‘HARD FACTS’ OR SOFT INSIGHTS? FACT-BASED AND PARTICIPATIVE APPROACHES TO ENTREPRENEURSHIP ECOSYSTEMS POLICY ANALYSIS AND MANAGEMENT

Erkko Autio, *Imperial College Business School, UK*
Jonathan Levie, *University of Strathclyde, United Kingdom*

Abstract

Policy practice focuses increasingly on entrepreneurship ecosystems, yet the implications of this concept for policy analysis and management remain under-studied. Drawing on research on analysis and management of other socio-economic ecosystems, primarily socio-ecological ecosystems but also innovation ecosystems and community development ecosystems, we conducted a theoretical examination of the challenges of policy analysis and management in entrepreneurship ecosystems. Using a Scottish entrepreneurship ecosystem initiative as our empirical context, we conclude that participative policy design approaches are likely to give rise to better informed, targeted, and implemented policy initiatives in the context of entrepreneurship ecosystems.

Introduction

Entrepreneurship ecosystems attract increasing policy interest (Acs et al., 2014; Drexler et al., 2014). This trend has highlighted a gap in our knowledge of how to improve the functioning of such ecosystems. Traditionally, entrepreneurship policy has employed top-down approaches designed to address specific, well-defined market failures by, for example, providing subsidized funding for new businesses or enhancing SME access to R&D facilities or government procurement systems (Lundström and Stevenson, 2005). As the policy focus shifts towards entrepreneurship ecosystems, more attention needs to be paid to understanding and managing system-level dynamics in ways that move beyond the traditional, market failure approach. In this paper, we review policy analysis and management approaches in a wide range of socio-economic ecosystems and apply these lessons to entrepreneurship ecosystems in general and to the specific case of Scotland's innovation-driven entrepreneurship ecosystem. Our findings raise fundamental questions about the efficacy of traditional entrepreneurship policy and the role of policymakers in entrepreneurship ecosystems.

Following Acs et al. (2014, p. 479), we define entrepreneurship ecosystems as: "*…the dynamic, institutionally embedded interaction between entrepreneurial attitudes, ability, and aspirations, by individuals, which drives the allocation of resources through the creation and operation of new ventures.*" Entrepreneurship ecosystems are complex socioeconomic structures that are driven by individual-level action. This action is embedded in complex interactions between individual and organizational stakeholders that make up the ecosystem, and it is expressed through the creation and operation of new ventures. The ultimate outcome of this trial-and-error dynamic is the allocation of resources towards productive uses. The system-level outcome of this dynamic, therefore, is increased total factor productivity.

Because the 'services' produced by entrepreneurship ecosystems are diffuse and produced through a complex resource allocation dynamic, it is not easy to trace gaps in ecosystem performance back to specific, well defined market failures. This is the main challenge that distinguishes analysis and management of entrepreneurship ecosystems from more traditional, market failure focused policy design and implementation. As we will elaborate in our theory section, the complexities of entrepreneurship ecosystems give rise to four key challenges to ecosystem policy analysis and implementation:

1 Uneven distribution of embedded knowledge within complex socio-economic systems makes it challenging to analyse them and identify specific market failures (Hayek, 1945; Kirzner, 1997)
2 Insufficient understanding of the system dynamic gives rise to unintended policy consequences (Merton, 1936)

3 Misalignment of stakeholder interests may undermine commitment to policy action and thus inhibit value co-creation within the ecosystem (Hanley-Brown et al., 2012)

4 Complexity of the system gives rise to strong path dependence and system inertia (David, 1985).

These challenges mean that appropriate approaches to analysis and management of entrepreneurship ecosystems may differ from policy approaches to address specific market failures. Yet, in spite of an increasing focus of policy on entrepreneurship ecosystems, there has been little work analysing which approaches might be best suited to dealing with these challenges.

We address this gap by borrowing from policy research that has addressed three different socio-economic ecosystems of similar complexity: socio-ecological, innovation and community ecosystems. We interpret and adapt insights thus learned to enhance the understanding of effective approaches to entrepreneurship ecosystem policy. As a result, we deduce two hypotheses: (1) Hard facts derived from secondary data provide an insufficient picture of entrepreneurial ecosystem dynamics for policy analysis and need to be supplemented by primary data gathered using participative approaches such as stakeholder workshops; (2) Intensive stakeholder engagement such as focus groups produces causative insights that lower the risk of unintended consequences in entrepreneurship ecosystem management, decrease the risk of inertia, and increase stakeholder alignment. We test these hypotheses with a policy experiment that sought to enhance the Scottish entrepreneurship ecosystem.

With this design we advance four distinct contributions to the entrepreneurship ecosystem literature. First, this is the first study to identify analysis and management challenges to policymakers posed by the systemic characteristics of entrepreneurship ecosystems. Second, this is the first study to translate policy insights accumulated in other ecosystem domains to the context of entrepreneurship ecosystems. Third, we illustrate the effectiveness of participative approaches in entrepreneurship ecosystem policy analysis and management. Finally, through our empirical case, we highlight examples of good practice that should help advance entrepreneurship ecosystem analysis and management in other national or regional contexts.

This paper proceeds as follows. We first review theory on systems of entrepreneurship – or entrepreneurship ecosystems. We then review policy research that focuses on policy analysis and management in complex socio-economic and socio-ecological systems, derive a general proposition on the effectiveness of our approach to entrepreneurial ecosystem analysis and management versus traditional entrepreneurship policy, and deduce our hypotheses. Next, we test these hypotheses on an on-going process of Scottish entrepreneurship ecosystem facilitation. We conclude by discussing the implications of our contribution to entrepreneurship ecosystem policy and practice.

Entrepreneurship Ecosystems: Characteristics and Policy Challenges

Although there is an increasing appreciation that entrepreneurship is subject to contextual influences (Autio et al., 2014), the systems approach to entrepreneurship remains nascent. This is because of two major shortcomings in received literatures. On the one hand, the National Systems of Innovation literature is largely silent about entrepreneurship. On the other hand, the entrepreneurship literature has remained almost myopically focused on the individual and tended to ignore the wider context. Because of these biases, the understanding of systems of entrepreneurship and entrepreneurship ecosystems remains constrained and implications for policy unelaborated.

The National Systems of Innovation literature sought to explain the innovative performance of nations (Edquist, 1997; Lundvall, 1992; Nelson, 1993). The main idea was that the innovative outcomes produced by a given nation were regulated by its innovation infrastructure. In the thinking of this literature, innovation was not so much determined by individual action, but rather, by the *structure* that the country had in place for innovative action. This aspect gave the NSI literature quite a static flavour (Acs et al., 2014). In this theorizing, the institutional structure – i.e., the setup of R&D performing organizations, funding agencies, educational institutions, as well as the rules, regulations, and established traditions governing the interactions between these, were seen as the pre-eminent determinant of the nation's innovative output. However, in this tradition, there was little or no appreciation of the importance of individual-level agency. The structure predominated, and action by individuals was expected to flow almost automatically if the structural setting was correctly designed. Because of this bias towards the optimization of static structure, the core NSI literature does not offer much insight to understand entrepreneurship ecosystem dynamics. Recently, however, a number of authors have begun to offer evolutionary systems approaches to understanding innovation systems, reflecting changes taking place in the practice of innovation policy, for example in Australia and the Netherlands (Dodgson et al., 2011; Gustafsson & Autio, 2011; Nill and Kemp, 2009). We review these further below.

On the other hand, the entrepreneurship literature has also been biased, only this time towards the individual, to the extent of ignoring the context within which this individual and the new venture are embedded (Acs et al., 2014). In most conceptions, the entrepreneur's context acts primarily as a source of opportunities, resources, competition, and external uncertainty, but the wider systemic interactions are not considered (McMullen & Shepherd, 2006). This individual-centric approach therefore offers little insight into the system-level dynamic.

Acs et al. (2014) and Autio et al. (2014) proposed that a way out of this 'institutions vs the individual' dilemma is to take a broader view of the various regulating influences of the entrepreneur's context than has been the case thus far in the entrepreneurship literature. The other part of the solution is to

consider a broader range of individual-level determinants of entrepreneurial action than has been the case in the mainstream NSI literature (Autio et al., 2014). The essence of their argument was that *institutionally* (in the broad sense) *embedded action* by *individuals* ultimately determines the efficiency with which resources within the system are allocated to productivity-driving uses. To understand the determinants of entrepreneurship ecosystem performance, therefore, we need to understand three sets of institutional determinants of individual-level entrepreneurial action. First, we need to understand determinants of individual-level entrepreneurial choice – i.e., institutionally reinforced entrepreneurial attitudes. Second, we need to understand determinants of individual-level entrepreneurial ability – i.e., what kinds of abilities are actually channelled into the entrepreneurial sector. Third, we need to understand determinants of entrepreneurial aspirations. According to the systems of entrepreneurship theory, it is the dynamic, institutionally embedded interaction between these three forces that drives entrepreneurial ecosystem performance.

Note that the definition by Acs et al. (2014) emphasizes the quality – rather than quantity – of the entrepreneurial resource allocation dynamic. What is important is not so much how many entrepreneurs there are in a given entrepreneurship ecosystem, but rather, what qualities the entrepreneurs and their ventures possess. Ultimately, it is the quality of the resource allocation dynamic that determines the ability of the entrepreneurship ecosystem to drive productivity growth.

The systems of entrepreneurship theory observes that entrepreneurship ecosystems are complex and involve numerous stakeholders, such as resource providers, regulators, research institutions, large firms, and support agencies in addition to the core economic actors – the entrepreneurs and their organisations. A distinction is made between individual-level attitudes, abilities, and aspirations, and the system level regulators of these. Moving beyond structure to emphasize the importance of embedded entrepreneurial agency, the theory departs from the NSI theory by emphasizing the importance of dynamic resource allocation, rather than static, structural characteristics for ecosystem performance. These complexities pose distinct challenges for the analysis of entrepreneurship ecosystems and for the design and implementation of policy initiatives within such contexts. However, thus far, the systems of entrepreneurship theory has not elaborated these challenges or their implications for policy.

We suggest that the complexity of entrepreneurship ecosystems presents four distinctive challenges for policy.. As noted in the introduction, the ‘services’ rendered by entrepreneurship ecosystems are diffuse: the allocation of resources towards productive uses through the creation and operation of new ventures. This trial-and-error activity is carried out in myriad micro-level interactions, which are embedded in an idiosyncratic institutional structure. Because opportunity pursuit decisions are influenced by local factors in addition to opportunity size (e.g., opportunity costs and local social norms), this implies that much of the knowledge relevant for understanding the ecosystem dynamic is

embedded in the ecosystem structure, and therefore, not easily extracted and codified (Hayek, 1945; Kirzner, 1997). This creates a distinctive challenge for policy analysis, as the distribution of relevant knowledge throughout the ecosystem makes it unlikely that any single individual or organization will have a full and complete understanding of how the ecosystem works. This also implies that 'hard', codified data on the ecosystem state and its inputs and outputs is likely to be insufficient for effective policy analysis.

The second challenge derives from the difficulty of fully understanding how entrepreneurship ecosystems work. If the processes that produce system outcomes are not fully known, policies designed to facilitate a given outcome may, when put to practice, actually solicit another. Thus, well-meaning policies may end up producing unintended consequences (Merton, 1936). The possibility of unintended consequences grows higher as the ecosystem grows more complex.

The third challenge is system alignment. Compared to a classical market or industry, a distinguishing feature of ecosystems is that their services are co-produced in interactions among mutually interdependent ecosystem stakeholders. Although collaboration and rational alignment of stakeholders is often assumed, there is a strong possibility of stakeholder misalignment arising from diverging and competing stakeholder interests and imperfect information flows between stakeholders. If left unattended, this may undermine collective commitment to implementing policy actions, sustain inefficient generalism among competing resource-providers, and inhibit value co-creation in entrepreneurship ecosystems.

The fourth and perhaps greatest policy challenge is posed by system inertia. Due to their complexity, socioeconomic systems tend to exhibit strong inertial properties and high path dependency (Acs et al., 2014; Gustafsson and Autio, 2011). Because of complex interactions between system elements, policy effort may simply dissipate into the system without leaving much visible impact on the system dynamic. There is a big risk that the policy-maker will see nothing in return to policy effort invested – except for wasted effort.

Although the four policy challenges appear salient, the entrepreneurship ecosystems literature has not discussed their implications for entrepreneurship ecosystems analysis and management. However, similar challenges have been recognized and discussed in other domains. We next take a look at this literature for insight that can be applied in entrepreneurship ecosystems policy.

Policy Analysis and Management in Complex Socioeconomic Systems

In some policy domains, there have been efforts to overcome or at least attenuate policy challenges arising from the systemic characteristics of complex socioeconomic systems. In the area of ecological economics, for example, studies have assessed the merits of different approaches to overcoming

problems of embedded knowledge, unintended consequences, stakeholder misalignment and system inertia (Kaplowitz and Hoehn, 2001; Pahl-Wostl, 2002; Wilson and Howarth, 2002). Broadly, these are known as Integrated Assessment (IA) methodologies (Pahl-Wostl et al., 1998; Rotmans, 1998). Natural ecosystems interact with the human society in multiplex ways to produce multiple outcomes, collectively labelled as 'ecosystem services'. They involve numerous stakeholders who interact with natural ecosystems in different ways and for different purposes. Societal interaction with natural ecosystems thus exhibits similar levels of complexity to entrepreneurship ecosystems, making methodological insights achieved in this domain potentially applicable in the context of entrepreneurship ecosystem policy.

To deal with complexity, a number of different approaches have been proposed in the ecological economics literature to complement codified data to better understand ecosystem dynamics. Approaches developed to deal with both the analysis challenge (understanding how ecosystems work) and the management challenge (avoiding unintended consequences, ensuring stakeholder alignment and preventing inertia) include stakeholder participation (Smit and Wandel, 2006; Stringer et al., 2006), focus groups (Kahan, 2001; Markova et al., 2007), individual interviews (Kaplowitz and Hoehn, 2001), surveys (BenDor et al., 2014), and agent-based simulation (Pahl-Wostl, 2002). To further address the management challenges of unintended consequences, misalignment and inertia, 'collective action' and 'transition management' approaches have been developed (Meinzen-Dick and Di Gregorio, 2004; Nill & Kemp, 2009; Meilasari-Sugiana, 2012).

At the heart of these approaches is the idea of incorporating the behaviours, attitudes, and actions by individual human actors distributed throughout the system, so as to produce a broader and deeper understanding of the system dynamic and greater commitment to resolving any problems. This reflects the recognition that macro-level indicators alone (e.g., inputs, outputs, indicators of system composition and structure) are not sufficient to understand how complex socio-ecological systems work. To uncover and account for hidden interactions, participative and individual-centric approaches are required to tap knowledge that is embedded within the system itself. This approach also enables stakeholders to identify how they can carve unique or specialist roles in the ecosystem, thereby filling gaps, reducing wasteful overlap and increasing stakeholder expertise.

Stakeholder participation approaches leverage engagement with and between various stakeholders of the ecosystem to tap into their insights and build consensus, commitment, and participation in the policy process (Pahl-Wostl, 2002) and thus improve stakeholder alignment and prevent inertia. These approaches recognise that different stakeholders have different perspectives to offer and may be differentially affected by the planned policies (Wilson and Howarth, 2002). Engaging with stakeholders is important to alleviate uncertainty and reveal different cause-effect relationships within

the system. Thus, stakeholder participation approaches facilitate a polycentric understanding of how the ecosystem works, thereby providing ground for management of the ecosystem.

An additional benefit of stakeholder participation approaches is their ability to facilitate mutual understanding between different stakeholders, which helps pre-empt potential conflicts that might arise due to misunderstandings and lack of mutual awareness. Participation approaches also help motivate policy stakeholders to become active participants in the policy process, not only in the analysis phase, but also during the management phase. This engagement also enables more adaptive and innovative management of the ecosystem (Pahl-Wostl, 2002; Smit and Wandel, 2006).

Focus groups approaches. Whereas stakeholder participation is broad-based and intended to promote alignment, focus groups are designed to provide insight into more narrowly defined aspects of the ecosystem (Kahan, 2001; Kaplowitz and Hoehn, 2001). Stakeholder participation mechanisms solicit broad understandings of the ecosystem as a whole, drawing on inputs from a range of different stakeholders. In contrast, focus groups facilitate deep insight on specific issues. This has implications for how focus groups are organized. As the purpose is digging deep into a specific issue or problem, coherence in participant backgrounds takes precedence over diversity. Focus group participants need to be well aware of the domain area, and their participants need to be able to communicate effectively with one another. Also, focus group discussions tend to be more narrowly focused on sets of closely related issues, in lieu of exploring and uncovering previously unrecognized and unexplored issues. Finally, consensus building and commitment building play less of a role in focus groups, whose purpose is more on the production of well-defined outputs such as specific calls to action. This tends to imply less free-flowing and more intense sessions that tend to be shorter in duration than stakeholder discussion groups (Kahan, 2001).

An ongoing debate in focus group research – also applicable to stakeholder participation – concerns the tension between rationality and social construction in focus group discussion (Belzile and Öberg, 2012). Is the primary function of focus groups to uncover already existing but previously unknown social reality, or do focus groups serve more as a medium for social construction, by creating social reality through debate, sharing, and combination of subjective, culturally embedded realities? The balance between the two is influenced by a number of factors, such as the nature of interaction within the group. In a rationalist tradition that is strongly present in, e.g., marketing research, the focus group facilitator tends to play a central role and ensure that the group keeps focused on the main issue (Merton, 1987). In this perspective, the experiences and opinions of individuals are assumed to be more or less fully formed, and the task of the focus group discussion is to bring these out. In the constructivist tradition, focus groups are seen as facilitating dynamic social processes where the group jointly constructs a shared narrative about a given topic (Belzile and Öberg, 2012; Markova et al.,

2007). Thus, the balance of the two appears to depend largely on how open-ended and familiar the issue under question is.

Stakeholder engagement meetings and focus groups are recognised as central participation-inducing approaches in ecological economics. These can be complemented with ***individual interviews***, ***surveys*** and ***agent based modelling*** (BenDor et al., 2014; Pahl-Wostl, 2002). Individual interviews, while costly, may elicit controversial information that might not be volunteered in focus groups (Kaplowitz and Hoehn, 2001). Surveys can be a useful tool to uncover revealed preferences within different constituencies, and also, the valuation of different ecosystem services (BenDor et al., 2014). Some of these insights can be fed into agent-based simulation models to explore different scenarios.

Collective action is a well-established approach to policy management in socio-ecological ecosystems (Meinzen-Dick and Di Gregorio, 2004). This approach is increasingly deployed in large scale renewal of neighbourhoods and even cities, under the term "collective impact" (Hanley-Brown et al., 2012). This approach also has parallels in the Dutch sustainable innovation policy approach of "transition management", or as policy-makers prefer to call it, "a transition approach" (Nill and Kemp, 2009). Collective action is not a panacea and requires careful and sensitive management. Some key principles of success in collective action that help to avoid unintended consequences, misalignment and inertia include reciprocity, recognition, validation, and differentiation (Meilasari-Sugiana, 2012). These help bind people collectively to the mission, whether it is to facilitate a sustainable yield of biomass or of high quality entrepreneurs. Collective impact follows similar lines, with five key success factors identified: a common agenda, shared measurement systems, mutually reinforcing activities, continuous communication, and the presence of a backbone organization (Hanley-Brown et al., 2012). Transition management has the following features: Long-term thinking (at least 25 years) as a framework for short-term action, thinking in terms of multiple domains, and a focus on learning, including learning-by-doing, doing-by-learning, and learning about a variety of options (Nill and Kemp, 2009).

What lessons for entrepreneurship ecosystems policy can we draw from these methods? All of these policies address complex socio-economic systems, and their ultimate aims are similar to that of entrepreneurship ecosystems policy. For example, the objective of the socio-ecological policy is to derive a resource allocation process which maximizes the varied benefits to human social and economic well-being of living ecosystems without destroying them. The objective of entrepreneurship ecosystems policy is a higher quality resource allocation process for entrepreneurial opportunity with consequent higher productivity. Because higher productivity means greater output for the same amount of input, it benefits society as a whole.

Furthermore, while all these branches of policy facilitate collective good in the medium to long term, some stakeholders may perceive personal short term risks or even losses in the short term. For example, in a marine ecosystem experiencing diminishing yields due to netting of juvenile fish, short-term losses may make fishermen reluctant to invest in new nets that do not destroy young fish. In entrepreneurship ecosystems, entrenched interests such as licensed taxi cabs may not welcome competition from new entrants such as the Uber service. In both these cases, although all system stakeholders are likely to ultimately benefit, desirable changes may be inhibited by stakeholder resistance, and well-meaning but unpopular sanctions may solicit unexpected consequences. All of these policy domains therefore face the challenge of facilitating alignment among system stakeholders.

Finally, just as these other forms of ecosystem analysis are explorative and emphasize sense-making (e.g., what is the value of ecosystem services for different stakeholders and for society?), so should entrepreneurial ecosystem analysis (e.g. how is entrepreneurship valued by different stakeholders, and how can value perceptions be influenced?). Without a methodology for sense-making within and by a society, entrepreneurship ecosystem analysis may miss cues that signal what is preventing individuals with high entrepreneurial potential from fulfilling that potential.

In conclusion, different human ecosystems appear to share similar challenges of ecosystem analysis and management. For ecosystem analysis, the challenges relate to uncovering system interactions and achieving a shared understanding of how the system works as a whole so that system optimisation becomes possible. For ecosystem management, the challenges relate to achieving consensus among different stakeholders regarding what the shared goals should be, soliciting commitment to these, and maintaining momentum in the new direction. Even if policy-makers may achieve an understanding of what needs to be done, there might be few direct levers to pull to facilitate desired outcomes. The results will only be generated by stakeholders, and stakeholder alignment will only be possible if consensus is achieved and stakeholders commit and are motivated to take action on ecosystem gaps or overlaps.

The implication of these parallels for entrepreneurship ecosystem policy is that a range of sense-making methodologies are required to uncover system bottlenecks. Broad participation by stakeholders is required to get an overall understanding of how the ecosystem works, and what its strengths and bottlenecks might be. In order to develop a deeper understanding of specific bottlenecks and solutions to them, more narrowly oriented focus group discussions may be more useful. In-depth interviews with key individuals may be necessary to uncover controversies or animosities that may be concealed in public. After analysis, techniques need to be deployed that build consensus on what needs to be done to improve the system, and different stakeholders need to commit to playing their part in achieving the shared mission while acknowledging the parts that can be best played by others.

Short term "quick wins" may be necessary to win over influential but sceptical stakeholders, but monitoring and learning from experiments needs to be maintained over at least the medium term.

Summarizing, our review suggests that the four challenges we have identified can be addressed by combining a range of methodologies that are very different from contemporary accounts of the formation and implementation of entrepreneurship policy, which are justified on theoretical grounds by the concept of market failure ((Lundström and Stevenson, 2005) but which in practice appear to be driven by serving the minister's political needs, at least in the UK (see, e.g. Arshed et al., 2014). This leads us to a general proposition:

> *Proposition 1: Participative policy analysis and collective action approaches to entrepreneurship ecosystem management are likely to facilitate more consequential and effective implementation of entrepreneurship ecosystem policies than traditional government-centred entrepreneurship policy approaches.*

We now deduce two hypotheses based around the four challenges of ecosystem policy. In relation to the first challenge – i.e., that of uncovering existing system interactions and achieving a shared understanding of how the system works as a whole, we learned from our review of other ecosystem policy domains that 'hard' aggregate facts describing inputs, outputs and alternative system states are not likely to be sufficient. 'Softer' insights produced through participative approaches are also required. From this, we hypothesize:

> *Hypothesis 1: Hard facts derived from secondary data provide an insufficient picture of entrepreneurial ecosystem dynamics for policy analysis and need to be supplemented by primary data gathered using participative approaches such as stakeholder workshops.*

For the other three challenges, i.e., avoiding unintended consequences, achieving alignment among different stakeholders on shared goals; and maintaining momentum in the desired direction, we found that several quite similar methodologies are in use in other ecosystem policy domains, including "collective action", "collective impact", and "transition management". From this, we hypothesize:

> *Hypothesis 2: Intensive stakeholder engagement such as focus groups produces causative insights that lower the risk of unintended consequences in entrepreneurship ecosystem management, increase stakeholder alignment, and decrease the risk of inertia.*

We next test these hypotheses in an empirical setting provided by an entrepreneurship ecosystem analysis and management experiment in Scotland.

Method and Empirical Setting

Our hypotheses describe complex policy processes in complex empirical settings. Because of the novelty of the ecosystems approach to entrepreneurship policy, there have been relatively few policy initiatives that qualify as entrepreneurship ecosystem analysis and management initiatives, and there is no database storing data on entrepreneurship ecosystem policy effectiveness. Furthermore, our hypotheses imply the testing of counterfactuals – i.e., considering what might have happened, had participative approaches to policy management not been applied. For these reasons, we chose a qualitative approach to hypothesis testing, using rich longitudinal data from an entrepreneurship ecosystem policy analysis and management initiative in Scotland to test our hypotheses. Because the still ongoing initiative has progressed in stages, we are able to compare insights produced by 'hard' systems data alone to insights produced through participative mechanisms (hypothesis 1). Because one of the authors has participated in the initiative as a participant-observer, we also have rich data to gauge levels of stakeholder alignment and commitment during the initiative, enabling us to test hypothesis 2. Consistent with a qualitative approach to hypothesis testing, we next describe our empirical context.

The Scotland entrepreneurship ecosystem policy initiative was triggered by participation of a Scottish team of policy-makers and policy stakeholders[1] in the inaugural MIT Regional Entrepreneurship Acceleration (REAP) Program from 2012 to 2014. The REAP Program seeks to facilitate policy targeting innovation-based entrepreneurship (IBE). Participating in REAP, the Scottish team soon realized that to realize the benefits of the program, factual data describing the state of the Scottish entrepreneurship ecosystem was needed. Thus, the Scottish team decided to ground their analysis of the Scottish entrepreneurship ecosystem on data provided by the Global Entrepreneurship and Development Index (GEDI) method (Acs, Autio, & Szerb, 2014). The GEDI methodology profiles the entrepreneurship ecosystem of a given country by combining both individual-level and country-level institutional indicators. In itself, the REAP approach uses secondary data and interviews to assesses regional innovation capacity and entrepreneurship capacity under six themes: People, Funding, Infrastructure, Policy, Rewards and Norms, and Demand. Potential growth clusters are then identified. Early work in the REAP exercise 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.

[1] The team comprised two senior enterprise agency managers, a university representative (the second author) and three entrepreneurs. It did not contain representatives from the government civil service or corporate Scotland. Representatives from both these omitted groups were consulted individually and collectively during the process. Consideration was given to including representation of these groups on the core team at several points in the process, but at the time of writing, no changes had been made to the core team.

The GEDI methodology builds on the systems of entrepreneurship theory and portrays the *quality* (instead of quantity) of the entrepreneurially driven resource allocation dynamic in entrepreneurship ecosystems. It does so by combining individual-level data on entrepreneurial attitudes, ability, and aspirations with data describing the context within which these processes are expressed or repressed. The outcome of this methodology is an index composed of a set of interactions between national-level measures of rates of individual attitudes, ability, and aspirations and institutional-level variables that moderate the impact of individual-level variables on productivity growth. Unlike measures quantifying rates of self-employment, which tend to decline with increasing rates of economic development at a decreasing rate (Carree and Thurik, 2008), the GEDI index is positively associated with GDP per capita for most of its range (Acs et al., 2014).

The distinctive characteristics of the GEDI methodology reflect well the complexity of entrepreneurship ecosystems, and therefore, the policy challenges described in our theory section. First, the GEDI methodology contextualizes individual-level data by weighting it with data describing a country's framework conditions for entrepreneurship, thereby seeking to capture embedded complexity in entrepreneurship ecosystems. Complexity is further reflected in GEDI's use of 14 context-weighted measures to portray entrepreneurial Attitudes, Ability and Aspirations in the ecosystem. The GEDI methodology also allows different index pillars to interact, and thus, co-produce ecosystem performance. This last feature also captures the notion that national entrepreneurial performance may be held back by *bottleneck factors* – i.e., poorly-performing pillars that may constrain system performance (see Acs et al, 2014 for a description of the Penalty for Bottleneck method).

The distinctive aspects of the GEDI approach fitted well with the aim of the REAP Program to describe, diagnose, and enhance regional entrepreneurial ecosystems. For example, the GEDI index features a holistic approach in which a deficiency in one factor can have knock-on effects on other parts of the ecosystem. The index also appeared to cover all the elements of the REAP framework outlined above with the exception of policy measures, though it did cover current institutions which could reflect past and current policy (see Table 1 for a cross-referencing of the REAP themes with the GEDI pillars). It also contained a combination of multiple input and output measures, which is necessary in any assessment of an ecosystem (see Table 2). What GEDI did not do was engage in any form of sectoral cluster analysis, which was part of the REAP framework. Fortunately, a great deal of work on clusters had already been done and growth sectors formed part of the Scottish Government's Economic Strategy (Scottish Government, 2011). At no time did the REAP team consider that additional analysis was required in this area.

The REAP Scotland team adapted the GEDI methodology to a regional level of analysis and used this to identify possible gaps between the areas of current policy focus and bottlenecks in the

entrepreneurship ecosystem suggested 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 should not be used as a computerized "policy-creating machine".

Policymakers want to know how they can achieve most leverage in enhancing an entrepreneurship ecosystem. Understanding the strength of the links between pillars that appear to be linked might help reveal critical leverage points. Unfortunately, the GEDI analysis did not reveal the strength of links between pillars. It assumed that all links have the same strength and that all pillars cost the same to change. Furthermore, it could not reveal whether the bottlenecks were causal or merely symptoms of underlying, deep-seated weaknesses in an innovation-based entrepreneurial ecosystem. Therefore, the Scottish REAP team decided it had to be supplemented by expert stakeholder judgement.

The method of entrepreneurship ecosystem analysis and management developed by the Scottish REAP team is outlined in Figure 1. The main steps in this method coincide with the four challenges identified in the previous section from the literature on ecosystem analysis and management. The process begins with data collection using the GEDI framework. Once bottlenecks have been identified using sensitivity analysis, the next step is to test the convergent validity of the bottlenecks themselves by employing alternative measures of institutional variables. 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 (in a sense, "empowered focus groups") to develop solutions and take action. This in turn could lead to a monitoring and learning phase in which momentum is maintained and the effect of different actions is compared.

Field Trial in Scotland

The core REAP 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 entrepreneurship ecosystem at the national level. The actual individual and institution variables employed are described in Levie et al. (2013) and the pillars are described in Autio et al. (2012). This list was debated by the Scottish REAP team both before and after the list was populated with data, resulting in several changes to the data specification, including a change from two year to four year moving averages because of the low frequency of entrepreneurs in the population, and a change in the institutional measure used for risk capital, which was subsequently adopted more generally by GEDI. This corresponds to step 1 of the method.

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.

The Scottish REAP team requested four benchmarking assessments: Scotland versus all 78 economies for which data was available, Scotland versus 27 innovation-driven economies 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 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.

Table 3 is an example of this benchmarking in tabular form (Scotland against 27 innovation-driven economies). The numbers in Table 3 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, ability and aspirations. In

this comparison, Scotland appears relatively weak in aspirations and 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 2 is an example of benchmarking using a spider diagram, in this case against 'Arc of Prosperity' countries. It plots Scotland's scores and shows visually where Scotland fits relative to the other countries. 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.

Against the UK's other home nations: England, Wales and Northern Ireland, Scotland appeared "worse" than England in Opportunity Perception and Start-up Skills, and "better" than Wales and Northern Ireland in some Ability measures and Opportunity Perception. (A full set of benchmark figures and tables is included in Levie et al, 2013.)

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 ability pillars in the next section.

Table 4 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 mentioned above. 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 it was silent on what the cut-off should be for which pillars to focus on. The team reached a consensus 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 a mix of prominent and representative members of Scotland's entrepreneurship ecosystem were invited to debate between one and three of the eight pillars. Four different sets of about a dozen stakeholders attended one of four meetings, which were chaired by members of the core REAP team and recorded verbatim by a professional court recorder. These meetings suggested a set of perceived weaknesses in Scotland's entrepreneurship ecosystem that crosslinked the bottlenecks. A 23-page summary report was written based on a content analysis of the stakeholder meetings. Identified concerns 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). Several participants noted how individuals who had had the opportunity to experience entrepreneurial environments such as Boston returned to Scotland fired with enthusiasm.

In a 24 hour retreat in May 2013, the core 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. (These correspond to the focus groups identified in the literature review above.) 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, the team agreed to adopt the "Collective Impact" approach of Hanley Brown et al. (2012) that seeks to get wide stakeholder buy-in and consensus on the direction of travel rather than a top-down directive approach. As mentioned in the literature review, 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.

Between May 2013 and November 2014, the task groups evolved in different ways. The financing for growth task group was already formed as a separate committee of the Royal Society of Edinburgh charged with coming up with proposals for the Scottish Government on the financing of early-stage growth companies. It published an advice paper in June 2014. An online questionnaire to assess the demand for growth finance was piloted. The effective connections group developed a guide to networking within Scotland for entrepreneurs and organised an event to bring networking organisations together in November 2014. The universities group developed a set of actions and planned a series of events for relevant university staff on each action point in 2015-16. The REAP team also consulted with experienced entrepreneurs to draw up a list of critical skills for CEOs of growth companies under the "skills for growth" bottleneck. Under the role models theme, an enterprise agency ran a series of events and initiatives to encourage women to become entrepreneurs and encourage women entrepreneurs to serve as role models to other women.

In June 2014, a 48 page report was released by the REAP team (Chisholm et al., 2014) to all stakeholders who had been invited to participate in the REAP process. The team deliberately chose a "soft launch" with minimal publicity as it wished to ensure that the process did not end with a report that might, like so many before it, be shelved and forgotten. The report listed the calls for action under each of the five themes, and also called for a backbone organisation independent of government agencies to take on the management of the process. At the time of the report, the team thought that a new organisation might need to be formed to do this. However, coinciding with the release of the report, the merger of two prominent independent stakeholder organisations in the Scottish entrepreneurship ecosystem, the Entrepreneurial Exchange and the Saltire Foundation, was announced. Subsequently, the incoming chief executive of this new organisation, Entrepreneurial Scotland, was invited to join the core group of REAP, and at the time of writing a proposal that Entrepreneurial Scotland serve as the backbone organisation from April 2015 was under active consideration.

Testing Hypotheses 1 and 2

In this section, we present evidence from the field trial in support of Hypotheses 1 and 2.

Hypothesis 1 stated that hard facts derived from secondary data provide an insufficient picture of entrepreneurship ecosystem dynamics for policy analysis and need to be supplemented by primary data gathered using participative approaches such as stakeholder workshops.

There are several pieces of evidence to support this hypothesis. The evidence includes questioning and finding weaknesses in the hard data, finding gaps in the hard data, and generating actions in priority areas that were not highlighted by the hard data.

First, the core team actively questioned the results in several of the items included in the GEDI analysis. For example, 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.

In another 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 stakeholders pointed out that 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.

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". The GEDI authors intended it to be a relative measure of product-market uniqueness, but it could also be a measure of a lack of competition due to low overall levels of entrepreneurship. Thus, Scotland appeared to do well on this measure, but it could be signalling weakness rather than strength, because of the way the original survey item was worded. The institutional measure for this pillar was for the UK rather than Scotland, and might therefore not reflect the dominance of firms in a regional market like Scotland. Again, this could have flattered Scotland's ranking.

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

Second, the stakeholder groups identified links between the bottlenecks suggested by the secondary data. This is something the hard data itself did not do. Following a content analysis and a full day of discussion by the core REAP team, combining the GEDI and stakeholder analyses, the Scottish REAP team was able to identify five linked issues that if tackled comprehensively, could lift a range of pillars. These five themes only partially overlapped with the bottlenecks thrown up by the hard data analysis. For example, one issue raised repeatedly by entrepreneurs in the stakeholder group sessions was the relatively low contribution by universities to the Scottish entrepreneurship ecosystem. This was not identified as an issue by the GEDI analysis. If indeed the university sector is a bottleneck, proceeding with policy based on the hard data alone would have omitted a bottleneck in the ecosystem.

Hypothesis 2 stated that intensive stakeholder engagement such as focus groups produces causative insights that lower the risk of unintended consequences in entrepreneurship ecosystem management, increase stakeholder alignment, and decrease the risk of inertia.

The university theme is interesting because it was raised repeatedly by entrepreneurs. Yet many of their claims were based on misunderstandings and not borne out by hard evidence subsequently collected by the REAP team and incorporated into its June 2014 report. Examples included the belief that entrepreneurs taught all entrepreneurship classes in US universities, that universities were detached from industry, that it was extremely difficult to get technology out of a university, and that academics and researchers were unwilling to network. In fact, Scotland had one of the highest rates of R&D expenditure in Higher Education (HERD) and one of the lowest rates of R&D expenditure in the business sector (BERD) in the OECD, and Scottish universities had relatively high rates of knowledge exchange compared with the rest of the UK (Chisholm et al., 2014, p.19). One of the tasks of the university task group then became not just how to enhance the connectivity of the universities but also to educate entrepreneurs on how the universities do engage in the ecosystem. On the other hand, it demonstrated that the degree of engagement varied greatly across the university sector and that universities had much to learn from each other: pockets of best practice were scattered through the university sector and not visible. This led to the idea of sharing of best practice within the sector by the university task group. The group also agreed a set of stretch goals for the sector, including "enterprise for all". This combination of sharing of best practice to produce "quick wins" and long term ambitious goals helped promote alignment and avoid inertia.

One issue raised by the effective connections task group was that there was a wide range of networking organisations for entrepreneurs in Scotland; the problem was that many entrepreneurs did not know this and the networking organisations were not themselves well networked to each other. This prevented the REAP team from developing new networking organisations but instead led it to create a guide to networking and an event that brought networking organisations together. These

actions are designed to improve alignment. While it is too early to draw strong conclusions on how the REAP process will aid alignment, the Scottish entrepreneurship ecosystem support landscape began to shift significantly in 2014 with the merger of two major support organisations in 2014. A visual representation of how the support structure to the entrepreneurship ecosystem may realign is presented in Figure 3.

Experience with the high level task groups to date suggests that regular monitoring and "holding of feet to the fire" is necessary to maintain momentum and prevent inertia. The core REAP team regularly reviews activity under each action plan and it is already clear that "what gets measured gets done".

Discussion

This paper was inspired by the observation that while the concept of entrepreneurship ecosystems has rapidly gained currency in policy practitioner circles, both the concept itself and its implications for policy analysis and management of policy implementation remain under-theorized. To address this gap, we have drawn on policy research in complex socio-economic systems to infer distinctive challenges faced by entrepreneurship ecosystem policy analysis and management, and also, elaborated on the implications they pose for policy practice. Our core observation was that in complex, multi-polar entrepreneurship ecosystems, where system performance is co-produced in complex interactions among ecosystem stakeholders, performance deficiencies are not easily reducible to well-defined market failures; participative policy analysis approaches are required to enhance the understanding of how the system works, identify coherent policy actions that are more likely to yield a desired impact, and to build stakeholder commitment to overcome systems inertia. We used the context provided by a Scottish entrepreneurship ecosystem facilitation initiative to explore our hypotheses.

While our explorations uncovered evidence for Hypotheses 1 and 2, there was also evidence that participative approaches alone in the absence of hard data provide an insufficient picture of entrepreneurship ecosystem dynamics for policy analysis and management. This evidence included stakeholders being informed and even surprised by the hard data. For example team members were surprised 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. A second surprise was that Scotland fared best in the ability pillars. The quantity of entrepreneurship in Scotland has long been perceived as relatively low. This demonstrated the advantage of the GEDI choice of ability variables that reflect innovative entrepreneurship, not all entrepreneurship.

Interestingly, throughout this whole process, no suggestions were made to add dimensions to the GEDI framework, only to improve certain measures of constructs. The hard data provided a foil, or basis for discussion rather than being accepted as the last word on the state of the ecosystem. It also enabled statements made by stakeholders to be compared with the hard data. In some cases, these statements were found to be untrue. In other cases, the measures used for the hard data were found to be unsuitable.

In an example where the systematic analysis of the hard data countered subjective bias, 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 was Opportunity Perception, and this was 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 entrepreneurship ecosystem in check, the sensitivity analysis spotlighted Opportunity Perception more than the relatively weak Aspiration pillars. This example supports the notion that "soft" insights complement, but do not replace, "hard" facts.

While it is too early to fully assess the impact of the collective impact approach in Scotland, it is striking that not one of the actions proposed in the Scottish REAP report summarising its findings required government to introduce new policies or change old ones. The actions focused on other stakeholders in the system, challenging them to commit to specific actions; through the high level task groups, critical stakeholders had already been co-opted, helped to shape and were committed to these actions. This stands in stark contrast to contemporary practices in the UK of superficial conference-style "consultation" of stakeholders and ministerial "surprise" announcements of policy decisions (Bridge, 2011; Arshed et al., 2014). This ecosystem analysis and management approach seems more humble, more cautious, more engaged and more long term-oriented; the analysis took around two years and the action phase has only just begun and is intended to last for the foreseeable future.

There may be two reasons for the absence of a clear role for central government in the actions. One is that the general regulatory background for entrepreneurship in Scotland is relatively favourable. For example, in 2014, the UK ranked 8th in the World Bank Ease of Doing Business ranking (World Bank, 2014). This may be why regulatory issues were not identified as bottlenecks. This raises the possibility that our main proposition may be contingent on the relative maturity of the regulatory regime for entrepreneurship in a country. In countries where regulation is burdensome or rule of law is weak, there may indeed be a need for government-centred entrepreneurship policy that is focused on adjusting the regulatory regime (Levie and Autio, 2011).

The second reason could be that while civil servants responsible for entrepreneurship policy in Scotland were kept informed of the REAP team's progress, they were not invited to become core team members. On the one hand, the REAP team was concerned that in the heated political atmosphere leading up to the Scottish referendum in September 2014, part-formulated policy solutions might be prematurely adopted and "announced" rather than analysed fully and managed bottom-up. But on the other hand, the central policymaker's perspective was not directly represented, and this may have led to some blind spots on the part of the core REAP team.

Another constituency that was missing from the core REAP team was corporate Scotland. While a representative group of senior corporate executives did participate at a separate stakeholder workshop, the presence of a corporate representative on the core REAP team might have changed the dynamics of the team. The three sectors represented: enterprise agencies, universities and entrepreneurs, all had their disagreements at times and felt they had to defend their sectors. A corporate representative might have been seen as an honest broker, more objective, and more results-focused – and was, in fact, recommended by the MIT REAP Program leaders.

Future research might compare the effectiveness of attempts at analysis and management in different entrepreneurship ecosystems. A realist synthesis methodology to comparison might be appropriate, since it has "the interpretive and explanatory purpose of understanding the processes or mechanisms underlying complex social interventions" (Tractenberg, 2013).

In conclusion, this paper has explored the various challenges an ecosystems approach to entrepreneurship policy presents for policy analysis and management. After 30 or so years of a market failure approach to entrepreneurship policy, an ecosystems approach offers the potential of new insights and, if correctly implemented, higher effectiveness. This paper has highlighted potential benefits of participative analysis and management approaches for ecosystems policy and suggested that where system performance depends on coordinated action by multiple stakeholders, bottom-up approaches that engage policy stakeholders are likely to work better than centrally designed policies implemented by civil servants. We hope that our study will inspire further explorations of this important, yet under-researched domain.

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Table 1. Cross-reference of REAP themes and GEDI pillars

Pillar/Theme	People	Funding	Infrastructure	Policy	Rewards and Norms	Demand
ATTITUDES						
Opportunity Perception	E		E, I, N			E,I,N
Start-up Skills	E		E,I,N			
Non-Fear of Failure	E		E,I,N		E,I,N	
Networking	E, N		E,I,N			
Cultural Support	E		E,I,N		E,I,N	
ABILITY						
Opportunity Start-up	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 2. 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
ATTITUDES				
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
ABILITY				
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 3. Scotland versus 27 'innovation-driven' economies

	Institutional Variable		Individual Variable		Pillars		Scotland Rank (27 innovation-driven countries)
Attitudes	Market Agglomeration	0.671	Opportunity Perception	0.382	Opportunity Perception	0.347	17
	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
Ability	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
Aspiration	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

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 27 participating innovation-driven economies plus Scotland from 0 to 1.
Economies included: Australia, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong, Iceland, Ireland, Israel, Japan, Republic of Korea, Netherlands, Norway, Portugal, Singapore, Slovenia, Spain, Sweden, Switzerland, Taiwan, United Arab Emirates, United Kingdom, United States.

Table 4. 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%
Start-up Skills	11%	11%	13%	8%	9%
Non-Fear of Failure	4%	3%	6%	5%	5%
Networking	11%	11%	9%	9%	9%
Cultural Support	3%	0%	0%	6%	6%
Opportunity Start-up	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 analysis and management of a regional innovation-driven entrepreneurial ecosystem

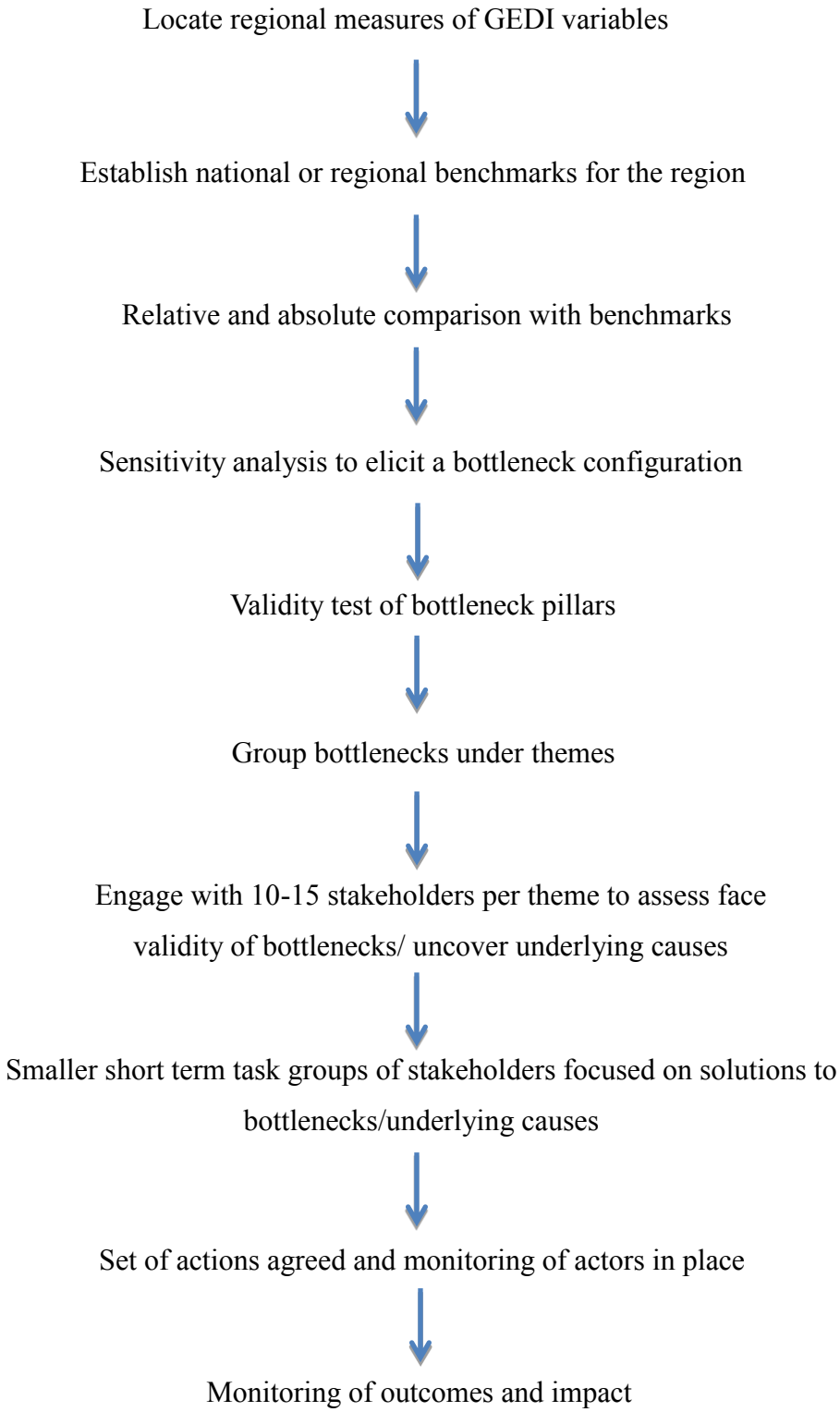


Figure 2. Scotland versus 'Arc of Prosperity' economies

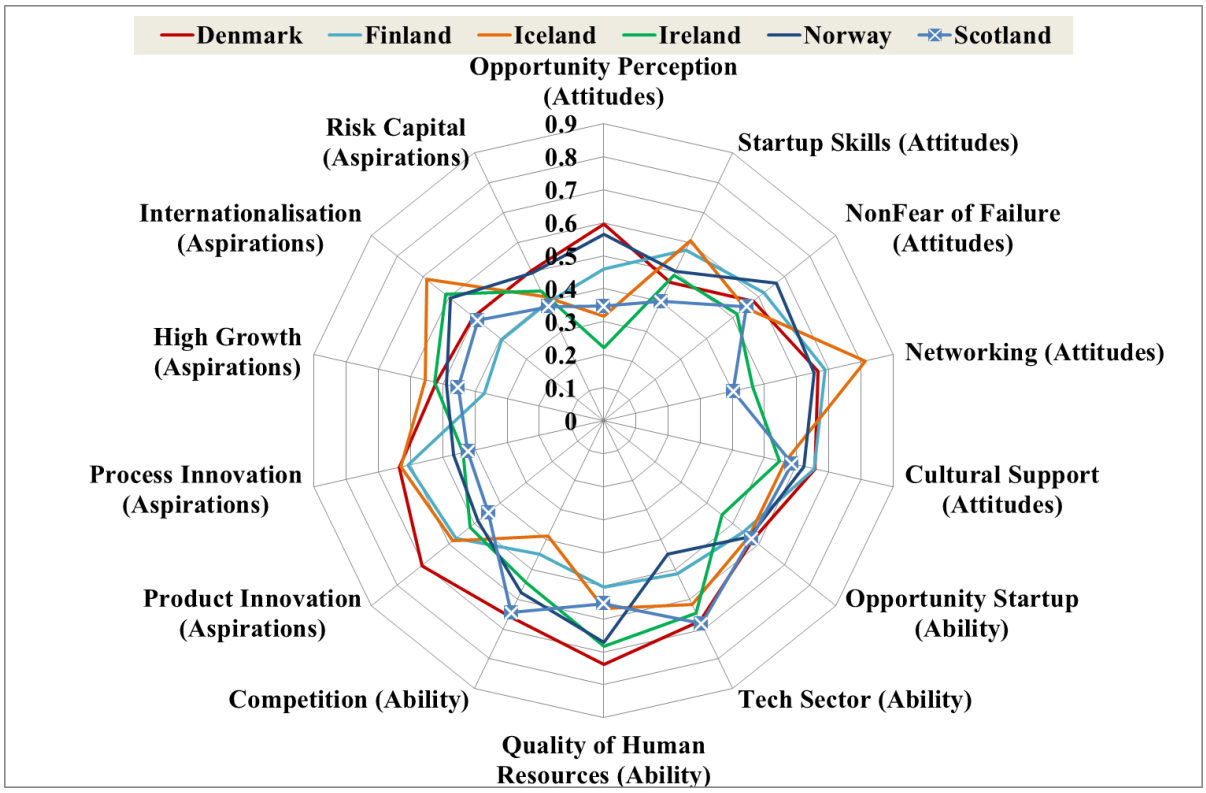
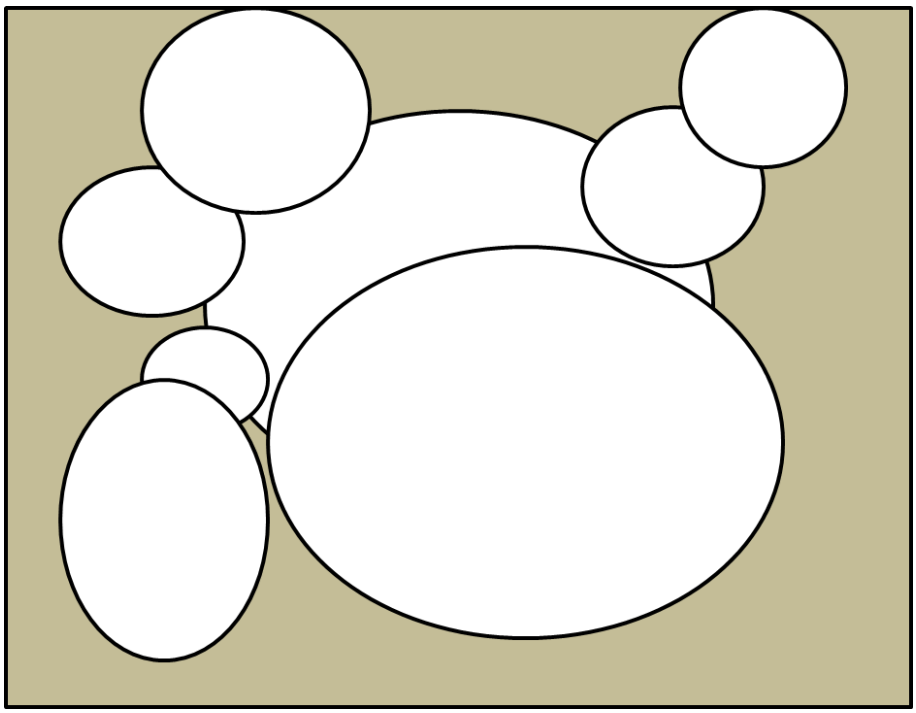


Figure 3. Visual representation of entrepreneurial ecosystem support organisations realignment to reduce overlap and fill gaps

Before realignment: competing (overlapping) generalists and specialists with considerable unsupported (grey) space



After realignment: One core generalist formed from merger, specialists realign in the spaces around the generalist