ASSESSING REGIONAL INNOVATIVE ENTREPRENEURSHIP ECOSYSTEMS WITH THE GLOBAL ENTREPRENEURSHIP AND DEVELOPMENT INDEX: THE CASE OF SCOTLAND

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Abstract

An assessment of Scotland's innovative entrepreneurship ecosystem is presented which employs the main variables of the Global Entrepreneurship and Development Index, adapted to the regional level for the MIT Regional Entrepreneurship Acceleration Program. This is the first time that this methodology has been applied to a region through consultation with a panel of regional experts in innovative entrepreneurship. A sensitivity analysis revealed eight bottlenecks in the ecosystem and a stakeholder analysis suggested five underlying possible causes of these bottlenecks which could be addressed by policy initiatives. An outline process model of regional innovation-based entrepreneurial ecosystem assessment is proposed.

Introduction

The entrepreneurship policy literature mainly focuses on increasing the quantity of new businesses (Hart, 2003; Lundström and Stevenson, 2005; Audretsch, Grilo and Thurik, 2007; Bosma and Levie, 2010). Less effort has been directed at firms which make the greatest contribution to value and job creation in the economy: growth-oriented businesses that combine innovation and global ambitions, and international measures of these firms remain under-developed (Hoffmann, 2007; FORA, 2010; Henrekson and Johansson, 2010). This paper addresses recent calls to combine insights on innovation and entrepreneurship to advance entrepreneurship policy (Hölz, 2010).

In 2012, as part of the inaugural Regional Entrepreneurship Acceleration Program (REAP) run by Massachusetts Institute of Technology (MIT) for regions that wished to increase their levels of innovative entrepreneurship, the REAP Scotland team commissioned an assessment of innovative entrepreneurship in Scotland from the research director of Global Entrepreneurship and Development Index. This paper describes the lessons learned from this process.

The REAP Scotland team comprised a panel of six experts in innovative entrepreneurship: two officials from two development agencies, a university professor, and three entrepreneurs, two of whom were also experts in finance for innovative entrepreneurship in Scotland. The interaction between this expert panel and the GEDI researchers led to greater understanding of the value and limitations of the GEDI and REAP approaches to understanding a region's innovation-based entrepreneurial ecosystem.

This paper describes the REAP and GEDI methodologies as applied to the sub-national (regional) level, and reflects on the value of regional experts in regional variable choice, sourcing, validation and interpretation. A multi-level benchmarking approach to regional GEDI-based assessment of innovative entrepreneurial ecosystems is outlined for the benefit of other regions that might wish to conduct similar assessments. Finally, an outline process model of assessment of a region's innovation-based entrepreneurial ecosystem is proposed.

Assessing a region's innovative entrepreneurship ecosystem

The REAP framework

The inaugural MIT REAP program's framework for analysis is shown in Figure 1. REAP distinguishes between small and medium-sized enterprises (SMEs) and innovation-based entrepreneurship (IBE). It is argued that IBE provides a greater contribution to regional economic development than SMEs, because the former can develop global advantage through innovation, whereas the latter tends to be restricted to regional or local advantage. IBE emerges from the linkages between a region's innovation capacity and its entrepreneurship capacity. A region's level of IBE, therefore, is a function of the strength of its innovation capacity, its entrepreneurship capacity, and the networks that link these capacities. If a region wishes to accelerate its IBE ecosystem, it needs to assess the current strengths of these three components, and identify what may be holding back the levels of IBE.

The REAP approach to assessing regional innovation-based entrepreneurial ecosystems was to assess innovation capacity and entrepreneurship capacity separately under six themes: People, Funding, Infrastructure, Policy, Rewards and Norms, and Demand, and then assess the networks in place to link these two capacities. Potential growth clusters were then identified. The assessment was based on available secondary data, plus interviews with individuals in the ecosystem. Early work on this model found that while good quality secondary data was often available at the regional level for innovation capacity and clusters, measures of entrepreneurship capacity were unsatisfactory. There was also a need for rigorous benchmarking of elements of the regional ecosystem against each other and against equivalent elements in other regions.

The two main sources of information on entrepreneurship in regions are official registers of new business creation and comparative surveys of individuals or businesses. Official registers are difficult to compare across national boundaries because of technical differences in the registration processes, although there have been attempts to harmonise and compare across national business registration databases, e.g. the OECD Entrepreneurship Indicators Programme (Lunati et al., 2010; OECD-Eurostat, 2007), and the World Bank's Entrepreneurship Survey (World Bank, 2011). Surveys like Global Entrepreneurship Monitor (GEM) and Eurobarometer estimate various "snapshot" rates of individuals' entry into business creation and individual business ownership in different sets of countries, and also measure a range of attitudes towards entrepreneurship (Reynolds et al., 2005; Gallup, 2009).

GEM's original theoretical model combined insights on the allocation of effort into entrepreneurship at the national (adult working age population) level with economics literature in the Austrian tradition (Levie and Autio, 2008). The model suggested that the relationship between national-level new business activity and the institutional environment, represented by a set of "Entrepreneurial Framework Conditions" (EFCs), is mediated by opportunity perception and the perception of start-up skills in the population.

Unfortunately, GEM's main measure of early-stage entrepreneurial activity combines SME creation with IBE creation. Since SMEs greatly outnumber IBEs, especially in developing countries, the main GEM measure of "Total Entrepreneurial Activity" (TEA) has a U-shaped relationship with GDP per capita (Bosma, Jones, Autio and Levie, 2008). The original model was subsequently updated (Bosma, Acs, Autio, Coduras and Levie, 2009) and EFCs were seen as acting on a "black box" containing a set of interacting entrepreneurial attitudes, activity and aspirations, which in turn generated economic growth via new jobs and technical innovation. The addition of an "aspirations" block of variables, which addressed entrepreneurial entry that was growth-oriented or innovation-oriented, went some way to addressing the weakness in the original conception of GEM. But the revised GEM model failed to address another issue: which aspects of the environment help or hinder which entrepreneurial attitudes, activities or aspirations?

The GEDI method

One group of GEM team scholars (Acs and Szerb, 2009; Acs, Autio and Szerb, 2013) addressed this issue by focusing on the quality as well as quantity of the business formation process and on the context within which these processes are expressed or repressed. In other words, they attempted to connect different measures of IBE-related attitudes, activity and aspiration to specific aspects of the environment for entrepreneurship. The outcome of this work was an index composed of a set of interactions between national-level measures of rates of individual attitudes, activity and aspirations and institutional-level variables that might theoretically be expected to moderate the impact of these individual variables on economic growth and development. Unlike the main GEM activity variable, or international measures of self-employment, which tend to decline with increasing rates of economic development at a decreasing rate (Carree et al., 2008), the Global Entrepreneurship and Development Index (GEDI) increases linearly with economic development (measured as GDP per capita) for most of its range (Acs et al., 2012).

GEDI assumes that entrepreneurship is fundamentally driven by individual-level action, as individuals recognise opportunities and choose to act (or not act) upon them (McMullen & Shepherd, 2006), and that action is regulated by the individual's context. This raises four issues (Acs, Autio, & Szerb, 2012):

1 First, the individual's context regulates the supply of third-person opportunities: does the economy create a sufficient flow of technological, economic and market opportunities for the individual to recognise (McMullen & Shepherd, 2006)?

2 Second, context regulates the trade-offs individuals face when deciding whether or not to act upon a given opportunity (Cassar, 2006): does the opportunity represent a better course of action relative to other options available to the individual (e.g., salaried employment)?

3 Third, context regulates the quality the entrepreneurial venture takes, if the individual decides to pursue the opportunity (Autio & Acs, 2010). For example, regulatory burden, availability of resources and barriers to entry may affect whether start-ups are innovative or not and pursue growth or not (Levie & Autio, 2011).

4 Fourth, the context regulates the relationship between actions and outcomes. Depending on context, a given venture may generate very different outcomes. Although start-up rates are very high in a number of developing economies, problems with, e.g., resource availability, infrastructure, regulations and corruption prevent most these from realising their full potential.

This means that at the country level, entrepreneurship should not be measured simply as the aggregate of new firms created or some other individual-level measure. Rather, individuals interact with their contexts to produce national entrepreneurial performance. That is why GEDI seeks to capture the *entrepreneurial dynamic* of a given country's economy, by combining *both* individual-level *and* country-level institutional indicators. GEDI defines country-level entrepreneurship as (Acs et al., 2012: 11):

> *the dynamic, institutionally embedded interaction between entrepreneurial attitudes, activities, and aspirations, by individuals, which drives the allocation of resources through the creation and operation of new ventures.*

Thus, GEDI considers country-level entrepreneurship as a dynamic resource allocation process, driven by individuals, which allocates resources to the most efficient uses. If the process works well, this will lead to more effective resource utilisation, and therefore, higher total factor productivity. If the process is inhibited, productivity growth will suffer.

The GEDI method is distinguished by: (1) its contextualisation of individual-level data by weighting it with data describing a country's institutional conditions; (2) its use of 14 context-weighted measures of entrepreneurial Attitudes, Aspirations and Activities, which are further organised into three sub-

indices; (3) its recognition that different pillars combine to produce system-level performance; and (4) the insight that national entrepreneurial performance may be held back by *bottleneck factors* – i.e., poorly-performing pillars that may constrain system performance (see Appendix 2 for a description of the Penalty for Bottleneck method).

Each of the 14 pillars is composed from national-level aggregates of individual (mainly GEM-based) data, weighted by measures of national institutional conditions from the World Bank, World Economic Forum, the Heritage Foundation and other sources. See Appendix 1 and Tables 1 and 2 for further information.

GEDI as an assessment of a regional innovation-based entrepreneurial ecosystem: a critique and extension

The GEDI approach of selective use of GEM individual-level data, focusing on opportunity-driven, innovative, and ambitious entrepreneurship, and of linking different facets of this type of entrepreneurship with variables that measure specific institutions, fits well with the aim of the REAP program to describe, diagnose and enhance regional entrepreneurial ecosystems. For example, it takes a holistic approach in which a deficiency in one factor can have knock-on effects on other parts of the ecosystem. It appears to cover all the elements of the REAP framework outlined above with the exception of policy measures, though it does cover current institutions which could reflect past and current policy (see Table 3 for a cross-referencing of the REAP themes with the GEDI pillars). It also contains a combination of multiple input and output measures which is necessary in any assessment of an ecosystem (see Table 4).

It struck the REAP Scotland team that a regionalised GEDI approach could provide the methodology for a rigorous approach to assessing innovation-driven entrepreneurial capacity in a region. However, the methodology would have to be adapted to a regional level of analysis, and extended to identify gaps between the areas of current policy focus and bottlenecks in the entrepreneurial ecosystem revealed by the GEDI analysis. It was recognised, first, that the GEDI analysis was only as good as the quality and choice of data, and second, that it could stimulate wider debate on the health of an innovative entrepreneurial ecosystem, but not act like some computerized “policy-creating machine”.

Policymakers want to know how they can achieve most leverage in enhancing an entrepreneurial ecosystem. Understanding the strength of the links between pillars that appear to be linked might help reveal critical leverage points. Unfortunately, the GEDI analysis does not reveal the strength of links between pillars. The current version assumes that all links have the same strength and that all pillars cost the same to change. Furthermore, currently GEDI cannot reveal whether the bottlenecks are causal or merely symptoms of underlying, deep-seated weaknesses in an innovation-based entrepreneurial ecosystem. Therefore, it has to be supplemented by expert judgement.

An extension of the GEDI methodology, developed by the Scottish REAP team, is outlined in a proposed process model of assessment in Figure 1. The first step is to test the convergent validity of the bottlenecks themselves by employing alternative measures of institutional variables. Given limited resources for policy intervention, “betting the house” on a set of bottlenecks which could be artifacts of their measures seems a risky proposition. If alternative measures of the bottleneck pillars generate radically different absolute pillar measures, then the value of the GEDI analysis could be questioned.

If the bottleneck measures are robust to alternative specifications, the next step is to test them on groups of expert stakeholders. Assuming the GEDI assessment passes this test, one could explore possible links between bottleneck pillars, underlying causes, and priorities for action with the experts. If there are a limited number of underlying causes, this should be apparent in the degree of agreement across the different stakeholder groups, providing both convergent validity and face validity to the assessment.

Assuming this consultative phase delivers a consensus on a limited number of linked causes and priorities for action, the next stage is to appoint short term task groups of lead stakeholders to develop solutions. This in turn could lead to a simulation phase in which the effect of different policy measures could be modelled.

Finally, the simulation results could aid a cost-benefit analysis of different combinations of policy interventions.

Conducting a field trial: The case of Scotland

The team drew up a project specification which 1) requested a GEDI-type assessment of Scotland's entrepreneurial performance against benchmark nations within and outside the UK on the set of six REAP themes, and 2) requested a sensitivity analysis of the results to identify likely bottlenecks to the acceleration of innovative entrepreneurship in Scotland.

The first stage was to regionalise the individual and institutional variables that the GEDI research team had found to best represent the quality and size of the entrepreneurial ecosystem at the national level. The actual individual and institution variables employed are in Tables 1 and 2, and the pillars are described in Appendix 1. This list was debated by the Scottish REAP expert panel both before and after the list was populated with data, resulting in several changes to the data specification.

One change was to the temporal specification. At a national level, GEDI employed two-year moving averages of individual data. The Scottish REAP team noticed that two-year moving averages could result in wide swings in point estimates from year to year in some of the GEM-based measures of "quality" entrepreneurship used by GEDI. This is because of the low frequency of "quality" entrepreneurs in the population, and thus in the annual samples. The solution was a four-year average of estimates from the years 2008 to 2011.

Secondly, the United Kingdom scored relatively poorly on the institutional measure of risk capital used by GEDI (a measure of corporate managers' perceptions of the availability of venture capital to early-stage ventures, published by the Global Competitiveness Index), but measured relatively well on other international measures of VC availability. The Scottish REAP team did not trust this measure, and it was replaced with a measure of the Depth of the Capital Market for Venture Capital published by the IESE/Ernst & Young PE/VC Country Attractiveness Index. This did not rely on perceptions of managers with little exposure to venture capital, but instead was composed of measures of capital flows relevant to VC exits. This measure correlated highly with actual VC flows at the national level.

Thirdly, six of the 14 measures were taken from perceptual measures generated for the Global Competitiveness Index by senior corporate managers in different countries, and it was not possible to find equivalent regional measures. These measures were of business risk, technology absorption capability, staff training, market dominance, technology transfer, and business strategy. Another three measures, business freedom, globalization, and venture capital, all drawn from different global indices with national-level indicators, were assumed to differ little at the home nation level of the UK. Truly regional estimates were found from published sources for seven of the 14 institutional measures. These are highlighted in bold font in table 2.

The Scottish REAP team requested four benchmarking assessments: Scotland versus all 78 economies for which data was available (see Table 5), Scotland versus innovation-driven countries according to the 2011 World Economic Forum's Global Competitiveness Report 2011, Scotland versus "Arc of Prosperity" countries, a Scottish Government term for small modern nations located around Scotland (Ireland, Iceland, Norway, Denmark, and Finland) and Scotland versus other home nations within the UK (England, Wales and Northern Ireland).

A second work package consisted of a sensitivity analysis of the results, which used the penalty for bottleneck methodology developed by Acs and Szerb (2009) to simulate how weaknesses in one

component might affect the whole entrepreneurship ecosystem. In this analysis, weak pillars were artificially boosted to gauge the effect of additional policy effort to improve them. This methodology is based on some naïve, if not unrealistic, assumptions, such as that the cost of improvement of each pillar is the same. But the purpose of this sensitivity analysis is not to be prescriptive; it is to serve as a basis for discussion by stakeholders in the next phase of assessment.

Results

Table 6 and Figure 2 benchmark Scotland against 78 economies for which data was available. The numbers in Table 6 refer to the standardized "score" for Scotland, where in each case the range is from 0 (representing weakness) to 1 (representing strength), while the colour coding around each number signifies the quartile of countries within which Scotland sits, given its score in each variable. The estimates are grouped column-wise into individual, environmental and interaction or "pillar" variables, and grouped row-wise into entrepreneurial attitudes, activity and aspirations. Scotland appears to be weak in individual attitudes towards entrepreneurship, relative to other countries, but scores well in most activity pillars. The spider diagram (Figure 2) plots Scotland's scores and shows visually where Scotland fits relative to the 25th (green), 50th (amber) and 75th (red) percentile country on each pillar. If Scotland were an independent nation, it would rank around 16th place in this GEDI-based league table, four places below the UK.

A more valuable comparison is with other "developed" economies. We show this in Table 7 and Figure 3, using the Global Competitiveness Index designation of "innovation-driven" economies for 2011. In comparison with 27 innovation-driven economies, Scotland appears relatively weak in aspirations as well as attitudes. Three weak institutional variables are the current level of participation in post-secondary education among young adults (aged 18-22), the level of internet usage, and Gross Expenditure in Research and Development (GERD). These have knock-on effects on their respective pillars: Start-up skills, Networking, and Process Innovation. Most individual aspiration variables are also relatively weak. Scotland is in the fourth quartile of innovation-driven nations in Process Innovation, Product Innovation and Risk Capital.

Figure 4 benchmarks Scotland against small modern North European economies about the same size as Scotland but which are independent nations: Ireland, Iceland, Norway, Denmark and Finland. Denmark appears strong in pillars where Scotland is relatively weak, such as Process Innovation and Networking, and where it is absolutely weak, such as Opportunity Perception. Ireland follows a similar pattern to Scotland, and is worse in some pillars, such as Opportunity Perception and Opportunity Start-up. Iceland fares worse than Scotland in Competition but better in some pillars where Scotland is weak, such as Process Innovation and Networking. Finland does better than Scotland in some Attitudes measures and most Aspiration measures.

Figure 5 benchmarks Scotland against the UK's other home nations: England, Wales and Northern Ireland. Broadly, Scotland appears "worse" than England in Opportunity Perception and Start-up Skills, and "better" than Wales and Northern Ireland in some Activity measures and Opportunity Perception.

The benchmarking also revealed areas where Scotland compares well with other countries. Scotland ranked second out of 78 countries in the Tech Sector, third in the Competition pillar, and fourth in the Opportunity Start-up pillar. We discuss these apparently strong activity pillars in the next section.

Table 8 shows the results of a sensitivity analysis illustrating the optimum additional allocation of policy effort for a 20% improvement in Scotland's GEDI score, based on the naïve assumptions listed in the Methodology section. This would bring Scotland from 16th place to around 4th place in the rank of 78 countries in the GEDI database, behind the United States, Denmark and Sweden and just ahead of Australia. The table shows that almost 50% of additional allocation should be focused on Aspiration pillars, with another 35% on three Attitudes pillars.

This sensitivity analysis assumes that the cost of improving each pillar is the same, which of course is unrealistic. It also assumes that the bottleneck pillars are causes rather than symptoms. Finally, it assumes that all pillars are amenable to policy change. Some institutional variables such as agglomeration and market size and perhaps some culture variables may not be sensitive in the short term to policy intervention.

The sensitivity analysis was a useful guide to possible areas for further investigation, but was silent on what the cut-off should be for which pillars to focus on. The team reached a view that an absolute score of less than 0.5 or a ranking of 19 or higher justified further investigation of the pillar. Three attitude pillars (Opportunity Perception, Start-up Skills, Networking) and all five Aspiration pillars met this criterion.

Having identified eight pillars to focus on, the next stage was to validate the bottleneck pillars with four stakeholder meetings in February 2013, to which experts were invited to debate between one and three of the eight pillars. Four different sets of about a dozen experts attended one of four stakeholder meetings. These meetings revealed a set of perceived weaknesses in Scotland's entrepreneurial ecosystem that seemed to crosslink the bottlenecks. A 23 page summary report was developed based on the stakeholder meetings. Repeating themes reported in the summary report across the stakeholder groups of areas that could be improved included: networking and networks (67 mentions), business, management and commercial skills (28 mentions) and in particular sales and selling skills (21 mentions), global outlook (10 mentions) and the need to connect with other cultures (11 mentions), the contribution of Scottish universities (12 mentions), mentors (12 mentions), role models (8 mentions), access to markets (4 mentions) and finance (12 mentions) including those outside Scotland, and exits (4). It was striking how individuals who had had the opportunity to experience entrepreneurial environments such as Boston returned to Scotland fired with enthusiasm.

In May 2013, the team whittled down the identified issues (and underlying causes) into five priority themes: "financing for growth' (including exits for investors in angel-backed companies, increasing access to institutional and international funds etc.); "effective connections" (this included networks but was more fundamental than "networking"), "skills for growth" for leadership teams within IBE ventures, "role of the universities in the IBE ecosystem", and "role models and positive messages". Chairs and members of the stakeholder community were identified for High level Task Groups who would be charged with developing solutions to each of the five themes. For the universities theme, two task groups were proposed: one internal to the universities and one external. At least one core member of the REAP team was appointed to each Task Group to facilitate information flows between Task Groups. In developing the briefs for the Task Groups, we agreed to adopt the "Collective Impact" approach of Hanley Brown, Kania and Kramer (2012) that seeks to get wide stakeholder buy-in and consensus on the direction of travel rather than a top-down directive approach. The five key aspects of this approach are a common agenda, shared measurement systems, mutually reinforcing activities, continuous communication, and the presence of a backbone organization.

Implications and Contribution

In Table 8, the suggested allocation of additional effort for Scotland is different to that suggested for the other UK home nations, and for the UK as a whole. This supports the REAP approach of regional-level IBE analyses.

Some of the comparative results surprised the Scottish REAP team. For example, the Scottish university sector tends to be seen within Scotland as a relative strong point of Scottish society. It was therefore a surprise to team members that in relation to other innovation-driven countries, the current gross enrolment ratio in tertiary education in Scotland (proportion of 18 to 22 year olds undergoing third level education) was relatively low.

In a second example, Scotland has a relatively low proportion of individuals who invest in other people's new business, and it is this that led to risk capital being identified as a bottleneck. But Scotland has a relatively well-developed business angel infrastructure, with some 22 angel syndicates and a transparent angel market, and the UK has exceptionally attractive incentives for wealthy individuals to invest in new ventures. Further research could test the sensitivity of the risk capital pillar to the inclusion of all informal investment rather than "sophisticated" investment. In the end, the REAP team chose to focus on the different finance issue of exits for investors that was emphasised in stakeholder meetings.

The third surprise was that Scotland fared best in the activity pillars. The quantity of entrepreneurship in Scotland has long been perceived as relatively low. This demonstrated the advantage of the GEDI choice of activity variables that reflect innovative entrepreneurship, not all entrepreneurship.

Further reflection on the pillars in which Scotland did well raised some doubts as to what was being measured within these pillars. For example, in the competition pillar, the individual measure is the "percentage of early-stage entrepreneurs who operate in markets where not many businesses offer the same product". Clearly, the GEDI authors intended it to be a relative measure of product/market uniqueness (see Appendix 1), but it could also be a measure of a lack of competition due to low overall levels of entrepreneurship. Thus, Scotland may appear to do well on this measure, but it may be signalling weakness rather than strength, because of the way the original GEM item was worded. The institutional measure for this pillar is for the UK rather than Scotland, and may therefore not reflect the dominance of firms in a regional market like Scotland. Again, this may be flattering Scotland's ranking.

Because Scotland has relatively few necessity-driven entrepreneurs, it scores highly on "Percentage of nascent and new early-stage entrepreneurs who initiated their business because of opportunity start-up motive". This measure is intended to penalize countries with high proportions of necessity-driven and by implication low quality start-ups. But, in Scotland, which has a relatively advanced social welfare system and a strong class-based society, it may simply reflect the lack of perceived economic need or self-efficacy on the part of those without employment.

The sensitivity analysis highlighted the need to focus on areas of absolute weakness, rather than relative weakness. Table 7 shows that Scotland ranks in the fourth quartile of innovation-driven countries for three aspiration pillars but no attitude pillars. Yet the worse score of any pillar is Opportunity Perception, and this is identified as the bottleneck deserving the greatest allocation of additional effort. Because the GEDI methodology is based on the premise that the weakest pillars, not the relatively weak pillars, hold the entire entrepreneurial ecosystem in check, the sensitivity analysis spotlighted Opportunity Perception more than the relatively weak Aspiration pillars.

Combining the GEDI and stakeholder analyses, the Scottish REAP team was able to identify a small number of linked issues that if tackled comprehensively, could lift a range of pillars. For example, one cross-cutting theme is information flows within the ecosystem, and between the ecosystem and the outside world. There are tremendous sources of commercially valuable information and skills in certain pockets of the ecosystem, such as experienced entrepreneurs and the research base. But this is not filtering through to less experienced entrepreneurs as much as it could. Connections by entrepreneurs with markets and resources outside Scotland also seem relatively weak. Current formal and informal networks appear to be inadequate or not working as well as they might be, and as a result fewer potentially successful entrepreneurs benefit from appropriate role models and mentors. This lack of conductivity of information may reflect low aspirations and poor networking and selling skills in addition to failures in delivery of some organised networks. Several programmes to raise aspirations and skill levels in networking and selling appear to have been successful, but scaling them up will be a challenge.

GEDI is designed to reveal the weaknesses in an entrepreneurial ecosystem. We have been challenged on this point by another REAP team which chose to focus on their country's strengths and developed their strategy by building comparative advantage. We think this is an important criticism and so we intend to connect the GEDI and stakeholder group findings to a SWOT analysis we conducted of Scotland's entrepreneurial ecosystem, to exploit Scotland's relative strengths as well as tackle absolute bottlenecks. This will form the outline strategy that will focus the task groups as they develop solutions to the issues raised by the sensitivity analysis and the stakeholder groups.

A further challenge will be measuring the effectiveness of the solutions that its task groups might propose. While the GEDI methodology enables us to benchmark against relevant countries and, potentially, regions, it will be slow to record changes in the entrepreneurial ecosystem because it is based on 4 year averages. We propose to supplement it with other measures from the biannual Community Innovation Survey and annual GEM-based measures that are not in the existing GEDI methodology but draw on larger sample sizes.

In conclusion, the GEDI methodology has proven to be a useful tool in comparing the nature of Scotland's innovative entrepreneurship ecosystem to Scotland's benchmark nations, and it could prove useful to other nations and regions. However, the GEDI methodology only provides the first step in a process of assessment. Stakeholder involvement is critical to deep understanding of a region's entrepreneurial ecosystem and to effecting real change.

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Appendix 1 Summary description of GEDI Index Pillars (Distilled from Autio et al., 2012)

The Opportunity Perception pillar captures opportunity perception – an essential precondition of entrepreneurial action (McMullen and Shepherd, 2006) – and combines it with the economic potential associated with those opportunities. Opportunity perception is measured as weighted percentage of the adult-age population perceiving good opportunities to start a firm. The value of perceived opportunities depends on the size of the market. We therefore weight this variable with two variables describing the domestic market: the size of the domestic market and the degree of urbanisation (combined here to reflect market agglomeration).

The Start-up Skills pillar captures the perception of start-up skills in the population, reflecting the importance of self-efficacy to taking action (Bandura, 1986) and weights this aspect with the quality of human resources available for entrepreneurial processes in the country, using the gross-enrolment ratio in tertiary education.

The Nonfear of Failure pillar captures the important inhibiting effect of fear of failure on entrepreneurial action (Caliendo et al., 2009). It is measured as the weighted percentage (reversed) of the population who believe that fear of failure would prevent them from starting a business. As weight, we used a measure of business risk, which reflects the availability and reliability of corporate financial information, the protection of creditors by law, and the institutional support for inter-company transactions.

Networks are an important determinant of prospective entrepreneurs' resource acquisition ability (Yli-Renko et al., 2001) and the ability of entrepreneurs to discover opportunities (Ozgen and Baron, 2007). We operationalised the Networking pillar by weighting the population average of individuals who personally know at least one entrepreneur with the number of internet uses per 100 inhabitants in the country. This weight captures the enhancing effect of the internet on social networking.

The Cultural Support pillar combines how positively a given country's inhabitants view entrepreneurs in term of status and career choice and how the level of corruption in that country affects this view. Cultural support regulates entrepreneurial action by influencing its perceived desirability (McMullen and Shepherd, 2006; Azjen, 1991). High levels of corruption can undermine the perceived status of entrepreneurs and dampen entrepreneurial aspirations (Baumol, 1996; Dreher and Gassebner, 2013; Levie and Autio, 2011).

The Opportunity Startup pillar captures the prevalence of individuals who pursue opportunity-driven start-ups and weights this against regulatory constraints. An entrepreneur's motivation for starting a business is an important signal of new venture quality (McMullen et al., 2007). Opportunity entrepreneurs are believed to be better prepared, to have superior skills, and to generate more value than what we call necessity entrepreneurs (Levie and Autio, 2008). However, regulatory burden may inhibit this pursuit (Djankov et al., 2002).

The Technology Sector pillar reflects the technology-intensity of a country's start-up activity. This measure provides an indication of the potential of start-up activity to drive productivity (Klepper, 2002; Coad and Rao, 2008). To form this pillar, we weighted the relative prevalence of technology-sector start-ups with a country's capacity for firm-level technology absorption.

It is widely held that entrepreneurs with higher education degrees are more capable and willing to start and manage high-growth businesses (Davidsson and Honig, 2003; Levie and Autio, 2008). The Quality of Human Resources pillar was formed by weighing the percentage of start-ups founded by individuals with higher than secondary education with a qualitative measure of the propensity of firms in a given country to train their staff.

The Competition pillar measures the level of the product or market uniqueness of start-ups, combined with the market power of existing businesses and business groups. The uniqueness aspect seeks to

capture the Schumpeterian ‘creative destruction’ process (Schumpeter, 1996), whereas the market power aspect captures the degree to which incumbents are able to prevent entry and the rules of the game are distorted to favour incumbents (Caves and Porter, 1977).

The Product Innovation pillar captures the tendency of entrepreneurial firms to create new products and to adopt or imitate existing ones. This pillar was created by weighting the percentage of firms that offer products that are new to at least some of their customers with a measure that combines private-sector R&D investment, the presence of high-quality research institutions, quality of technology transfer, and the protection of intellectual property.

The Process Innovation pillar captures the use of new technologies by start-ups. This is an important regulator of new firms’ ability to add value (David, 2001). To create this pillar, we combined the percentage of businesses whose principal underlying technology is less than five years old with the Gross Domestic Expenditure on Research and Development (GERD).

The High Growth pillar is a combined measure of the percentage of high-growth businesses that intend to employ at least ten people and plan to grow more than 50% in five years and business strategy sophistication. It is not enough to intend to grow; organisational growth is more likely to be realised if one has a strategy to capture and hold sufficient market share to enable growth.

The Internationalisation pillar captures the degree to which a country’s entrepreneurs are internationalised, as measured by businesses’ exporting potential. Internationalisation is believed to be a major determinant of entrepreneurial firm growth (De Clercq et al, 2005). To compute the pillar, this measure was weighted with the extent to which the country is economically globalised.

The Risk Capital pillar combines two measures of finance: informal investment in start-ups and a measure of the depth of the capital markets for institutional venture capital. Availability of risk capital is considered an important precondition of the ability of growth-oriented new firms to fulfil their growth aspirations (Gompers and Lerner, 2004).

Table 1. Individual variables, based on the average for 2008 to 2011 Global Entrepreneurship Monitor databases.

Individual variable	Description (All are 4 year average measures for 2008 to 2011)
OPPORTUNITY	Percentage of the 18-64 year old population who perceive good opportunities to start a new business during the next 6 months in the area where they live
SKILL	Percentage of the 18-64 year old population who believe that they possess the required knowledge and skills to start a new business
NONFAIRFAIL	Percentage of the 18-64 year old population stating that fear of failure would prevent them from starting a business (reverse coded)
KNOWENT	Percentage of the 18-64 year old population who personally know someone who has started a business during the previous 2 years
NBGOODAV	Percentage of the 18-64 year old population indicating that people consider starting a new business as a good career choice
NBSTATAV	Percentage of the 18-64 year old population thinking that people attach a high status to successful entrepreneurs
CARSTAT	Status and respect of entrepreneurs calculated as the average of NBGOODAV and NBSTATAV
TEAOPPORT	Percentage of nascent and new early-stage entrepreneurs who initiated their business because of opportunity start-up motive
TECHSECT	Percentage of early-stage entrepreneurs that are active in high or medium technology sectors
HIGHEDUC	Percentage of early-stage entrepreneurs who have participated in higher than secondary education
COMPET	Percentage of early-stage entrepreneurs who operate in markets where not many businesses offer the same product
NEWPRODUCT	Percentage of early-stage entrepreneurs offering products that are new to at least some of their customers
NEW TECHNOLOGY	Percentage of early-stage entrepreneurs with businesses that use new technology that is less than 5 years old
GAZELLE	Percentage of early-stage entrepreneurs with high job expectations (over 10 more employees and 50% in 5 years)
EXPORT	Percentage of early-stage entrepreneurs for whom at least some customers are located outside their own country
INFINVMEAN	The mean amount of informal investment where informal investment has been provided over the last three years
BUSANG	Percentage of the 18-64 year old population who provided funds for new business in past 3 years excluding stocks & funds, average. NB this is mainly family and friends investment; it includes business angels but they represent less than 10% of total.
INFINV	The amount of informal investment calculated as INFINVMEAN* BUSANG

Table 2. Institutional variables used in the GEDI analysis

Institutional variable	Description (Items highlighted in bold denote measures where regional estimates could be sourced)
MARKETDOM	**Domestic market size that is the sum of gross domestic product plus value of imports of goods and services, minus value of exports of goods and services, normalized on a 1–7 (best) scale data are from the World Economic Forum Global Competitiveness Index (GCI) report 2010/11. Data for UK home regions are calculated from latest available input/output tables.**
URBANIZATION	**Urbanization that is the percentage of the population living in urban areas, data are from the Population Division of the United Nations, 2010 estimate. Data for UK home nations are taken from 2009 small area population estimates.**
MARKETAGGLOM	**The size of the market: A combined measure of the domestic market size and the urbanization that later measures the potential agglomeration effect. Calculated as MARKETDOM*URBANIZATION**
EDUCPOSTSEC	**Gross enrolment ratio in tertiary education, 2009 or latest available data (for 18 to 22 year olds in tertiary education in that year). National data taken from UNESCO Global Education digest, 2011. UK home nation data extracted from Eurostat estimates for 2009.**
BUSINESS RISK	The business climate rate "assesses the overall business environment quality in a country… It reflects whether corporate financial information is available and reliable, whether the legal system provides fair and efficient creditor protection, and whether a country's institutional framework is favorable to intercompany transactions" (http://www.trading-safely.com/). It is a part of the Country Risk Rate. The alphabetical rating is turned to a seven point Likert scale from 1 ("D" rating) to 7 (A1 rating). 30 December 2010 data.
INTERNETUSAGE	**The number Internet users in a particular country per 100 inhabitants, 2009 data from International Telecommunications Union. UK home nation data taken from OFCOM NATIONS & REGIONS TRACKER - QUARTER 1 2010. 4th January to 28th February 2010, adjusted using the OFCOM TECHNOLOGY TRACKER - QUARTER 4 2009 1st October to 10th December 2009.**
CORRUPTION	**The Corruption Perceptions Index (CPI) measures the perceived level of public-sector corruption in a country. "The CPI is a "survey of surveys", based on 13 different expert and business surveys." (http://www.transparency.org/policy_research/surveys_indices/cpi/2009) Overall performance is measured on a ten point Likert scale. Data are from 2010.**
FREEDOM	"Business freedom is a quantitative measure of the ability to start, operate, and close a business that represents the overall burden of regulation, as well as the efficiency of government in the regulatory process. The business freedom score for each country is a number between 0 and 100, with 100 equaling the freest business environment. The score is based on 10 factors, all weighted equally, using data from the World Bank's Doing Business study". (http://www.heritage.org/Index/pdf/Index09_Methodology.pdf). Data are from 2010.
TECHABSORP	Firm level technology absorption capability: "Companies in your country are (1 = not able to absorb new technology, 7 = aggressive in absorbing new technology)".
STAFFTRAIN	The extent of staff training: "To what extent do companies in your country invest in training and employee development? (1 = hardly at all; 7 = to a great extent)".
MARKDOM	Extent of market dominance: "Corporate activity in your country is (1 = dominated by a few business groups, 7 = spread among many firms)".
TECHTRANSFER	These are the innovation index points from GCI: a complex measure of innovation including investment in research and development (R&D) by the private sector, the presence of high-quality scientific research institutions, the collaboration in research between universities and industry, and the protection of intellectual property.
GERD	**Gross domestic expenditure on Research & Development (GERD) as a percentage of GDP, year 2009 or latest available data Puerto Rico, Dominican Republic, and United Arab Emirates are estimated**
BUSS STRATEGY	Refers to the ability of companies to pursue distinctive strategies, which involves differentiated positioning and innovative means of production and service delivery.

GLOB	A part of the Globalization Index measuring the economic dimension of globalization. The variable involves the actual flows of trade, Foreign Direct Investment, portfolio investment and income payments to foreign nationals as well as restrictions of hidden import barriers, mean tariff rate, taxes on international trade and capital account restrictions. (http://globalization.kof.ethz.ch/static/pdf/variables_2009.pdf) . Data are from the 2010 report and based on the 2007 survey.
VENTCAP	A measure of the depth of the capital market for venture capital, taken from the 2011 PE/VC country attractiveness index.

Table 3. Cross-reference of REAP themes and GEDI pillars

Pillar/Theme	People	Funding	Infrastructure	Policy	Rewards and Norms	Demand
ATTITUDE						
Opportunity Perception	E		E, I, N			E,I,N
Start-up Skills	E		E,I,N			
NonFear of Failure	E		E,I,N		E,I,N	
Networking	E, N		E,I,N			
Cultural Support	E		E,I,N		E,I,N	
ACTIVITY						
Opportunity Startup	E		E		E	E
Tech Sector	E, I,N		E,I,N			
Quality of Human Resources	E, I		E,I,N			
Competition	E, I,N		E,I,N			E,I,N
ASPIRATION						
Product Innovation	I		E,I,N			
Process Innovation	I	E, I, N	E,I,N			
High Growth	E, I		E,I,N			
Internationalisation	E, I		E,I,N			
Risk Capital	E, I	E.I,N	E,I,N			

Code: E: Entrepreneurship capacity I: Innovation capacity N: Linking networks

Table 4. Classification of GEDI variables into input and output measures of the innovative entrepreneurial ecosystem

Pillar	Institutional variable	Input or output	Individual variable	Input or Output
ATTITUDE				
Opportunity Perception	Market Agglomeration	I	Opportunity Perception	I
Start-up Skills	Education PostSec	I	Skill Perception	I
NonFear of Failure	Business Risk	I	Nonfear of Failure	I
Networking	Internet Usage	I	Know Entrepreneurs	I
Cultural Support	Corruption	I	Career Status	I
ACTIVITY				
Opportunity Startup	Economic Freedom	I	TEA_Opportunity	O
Tech Sector	Tech_Absorption	I	TEA_Technology	O
Quality of Human Resources	Staff Training	I	TEA_Education	O
Competition	Domestic Market	I	TEA_Competition	O
ASPIRATION				
Product Innovation	Technology Transfer	I	TEA_NewProduct	O
Process Innovation	GERD	I	TEA_NewTech	O
High Growth	Business Strategy	I	TEA_Gazelle	O
Internationalisation	Globalisation	I	TEA_Export	O
Risk Capital	Venture Capital	I	Informal Investment	I

Code: I: Input measure O: Output measure

Table 5. List of 78 economies included in global comparison with Scotland (asterisked economies are "innovation-driven" economies: see text)

Algeria	Hong Kong*	Poland
Angola	Hungary	Portugal*
Argentina	Iceland*	Romania
Australia*	India	Russia
Bangladesh	Iran	Saudi Arabia
Barbados	Ireland*	Serbia
Belgium*	Israel*	Singapore*
Bolivia	Italy	Slovakia
Bosnia and Herzegovina	Jamaica	Slovenia*
Brazil	Japan*	South Africa
Chile	Jordan	Spain*
China	Korea*	Sweden*
Colombia	Latvia	Switzerland*
Costa Rica	Lebanon	Syria
Croatia	Lithuania	Taiwan*
Czech Republic*	Macedonia	Thailand
Denmark*	Malaysia	Trinidad and Tobago
Dominican Republic	Mexico	Tunisia
Ecuador	Montenegro	Turkey
Egypt	Morocco	Uganda
Finland*	Netherlands*	United Arab Emirates*
France*	Nigeria	United Kingdom*
Germany*	Norway*	United States*
Ghana	Pakistan	Uruguay
Greece*	Panama	Venezuela
Guatemala	Peru	Zambia

Table 6. Scotland versus 78 other economies, including the UK

Institutional Variable		Individual Variable		Pillars		Scotland Rank (78 GEDI countries)
Market Agglomeration	0.671	Opportunity Perception	0.382	Opportunity Perception	0.347	42
Education PostSec	0.632	Skill Perception	0.448	Start-up Skills	0.401	39
Business Risk	0.860	Nonfear of Failure	0.502	NonFear of Failure	0.555	11
Internet Usage	0.793	Know Entrepreneurs	0.357	Networking	0.403	32
Corruption	0.924	Career Status	0.464	Cultural Support	0.585	10
Economic Freedom	0.757	TEA_Opportunity	0.628	Opportunity Startup	0.573	6
Tech_Absorption	0.673	TEA_Technology	0.813	Tech Sector	0.683	2
Staff Training	0.692	TEA_Education	0.642	Quality of Human Resources	0.554	19
Domestic Market	0.765	TEA_Competition	0.718	Competition	0.644	3
Technology Transfer	0.771	TEA_NewProduct	0.471	Product Innovation	0.446	29
GERD	0.668	TEA_NewTech	0.416	Process Innovation	0.421	24
Business Strategy	0.728	TEA_Gazelle	0.521	High Growth	0.453	23
Globalisation	0.684	TEA_Export	0.592	Internationalisation	0.487	28
Venture Capital	0.716	Informal Investment	0.455	Risk Capital	0.384	34

Note: The colour coding denotes the quartile within which Scotland is located for each element and pillar.
Blue: Top quartile; Green: second quartile; Amber: third quartile; Red: Bottom quartile
Numbers are Scotland's score within a normalised scale for all 78 participating economies plus Scotland from 0 to 1.

Table 7. Scotland versus 27 'innovation-driven' economies

Institutional Variable		Individual Variable		Pillars		Scotland Rank (27 innovation-driven countries)
Market Agglomeration	0.671	Opportunity Perception	0.382	Opportunity Perception	0.347	18
Education PostSec	0.632	Skill Perception	0.448	Start-up Skills	0.401	19
Business Risk	0.860	Nonfear of Failure	0.502	NonFear of Failure	0.555	11
Internet Usage	0.793	Know Entrepreneurs	0.357	Networking	0.403	21
Corruption	0.924	Career Status	0.464	Cultural Support	0.585	9
Economic Freedom	0.757	TEA_Opportunity	0.628	Opportunity Startup	0.573	4
Tech_Absorption	0.673	TEA_Technology	0.813	Tech Sector	0.683	2
Staff Training	0.692	TEA_Education	0.642	Quality of Human Resources	0.554	17
Domestic Market	0.765	TEA_Competition	0.718	Competition	0.644	3
Technology Transfer	0.771	TEA_NewProduct	0.471	Product Innovation	0.446	22
GERD	0.668	TEA_NewTech	0.416	Process Innovation	0.421	23
Business Strategy	0.728	TEA_Gazelle	0.521	High Growth	0.453	15
Globalisation	0.684	TEA_Export	0.592	Internationalisation	0.487	20
Venture Capital	0.716	Informal Investment	0.455	Risk Capital	0.384	25

Table 8. Sensitivity analysis illustrating the optimum additional allocation of policy effort for a 20% improvement in Scotland's GEDI score

	Scotland	Wales	N. Ireland	England	UK
Opportunity Perception	13%	21%	24%	8%	9%
Startup Skills	11%	11%	13%	8%	9%
NonFear of Failure	4%	3%	6%	5%	5%
Networking	11%	11%	9%	9%	9%
Cultural Support	3%	0%	0%	6%	6%
Opportunity Startup	4%	3%	1%	5%	5%
Tech Sector	0%	6%	0%	0%	0%
Quality of Human Resources	4%	3%	5%	4%	4%
Competition	0%	0%	0%	3%	3%
Product Innovation	9%	9%	6%	10%	10%
Process Innovation	11%	11%	13%	9%	9%
High Growth	9%	6%	7%	11%	10%
Internationalisation	7%	6%	4%	10%	10%
Risk Capital	12%	11%	12%	13%	11%
	100%	100%	100%	100%	100%

Note: This sensitivity analysis is based on the following technical assumptions:

1. The weakest pillar in the system holds back the system
2. Additional allocation of resources would be provided to the bottleneck pillars
3. The additional cost of resources is the same for all pillars

Figure 1. Process model of assessment of a regional innovation-driven entrepreneurial ecosystem

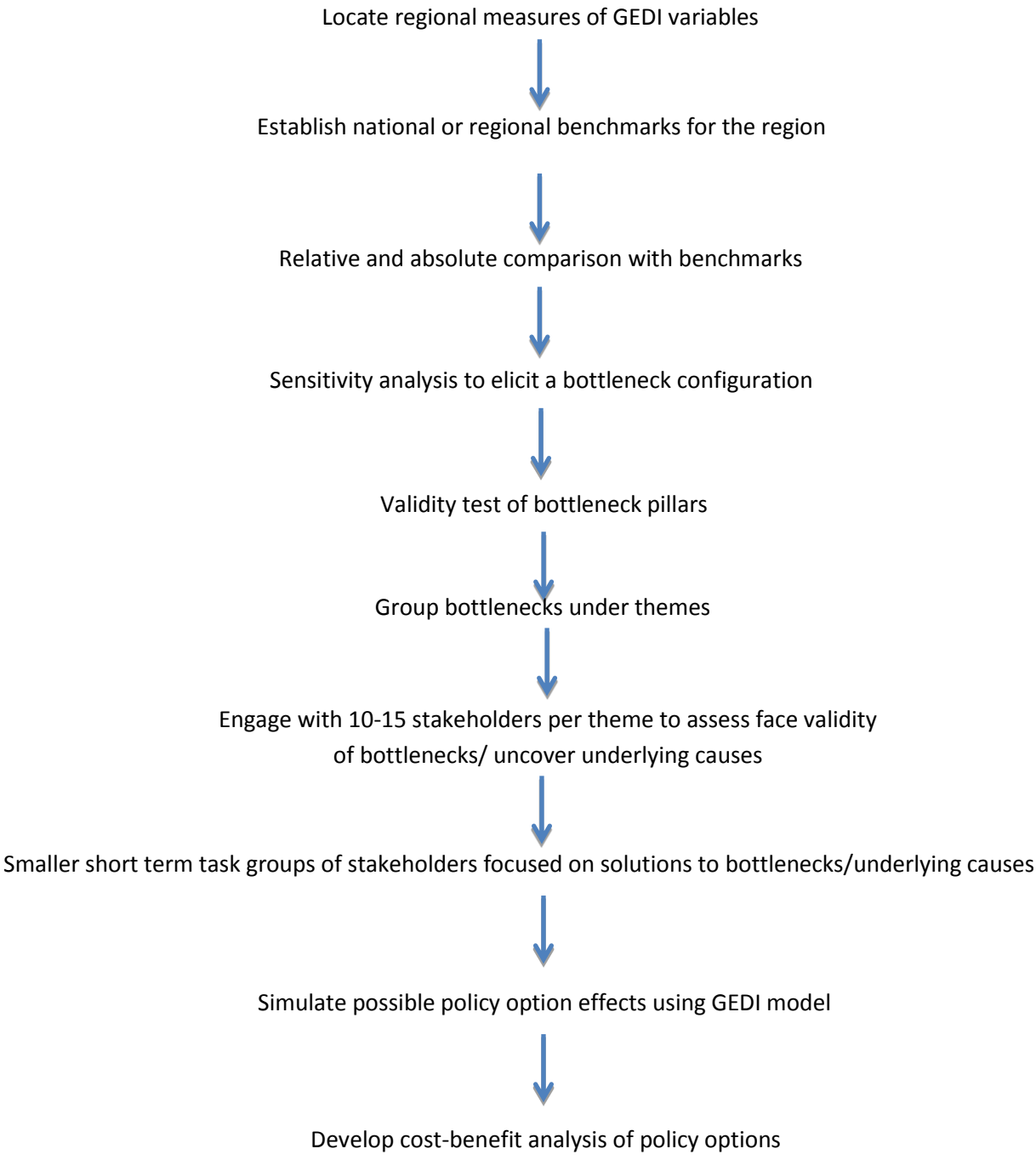

Figure 2. Scotland versus 78 economies

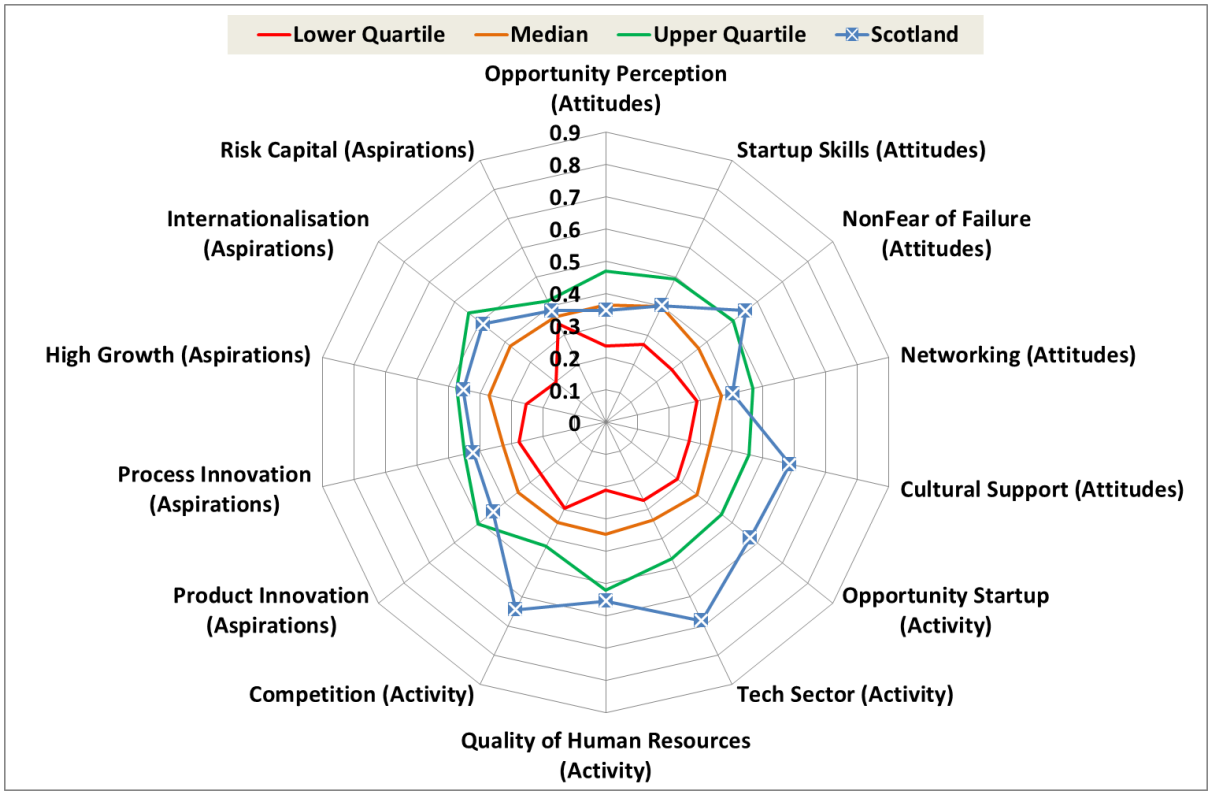

Figure 3. Scotland versus 27 innovation-driven economies

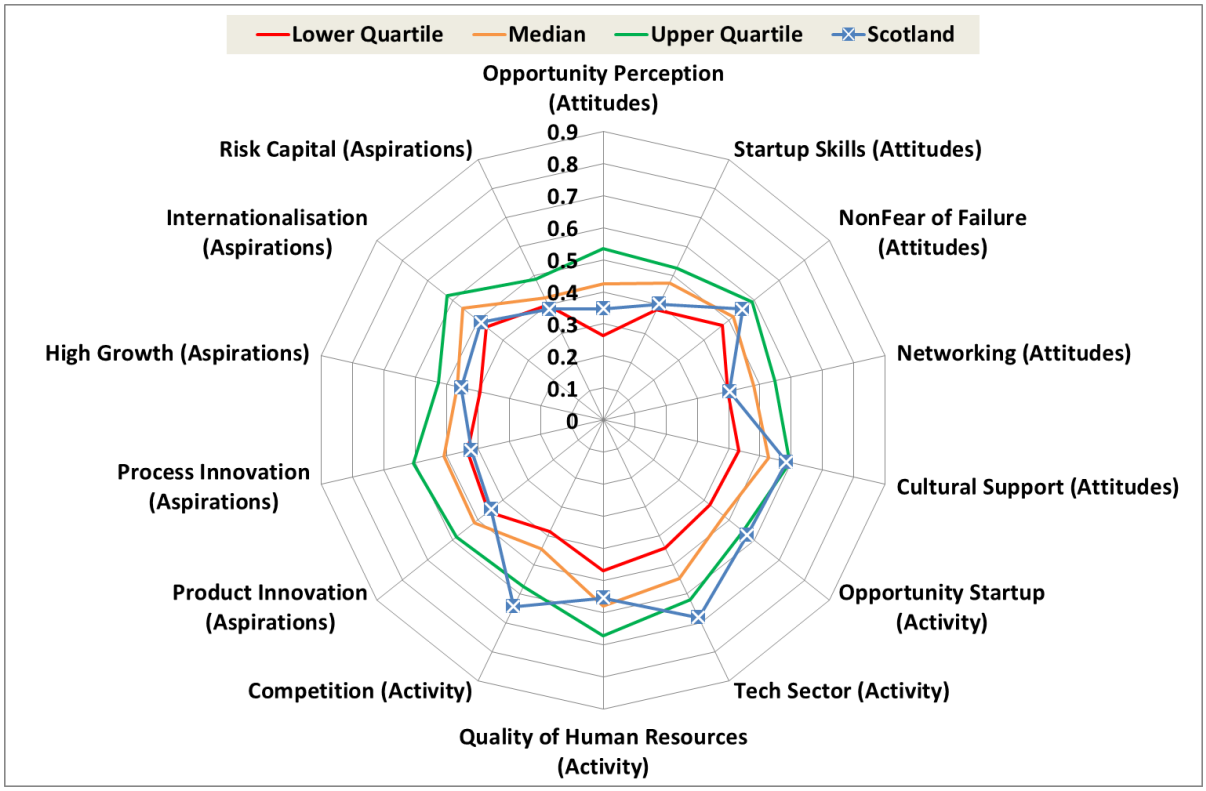

Figure 4. Scotland versus 'Arc of Prosperity' economies

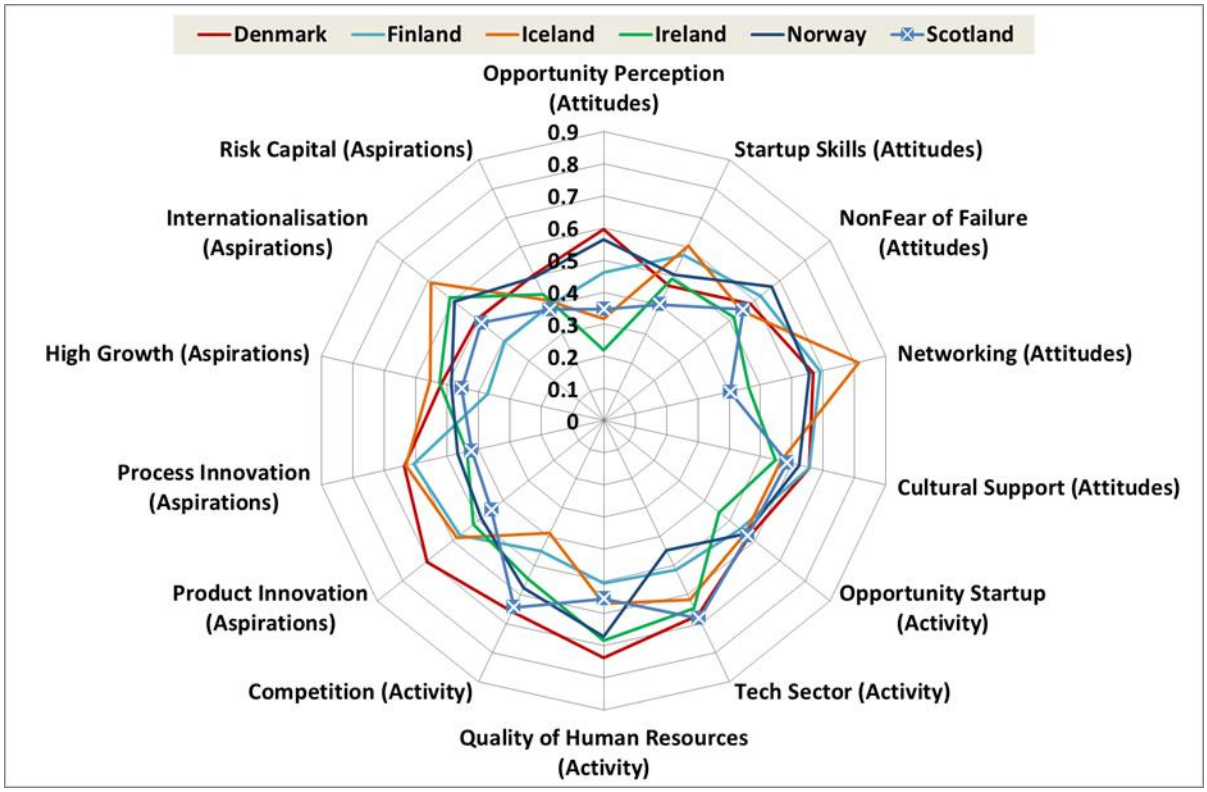

Figure 5. Scotland versus other UK home nations