UK Levelling Up R&D Mission Effects:

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UK Levelling Up R&D mission effects:
A multi-region input-output approach

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Abstract:

This paper examines the UK implications for regional and national growth associated with different geographical investment patterns of publicly-funded R&D, in the light of the recommendations of the 2022 Levelling Up White Paper, aimed at balancing the national economy. The White Paper outlines twelve main "missions" focused on science, technology, and education to achieve this goal. One of these missions aims to increase domestic public Research and Development (R&D) by at least 40% outside the Greater South East (GSE) by 2030. We develop three scenarios based on different assumptions about extra R&D allocation. We use data from UKRI and ONS to determine the current distribution of R&D investment in the UK, and then using the multi-regional Socio-Economic Impact Model for the UK we evaluate our three proposed R&D spending scenarios. Our findings suggest that the regional impact varies significantly across the different proposed scenarios. The scenario that allocates more GERD to areas with previously low funding levels yields the largest effect. On average, output, employment and GVA in regions outside GSE increase by 0.33%, 0.37% and 0.34%, respectively, showing a potentially positive effect on the levelling up of R&D in the country. Our analysis of both internal and external multipliers highlights the importance of investing in regional redistribution. We demonstrate that the GSE is more self-sufficient as it has much higher internal multipliers than the rest of the UK. However, we identified a potential obstacle: the capacity to absorb human capital, which could reduce the expected positive results of a more spatially balanced R&D expenditure across the UK.

Keywords: Multi-region input-output, R&D, levelling-up, UK.

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1. Introduction

The aim of the paper is to assess the likely implications of different approaches and different logic of shifting publicly funded R&D across UK regions. Alternative redistributive approaches may give rise to other regional and national implications, so understanding how the various policy approaches interact with the regional economic structures is essential. We deploy a UK-specific multi-regional input-output model to analyze these issues but set it in the context of the international evidence to motivate our framing of alternative scenarios.

The context to this aim is that in 2022, the UK Government launched the Levelling Up White Paper (HM Government, 2022a). A central theme of the white paper is to address the high levels of centralization in the UK and the uneven economic outcomes observed across UK regions in recent decades (McCann, 2016; Martin et al., 2021). To rebalance the national economy, the White Paper sets twelve main “missions” to level up the UK economy centered around science, technology, and education (HM Government, 2022b).

One of its twelve core “missions” is focused on increasing the levels of domestic publicly funded Research and Development outside the Greater South East of England (GSE) by at least 40% by 2030:

"By 2030, domestic public investment in R&D outside the Greater South East will increase by at least 40%, and over the Spending Review period by at least one-third. This additional government funding will seek to leverage at least twice as much private sector investment over the long term to stimulate innovation and productivity growth." (UK HM Government, 2022)

For a long time, current publicly funded R&D in the UK has been heavily skewed toward London and the Greater South East (GSE). Sub-national R&D distribution in the UK, based on the UKRI and ONS databases, is unevenly distributed, with GSE accounting for 53.5% of the UK’s Private R&D spending and 57.5% of the UK’s Government and UKRI R&D expenditure in 2019. UKRI data (2023) shows that 53.1% of Research Council and Innovate UK spending in England in FY2020/21 (and a combined total of the two) were spent in London (19.7%), the South East (22.3%), and the East of England (11.1%). These figures include grants awarded to universities and research institutes, including research grants, training grants, fellowships, and research infrastructure capital. Innovate UK spending includes innovation grants as well as other funding spent on the national network of Catapult centers, Knowledge Transfer Network, and Enterprise Europe, while the data excludes Research England QR funding data, devolved administration equivalents, or any other centrally managed UKRI spending from programs such as Strength in Places (HM Government, 2022c). Significantly changing this spatially skewed distribution will be a major challenge.

The proposed increased public investment in R&D (*R&D Levelling up mission*) is set to expand across the North, Midlands, South West, Scotland, Wales, and Northern Ireland. It will seek to leverage at least twice as much private sector investment over the long term to stimulate innovation and productivity growth across the country (HM Government, 2022b). This mission aims to increase research and innovation capacity around the UK, reducing spatial disparities in R&D investment and activity and improving intangible capital and living standards across the UK.

While the 2021 Autumn Budget and Spending Review (HM Government, 2021) provided indications of the government's commitments to increasing annual public R&D spending from a bit less than £15 billion to £20 billion over the next three years, and the UK Science and Technology Framework takes a systemic approach to science and technology in the UK (HM Government, 2023), the Levelling Up White Paper sets up clearer plans for how it should be spent and locally redistributed (Jones, 2022). Based on these documents and combining information from data from different UKRI and ONS sources, we calculate the current UK R&D sub-national and sectoral distribution (public and Business enterprise Expenditure on R&D (BERD)) and set up different redistribution scenarios of R&D spending in the UK.

The rest of the paper is structured as follows. In the following section, we briefly review the literature that evaluates the effect of innovation policy on economic growth and economic cohesion in general and using input-output in particular. Next, we detail the data and method used, establishing three potential scenarios for the distribution of R&D investment across UK regions. Afterwards, we present our findings, differentiating the national, regional, and sectoral effects. Finally, the consequences of levelling up are discussed.

2. Assessing the effect of R&D public support on economic growth and cohesion

2.1. The effect of R&D on economic growth and cohesion

Empirical studies have been conducted for decades using various methodologies and data to evaluate the impact of government investment in R&D on performance measures. At national and sub-national levels, the results of policies have acknowledged the benefits of investments in intangibles, and in particular, R&D programs (Becker, 2015).

Theoretically, two main theories have explained the positive impact of R&D investments and expenditures on economic growth and convergence: the neoclassical growth theory and the evolutionary economics theory.

According to the neoclassical growth theory, funding for R&D through the development and adoption of new technologies and innovations, human capital development, and new ventures contributes to improving economic growth and convergence. Firstly, neoclassical theory indicates that public R&D can lead to the development of new technologies and innovations that can enhance performance measures, such as productivity and efficiency, in various sectors of the economy, ultimately leading to economic growth and improved standards of living. These innovations will normally include new products, services, and processes that can transform industries and make them more globally competitive (Solow, 1956). Secondly, R&D is a good promoter of human capital development as it helps attract and retain talented researchers and scientists. These actors contribute to the growth of the local knowledge economy by creating new knowledge and ideas, which can be applied in different sectors of the local economy (Lucas, 1988; Romer, 1990). Lastly, R&D can stimulate entrepreneurship and innovation by creating new business opportunities and jobs. This can lead to an increase in local economic activity and ultimately economic cohesion, as new businesses can help to reduce unemployment rates, increase income levels, and improve the overall local quality of life (Geroski, 1989; Aghion and Howitt, 1992).

The evolutionary economics theory considers that economies are dynamic and constantly changing. Places learn from previous experiences and failures as well as successes. Historical paths, interrelations (Cohen and Levinthal, 1990), and technological change (creative destruction, Schumpeter, 1942) play key roles in explaining the dynamism of economies. Funding in R&D contributes to the creation of innovations (creative destruction) in the form of new ideas, products, and technologies replacing the old ones, which will have an associated increase in productivity and, ultimately, economic growth. Entrepreneurship and jobs supported by the implementation of new technologies will create new profitable opportunities and associated competitive advantages for places. Examples of disruptive technologies in today's world are new software products (Chat GPT), the rise of streaming services (Netflix), the growth of e-commerce, fintech startups, or the development of new energy technologies (solar and wind power). However, evolutionary processes have emphasized the economic benefits of the first mover advantage and the way for new structures to emerge, creating long-term economic prospects and progress but at the same time potential economic divergence between places that are at the forefront of these developments and places that are lagging (Rodríguez-Pose, 2018; Vermeulen and Psenner, 2022).

Funding for R&D can have varying impacts on economic convergence based on a range of factors. The nature and quality of the R&D activities, the policy measures in places, and the absorptive capacity of the local economy are all key factors that can influence the outcome of R&D funding. If R&D funding is focused on narrow areas or not aligned with the local economy's needs, it may not achieve its intended results. This is because the R&D activities may not be well-suited to the local economy, which can limit their potential impact. Similarly, if there is insufficient infrastructure and institutions to support R&D activities, such as incubators, accelerators, and a trusted intellectual property system, the impact of R&D funding on economic development and convergence may be limited. It is therefore important to ensure that R&D funding is complemented by a supportive policy and quality institutional environment to maximize its potential impact (McCann and Ortega-Argilés, 2015 and 2022).

2.2. Measuring R&D on economic growth and cohesion

The modeling approach we adopt here to examine the impacts of R&D investment funding on UK regions has some comparators developed in other settings. Various types of general equilibrium empirical models, such as the HERMIN (Bradley et al. 1995) and QUEST (in't Veld, 2007; Roeger et al., 2008) suites of models, have been developed by the European Commission in order to examine the macroeconomic effects of EU regional policy. The former HERMIN models were constructed to assess the impacts of regional policy on the EU member states receiving funding, while the more recent family of QUEST models based on a fusion of Dixit-Stiglitz (1977) product-variety and Jones (1995) semi-endogenous growth-type frameworks were aimed at capturing the effects of human capital, technological change (QUESTII) and public infrastructure investments (QUESTIII). All these families of European Commission evaluation models displayed broadly positive output results from regional policy expenditure[1] in terms of patenting, consumption, import demand, and ultimately GDP. Unsurprisingly, the results are seen to vary according to country, but there is also evidence that the overall results are also beneficial for countries which are net contributors to the EU budget, due to the market expansion effects in weaker countries. Meanwhile, other types of evaluation approaches examining the externalities associated with R&D have been developed using input-output techniques (Dietzenbacher and Los 2002; Belegri-Roboli and Michaelides 2005; Brautzsch et al. 2015; Mardones and Velasquez 2021) or propensity-score matching-spatial econometric models (Scotti et al. 2022) applied to individual countries such as Germany, Greece, and Chile, as well as to groups of OECD or EU countries. These various model frameworks have found that R&D typically generates positive spillovers to the wider economy, both at the regional level and also via broader forwards and backwards inter-regional and inter-industry linkages, the magnitude of which depends on the nature and scale of the particular policy funding program. Importantly, these lines of research underscore the overall importance of R&D investments as potential wider growth catalysts.

The research approach we take here builds on and extends these traditions, but also adds a novel twist to the debates. Specifically, we consider the potential impact of R&D investments across a range of alternative regional funding-distribution scenarios using a under a multi-region and multi-sectoral input-output approach. This allows us to understand the wider regional and sectoral implications of R&D investments under different policy-funding regimes and different R&D allocation and distributional logics associated with these different policy approaches. As far as we are aware, these techniques have not before been used for these purposes and in this setting, and our research is motivated by explicit regionally-based investment shift commitments made recently by the UK government, the regional and national implications of which have not previously been assessed.

[1] The results show short-run smaller demand effects in the micro-founded QUESTII model than in the HERMIN model. The long-run output effects were similar in the QUEST and HERMIN, but larger in the EcoMod, (Bayar et al., 2007), while the employment effects in QUEST were smaller as in this model, productivity gains are passed on into higher wages (European Commission, 2007).

2.3. Absorptive capacity, returns to public R&D and economic growth and cohesion

Another theory that has provided a useful framework for understanding how institutional settings acquire and use external knowledge to improve performance measures is the absorptive capacity theory (Cohen and Levinthal, 1990). This theory advocates that institutions have a limited ability to absorb new knowledge (absorptive capacity). Absorptive capacity is a cumulative process that is heavily conditional to the prior related knowledge that the organization has as well as the framework conditions. Firms with higher absorptive capacity are better able to identify valuable external knowledge and to integrate it into their existing capabilities to, ultimately, improve performance. R&D investments, through human capital programs, promotion of networking activities, and research collaborations, are important to enhance the absorptive capacity of organizations and their places (Griffith et al., 2004; López-Bazo et al., 2006). World-leading R&D efforts often require significant local investment. Equally important is the presence of a skilled local workforce, which can greatly enhance a region's absorptive capacity. Highly skilled workers not only improve production capabilities and technology adoption but also make the region more attractive to potential investors (De la Fuente, 2011; Castellani and Pieri, 2013). It is important to note that not all regions can apply the same strategies for research and development, innovation, productivity, and economic growth. Albeit advanced technological regions generally benefit from these technologies, it may not be the case for converging countries or regions. Filipetti and Peyrache (2015 and 2017) show that in fast-growing EU regions, reducing the technology gap can be achieved by increasing endogenous technological capabilities, which can significantly contribute to growth. However, for regions that are far behind the technology frontier, labor productivity growth rates may not necessarily accelerate. This is because, in many cases, these rates are driven, with the gap related to technical change unchanged. Innovation, as we have seen, is a crucial driver of economic growth and development in today's world. However, innovation may vary in quality. Some less advanced countries and regions have made significant strides in advancing their technological capabilities, while others have fallen far behind the global technological frontiers. This disparity in innovation quality can be attributed to various factors, including differences in access to resources, education, and institutional support. As a result, these lagging countries and regions may face significant challenges in catching up to their more advanced competitors (Crescenzi et al., 2014; Dunning and Lundan, 2009).

Absorptive capacity has also been important in explaining the varied performance of specific programs and projects. Authors have argued that having a mix of local endowments (Sotiriou and Tsiapa, 2015), top-down and bottom-up policy balance (Crescenzi and Giua, 2016 and 2020) and a broad set of investments (Di Cataldo and Monastiriotis, 2020) aligned with local requirements (Crescenzi et al., 2017) will determine the success of R&D programs and projects at the local level. This also includes having the right prioritization (Driver and Oughton, 2008; Wostner, 2017).

As the Levelling Up White Paper highlights, investing in public R&D can generate knowledge spillovers that will benefit local communities (HM Government, 2022). By achieving the R&D Levelling Up mission, high-skilled jobs can be generated, and productivity and growth can be increased in regions outside London and the South East.

Following the research literature, we argue that the new redistribution of R&D public investments will generate benefits across the country. These benefits are expected to be higher in the most innovative regions as they have the innovative environment to acquire the funds (universities, high-tech firms, and other technological agents) as well as higher absorptive capacity. However, due to the interlinkages between UK regions and industries, the new redistribution will generate potential indirect effects (spillovers). Non-innovative and non-core areas will also benefit from the redistribution, but these benefits will be spatially and industrially uneven.

3. Data and Methods

As indicated in the previous section, there have been previous attempts to evaluate the impact of public R&D or cohesion programs using input-output techniques (Dietzenbacher and Los, 2002; Brautzsch et al., 2015). However, to our knowledge, there is yet to be any research trying to link the potential uneven sub-national spatial effects of R&D policy mechanisms with internal and external input-output multipliers (as a proxy of spatial spillover effects) as well as for the UK context.

3.1. The SEIM-UK model

To conduct a detailed impact assessment of the R&D policy mechanisms in the UK, we employ the recently created Socio-Economic Impact Model for the UK (SEIM-UK)[2]. The SEIM-

[2] Full notation on the estimation of the SEIM UK can be found in Carrascal Incera et al. (2021)

UK is a multi-regional input-output table for the UK, which shows a complete picture of the flows of goods and services in the UK economy (the base year of the tables is 2016).

SEIM-UK is a UK multi-regional input-output model (MRIO) that is extended to include features of the regional labor market and distinguish between the socioeconomic characteristics of households and their consumption patterns. Compared to a single region IO model, MRIO enables us not only to estimate the additional production that will take place to satisfy the increased demand but also to estimate spillover effects, which include the impacts of increased demand in one region on other regions. The SEIM-UK contains information on 41 UK NUTS2 regions, 12 UK NUTS1 regions, and 30 sectors (including manufacturing and services industries).

Given its extensive spatial and geographical granularity, the SEIM-UK model is a powerful tool for analysis that lies at the intersection of sectors and regions. For analyses that aim at capturing the systemic approach of sub-national economies and their interactions, such as capturing knowledge spillovers and multiplier effects.

3.2. The Leontief demand model

In this paper, we model the impact of changes in regional R&D expenditure using a Leontief demand model derived from the base SEIM-UK tables. A is a square matrix with dimensions $nm \times nm$, referred to as the matrix of technical coefficients. Within this matrix, each element a_{ij}^{rs} corresponds to the direct input requirements of sector j in region r for producing one unit of output in sector i of region s (Miller and Blair, 2010).

Then, the Leontief demand model can be expressed as:

$$X = (I - A)^{-1} f \qquad (1)$$

where I is an $nm \times nm$ identity matrix and f represents a $nm \times 1$ vector final demand. $(I - A)^{-1}$ is the Leontief inverse and often referred as type I output multipliers. The Leontief inverse enables us to track the economic wide impact on output changes in final demand (Miller and Blair, 2010).

In our analysis, we treat additional spending from the UK government on R&D as exogenous changes in final demand. Denote C as a vector of distribution of R&D spending across sectors and regions, then the new vector of final demand f^* after government increased spending is $f^* = C + f$.

In our analysis, we model three different scenarios of how C and f^* for the distribution of R&D across regions (detailed in section 3.2). Our focus is on the interregional redistribution. We assume the intraregional distribution of R&D expenditure within a region across sectors remain constant across all three scenarios.

The SEIM-UK, like other input-output models, has some limitations that should be outlined. When considering increases in R&D expenditure, it is likely that the technology and productivity within the industry will also increase (Solow, 1956; in't Veld, 2007; Roeger et al., 2008). However, static input-output models have fixed technology and productivity coefficients which fail to model changes in total factor productivity (Miller and Blair, 2010). The next phase of development for SEIM-UK analysis involves incorporating dynamic coefficients, which is essential when analyzing changes in total factor productivity. However, as our analysis focuses on improving the efficacy of levelling up policy measures by finding the best redistributive arrangements, dynamic coefficients are unnecessary.

3.3. Three potential scenarios for the distribution of R&D funding

Given the headline statistic that R&D spending will increase by 40 per cent outside the GSE, we consider three potential scenarios of how this spending could be distributed across regions. The three scenarios are informed by Ioramashvili (2022) and WMREDI (2022). In all scenarios, it is assumed that increased public funding is matched by two times the BERD. It is important to recognize that double matching by the private sector is a strong assumption and will likely vary by region. To address this, we provide a market-driven scenario to compensate for the difference in the distributional preferences of the private sector.

Scenario 1, 'Equal Uplift', assumes that the 40% increase is allocated to regions outside the GSE, maintaining the same distribution pattern as previous allocations of public funds. Under this scenario, we assume that the current distribution of public R&D funding is the most effective. The only issue identified is the total amount of funding, which we propose should be increased.

The formula for calculating the additional funding is as follows:

$$\text{Additional Funding} = \text{G} \times 0.4 \times \frac{\text{RG}}{\text{G}} \qquad (2)$$

where G stands for the original total public spending, RG stands for the original regional public R&D spending. $\frac{RG}{G}$ calculates the proportion of regional public R&D spending.

Scenario 2, 'Redistributive', assumes that there will be an overall 40% in public funding, which will prioritize regions that had historically received lower levels of public R&D funding. This scenario is based on the premise that the present regional distribution of public R&D spending is inefficient. It posits that a redistribution or rebalancing of funds could help narrow the disparities between developed and lagging regions.

The formula for calculating additional funding is as follows:

$$\text{Additional Funding} = \quad G \times \ 0.4 \ \times (\left(1 - \frac{RG}{G}\right))/8 \qquad (3)$$

Scenario 3, 'Market Driven', assumes that the government allocates funds based on market signals and that additional funding is distributed following the same pattern of private sector R&D expenditure. Under this scenario, we assume that an increase in public spending on R&D is most sufficient in regions already witnessing high R&D spending.

The formula for calculating additional funding is as follows:

$$\text{Additional Funding} = G \times \ 0.4 \ \times \frac{BERD}{G} \qquad (4)$$

In Table 1, we show the regional distribution of additional funding under three scenarios.

[Table 1 here]

3.4. Distributing increased public funding by sectors

Before discussing the potential outcomes of these scenarios, a discussion about the method used to disaggregate increased public funding is necessary. In total, we distinguish three sources of additional funding in each scenario: government, UKRI and BERD are distinguished, and each source of funds is disaggregated into 12 NUTS1 UK regions and 30 sectors. All data sources used to disaggregate additional funding are from 2019.

First, the UK National Statistical Office (ONS, 2022) provides information on the national distribution of BERD disaggregated in 30 NACE industries. Assuming that distribution across industries is the same for all NUTS1 regions, increased BERD has been disaggregated into 30 sectors within the 12 NUTS1 UK regions. The regional distribution of BERD is shown in Table 2.

[Table 2 here]

Second, UK Research and Innovation (UKRI, 2023) provides detailed data on the regional distribution of public funding. Four categories of organizations receive funding from UKRI: private businesses, public sector organizations, research organizations and universities. While the distribution of funding by organization type is not provided by UKRI directly, Innovate UK (2023) offers detailed information on funded projects, which can be used to infer how funding is distributed across different types of organizations. It also allows us to disaggregate private sector spending into 30 industries for all 12 NUTS1 UK regions, which is shown in Table 3.

[Table 3 here]

The latest independent evaluation of UKRI provides a clear illustration of the financial year 2020/21 disaggregation of research council and Innovate UK spending in the UK (HM Government, 2022c). Table 4 shows the proportion of research council and Innovate UK spending in England. As can be seen, there is a clear unbalanced distribution of funds across the UK England regions. The combined figure of research councils and Innovate UK shows that 59.3% of the funds in 2020/21 were spent in Greater South East (GSE) regions.

[Table 4 here]

To illustrate the distribution of UK R&D public funds among its devolved administrations, Table 5 shows the distribution by research council and Innovate UK spending. Figures provide information on grants awarded to universities and research institutes, including research, training grants and fellowships, as well as research infrastructure capital. Innovate UK spending includes innovation grants as well as funding on the national network of Catapult centers, Knowledge Transfer Network and Enterprise Europe. Data excludes Research England QR data, DA equivalents or any other centrally managed UKRI spending from programs such as the Strength in Places Fund (HM Government, 2022c, pp. 36). The distribution of UKRI spending on grants to Higher Education Institutions, research institutes, and businesses in the four nations shows a clear geographical imbalance. Between 2018 and 2021, an average of 87.8% of the total funding from research councils and 91% of the total funding from Innovate UK went to England's institutions.

[Table 5 here]

Finally, government R&D funding is further disaggregated into four categories using data from ONS (2022): defense, non-defense within department spending, private sector, and education. Private R&D spending is disaggregated in the same way as BERD.

4. Findings

4.1. National impact

Table 6 shows the change in the aggregate effect dditional public funding in three scenarios in terms of output, employment, and GVA in £m for the UK counof atry (national level)[3]. The overall effect is similar for all three scenarios, given an equivalent amount of additional funding.

[Table 6 here]

4.2. Regional impact

Figures 1A-1C show the regional difference in terms of GVA under the proposed three scenarios. As can be seen, each scenario shows a different distribution of regional GVA changes.

Scenario 1 assumes a 40 percent increase in R&D funding based on the previous distribution of public funds. Under scenario 1, Yorkshire and the Humber and North West are the greatest beneficiaries, with £641 million and £644 million uplifting in regional GVA, respectively. The South West and West Midlands see a significant uplift in regional GVA with £573 million and £621 million, respectively. Devolved nations of the UK see a mixed picture, with Scotland seeing a significant uplift of £502 million, whereas Wales and Northern Ireland see a modest uplift in GVA of £134 million and £54 million, respectively. Despite the intention of the policy to focus attention away from the GSE, London and the South East outperform Wales and Northern Ireland under this scenario.

[3] The direct output of model simulation is changes in output in £million by sector and region. Employment and GVA changes are calculated using the pre-simulation ratio between the output and employment/GVA. We assume that the ratio between output and employment/GVA is fixed by any increase in output.

In scenario 2, West Midlands benefit most followed by East Midland, receiving a £468 million and £458million increase in GVA, respectively. West Midlands and North West are the top receivers in scenario 3. However, compared to scenario 2, because more additional funding is allocated to regions with relatively higher levels of public funding, a higher proportion of benefits are captured by regions like North West, North East, and Yorkshire.

[Figure 1A & 1B here]

West Midlands and North West are still the top receivers in scenario 3. East Midlands and South West are also benefiting but moderately. The nations have a mixed picture. While Scotland has a moderated uplift, Wales and Northern Ireland are missing out.

[Figure 1C here]

Each scenario has a different regional effect. The redistributive scenario seems to benefit all the regions more equally[4].

Regions differ significantly in terms of their initial economic conditions and the intensity of R&D activities. If the goal of the levelling-up is to reduce gaps between regions, then it is essential that worse-off regions receive higher benefits from the implementation of the levelling-up proposed missions. With the aim to analyze the moderating effect of the level of regional absorptive capacity on the impact of the R&D mission on regional performance, we perform the analysis considering different regional taxonomies.

Table 7 presents our adopted regional classifications. We classify NUTS-1 regions according to two criteria. The first classification is from OECD (Marsan and Maguire, 2011), which is based on the region's dominant R&D activities. There are four types of regions: medium-tech manufacturing and service providers, which include 7 of the 12 regions; knowledge and technology hubs, including South West, South East and East; knowledge-intensive city/capital districts, which only include London and Service and natural resource regions which only includes Scotland.

[4] To check this, we calculate the coefficient of variation to measure regional inequality pre and post demand shock. The coefficient of variation in terms of GVA decreased by 0.13, 0.19 and 0.129 respectively for scenario 1, 2 and 3, collaborating with the visual examination that scenario 2 deliveries highest level of regional convergence.

The second type of classification is based on the region's initial level of total GVA per head of population compared to the arithmetic average GVA of NUTS-1 regions (excluding GSE) in 2016. Out of the 9 regions, five are below average, while 4 regions, including West Midlands, are above average.

[Table 7 here]

Table 8 shows the impact of three scenarios on four types of OECD regions. In all three scenarios, medium-tech manufacturing and service providers receive the largest share of benefits in terms of output, employment and GVA.

[Table 8 here]

Table 9 shows the results of the final impact based on the level of GVA compared to the mean level (excluding GSE). As expected, in scenario 1 and scenario 3, regions with above-mean GVA levels receive most of the benefits and regions. Only in scenario 2, regions with below-average GVA receive higher levels of benefits compared to above-average GVA.

[Table 9 here]

Looking at the results, we can confirm that the R&D redistribution of funds (Scenario 2) seems to be the optimal one as it induces greater gains in a more balanced way across regions.

4.3. Sectoral impacts

To dig more deeply into the impact of the R&D mission proposed by the UK Levelling Up White Paper across sectors, we also classify industries according to their technological and knowledge component. We aggregate our 30 industries into three main groups (high-tech/knowledge-intensive, medium-tech and low-tech/less knowledge-intensive) following the definition of Eurostat (2016). The sectoral disaggregation is presented in Table 10.

[Table 10 here]

Figure 2 shows the overall impact of sectoral GVA (£m) change. Our results demonstrate that high-tech/knowledge-intensive industries benefit most from increased public funding, as expected. However, both low-tech/less knowledge-intensive and medium-tech industries benefit as well. This is due to a high inter-industry linkages between low-tech and high-tech industries.

[Figure 2 here]

Our findings also suggest that increasing R&D expenditure promotes a positive interindustry spill-over effect, increasing the benefits of R&D returns in GVA, not only in high-tech but also in less technologically and knowledge-intensive industries.

5. R&D spillover effects embodied in regional internal and external multipliers.

With the aim to provide an explanation for the different distributional regional effects associated with the different scenarios and an approximation of computation of knowledge spillover effects, we proceed to calculate the internal and external matrix of output multipliers in our multi-regional input-output model. The internal and external matrix highlights the degree of inter-regional linkage on an industrial and regional basis (Hewings et al., 2001).

The multipliers show the coefficients of the induced effects on output or input activities between regions and can be called the production-generating process in succession (Miyazawa, 1966).

5.1. Multiplier construction

As Miyazawa (1966) and Hewings et al. (2001), we calculate the internal-and-external matrix multiplier dividing the UK economy into two macro-regions: GSE versus the Rest of the UK (RUK).

The technical coefficient matrix A of an economy made of two regions can be partitioned into:

$$A = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \qquad (5)$$

where A_{11} and A_{22} are the matrices of the intraregional flow of inputs for the GSE and RUK, respectively, and A_{21} and A_{22} are the matrices of the interregional flow of inputs between two regions.

Then, the standard Leontief inverse can be represented as:

$$L = (I - A)^{-1} = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} = \begin{bmatrix} (I - A_{11})^{-1} & (I - A_{12})^{-1} \\ (I - A_{21})^{-1} & (I - A_{22})^{-1} \end{bmatrix} \qquad (6)$$

where $B_1 = (I - A_{11})^{-1}$ and $B_2 = (I - A_{22})^{-1}$ depict the propagation of economic activities within each region. B_1 and B_2 are then defined as the internal multipliers for region 1 and region 2, respectively (Hewings et al., 2001).

Here, $P_1 = A_{21} B_1$ and $S_1 = A_{12} B_2$ are the multiplier matrices regarding input used by region 2 from region 1 as a result of region 1's and region 2's internal propagation, respectively. Similarly, $P_2 = B_1 A_{12}$ and $S_2 = B_2 A_{21}$ are the multiplier matrix regarding input used by region 1 from region 2 due to internal propagation of regions 1 and region 2, respectively.

Then the external multiplier for both regions are:

$$\Delta_{11} = (I - P_2 S_2)^{-1} = (I - B_1 A_{12} B_2 A_{21})^{-1} \qquad (7)$$

$$\Delta_{22} = (I - S_2 P_2)^{-1} = (I - B_2 A_{21} B_1 A_{12})^{-1} \qquad (8)$$

The external multipliers matrix shows the total effect of external propagation in region 1 and region 2, respectively.

Sonis and Hewings (1993) produce decomposition of the Leontief standard multiplier:

$$(I - A)^{-1} = \begin{bmatrix} \Delta_{11} & 0 \\ 0 & \Delta_{11} \end{bmatrix} \begin{bmatrix} I & B_1 A_{12} \\ B_2 A_{21} & I \end{bmatrix} \begin{bmatrix} B_1 & 0 \\ 0 & B_2 \end{bmatrix} \qquad (9)$$

Sonis and Hewings (1993) show that the first two matrices of the above multiplicative structure can be combined and depicts the interregional feed-back effects.

Furthermore, Sonis and Hewings (1993) also show that $\Delta_1 = \Delta_{11} B_1$ which is the external multiplier of region 1 under the influence of region 2 and $\Delta_2 = \Delta_{22} B_2$ which is the external multiplier of region 2 under the influence of region 1.

Table 11 shows the internal and external matrix of output multipliers in each macro-region, but only cites the column sum or row sum of the elements of the matrices because of limited space. The economic meaning of the column sum is "the power of dispersion" or the degree of backward linkage of industries in each macro-region, and the economic meaning of the row sum is "the sensitivity of dispersion" which summarize the extent of forward linkage for industries in each macro-region (Miyazawa, 1966).

[Table 11 here]

As shown by the figures in Table 11, the GSE has an internal multiplier of 1.5033 on average, and it has an external multiplier of 1.0078, and therefore it generates an effect on the Rest of the UK of around 0.78% on average. The total multiplier of the GSE thus equals 1.5189 on average. On the contrary, the internal multiplier in the RUK is 1.5784 on average, and it has an external multiplier of 1.0069 which means it generates an external effect on the GSE of around 0.7% on average.

Table 11 also highlights sectoral disparities. High-tech industries within the GSE, led by Professional, Scientific, and Technical activities, show the highest average internal multiplier. This is followed by the Information and Communication sector. Conversely, high-tech industries in the RUK have a lower-than-average internal multiplier and lag behind non-manufacturing and non-service sectors.

Examining the average external multipliers for the GSE's high-tech industry, we find that it exhibits the lowest row sum of external multipliers and the highest column sum amongst all industries. This suggests that the GSE exerts a more significant influence on the RUK as a high-tech supplier.

These findings suggest that the GSE's high-tech sector is largely self-contained. Consequently, investments within this sector yield fewer benefits to the Rest of the UK (RUK) due to the industry's low levels of backward linkage. In contrast, the GSE benefits more from RUK investments due to its higher levels of forward linkages.

As anticipated, sectors such as services, construction, and utilities (including Electricity, Gas, Steam, or Air-conditioning supply) have higher internal multipliers than external ones. These sectors are typically local and lack extensive interregional linkages. The external multipliers for these sectors are quite comparable when comparing the GSE with the RUK. Higher internal multipliers in the GSE's sectors reveal pronounced industrial and knowledge clusters.

These sectoral differences demonstrate each macro-region's industrial contribution and its role within the national economy. However, they also suggest that investments in GSE's R&D, heavily concentrated in high-tech industries, yield minimal benefits for the RUK due to low backward linkages.

Table 12 further illustrates this by computing the external and internal multipliers of high-tech industries for each region outside the GSE. Notably, high-tech industries located in these regions are not well interconnected, as evidenced by the highest row sum multiplier of 1.0018 found in the North West—a value significantly lower than that observed in the GSE. Moreover, these regions exhibit lower internal multipliers with minimal variation. These findings suggest that concentrated investments in one or a few regions outside the GSE yield minimal benefits to other regions, offering little support for the 'levelling up' objective. This partly explains why a redistributive scenario, which ensures more equitable funding allocation, generates maximum benefits in terms of reducing regional disparities.

[Table 12 here]

In the appendix, we provide the internal and external output multipliers for every region within the Greater South East macro-region. The results confirm that the higher average internal output multipliers can be seen in the areas within the Greater South East in comparison with the Rest of the UK. The analysis demonstrates that the region that benefits the most from the external multipliers generated in the Rest of the UK is London.

6. Absorptive capacity in the regional labor market

Modern macroeconomic theories highlight the importance of both physical capital and human capital. In the endogenous growth model of Romer (1990) and Lucas (1988), the production function takes physical capital, labor and human capital as factors of production. Further development of the model, such as Galor and Moav (2004), suggests that human capital's importance would gradually overtake physical capital due to higher marginal productivity. Redding (1996) adds to the endogenous growth model by showing that investments in human capital and investments in R&D exhibit positive externalities and are strategic complements of each other.

Inadequate human capital reduces the absorptive capacity of R&D expenditure even when there is sufficient physical capital. Firm-level evidence suggests that firm R&D success is often highly related to the availability of regional human capital. Acs, Armington and Zhang (2007) show that firm survival rate is higher in regions with higher levels of human capital stock. Vinding (2007) highlights the importance of firm human capital availability in innovation output. A number of studies in this journal also emphasized labor absorptive capacity from a regional perspective (Azagra-Caro et al., 2006; Cabrer-Borrás and Serrano-Domingo, 2007; Sterlacchini, 2008).

Because of this literature, any investment in R&D capital would only bring minimal benefits if there were no matched human capital support. Therefore, for any policies to address the human capital inefficiency, it is essential to understand how additional investments in R&D affect employment demand and the distribution of such demand by regions. To answer this question, we estimated additional demand for workers by occupation and by region through the SEIM-UK labor module - see Carrascal-Incera et al. (2021) for more details-.

In Table 13, we classified 25 occupations (see Appendix B for the full table) into three groups based on skill levels and show increased demand for workers by region. It is evident that inflows of additional R&D investments require a substantial increase in high-skilled workers to absorb additional capacity. As with outputs and GVA, the total effects on employment by skill levels are similar in all three scenarios. However, there are wide regional differences. In scenario 1, demand for high-skilled workers ranges from 0.74% (North East- UKC) to 0.03% (Northern Ireland–- UKN). In scenario 2, the variation becomes larger, with demand ranging from 1.39% (Northern Ireland–- UKN) to 0.03% (East of England–- UKH). In scenario 3, it is East Midland (UKF) which has the largest increase in demand for high-skilled workers.

[Table 13 here]

In Table 14, we further aggregate regions based on their R&D categories as defined in section 4.2. Regions classified as medium-tech manufacturing and service providers experienced the largest percentage increase in demand for labor across the three skill groups. In particular, the redistributive scenario leads to the highest increase for regions within this category. Service and natural resource regions also have a significant increase in the demand for labor. Such an increase is most significant in the equal uplift scenario. Regions classified as knowledge and technology hubs will also experience substantial increases in demand for high-skilled workers. London’s increased demand is similar in all three scenarios.

[Table 14 here]

The above analysis shows that regions with lower R&D capabilities will likely experience the largest increase in high-skilled workers to absorb additional R&D investments. This raises the concern of whether the local labor market can accommodate the required high-skilled workers.

We use the existing education levels of the regional labor force to approximate the availability of high-skilled workers. Figure 3 plots the percentage of workers with National Qualification Framework (NQF) level 4 or above qualifications against the additional demand for high-skilled workers by the NUTS-1 region. The percentage of local workers with NQF level 4 or above is obtained from the 2016 October to December Quarterly Labour Force Survey (QLFS).

Figures 3a to 3c represent three scenarios, respectively. A linear fitted line is included for clarity. The fitted lines are downward sloped in all scenarios. The patterns reflected in figures 2a-c show that regions with a relatively lower percentage of workers with NQF4 or above will have greater demand for high-skilled workers. Our findings highlight the importance of investment in human capital to match increased investments in R&D.

[Figure 2a, 2b & 2c here]

7. Discussion and policy conclusions

In this paper, we use input output techniques to evaluate three policy implementation scenarios based on the R&D mission published by the UK Government in its recent Levelling Up White Paper (HM Government, 2022b). The UK Levelling Up White Paper sets plans for how R&D investment will be spent and locally redistributed in the UK, however, the way that these funds are going to be distributed is still undefined. Combining information from different official data sources, we calculate the current UK R&D sub-national and sectoral distribution and set up different redistribution scenarios of R&D spending in the UK based on the target of assigning 40% of the funds outside the London and the South East of England area. What is still unclear is exactly how the 40% increase in R&D proposed by this mission is going to be materialized. In this paper, we build three different scenarios that illustrate different opportunities for this mission to be implemented.

We have employed input-output techniques and assessed various scenarios to determine the best approach for implementing the R&D levelling up mission. The different scenarios produce different regional winners and losers. The scenario that presents the highest level of regional convergence is the redistributive one, which allocates more funding to areas with previously low funding levels.

In England and linked with the recommendations set up in the UKRI Independent Review of the Place agenda (pp.34 UK HM Government, 2022c), the UK government may need to reconsider their approach to decision-making to meet widened government objectives while supporting the quality and strength of the UK research base. In their Levelling Up White Paper agenda, the government is set to "deliver economic, social and cultural benefits from research and innovation to all of *our* citizens, including by developing research and innovation strengths across the UK".

In the devolved administrations, as the evidence shows, there has been a clear imbalance in the levels of funding awarded by the UK Councils and UKRI to the devolved administrations (Northern Ireland, Scotland, and Wales). Scotland tends to receive similar levels of UKRI funding to England in per capita terms, receiving 7.4% of the research council and Innovate UK funding in FY2020/21. However, Wales and Northern Ireland underperform with Wales receiving 2.4% and Northern Ireland 0.9% of research council and Innovate UK funding in FY2020 significant major cities like Edinburgh and Cardiff still receive most of the public money flowing to the Devolved Administrations. Among the recommendations, we find that Levelling Up agenda should also consider the within-distribution in the Devolved Administrations, ensuring that areas outside of the major cities are compensated for this unbalanced distribution of funding.

As our analysis demonstrates, the ways in which these economic and knowledge-related mechanisms will be stimulated at the regional level will depend heavily on the specific ways in which changes in the geography of publicly related R&D funding is undertaken. The Levelling Up mission of R&D investment is expected to generate benefits across the country, with potential indirect effects on non-innovative and non-core areas. Still, the way that this R&D mission is implemented will determine its success.

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Table 1. Distribution of R&D funds per scenario

	Scenario 1 Equal Uplift		Scenario 2 Redistributive		Scenario 3 Market Driven	
Region	**Additional Funding (£m)**	**Percentage Increase**	**Additional Funding (£m)**	**Percentage Increase**	**Additional Funding (£m)**	**Percentage Increase**
North East	150.22	83%	195.09	107%	58.41	32%
Wales	59.56	83%	206.42	287%	62.81	87%
Northern Ireland	23.99	83%	210.87	727%	85.41	295%
Yorkshire and The Humber	280.51	83%	178.81	53%	143.81	42%
East Midlands	190.84	83%	190.01	82%	273.13	118%
South West	242.46	83%	183.56	63%	260.77	89%
Scotland	231.62	83%	184.92	66%	200.23	72%
West Midlands	251.40	83%	182.45	60%	334.94	110%
North West	280.35	83%	178.83	53%	291.46	86%
London	0.00	0%	0.00	0%	0.00	0%
East	0.00	0%	0.00	0%	0.00	0%
South East	0.00	0%	0.00	0%	0.00	0%

Source: own elaboration

Table 2. BERD regional distribution

		Scenario 1 Equal Uplift (£ millions)	Scenario 2 Redistributive (£ millions)	Scenario 3 Market Driven (£ millions)
UKC	**North East**	283.71	368.28	110.25
UKL	**Wales**	112.60	389.68	118.57
UKN	**Northern Ireland**	45.26	398.07	161.22
UKE	**Yorkshire and the Humber**	529.45	337.54	271.48
UKF	**East Midlands**	360.32	358.70	515.59
UKK	**South West**	457.53	346.52	492.26
UKM	**Scotland**	437.05	349.07	377.98
UKG	**West Midlands**	474.33	344.41	632.29
UKD	**North West**	529.22	337.58	550.20
UKI	**London**	0	0	0
UKH	**East of England**	0	0	0
UKJ	**South East**	0	0	0
	Total BERD uplift	3229.47	3229.84	3229.84

Table 3. Attribution of R&D across sectors in the SEIM-UK using UKRI data

	SEIM-UK Sector	R&D Proportion
s01	Agriculture, forestry and fishing	0.0%
s02	Mining and quarrying	0.0%
s03	Manufacture of food, beverages and tobacco	0.1%
s04	Manufacture of textiles, wearing apparel and leather	0.3%
s05	Manufacture of wood and paper products and printing	3.9%
s06	Manufacture of petroleum, chemicals and pharmaceuticals	0.7%
s07	Manufacture of rubber, plastic and non-metallic minerals	0.6%
s08	Manufacture of basic and fabricated metal products	16.7%
s09	Manufacture of computer, electronic and optical products	3.7%
s10	Manufacture of electrical equipment	2.1%
s11	Manufacture of machinery and equipment	1.3%
s12	Manufacture of transport equipment	8.6%
s13	Other manufacturing, repair and installation	2.6%
s14	Electricity, gas, steam and air-conditioning supply	2.0%
s15	Water supply; sewerage and waste management	0.3%
s16	Construction	1.5%
s17	Wholesale and retail trade; repair of motor vehicles	0.9%
s18	Transportation and storage	0.6%
s19	Accommodation and food service activities	0.0%
s20	Information and communication	11.8%
s21	Financial and insurance activities	0.9%
s22	Real estate activities	0.4%
s23	Professional, scientific and technical activities	27.8%
s24	Administrative and support service activities	7.7%
s25	Public administration and defence; compulsory social security	0.0%
s26	Education	0.0%
s27	Human health and social work activities	0.6%
s28	Arts, entertainment and recreation	0.1%
s29	Other service activities	3.3%
s30	Activities of households	0.0%

Table 4. Proportion of research council and Innovate UK regional spend in England regions FY2020/21

Region	Research councils	Innovate UK	UKRI Total
North East	2.7%	3.7%	3.4%
North West	7.8%	3.2%	7.4%
London	21.6%	15.4%	22.1%
East Midlands	4.7%	8.4%	6.5%
South East	22.9%	20.6%	24.9%
South West	5.2%	9.1%	7.1%
East of England	12.5%	7.7%	12.3%
West Midlands	4.3%	20.6%	10.1%
Yorkshire and the Humber	6.5%	3.4%	6.2%
Total (£ million)	3,763	1,526	5,289

Source: UKRI and ONS (HM Government, 2022c, pp. 34)

Table 5. Research council and Innovate UK spend in the UK FY2018/19 to FY2020/21

Nation	UKRI spend on grants to HEIs, research institutes and businesses in the four nations (£ million)					
	2018/2019		2019/2020		2020/2021	
	Research councils	Innovate UK	Research councils	Innovate UK	Research councils	Innovate UK
England	2,111	873	2,930	1,088	3,319	1,405
Wales	66	30	66	27	86	62
Northern Ireland	25	11	25	13	29	19
Scotland	248	57	279	49	329	62
Total	2,450	971	3,300	1,177	3,763	1,548

Source: UKRI included in HM Government (2022c, pp. 36)

Table 6. Total impact across the UK

	Scenario 1 Equal Uplift		Scenario 2 Redistributive		Scenario 3 Market Driven	
	Value	**%**	**Value**	**%**	**Value**	**%**
Output Difference (£m)	7229.79	0.21%	7201.70	0.21%	7252.84	0.21%
Employment Difference (FTE)	73590.15	0.25%	73576.05	0.25%	74040.30	0.25%
GVA Difference (£m)	4338.90	0.21%	4300.45	0.21%	4344.12	0.21%

Source: own elaboration

Table 7. Regional classification by technology and knowledge intensity

Regions	R&D categories	GVA
North East	Medium-tech manufacturing and service providers	below average
Wales	Medium-tech manufacturing and service providers	below average
Northern Ireland	Medium-tech manufacturing and service providers	below average
Yorkshire and the Humber	Medium-tech manufacturing and service providers	below average
East Midlands	Medium-tech manufacturing and service providers	below average
South West	Knowledge and technology hubs	above average
Scotland	Service and natural resource regions in knowledge intensive countries	above average
West Midlands	Medium-tech manufacturing and service providers	above average
North West	Medium-tech manufacturing and service providers	above average
London	Knowledge-intensive city/capital districts	
East of England	Knowledge and technology hubs	
South East	Knowledge and technology hubs	

Table 8. Impact of increased public R&D expenditure – OECD regional classification

	Output (£ m)			Employment (FTE)			GVA (£ m)		
	Scenario 1 Equal Uplift	Scenario 2 Redistributive	Scenario 3 Market Driven	Scenario 1 Equal Uplift	Scenario 2 Redistributive	Scenario 3 Market Driven	Scenario 1 Equal Uplift	Scenario 2 Redistributive	Scenario 3 Market Driven
Medium-tech manufacturing and service providers	4,807.09 (0.350%)	5,102.34 (0.039%)	4,869.41 (0.607%)	52,305.78 (3.805%)	55,431.45 (0.421%)	53,135.52 (6.629%)	2,884.73 (0.210%)	3,042.72 (0.023%)	2,914.14 (0.364%)
Knowledge and technology hubs	1,215.58 (0.112%)	1,020.76 (0.011%)	1,281.24 (0.195%)	10,911.95 (1.002%)	9,068.24 (0.098%)	11,559.38 (1.758%)	733.09 (0.067%)	614.65 (0.007%)	772.71 (0.118%)
Knowledge-intensive city/capital districts (London)	368.36 (0.048%)	391.25 (0.008%)	366.08 (0.078%)	2,392.67 (0.314%)	2,571.36 (0.051%)	2,371.43 (0.508%)	218.95 (0.029%)	232.70 (0.005%)	217.49 (0.047%)
Service and natural resource regions in knowledge -intensive regions (Scotland)	838.76 (0.312%)	687.36 (0.028%)	736.12 (0.479%)	7,979.74 (2.968%)	6,504.99 (0.262%)	6,973.98 (4.542%)	502.13 (0.187%)	410.37 (0.017%)	439.78 (0.286%)

Note: percentage change in parenthesis.

Table 9. Impact of increased public R&D expenditure – Compared with average GVA

	Output (£ m)			Employment (FTE)			GVA (£ m)		
	Scenario 1 Equal Uplift	Scenario 2 Redistributive	Scenario 3 Market Driven	Scenario 1 Equal Uplift	Scenario 2 Redistributive	Scenario 3 Market Driven	Scenario 1 Equal Uplift	Scenario 2 Redistributive	Scenario 3 Market Driven
Above mean	3,915.23 (0.343%)	2,942.01 (0.258%)	2,341.95 (0.371%)	39,666.19 (0.373%)	29,471.38 (0.277%)	43,236.00 (0.407%)	4,230.12 (0.352%)	1,755.81 (0.264%)	2,531.16 (0.381%)
Below mean	2,678.98 (0.353%)	3,582.37 (0.473%)	1,618.44 (0.315%)	29,659.98 (0.400%)	39,459.87 (0.532%)	26,558.76 (0.358%)	2,389.27 (0.366%)	2,141.76 (0.484%)	1,436.58 (0.324%)

Table 10. Technology intensity sectoral categorisation

Sectoral categories	Sectoral category (manufacturing vs. services)	SEIM UK code	Sector Name
High-Tech/Knowledge-Intensive	High-technology	CI	Manufacture of computer, electronic and optical products
	Knowledge-intensive (market) services	K	Financial and insurance activities
		M	Professional, scientific and technical activities
		O	Public administration and defence; compulsory social security
		P	Education
	Other knowledge-intensive services	J	Information and communication
		Q	Human health and social work activities
		R	Arts, entertainment and recreation
Medium-Tech	Medium-low technology	CD-CF	Manufacture of petroleum, chemicals and pharmaceuticals
		CG	Manufacture of rubber, plastic and non-metallic minerals
		CH	Manufacture of basic and fabricated metal products
	Medium-high technology	CJ	Manufacture of electrical equipment
		CK	Manufacture of machinery and equipment
		CL	Manufacture of transport equipment
Low-Tech/ Less Knowledge-Intensive	Low technology manufacturing	CA	Manufacture of food, beverages and tobacco
		CB	Manufacture of textiles, wearing apparel and leather
		CC	Manufacture of wood and paper products and printing
		CM	Other manufacturing, repair and installation
	Less knowledge-intensive (market) services	G	Wholesale and retail trade; repair of motor vehicles
		H	Transportation and storage
		I	Accommodation and food service activities
		L	Real estate activities
		N	Administrative and support service activities
		S	Other service activities
		T	Activities of households

Table 11. Summary internal and external multipliers of two-macro-region model (GSE, including London, South East and East of England)

		GSE				Rest of the UK			
		Internal		External		Internal		External	
Industry Tech Categories	Industries	Row Sum	Column Sum	Row Sum	Column Sum	Row Sum	Column Sum	Row Sum	Column Sum
Non-Manuf + Non-Services	Agric.	1.1306	1.4846	1.0096	1.0015	1.2646	1.7580	1.0038	1.0020
	Mining	1.0409	1.2013	1.0039	1.0008	1.2616	1.7091	1.0052	1.0040
	Elect.	1.9040	1.7445	1.0094	1.0035	2.4572	1.9316	1.0033	1.0100
	Water	1.2835	1.8354	1.0126	1.0007	1.3983	1.9429	1.0074	1.0019
	Construction	3.0727	1.6248	1.0018	1.0225	3.0436	1.5693	1.0030	1.0133
Average Non-Manuf + Non-Services		1.6863	1.5781	1.0075	1.0058	1.8851	1.7822	1.0046	1.0062
High-tech/Knowledge-intensive	Computer	1.1124	1.3292	1.0052	1.0058	1.1883	1.3086	1.0054	1.0021
	Finance	2.0547	1.6921	1.0093	1.0246	1.8665	1.6703	1.0084	1.0079
	Profess.	3.6585	1.5410	1.0057	1.0395	2.7355	1.4846	1.0077	1.0255
	Public Adm.	1.1894	1.6173	1.0052	1.0013	1.1961	1.5497	1.0063	1.0012
	Education	1.3193	1.3369	1.0024	1.0016	1.3208	1.3017	1.0037	1.0013
	Health	1.0955	1.5335	1.0069	1.0002	1.1240	1.5067	1.0084	1.0006
	Inform&Comm	2.2361	1.5785	1.0055	1.0296	1.7058	1.4471	1.0091	1.0066
	Arts&Rec	1.1940	1.5936	1.0050	1.0019	1.1232	1.4110	1.0087	1.0010
Average High-Tech		**1.7325**	1.5278	1.0057	1.0131	1.5325	1.4600	1.0072	1.0058
Medium-Tech	Chemicals	1.2544	1.3176	1.0114	1.0129	1.6691	1.6026	1.0082	1.0139
	Plastics	1.2958	1.8022	1.0149	1.0030	1.7583	2.0016	1.0065	1.0165
	Metal	1.3014	1.4062	1.0167	1.0044	1.6570	1.6553	1.0079	1.0104
	Electrical	1.0831	1.4358	1.0078	1.0038	1.2198	1.5691	1.0105	1.0026
	Machinery	1.1655	1.5178	1.0145	1.0074	1.3574	1.8656	1.0113	1.0054
	Transport equip	1.1131	1.2509	1.0093	1.0066	1.3608	1.6411	1.0083	1.0152
Average Medium-Tech		1.2022	1.4551	1.0124	1.0063	1.5037	1.7225	1.0088	1.0107
Low-Tech	Food&Bev	1.3812	1.3080	1.0051	1.0045	1.7318	1.4677	1.0036	1.0106
	Textiles	1.0141	1.2362	1.0060	1.0003	1.0449	1.4416	1.0050	1.0005
	Wood&Paper	1.4923	1.7554	1.0144	1.0052	1.6423	1.8199	1.0094	1.0114
	Other Manuf	1.4068	1.5782	1.0141	1.0085	1.5353	1.7568	1.0106	1.0063
	Retail trade	1.9822	1.7281	1.0054	1.0157	2.4766	1.6523	1.0085	1.0087
	Transport&Storage	1.7695	1.7533	1.0098	1.0100	1.6639	1.6532	1.0094	1.0107
	Accommodation	1.2343	1.6218	1.0069	1.0019	1.2715	1.5534	1.0100	1.0033
	Real estate	1.7546	1.3230	1.0025	1.0094	1.7741	1.2925	1.0037	1.0030
	Admin&Support Serv	1.3189	1.4884	1.0079	1.0048	1.2994	1.4195	1.0066	1.0102
	Other services	1.2408	1.4639	1.0041	1.0017	1.2043	1.3691	1.0071	1.0011
	Household activities	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Average Low-Tech		1.4177	1.4778	1.0069	1.0056	1.5131	1.4933	1.0067	1.0060
Macro-region Average		1.5033	1.5033	1.0078	1.0078	1.5784	1.5784	1.0069	1.0069

Table 12. Summary average high-tech industry internal and external output multipliers of two-macro-region model (individual region outside the GSE macro-region)

	High-Tech Internal Multiplier		High-Tech External Multipliers	
Region	Column sum	Row sum	Column sum	Row sum
North East	1.3427	1.3505	1.0006	1.0005
North West	1.4030	1.4857	1.0018	1.0020
Yorkshire and The Humber	1.3495	1.3556	1.0015	1.0009
East Midlands	1.3587	1.4249	1.0015	1.0012
West Midlands	1.4032	1.4981	1.0016	1.0013
South West	1.4244	1.4923	1.0010	1.0016
Wales	1.3884	1.4066	1.0009	1.0004
Northern Ireland	1.3049	1.3206	1.0005	1.0004
Scotland	1.4222	1.5124	1.0015	1.0019
Average	1.3774	1.4274	1.0012	1.0011

Table 13.Employment effect by skill levels and NUTS-1 region

		UKC	UKD	UKE	UKF	UKG	UKH	UKI	UKJ	UKK	UKL	UKM	UKN	Sum
S1	**High Skill**	3628 (0.74%)	6922 (0.45%)	7119 (0.65%)	5499 (0.58%)	7030 (0.61%)	380 (0.03%)	1525 (0.06%)	637 (0.03%)	5427 (0.48%)	1406 (0.24%)	4848 (0.41%)	583 (0.17%)	45003 (0.31%)
S1	**Medium Skill**	1401 (0.48%)	2612 (0.29%)	2674 (0.41%)	2023 (0.36%)	2608 (0.38%)	185 (0.03%)	510 (0.04%)	267 (0.02%)	2142 (0.32%)	581 (0.16%)	1858 (0.26%)	224 (0.11%)	17087 (0.21%)
S1	**Low skill**	931 (0.37%)	1777 (0.22%)	1756 (0.30%)	1254 (0.23%)	1697 (0.26%)	136 (0.02%)	358 (0.03%)	266 (0.03%)	1472 (0.24%)	423 (0.14%)	1274 (0.22%)	156 (0.09%)	11501 (0.16%)
S2	**High Skill**	4700 (0.96%)	4574 (0.30%)	4623 (0.42%)	5495 (0.58%)	5211 (0.45%)	438 (0.03%)	1651 (0.06%)	708 (0.04%)	4196 (0.37%)	4644 (0.80%)	3946 (0.33%)	4740 (1.39%)	44925 (0.31%)
S2	**Medium Skill**	1813 (0.62%)	1740 (0.20%)	1754 (0.27%)	2022 (0.35%)	1949 (0.28%)	203 (0.03%)	548 (0.04%)	293 (0.03%)	1658 (0.24%)	1851 (0.51%)	1518 (0.21%)	1756 (0.85%)	17104 (0.21%)
S2	**Low skill**	1201 (0.48%)	1202 (0.15%)	1170 (0.20%)	1254 (0.23%)	1297 (0.20%)	145 (0.02%)	372 (0.04%)	286 (0.03%)	1142 (0.19%)	1307 (0.42%)	1041 (0.18%)	1131 (0.63%)	11547 (0.16%)
S3	**High Skill**	1449 (0.30%)	7178 (0.47%)	3748 (0.34%)	7767 (0.82%)	9252 (0.80%)	389 (0.03%)	1515 (0.06%)	634 (0.03%)	5816 (0.52%)	1477 (0.26%)	4232 (0.36%)	1949 (0.57%)	45407 (0.31%)
S3	**Medium Skill**	566 (0.19%)	2708 (0.31%)	1430 (0.22%)	2841 (0.50%)	3414 (0.49%)	187 (0.03%)	506 (0.04%)	267 (0.02%)	2294 (0.34%)	609 (0.17%)	1626 (0.23%)	727 (0.35%)	17176 (0.21%)
S3	**Low skill**	386 (0.15%)	1840 (0.23%)	960 (0.16%)	1729 (0.32%)	2185 (0.34%)	137 (0.02%)	350 (0.03%)	260 (0.03%)	1575 (0.26%)	442 (0.14%)	1116 (0.19%)	477 (0.26%)	11457 (0.16%)

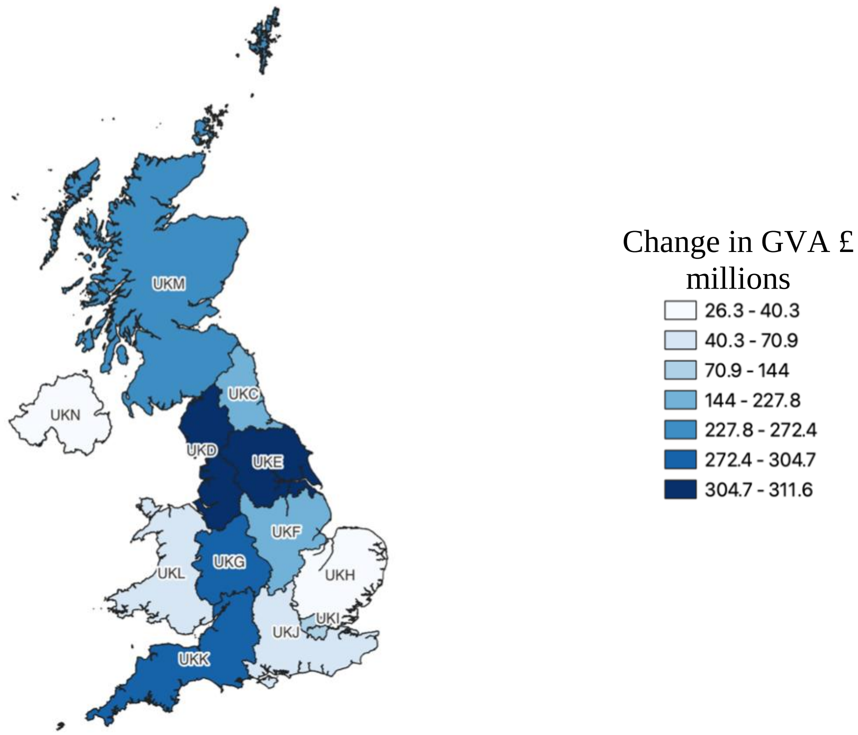
Note: Employment is in Full-Time Equivalent (FTE) and rounded to nearest integer. Percentage increase in parentheses.

Table 14. Employment effect by skill levels and R&D regions

		Knowledge-intensive city/capital districts	Knowledge and technology hubs	Medium-tech manufacturing and service providers	Service and natural resource regions
Equal Uplift	**High Skill**	1525 (0.06%)	6444 (0.15%)	32187 (0.52%)	4848 (0.41%)
	Medium Skill	510 (0.04%)	2594 (0.1%)	12125 (0.33%)	1858 (0.26%)
	Low skill	358 (0.03%)	1874 (0.08%)	7994 (0.24%)	1274 (0.22%)
Redistributive	**High Skill**	1651 (0.06%)	5342 (0.12%)	33987 (0.55%)	3946 (0.33%)
	Medium Skill	548 (0.04%)	2154 (0.09%)	12884 (0.35%)	1518 (0.21%)
	Low skill	372 (0.04%)	1573 (0.07%)	8561 (0.26%)	1041 (0.18%)
Market Driven	**High Skill**	1515 (0.06%)	6839 (0.15%)	32821 (0.53%)	4232 (0.36%)
	Medium Skill	506 (0.04%)	2749 (0.11%)	12296 (0.34%)	1626 (0.23%)
	Low skill	350 (0.03%)	1972 (0.09%)	8019 (0.24%)	1116 (0.19%)

Figure 1.A. Regional GVA change (in £m) Scenario 1 - Equal Uplift

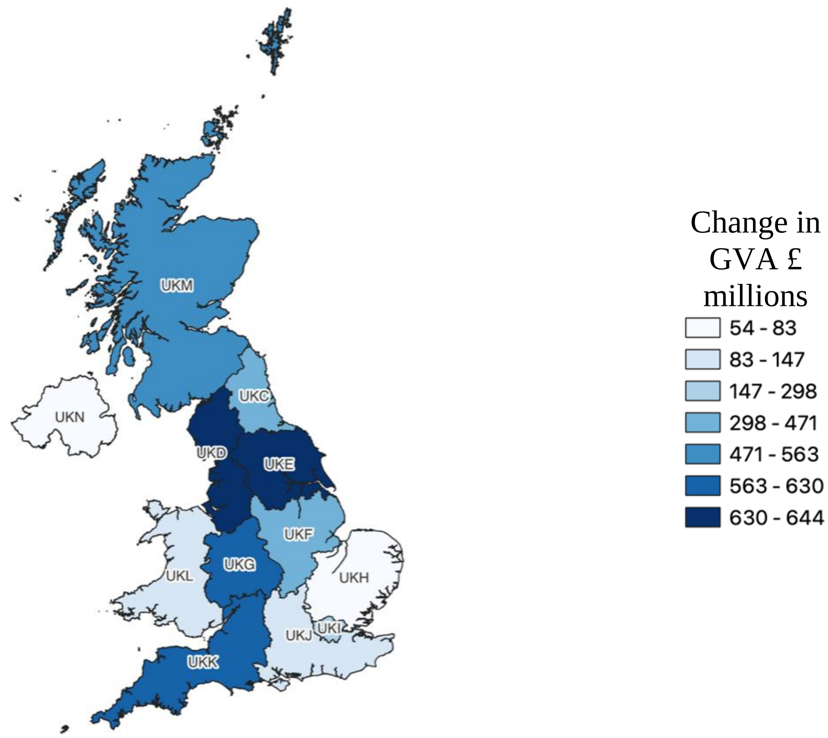
Map: Scenario 1 – Equal Uplift



Note: London (UKI), South East (UKJ), East of England (UKH), North West (UKD), West Midlands (UKG), South West (UKK), East Midlands (UKF), Yorkshire and The Humber (UKE), Scotland (UKM), North East (UKC), Wales (UKL), Northern Ireland (UKN).

Figure 1.B. Regional GVA change (in £m) Scenario 2 - Redistributive

Map: Scenario 2 – Redistributive

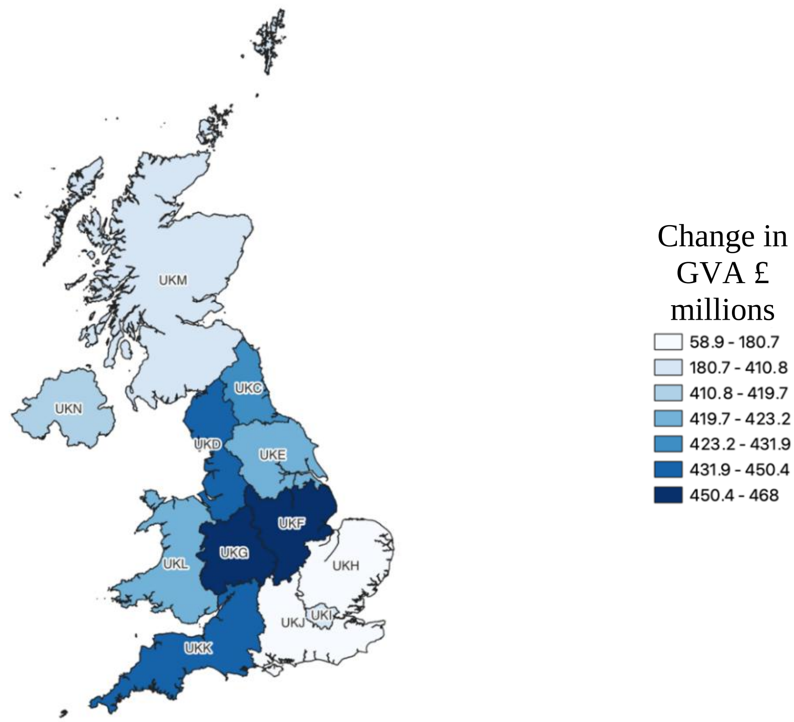


Note: London (UKI), South East (UKJ), East of England (UKH), North West (UKD), West Midlands (UKG), South West (UKK), East Midlands (UKF), Yorkshire and The Humber (UKE), Scotland (UKM), North East (UKC), Wales (UKL), Northern Ireland (UKN).

West Midlands and North West are still the top receivers in scenario 3. East Midlands and South West are also benefiting but moderately. The nations have a mixed picture. While Scotland has a moderated uplift, Wales and Northern Ireland are missing out.

Figure 1.C. Regional GVA change (in £m) Scenario 3 – Market Driven

Map: Scenario 3 – Market Driven



Note: London (UKI), South East (UKJ), East of England (UKH), North West (UKD), West Midlands (UKG), South West (UKK), East Midlands (UKF), Yorkshire and The Humber (UKE), Scotland (UKM), North East (UKC), Wales (UKL), Northern Ireland (UKN).

Figure 2. Levelling up R&D mission - Sectoral breakdown

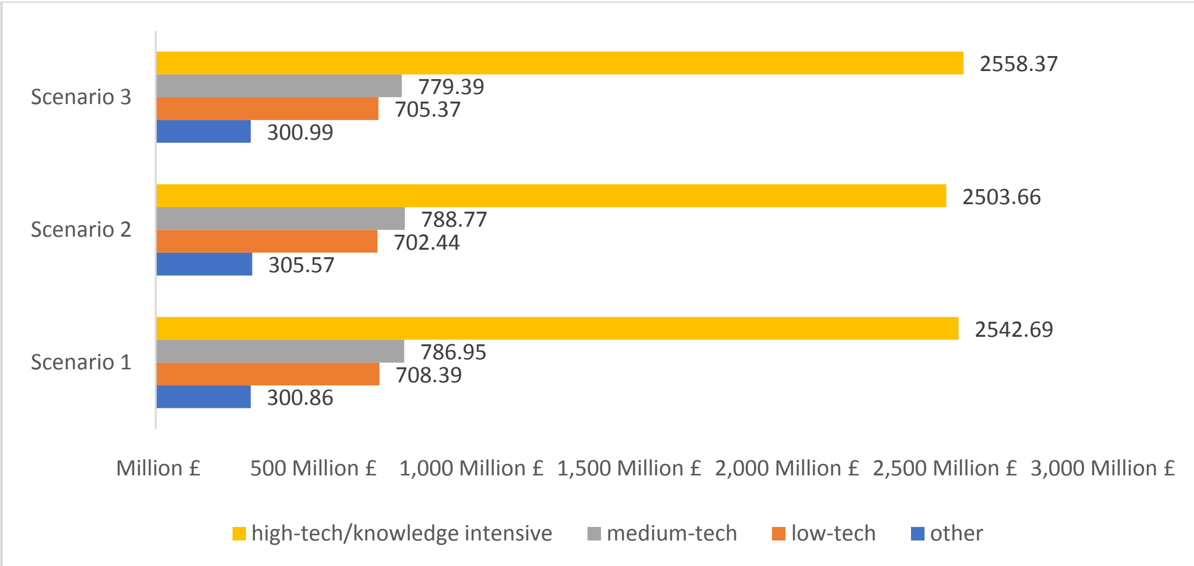


Figure 3.A. Education level and increase in demand of workers – Scenario 1 Equal Uplift

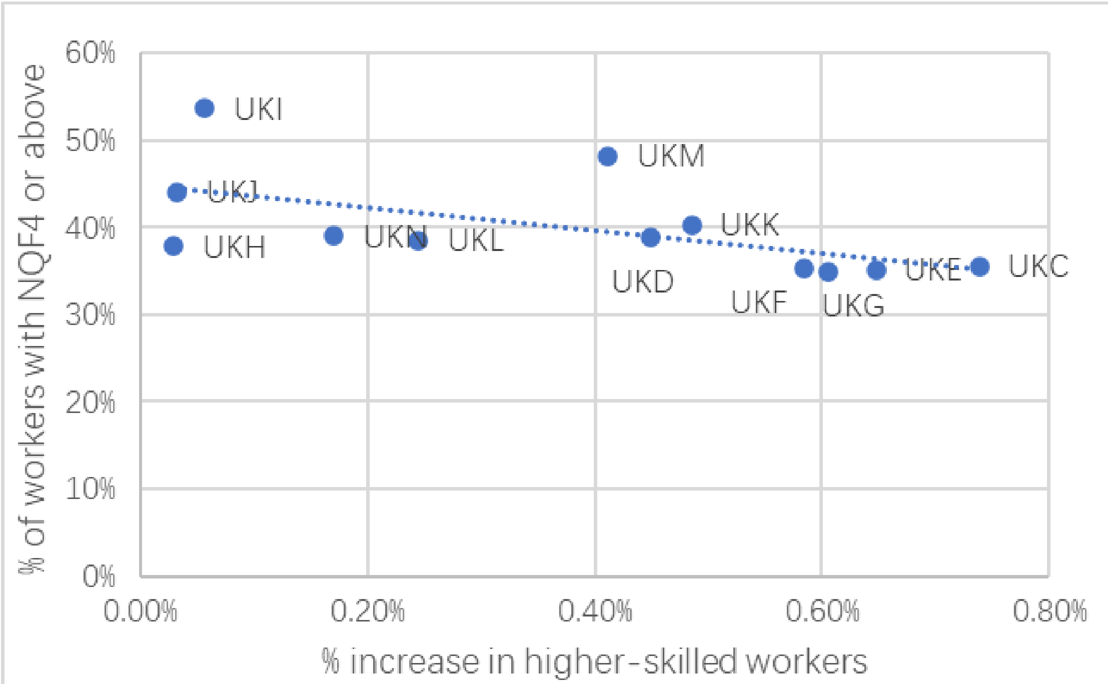


Figure 3.B. Education level and increase in demand of workers – Scenario 2 Redistributive

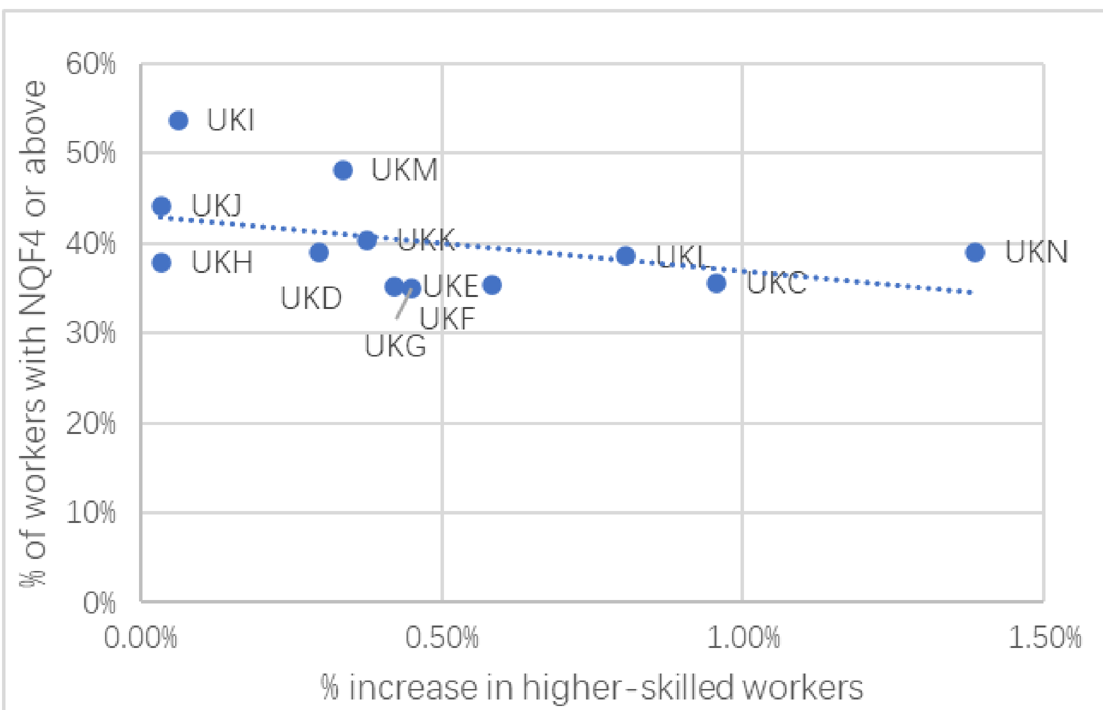
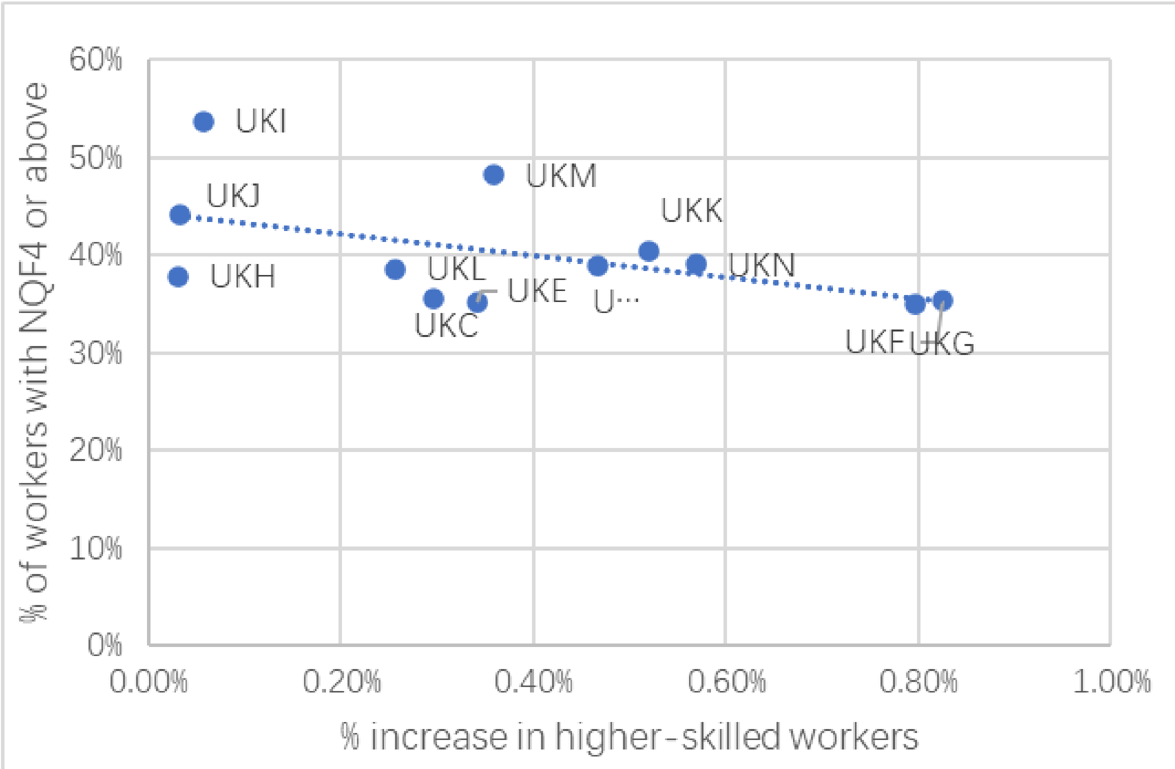


Figure 3.C. Education level and increase in demand of workers – Scenario 3 Market Driven



Note:% of workers with NQF4 or above obtained from 2016 October to December LFQS

Appendix A: Internal and external multipliers for regions within GSE

Table A1. Internal and external multipliers of two-region model (London and rest of the UK)

	London				Rest of the UK			
	Internal		External		Internal		External	
Industries	Row	Column	Row	Column	Row	Column	Row	Column
Agriculture, forestry and fishing	1.0014	1.0607	1.0001	1.0030	1.2640	1.7850	1.0015	1.0015
Mining and quarrying	1.0058	1.0767	1.0005	1.0011	1.2422	1.7099	1.0016	1.0012
Manufacture of food, beverages and tobacco	1.2007	1.2370	1.0024	1.0041	1.7380	1.4779	1.0065	1.0030
Manufacture of textiles, wearing apparel and leather	1.0140	1.2393	1.0002	1.0055	1.0448	1.4427	1.0002	1.0033
Manufacture of wood and paper products and printing	1.2157	1.4478	1.0008	1.0167	1.7083	1.9252	1.0084	1.0061
Manufacture of petroleum, chemicals and pharmaceuticals	1.0301	1.0931	1.0017	1.0044	1.7712	1.6373	1.0068	1.0028
Manufacture of rubber, plastic and non-metallic minerals	1.0741	1.4654	1.0011	1.0086	1.7723	2.0960	1.0081	1.0035
Manufacture of basic and fabricated metal products	1.0641	1.1389	1.0012	1.0065	1.6968	1.7493	1.0041	1.0019
Manufacture of computer, electronic and optical products	1.0155	1.0657	1.0007	1.0015	1.2594	1.4258	1.0010	1.0029
Manufacture of electrical equipment	1.0163	1.1965	1.0010	1.0039	1.2432	1.6746	1.0009	1.0051
Manufacture of machinery and equipment	1.0111	1.1831	1.0006	1.0069	1.4131	1.9261	1.0024	1.0029
Manufacture of transport equipment	1.0584	1.2451	1.0018	1.0058	1.4154	1.6194	1.0072	1.0046
Other manufacturing, repair and installation	1.0899	1.2848	1.0019	1.0085	1.6529	1.8617	1.0034	1.0047
Electricity, gas, steam and air-conditioning supply	1.5983	1.5732	1.0014	1.0077	2.4596	1.9804	1.0050	1.0017
Water supply; sewerage and waste management	1.2058	1.6354	1.0003	1.0129	1.3852	2.0184	1.0021	1.0054
Construction	2.5988	1.5578	1.0112	1.0025	3.2760	1.6209	1.0151	1.0028
Wholesale and retail trade; repair of motor vehicles	1.5995	1.6179	1.0096	1.0068	2.5131	1.7288	1.0087	1.0088
Transportation and storage	1.7630	1.6613	1.0092	1.0085	1.7315	1.7462	1.0104	1.0099
Accommodation and food service activities	1.1968	1.5401	1.0019	1.0071	1.2778	1.6171	1.0024	1.0115
Information and communication	2.1408	1.5222	1.0303	1.0062	1.9235	1.5173	1.0111	1.0101
Financial and insurance activities	1.8997	1.5885	1.0361	1.0078	1.9046	1.7400	1.0063	1.0096
Real estate activities	1.5790	1.2781	1.0090	1.0028	1.8548	1.3235	1.0031	1.0042
Professional, scientific and technical activities	3.1611	1.4402	1.0437	1.0059	3.1554	1.5553	1.0310	1.0084
Administrative and support service activities	1.2738	1.4395	1.0046	1.0079	1.3496	1.4742	1.0091	1.0072
Public administration and defense; compulsory social security	1.1617	1.5328	1.0014	1.0063	1.2052	1.6104	1.0007	1.0065
Education	1.3182	1.2985	1.0013	1.0026	1.3292	1.3311	1.0012	1.0043
Human health and social work activities	1.0752	1.4417	1.0002	1.0064	1.1238	1.5609	1.0005	1.0095
Arts, entertainment and recreation	1.2319	1.5732	1.0021	1.0053	1.1382	1.4834	1.0009	1.0100
Other service activities	1.2566	1.4231	1.0017	1.0048	1.2132	1.4238	1.0013	1.0078
Activities of households	1	1	1	1	1	1	1	1
Average	1.3619	1.3619	1.0059	1.0059	1.6354	1.6354	1.0054	1.0054

Table A2. Internal and external multipliers of two-region model (South East of England and rest of the UK)

	South East				Rest of the UK			
	Internal		External		Internal		External	
Industries	Row	Column	Row	Column	Row	Column	Row	Column
Agriculture, forestry and fishing	1.0998	1.3825	1.0006	1.0043	1.2590	1.7914	1.0007	1.0014
Mining and quarrying	1.0564	1.2831	1.0004	1.0018	1.2176	1.6281	1.0016	1.0030
Manufacture of food, beverages and tobacco	1.2828	1.2417	1.0008	1.0018	1.7611	1.5048	1.0039	1.0015
Manufacture of textiles, wearing apparel and leather	1.0037	1.1468	1.0001	1.0015	1.0477	1.4704	1.0002	1.0030
Manufacture of wood and paper products and printing	1.5025	1.7293	1.0030	1.0060	1.6883	1.9429	1.0046	1.0050
Manufacture of petroleum, chemicals and pharmaceuticals	1.2641	1.3203	1.0089	1.0051	1.6554	1.6150	1.0063	1.0053
Manufacture of rubber, plastic and non-metallic minerals	1.2837	1.7662	1.0012	1.0060	1.7489	2.0954	1.0063	1.0038
Manufacture of basic and fabricated metal products	1.3350	1.4219	1.0021	1.0076	1.6491	1.6995	1.0042	1.0051
Manufacture of computer, electronic and optical products	1.1248	1.4004	1.0038	1.0035	1.1997	1.3353	1.0013	1.0038
Manufacture of electrical equipment	1.0837	1.4802	1.0022	1.0046	1.2151	1.6196	1.0015	1.0074
Manufacture of machinery and equipment	1.1133	1.3877	1.0053	1.0058	1.3629	1.9362	1.0032	1.0075
Manufacture of transport equipment	1.0653	1.1520	1.0034	1.0034	1.4082	1.6972	1.0065	1.0046
Other manufacturing, repair and installation	1.4850	1.5964	1.0059	1.0067	1.5428	1.8201	1.0034	1.0067
Electricity, gas, steam and air-conditioning supply	2.1109	1.8051	1.0031	1.0025	2.3626	1.9691	1.0022	1.0024
Water supply; sewerage and waste management	1.3010	1.7933	1.0006	1.0049	1.3819	2.0489	1.0005	1.0043
Construction	2.9911	1.5891	1.0097	1.0009	3.2954	1.6493	1.0067	1.0013
Wholesale and retail trade; repair of motor vehicles	1.9993	1.6304	1.0097	1.0032	2.4356	1.7934	1.0049	1.0040
Transportation and storage	1.6126	1.6360	1.0045	1.0050	1.8518	1.8254	1.0052	1.0043
Accommodation and food service activities	1.2086	1.5170	1.0006	1.0037	1.3026	1.7031	1.0012	1.0037
Information and communication	1.8661	1.4524	1.0138	1.0034	2.2142	1.6179	1.0075	1.0041
Financial and insurance activities	1.7239	1.6455	1.0042	1.0045	2.2646	1.7963	1.0098	1.0036
Real estate activities	1.8747	1.2833	1.0029	1.0014	1.8543	1.3531	1.0022	1.0017
Professional, scientific and technical activities	3.1950	1.4886	1.0153	1.0034	3.5601	1.5967	1.0168	1.0032
Administrative and support service activities	1.2103	1.3619	1.0030	1.0039	1.3964	1.5505	1.0045	1.0034
Public administration and defense; compulsory social security	1.1737	1.5525	1.0003	1.0023	1.2185	1.6715	1.0006	1.0027
Education	1.2897	1.2971	1.0009	1.0014	1.3482	1.3658	1.0005	1.0014
Human health and social work activities	1.1092	1.4700	1.0001	1.0033	1.1249	1.6295	1.0001	1.0029
Arts, entertainment and recreation	1.1231	1.4700	1.0005	1.0031	1.2009	1.6009	1.0005	1.0034
Other service activities	1.1877	1.3761	1.0007	1.0024	1.2549	1.4952	1.0004	1.0031
Activities of households	1	1	1	1	1	1	1	1
Average	1.4559	1.4559	1.0036	1.0036	1.6608	1.6608	1.0036	1.0036

Table A3. Internal and external multipliers of two-region model (South East and rest of the UK)

	East of England				Rest of the UK			
	Internal		External		Internal		External	
Industries	Row	Column	Row	Column	Row	Column	Row	Column
Agriculture, forestry and fishing	1.1987	1.5878	1.0012	1.0017	1.2321	1.7656	1.0005	1.0025
Mining and quarrying	1.0609	1.2946	1.0003	1.0027	1.2149	1.6105	1.0009	1.0022
Manufacture of food, beverages and tobacco	1.4052	1.3340	1.0028	1.0011	1.7392	1.5000	1.0023	1.0012
Manufacture of textiles, wearing apparel and leather	1.0086	1.1973	1.0001	1.0009	1.0478	1.4765	1.0001	1.0012
Manufacture of wood and paper products and printing	1.5505	1.7312	1.0030	1.0020	1.7022	1.9761	1.0009	1.0031
Manufacture of petroleum, chemicals and pharmaceuticals	1.2257	1.2926	1.0075	1.0040	1.6599	1.6255	1.0062	1.0038
Manufacture of rubber, plastic and non-metallic minerals	1.4764	1.8736	1.0021	1.0036	1.7278	2.0976	1.0033	1.0029
Manufacture of basic and fabricated metal products	1.3951	1.4532	1.0027	1.0052	1.6276	1.7080	1.0038	1.0041
Manufacture of computer, electronic and optical products	1.1359	1.3407	1.0021	1.0019	1.2199	1.3864	1.0009	1.0017
Manufacture of electrical equipment	1.1121	1.4321	1.0012	1.0025	1.2203	1.6660	1.0010	1.0032
Manufacture of machinery and equipment	1.2488	1.6633	1.0033	1.0047	1.3604	1.8893	1.0020	1.0049
Manufacture of transport equipment	1.1109	1.3080	1.0032	1.0023	1.4048	1.6591	1.0038	1.0026
Other manufacturing, repair and installation	1.5735	1.5914	1.0024	1.0030	1.5811	1.8559	1.0016	1.0037
Electricity, gas, steam and air-conditioning supply	1.7970	1.5652	1.0005	1.0033	2.3698	1.9902	1.0038	1.0011
Water supply; sewerage and waste management	1.2697	1.7213	1.0004	1.0031	1.3865	2.0788	1.0003	1.0030
Construction	3.0366	1.5877	1.0106	1.0006	3.2839	1.6556	1.0033	1.0009
Wholesale and retail trade; repair of motor vehicles	2.1996	1.6371	1.0026	1.0018	2.4794	1.8184	1.0024	1.0018
Transportation and storage	1.5179	1.6180	1.0022	1.0027	1.8966	1.8603	1.0018	1.0021
Accommodation and food service activities	1.1851	1.4968	1.0004	1.0024	1.3100	1.7274	1.0007	1.0016
Information and communication	1.7717	1.4149	1.0021	1.0020	2.3563	1.6477	1.0035	1.0015
Financial and insurance activities	1.6019	1.5699	1.0015	1.0029	2.3006	1.8227	1.0054	1.0022
Real estate activities	1.7954	1.2792	1.0016	1.0009	1.8821	1.3664	1.0014	1.0006
Professional, scientific and technical activities	3.1007	1.4682	1.0099	1.0019	3.6617	1.6213	1.0085	1.0017
Administrative and support service activities	1.2394	1.3778	1.0018	1.0018	1.4170	1.5703	1.0016	1.0017
Public administration and defence; compulsory social security	1.1917	1.5413	1.0002	1.0015	1.2160	1.6863	1.0005	1.0018
Education	1.2632	1.2818	1.0003	1.0010	1.3551	1.3764	1.0004	1.0007
Human health and social work activities	1.0963	1.4329	1.0001	1.0024	1.1259	1.6488	1.0001	1.0015
Arts, entertainment and recreation	1.0913	1.3829	1.0003	1.0016	1.2042	1.6376	1.0003	1.0011
Other service activities	1.1696	1.3549	1.0002	1.0014	1.2601	1.5188	1.0003	1.0011
Activities of households	1	1	1	1	1	1	1	1
Average	1.4610	1.4610	1.0022	1.0022	1.6748	1.6748	1.0021	1.0021

Appendix B: Occupation skill classification

Skill Level	Occupation	SOC 2 Digit
High Skill	Corporate Managers And Directors	11
	Other Managers And Proprietors	12
	Science, Engineering, Tech Professionals	21
	Health Professionals	22
	Teaching And Educational Professionals	23
	Business, Media And Public Service Professionals	24
	Science, Engineering ,Tech Associate Prof	31
	Health And Social Care Associate Professionals	32
	Protective Service Occupations	33
	Culture, Media And Sports Occupations	34
	Business, Public Service Associate Prof	35
Medium Skill	Administrative Occupations	41
	Secretarial And Related Occupations	42
	Skilled Agricultural And Related Trades	51
	Skilled Metal, Electrical, Electronic Trades	52
	Skilled Construction And Building Trades	53
	Textiles, Printing And Other Skilled Trades	54
	Caring Personal Service Occupations	61
	Leisure, Travel And Related Personal Servic	62
Low skill	Sales Occupations	71
	Customer Service Occupations	72
	Process, Plant And Machine Operatives	81
	Transport And Drivers And Operatives	82
	Elementary Trades And Related Occupations	91
	Elementary Administration And Service Occupations	92

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