the model proves

effective in Glasgow was raised alongside concerns about whether further and additional investment in other academically-driven centres will be able to make links to SMEs and other firms and stimulate wider economic development in the Central Belt and beyond.

Fifth is the concern with skills gaps and manufacturing workforce renewal and career paths. Skills gaps are evident across occupations, from shop floor precision machining staff through to graduates. These issues have caused labour poaching, staff turnover and wage inflation. Such effects “end up squeezing margins” because in key sectors such as aerospace “output cost and price won’t move” and examples exist of the loss of business to operations in France and Germany because the firms “didn’t have the skills locally” (Chief Executive, business association, author’s interview, 2019). The ageing manufacturing workforce and broader population in Scotland is creating a replacement skills challenge that is “acute in Scotland compared to England” because of its demography (negative population replacement rate), relatively narrow cohorts of younger people, loss of EU nationals since the 2016 EU referendum and Brexit, and uncertainty over future immigration regulation (Chief Executive, business association, author’s interview, 2019). Key challenges are in the attraction and retention of people and upskilling existing workforces especially those with “with some level of knowledge but not formal skills or accreditation” to “get them quickly to the level of being useful in manufacturing” (Chief Executive, business association, author’s interview, 2019). Skills shortages are stymying capital investment in equipment that could increase productivity because firms “can’t find people to work it” (Policy lead, economic development agency, author’s interview, 2019).

As the “world of work is changing, skills [are] changing”, a strategic challenge is ensuring a “long-term skills pipeline” to “meet demand from existing and new entrant companies” and “always having to make sure we match the reality of modern manufacturing and shift people’s perceptions” (Director, trade association, author’s interview, 2019). Especially for younger people, perceptions of manufacturing as “dirty, uncertain, low productivity” (Policy lead, economic development agency, author’s interview, 2019) are considered incorrect and/or outdated given much of it, especially in HVM, is clean and high-tech. Manufacturing firms also perceive that

“young people can’t hack it or don’t want to enter the sector” (Director, trade association, author’s interview, 2019). This situation has created a clear need to “build the sector as a positive destination for young people” (Policy lead, economic development agency, author’s interview, 2019). Apprenticeships programmes are in place but the Apprenticeship Levy is interpreted as “extra tax” by some businesses and, while the delivery system is different to England and administered by Skills Development Scotland, firms claim they get much less back than they are paying in the levy and for the larger firms this is a small proportion of what they are contributing and assess they need to invest in training (Chief Executive, business association, author’s interview, 2019).

Substantial potential exists to better link HVM’s skills issues with the Scottish Government’s inclusive growth agenda in matching demand for skills from HVM companies and providing a pool of appropriately skilled labour to take up the opportunities and close the skills gaps. Indeed, the Fairer Scotland (2018) duty means those in receipt of public funding, such as NMIS, are assessed on their compliance and contribution. For manufacturing firms, the inclusive growth agenda is considered “not too difficult to sell” since most already pay above minimum wage levels and have the potential to help address the “skills conundrum”, for example through bringing in more women and people from black and minority ethnic groups (Chief Executive, business association, author’s interview, 2019). Glasgow City Innovation District, for example, is addressing wider benefits for the local community including recruitment, apprenticeships, work readiness programmes, and internships. Specific initiatives have included gender-focused programmes to encourage more women to consider engineering and manufacturing careers in traditionally male-dominated sectors and outreach activities to engage students at school. Further and higher education institutions too are committed to widening participation and links to provide pathways through engineering programmes as springboards to university entrance, for example City of Glasgow College’s 2-year HND does not require a physics qualification and aims to provide a catch-up qualification.

Benchmarking and understanding adaptation gaps amongst manufacturers in the Central Belt and Scotland for the ‘4<sup>th</sup> industrial revolution’ or ‘Industry 4.0’ transitions towards digitisation and integrated cyber-physical systems is a sixth issue. Currently,



Scottish Enterprise and SMAS have undertaken diagnostic reviews of 180 mostly SME firms from HVM and other manufacturing sectors across Scotland<sup>18</sup>. The reviews compared each company's current to desired future state and sought to align business strategy with new technology adoption projects to close the gaps identified. Creating a tailored 'digital roadmap' for each firm, the aim is "laying the groundwork for industry 4.0" (Policy officer, economic development agency, author's Interview, 2019), especially since "some of the companies we're dealing with are at 2.0!" (Policy manager, Scottish government, author's interview, 2019). Overall, the review found many individual firms have invested in specific technologies but had not developed longer-term industry 4.0 strategies. Key issues include effective utilisation of business data, upskilling existing workforces, recruiting people with the new digital skills, leadership and change management, process optimisation, product development especially links to services and low carbon, and integrated software systems. Some manufacturing SMEs, for example, "are still running spreadsheets" or "stuck with old systems" that need moving onto more flexible, cloud-based systems (Chief Executive, business association, author's interview, 2019). Existing integrated services and facilities to support adaptation were noted by the firms reviewed. Identifying and providing productive capacity at scale is a key issue for specific sectors, for example large scale additive or 3D printing technologies for the aerospace sector (Director, aerospace supplier, author's interview, 2020). Further promotion of the new institutions to support HVM – such as AFRC and NMIS – is seen by some as key to raise awareness of the specialist services available, especially amongst SMEs. Difficulties were acknowledged in relating new technologies to delivering benefits to customers and connecting investments in new technologies to improved financial returns. Of vital importance was shifting SME time frames from short-term concerns such as "covering next month's salaries" towards medium to longer-term, 5 to 10 to 15 year "over the horizon" issues such as new materials and technologies (Director, trade association, author's interview, 2019).

Strategies include building a "translational partnership with industry to ensure the demand side is there" for new innovations and technologies (Principal, university,

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<sup>18</sup> Scottish Enterprise (2020) Industry 4.0 Review: Findings and Recommendations, Scottish Enterprise: Glasgow.

author's interview, 2019) and "democratising" and embedding the wider culture of "lean, continuous improvement" across a broader range of SMEs across Scotland (Chief Executive, business association, author's interview, 2019). Initiatives have included supply-chain focused activities for key and lead firms to explain their strategy and future direction to encourage SMEs to be more strategic and to provide confidence to underpin potential investments in new technologies for example additive or 3D manufacturing. Transitions towards Industry 4.0 also magnifies the skills issue and demand for people with digital skills to "understand how things can connect in different ways" (Chief Executive, business association, author's interview, 2019).

A last issue concerns the UK's future trading arrangements in the wake of Brexit. HVM sectors in the Central Belt and across Scotland are unevenly internationalised. There is some potential for 'reshoring' or 'onshoring' activities previously undertaken overseas. Scottish Enterprise is keen to attract more HVM FDI as expansions or greenfield investments, especially to build co-locations of supply chains and, through after care and embedding activities, to retain and secure future re-investments. There are few examples of reshoring to date but evidence of a "change in attitude" and desire "to have supply chains closer to be able to exert more control" with SMAS focusing on "saving money and on-shoring" (Chief Executive, business association, author's interview, 2019). In parallel, and amidst the uncertainty about future economic conditions and trading arrangements, there is potential for further internationalisation within existing European markets and key growth areas China, Indonesia, India, and central Africa.

## **6. Conclusions and recommendations**

The strategic prioritisation of manufacturing and HVM specifically in Scotland is underpinned by dedicated institutional and policy support for its further development and growth. In this way, it demonstrates and underlines its potential to contribute to spatial rebalancing or 'levelling up' across the UK by retaining and growing AM in Scotland. Indeed, there may be further potential to expand supported by the current UK government's aims to disperse innovation and science capacity more evenly

across the country and reduce its geographical concentration on the ‘golden triangle’ in London and the South East. The impact of the COVID-19 pandemic, recession and economic recovery will also shape how AM in the Central Belt and Scotland develop, presenting both potential opportunities and problems. The distinct geography of AM in the Central Belt and Scotland does raise issues about balancing the emphasis upon geographical concentration around innovation hubs and the spatial reach and connections across Scotland.

How much HMV is able to retain and increase its contribution in terms of R&D, exports and high quality employment in the Central Belt and across Scotland more widely will be shaped by broader economic shifts and industry dynamics as well as how successfully its firms and institutions and policies are able to address key strategic and longer-term issues. Such concerns include accessing public support programmes especially for innovation and R&D, improving productivity and upgrading activities and positions in often international value chains, appropriately connecting technological and sectoral support, managing the geographical concentration and national Scotland-wide reach of initiatives, addressing the skills and inclusion challenges, adaptation for Industry 4.0 transitions, and the UK’s changing future trading arrangements.

Potential changes for approaches, institutions and policies centre upon co-ordinating, integrating and refining the existing package of interventions to support and nurture AM’s development in the Central Belt and Scotland – “gardening rather than engineering” (Director, research institute, author’s interview, 2019). The potential areas include:

- Designing new and reforming existing initiatives and incentives to increase the connection and flow of university research into AM business R&D and innovation activities in the Central Belt and across Scotland. There is potential to link this aim into the new UK Shared Prosperity Fund and replacements for other EU regional policy funded initiatives in Scotland. Building upon its

broadly positive earlier evaluation and key areas for improvement<sup>19</sup>, the SMAS has a key role to play specifically in reaching, connecting and translating the innovation challenge and cross-sectoral approach into concrete and practical actions and projects amongst SMEs through its tailored advisory approach.

- Connecting the Scottish Government’s inclusive growth focus into the UK Government’s ‘levelling up’ agenda and the HM Treasury Green Book review on appraisal for business cases for public sector intervention. The challenge here is to “find measures more sensitive than just GVA” and “recognise the value of investment in jobs in certain places...for example, X jobs in location A in disadvantaged place [is the] same as X+1 jobs in local economy B the more prosperous and buoyant economy” (Managing Director, economic development agency, author’s interview, 2019).
- Creating ‘STEM Ambassadors’ for primary and secondary schools to “inspire the next generation” to become the “engineers and scientists in future” and “get involved in the value chains on your doorstep” (Director, aerospace firm, author’s interview, 2020).
- Providing further incentivisation for further and higher education institutions to innovate in their programmes and pathways with a STEM focus to support building a wider and deeper skills pipeline into AM, linking to the widening participation and inclusive growth agendas. Potential opportunities exist through the Scottish Government’s devolved powers and Scottish Funding Council management and governance.
- Tailoring of national UK apprenticeships funding and policy to Scotland-specific skills challenges. Work has been undertaken in this area and further potential opportunities exist through the Skills Development Scotland delivery system.

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<sup>19</sup> EKOS (2012) Strategic Evaluation of SE Efficiency Support (including the Scottish Manufacturing Advisory Service), EKOS: Glasgow.

- Reviewing and refining the current support for adaptation and Industry 4.0 transitions. AM industry actors called for a shift from grants which were seen as too complicated, time consuming, expensive and with uncertain outcomes especially for SMEs – “a long way to say no” (Chief Executive, business association, author’s interview, 2019). New approaches were identified, for example considering the potential for a higher level tax incentive approach to encourage investment such as the approach in Italy<sup>20</sup>. Such opportunities would need Scottish and UK government alignment given devolved and reserved powers on tax policy.
- Considering an increased policy focus and emphasis upon technology absorption and readiness amongst especially AM SMEs<sup>21</sup>. Specifically, one idea is developing the service-orientation of the existing and newly established technology institutes to enable start-up and SME access to high cost capital equipment and avoid having to raise finance for its purchase or lease. Potential exists for initiatives through SMAS, linking to the new Scottish Investment Bank.
- Enhancing the monitoring and evaluation of the strategy and initiatives supporting AM. The evidence of the effectiveness of the overall approach and specific projects and programmes was somewhat mixed and uneven. Actors involved recognised the need for strengthened monitoring and assessment better to inform the continuing evolution of the institutional arrangements and policies for HVM.

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<sup>20</sup> HP and AT Kearney (2019) 3D printing: The 4<sup>th</sup> Industrial Revolution – Ensuring Manufacturing Leadership in the 21<sup>st</sup> Century, Palo Alto, CA. and Chicago, IL.

<sup>21</sup> Harris, R., Sunley, P., Evenhuis, E., Harris, J., Martin, R., Moffat, J. and Pike, A. (2020) The Effect of Spatial Proximity on R&D and Innovation – Evidence from British Advanced Manufacturing, Presentation, Available at [http://www.manufacturing-regions.org.uk/working\\_papers\\_&\\_downloads/](http://www.manufacturing-regions.org.uk/working_papers_&_downloads/)