SCOTTISH TECHNOLOGY ECOSYSTEM REVIEW

25 August 2020

By Mark Logan
An independent review commissioned
by the Scottish Government

Contents

Executive Summary

In May 2020, Mark Logan was commissioned by Kate Forbes, Cabinet Secretary for Finance, to undertake a short-life review into how Scotland's technology sector can contribute to the country's economic recovery after the COVID-19 pandemic. The review's recommendations are primarily concerned with stimulating and accelerating the maturity of Scotland's "Technology Ecosystem". By this we mean the system, in its widest sense, that supports and nurtures technology businesses in Scotland, from the early start-up phase through to fully scaled maturity.

The output of this ecosystem should be a stream of technology start-ups that reach sustained profitability, including a significant proportion that do so at scale; with consequent benefits in opportunity for our people, in job creation and in tax revenues. The review's recommendations are intended to significantly improve upon current outcomes against this goal; that is to say, our recommendations are intended to increase the creation rate of profitable, scaled tech businesses and to reduce the time taken for viable individual start-ups to reach scale.

Technology ecosystems exist in one of two states. The preferred state is where the ecosystem has passed through a "tipping-point" in its development, which is the point at which the ecosystem hosts a critical mass of viable start-ups and scale-ups. At this point, several virtuous network effects start to spontaneously operate to continually strengthen the ecosystem without further intervention being required. Although there are many positive aspects to Scotland's current technology ecosystem, we identify it as *pre-tipping point*, where these network effects are not yet operating. Our over-arching strategy, therefore, is to identify a balanced portfolio of interventions and support that accelerate the ecosystem past its tipping point, after which, support can be tapered-down over time.

The review identifies three fundamental supporting areas upon which the performance of the Technology Ecosystem depends. In each of these areas, improvements are available which we believe would, taken together, accelerate the ecosystem towards its tipping-point and substantially improve its performance. The ecosystem's fundamental dependencies are:

- *Education and Talent:* at school level, at university (and parallel access paths), and at start-up/scale-up level.

- *Infrastructure:* including physical co-location environments for start-ups and the social infrastructure required to support a vibrant technology ecosystem.

- *Funding:* including grant funding, public and private investment regimens.

The review conducts a detailed analysis of each of these areas. It then presents a blended portfolio of interventions, combining those that provide immediate performance benefits with others designed to significantly improve the long-term performance of the ecosystem.

It is important that the full portfolio of interventions identified in this document is implemented in its entirety. This is because the interventions identified are mutually reinforcing. Implementing one or two isolated recommendations will yield incremental outcomes only, whereas what is actually required, especially in the context of the country's post-COVID-19 response, is a transformation of our industrial performance in this area.

An important recurring theme in this review is that the value of interventions should be assessed only with respect to their impact on the overall ecosystem's output, rather than being limited to the scope of that part of the ecosystem in which they are applied. To take one example as an illustration of this point, it is undoubtedly non-trivial to transform how we teach Computing Science at school level. And if we considered this point in isolation of the overall ecosystem, perhaps we wouldn't try. But if doing so significantly raises the likelihood of many more successful start-ups later being born and raised to maturity in Scotland, then we must.

Such considerations will require stakeholders to work together to implement the recommendations made here, and to be willing to overcome local implementation difficulties for the betterment of Scotland's overall technology ecosystem. It will sometimes require us to think about the ecosystem in counter-intuitive ways. To support these imperatives, the review begins by developing a comprehensive model of Scotland's technology ecosystem, thereby making it easier to place these considerations in context. It is our hope that all of our committed stakeholders in Scotland's technology ecosystem can coalesce around this model, or some descendent of it, to better the coordination of our efforts to improve the ecosystem's performance.

In all, we present 34 specific, directly actionable recommendations. The major recommendations can be categorised and summarised as follows:

- **Tech-Scaler National Backbone**
  Recommendations in this category are concerned with building a national backbone network of "Tech-Scalers", whose capabilities build upon and extend beyond traditional incubation programmes. Tech-Scalers combine best practice in incubation, intensive founder education in *Internet Economy* best practice, ecosystem social infrastructure, and integrated funding. Access to all services would be provided both physically and in a fully-virtualised form, enabling country-wide participation in Scotland's high-technology economy.

- **Foundational Talent Pipeline**
  Recommendations in this area concern interventions and improvements across the education spectrum as it relates to the teaching of Computing Science and related disciplines. We propose a transformation of Computing Science education at school level, with the principle that the subject must be treated, from 1st year at secondary school level with the same focus as Mathematics or Physics. We also recommend considerable expansion of extra-curricular support. At university level, we propose specific interventions intended to better equip technical students with international-class start-up skills and to improve the success rate and volume of university spin-outs. We also present a number of recommendations to swell the size of the overall talent pool in parallel access paths into technology.

- **Social Infrastructure/International Market square**
  The world's best technology ecosystems depend on their social infrastructure to facilitate start-up education, propagation of best practice, networking, peer-support and hiring. Recommendations in this area are designed to considerably strengthen our technology ecosystem's social infrastructure across all levels of scale, from our small tech meet-ups to our international conferences. A major theme running through the review is the need to learn from international best practice when establishing this "market square" within our ecosystem.

- **Integrated Ecosystem Grant Funding**
  Recommendations in this category are designed to better align public grant funding support to the specific needs of technology start-ups and those of the ecosystem as a whole. The goals here are to realise an improved return on investment and more effective support for start-ups while avoiding the risk of a dependency mentality forming within the ecosystem. We also propose a novel treatment for assessing return on investment that is better aligned to the ecosystem's actual value creation process and which, consequently, should better direct the types of intervention made, and their resulting impact.

- **Investment Funding**
  This focal area identifies two problematic areas for Scottish start-ups attempting to access venture funding. These are the *Early-Seed* and S*eries A* stages. To address them, we make a series of proposals, based on a partnership approach between government and Scotland's venture capital community, all recommendations being designed to better support the flow of investment funding to worthy start-ups.

Finally, we recommend an approach to managing the adoption of these recommendations through to full implementation. A mechanism has been sought that provides both the necessary coordination and the agility needed to evolve our ecosystem at pace.

We thank you for taking the time to consider these recommendations and look forward to working together to make Scotland's technology ecosystem an outstanding contributor to our country's well-being.

Introduction, Purpose of this Paper

This document forms part of a review of Scotland's technology ecosystem, requested by the Scottish Government. The review's recommendations are primarily concerned with stimulating and accelerating the maturity of Scotland's "Technology Ecosystem". By this we mean the system, in its widest sense, that supports and nurtures technology businesses in Scotland, from the early start-up phase through to fully scaled maturity.

The output of this ecosystem should be a stream of start-ups that reach sustained profitability, including a significant proportion that do so at scale. The review's recommendations are intended to significantly improve upon current outcomes against this goal; that is to say, all of our recommendations should act to increase the rate of profitable, scaled tech businesses and/or reduce the average time taken for viable individual start-ups to reach scale.

Scope

The review is not a direct response to the COVID-19 crisis; the majority of recommendations made here were equally applicable prior to the emergence of the present situation and are generally "strategic" in nature rather than "tactical". However, the recommendations do take into account the anticipated environment in which the tech industry in Scotland will be operating into the future as a result of the pandemic. In other words, if the timeline can be segmented into three stages – (1) Immediate Crisis Management, (2) Convalescence and Recovery, and (3) Future Growth, then this review focusses primarily on (3) with some consideration given to (2).

The review does not cover the wider topic of *digital literacy* in Scotland, which is the subject of other policy reviews.

Relationship to Report of the Advisory Group on Economic Recovery

The Advisory Group on Economic Recovery (which was established by the Scottish Government in April 2020 to provide advice on supporting the different regions and sectors of Scotland's economy in their recovery from the impacts of COVID-19) published its report on the 22 June 2020. That report covers a broad scope, with recommendations directed at both the Scottish Government and other actors across the whole of Scotland's economy. The report identifies digital innovation as an important growth area of Scotland's future economy but doesn't put forward detailed recommendations as to how to stimulate this sector.

The present report is complementary to the Advisory Group's report and aims to provide those detailed recommendations as they relate to the Scottish tech sector.

Structure of the Response

The recommendations put forward in this document are provided in the following context: a **model for Scotland's Technology Ecosystem** is first developed. The purpose of this model is to ensure a common definition for the ecosystem, a common understanding of how it works and, consequently, a common framework for assessing problems and interventions within it. For example, what do we mean by *Tech Ecosystem?* What do we mean by *Tech?* And what does it mean to *improve the tech ecosystem?* What are its outputs? How can those outcomes be improved? These and other key questions are addressed by this model definition.

In the context of that model, an **analysis of deficiencies in the Scottish tech ecosystem** is then conducted. This analysis examines, in turn, each part of the ecosystem, in each case identifying deficiencies and areas for improvement, as they impact on the ecosystem's performance. Each of the issues identified constrains the ecosystem's output in some way. For each of these areas, a brief summary of the recommended strategic approach to address the identified deficiencies is provided. These frameworks form the basis of the recommendations section of the report.

A consolidated set of **recommendations for improving and accelerating outcomes** is then presented, distilling the analysis of the various parts of the ecosystem model into one cohesive set of recommendations. Recommendations are made in five main focal areas, which are derived from the above analysis.

Finally, an **implementation model** is proposed, which is intended to support the implementation of the recommendations, with the required level of coordination and momentum.

Tone and Focus of the Analysis

Before commencing our analysis, let us state here that there are many commendable aspects to Scotland's tech ecosystem. Scotland hosts multiple accelerators, innovation centres, industry networks, one of Europe's largest incubators, one of Europe's largest tech conferences, novel public initiatives such as CivTech and other innovative publicly financed support mechanisms (for example, SIB and Techstart), and effective investment syndicate networks and VC firms. Many highly committed individuals have contributed their time and energy to bringing the ecosystem to this point, and they continue to do so. We commend these initiatives and the people who champion them, and we don't propose to tamper with their work in this review.

However, Scotland cannot not yet boast a world-class tech ecosystem. Though we have laid some of the foundations, we do not produce enough scaled, sustainable tech businesses from our ecosystem. Why not? What can we do about that?

The aim of this review is to address these questions. Correspondingly, whilst acknowledging the above virtuous aspects, our review will focus on what's wrong with our ecosystem today; what we aren't doing that we should be, what we are doing that we need to do more of, and what we're doing that we shouldn't be. The intent is not to set a negative tone, but rather one of impetus to action. Building on our earlier foundations, it is within our collective gift to dramatically improve the outputs from our ecosystem.

Importance of Establishing a Common Model of the Ecosystem

We have chosen to place the review's findings in the context of a comprehensive model of the Scottish tech ecosystem, for the following reasons:

It is highly desirable that all of the stakeholders in Scotland's technology sector coalesce around the same model of how the ecosystem works and how it can be improved. The existence of a widely understood, circumscribed target model for our tech ecosystem conveys several important benefits. Firstly, it is more likely that interventions will be identified that improve the performance of the ecosystem as a whole and that they will be understood in context. For example, it enables the *specific desired outputs* of our ecosystem to be clearly defined. Secondly, it increases the likelihood that initiatives from different stakeholders can amplify others' beneficial effects towards those outcomes. Thirdly, a shared model enables all interventions to be assessed and justified in a consistent way, across all stakeholder groups. Finally, it enables collaboration and cross-amplification of impact without requiring intensive coordination.

Without a common model, multiple problems arise. For example, we increase the risk that different stakeholders make conflicting interventions. It is also more likely that stakeholders default to optimising for locally important organisational goals and Key Performance Indicators (KPIs). Some of these interventions may well benefit the wider ecosystem but their effectiveness is reduced because they are made without consideration to the ecosystem's wider context. Others may be blindly detrimental or inertial to the ecosystem as a whole. Conversely, there exist interventions that may be difficult or unpalatable to implement for certain ecosystem participants (and hence would normally not be implemented for that reason) but that nevertheless could increase the ecosystem's performance overall. Visualising a common model of the ecosystem helps considerably in navigating these "local versus global optimisation" considerations.

Accordingly, we next define this model for Scotland's technology ecosystem. After that, we conduct an analysis of the ecosystem using the model as a guide. We then present our recommendations for improving its performance resulting from that analysis.

Chapter 1 – Model for Scotland's Technology Ecosystem

In this section, we describe Scotland's Technology Ecosystem according to a model that will be used throughout the rest of this document and which sets the context in which all recommendations to support and improve the ecosystem will be made. We outline the basic structure of the model and then explore its dynamic aspects. This provides a foundation from which to later identify deficiencies in our ecosystem as it is currently operating and to propose remedies for those deficiencies.

What we mean by "Technology" and "Tech"

Before examining the model in detail, we'll first define what we mean by a "tech business", "tech start-up" etc. This is an important question because nowadays all businesses are "tech" businesses to some extent or other, in the sense that they are all at least tech-enabled. But, if we cast our definitional net too widely, it will be impossible to identify meaningful interventions that effectively benefit any particular sub-sector. Even within that category of businesses that can be described as technology-intensive, or "high-tech", precise definition can be problematic.

Another complication arises from the question as to whether it is meaningful, in the context of this review, to segment businesses by domain; for example, Fintech, Greentech, Cybertech, Healthtech, Biotech etc.

We have chosen to address these definitional problems by focussing the review on start-ups and scale-ups that exhibit – or aspire to exhibit – certain attributes and characteristics common to successful tech start-ups internationally, regardless of the particular domain in which they operate. These attributes are:

- Develops a product or service with a high degree of software engineering required to develop it.

- Aspires to operate according to *Internet Economy* methodologies. We use this term to characterise a certain approach to product development and management. It is characterised by a strong focus on *speed of iteration* within a business context, on *organisational agility* at all levels of scale, on a relentless pursuit of *product-market fit*, on the application of modern *growth engineering techniques* such as the exploitation of *compounding growth mechanisms*, and on a very high degree of *data-driven experimentation*, to highlight just a few examples. Another short-hand term that could be applied to summarise these practices is *The Silicon Valley Playbook.*

This deliberately is not a rigorously bounded definition. There will be businesses that don't completely overlap with the attributes described but which will benefit from the recommendations put forward in this review. Think of those attributes, therefore, more as a "centre of gravity" for how a business should operate to be considered a "tech start-up". This matters because our global competition, such as those start-ups that are located in the Silicon Valley, operate on exactly these terms. They are Scotland's competition. Our ecosystem must meet the standards of global best practice to be competitive. Therefore, the model presented below and the recommendations that flow from it, are designed to support businesses with this centre of gravity.

We are deliberately agnostic on business domain, preferring to focus instead on developing and supporting start-ups with the above attributes, independent of domain. To illustrate the reason for this decision, consider that Zoom, Slack, Tesla, Google and Pinterest, to name just a few examples, all operate in different domains but operate to the same *Internet-Economy* business practices and draw from the same talent pool.

This is not to say that focussing on supporting specific domains isn't valuable as part of our wider industrial strategy, in terms of developing network clusters of expertise, etc. However, we argue that this should not be our underlying *core strategy* but is instead additive to it. It is a relatively simple matter to select domains of interest, but quite another to execute at a world-class level within them. Thus, this review focusses on the latter, while acknowledging the desirability of the former. We also note that it is unlikely that a highly prescriptive national domain-support strategy would have identified Skyscanner or FanDuel (two of Scotland's most successful tech start-ups and then scale-ups) as worthy of support or attention, for example. Or that it would have identified, ahead of time, the emergence of the Games sector in the North-East. Therefore, our primary focus on this review is on levelling-up our general capability to produce world-class scalable tech companies, regardless of domain membership.

Finally, we note that the definition of a tech start-up used in this review also includes those born via the university spin-out route.

With that context in place, let's now develop the ecosystem model on which the rest of this review will base its analysis and recommendations.

Ecosystem Model Overview

The technology ecosystem can be thought of as a funnel, as depicted below. We start, on the left-hand side of the diagram, with a relatively large number of potential founders considering starting a tech company, or in the very earliest stages of running a start-up, and we then proceed through various stages of scaling until companies reach "unicorn" size or larger[1]. In other words, the eventual output that our model is optimising for is the rate of creation of successful, large-scale tech businesses. Of course, as we'll see, this also results in the creation of many more tech businesses of other sizes along the way which, together, also create enormous value.

---
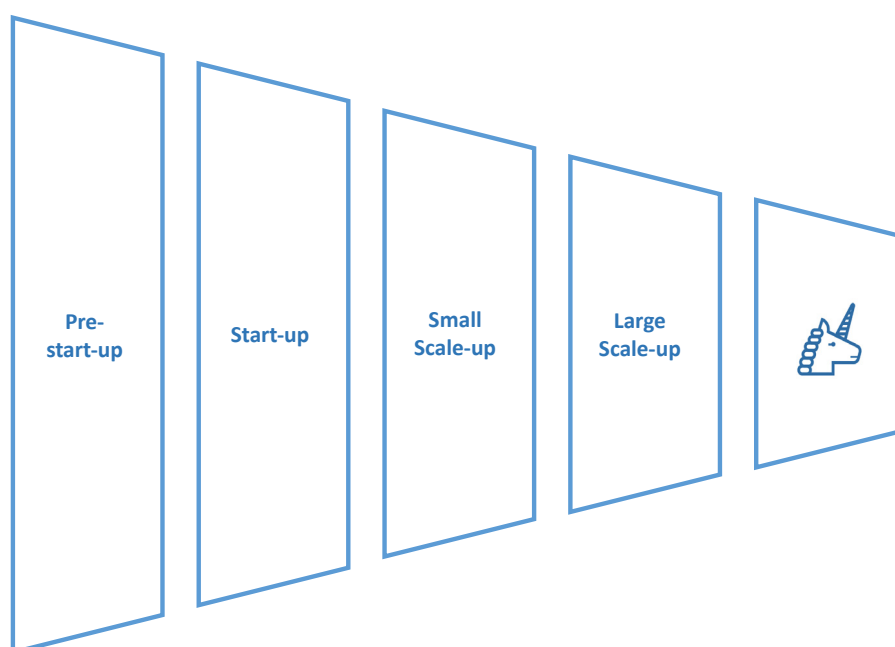
1   We'll use the term "unicorn" here as a short-hand for relatively large-scale private tech companies, for example valued at £1B+ and typically employing several hundreds or thousands of people.

Naturally, the funnel narrows from left to right – not all start-ups become scale-ups and not all scale-ups become unicorns, nor should they. So, there's a minimum narrowing rate of the funnel that it's impossible to improve upon. But, in most ecosystems, the rate of narrowing is much faster in practice than this natural rate. This is certainly true of Scotland's ecosystem. The difference between these two rates is the opportunity available to us.
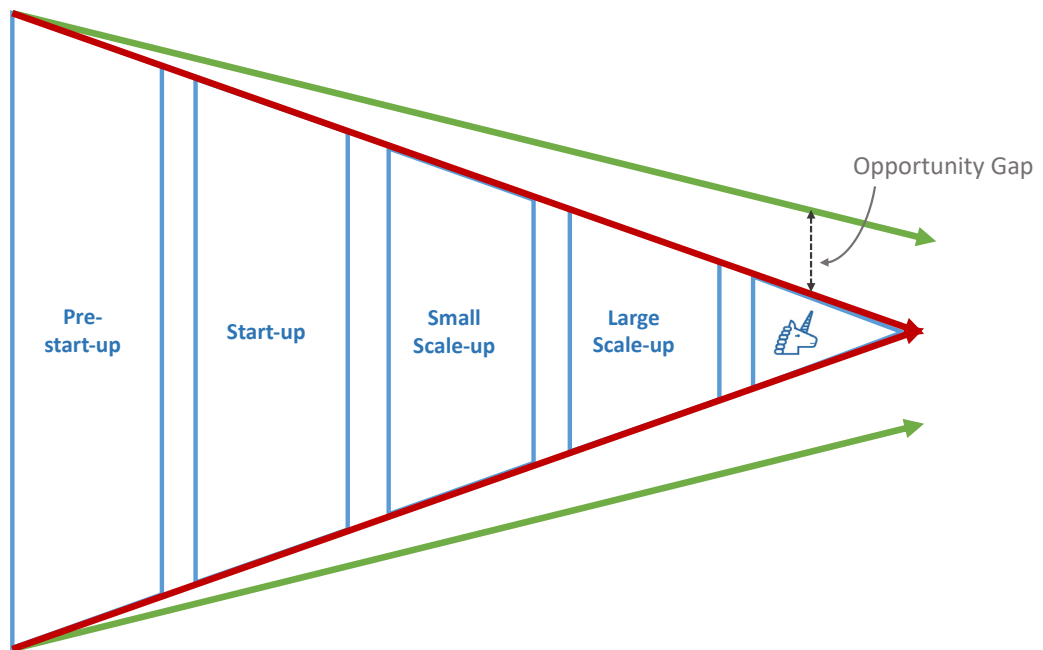
We assert that the difference in these two rates is due to deficiencies in the local ecosystem's support environment for start-ups and scale-ups. One aim of this review is to make recommendations that close the gap between our current rate of funnel decay and the natural rate.

Let's now explore some important dynamics associated with this model.

Importance of the early funnel stages

The technology industry is characterised by an astonishing rate of technological and market change. The consequences of this are that many once-successful companies later fail, while many more will fail on the way to scale. That's one of the reasons why the early stages of the funnel are so foundationally important. If these stages are vibrant and well populated then, regardless of technological and market changes, the ecosystem is more likely to regularly produce larger-scale companies from their midst and replace those that have not maintained currency with markets and technology. Additionally, founders and employees from early-stage companies in the funnel that fail will take those hard-earned lessons to other start-ups, thereby strengthening them. The Silicon Valley is the archetypal example of these effects in operation.

This is what's known as an *antifragile ecosystem*[2] – stressors acting on the system actually make it stronger (*c.f.* a fragile ecosystem where stressors weaken or break it). It's a highly desirable feature of our target ecosystem.
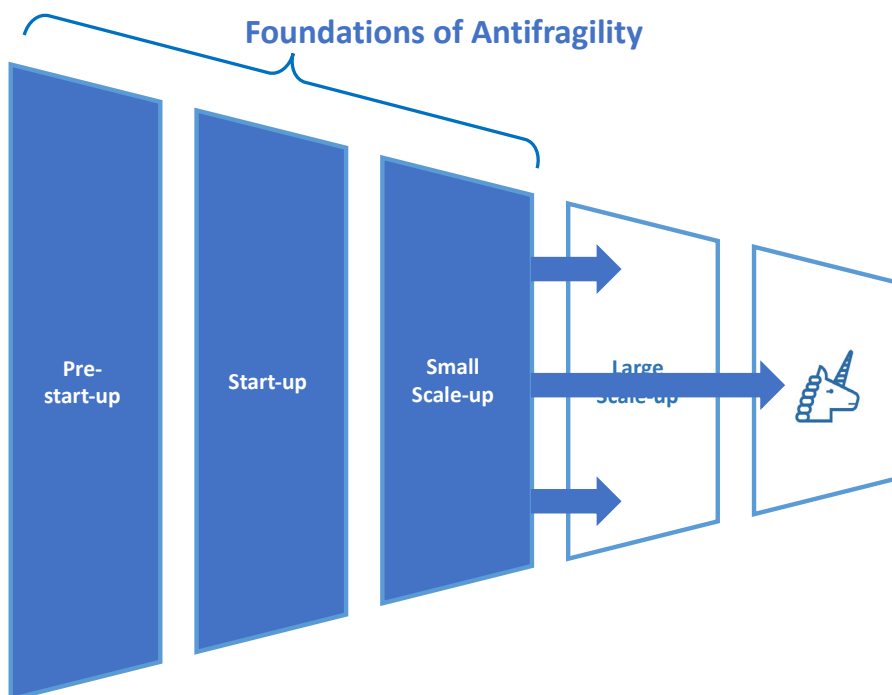
By contrast, consider the technology ecosystem in Scotland during the 1980s. Essentially, we skipped the early stages of the funnel and imported large-scale tech companies from abroad. The funnel therefore looked like this:
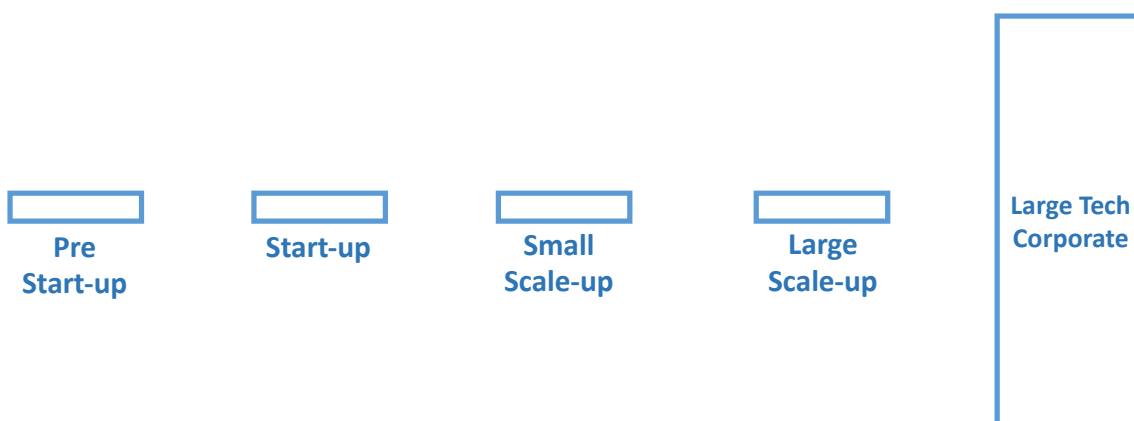
When the economic cycle turned over, and those companies left, the earlier stages of the ecosystem were practically non-existent, and couldn't replace those lost jobs quickly. To be clear, it is welcome and desirable that our ecosystem includes large-scale external companies; they bring several benefits to the ecosystem, in terms of employment, engineering and management technique, and exposure to large-scale business practices, to name just a few. But the ecosystem must be healthy at *all* stages to be anti-fragile.

---

2   See *Antifragility*, Taleb.

How many start-ups are needed to create one unicorn?

The other reason why the early funnel stages are so important returns us to the concept of the natural narrowing rate of the funnel. An interesting question to explore in this regard is: how many start-ups are needed to (eventually) create one unicorn?

The following figures are estimates but serve for illustration purposes: working backwards through the funnel from right to left, we probably need at least 10 large scale-ups, on average, for one unicorn to emerge from them. For each of those large scale-ups, we likely need at least five small-scale ups from which one large scale-up may emerge. Continuing from right to left, we find that, overall, we need approximately 500 start-ups to produce one unicorn, on average. This also illustrates one of the reasons why the concept of a minimum scale for our ecosystem is important. And it certainly indicates the size of the task before us.
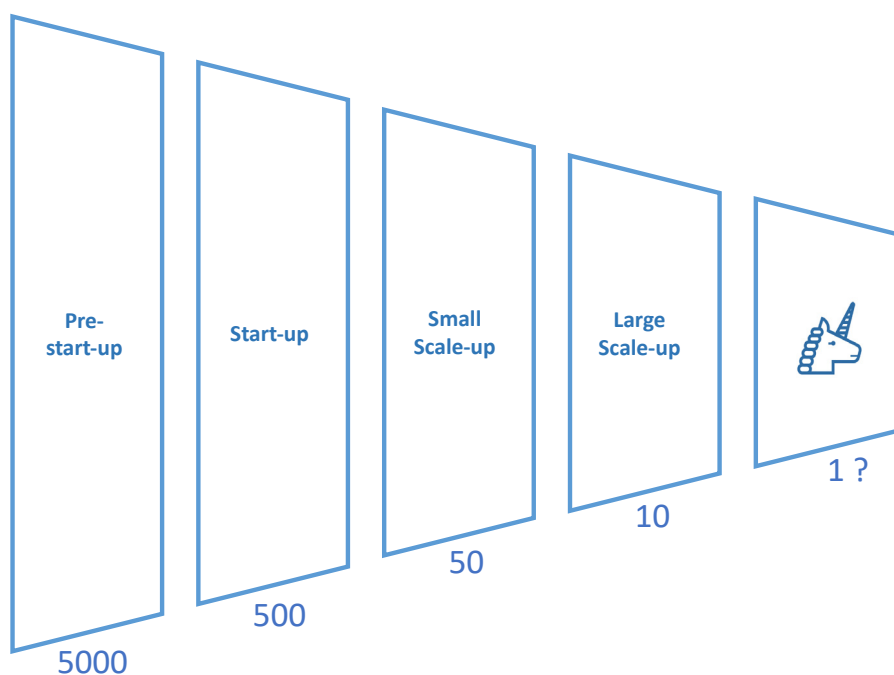
Funnel Tipping Point

There are non-linearities in the model. If the number of start-ups reduces below a certain threshold level, the funnel collapses. The funnel then appears as below. In this state, there is an insufficient number of earlier-stage companies to fuel the emergence of larger scale-ups and unicorns.
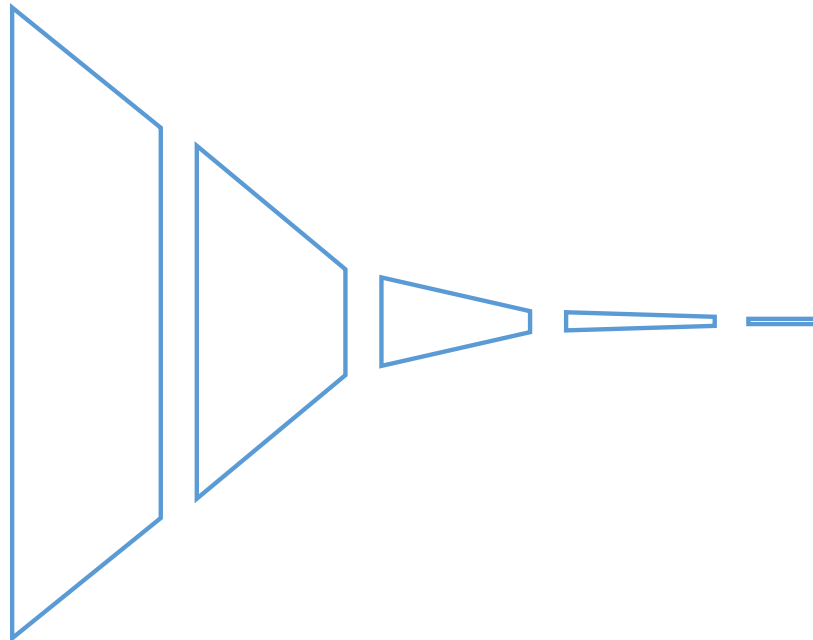
Below this threshold point the following factors contribute to this funnel collapse:

- **There just aren't enough companies to create a sustained learning and experiential environment.** This, in turn, means that there aren't enough experienced employees emerging who know how to take a start-up to scale.

- **The ecosystem is too small to attract outside talent.** The risk is just too great that if a job doesn't work out at a particular company for which an executive relocated her family from London, then there aren't other companies to move to locally, and she has to return home. Few people will relocate their families in the first place, in these circumstances.

- **The ecosystem doesn't attract larger investors.** VCs regard the ecosystem as too small to be worth exploration or they consider it unlikely that the ecosystem is capable of producing viable scale-ups. Consequently, they don't invest or limit their investments. This in turn reduces the number of viable start-ups flowing through the funnel. The gap is partly filled by private individual investors and government, but their limited aggregate capital is unable to fuel the growth of businesses beyond the earliest stages of the funnel.

In a post tipping-point ecosystem, all of the above effects are reversed. If the number of high-quality, non-frivolous and well-run start-ups rises above a certain threshold, beneficial *network-effects* start to operate that accelerate the growth of businesses at all stages of the funnel.

Consider these examples: employees from successful later-stage companies typically start to take more senior positions in earlier-stage companies as a career-path opportunity. This significantly improves the experience level in those earlier stage businesses, which increases their likelihood of them being successful. This, in turn, creates a larger pool of recirculating talent. For example, there are already ex-employees of Skyscanner and Fan Duel working in multiple start-ups across Scotland.
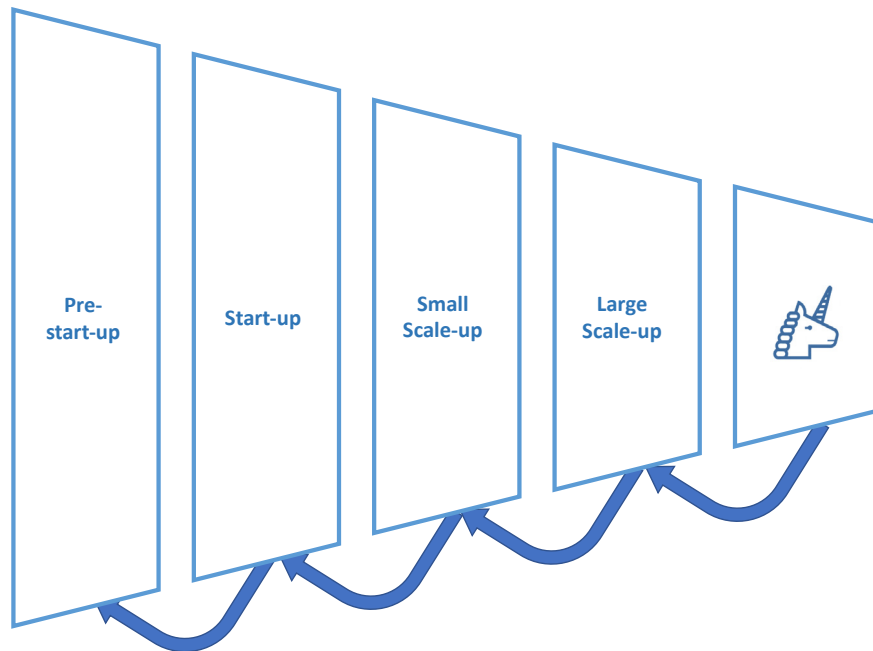
The second effect is that, above that tipping point, outside talent is attracted into the ecosystem (if a particular role at a business doesn't work out then there are nearby companies that inbound executives can join without having to relocate back to their home city or country). This leads to the creation of both more start-ups and more successful ones at that. This in turn attracts more talent, and a virtuous cycle again establishes itself.
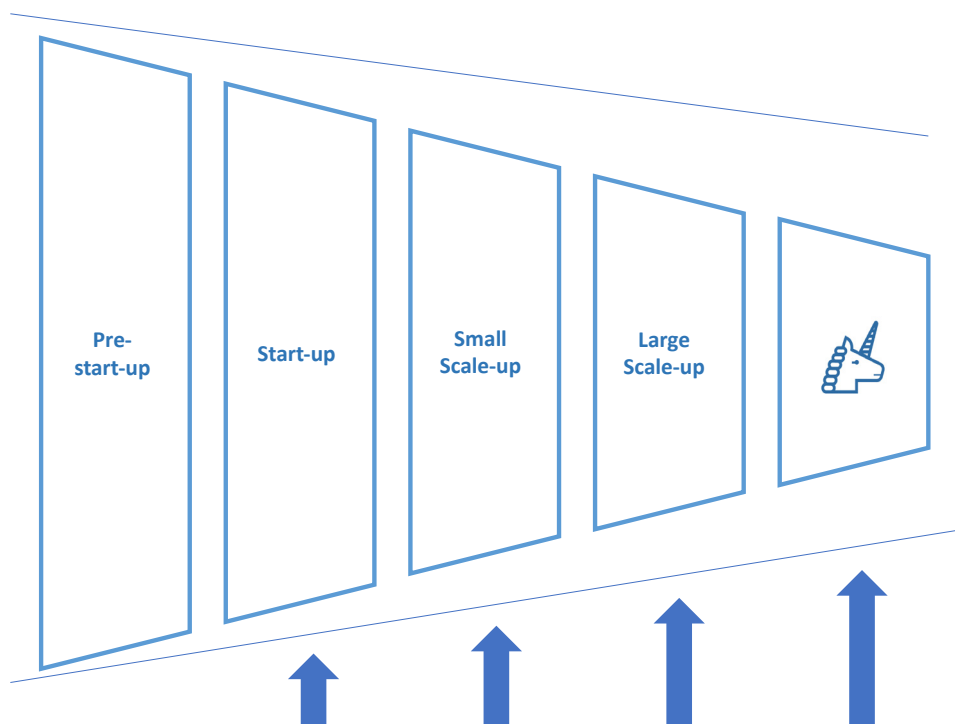
The third network effect is that investment firms start to pay greater attention to the ecosystem, and spend more time within it. This brings more money and expertise into the ecosystem, which leads to more and stronger businesses, which attracts more investors.

How do we know when an ecosystem has passed the tipping point? While it isn't a simple matter to predict the precise number of businesses required to pass through the tipping point, it's readily apparent through observation whether or not this has occurred.

For example, it is clear that Scotland's ecosystem currently operates in the pre-tipping point state. The above network effects are not yet operating. Our over-arching strategy, therefore, must be to implement support and interventions that accelerate the ecosystem towards the tipping point. That support can then be tapered-down as the strengthening network effects described above start to develop.

It can be argued that Scotland's ecosystem, certainly prior to the economic crisis brought about by COVID-19, was closer to this tipping point than at any time in its modern history. By the end of 2019 there were more start-ups (and more unicorns) in our ecosystem and more investment into those start-ups than ever before.

This presents us with an important opportunity, provided the appropriate interventions are made. When just below the tipping point, small interventions can have a dramatically accelerative effect on the ecosystem. There are multiple examples of such interventions – relatively simple actions that result in disproportionate benefit – contained in the recommendations section of this review.

Near the tipping point, small interventions have disproportionate benefits
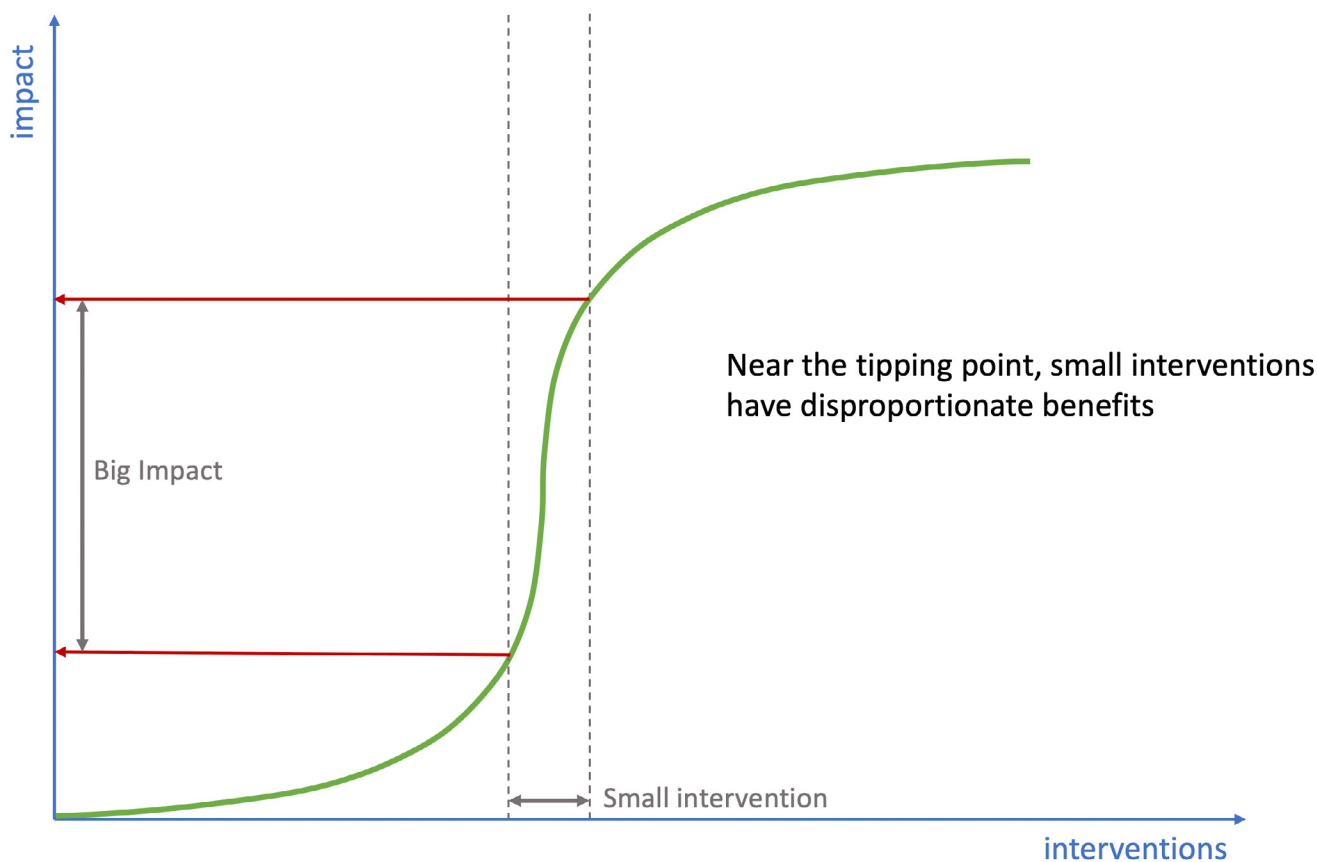
Global Versus Local Optimisation

A critical point regarding the model is that all interventions in the ecosystem should be assessed *only* with respect to the output of the overall *global* model, rather than with respect to localised areas within it.
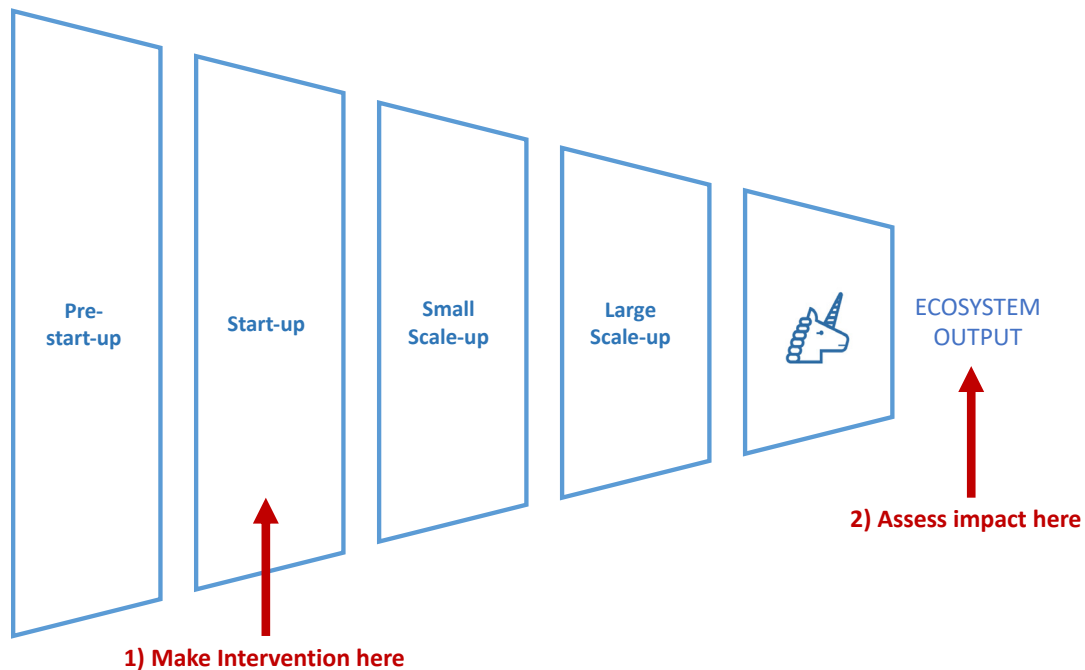
The importance of this point cannot be emphasised strongly enough. In this review, there are several actions recommended that certain stakeholders may find difficult to implement for local reasons[3]. They will certainly run counter to existing, local KPIs in some cases. And because they do, absent our model and our understanding of this principle, they would be disregarded, to the detriment of our ecosystem.

But the impact of implementing such recommendations will have a profoundly positive effect on the output of the ecosystem as a whole. Similarly, some of our recommendations are "unglamorous" and when viewed in a context local to a given part of the ecosystem, they would be deemed unworthy of attention. But they conform to the optimisation principle that certain small interventions in a given part of a system can have a disproportionately positive impact upon the overall output of the system.

Because this principle is somewhat counter-intuitive, we will return to it when we present the specific recommendations of this review. In the meantime, it is very helpful to bear the principle in mind, as we shortly review the three categories of intervention types that can be applied across the ecosystem model.

---

3   The terms "local" and "global" apply with respect to the ecosystem model, no geographical inference should be made.

Importance of a Portfolio Approach to Interventions

In general, interventions made in the very early stages of the ecosystem funnel, or in its dependent areas (discussed next) will have greater eventual impact overall than interventions made later in the funnel. This is because interventions made at the start of the funnel affect all later stages too. Conversely, investments made in later stages will yield a return sooner, because tangible start-up success only manifests from the middle of the ecosystem funnel onwards. Therefore, our interventions should constitute a balanced portfolio across the ecosystem's stages, to bring about both early improvements and long-term high growth.

It might be tempting to only make interventions in later stages of the funnel because they yield an earlier return and because, as we shall see, they tend to be easier to make than earlier-stage interventions. But this would be a mistake. The effectiveness of later-stage interventions is permanently reduced if they are not made in conjunction with earlier-stage interventions. This is because earlier-stage interventions effectively create more "fuel" to power the beneficial effects of later-stage interventions.

Major factors influencing the performance of the ecosystem

The ecosystem model is dependent upon our combined approach in three categories. These are:

- Education
  Scope: across all stages of the ecosystem funnel, including, for example, start-up founder-team education in the Silicon Valley playbook.

- Infrastructure
  Scope: co-location and social infrastructure (the "market square", in our parlance). Infrastructure refers both to physical and virtual versions, in each case.

- Funding
  Scope: includes public-funding and the stimulation of private funding capacity and capability. Covers investment and grant funding.

We will expand on these definitions in the analysis that follows shortly.

The overall ecosystem model can therefore be updated to reflect these dependencies as follows:

Ecosystem Funnel

Ecosystem Infrastructure   Education Funnel   Funding System
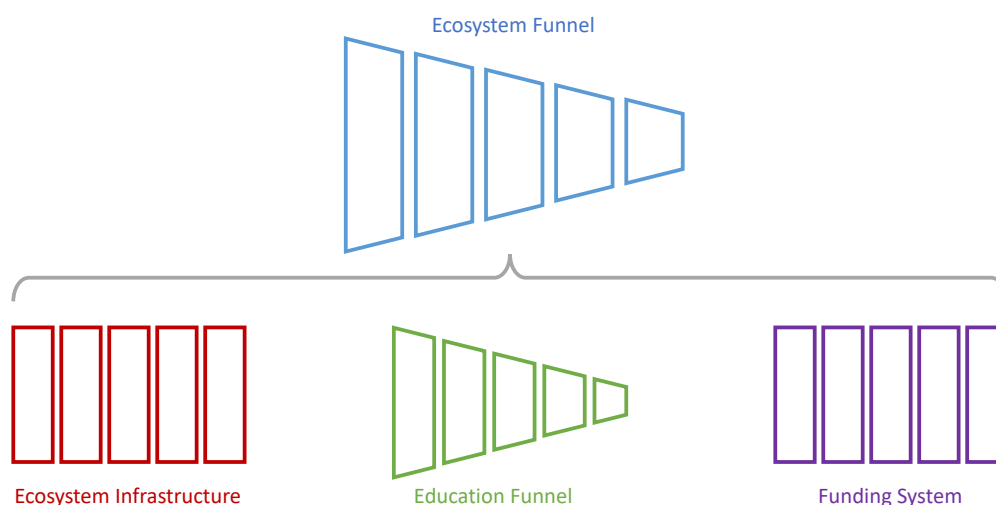
Our approach in this review is therefore to identify deficiencies of provision in each of these supporting categories that materially impact the sustainable output of the ecosystem funnel. We summarise this analysis in the following three sections of this review. Each section is structured as follows:

- We review the overall dynamics of each category.

- Deficiencies and areas for improvement are identified.

- A strategic framework for improvement is defined, which forms the basis of the later report recommendations.

In the final sections of this report, we then consolidate a set of specific recommendations intended to address the deficiencies identified.

Ranked, Relative Importance of the Factors

None of the above three areas can be omitted from our scope if we are to successfully accelerate our ecosystem towards and past its tipping point. All are important. But, in this review, we assign the greatest importance to recommendations in the *Education* category, followed by *Infrastructure* followed by *Funding*.

To some, this may appear to be exactly the wrong way around. After all, the argument goes, without funding, it's impossible for our start-ups to reach maturity. But public seed investment funds already struggle to find enough credible candidate early-stage start-ups in which to invest. And, at the Series A stage[4], external investors believe that the ecosystem produces too few well-run, non-frivolous start-ups and scale-ups to consider setting up a presence in Scotland or spending time here.

The funding will come to Scotland when the country regularly produces a sufficient number of credible candidates in which to invest. In other words, the virtuous network effects described earlier will become established as we near and then pass the ecosystem tipping point. To achieve that, we need to increase the average likelihood for success of our start-ups. And education – including in world-class, best practice start-up leadership and related techniques – is foundational to achieving that goal. Put simply, we need to educate our way to sufficient deal-flow to attract the interest of Series A funding institutions. Our ecosystem infrastructure is then the platform from which that education – both formal and informal – can be delivered.

---

4   An investment round following seed rounds, when the start-up has market traction and wishes to scale operations, typically raising of circa £10m-£15m.

Chapter 2 – Ecosystem Supporting Categories – Education

It is generally understood that interventions in our ecosystem that create more talent in programming, engineering and adjacent disciplines are essential to increasing the output of our ecosystem. An often overlooked but equally critical point is that the ecosystem also fundamentally depends on access to leadership talent (technical, strategic, and of people) at each stage of the funnel. Without suitably equipped people in sufficient numbers, smaller businesses are unable to successfully scale, even if their products have high potential. Opportunity and investment are squandered. See Appendix A Why Can't Start-ups Scale? for a deeper illustration of the importance of founder-team education to successfully scaling start-ups. A further key point is that entrepreneurship itself is also teachable.

The outcomes of our ecosystem are therefore heavily dependent on our Education Funnel (we'll shortly explain why we depict education as a funnel in its own right). The more people our education funnel produces with the above capabilities, the higher will be the output of our ecosystem.

The Tech Ecosystem depends on the Education Funnel

Ecosystem Funnel
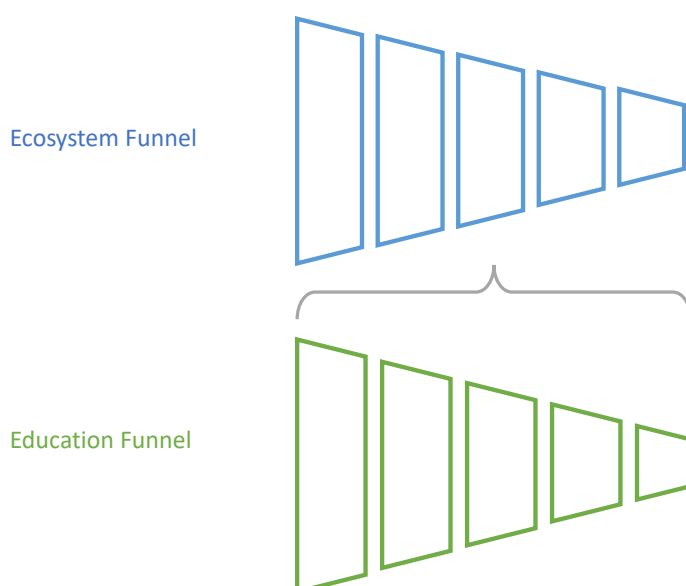
Education Funnel

In this section, we'll first define in detail what we mean by the education funnel. We'll then examine each stage of the funnel as it currently operates in support of our ecosystem and identify weaknesses and areas for improvement. For each stage, we'll outline an overall strategic approach for how the funnel could be systematically improved. In the recommendations section at the end of this document, we'll present consolidated recommendations in this category alongside those in the other supporting categories of the ecosystem (Infrastructure and Funding).

Definition of the Education Funnel

The education funnel can be depicted as follows:

The Education Funnel

Leadership, Strategy, Internet Economy Operations

School

University

Start-up Founders,

Leaders: 10-20 people

Engineers, etc

Leaders: 50-100 people

At-scale, experienced engineers, etc.

Leaders: 100-500 people

Product Engineering and related skills
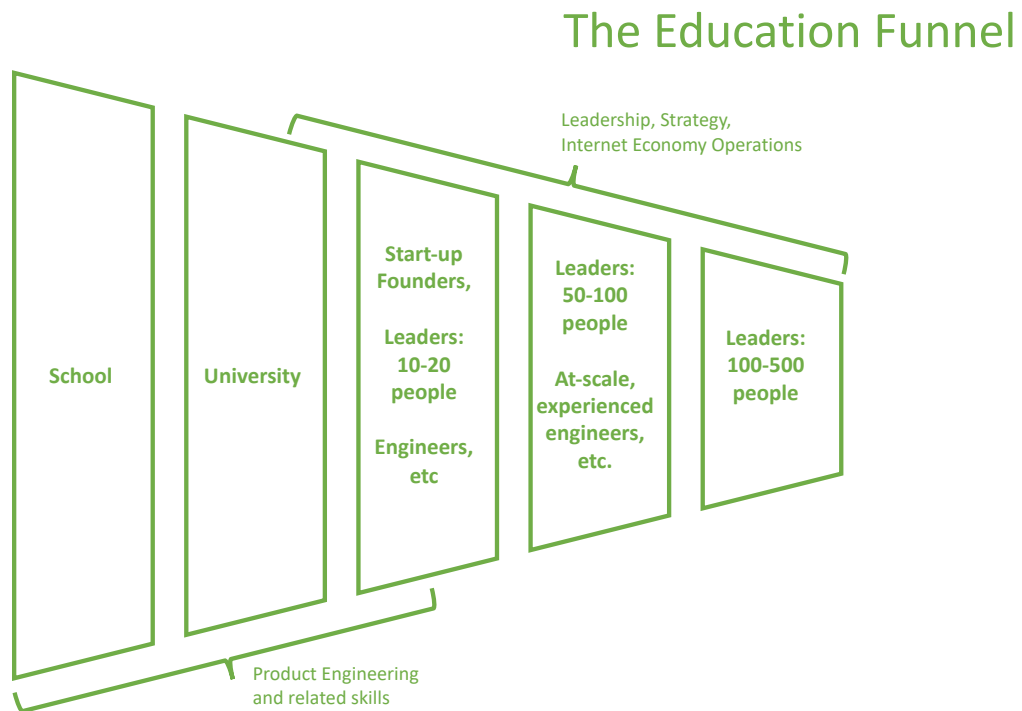
Starting from the left-hand side of the diagram and proceeding towards the right-hand side, we are first concerned with nurturing the foundational skills in software programming at school level. This constitutes much of the engine that will power future tech start-ups. The larger the pool of engaged and skilled young people at this stage, the easier it will be later for start-ups to form and to grow. This focus on raw engineering skills continues as we move to university-level where they are significantly enhanced. At this stage they are joined by rudimentary business and leadership skills. As we move further to the right of the funnel, we come to the needs of early-stage and then later-stage start-ups, and beyond. At these stages of the education funnel, we are more concerned with growing the base of people with skills in *Internet Economy* business operations, people leadership, technical leadership and technology strategy development.

This emphasis on the *Internet Economy* version of these skills is extremely important. We use this term to characterise a certain approach to product development and management. It is characterised by an unwavering focus on *speed of iteration* within a business context, on *organisational agility* at all levels of scale, on a relentless pursuit of *product-market fit*, on the application of modern *growth engineering techniques* such as the exploitation of *compounding growth mechanisms*, and on a very high degree of *data-driven experimentation*, to highlight just a few examples. Only if Scottish start-ups and scale-ups embed these working practices within their organisational models can they expect to compete with the Silicon Valley's best businesses. And they must – the internet age not only brings global customers to our doorstep; it brings global competition too. A key related point is that, because these skills are only sparsely represented within the Scottish ecosystem, they will partly need to be sourced from outside the country by various means.

Returning to the education funnel, we should note here that there are multiple versions of this funnel reflecting the different industries that constitute "tech" (though there is considerable commonality between them, particularly in the later stages of the funnel). So, it's more accurate to draw the above diagram as follows:
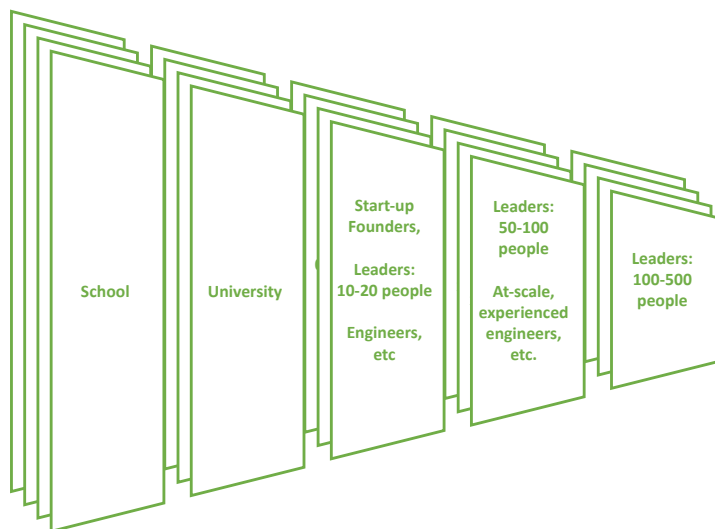
For simplicity, we will depict this funnel in the singular for the remainder of this document and will focus on the funnel specifically rooted in software engineering, as that is the primary focus of this review. It should be borne in mind, however, that there are actually multiple funnels in play, reflecting e.g. pure software businesses, electronic engineering, mechanical engineering, biotech, etc, and that the overall ecosystem model is applicable to all root technology types.

Naturally, just as with the ecosystem itself, the education funnel also narrows from left to right – not every Computing Science student can or should found a start-up, for example. But again, we meet the problem that the funnel's *natural* narrowing rate and *actual* narrowing rate are not the same.
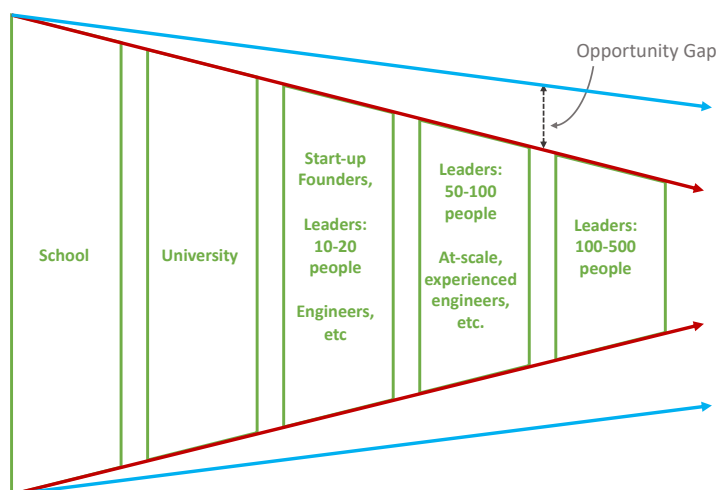
This is because, currently in the Scottish ecosystem, there are areas requiring significant improvement in each of the stages of the education funnel as it relates to the subject of this review[5]. We believe that this situation, probably more than any other factor, undermines Scotland's capability to produce a steady flow of world-class scaled-up technology businesses.

---

5   To be clear, we acknowledge that Scotland has, overall, a strong general education system. It's as it pertains to the tech ecosystem specifically, and at each of its stages, where the commentary mainly applies.

This is also the major influenceable reason for the imbalance in our tech ecosystem (many small start-ups and very few scale-ups). Without sufficient capacity and capability in the education funnel – particularly in the area of Internet Economy leadership and strategy – the tech ecosystem funnel collapses, as we've seen earlier. We just don't have the knowledge, skills or experience in sufficient volume in our earlier stage start-ups to navigate them to scale.

Ecosystem Funnel

The ecosystem collapses as the education funnel narrows

Education Funnel
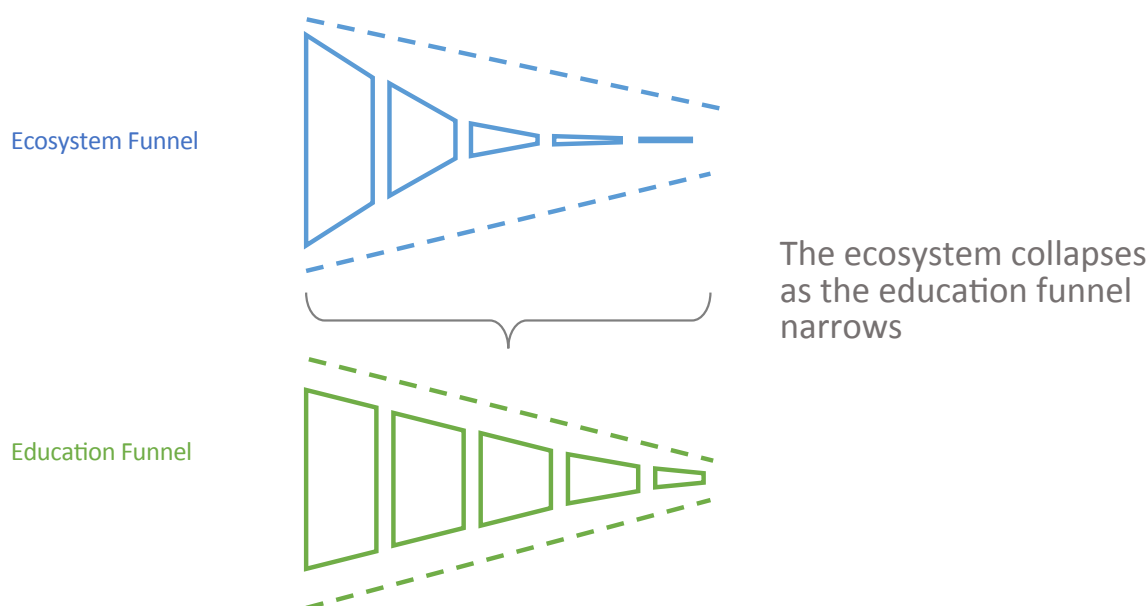
This is why Education is so important to the Ecosystem. For example, increasing the funding available to start-ups won't make much difference to outcomes if the competence doesn't exist within the ecosystem to build businesses that are capable of putting that capital to good use.

Put more positively, the right interventions in the education funnel create the conditions to move the ecosystem funnel through its tipping point. Without pre-empting the recommendations listed later in this document, one illustrative way to explore this point is to ask the question: what effect would it have on our tech ecosystem if universities produced twice as many graduates who were ready, willing and able to form start-ups and run them competently? What changes in university teaching, intra – and extra-curricular activities etc. would bring that change about? This is just one example. We can ask analogous questions of other stages in the education funnel.

Such questions are the starting point in the identification of practical interventions in the education funnel. In the recommendations section of this report, we will propose a comprehensive set of such interventions and support.

Conceptually, these interventions must impact the education funnel in one or more of three ways if they are to be valuable. In summary, they must *Reduce the Rate of Narrowing, Widen the Down-Funnel Stages* and/or *Shorten the Funnel.* Let's now briefly review each of these categories.

1. Reduce the Rate of Narrowing

We are effectively leaking talent between stages of the funnel (hence the over-narrowing as we move through the funnel) and our portfolio of interventions and support should address this loss. Clearly some leakage is natural, but our opportunity is, as before, to reduce the gap from the actual rate towards the natural rate.
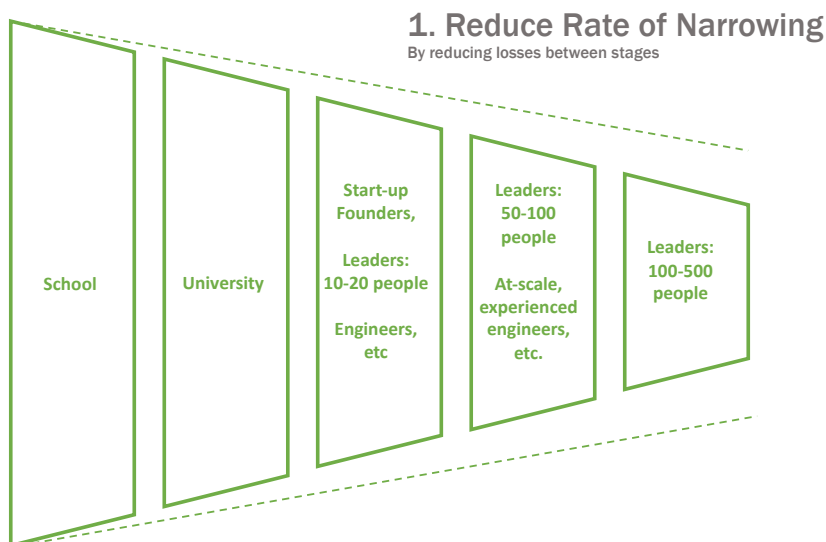
2. Widen the Down-Funnel Stages

Actions in this category attempt to return talent to the pipeline that was lost in earlier stages. Again, without wishing to jump to solutions at this stage and for illustration only, Codeclan is an excellent example of this type of initiative – creating engineers who missed the conventional university degree route into software engineering the first-time round. We could relatively easily support Codeclan to double or more its graduate numbers. Encouraging talent immigration is another example.
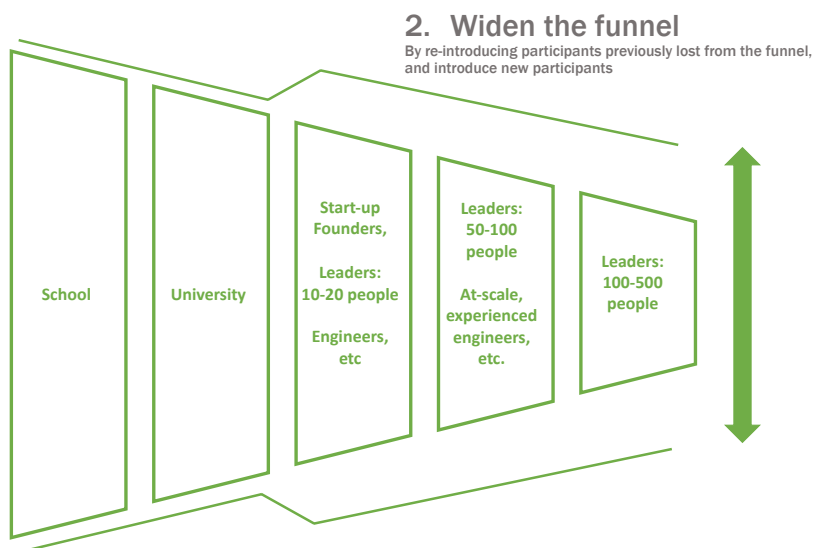
3. Shorten the Funnel

These actions accelerate the experience and knowledge of funnel participants. As an illustrative example, world-class training courses in Silicon Valley start-up growth techniques exist and would be enormously beneficial to our ecosystem. However, these are currently only partially available to some start-ups due to cost and exclusivity reasons. What if all of our start-ups had access to this material through a national license? Another example: we have a large international pool of Scots working in the Silicon Valley and around the world in senior leadership positions. Many would gladly support our emerging young leaders. What if we tapped that diaspora to a much greater extent than we currently do?

3. Shorten the funnel
By reducing the time taken to move through stages
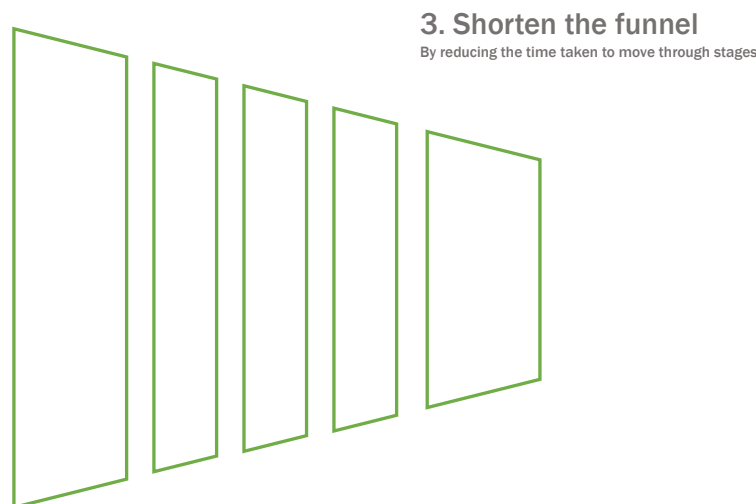
As we now begin our analysis of the Education Funnel, starting with the *School* and *University* stages, we note that there's a particularly close relationship between these first two stages; related problems tend to exist in pairs at the interface between these stages. Later interventions to address those problems must take this relationship into account[6].
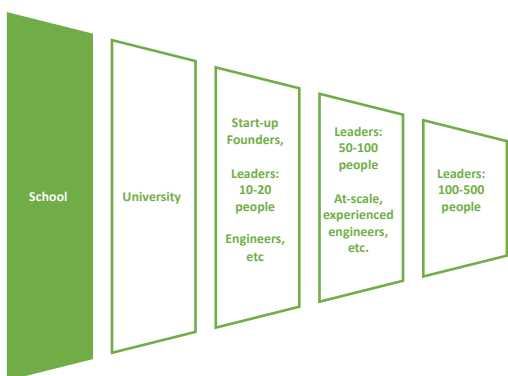
Stage Analysis – School

The human capacity to support start-up creation and growth at all later stages of the tech ecosystem is already largely determined by the time our young people leave school. The more of them we equip with programming and related skills at school level, the more start-ups we'll have later[7].

This principle doesn't just apply to the supply of future software engineers. It also predicts the number of future founders too. Starting a technology-intensive business requires two things at the outset: an idea and the means to *demonstrate that idea*. The greater the level of software skills held by the would-be founder, the easier it is to do that.

---

6 This is another manifestation of the local versus global optimisation phenomenon.
7 Of course, this also improves youth employment prospects generally – higher-end computing skills lead to substantially enhanced employability, and at significantly higher than average salary levels.

For example, there's one principle reason cited by undergraduates studying "non-technical" courses at university and who are interested in starting a business as to why they struggle to do so: they lack the prototyping skills needed to demonstrate or develop their idea. Of course, later in the development of a start-up, non-technical founders may well be in a position to hire specialist programmers to further build out their products, but at the outset they cannot. Business undergraduates, for example, (and those in related disciplines) are amongst the most business-minded of students and produce a relatively high level of start-up ideas. They just can't test them out.

This mismatch between desire and agency represents a considerable loss of start-up potential. The same principle, of course, applies to those who wish to start a technology-intensive business without following the university route.

So, to recap, the more people we equip at school level with a basic level of competence in Computing Science, the more start-ups we'll eventually produce and the greater the pool of engineers we'll have available for those start-ups to hire from as they develop. In a country with a very small population such as ours, this point is of even greater importance.

Against that starting point, our fundamental strategic error as a country is that we don't treat Computing Science in the same way as we do Mathematics or Physics. For that matter, we don't treat it with the same importance as History or Geography, for example, either.

Subject	Intensively taught from stage:	Secondary teachers typically hold relevant degree qualification?
Mathematics	Primary 1	Yes
History	Late primary/1st year Secondary	Yes
Computing Science	3rd year Secondary (optional)	No

Below, we examine some of the consequences of that treatment of Computing Science. In the recommendations section, we'll propose actions to improve our country's performance in this critical area.

But the summary is: given that this stage in our ecosystem is foundational to all future stages, the present situation is not compatible with our ambitions for Scotland's technology sector. And the impact is not limited to the tech sector; many sectors of our traditional economy, such as Law and Financial Services, are increasingly being disrupted by Internet Economy business models and techniques. It would be wise to equip our future professionals with a basic grounding in the discipline.

Unfortunately, the situation is deteriorating. Figures from the Scottish Teaching Census and the SQA indicate that the number of Computing Science teachers in our schools is falling[8] as is the number of pupils taking the subject[9].

We need to treat Computing Science seriously, as if it were Mathematics or Physics, if we are genuine in our ambitions to be a competitive technology economy. This *must* be our direction of travel. It implies that a more-than-incremental approach to the problem will be required.

---

8   Source: Scottish Teachers Census: between 2008 and 2018, number of teachers whose main subject is Computing Science has fallen by almost 23%.
9   Source: SQA Annual Statistics Report. From 2016-2018 (the last date for which analysis is available at the time of writing) National 5 participation in Computing Science fell by 19% (versus Mathematics, which fell by <1%) with a participation rate at 15% of Mathematics' participation rate. Participation in Higher Computing Science fell by 8% over the same period (versus Mathematics, which fell by 1%) with a participation rate at 22% of Mathematics' participation rate.

Gender stereotypes are already in place prior to formal teaching of Computing Science

Before we can influence our children to the contrary (we generally don't formally teach Computing Science until 3rd year in Secondary school), gender stereotypes have already taken hold. On average, 84% of students studying higher Computing Science are male in any given year[10]. It's not hard to see the massive loss of talent from our future start-up pipeline brought about by this state of affairs (in addition to the removal of opportunity from girls that it represents).

The syllabus is restricted to what can be taught by non-specialists; it's boring

In general, Computing Science is not taught by specialists. i.e. Computing Science graduates or those from related technical disciplines. This may perhaps be because such graduates generally have many highly paid career choices open to them. Or it may be because the education system does not actively compete with other employers to hire them into the profession from university.

Within schools, teachers are often co-opted from other disciplines, such as Business Studies, to teach Computing Science. This is perhaps not surprising when we consider that 17% of our secondary schools have no dedicated Computing Science teachers[11].

Our reliance on non-dedicated[12] and non-specialist teachers impacts upon the syllabus, by restricting what can be taught. The interest level inherent in the syllabus, including associated projects, is therefore reduced. Put simply, the curriculum is boring; it is the author's experience that, anecdotally, many children who profess an interest in Computing Science before commencing National 5 studies are put off the subject during those studies. Approximately only 50% of students who study Computing Science at National 5 level choose the subject at Higher level, compared to 70% for History and Geography, for example[13]. For a subject that is inherently magical (the ability to build almost anything), this is disappointing, and something is wrong.

The subject is not signalled as important to future career opportunities

We formally teach Mathematics and English from Primary 1. We formally teach History, Geography, Physics, Chemistry and Biology from Secondary 1. In contrast, we formally teach Computing Science in Secondary 3, and as an optional subject. This sends signals to children and parents as to the subject's importance. This state of affairs is not aligned to the needs of our economy. Skills Development Scotland reports that annual vacancies in ICT in Scotland average 13000, with average salaries in the sector 26% higher than the overall average (and rising more quickly).[14]

Lack of support given to voluntary/extra-curricular organisations

There are several national and local programmes supporting extra-curricular programming support for children, including *Young Engineers and Science Clubs (YESC), CoderDojo, Code Club, Make it Happen, Prewired, The DataKirk* (which supports data literacy for BAME young people), *Digital Skills 4 Girls* and *dressCode* (these last two clubs work to mitigate the horrendous under-participation of girls in Computing Science). They are mostly volunteer-led and receive a mixture of public and private funding support.

10 Source: SQA Annual Statistics Report.
11 Source: After the Reboot: Computing Education in UK Schools, The Royal Society.
12 In the sense of percentage of working hours available for the subject.
13 Source: SQA Annual Statistics Report
14 https://www.skillsdevelopmentscotland.co.uk/media/46258/scotlands-digital-technologies-summary-report.pdf

This area is an excellent example of a point we discussed earlier – that small interventions in the ecosystem can eventually have a profound impact on the performance of the ecosystem as a whole, including by enriching the diversity of the tech sector. However, provision is very patchy, with some areas and age groups under-represented. Most clubs report equipment and staff limitations to scaling their activities. There seems to be an opportunity here to provide more strategic support to this important area at relatively limited cost.

The entry level of students into University Computing Science courses is relatively basic, requiring remedial teaching

Let's explore this point by analogy: imagine if Mathematics was formally taught only as an option and only from Secondary 3 onwards. At what capability level would a university Mathematics degree programme be required to start from in its 1st year, in consequence? What effect would that, in turn, have on the final knowledge level of our mathematics graduates?

Strategic Framework for Action – School stage

- To address the issues outlined above, the guiding principle to our interventions at this stage of the education funnel must be that *Computing Science should be considered as equal to other sciences or mathematics in the school curriculum*. Such a treatment has a number of significant implications, in terms of from when and how, by whom and how much the subject is taught in our schools, which we review in our recommendations section.

- In the intervening period and beyond, those voluntary organisations currently providing extra-curricular programming clubs would benefit from a more strategic approach to support, to increase the coverage of programming clubs across Scotland, and across demographics.

- Specific focus must be brought to the acute and chronic gender imbalance in Computing Science at school level. Strategically, we must start from the principle that the situation is unacceptable rather than "normal."

We'll make specific proposals based on these strategic principles in the recommendations section of this document.

Stage Analysis – University[15]
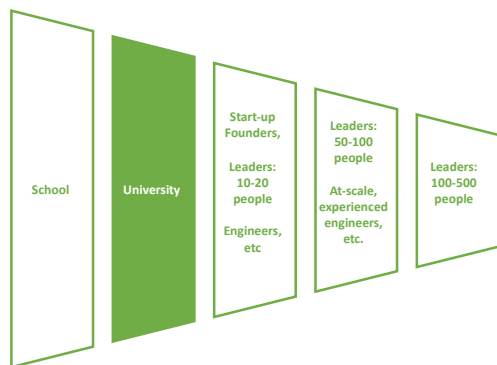
There are three outputs pertinent to the review that should be optimised at this stage of the Education Funnel. The first is the number of graduates who are interested in founding or joining a start-up, and who are *equipped with the key start-up skills* required to do that. The second is the number of Computing Science graduates (and those from related disciplines) produced by our universities. The third is the rate and viability of spin-outs from our universities. We'll consider each of these in turn.

Computing Science Graduates Equipped with Necessary Tech Start-up Leadership/Business Skills

Within the scope of this review, we consider this to be the most important of the three outputs at the *University* stage of the Education Funnel in increasing the subsequent ecosystem start-up success rate. But it currently receives relatively little focus at university level.

Below, we review the main areas where performance could be improved at this stage. There are two summary observations from that analysis that should be addressed in our ecosystem strategy as it relates to the *University* stage. The first is that there's a large variation in performance across institutions, with some far ahead of others in their embrace of entrepreneurship across the curriculum and in spin-out and start-up support. The second is that improvements can be made in how even our best institutions approach this problem relative to international best practice. In the discussion points below, we do not wish to embarrass individual institutions and so have expressed our points in general terms.

Let's begin our analysis by considering what good looks like internationally, and then examine the gap between that and *typical* practice in Scotland (recognising that there is considerable variation across institutions).

The best universities view industrial collaboration in general, and start-up facilitation in particular, as equally important to their other missions of teaching and research. They understand that it is difficult to be genuinely world-class in teaching and research without being world-class in industrial liaison and entrepreneurial support. With any of these missing the others are diminished.

What makes a university world-class?
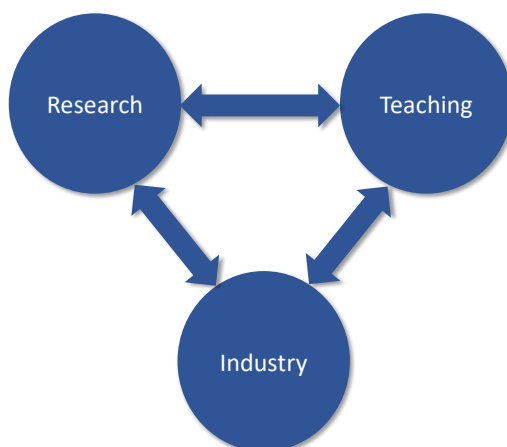
Lets consider Stanford University, in California. It's worth remembering that the Silicon Valley came into being in the first place largely because of the start-up-friendly, supportive environment created by Stanford in the Valley's earliest days. More recently, of the 300 private tech companies valued at more than $1 billion in 2019, 63, or one fifth, of their founders studied at Stanford. The university runs 145 courses on entrepreneurialism, including many full-semester courses specifically on high-technology entrepreneurialism, it actively encourages students to explore start-up ideas, gives them facilities to do so and even directly and indirectly invests in student start-ups. In return, multiple benefits flow back to the university from its alumni, including endowments, research grants, world-class speakers and mentors, student placements in alumni businesses, access to cutting edge technology, teaching partly led by top technology industrialists, and brand benefits. In this last regard, it's difficult to place too high a value on the kudos that flows to Stanford from the fact that Google's founders started the company there, to name but one example. This attracts further talent and funding.

In contrast, the following issues are more typical of Scotland's approach:

Little or no incentivisation to encourage an entrepreneurial mindset amongst technical students

University science courses, including Computing Science, are measured on many KPIs, typically none of which include entrepreneurial aspects. For example, there's no KPI which measures the number of graduates founding or joining a start-up within 12 months of graduating (or similar).

Therefore, no real incentive exists to invest in this type activity.

In fact, existing KPIs risk operating to *actively reduce* institutional enthusiasm for entrepreneurialism to below its otherwise natural level. Universities are partly measured by the proportion of students who finish courses. If Larry Page[16] had attended a Scottish university, a KPI somewhere would have tipped towards amber when he co-founded Google, then towards red when Sergey Brin joined him. In effect, it is in the local interests of universities to disincentivise entrepreneurial start-up activities, lest students drop out and form start-ups[17]. This is not to say that universities literally operate according to this disincentivising KPI, the point is that there is no funding benefit to the university in doing otherwise (note that we are not suggesting that drop-out rates shouldn't be tracked or don't matter, rather that they must be placed in their proper context).

The above is a typical example of the issue of local versus global optimisation within the technology ecosystem, discussed earlier.

A further pertinent issue is that the extra-curricular activities (for example, summer start-up schools) and facilities (such as incubators) required to support entrepreneurial activities are not included in the funding settlement for Computing Science students, or those from related disciplines (*c.f.* Clinical disciplines, for which analogous lab costs are already accounted).

These root issues lead to consequential problems:

Inadequate staffing to support entrepreneurial activities

Universities employing several thousand people have, in some cases, as few as two FTEs dedicated to supporting student entrepreneurialism. Again, this figure varies considerably according to the attitudes of respective institutions towards entrepreneurialism. But, on average, it contrasts poorly with best practice elsewhere.

---

16   Co-founder of Google, with Sergey Brin
17   Historical examples of this career path include Google's co-founders, Bill Gates, Steve Jobs and Mark Zuckerberg. The combined worth of their companies today is $4.5 trillion.

Limited incubation space for student start-ups

The general question of incubation facilities will be discussed in Ecosystem Supporting Categories – Infrastructure shortly. Here, we are referring to incubation space for students, recent graduates and post-graduates to experiment with early start-up ideas.

The provision of incubation varies considerably across our major universities, with some providing excellent facilities and some, despite running multiple Computing Science and engineering courses, having no such facilities.

Computing Science (and related) courses have little tech start-up leadership teaching content

To prepare and engage students in graduating to start-ups after university, Computing Science and related courses should feature, at least to an elective level, the following or similar content, in addition to, or partly as an alternative to, the existing, strongly technical syllabus:

Core-curricular

- *Internet-Economy* best practice in product introduction and growth engineering.

- Fundamentals of internet-economy business operations.

- Case studies of multiple well-known tech start-ups and scale-ups, both successful and unsuccessful.

Cross-curricular

- Inter-school/faculty collaboration projects (for example, Business, Computing Science, Engineering, Design schools), start-up simulation exercises.

In practice, this tends not to be the case or is provided to a minimal level (the less interested an institution is in entrepreneurialism, the worse the problem is likely to be).[18] This problem is exacerbated by the squeeze incurred by the remedial teaching time required by universities to bring first year students to a common basic level of knowledge about Computing Science, which we discussed above.

Therefore, Computing Science students tend to graduate with very strong technical knowledge but very little knowledge of how to take a product to market, per the Silicon Valley start-up "playbook". The consequences of these gaps are two-fold. Firstly, many students don't feel equipped to consider start-ups as a career option (or are not even aware that this is indeed an option). Secondly, students who, as undergraduates, attempt to form a start-up are usually ignorant as to how to do so and make basic mistakes leading to avoidable failure. This results in disillusionment, which tends to turn students away from this career option and towards more established, "safer" businesses.

Business and technical students tend to be taught apart

To illustrate this particular point, consider the following pathology. Computing Science students know how to build software but frequently lack business acumen or awareness. Business students often brim with start-up ideas but lack the means to build software. If they were brought together frequently, it is likely that start-ups would emerge from these combined skillsets and, at the very least, everyone would learn useful techniques for later business life. But these two groups usually move in separate circles; they are taught separately, and their core-curricular projects are separate.

---

18   Note that the familiar and token "how to create a business plan" and similar courses provided to science students in the final year of study is not sufficient to create start-up savvy computing science graduates.

There are bright spots; for example, in one of our universities, students across all subjects are introduced to entrepreneurship within the curriculum and encouraged to interact with students from other disciplines in entrepreneurial projects. In another of our institutions there is an annual weekend "collider" event, where students from different schools in the university take part in a cross-disciplinary start-up competition. But, overall, we are a long way from the regular co-mingling of knowledge and mindsets required here across all of our institutions.

We discuss, in Ecosystem Supporting Categories – Infrastructure, the need for our start-ups to have access to *social infrastructure*, those "market squares" where people can meet, physically or virtually, to exchange ideas, learn from each other and collaborate across specialisms and domains. The same requirement exists at university level, and universities are particularly well-placed to fulfil this need for their students. However, this tends not to happen because individual schools within a university tend to operate largely independently of each other and are largely occupied with their own KPIs. The consequence of this is to reduce the start-up learning experience for students and to reduce the number of student start-ups.

Little to no support for funding student start-ups

Best practice institutions such as Stanford have facilities to support student and early post-graduate start-up activity through limited seed-funding mechanisms. Such funding mechanisms bridge the gap for start-ups prior to being ready to seek funding from other routes, while they develop their early ideas. Such facilities are not generally available across Scotland's institutions.

Provision of start-up summer schools is limited

Some universities run excellent start-up summer schools for students and recent graduates. In these, students form start-ups and work to build a real product or service. During the summer, they receive advice and training on a variety of product and business areas. These programmes are particularly valuable because they provide real-world experience to consolidate, supplement and enhance knowledge gained during the academic year. We consider these to be a best practice element of a university education as regards the scope of this review. A similar scheme, *Converge*, operates in support of recent university spin-outs.

However, the provision of such programmes across our universities is patchy. There are two possibilities here, which are not mutually exclusive. One is for more/all of our universities to adopt the summer-school approach. Another is for Scotland, nationally, to adopt the successful *tranzfuser* initiative from the UK Games Talent and Finance CIC. This is a UK-wide summer school for games software graduate student start-ups, resulting in a funding prize and accelerator programme for the best companies. Such an approach could be generalised and applied across Scotland.

Provision of summer internships at tech start-ups is limited

Summer internships are an excellent means by which students gain business and commercial experience during their studies. Universities provide some support to students looking for internships while the *Saltire Scholars Programme,* organised by Entrepreneurial Scotland, placed 181 students internationally in 2019. For those students wishing to take up an internship, the main barriers to doing so are the availability of internships domestically – especially in tech start-ups – and the availability, cost and difficulty of accessing international internships. Initiatives to increase the supply of internships to Computing Science students, and those from related disciplines, should be actively examined. We make specific suggestions in this regard, in the Recommendations section of this report.

Locally resident Computing Science graduates (and related disciplines) produced by our universities

The second output from the *University* stage of the Education Funnel concerns the number of software engineers (and related disciplines) produced by our universities. Scotland has a very small population, which in turn affects the number of software engineers that it can produce to satisfy the needs of a growing and improving ecosystem. Although not the only means by which software engineers can enter our tech ecosystem, the university route is nevertheless the main source of supply. It's therefore important that we maximise the number of software engineers graduating from the university system who can then reside and work in Scotland for the long-term. But it is anticipated that, from 2021, we will experience a supply-side shock due to a likely collapse in participation by EU students as a result of Brexit.

An influenceable constraint in this category is the number of Scottish students gaining access to Computing Science and related degree programmes in Scotland. This level is heavily influenced by the relative value of Scottish students, in funding terms, compared to far more lucrative overseas students (who generally return to their home countries[19]). It would be unfortunate if improvements in the School stage of the Education funnel were not matched by an increase in capacity at the University level to accommodate them. If it is a strategic imperative of government to increase the supply of engineering talent into the tech ecosystem in Scotland, then an appropriate financial settlement and KPI model should be reached with the university system in Scotland in support of that goal.

Number and Viability of University Spin-outs

The third output from this funnel stage is the number of viable spin-outs produced. It would be easy to be complacent about Scotland's spin-out performance; the country has the highest spin-out rate outside of London. But, in this category, it's important to consider both the rate *and* viability together of university spin-outs. Scotland's spin-out rate is heavily bolstered by relatively high levels of government investment but there are few success stories, in terms of businesses that have grown to scale or exited at high valuations. Rate and viability must be considered, and improved, together.

Universities report that activities related to licensing and spin-out creation are expensive and are usually regarded as a cost base rather than an income stream[20]. This likely acts as a disincentive to invest effort in this area, though we note here that our institutions vary very widely in their enthusiasm and support for spin-out activity.

Our view is that focus should be brought to bear on the *income* part of that equation rather than the *cost* part; by increasing the general success rate of spin-outs, the cost issue will resolve itself. In this regard, several factors act to reduce both the rate of spin-outs and their viability. These should be addressed in our strategic response.

Equity stakes too high/too rigid

Equity stakes taken by universities in spin-outs are often too high; up to 50% in some cases. By comparison, at Stanford the average is 10%, at Massachusetts Institute of Technology (MIT), 5%[21]. This level of equity acts as a disincentive both to founders and investors and makes follow-on investment more difficult to obtain. Later potential investors are wary to invest where they see that founder stakes are already heavily diluted. Their concern is that such dilution retards the motivation of founders in what is an extremely demanding personal journey. This issue is amplified by the fact that university spin-outs generally require more funding than other start-ups to reach a minimum viable product (because they are typically attempting to exploit technologies which are relatively new and unproven). So, founder dilution is likely to be more severe than would otherwise be the case.

19   In this regard, the recent re-establishment of the post-study visa for foreign students in the UK is obviously welcome.
20   Source: The Muscatelli Report Driving Innovation in Scotland – A National Mission
21   Source: Nature: Guideline University Share of Equity Taken by US Universities

It is, of course, reasonable for a university to expect an equity stake in a business that has been nurtured by the university, through its research, expertise and facilities. But this stake must be practically workable in the world outside of the institution. Compare with Stanford and Imperial College London (ICL), for example, which both take a flexible approach in this area, for example, by varying equity stakes based on the specific level of pre-incubation and follow-on support provided to the fledgling start-up.

Lack of start-up business acumen amongst academics

It's generally accepted that academics tend not to make the best CEOs over the lifetime of a company (or even at the start in many instances); the skills required bear little resemblance to those required in academia. This has a direct bearing on the likely success rate of spin-outs, subsequently. There are three problem areas which should be addressed.

The first is that some universities implement articles for spin-out companies that significantly reduce their chances of success because they make it very difficult for a founding CEO to be moved to another position later, or exited by a board, as the company develops, without their express agreement. This reduces the company's credibility as an investment opportunity too.

The second problem is that universities frequently do not place enough of a requirement on a potential spin-out to recruit seasoned start-up executives as part of the spin-out process. Of course, such people need not be permanent employees of the spin-out, they can occupy mentoring positions, for example.

The third area for improvement is that universities could do more to equip spin-out founders themselves with the modern start-up skillset that we discussed earlier in this document as pertaining to students. This has a direct bearing on the later success of those spin-outs. This is a slightly difficult point to implement in practice because ego often comes into play and because the spin-out academic founder may underestimate the importance of start-up technique. At any rate, its rarely a pre-requisite for spin-out support, currently. One way of implementing this requirement, and which doesn't require direct support from universities, is to place emerging spin-outs into the Tech-Scaler network initially, where founders could then benefit from the education programme operating there. We develop the Tech-Scaler concept in the Infrastructure section of this document.

Strategic Framework for Action – University stage

To address the issues outlined above, we believe that the following strategic principles should apply:

University policy is naturally influenced by the financial settlement between the sector and government. Therefore, the KPIs and associated financial incentives governing university funding should be adjusted such that:

- start-up entrepreneurial and internet-economy techniques are embedded into Computing Science and engineering courses, with institutions incentivised to include the attributes discussed above in those programmes.

- universities produce more software engineers.

- universities produce more – and more viable – spin-outs, with institutions incentivised to include the attributes discussed above in those initiatives.

It should be acknowledged that to achieve this focus, other KPIs will likely have to be adjusted. Simply adding more KPIs to any organisation only dilutes focus.

It should also be recognised that much of our discussion above adds up to an additional tax on universities to support Computing Science students. Today, extra-curricular activities, incubators, summer schools, etc., are not included in the funding settlement for Computing Science students. Compare with Clinical disciplines, where the need for provision beyond basic teaching is already recognised. A similar settlement model could be used for Computing Science and its related disciplines. Costs could be managed by sharing capabilities and programmes across universities, similar to the *Research Pool* model already employed to bring scale and efficiency to certain research programmes.

Stage Analysis – Early-Stage Leadership, Engineers, etc.
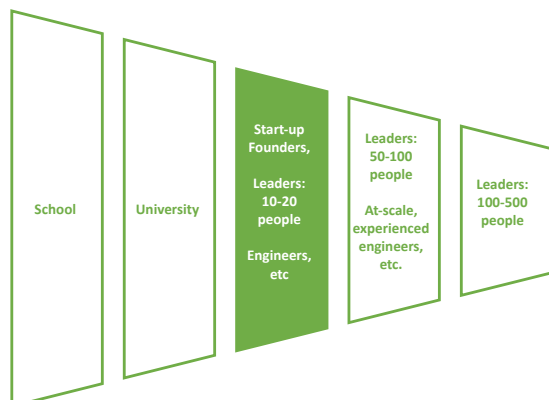
It's difficult to overstate the importance of this stage of the pipeline to the successful scaling-up of our start-ups. Of all the stages in this Education Funnel, improvements at this stage have the most immediate positive impact on the likely success of our current early-stage start-ups and later scale-ups, and therefore generate the fastest returns on interventions made, as well as on-going returns at every later stage of company scale.

There are two distinct categories at this stage of the education funnel. In this section we'll first define what we mean by early-stage leadership in more detail and analyse the ecosystem's performance in delivering that education, highlighting a number of areas for improvement. We'll then consider how to further increase the supply of engineering talent at this stage of the pipeline (i.e. post the formal university-education stage).

Finally, we'll develop a strategic framework for interventions in this area. Specific recommendations based on this framework are put forward in the Recommendations section of this review.

Definition of Early-Stage Leadership

Early-stage start-up leadership skills refer to the following categories (with illustrations in parentheses):

- Silicon Valley business models (for example, network effects, platforms, growth models and techniques, compounding growth mechanisms, commercial models and techniques, etc.)

- Internet-Economy working practices (lean start-up techniques, speed of iteration, experimentation, bottleneck constraint analysis, etc.).

- Fundamentals of team and people management (for example, staff development, communications, performance management, conflict management etc.).

- Fundamentals of funding models (for example, explanation of investment stages and terms, building relationships with VCs, pitching skills, alternatives to venture funding, etc.).

- Basic operating hygiene (including legal compliance, IP management and HR sufficiency).

The degree to which a start-up's founders and early leadership team have proficiency in the above skills determines the degree to which investor capital and time are effectively spent (or wasted).

There are three ways to inculcate these skills; through experience, through education or both. Of course, the last of these is most preferable. But since Scotland's ecosystem is currently short on experience, we must go long on education.

By education, we mean here *structured education.* In so saying, we recognise that a lot of good business education is gained through what we term in this review *market square*[22] activities, those interactions between founders, experienced executives etc. that happen in meet-ups, conferences, in the lunch areas of incubators and so on. These are undoubtedly very valuable; but although they are necessary, they are insufficient. Formal grounding in the above fundamentals is also required.

Analysis of the Provision of Early-Stage Leadership Skills

Against these requirements, we now assess Scotland's ecosystem in this area. There are three related areas of concern:

Fundamental internet economy start-up skillset is not present in the majority of our start-ups

To re-state the root issue, not enough of our founders and early-stage start-up leadership teams have the above skillset. This reflects the pre-tipping point, relatively immature state of our tech ecosystem. There is a general lack of experience in the ecosystem. In a post-tipping point ecosystem experience and best practice circulate between businesses as experienced employees move between them. In our ecosystem this happens to a much lesser extent. We must therefore mitigate that lack of experience by more intensive education in the areas listed above. We must not be complacent on this point; Scotland's tech start-ups are competing internationally (the internet effectively reduces the distance to all markets to zero, but all international competitors benefit in the same way). We therefore have no choice but to operate to international best practice in order to compete.

Ecosystem too internally focussed, not learning enough from outside

The consequences of the above point are that inexperienced executives tend to educate each other, in our various market squares (accelerators, incubators, conferences and meet-ups). This sets a relatively low ceiling on skills in our ecosystem. To overcome this, it's important that we turn the eco-system outwards to learn from international best practice. What this means in practice is that, in addition to formal education (covered in the next point) our various start-ups, our conferences and even meet-ups need to, as much as possible, have access to international expertise.

Not enough formal education taking place at start-up level, in incubators and accelerators

Most of the education done in accelerators and incubators is somewhat informal and ad-hoc. The same is true, of course, of conferences and the like. It tends to take the form of presentations and Q&As with successful practitioners. This is valuable, necessary even, but it is not sufficent. Recognising our pre-tipping point status as an ecosystem, structured, intensive education to start-ups in the disciplines listed above is required. We'll discuss how this might be delivered in Ecosystem Supporting Categories – Infrastructure, later in this document.

---

22   We explore in detail how to best support market square activities in our analysis of Ecosystem Infrastructure, later in this document.

37

Increasing the number of engineers at this stage of the pipeline

In addition to the leadership skills discussed above, our start-ups and scale-ups also need a steady supply of engineering talent. As we've seen, the ecosystem tends to "leak talent" during its earlier stages (for example, children who didn't develop their interest in Computing Science at school level and who might have done in other circumstances). This creates an impetus to complement the supply of engineers coming through the traditional educational route with other options. Essentially, we are "widening the funnel" by creating these additional supply routes.

2. Widen the funnel

By re-introducing participants previously lost from the funnel, and introduce new participants

School

University

Start-up Founders,

Leaders: 10-20 people

Engineers, etc

Leaders: 50-100 people

At-scale, experienced engineers, etc.

Leaders: 100-500 people
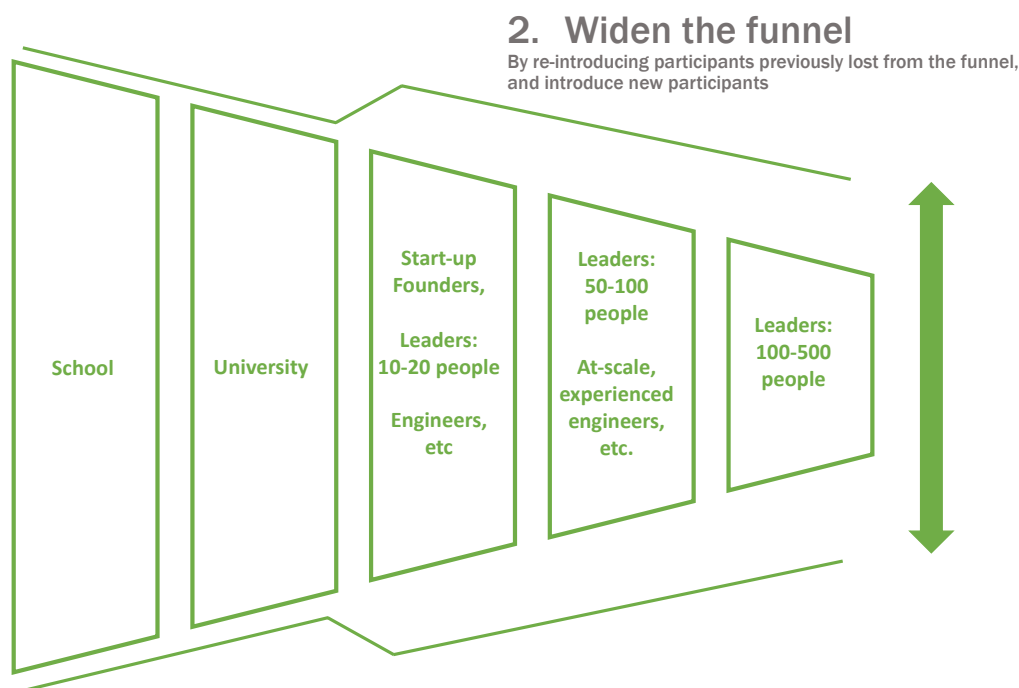
Scotland has already established Codeclan, an organisation that provides a 16-week intensive training programme in software engineering from bases in Edinburgh, Glasgow and the Highlands. When compared to comparable college-level courses, Codeclan significantly outperforms. Completion rates are higher, employers are enthusiastic and engaged with the organisation and are starting to compete to employ its graduates. Students tend to be changing careers into software engineering, with more life-experience than typical students, which makes them particularly interesting for industry[23]. The gender balance of graduates is better than is typical it is in software engineering courses.

The courses cost circa £6000, though there are some loan and grant options available to help students meet these costs.

We believe that Codeclan is an excellent mechanism for widening the funnel at this point, bringing a new supply of life-experienced and motivated students into the ecosystem. This resource is not currently being treated sufficiently and strategically as a key "funnel-widener." We should significantly scale Codeclan, so that far more graduates can be produced and we should scale the access funding paths for prospective students.

We should also examine how Codeclan's approach could be replicated to some extent throughout our colleges.

---

23   The average age of students is 32, according to Codeclan.

Strategic Framework for Action – Early-stage Leadership, Engineering, etc.

To address the issues outlined above, we believe that the following strategic principles should apply:

- Our ecosystem needs to instantiate an appropriate platform where the following skillsets can be routinely taught at the required scale to our start-ups as they move through the early start-up stages: Silicon Valley business models, Internet Economy operating practices, fundamentals of team and people management, funding models and business hygiene. Where appropriate, these materials should be sourced from best-in-class international training resources (such as Reforge.com, for Silicon Valley business models, for example) and national licenses negotiated where possible.

- Access to learning from world-class practitioners, invited to participate in our ecosystem through various forums should be facilitated and supported. In essence, we need to turn our market square outwards, to learn from the best. This is with particular reference to our conferences.

- Our international diaspora should be tapped more actively as a strategic resource following. For example, Ireland's successful model where a comprehensive, coordinated and long-term diaspora strategy was created at the outset of activities in this area. Our diaspora includes executives placed in many of the world's most admired technology companies. Diaspora networks exist today in the form of SE's Global Scot and the independent SBN. We should examine how to leverage and scale these resources more effectively under the umbrella of an ambitious exploitation strategy. We also note that many "exiled Scots" return to Scotland later in their careers, representing a potentially valuable seam of experience that should be more actively tapped where possible.

- We should encourage our large number of self-organised tech meet-ups by giving them access to free meeting space and resources.

- We should provide funding support to our successful "funnel-wideners" and treat them as a strategic asset to be carefully scaled. Best practice "funnel-wideners" such as Codeclan, should be studied as to how their success can be replicated in our colleges, to the extent that it is transferable.

Stage Analysis – Mid-to-Late-Stage Leadership
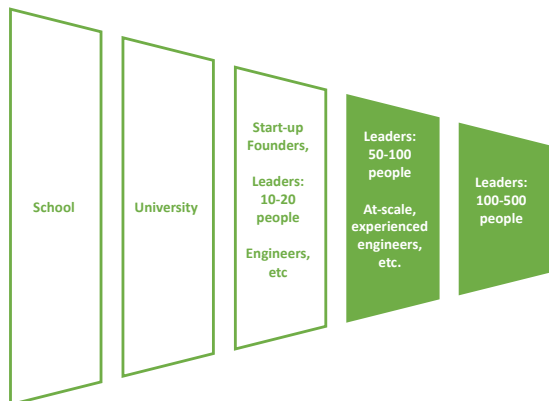
These organisations have similar requirements to earlier stage businesses but are additionally concerned with operating these skills at much higher levels of scale. Being larger, they are generally more capable of addressing their own needs in many of the areas that are challenging for smaller start-ups but there are still issues to be addressed.

Very difficult to attract senior executive tech talent to Scotland

Earlier, we discussed how difficult it is to bring senior, experienced leaders and senior individual contributors such as senior engineers to Scotland from, for example, London and the Silicon Valley. In summary, this is due to the pre-tipping point nature of our ecosystem and the sparseness of alternative opportunities for an executive if the job for which he/she originally relocated doesn't work out (which is common at this level of seniority). Without those alternatives, they won't relocate their families, so they don't come to Scotland.

Contributing further to this issue, such executives and engineers are expensive for the local market and most of our scale-ups struggle to meet compensation expectations.

Access to this talent and experience is absolutely necessary for our start-ups to continue to scale beyond a certain point. Of course, our local leaders can develop into such people. But, in general, they are currently too few to support the further scaling needs of our scale-ups. This will remain the case until our ecosystem passes its tipping point, at which point sufficient experience is generated by the ecosystem on its own, and external, experienced executives are spontaneously attracted to work within it.

In the meantime, the consequences of this constraint are that, beyond a certain level of scale, our scale-ups either stop growing or they open offices in London to attract executive talent. Those executives then start to hire around them. Within a few years, most of the job creation in the growing company is happening outside of Scotland. This pathology is not limited to Scotland, of course, and affects many of the smaller tech ecosystems.

Strategic Framework for Action – Later-stage Leadership, Engineering, etc.

Until the ecosystem tipping point is reached, novel solutions must be explored to mitigate this issue. We'll make corresponding proposals in the recommendations section of this review. These proposals are based on a strategy involving risk reduction to candidate executives and cost reduction for early-stage scale-ups.

Chapter 3 – Ecosystem Supporting Categories – Infrastructure

The technology ecosystem's second dependency is on Ecosystem Infrastructure. In this section, we'll first define what we mean by the term Ecosystem Infrastructure. We'll then examine each of the funnel stages and identify areas for improvement in this category. Finally, we'll outline an overall strategic approach for how our ecosystem infrastructure could be systematically improved in support of our ecosystem. In the final section of this document, we'll present consolidated recommendations resulting from this strategy, alongside those in the other supporting categories of the ecosystem (Education and Funding).

The Tech Ecosystem depends on Ecosystem Infrastructure
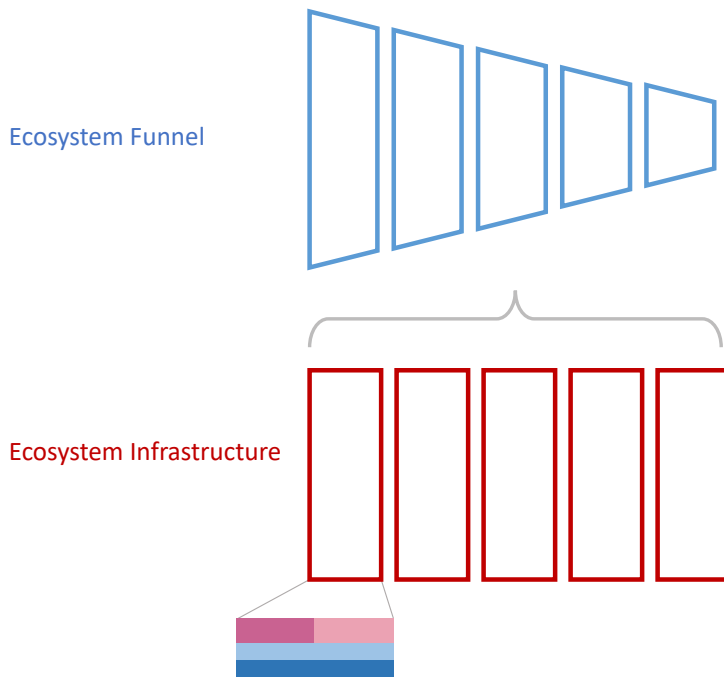
Definition of Ecosystem Infrastructure

Expanding the lower-left part of the above diagram, the ecosystem funnel depends on the following infrastructure being sufficiently available at each stage of the funnel:

Places where a company's staff can work together

Shared, extra-company environment for knowledge-exchange, networking, education

Staff Co-Location

Market-Square

Virtual

Physical

Services should be both physically and virtually available
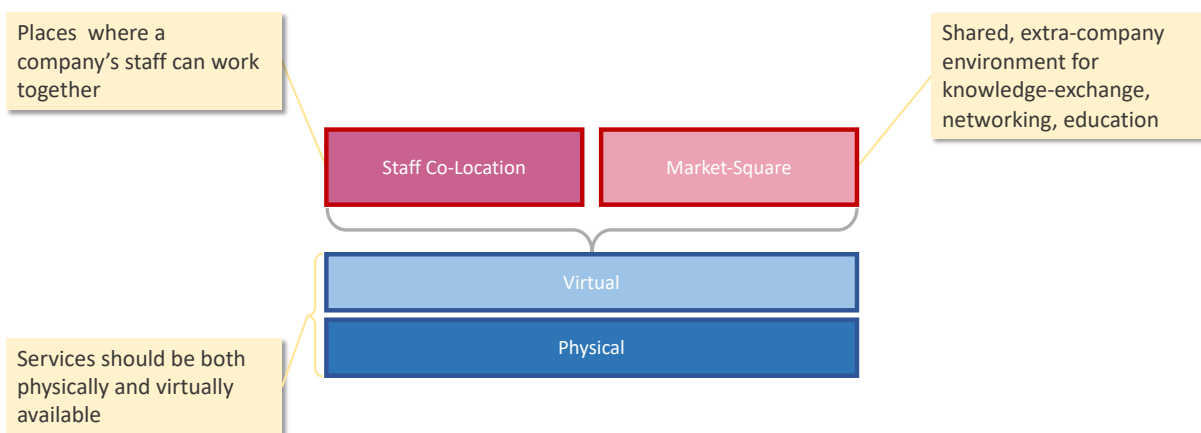
Infrastructure, in the ecosystem context, is often mistakenly thought of as only relating to *Co-location*; i.e. the (usually) physical offices and associated resources out of which start-ups can work. This is certainly an important component of the category. But the *Market square* category is equally important.

41

To define and to illustrate the importance of the latter category, consider this example: the Edinburgh tech start-up scene today exhibits the following desirable attributes to a reasonably evolved extent while the Glasgow start-up scene largely does not:

- A strong sense of identity and confidence. Start-ups believe that they can be successful in their chosen location and that there's a peer-support network around them.

- A well-known place where ecosystem participants can meet, attend talks, share ideas, be efficiently introduced to prospective companies and future employees and feel part of a thriving community.

- A place where investors can access multiple businesses easily. As we'll discuss further later, this is particularly important for venture firms outside Scotland. Relative to working with companies in London, where each prospective portfolio start-up is a short tube-ride away, there's considerable time involved for a VC in visiting Scottish start-ups. Having a single meeting point where investors can assess several interesting candidates in one visit is helpful.

What accounts for the difference between the cities? In the large part, organisations such as Codebase, Turing Fest and EIE/Informatics Ventures, all based in Edinburgh and which, along with several others, instantiate the above environment there to a much greater extent than is to be found in Glasgow.

It's germane here to note that an important component of the world's great renaissance cities in history was the market square where people with differing skills and experience could intermingle and share ideas. Large tech businesses understand this and create market squares within their own worksites towards the same end. They have the resources to extend those market squares outside of their companies (for example to connect with peers in the Silicon Valley). Earlier-stage businesses rely on others to provide them, for example, within incubators, at meet-ups, founder dinners and in conferences. A key ingredient in the success of the tech ecosystems in Finland and Israel is the degree of "connectedness" between their respective participants, promoted through a high level of networking mechanisms.

Each of these categories – co-location and market square – needs to exist in both **physical** and **virtual** forms. Even without the additional requirements placed on working arrangements brought about by COVID-19, being able to participate in both co-location and market square categories remotely from physical centres is important, for several reasons:

- Enabling businesses to hire from a larger talent pool.

- Balancing work and life more easily, which has the effect of bringing more skilled people into employment and retaining more of them. It is also likely to improve gender balance and diversity profiles within our start-ups.

- Opening access to expertise, education and community identity throughout all of the regions of Scotland. This is an essential component of making our ecosystem operate effectively in a COVID-19 world.

Physical interaction will continue to be important too. COVID-19's aftermath (whenever the day might arrive when we can safely talk about an aftermath) won't completely, or even largely, remove the requirement for some level of physical co-location. Therefore, affordable, low-friction access to these physical facilities will also continue to be essential.

Summarising the above, we can expand the core-services that need to be provided by the ecosystem infrastructure at each stage of the ecosystem funnel as follows:
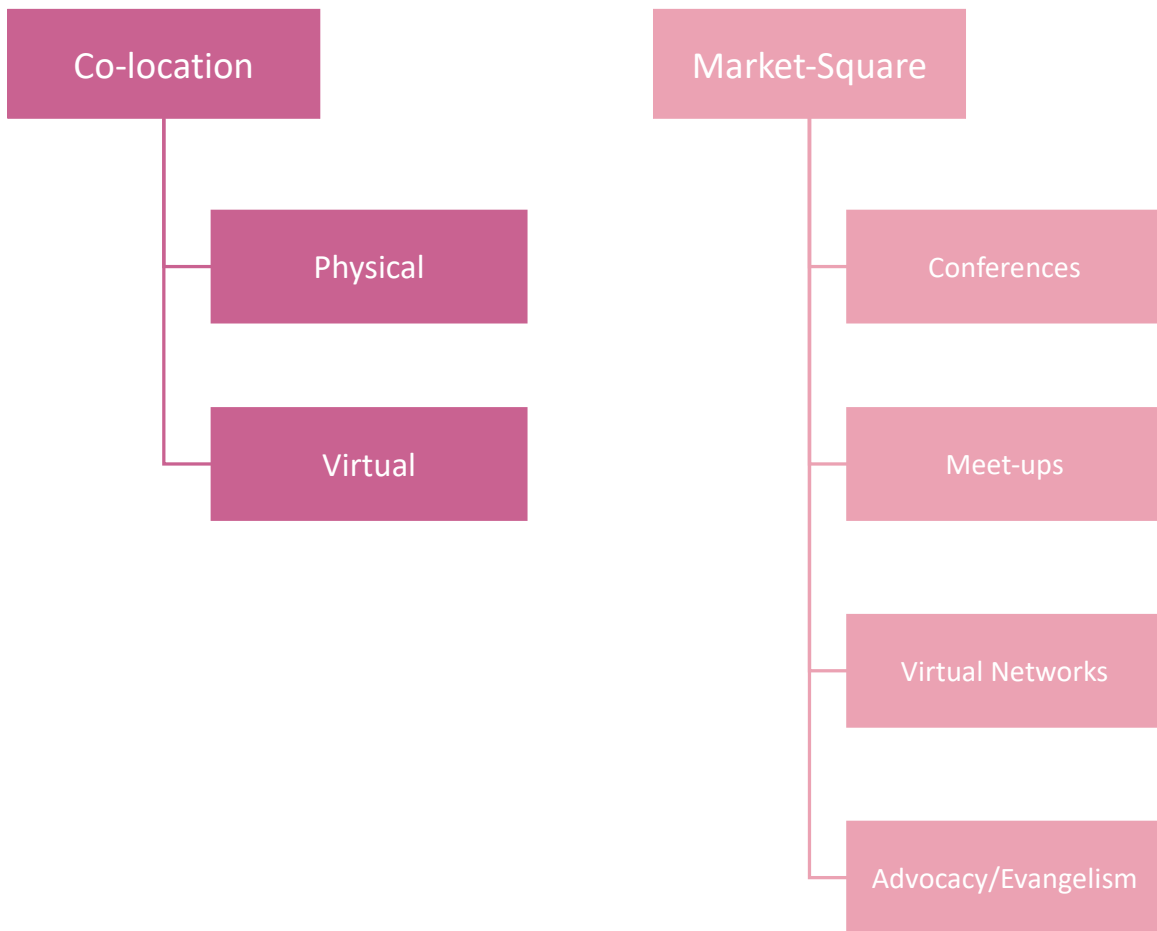
In our earlier analysis of the Education ecosystem-supporting category, we discussed how the third stage in the Education Funnel (educating our start-up leaders, etc.) is critically important and that Ecosystem Infrastructure is one of the platforms from which much of this education can be delivered, in both the formal sense and through more indirect, market square activities.
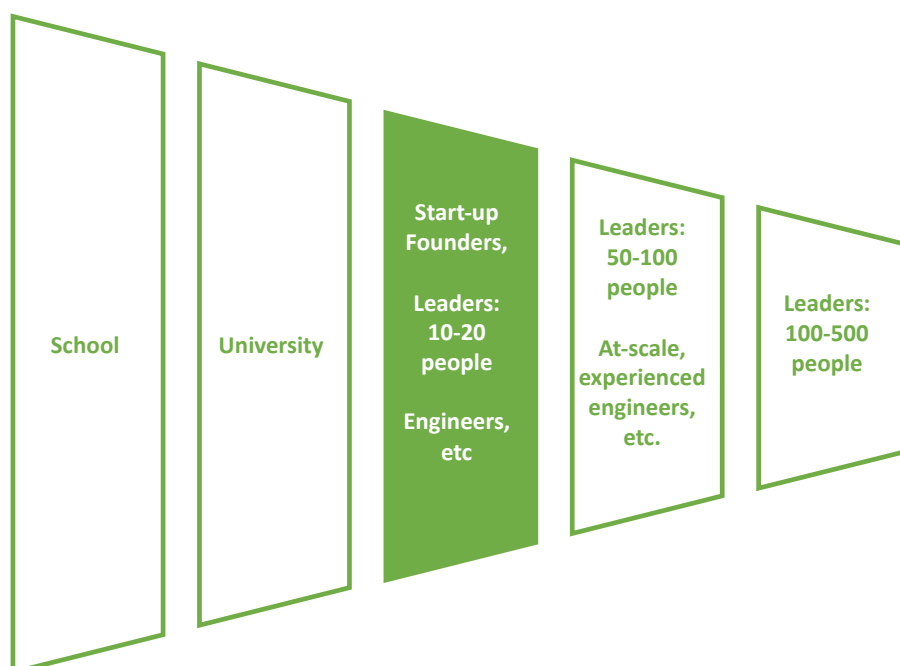
Therefore, it is a more complete depiction of our Ecosystem Infrastructure requirements to include reference to this element, for the purposes of our analysis that follows:

Co-location
- Physical
- Virtual

Market-Square
- Conferences
- Meet-ups
- Virtual Networks
- Advocacy/Evangelism

Education
- Start-up Leadership
- Technical
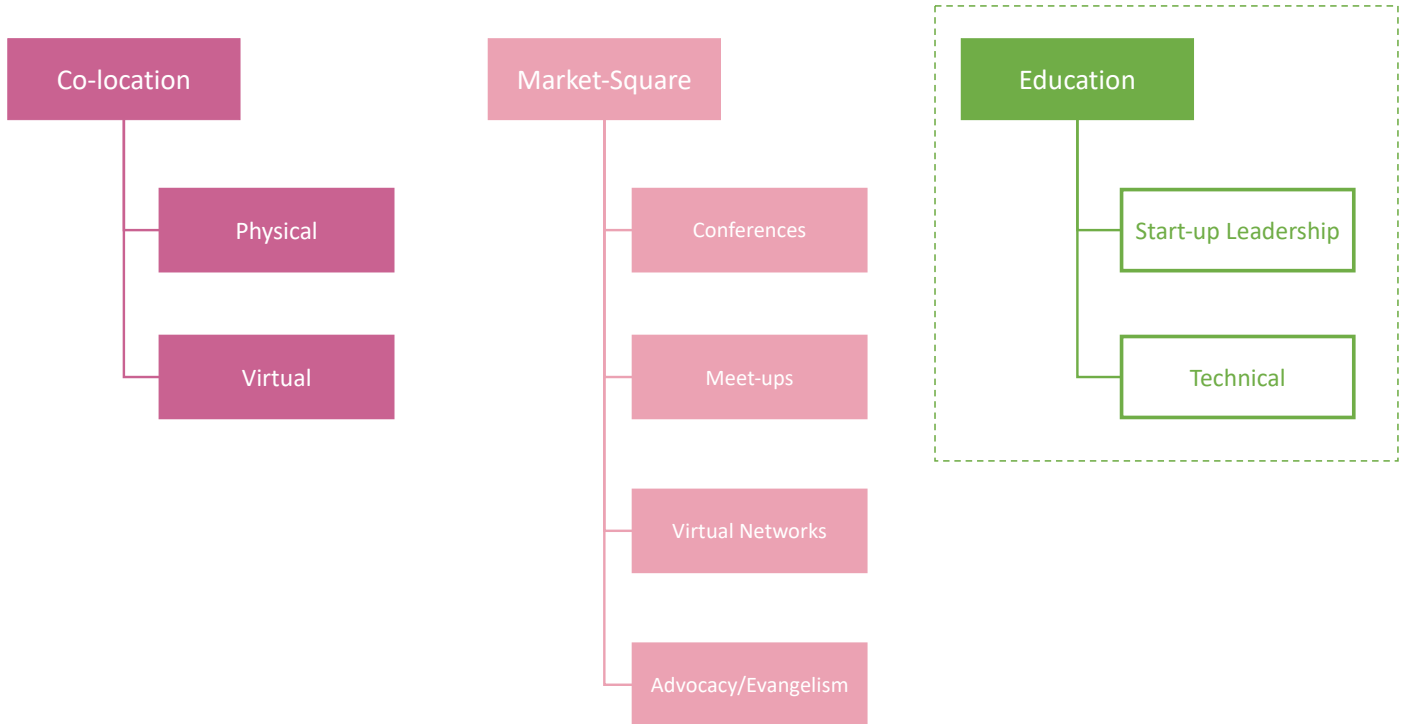
Analysis – Provision of Co-Location and Market square Infrastructure

The adequacy of provision of the Co-Location and Market square infrastructure components varies by funnel stage:
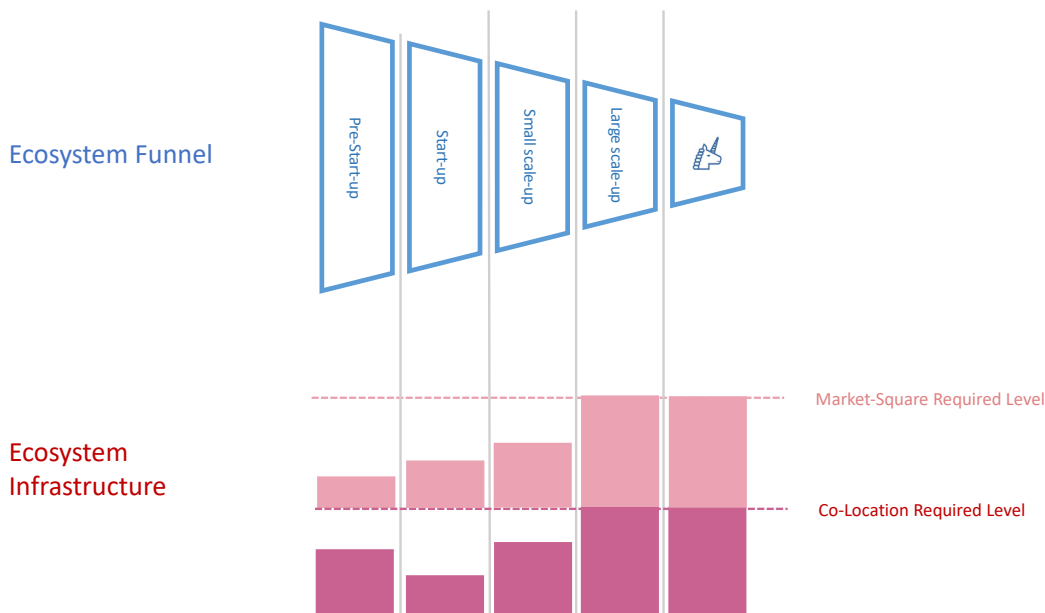
Later funnel stages (large-scale up and beyond) are increasingly capable of meeting their own needs from their own resources as we move from left to right through the funnel. Co-location and access to the market square become easier as a company scales – it has more resources, including financial, to secure that access.

The exception to these general trends is *co-location* at the *pre start-up* stage – it's easier for a two-person business to find shareable working spaces – a spare room in a house will do (though this is not ideal, of course, and does not grant access to a market square). The task then immediately gets more difficult as the start-up progresses beyond this minimal scale, before aligning to the general trend described above.

In view of the above trends, our analysis will focus on addressing the general infrastructure shortfall in the earlier funnel stages. To perform that analysis, let's first map out the ecosystem participant types that fulfil these infrastructure services in Scotland today. There is often confusion as to the differences between participant types in the Ecosystem Infrastructure. For example, the terms incubator and accelerator are often conflated.

In our analysis of our provision of Ecosystem Infrastructure that follows, we'll use the following model, for clarity. As we will see, these definitions are helpful in identifying areas of under-provision.

Participant Type	Co-location	Typical Size	Market square Activities	Education
Incubator	Long-term	Medium to Large	Yes, medium to large	No
Accelerator	Short-term	Small	Yes, small	Yes
Temporary Market squares (Meet-ups, Conferences)	No	Small to Large	Temporary, Regular	Yes

We now explore existing issues and areas for improvement in our Ecosystem Infrastructure, using the above table of participant types as well as other considerations for context.

Insufficient Incubation Capacity

At first glance, it appears that Scotland is well served by infrastructure participants. Across Scotland, a simple search will return over 50 accelerators, incubators and innovation centres providing a mix of co-location, market square and education services. But, when we apply the above definitions, we find that important areas of under-provision emerge. Our analysis finds that, supporting the tech ecosystem in Scotland, there are:

- 13 Accelerators,

- 8 University Incubators, and

- 3 Non-University Technology Incubators.

Accelerators are very valuable to the ecosystem because of the concentrated founder education that they provide. But tenure for start-ups admitted to accelerators is relatively short, ranging from a few weeks to a few months. At the end of an accelerator programme, the start-up loses both its co-location and its market square. The number of simultaneous businesses resident within accelerators is typically small, which means that the market square within them is small too, and somewhat homogenous (the start-ups are the same size, with consequently limited scope for cross-learning). This is why genuine incubators are very important to the ecosystem – start-ups need a semi-permanent place to locate, until increased scale eventually takes them to their own premises. And they benefit from a larger, heterogeneous market square, which a scaled incubator can provide.

University incubators are generally very small and restricted to current or recent students, and staff. Though undoubtedly valuable in the context of their specific remit, they can't be considered as a general solution to incubation.

Of the three *general* tech incubators, only Codebase in Edinburgh has achieved relative scale and relative success (it also has a growing presence in Aberdeen and Stirling, none in Glasgow or elsewhere). However, prior to COVID-19, the incubator was essentially full, and turning away viable start-ups that would otherwise have passed its curation assessment process.

This general lack of semi-permanent incubation infrastructure must be addressed by our ecosystem strategy. Later in this section, we'll examine some of the reasons for the lack of incubation space in the ecosystem. But first, let's examine the other important dimension as regards incubation, namely alignment of our existing *incubation services* to what's required in the ecosystem if it is to perform better.

Provision of Incubation Services

The second dimension to incubation is the breadth and quality of the provision of required services that incubators provide. With the emphasis placed on founder education in this review, we believe that the ideal incubator model would be one in which incubators provide long-term co-location and market square services, including virtual access, *and* provide a platform for on-going formal start-up education, or low-cost access to it. How do our current incubators compare to this standard?

As the most evolved example, we'll use Codebase Edinburgh as the basis of this comparison.

Co-location
Very Good. A wide range of low-cost accommodation sizes and associated meeting space, with flexible leasing. On-going tenancy is subject to two criteria:

- On-going curation – i.e. does the start-up still meet or exceed the original selection criteria. This ensures that the available space is directed to the most promising businesses and also ensures that the market square aspects of the incubator maintain a relatively high quality.

- Size – eventually scaling businesses must relocate, to make way for new start-ups. Otherwise, subject to the point above, they have indefinite tenure.

Traditional property models are not well suited to start-ups, with high costs due to start-ups' lack of covenant strength and long lease terms. Larger incubators like Codebase provide a bridge for start-ups due to their own scale, where costs can be reduced by leveraging stronger covenants (especially when partly state-funded). Incubators also significantly benefit start-ups in accessing affordable, high-speed internet connections, where economies of scale again come into play.

Codebase hosts businesses of varying sizes, from 1-2 person start-ups to those with up to 80 employees. This has the considerable advantage that earlier-stage businesses can learn from later-stage businesses. In other words, the market square is much enriched by this mix. Contrast this situation with the more prevalent approach in many incubators and accelerators, where all of the tenants are at exactly the same stage, and where the market square's value is correspondingly reduced.

The physical building in which Codebase is housed is, however, tired and not well laid-out for incubation. In a more adapted building, Codebase would score more highly in this category.

Scale (within Edinburgh)
Very Good, but full. Prior to COVID-19, the incubator was full and having to turn away clients that would otherwise have passed the entrance criteria. At that point, Codebase housed over 80 start-ups of sizes ranging from two to 80 staff. Although COVID-19 will cause several start-ups to leave Codebase, we should assess this point on a longer timeframe – i.e. it is likely that Codebase will become full again quite quickly.

Scale (Scotland-wide)
Good but could be improved. For example, Codebase has no presence in Scotland's largest city.

On a separate point in this category, the organisation, which itself is a start-up, also needs to continue to evolve its corporate governance and leadership model, in order to support further scaling, as with any other start-up moving through levels of scale.

Market square activities
Very Good. Codebase has become regarded by the tech community as the heart of Edinburgh's tech scene. There are regular meet-ups, presentations and networking events held there. Many of Edinburgh's meet-ups have gravitated towards the location. Codebase has created an atmosphere and "vibe" where start-ups want to be. This is important – if the start-up community embraces a location's style and atmosphere, it is far more likely to attract the most promising start-ups. Credit should be given to the Codebase team for achieving this status, even within a non-ideal physical space – the Codebase building isn't physically well-suited to collaboration and accidental conversations between start-ups. Although earlier in their lifespans, ONE Codebase in Aberdeen (a partnership between the excellent ONE programme and Codebase) and Codebase Stirling are also rapidly moving towards this status locally, albeit at a smaller scale, currently.

Education
Lacking. Although Codebase provides founder education services, most of these are not directed towards tenants. The reason for this is that the organisation has been forced to earn money through the provision of corporate education outside of Scotland in order to mitigate the low rents it charges (and needs to charge) to tenants.

Virtual/Remote-Access
Lacking. Codebase is configured towards in-person attendance. Meeting spaces tend to be poorly equipped for remote participation relative to best practice while, events, meet-ups, etc. tend not to be live-streamed or virtually accessible/and or recording equipment is relatively poor.

So, in summary of the above, two points emerge: firstly, the success rate of start-ups such as those in the Codebase incubator could be improved through access to best practice education services and more suitable facilities, were the money and will available to provide them. Secondly, Scotland's general tech incubator provision is small and inconsistently available across our major population centres.

This raises the question: is the size of the ecosystem (in terms of participants) restraining the scale of the infrastructure, or is the scale of the infrastructure restraining the size of the ecosystem? Given that Codebase regularly must turn away credible start-ups and has no presence in Glasgow, Scotland's largest city, we argue that the latter is the case. If this is indeed the case, then what is the constraint on increasing the size of this vital component of ecosystem infrastructure? We'll explore this point in detail next.

Barriers to Scaling Ecosystem Infrastructure – Pre-Tipping point state of Ecosystem

A general barrier to scaling Scotland's incubator infrastructure is the pre-tipping point state of the ecosystem. To be clear, this barrier can be surmounted. But to do so, we must understand its nature and adjust our interventions accordingly.

To illustrate the significance of this pre-tipping point state to the funding of our incubators and accelerators, let's compare Codebase, Scotland's most successful incubator with Silicon Valley's famous Y-Combinator accelerator. Y-Combinator funds itself by taking a large (7%) stake in every tenant start-up in return for its services and $150k in funding. Why can't Codebase and others in Scotland do the same?

Y-Combinator was started in 2005, born into an already very mature ecosystem. The ratios of companies growing to scale versus those that don't is far more favourable than in Scotland, a pre-tipping point ecosystem. Its curation process yields a set of businesses with a relatively high likelihood of success, and much higher than in Scotland. Therefore, Y-Combinator can rely on a relatively predictable revenue stream.

In Scotland's pre-tipping point ecosystem, on the other hand, there is a much longer and far more uncertain period between an equity stake being placed and a return being generated, and the returns are fewer in number. And because Codebase doesn't manage a fund, the equity stake taken in its tenant start-ups must be correspondingly smaller. Provided Codebase is extremely careful in how it manages its costs, this could work. But it certainly isn't a recipe for scaling incubation space to meet demand, in the pre-tipping point state.

Therefore, Codebase relies on two main funding sources outside of grant support. The first is rent from tenant start-ups. In return for a necessarily relatively low rent (the tenant start-ups have little money, remember), Codebase returns physical co-location and various market square benefits. If the start-up becomes successful, the early value contributed by Codebase is accounted for outside of Codebase, and none of that value is returned to Codebase. During the journey to scale, the start-up will leave Codebase to seek larger, more permanent business premises. Therefore, Codebase only ever receives revenue from early stage companies that can't afford to pay much towards their rent. This places a considerable limit on its scale, which is exacerbated by the high-failure rate that start-ups inevitably experience.

Therefore, it is difficult for Codebase to invest in expansion beyond that supportable by those tenant rents. The organisation barely breaks even (and the COVID-19 situation has made even this modest goal very challenging).

This reality has caused Codebase to put a considerable amount of its time and energy into paid training activities in London and elsewhere, which bring little benefit to its Edinburgh, Aberdeen or Stirling-based tenants. In a system with better overall alignment to ecosystem goals, Codebase could focus that energy on its Scottish start-up tenants, which is very much in the spirit of this review.

Only where Codebase has been partly supported by public or private (in the case of ONE) funding has it been able to provide services to cities in our pre-tipping point ecosystem. But overall, provision of this kind of funding is ad-hoc, sporadic and does not currently follow a country-based strategy. This brings us to our second barrier to scaling incubation space…

Barriers to Scaling Ecosystem Infrastructure – Funding misalignment to Ecosystem goals

The primary purpose of Ecosystem Infrastructure is to create value for start-ups within the Ecosystem. This value manifests months or years after the initial investment in the ecosystem is made, and manifests within the companies supported by the infrastructure rather than in the infrastructure itself.

This presents difficulties for public funding bodies seeking to justify support for infrastructure ecosystem partners. For example, it is certainly convenient for a funding organisation to assess an incubator like Codebase on direct P&L terms (the inner circle below) rather than on the value delivered to the ecosystem) outer circle. But to do so is to entirely disregard the value created by the incubator.

Value delivered to Ecosystem

Directly profitable over a business cycle?
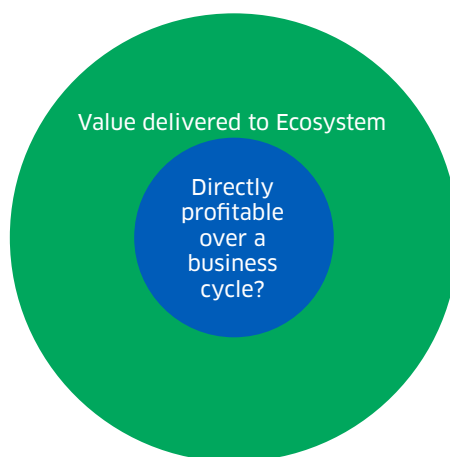
Another approach is to assess the incubator on the basis of *deal-flow.* Here the argument is that the incubator should be funded according to the general rate of investible start-ups that it produces – i.e. success funding further success. But, as we have discussed above, in a pre-tipping point ecosystem, this deal-flow is somewhat sparse. It will strengthen as the ecosystem approaches its tipping point but, in the meantime, deal-flow is a problematic way of assessing funding support (by contrast, on the other side of the tipping point, public funding support for incubators could be reduced or even withdrawn over time as deal-flow becomes sufficient to sustain the incubator).

Such is the infliction of an incubator in a pre-tipping point ecosystem. It can't fund its own way to scale through rent and it struggles to receive grant funding because the funding process doesn't easily recognise the value created by Codebase within the ecosystem at large. It is, perhaps, the archetypal example of the essential need to embrace the differences between local and global optimisation of the ecosystem, if we are to make progress.

Barriers to Scaling Ecosystem Infrastructure – Analogous Issues for Conferences, Meet-ups

Recalling our identification of ecosystem infrastructure participants from above, we identified a third category, after Incubators and Accelerators, which we have named *Temporary Market squares,* for the purpose of this analysis. These are organisations which provide temporary market square services at a given frequency rather than operating a physical market square. Larger examples in Scotland include Turing Fest's conferences and founder-dinners, DataLab's[24] DataFest, ScotlandIS' Scotsoft[25] and FutureX's Start-up Summit[26]. Smaller examples are the more than 200 regular meet-ups that take place in Scotland.

Participant Type	Co-location	Typical Size	Market square Activities	Education
Incubator	Long-term	Medium to Large	Yes, medium to large	No
Accelerator	Short-term	Small	Yes, small	Yes
Temporary Market squares (Meet-ups, Conferences)	No	Small to Large	Temporary, Regular	Yes

We can generalise the funding misalignment issues discussed earlier across to the market square actors in our ecosystem. Let's take the example of Turing Fest which is arguably our most successful international start-up/technology conference, and the only one focussed purely on technology start-ups. Turing Fest also runs an investment conference and regular founder education sessions. The organisation has considerable ambition to develop Scotland as an international market square along the lines of Finland's model, to which talent and teaching expertise is attracted. If we were to consider the simple P/L statement of the organisation, we'd see that it essentially just about breaks-even. We'd perhaps question whether any investment in the organisation is wise.

But if we give proper consideration to its external, market square value creation, the situation would look different. For example, at the Turing Fest conference, 800 attendees interact with each other and are both peer-educated and expert-educated. Networks are formed which provide on-going learning and shared experience. Start-ups find employees, and people find jobs. Overall, considerable value is returned to the wider ecosystem. As a reference point here, one of the key focal areas of Finland's approach has been to use similar mechanisms for both stimulation of peer-networks within the tech community and to present Finland as a credible global destination for technology and start-ups.

Assessing our "temporary market square providers" through a P/L lens rather than with respect to value returned to the overall ecosystem has a number of consequences for organisations such as Turing Fest. The first is that conference ticket prices tend to be beyond the reach of many start-ups. The second is that it is difficult to attract enough of the best international educators to our conferences. Such speakers usually expect to be compensated. Therefore, too high a proportion of the educators are inexperienced, local start-up founders and executives. In effect, the blind are leading the blind.

At the other end of the scale from Codebase and Turing Fest are the dozens of tech meet-ups that regularly take place throughout Scotland, organised by volunteers and paid for by those same volunteers, or through occasional sponsorship. There are over 200 meet-ups of which we are aware. Their frequency and volume of attendance is limited by their ability to find and pay for premises in which to hold those meet-ups. But their educational value, in aggregate, is immense. They don't suffer the same risk of parochialism that leadership-oriented conferences do because they are more technical in nature, and those skills are far more available in Scotland than start-up leadership skills.

---

24 DataLab also provides other services, of course, in its role as an Innovation Centre.
25 A general tech conference not specifically focussed on tech start-ups but includes relevant content.
26 Not solely a tech summit, but with a high degree of tech start-up content

A greater provision of physical market squares for our meet-ups (through an expanded incubation capacity), complemented by excellent remote-access facilities, would significantly increase the reach and participation in these events.

The preceding discussion asserts that traditional funding assessment mechanisms are not well-suited to measuring the value that ecosystem infrastructure provides and that this mismatch risks strangling our ecosystem through inadequate support for pre-tipping point ecosystem infrastructure. We also discussed that the reason for this mismatch is that the value generated by ecosystem infrastructure is always manifested outside of this infrastructure and months, or even years, later.

This, of course, raises the question as to how a more appropriate assessment mechanism should work, and which organisations would be within its scope? There are various ways in which this question could be answered. In the recommendations section of this document we will propose one such approach. But we recognise that other good options also exist.

We now examine further areas in our provision of ecosystem infrastructure that should be improved.

Market square and Education focus is generally too parochial

As we touched-upon above, and in our analysis of Education provision, it is extremely important that a pre-tipping point ecosystem educates itself from sources that include those outside the ecosystem. This is because the ecosystem participants, prior to the ecosystem's tipping-point being reached, do not possess enough exposure in sufficient volume to world-class, best practice start-up methodologies at the various levels of scale that growth brings. When participants in an ecosystem only learn from each other, a relatively low ceiling is placed on expertise within that ecosystem. Scotland needs to regularly escape these "local-optima" if it is to bring its tech companies consistently to global best practice.

This consideration extends also to market square provision. A permanent, physical market square – such as is to be found in an incubator like Codebase – tends towards peer-to-peer education because of the interaction between start-up tenants. This still has significant value, of course, but it *must* be complemented by a healthy dose of external participation and input. Conferences (our temporary market squares) such as Turing Fest, Start-up Summit, Scotsoft and DataFest are also particularly well-placed to act as a platform for external participation.

Overall, today in Scotland's ecosystem, there is too little external participation in our market squares. The ability of our conferences to attract external speakers is financially limited and, compared to, for example Ireland, we make limited use of our international diaspora, nor do we have a clear country-level strategy to develop it.

We note, in this regard, Turing Fest's ambition to take its brand and formula world-wide in order to create a network of international conferences, configured in such a way as to place Scotland at the centre of that network. This is modelled on the successful Slush model in Finland, which brings expertise and talent (both on a temporary and permanent basis) to the country. It would seem that, as part of our consideration of this category, we should reconsider funding such an initiative on an exploratory basis. We'll return to this topic in our recommendations section.

Size of Scotland's start-up-savvy population, and relationship to infrastructure

Scotland's start-up-savvy population size is small and this acts to constrain start-ups as they attempt to scale. This state of affairs is not *directly* brought about by ecosystem infrastructure issues, of course. But, as we will shortly examine, our ecosystem infrastructure strategy has a significant impact on the effective size of this population in practice.

Our ecosystem infrastructure strategy should act to maximise the size of the indigenous tech start-up-savvy population available to our businesses whilst other initiatives act to encourage talent to come to Scotland. In this regard, and additional to questions of education covered elsewhere in this document, there are a number of current barriers to maximising this population size that we should address. These are covered in the next three points below.

Population Constraints – Lack of virtual/remote participation in market squares

We have touched upon this point earlier, but it is such an important area that it merits its own category. Today most of Scotland's conferences are not live-streamed and our meet-ups, founder-dinners and similar events require in-person attendance. Our incubators are designed for in-person participation only. This limits the participation of regional start-up founders and caps the number of attendees generally. COVID-19 is forcing us to reconsider prior norms in this area. We believe that there is a significant opportunity to capitalise on our cultural re-baselining in this area.

For example, if our physical market squares were enabled with frictionless, high-quality virtual/remote-attendance facilities, and if our meet-ups took place within them, we could dramatically increase their reach and conference attendance figures. Conferences worldwide that have been virtualised during the COVID-19 crisis have found that attendances of up to ten times the normal rate are possible.

Population Constraints – One-city versus multi-city strategy

In the past, policymakers have debated whether to concentrate Scotland's high-tech start-up sector – along with any support provided – in one city (Edinburgh) or whether instead to take a more country-wide approach. The former approach has tended to hold sway over time.

There are many considerations in respect of this point, but our summary view is that concentrating efforts on one city only is detrimental to the performance of the overall ecosystem, including to the city in which efforts are to be concentrated.

As stated above, Scotland's start-up-savvy population size is small and this acts to constrain start-ups as they attempt to scale. This effect is accelerated when more businesses start to become successful, in line with improvements to the ecosystem. In effect, they will fight over the same employees within a limited hiring radius. In a post-Brexit UK, where the availability of European talent will be much reduced, the problem is already set to worsen. In this context, the larger the general start-up-savvy population across the country is, the better. Therefore, our strategy should be to be region-wide to the greatest extent possible.

Population Constraints – Cost of travel in Scotland severely constrains hiring radius for start-ups

A distinct but related further consideration is the ability to easily and/or affordably travel between city locations. For example, the cost of rail travel between Edinburgh and Glasgow – our two most populated cities – is among the most expensive rail journeys per mile in Europe, with the cheapest fare option costing approximately £4200 per annum, at the time of writing. This effectively disqualifies many people living in one of our two largest cities from working in businesses located in the other. Or it requires start-ups to open offices in both cities if they wish to hire across the central belt, which in itself is prohibitively expensive.
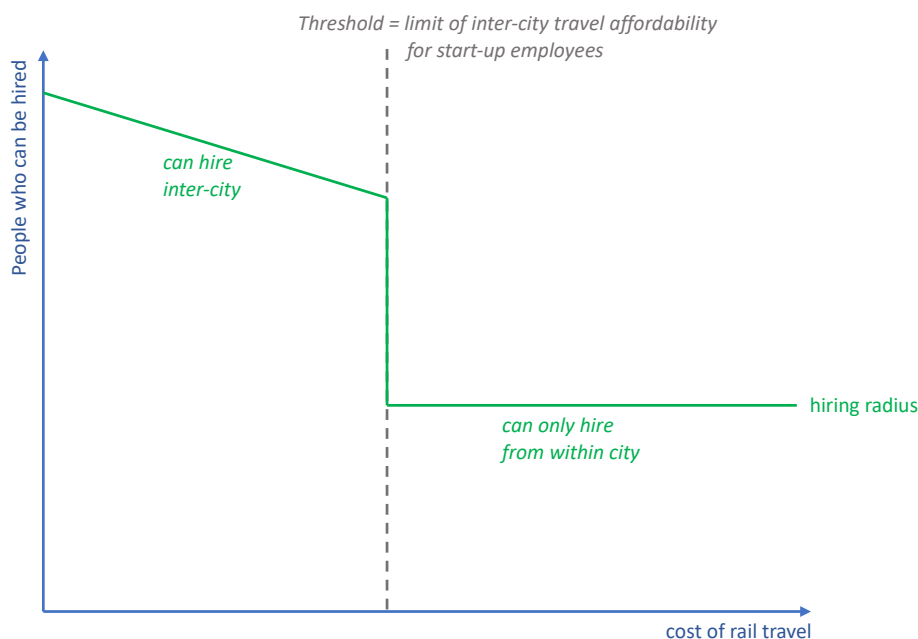
The effect of the cost of travel, once it rises above a certain threshold, is to constrain start-ups' ability to hire to a relatively small radius around their home city (the relationship between travel-cost and hiring radius is not linear because the population is not evenly distributed across the country). Below that travel cost threshold, the hiring radius is much larger because the start-up can attract people living in other cities.

In a small country like ours, with a relatively small population, it is highly desirable to understand where that cost threshold asserts itself, and to intervene on inter-city travel costs accordingly. This is another example of an intervention that might be difficult to achieve when considered in isolation but that will have significant positive effects on the overall output of the tech ecosystem (and, indeed, other business ecosystems).

Lack of direct US flights constrains participation of US venture capital firms, expert speakers

Venture capital (VC) firms operate on high-ratios – for every investment made, a VC will consider literally hundreds of potential candidates. For this to work, the minimisation of friction from this sifting process is extremely important. Where greater friction exists, VCs will avoid working in those areas. In the case of attracting investors from the US and, in particular, Silicon Valley, there are virtually no direct-flight options to Scotland. The same applies to attracting, for example, expert Silicon Valley speakers. We shouldn't under-estimate the impact this has on our ability to attract Silicon Valley investor interest and Silicon Valley-based speakers and educators, where a very high value is placed on time, in each case. In so saying, we do recognise that assessing this particular point in the context of the global climate crisis and in the age of COVID-19 is not straightforward.

Infrastructure – Strategic Framework for Improvement

From a review of the above issues, we can determine elements that an ecosystem infrastructure strategy must possess. In the Recommendations section of this report, we'll convert these elements into a set of specific recommendations, alongside those suggested by our analysis of the Education and Funding category analyses.

We consider the elements of that strategy to be as follows:

- There is a gap between the services provided by our incubators and accelerators today and the required level of service provision if the ecosystem is to thrive, for example with regard to start-up team education services (both market square based and formal), remote participation and presence in major cities. Our strategy should address closing this gap.

- Our ecosystem would benefit greatly from the creation of a new type of entity, which we'll term here a "Tech-Scaler". This is based on the core capabilities of incubators but extends these to include the education services provided by accelerators and then extends them further to include intensive formal education in *Internet Economy* skillsets. Access to all services, including all education and market square activities, is seamlessly provided in virtual as well as physical formats.

- We should act to increase Tech-Scaler capacity. Coverage should include more of our major cities. The provision of any public funding in support of this imperative should take into account two points. The first is the pre-tipping point nature of the ecosystem, the second is that most of the value provided by existing incubators to start-ups is eventually realised outside of the incubator and outside of typically applied assessment timeframes. A new treatment is required that ensures responsible investment in this national resource whilst taking account of these points.

- Provision of education services delivered using Tech-Scalers as a platform should not be parochial but should instead be based on the best available international training resources, to ensure that global best practice is inculcated into our start-ups.

- Similarly, the strategy should recognise the considerable value provided to the ecosystem by other market square providers, both large and small. Again, a gap exists between current and required levels of service provision, in the case of the top-tier providers. The strategy should operate to incentivise and support increasing the quality, level of internationalism and the affordability of the market square services that they provide. And, in regard to the internationalisation of our approach, a specific strategy should also be developed on the exploitation of Scotland's diaspora.

- The strategy should work to maximise the start-up-savvy talent pool available to Scottish start-ups. For example, it should not concentrate on one city and should also endeavour to make travel between our cities as affordable as possible. And it should attempt to attract international talent to Scotland to the maximum extent possible within policy constraints.

Chapter 4 – Ecosystem Supporting Categories – Funding

The technology ecosystem's third dependency is on Funding. As with the other supporting categories, we'll first define the scope and state of the category as it currently operates in support of our tech ecosystem and then identify areas for improvement. In the final major section of this document, we'll present consolidated recommendations alongside those in the other supporting categories of the ecosystem (Education and Infrastructure) to address those deficiencies identified.

The Tech Ecosystem depends on the Funding System
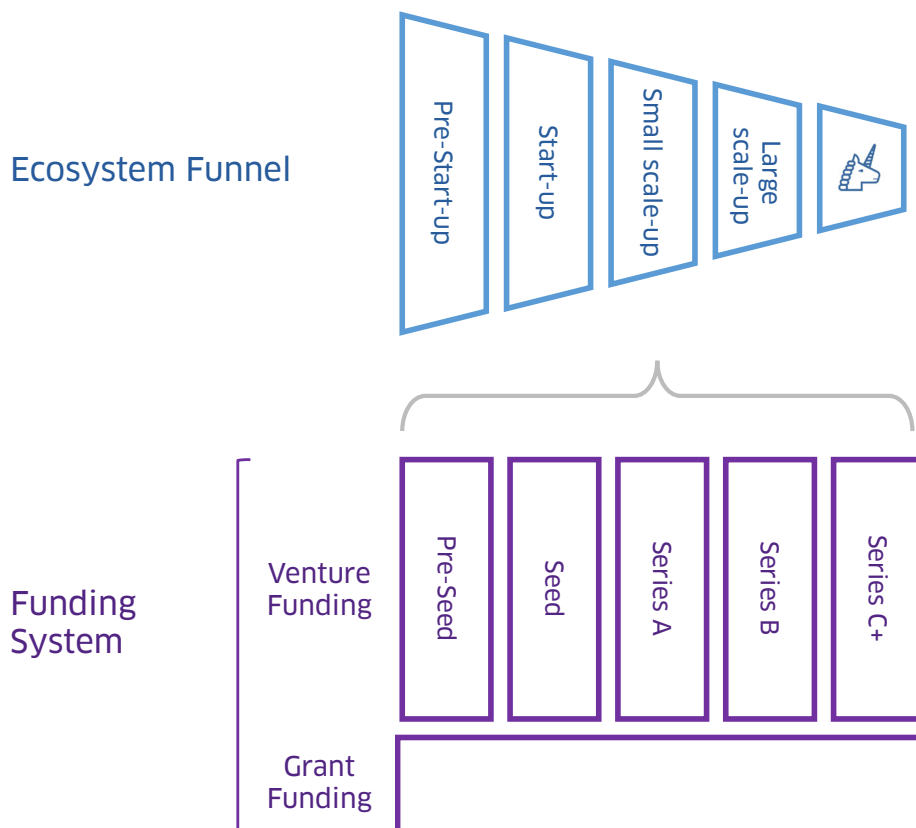
Definition and Context for Ecosystem Funding

There are two main components to the Funding category within the scope of this review. The first is Venture Funding, which proceeds, approximately, through the stages shown above, in line with the growth of a start-up. The second is grant-based funding.[27] We now examine each of these in turn.

Venture Funding

Scotland's existing investment framework can boast several assets. It's angel investor networks and syndicates rank amongst the world's most developed. The country also operates two separate, publicly funded investment/co-investment vehicles through Scottish Enterprise's Scottish Investment Bank (SIB) and Techstart, part of the Scottish Growth Scheme.

Nevertheless, the ecosystem still exhibits problems in supporting start-ups from a funding perspective. We'll now examine these and their causes, before developing a strategy to address them.

---

27   The third category is debt, including venture debt, which we have considered to be outside the scope of this review.

We previously introduced the concept of a "tipping point" in technology ecosystems, when the ecosystem reaches a certain number of well-run, non-frivolous start-ups and later stage companies, and virtuous network effects begin to kick-in. These network effects strengthen the performance of businesses within the ecosystem and attract both external talent and investor interest. In effect, after that tipping point, the ecosystem essentially "takes care of itself", requiring little intervention to support it. In contrast, a pre-tipping point ecosystem struggles to overcome "funnel-collapse"; it is characterised by a relatively large number of very early-stage start-ups, with few making it through to later stages of scale.

A contributing factor to funnel collapse is funding starvation at key stages of the pipeline. Therefore a pre-tipping point ecosystem can be accelerated towards its tipping point with the application of appropriate interventions in these areas, in conjunction with others in Education and Infrastructure.

As we explored earlier, Scotland's technology ecosystem is still pre-tipping point. Therefore, our ecosystem funding strategy should be concerned with interventions that take the ecosystem towards and then past the tipping point. These interventions should then be carefully tapered-down, to avoid impairing the health of the ecosystem through inadvertently establishing a "dependency culture" that suppresses the development of a vibrant private venture capital environment.

We can summarise the difference between the pre-tipping point and post-tipping point states of an ecosystem as follows:

Pre-tipping Point	Post-tipping Point
• Mostly "angel" capital	• Mostly VC capital
• Small investments	• Small to very large investments
• Poor discoverability of prospects	• High discoverability of prospects
• Higher friction for investors	• Lower friction for investors
• Low pitching expertise among founders	• Higher pitching expertise among founders
• High-level of government funding	• Low-level of government funding

With the above context in place, we now examine each stage of Scotland's investment funnel, identifying areas where interventions and adjustments are required.

Venture Funding – Stage Analysis

Relative to need and accessibility, the funding landscape in the Scottish Tech Ecosystem consequently operates as shown below. Similar to the case with ecosystem infrastructure, the under-provision of funding in the ecosystem is concentrated in the earlier stages of the pipeline.
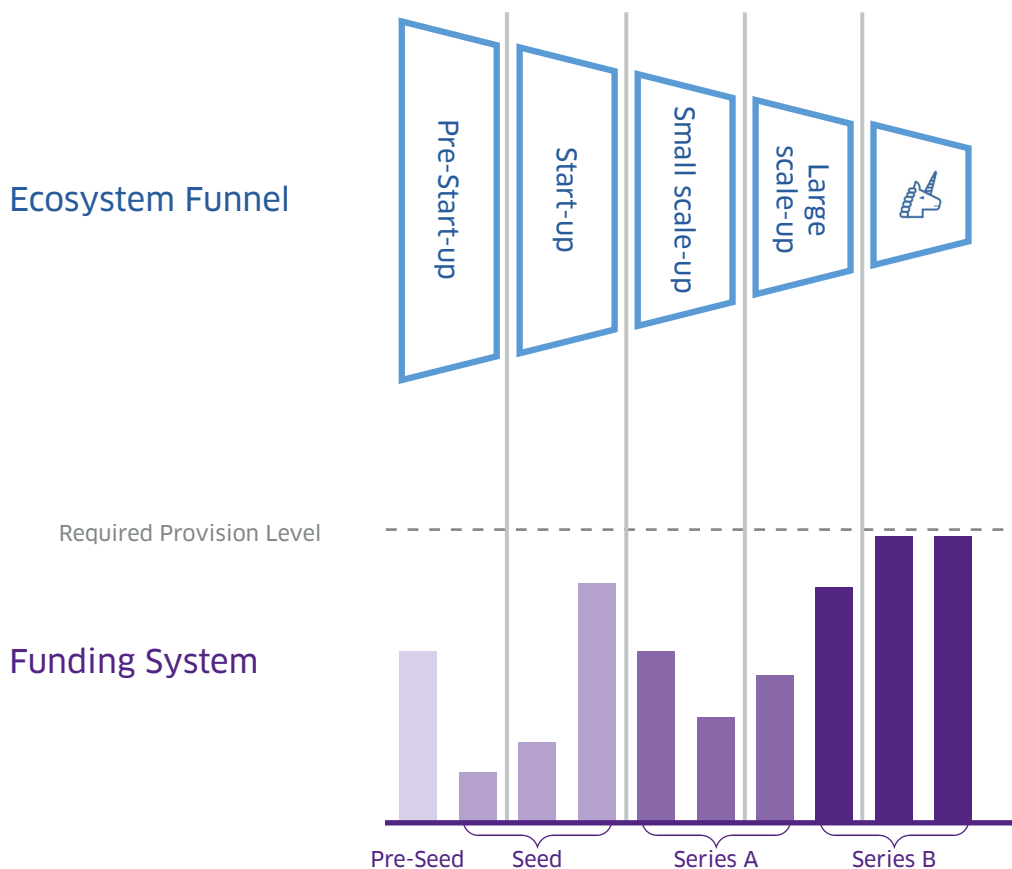
Pre-Seed Stage

The very earliest-stage start-ups have very low operating costs and typically fund themselves by traditional means (founders, friends-and-family, the occasional angel investor, etc.). In this respect, Scotland's tech ecosystem is not particularly worse-off than any other. It could be argued that this funding mechanism locks out potential founders from more disadvantaged backgrounds. However, in these very early stages of a start-up, it remains a difficult problem to attract other sources of funding to an unproven founder with a non-demonstrable idea, even if there are more investors in the ecosystem.

Seed Stage

As start-ups move beyond the pre-seed stage, funding in the early seed stages immediately becomes relatively difficult to obtain before becoming easier in the later seed stages. The main reason for this is that seed funding is largely provided in Scotland through angel investors. Increasingly, angels are operating in syndicates, which tend to prefer larger investment quanta (and, therefore, later-stage start-ups) for reasons of efficiency. There are many benefits to so doing, but it does mean that early stage seed requirements must be met largely by a smaller group of remaining individual angels (with additional support provided by government). There is a "discoverability problem" between the start-ups and individual angel investors – it's difficult for individuals to have full visibility of investible seed-stage start-ups. Our strategy must therefore include measures to address such issues encountered at this stage of the investment pipeline.

Series A Stage

As start-ups begin to scale, the environment again becomes more difficult. Scotland's ecosystem is dominated by angels and angel-syndicates, complemented by government investment through SIB and Techstart. As part of a well-balanced investment landscape, such angel activity is of course a key and welcome ingredient. But when angel investment dominates the mix of investment types, it results in a relatively low upper limit on the capital that can locally be invested in a given business relative to a post-tipping point ecosystem. Angel investors are also typically unable to support the further growth needs of businesses beyond the start-up stage. Syndicates have more reach, but the same general limit problem still applies.

So, at this point, it's desirable to be able to hand the investment baton to larger VC funds. But here we encounter problems:

- There aren't enough VC firms in Scotland. Of those that are based in Scotland, most of their investment activity is outside Scotland.

- External VCs are not focussed on the Scottish ecosystem, and do not have a meaningful presence in Scotland, nor do they spend much time here.

- The cap tables of Scottish start-ups can be off-putting to some external VCs because they look different to those that the VCs are accustomed to seeing elsewhere. Specifically, they often include a large number of passive investors (because of earlier syndication) instead of, for example, one or two active angel investor and some VCs, as is more typical. Those cap tables also frequently include a relatively large percentage that is public money.

A pre-tipping point ecosystem suffers from poor discoverability of potential prospects at the Series A stage as well as higher friction and opportunity costs for external venture capital companies in pursuing investments. These act to reduce their involvement level. The VC industry works on the basis of high sifting ratios. A very large number of potential prospects must be reduced to a handful of annual investments. The smaller the scale of an ecosystem, the more remote that it is from where VCs are located, and the lower the density of interesting prospects within it, then the greater the friction encountered by VCs in identifying them. Simply put, they can better invest their time elsewhere. This is disruptive to the process of rapidly sifting prospects, which results in VCs being less willing to engage in the ecosystem.

Contrast this state of affairs with an ecosystem where VCs either have a local presence because the scale of the ecosystem merits having one, or where the ecosystem's scale justifies regular travel to it. For a VC based in London, it's possible to physically visit five or more interesting prospects per day on the tube. A full daytrip to Edinburgh to visit just one prospect can seem like a poor economy in comparison, so it tends to happen less often.

Likewise, from a start-up's perspective, the cost to Scottish start-ups of meeting London-based VCs "on their turf" is obviously higher than for London-based start-ups, and often prohibitively so. In considering this point, bear in mind that a start-up typically has to build a relationship with VCs over an extended period of time before moving to raise a round so the time and cost is higher than it might at first look[28].

---

28 Undoubtedly, the issues posed by COVID-19 will shift some of this effort online, which benefits Scotland. But we can probably safely assume that much relationship building and pitching will still be done in person.

Of course, our start-ups *do* connect with external VCs, and deals *do* get done. However, until our ecosystem passes the tipping point – i.e., until VCs either establish a presence in Scotland or can justify a regular visiting schedule because a sustained, critical mass of credible start-ups exists – then the Series A investment stage carries greater friction than experienced in a post-tipping point ecosystem. So, less investment happens at the Series A stage as a result. Therefore, the Venture component of our Funding strategy should also focus on this critical stage of the investment pipeline.

Finally, we also note that the Scottish European Growth Co-Investment Programme (SEGCP), set up relatively recently in a joint initiative between SE and the European Investment Fund (EIF) to, amongst other goals, support Series A funding for Scottish start-ups, is now discontinued due to Brexit. Analogous schemes are, of course, still available to other European start-ups. This is a disparity that should be addressed by a replacement mechanism; we'll explore options here in the recommendations section of this report.

Series B+ Stage

Even in a pre-tipping point ecosystem such as ours, those businesses that do break through to larger scale will attract both domestic and international investor attention due to their higher visibility and relative success. Additionally, interventions that address the Series A issues just discussed will also benefit the later stages of the funding pipeline. Therefore, no special additional measures are required for these later stages in our opinion.

Grant Funding Analysis

The second category of funding available to the ecosystem is grants made by government through Scottish Enterprise. There are two areas here where improvements could be considered to better align the grant system with the needs of the Scottish tech ecosystem.

Alignment of grants to start-up requirements

Undoubtedly helpful as they are to early-stage businesses, there is nevertheless a misalignment between the criteria and mechanisms through which existing grant categories are awarded on the one hand, and the needs of technology start-ups on the other. This is not to say that these grant categories should be deleted but, rather, that the overall portfolio of grant funding options should be adjusted to include those that are specifically tailored to the needs of tech start-ups. That is to say, additional money isn't necessarily required; but instead that existing funding should, in part, be re-purposed to more appropriately tailored vehicles.

For example, one category of grants is awarded when a start-up reaches certain pre-agreed headcount goals. This is a convenient metric by which the grant's effectiveness can be justified within the awarding organisation. But it frequently acts as a perverse incentive for tech start-ups. The grant naturally incentivises the start-up to hire more people. But that is often the very last thing that a start-up should be doing in its earlier phases. What a start-up needs during that period is *runway* to be able to stay in business for as long as possible with a *small* team until it can demonstrate product-market fit. After that point, the start-up can begin to scale as dictated by the needs of its market strategy. Incentivising the start-up to hire more people, in isolation of these considerations, risks making the business more fragile and can distract the executive team from these imperatives.

Another grant category involves constructing the definition of a research or innovation project, with a fixed, measurable deliverable. This requires a non-trivial level of effort to define such a project. But, for tech start-ups, it is usually an artificial exercise and a distraction because, in fact, the *start-up itself* is the project.

These examples are both typical of the conflict between local and global-system optimisation that we discussed previously. Generalising from these examples, there is a category problem in aligning what's measurable in a short-term, clear manner from the perspective of the grant-funder (with due note to regulations that they must adhere to) and what's useful and aligned to business goals for the recipient.

Difficulty in navigating the grant map

Another, albeit lesser, concern put forward by start-up founders is the perceived complexity in navigating the available grant options across Scotland and the UK as a whole. This translates to friction in receiving grant support which, in turn, means that there are start-ups which should have received grant support but that miss out. We should bear in mind that start-ups typically do not have personnel they can dedicate to this exploration.

Funding – Strategic Framework for Improvement

The above points, taken together, suggest the following strategic framework for funding interventions. We'll make specific recommendations based on this framework in the final section of this review document.

Interventions in Investment Funding

Interventions in this category should be designed to achieve the following:

- **Increasing *Early-Seed* investment levels**: by improving discoverability between angels and start-ups. We'll review ways that this could be done in the recommendations section of this report. Given the favourable SEIS and EIS tax incentives available at the *early-seed* and *seed* stages, we do not consider it practicable to create further financial incentivisation to invest at the *early-seed* stage.

- **Increasing *Series A* stage investment levels:** One way to do this is to support start-ups in much more intensive engagement with the VC community in London right from the outset of the company. This is likely to favourably alter the balance of investor types in early-stage cap tables and educate both the start-up founders themselves and the London-based VCs about each other much earlier in the funding journey.

  Another mechanism worth examining is a partnership model which partly leverages government funding combined with the expertise of private local and external VC firms that are accustomed to operating at the Series A level. We'll explore one such mechanism for how this could be achieved in the recommendations section of this report.

- Measures to **reduce friction for start-ups and venture capital firms** through improved discoverability and ease of access for start-ups and external VCs.

In considering this general strategy for addressing the issues identified above in regards to investment, we note here some difficulties peculiar to this category:

The first is that it is not effective for government to incentivise external VCs to establish a presence in Scotland. Nor is it effective to encourage indigenous VCs to invest more time and money in Scotland. For VCs, opportunity cost trumps all other considerations, and the returns from the right investments hugely outweigh any incentivisation that may be on offer.

As we have already discussed in this review, we will only attract more inward investment activity towards our start-ups when we fix the problem of not having enough credible start-ups in which to invest. That is why this review places such a strong emphasis on the education element of the ecosystem, followed by having the right infrastructure to support the fruits of that education.

The second difficulty is that "too much" public financial support for Scottish start-ups may undermine the credibility of the ecosystem to external parties. If the ecosystem is worth investing in, this argument goes, then why does the government need to support its start-ups to such a high degree? There is a balance point, beyond which this perception may take hold. A related note on this last point: Scotland currently operates two innovative, but separate and uncoordinated mechanisms to deploy public money into start-ups – SIB and Techstart (the latter of which operates to the same model as VCs, but whose sole Limited Partner is the Scottish Government). It would be sensible to pay attention to the relative future success of these respective approaches, in terms of return on overall investment, and to increase/adjust funding support as appropriate, in consequence.

In developing our strategic framework above, we are conscious of all of these points. We also recognise that the COVID-19 crisis shifts the normal balance point to some extent.

Interventions in Grant Funding

Interventions in this category should be designed to achieve the following:

- **Adjustments to grant systems to better align to the needs of start-ups,** optimising for what's needed within the ecosystem rather than what's most measurable for the grant-awarding body. Rationalisation of grant options as part of this exercise would also be helpful to reduce discovery friction and increase uptake. Again, we'll illustrate this point with specific proposals in the recommendations section of this report.

- **Adjustments to grant funding levels.** We note here that, in the COVID-19 era, it is probably necessary to increase the general provision of grant, EDGE and similar funding to start-ups. However, great care must be taken to not artificially support start-ups that would have failed anyway, regardless of the COVID-19 crisis. To do so is detrimental to the ecosystem because it reduces the circulation of experience and creates a dependency culture. We are aware that these points are currently being addressed by SE separately to this report.

Chapter 5 – Recommendations – Guiding Principles and Focal Areas

In this section, we set the context for the review recommendations. We first state the strategic principles leading to the recommendations, which have been derived from our earlier analysis. We then present a set of focal areas under which the recommendations are grouped, based on these principles.

Strategic Principles

The recommendations presented in this document are guided by the following principles, which are derived from our analysis of the Scottish tech ecosystem presented earlier.

1. **What we mean by Improving Ecosystem Output:** Improving the ecosystem means increasing the creation rate of profitable, scaled tech businesses and reducing the average time taken for viable individual start-ups to reach scale. A desirable side effect of so doing is that more viable businesses will be produced at various other scales too.

2. **The ecosystem has three main dependencies: education, infrastructure and funding**. All three are important, but we have listed them here in order of descending importance. What this means is that doubling our investment in (the right kind of) education, for example, will produce more successful scale-ups than doubling the availability of early-stage funding. Between these two, the importance of infrastructure is the extent to which it acts as a platform for the formal and informal education that our ecosystem participants require.

3. **Interventions that accelerate the ecosystem towards the tipping point**: There is a tipping-point within tech ecosystems after which certain virtuous network effects establish themselves, and at which point the ecosystem is essentially self-sustaining. Scotland's tech ecosystem has not reached this tipping point, whereas, for example, London and Silicon Valley have. Therefore, the treatment of Scotland's ecosystem must be different from post-tipping point ecosystems. The collective purpose of the interventions that we make in the ecosystem must be to take our ecosystem towards that tipping point, at which time interventions and support can be tapered back.

4. **Avoid artificial stimulation of start-ups that should be allowed to fail:** Our interventions must only be for the purpose of acceleration towards the ecosystem tipping point. In particular, interventions by government must be carefully chosen in order to avoid creating a dependency culture within the ecosystem. Most start-ups *should fail;* the employees of those start-ups that do fail usually move on to other start-ups, which are strengthened by their greater experience gained first-time around. This is a key principle of tech ecosystems generally. Our goal is not to artificially arrest this natural process, but instead to ensure that those start-ups that would have succeeded in a post-tipping point ecosystem also succeed in ours.

5. **Target 'global'[29] ecosystem optimisation, not local optimisation of its parts:** Interventions and support for our ecosystem must be made according to the principle of "global over local optimisation" of the ecosystem. We also embrace the principle that, in the context of this optimisation approach, small interventions made at a certain point within the ecosystem can often have a profoundly positive impact on the overall performance of the ecosystem. Conversely, headline-grabbing interventions don't necessarily lead to headline-grabbing results, when measured in terms of overall ecosystem outputs.

---

29   Used here not in the geographic sense, but the systems sense.

6. **Measure Return on Investment (ROI) of interventions in relation to the overall ecosystem:** Related to this point, a key principle is that investment made at a certain part of the ecosystem usually won't manifest the resultant value in that same area. For example, investment in infrastructure will not yield a local value return to that infrastructure. It will instead manifest as output from the ecosystem as a whole (in terms of more successful start-ups and scale-ups). Therefore, support given at a certain point in the ecosystem should not be measured on local Profit/ Loss (PL) criteria, or similar. Although this would be locally convenient from the point of view of measurability, it undervalues or disregards completely the value created by that part of the ecosystem. This requires us to adopt more novel approaches to measuring ecosystem value.

7. **The ecosystem must learn from outside itself:** In the Internet age, just as all potential customers are much closer than before, so are all competitors. Scotland's ecosystem must therefore encourage international best practice within its start-ups and scale-ups if they are to compete with the world's best (which they must). In our pre-tipping point ecosystem, we will not achieve this by only learning from each other or by iterating on improvements atop our own local best practice. When we talk about Education, it must include a large element of best practice coming into our ecosystem. There is no room for historical complacency on this point.

8. **Focussed approach, focus on core horizontal capability, avoid over-dilution of support:** Our recommendations are intended to establish a core, world-class *Internet Economy* start-up capability, that spans all software tech and market domains. This is because the same start-up and scale-up techniques apply across almost all tech and market domains. Consequently, we do not make sector-specific recommendations, either in specific market domains or in specific niche technology domains. Various initiatives already exist, both publicly and privately-financed, to organise around specific domains. All of these rely on, in turn, a strong foundational ecosystem, which is the focus of this review; the job is only done when we can *execute at a world-class level* within our selected domains. However, we do make a general recommendation on the identification and support of emerging market-specific domain ecosystems.
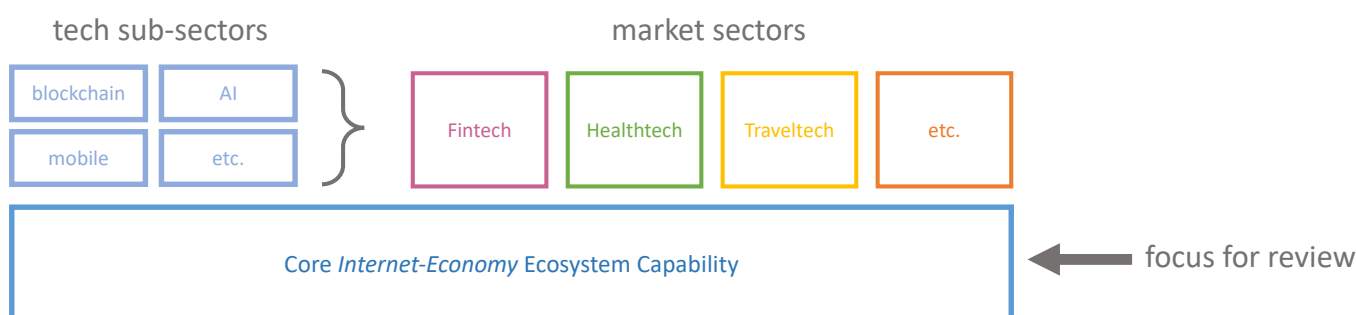
9. **Balanced portfolio:** In general, interventions in the early stages of the ecosystem funnel or its dependent areas (education, infrastructure and funding) will have greater eventual overall impact. This is because interventions made at the start of the funnel affect all later stages too. Conversely, investments made in later stages will yield a return sooner, because tangible start-up success only manifests from the middle of the ecosystem funnel onwards. Therefore, our interventions should constitute a balanced portfolio across this spectrum to bring about both early improvements and long-term high growth.

10. **Focus on building-out a world-class backbone implementation of core capability:** There already exists in Scotland today a range of novel and creative acceleration programmes and interest groups from our innovation centres, through public and private start-up accelerators and sector-specific interest groups. We applaud the work that these groups do, and the contribution that they make to the ecosystem.

One approach that we could have taken in this review is to recommend further financial support to each and all of these bodies above current levels. We have not taken this approach. In general, these groups are already sufficiently funded and operating well. To further support them on a wide scale, on top of routes to funding that already exist, risks over-dilution of resources and would lead to returns that are, at best, incremental on the status quo.

Instead, our approach is to bring particular focus to those areas of the ecosystem that, together, constitute the basis of a strategic "backbone" implementation of our core ecosystem capability. In doing so, we have chosen to recommend providing support to those in-scope ecosystem participants that are most advanced in their current provision of services towards that backbone core capability. We note that, in each of those cases, a gap exists between current provision of services by each given participant and the level of provision required to meet the strategic goals of this review. The recommended approach, therefore, is to provide staged support in return for the participants in question closing the identified gap on service provision.

Another cause, and consequence, of this approach is to limit the number of recommendations to five main *focal areas,* with a relatively small number of detailed recommendations being presented in each focal area. In so doing, we hope that this will provide greater focus for stakeholders in actioning them.

Focal Areas

Recommendations are grouped according to five main *focal areas,* summarised in the diagram below and described thereafter.

Foundational Talent Pipeline	Tech-Scaler National Backbone	International Market Square

Integrated Ecosystem Grant Funding

Foundational Talent Fund	Tech-Scaler Fund
Ecosystem-Builders Fund	International Market Square Fund

Investment Funding
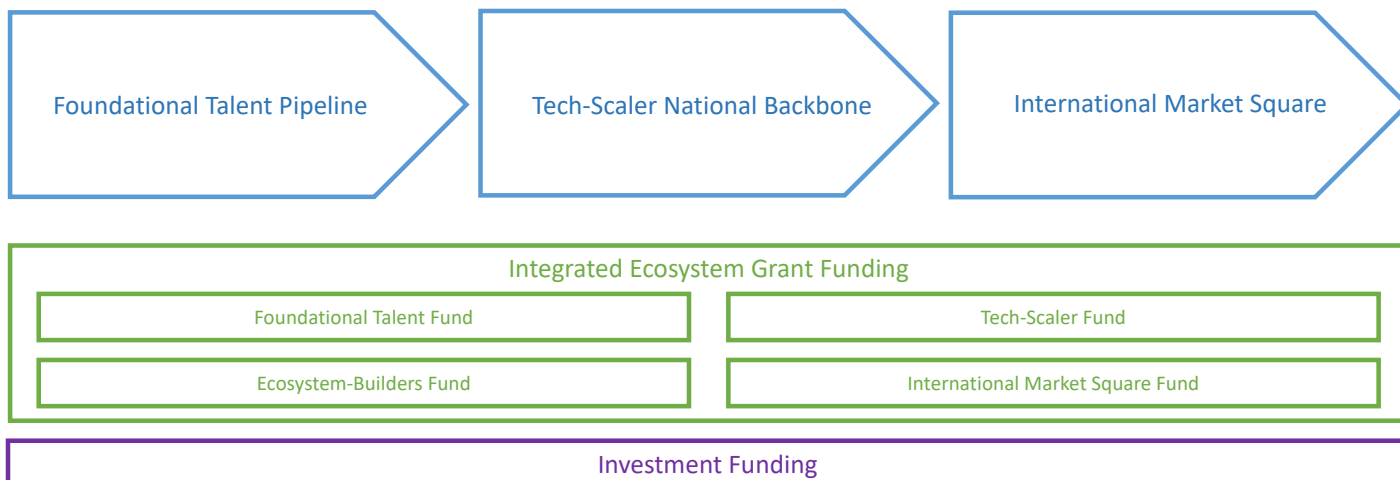
Foundational Talent Pipeline
This focal area groups recommendations for interventions and improvements at School and University level as well as "funnel wideners" such as Codeclan, extra-curricular organisations, and the attraction of external talent and experience into the ecosystem.

Tech-Scaler National Backbone
This focal area concerns building a national network of "Tech-Scalers", combining best practice in incubation, acceleration and education, and including integrated grant funding.

International Market square
This focal area groups recommendations designed to enhance Scotland's market square activities across all levels of scale from small meet-ups to international conferences.

Integrated Ecosystem Grant Funding
This focal area groups all recommendations designed to align public grant funding support to the above areas. The emphasis in this category is on achieving close alignment to the ecosystem's needs.

Investment Funding
This focal area groups all recommendations designed to better support the flow of investment funding to start-ups.

In the next section we present the specific recommendations of this report, grouped under the above categories.

Chapter 6 – Specific Recommendations

We now detail our specific recommendations, grouped according to the foundational areas described above and governed by the principles developed earlier. Each recommendation is uniquely numbered across all focal areas for easier reference. We'll review the focal areas in the following order:

- Tech-Scaler National Backbone

- Foundational Talent Pipeline

- International Market square

- Integrated Ecosystem Grant Funding

- Investment Funding

Tech-Scaler National Backbone, Recommendations

This focal area concerns building a national network of "Tech-Scalers", combining best practice in incubation and acceleration and including integrated grant funding.

Foundational Talent Pipeline	Tech-Scaler National Backbone	International Market Square

Integrated Ecosystem Grant Funding	
Foundational Talent Fund	Tech-Scaler Fund
Ecosystem-Builders Fund	International Market Square Fund

Investment Funding
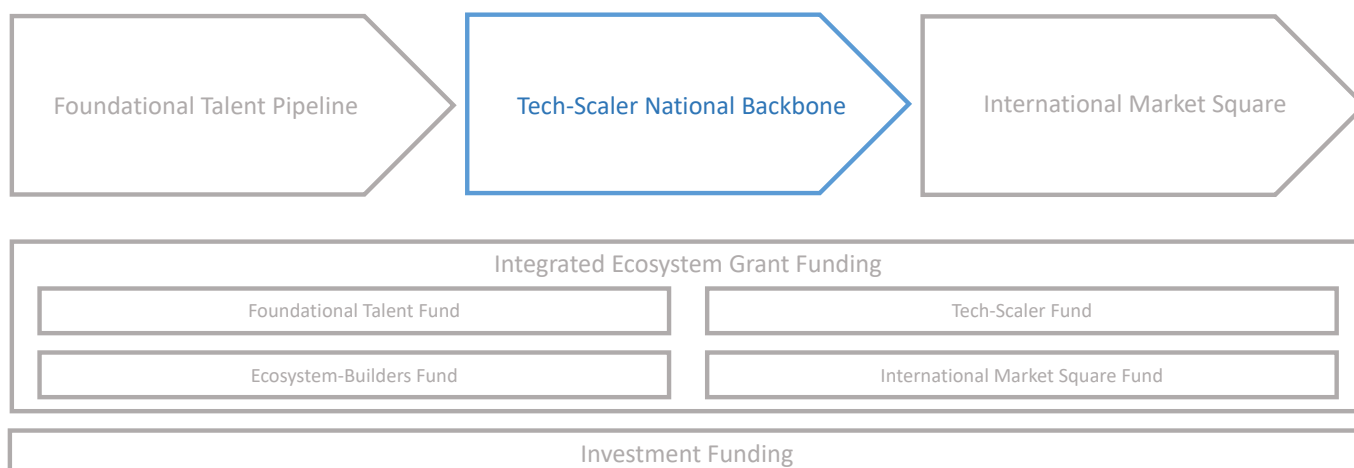
The recommendations are:

Rec. 1. Creation of a Tech-Scaler National Backbone.

Scotland should create a nationwide network of Tech-Scaler centres. We recommend that these are initially created in six cities nationwide; for example: Edinburgh, Glasgow, Aberdeen, Dundee, Stirling and Inverness.

A Tech-Scaler is an incubation facility that is enhanced in line with the strategy outlined in this review. Specifically, a Tech-Scaler has the following minimum attributes:

- *Provides long-term, affordable, high-quality incubation space.* A transparent curation policy is in place at entry, and is ongoing throughout the subsequent tenancy, to ensure that the quality of incubated tenant start-ups remains high (which, for example, directly affects the quality of the market square learning environment for other tenants). Otherwise tenancy is offered until the start-up becomes a scale-up (100+ staff). This intentionally results in start-ups of widely varying scales being co-located, which again enriches the learning environment for many of them. Tech-Scalers could also be the default home for university spin-outs as they graduate from their respective source institutions.

- *Provides free, high-quality foundational start-up education to its tenants* in the following areas:

   o Silicon Valley business models (for example, network effects, platforms, growth models and techniques, compounding growth mechanisms, commercial models and techniques, etc.).

   o Internet-Economy working practices (lean start-up techniques, speed of iteration, experimentation, bottleneck constraint analysis, etc).

   o Fundamentals of team and people management (for example, staff development, communications, performance management, conflict management, etc.).

   o Fundamentals of funding models (for example, explanation of investment stages and terms, building relationships with VCs, pitching skills, alternatives to venture, etc.).

   o Basic operating hygiene (including legal compliance, Intellectual Property (IP) management and Human Resource (HR) sufficiency).

As regards the above, note that no single organisation can or should provide this education; it should be sought from best practice providers nationally and internationally, but delivered through the Tech-Scaler. In support of this, a detailed skills matrix should be created, clearly identifying the "education route-map" for tech leadership teams.

Targeted coaching and mentorship (these are not synonymous) should also be integrated into the overall programme.

- *Provides "market square" space that is free for all local tech meet-ups to use* regardless of whether their participants are tenants of the scaler. The only requirements on this use are that in-person meet-ups can also be attended remotely by default. All facilities, from meeting rooms to market square areas, are fully equipped to provide seamless remote participation.

A reasonable approach to implementing the Tech-Scaler model is to build upon one of our existing incubation programmes. This approach would likely yield the fastest implementation, but must also recognise that, in every case, additional development is required to meet the Tech-Scaler standard.

An alternative option is to put the Tech-Scaler definition and model to general tender, and to invite local and external parties to bid, creating a competitive process and, perhaps, a greater diversity of implementation options, but with a longer implementation timescale.

Rec. 2. Structure of Scottish Government contract model for the provision of services.

We recommend at least a five-year contract window (with appropriate exit clauses for non-performance), based on a combination of key build-out milestone, occupancy milestones and performance against an ecosystem-value-based *north-star metric* with associated target levels (see next recommendation). This timescale provides a sufficient period for the Tech-Scaler model and implementation to demonstrate its value to the ecosystem, and aligns the measurement of that value with the point in the ecosystem where the value is manifested.

Rec. 3. The Tech-Scaler North Star Metric should be aligned to value created, using the Current and past tenant value (CPTV) metric.

Specifically, we recommend the following metric, or the closest approximation to it:

Current and past tenant value (CPTV)

CPTV is the aggregate of the valuations of all current tenant start-ups and those that were tenants within the prior five years. It would be calculated annually and would serve as input to an annual contract review with the Scottish Government. Where start-up valuations could not be precisely determined, they would be estimated by a fair process. Supporting leading-indicator KPIs would also be reviewed monthly at board level. These could include measures such as:

- Number of start-up tenants.

- Number of training courses delivered with 4-star or higher quality rating.

The purpose of the CPTV metric is to align the measurement of Tech-Scaler performance with actual value delivered to the ecosystem, recognising the issue discussed in our analysis, that the value returned from Tech-Scaler investment is manifested later and outside of the Tech-Scaler, thereby making traditional measures, such as P/L performance problematic.

Rec. 4. Tech-Scaler Grant Funding Should be Integrated into the Tech-Scaler Network.

See also the recommendations section Integrated Ecosystem Grant Funding, Recommendations. The Tech-Scaler grant fund described in that section, which is generally available to all start-ups regardless of tenancy in the tech-scaler network, should also be operated in an integrated fashion within the Tech-Scaler network, for example, through a joint initiative between Scottish Enterprise (SE) and the Tech-Scaler operator. This joint initiative would share the same curation process, such that start-ups considered appropriate for the Tech-Scaler would also be (almost) automatically eligible for consideration to receive one of more of the Tech-Scaler grant types. This would lead to a considerable streamlining of efforts for start-ups.

Foundational Talent Pipeline, Recommendations

This focal area covers the development and attraction of talent prior to start-up formation in the ecosystem funnel and also includes subsequent talent funnel-widening activities.
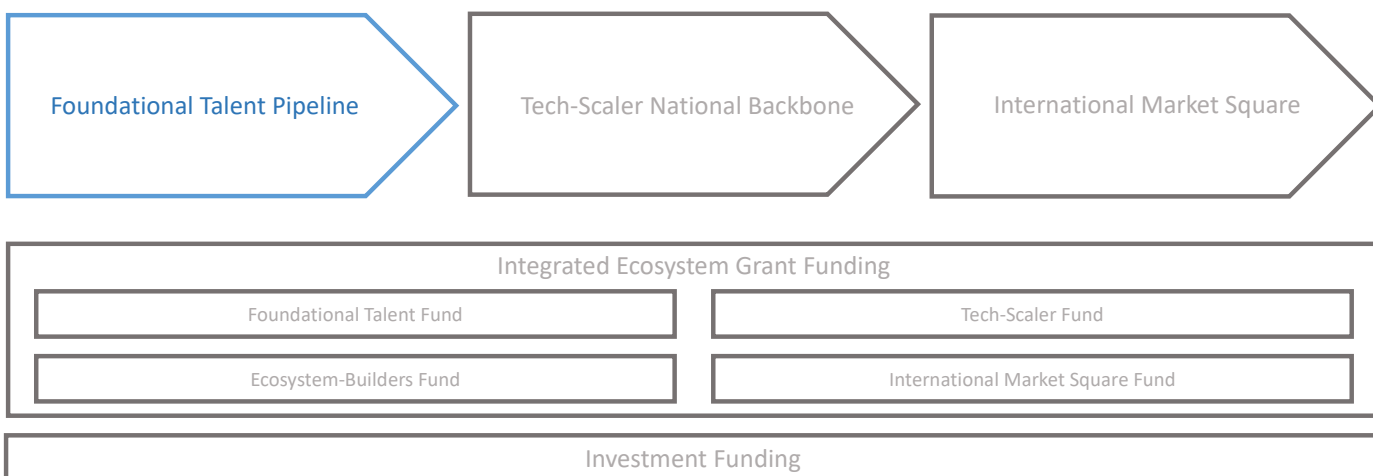
There are three main areas within this overall category; school-level education in Computing Science, university-level education in Computing Science and related subjects; and "funnel-wideners", i.e. those activities that bring additional talent into the tech ecosystem that don't follow the main path.

```
┌─────────────────────────────────────────────┐
│         Foundational Talent Pipeline          ╲
│  ┌─────────┐  ┌──────────┐  ┌──────────┐      ╲
│  │         │  │          │  │ Funnel-  │       ╲
│  │ School  │  │University│  │ Wideners │        ╲
│  │         │  │          │  │          │        ╱
│  └─────────┘  └──────────┘  └──────────┘       ╱
│                                               ╱
└─────────────────────────────────────────────┘
```
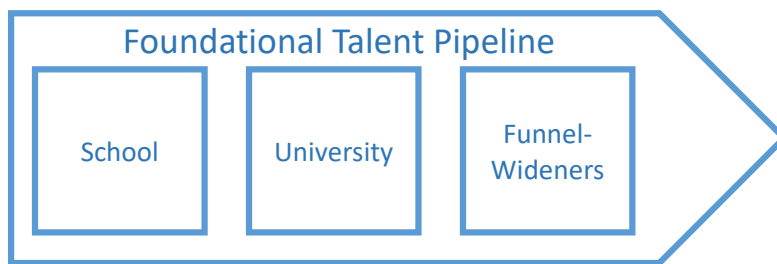
Area: Foundational Talent Pipeline: School-Level

This is the first of the three key areas within the Foundational Talent Pipeline. Recommendations are:

Rec. 5. Treat Computing Science like Maths or Physics and follow through on the consequences of that decision.

The simplest expression of what needs to be improved at school level is that we should treat Computing Science likes Maths or Physics at secondary school level. The consequences of that principle are listed below. We acknowledge that these changes are non-trivial. However, change of this kind is necessary if we are serious about Scotland's future in the global technology arena.

- Computing Science should be formally taught from first year at secondary school in the same way that we do with science.

- The teaching profession needs to attract more Computing Science (and related disciplines) graduates into teaching. The more teachers we have with industrial programming skills, the more interesting the syllabus will be for pupils, and the greater its relevance will be to further education and industry. Areas to be examined include:

  - The likely need to align salary levels accordingly.

  - Active promotion of teaching as a career option to undergraduates on such courses.

  - A rapid-access path into teaching for Computing Science graduates.

- Existing Professional Graduate Diploma in Education (PGDE) entry routes into Computing Science teaching should be significantly strengthened as regards Computing Science skills. For example, all prospective teachers could undergo Codeclan's 16-week intensive training programme as part of their training, and a partnership with industry could be established to expose recruits to industrial software engineering environments for a period during their training.

- The curriculum should be correspondingly revised to include far more programming and project work. Only by making the above changes does this become possible.

- Curriculum designers should work closely with the university sector to ensure that the school and university curricula join-up effectively.

- Recognising the unique pace of change in Computing Science relative to other subjects, its teachers should be given dedicated training time each year in order to stay current. For example, cloud computing is a dominant theme in software engineering today but wasn't much talked about ten years ago.

- An annual Computing Science Teaching Conference should be established in Scotland, to promote best practices in teaching and for knowledge sharing between schools.

- Informative material should be made available through schools to parents and guardians, to educate them on what Computing Science is and the employment prospects for children who follow this path, etc.

- A *Digital Schools* award standard should be established and awarded to schools that conform to a minimum level of curricular and extra-curricular activity as regards Computing Science and related areas.

Rec. 6. Establish an industry partnership with schools to give Computing Science pupils summer work experience.

An excellent way to increase interest levels for pupils is to establish summer work experience programmes with Scottish software businesses. We recommend that the government investigate the appetite for this within industry.

Rec. 7. School-stage extra-curricular programming clubs should be strategically supported.

The Scottish Government should work with councils across Scotland to create a database of extra-curricular programming clubs profiled by their geographic and demographic coverage to identify gaps in provision (and including, for example, by gender, ethnicity, age group and areas of deprivation). Funding should be increased to existing club networks, such as *Young Engineers and Science Clubs (YESC), CoderDojo*, *Code Club*, *Make it Happen, Prewired, The DataKirk, Digital Skills 4 Girls* and *dressCode* to support the purchase of additional equipment and to cover operating expenses; two constraints to scaling their current activities.

Rec. 8. Overcoming gender-stereotyping in early years.

We stated earlier in this report that, by the time pupils take the Higher Computing Science qualification, only 16% of them are female on average; a ratio that worsens as they continue on through university and into industry. Put simply, gender role stereotyping removes almost half of our best future engineers. It would be economically and societally beneficial if Scotland was to lead on addressing this aberration. Gender role stereotyping is established by society during the primary-school years, and it is here that work should be particularly focussed.

We recommend that the Scottish Government conduct a sustained public information campaign aimed at countering role stereotyping as it relates to science, Computing Science and engineering, enlisting role models and others as part of that campaign.

Particular focus should also be given to supporting initiatives, such as dressCode which encourages school-age girls into programming. An interesting observation: at Higher Computing Science level, 16% of students are girls, on average across Scotland. In dressCode founder Toni Scullion's school, where she first pioneered dressCode, the female intake is more than double that figure. Ms Scullion could be engaged to consult on how best to scale this support across Scotland, and perhaps be given a full or part-time role in advising the government on Computing Science in-curricular design and extra-curricular support in Scotland, given her many other innovations in promoting general student interest in Computing Science.

Area: Foundational Talent Pipeline: University-Level

This is the second of the three key areas within the Foundational Talent Pipeline. Recommendations are:

Rec. 9. Adjust university incentivisation and funding to improve tech-entrepreneurial focus.

To support the wide range of activities required to improve the entrepreneurial skills of students in Computing Science and its related disciplines, the university course funding model should operate similarly to Clinical disciplines, where the need for funding provision beyond basic teaching is already recognised. Costs could be managed here by employing models similar to the existing *Research Pool* scheme to share programmes and initiatives across institutions, instead of replicating them at all sites.

Universities should be assigned a KPI to increase the entrepreneurial skills and knowledge of the Silicon Valley/Internet Economy start-up playbook amongst Computing Science students (and those in related disciplines). Attributes that should be incentivised are:

1.   Computing Science curriculum incorporates classes covering:

- Internet-Economy best practice in product introduction and growth engineering.

- Fundamentals of Internet-Economy business operations.

- Case studies of multiple well-known tech start-ups and scale-ups, both successful and unsuccessful.

2.   Joint start-up projects between Computing Science and Business school students.

3.   Start-up summer school programme.

4.   Incubation space available for students and recent students.

Rec. 10. Increase university funding to create more local software engineers.

Universities should be assigned a KPI to increase the number of locally-resident Software Engineering/Computing Science graduates. Funding should be adjusted in recognition that such students are not as lucrative to universities as students who are resident outside Scotland.

Rec. 11. Adjust university incentivisation to improve spin-out scale and quality.

Universities should be assigned a KPI to increase both the number and quality of spin-outs. Attributes for consideration in meeting this KPI could include:

1. Reducing equity stakes to levels that motivate founders and attract investors.

2. Improving spin-out founders' readiness to run start-ups.

3. Working with start-up industry experts to ensure company articles are appropriate.

4. Assigning founder mentorship from experienced start-up executives.

Rec. 12. Relax other KPIs in the overall university KPI portfolio to accommodate the new KPIs.

It should be recognised that only adding KPIs does not increase focus and is more likely to reduce it. Therefore, the above KPIs should be added simultaneously with others being relaxed or removed entirely.

Rec. 13. National, pan-university Tranzfuser-style summer-school.

The Scottish Government should fund a start-up summer school competition for recent graduates, following the UK Games Fund's successful *Tranzfuser* model. We recommend that Paul Durrant, one of the originators of *Tranzfuser,* be engaged to advise on and/or operate this generalised competition. Attributes of the competition should include:

- Winners from the event would gain automatic entry into the Tech-Scaler network.

- The attendees should be paid during this period of the summer competition; experience from *Tranzfuser* indicates that the best graduates are more likely to be retained in the programme if this is the case.

Rec. 14. Increase the number of start-up internships available to students.

We believe that this can be supported in two ways. The first is to provide grant support (through the Tech-Scaler Fund, discussed later) to start-ups who take on interns during the summer period, provided they meet certain quality standards in the provision of those internships. The second route is to work with and support Entrepreneurial Scotland to increase the number of available international internships, particularly targeting international tech start-ups.

Area: Foundational Talent Pipeline: Funnel-Wideners

This is the third of the three key areas within the Foundational Talent Pipeline. Recommendations are:

Rec. 15. Codeclan should be treated as a strategic ecosystem asset.

Codeclan, as a funnel-widener, has been particularly successful at bringing engineers into the ecosystem that have not followed a more traditional entry path earlier in their careers. However, the capacity of the organisation is constrained by two factors: uncertainly around future finances, which undermines the organisation's confidence to expand its provision of training places, and the cost of courses, which are in many cases too expensive for prospective students.

We recommend that Codeclan is set a target to triple its annual number of graduates, to be implemented over a 24-month period (allowing for the realities of scaling capacity while maintaining quality). We recommend that the organisation is part-funded by government to support this expansion using the Foundational Talent Fund proposed in the Integrated Ecosystem Grant Funding, Recommendations section.

We propose that grant availability for prospective students should be increased to ensure that participation can be widened, particularly from those groups in society for whom the cost of courses would otherwise be prohibitive. We also recommend that grant support be configured to particularly support female applicants. This is an excellent opportunity to mitigate the effects of gender role stereotyping earlier in the education funnel.

Complementary funding methods could also be considered. For example, *Lambda School* in the US offers a very similar programme to Codeclan. In that model, students pay for their tuition by a shared-income agreement (students give a small percentage of their post-study salaries to Lambda School for the first two years after graduating).

There is also an opportunity here to provide a retraining path for people forced to change industry due to the impact of the COVID-19 pandemic on Scotland's traditional economic sectors. This concept can of course be extended to the re-skilling of our workforce generally, in line with shifting patterns of employment.

Finally, we recommend that Codeclan's successful approach be studied to determine to what extent it could be replicated within our college system.

Rec. 16. Introduction of a Scottish Tech-Visa.

We understand that the Scottish Government has limited powers in respect of immigration policy. Notwithstanding that point, we put on record here that mechanisms to attract international tech talent to Scotland, such as a Tech-Visa similar to the H1-B Visa in the US, are highly desirable as a means of widening the talent funnel.

Rec. 17. Attraction of executive-level talent to Scotland.

We discussed earlier how growing Scottish scale-ups reach a point where they can no longer hire locally in sufficient numbers to fulfil their leadership requirements (both technical and managerial) to support the next level of scale. They either stop growing or set up offices outside Scotland to attract that talent. Later these offices become the centres for growth of the company. The difficulty in hiring these executives stems largely from the risk to them of relocating their families to join companies in a sparse, pre-tipping point ecosystem.
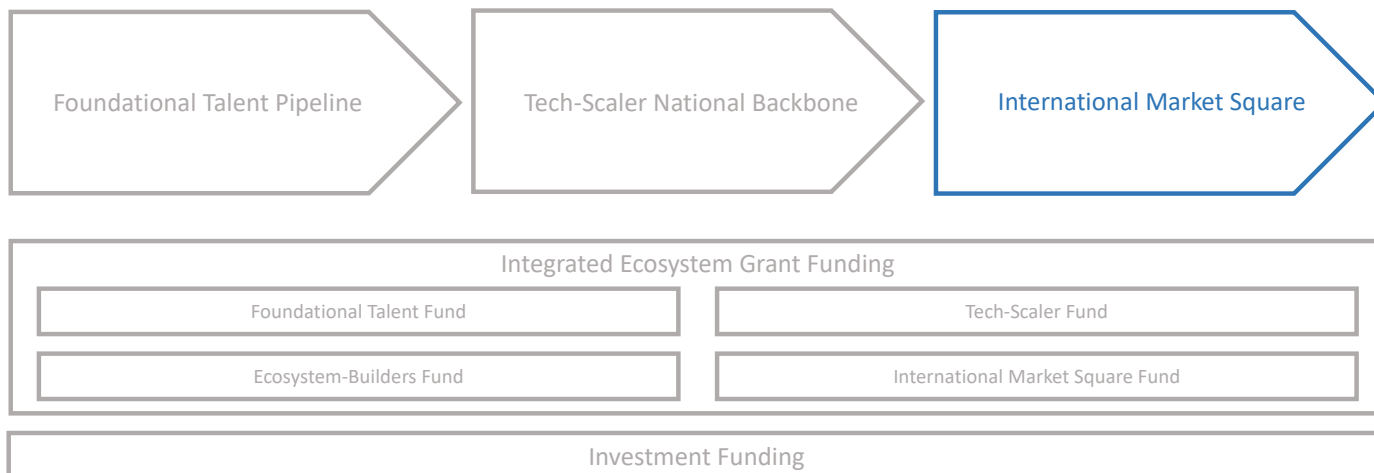
We recognise that the political palatability of the following may be challenging, but we recommend that options are explored in the area of providing to (means-tested) start-ups a government bond to support the 12-month salary costs and relocation costs of an executive who leaves a Scottish scale-up within the first two years of joining. This provides some risk protection for the prospective hire while not being unaffordable for the start-up. In most cases, the bond would not be called upon. Variations on this theme exist, of course. The point we wish to emphasise is that it is far more expensive to the Scottish economy for our scale-ups to gradually relocate themselves outside of Scotland than it is to provide these insurance policies.

Rec. 18. Reduction in inter-city rail travel costs.

Whilst recognising that there are external constraints in the flexibility of rail travel pricing, we repeat here that current prohibitive inter-city rail travel prices are likely significantly impacting the size of workforce available to start-ups in any particular city. For example, this makes the difference between a start-up being able to hire across the central belt or only in Edinburgh. In a very small country such as ours, where access to talent capacity is correspondingly limited, this is unhelpful. We recommend that pricing be reviewed with the aim of reducing it below inter-city threshold rates.

International Market Square, Recommendations

This focal area groups recommendations designed to enhance Scotland's market square activities, across all levels of scale from small meet-up to international conferences.

Foundational Talent Pipeline	Tech-Scaler National Backbone	International Market Square

Integrated Ecosystem Grant Funding	
Foundational Talent Fund	Tech-Scaler Fund
Ecosystem-Builders Fund	International Market Square Fund

Investment Funding

Recommendations in this category are:

Rec. 19. Provide support for our major tech conferences, to internationalise them.

Financial support should be provided to our major start-up tech conferences, for three reasons. The first is to increase the mix of world-class international speakers in attendance. This is important because our ecosystem founders need to learn from international best practice to a greater extent than they do currently. Secondly, because the conferences will consequently attract more outside interest, this will, in turn, increase the visibility of the Scottish tech ecosystem to external investors, and other parties. Thirdly, the conferences would be more affordable for our start-ups.

Additionally, Turing Fest has a particularly bold proposal to construct an international tech industry conference and founder education network, with Scotland at its heart, running along the lines of Finland's successful Slush model. We recommend that serious consideration is given to supporting this vision for a limited funding period to determine whether similar results can be achieved here.

Rec. 20. Establish International Investor Conference, not limited to Scottish Start-ups.

Scotland currently runs two annual tech investor conferences, the well-established EIE and the smaller but growing *Turing Founders,* part of Turing Fest.

The EIE conference currently largely showcases Scottish start-ups. This partly reflects its origins (it was originally funded by SE) and is also partly due to the fact that entry to the conference is via a (well regarded) training programme for founders on pitching skills, which, as a consequence, tends to skew attendance towards local start-ups. *Turing Founders* is not specific to Scottish start-ups, but is smaller than EIE, currently.

For the avoidance of doubt, we consider having more than one investor conference to be a virtue in strengthening the perception of Scotland as a vibrant tech centre to outside investors; indeed, this is precisely the approach taken in Finland.

We recommended that these conferences are internationalised to showcase start-ups regardless of their origin country, and that a level of public finance support is provided, to ensure that ticket prices, pitch-entry prices etc., are not prohibitive.

The reason for doing so is to attract external investors and international industry expertise to Scotland that won't come to see a solely domestic portfolio. In Scotland's pre-tipping point ecosystem, there isn't a large enough contingent of investible start-ups (and hence, deal-flow) at this stage to attract these parties. So, either they don't attend the conference, or they don't attend more than once. But combining Scotland's start-ups with other European start-ups as a single body would create a sufficient critical mass of interesting investible propositions. In attracting those external investors to Scotland for the conference, we also build their general awareness of Scotland's start-up ecosystem and build relationships between them and our local ecosystem participants.

We propose that such funding would be supplied from the International Market square Fund discussed later.

Rec. 21. Provide support for the Scottish tech meet-up network.

There are currently over 200 tech meet-ups running across Scotland's tech ecosystem. This is an extremely valuable network-building and education resource, and we should maximise its impact. The frequency and scale of these meet-ups is challenged by a lack of meeting space and basic hosting expenses.

We recommend that the new proposed Tech-Scaler network provide free meeting space and hosting facilities for all of Scotland's tech meet-ups, fully enabled for remote participation.

Rec. 22. Support and strategy for specific economic sectors.

We acknowledge the potential value of a domain/sector focus and the attractive power of domain clusters in an ecosystem, as demonstrated by Fintech in Scotland, for example. We should (and generally do) support our existing domain strengths well.

But we note also that *a priori* choosing winning domains to focus on – and then being right – is difficult for the public sector to do well. The tech industry develops and mutates far more quickly than any government or enterprise agency can move. And it can send a disenfranchising signal to those companies that don't fit a particular sector strategy if a domain approach, and the communication around it, become over-emphasised or myopic.

So, in general, we do not propose that the Scottish Government should attempt to "over-plan" the specific focal areas in Scotland's tech economy, by predicting a comprehensive set of future winning areas for Scotland. Instead, we recommend that the Scottish Government provides grant funding support for industry-domain networks as they emerge and as the industry participants in those sectors organise themselves into those networks. We propose that such funding would be supplied from the Ecosystem Builders Fund, discussed later. Alternatively, this could be a function of the upcoming Scottish National Investment Bank.

We believe that this approach provides the best balance of letting the industry self-identify emerging areas of importance while providing support to that self-organisation, provided we put in place the mechanisms to be alert to emerging areas of potential strength.

We could summarise this approach as "embrace what works and be hyper-alert to emerging strengths".

In asserting the above, we note that exceptions will exist; for example, the climate crisis may influence our considerations as to focal areas (a point developed further in the *Report of the Advisory Group on Economic Recovery*).

Finally, noting the importance of clarity in this area, there is, as far as we can ascertain, no single Domain Strategy guiding these considerations in Scotland today. It is beyond the scope of this review to articulate that strategy further than our recommendation here, but we encourage such a strategy to be developed.

Rec. 23. Establish a strategy to exploit Scotland's Diaspora.

Our international diaspora should be tapped more actively as a strategic resource following, for example, Ireland's successful model. This resource includes executives placed in many of the world's most admired technology companies. Such a resource could be used to, for instance, provide a regular programme of visits to Silicon Valley companies for Scottish start-up founders, (as demonstrated by SBN/FutureX, these visits always raise the ambition level of returning founders).

Our general recommendation here is to assign the Scottish Government responsibility for generating a comprehensive, multi-year diaspora exploitation plan, following Ireland's successful model, a country with very similar international brand assets to Scotland but that makes considerably more use of them. The strategy should take into account existing assets, including *Global Scot* and The *Scottish Business Network.* It should include an objective assessment of the current network-strength and effectiveness of these networks, and their respective potential. We also note that many "exiled Scots" return to Scotland later in their careers, representing a potentially very valuable seam of experience; accessing this resource should be within the scope of the strategy.

Integrated Ecosystem Grant Funding, Recommendations

This focal area groups all recommendations designed to align public grant funding support to the above areas. The emphasis in this category is on achieving close alignment to the ecosystem's needs.
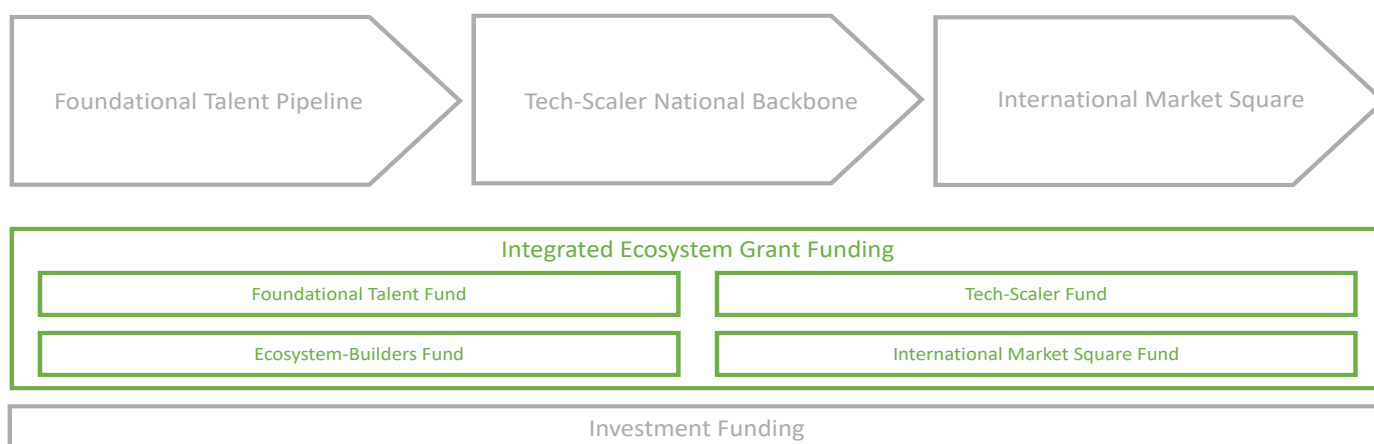
Rec. 24. Establish Funding Coverage in Four Ecosystem Areas.

We recommend that the Scottish Government establishes funds in four important areas related to the Scottish tech ecosystem in order to fund the areas called out above. These are each described in the four recommendations that follow. Note that we are not necessarily proposing that special funds with these names are literally established, although this is certainly one possible approach and is our preferred approach. An alternative approach is to utilise existing funding mechanisms, adjusting their scope and remit as appropriate to instantiate these logical funds. The key point, though, is that, whichever mechanism is selected, the activities described below can be funded with clear line of sight to the subjects of their intended support.

An essential aspect to these funds is that, in general, they should not attempt to measure return on investment as local to the party receiving the grant (with the exception of funding destined for start-ups directly). Rather, return should be considered with respect to the wider ecosystem's output. In our earlier analysis we identified a structural problem that value delivered by ecosystem participants is, in many cases, manifested outside of those participants and outside of typical measurement windows. Therefore, assessment measures that are overly localised do not capture this value. Of course, appropriate measurement is still required, but mechanisms should be designed with this point in mind.

Rec. 25. Foundational Talent Fund.

Purpose: Provides funding to those talent funnel-wideners in the early stages of the ecosystem.

Scope: Part funding the operation of Codeclan. Subsidising Codeclan student fees. Funding extra-curricular school programming clubs, such as CoderDojo and dressCode (for example).

Types of grant:

- Codeclan student grants
  - o *Measurement*: None.

- Subsidy of operating costs for Codeclan
  - o *Measurement*: Growth in graduate numbers. Placement rates in industry.

- Micro-grants for extra-curricular clubs
  - o *Measurement*: None.

Rec. 26. Tech-Scaler Start-up Fund.

Purpose: Providing targeted grant funding to technology start-ups.

Scope: includes those start-ups resident in the physical Tech-Scaler network as well as other qualifying start-ups that are not resident. In the former case, we propose that grant assessment is fully integrated with the start-up curation process operated by the Tech-Scaler network (for example, employees from the Tech-Scaler network and SE work "side-by-side"). This grant category maps to existing grant funds operated by SE currently.

Types of grant:

PMF Grant

Grants based on headcount targets and innovation projects, though certainly useful in some contexts, are not well aligned to the needs of pre-PMF[30] start-ups, as discussed earlier. We recommend the addition of a PMF Grant with some re-allocation of funds between the existing and new grant category. This grant contributes to extending the runway of a start-up until it reaches PMF. Once this point is reached, the more traditional grants become more relevant. Award criteria for the PMF Grant would consist of those start-ups that can demonstrate adherence to best practice in the PMF-finding process.

- *Measurement***:** The grant should be phased, with subsequent payments contingent on progress on key metrics towards PMF.

---

30   where PMF stands for Product-Market-Fit, a key stage concept in the evolution of a start-up.

Investment Seekers' Grant

We also recommend the creation of a small grant category to support the costs that Scottish start-ups incur in seeking investment outside of Scotland. For example, securing investment from London-based investors requires many trips to London which, for a small start-up is a significant expense, and one not borne by London-based start-ups. As we discussed earlier, at this pre-tipping point stage of our ecosystem, those investors are generally unwilling to make the reverse journey. But getting their investment expertise into our ecosystem and into our start-ups is highly desirable. We propose that this grant is combined with some level of mentoring support and diaspora support in how to seek investment, etc.

- *Measurement:* Evidence of investment seeking activity outside of Scotland

Student Internship Grant

We recommend that start-ups are supported in placing students in summer internships, to increase their business awareness in general and their understanding of the realities of operating in a start-up environment, in particular.

- *Measurement:* Evidence of the operation of a high quality internship.

Rec. 27. Ecosystem-Builders Fund.

Purpose: To support those organisations that contribute to strengthening the ecosystem through peer networking and informal education.

Scope: Tech Meet-up network, domain-specific industry networks.

Tech Meet-up network: micro-grants for hosting, operating and publicising tech meet-ups. An additional/alternative resource to this grant is that the above is managed through our Tech-Scaler network (for example, meeting space is made available for free to meet-ups).

- o *Measurement:* Events can be demonstrated to have taken place as per the frequency agreed.

Domain-Specific industry networks: annualised funding to support emerging common-interest industry bodies. An archetype for this category is Fintech Scotland. As stated earlier, we do not propose that the Scottish Government attempts to "predict winners" in the technology sector, neither by technology type nor market domain. Instead, we propose that, as nascent sectors emerge, participants can organise an industry network, and apply for grant funding to support that organisation.

- o *Measurement:* Fintech Scotland's governance model should be used as a template here.

Rec. 28. International Market square Fund.

Purpose: To support those organisations that contribute to strengthening the ecosystem through large-scale market square events. Such events bring international expertise and awareness of Scotland's tech ecosystem. They play an important part in turning our ecosystem "outwards" to learn from international best practice.

Scope: Premier Tech Conferences (for example, Turing Fest, Start-up Summit, Data Summit and premier tech investment conferences.
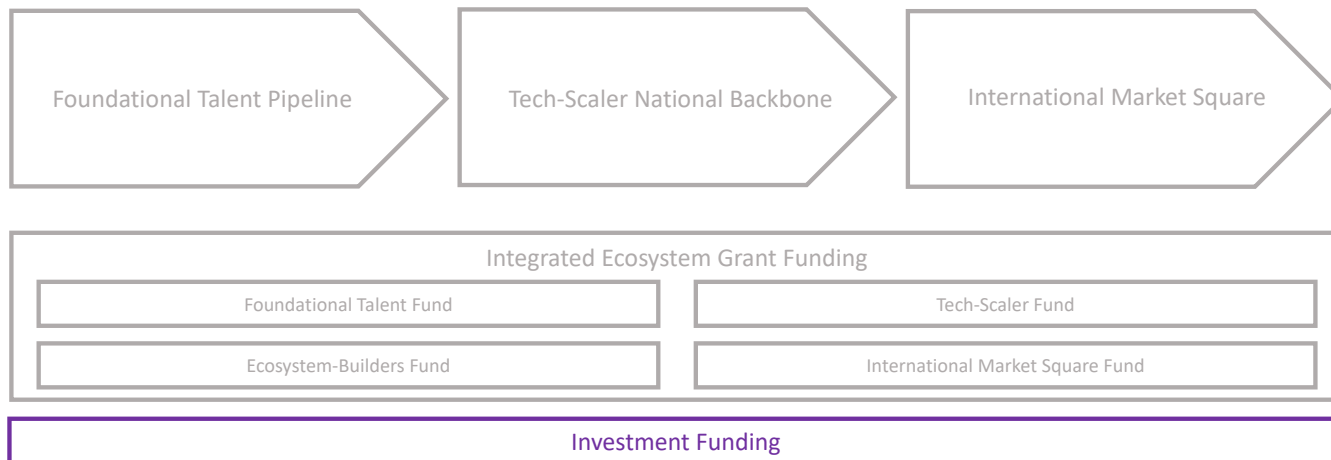
Types of grant:

Large Market square: covering grant support to our large tech conferences, to help them internationalise.

   o   *Measurement:* Milestone-based, according to agreed development goals.

Investment Funding, Recommendations

This focal area groups all recommendations designed to better support the flow of investment funding to start-ups.

```
┌──────────────────────┐    ┌──────────────────────┐    ┌──────────────────────┐
│ Foundational Talent   \   │ Tech-Scaler National  \   │ International Market   \
│ Pipeline              /   │ Backbone              /   │ Square                 /
└──────────────────────┘    └──────────────────────┘    └──────────────────────┘
```

┌───┐
│   Integrated Ecosystem Grant Funding   │
│ ┌──────────────────────────────┐   ┌──────────────────────────────┐   │
│ │   Foundational Talent Fund   │   │   Tech-Scaler Fund   │   │
│ └──────────────────────────────┘   └──────────────────────────────┘   │
│ ┌──────────────────────────────┐   ┌──────────────────────────────┐   │
│ │   Ecosystem-Builders Fund   │   │ International Market Square Fund│   │
│ └──────────────────────────────┘   └──────────────────────────────┘   │
└───┘

┌───┐
│   Investment Funding   │
└───┘

The recommendations in this area are:

Rec. 29. Scottish VCs should partner with the Scottish Government on various joint initiatives, (as subsequently listed).

We propose that the Scottish Government, including through its agencies, work with Scotland's major investors to identify ways in which they can jointly assist in addressing the problems identified in our earlier analysis which, in summary, include availability of seed capital, discoverability of prospects, availability of Series A capital and investment education for founders. Some early recommendations in these areas are presented below.

Rec. 30. Explore the possibility of establishing a Series A fund in a partnership between the Scottish Government, Scottish VCs and External Investors.

In our earlier analysis, we discussed that, in our pre-tipping point ecosystem, Series A investment is difficult to attract. It relies largely on external investors who have little knowledge of the Scottish tech ecosystem, and little appetite to explore it due to the opportunity costs involved. We also stated that our over-arching strategy in this review is to identify interventions that can accelerate the ecosystem to its tipping point, after which time certain interventions can be carefully withdrawn as the ecosystem approaches self-sufficiency. At all times, we wish to avoid building a dependency culture, where start-ups expect government support rather than developing the skills and wit to compete to attract VC investment.

With all of these points considered, we recommend that the Scottish Government explore setting up a Series A fund, as a joint initiative between the government/SE, Scottish VCs or syndicates and, potentially, external VCs also. Funds would be contributed by both government and the VCs involved, and the government would leverage the knowledge of those VCs to manage the fund or provide expertise and capacity in due-diligence at Series A level.

Rec. 31. Introduce an investment vehicle specifically supporting female founders.

In industry as a whole, women found 20% of our businesses but receive 1% of total investment capital.[31] The Scottish Government/SE should consider creating a specific vehicle to make seed investments in technology start-ups founded by women, to contribute to rebalancing this aberration.

Rec. 32. Introduce an education/mentoring scheme for start-ups in funding models, venture capital, pitching.

As part of a partnership with government – "and a call to arms" during this challenging period in our country's history – we propose that a limited group mentoring scheme is established between our experienced VCs and syndicates on the one hand, and our early-stage start-ups on the other. For example, one implementation of this would be for our investors to perform the training component on investment proposed in our Tech-Scaler recommendations section. The goal of this relationship is to help to educate our founders on the investment world, the realities of raising money in London and elsewhere, cap table management, pitching technique, alternative funding sources, when to seek capital, etc. Our investors have enormous experience to offer our start-ups, which is normally only tapped if they actually invest in a business.

Rec. 33. Grant support for Scottish start-ups to support external raising expenses.

As already discussed in Integrated Ecosystem Grant Funding, Recommendations we recommend the creation of a grant category to support the costs that Scottish start-ups incur in seeking investment outside of Scotland, combined with some mentoring support from local VCs or experienced ex-founders.

Rec. 34. Maintain and publicise a live database of all angels and all start-ups in Scotland. In due course extend concept into a specialised crowdfunding platform for angels and Scottish start-ups.

We recommend that methods are investigated to improve discoverability between, particularly, individual angel investors and early seed-stage start-ups. EIE and Turing Founders partly serve this purpose but are not a complete solution to the problem.

In particular, we recommend the creation of a live, updated database of all of seed-stage start-ups (including their sector, status and progress, for example) that can be accessed by investors. This list should be actively curated and publicised. Various routes exist to implement this facility.

A step beyond this idea to promote the concept to the level of a specialised crowdfunding platform where investors can not only discover the existence of Scottish start-ups but fund them directly too. The platform could be overseen by LINC Scotland, for example.

---

31   Source: Women's Enterprise Scotland

Chapter 7 – Governance and Oversight Model

The recommendations in this review cover multiple, disparate areas, each with different stakeholders and owners. Some of the recommendations are naturally easier and faster to implement than others, some of which will take several years to fully implement. Only by a *relentless* and *coordinated* application of these recommendations will meaningful progress be made in improving outcomes from Scotland's tech ecosystem.

However, we should recognise that such an approach is not necessarily the default model for multi-agency programmes in Scotland; it will not spontaneously form around these recommendations of its own accord. It's naturally more convenient for our various agencies and institutions to manage to their own KPIs and imperatives. To overcome such potential inertia as regards this initiative, we propose the following principles for governing the programme. If all stakeholders operate to these principles, the initiative is likely to be transformative to ecosystem outcomes, otherwise results will be incremental and unremarkable.

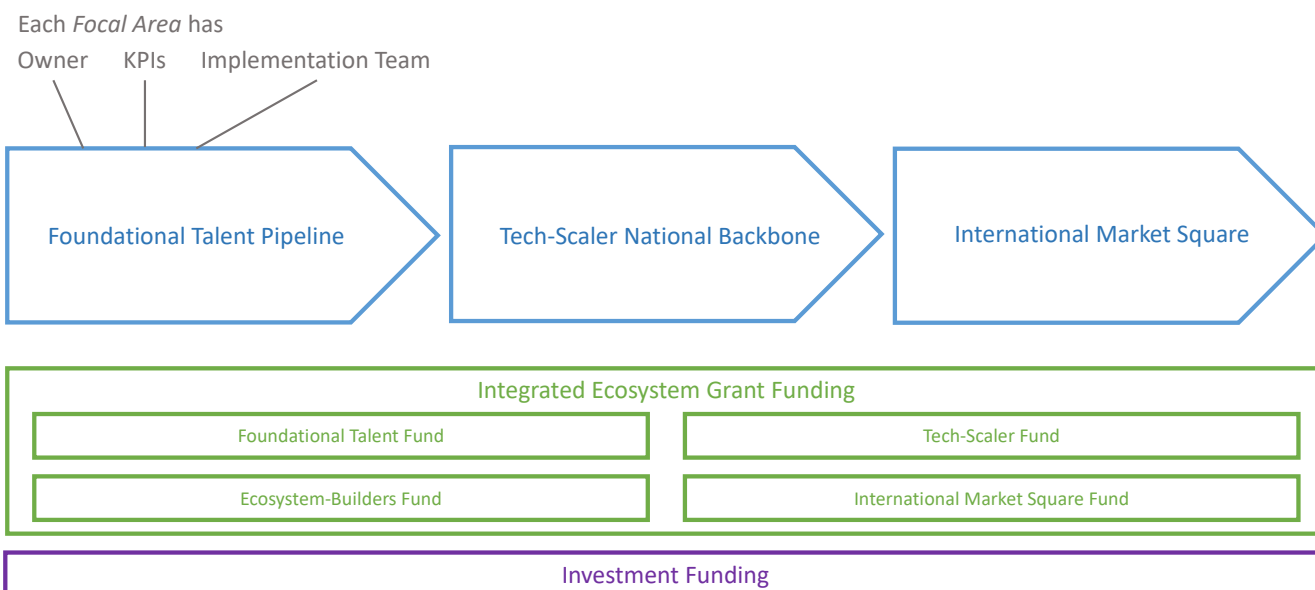## Principles for Governance and Oversight

In the principles below, we use the term *programme* to refer to the delivery of the collective recommendations contained in this review.

- **The programme should be designated as a primary strategic goal of the Scottish Government**. Such a designation creates more impetus for stakeholders to work together to deliver it. A Scottish Government Cabinet Secretary should own the programme and be accountable for its outcomes.

- **All participating agencies and institutions should explicitly and publicly commit to the delivery of the programme.** Where an institution is unable or unwilling to make such a commitment, and where practical, the party should be removed from involvement in the programme and other routes to implementation sought. Passive resistance is an effective mechanism for suffocating a programme of this nature. We should be realistic about that.

- **Where possible, all participating agencies and institutions should be strategically incentivised to deliver the programme outcomes.** Without this incentivisation, the risk is that some participants pay nominal attention to the programme but subordinate it to local considerations. Participating parties need some reason to spend time and energy on a programme that doesn't immediately deliver some local benefit in return for that effort.

- **A Programme Management Office (PMO) should be set-up to manage delivery of the programme, run by a senior Programme Director, who reports to the Owning Cabinet Secretary.** The programme is broad and complex. It will require intensive and continuous management. A multi-agency approach won't work without over-arching coordination by a properly-supported, single responsible party.

- **All stakeholders should use the ecosystem model described in this document as the basis for assessing interventions, measurement and outcomes.** The importance of this point is that the programme will not be successful unless all stakeholders share a common terminology and appreciation of its goals, and a shared understanding of its operating mechanisms.

- **Governance of the programme should include people who actually work within the ecosystem, and who understand it.** Otherwise the programme will drift from its original purpose and imperatives.

- **The programme should avoid "over-coordination" and "bureaucracy as the goal".** In formulating these proposals, we recognise that over-coordination is detrimental to the ecosystem's goals; we would risk retarding the work of the many organisations and volunteers that support our technology industry already. An approach must be sought that provides the necessary level of coordination but no more than that; the agility and independence needed by ecosystem participants to evolve our ecosystem at world-class pace must be preserved.

- **The PMO should operate a balanced scorecard, based on the five focal areas.** The scorecard would provide a summary means of tracking progress over the lifetime of the initial programme, and beyond if necessary.

Balanced Scorecard

Each *Focal Area* has

Owner   KPIs   Implementation Team

Foundational Talent Pipeline	Tech-Scaler National Backbone	International Market Square

Integrated Ecosystem Grant Funding

Foundational Talent Fund	Tech-Scaler Fund
Ecosystem-Builders Fund	International Market Square Fund

Investment Funding

Governance Operating Model

The PMO would be responsible for implementing the above principles and reporting on progress against the balanced scorecard. It would be structured as follows (titles are nominal):

- **Senior Programme Director,** reporting to the Owning Cabinet Secretary.

- **Foundational Talent Pipeline Programme Manager**
  Recapping, this focal area groups recommendations for interventions and improvements at School and University level as well as "funnel wideners" such as Codeclan, extra-curricular organisations, and the attraction of external talent and experience into the ecosystem.

- **Tech-Scaler National Backbone Programme Manager**
  This focal area concerns building a national network of "Tech-Scalers", combining best practice in incubation and acceleration and including integrated grant funding.

- **International Market square Programme Manager**
  This focal area groups recommendations designed to enhance Scotland's market square activities, across all levels of scale from small meet-up to international conferences.

- **Integrated Ecosystem Grant Funding Programme Manager**
  This focal area groups all recommendations designed to align public grant funding support to the above areas. The emphasis in this category is on achieving close alignment to the ecosystem's needs.

- **Investment Funding Programme Manager**
  This focal area groups all recommendations designed to better support the flow of investment funding to start-ups.

As necessary, the owning Programme Manager in a given focal area would convene a sub-group, consisting of representatives from the key stakeholders, including those that directly work within the industry, its agencies and institutions to coordinate the tracking and implementation of recommendations.

Of course, variations on this model exist. The point we wish to emphasise is that, in a programme with such a broad scope and which requires the active participation of multiple agencies over a long period of time, the risk of outcomes dissipating to zero is high without the up-front buy-in of all participants and the ongoing intensive application of the above principles.

Appendix A – Why can't start-ups scale?

This appendix supports the section Ecosystem Supporting Categories – Education with a deeper illustrations as to the importance of founding-team education to start-up success.

There are two main reasons that start-ups fail. Either the start-up's product or service doesn't fit the intended market, or it does but the organisation isn't capable of supporting and driving growth subsequently. The first issue is referred to as "finding product-market fit (PMF)" while the second is often called "organisational scaling".

Product-market fit (PMF)

It's generally not well understood within the Scottish ecosystem (and many others) how a start-up should go about the process of iterating its product or service to the point where it fits the needs of its market. This is an extremely important point because, once this has been achieved, the start-up's strategy shifts to one of scaling its markets and scaling its organisation to support that growth.

It is very common to see start-ups declare that PMF has been achieved, and start to attempt scaling when, in fact, the market isn't interested in the product. This situation always ends unhappily. The Silicon Valley has a well establish playbook for how to go about this process and how to measure progress to the PMF goal. It's vital that this playbook is widely understood within our ecosystem.

Organisational Scaling

Of those start-ups that do establish PMF, most will still fail to grow to scale due to fundamental errors in managing subsequent organisational growth. In regard to this point, it's interesting to note how many start-ups that appear to have PMF fail to expand their team size much beyond 30-40 people. The common pathology is that a series of organisational "micro-implosions" happen as the organisation attempts to expand, resulting in staff leaving, management being changed out, and so on. The process then repeats. And so, the start-up is unable to fully exploit its market potential. What's happening inside those organisations?

Consider the following chart, which plots the *Outcomes* intended by a business (a start-up or scale-up, for example) against the number of employees in the business. "Outcomes" here is meant in the context that's relevant to the particular start-up in question; for example, products shipped, customers won, etc., these are all examples of desired *Outcomes.* What every start-up wants to achieve is the dotted-line outcome – outcomes grow faster with each new hire. But most would settle for the solid line – as more people join the business, more outcomes are generated.
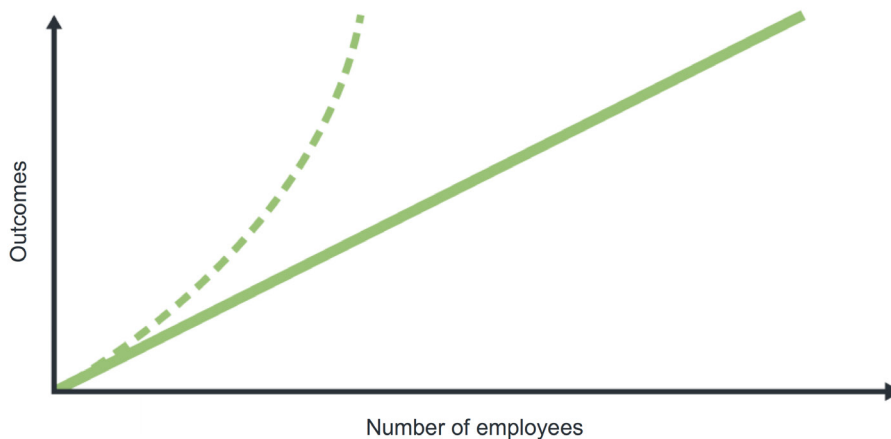
In reality, the following pattern is far more common – at around 30-50 employees, outcomes start to level off as more employees are added. A minority of start-ups make it through this stage (following the path of the solid line), but many more fail to do so, and eventually follow one of the dotted-line paths.
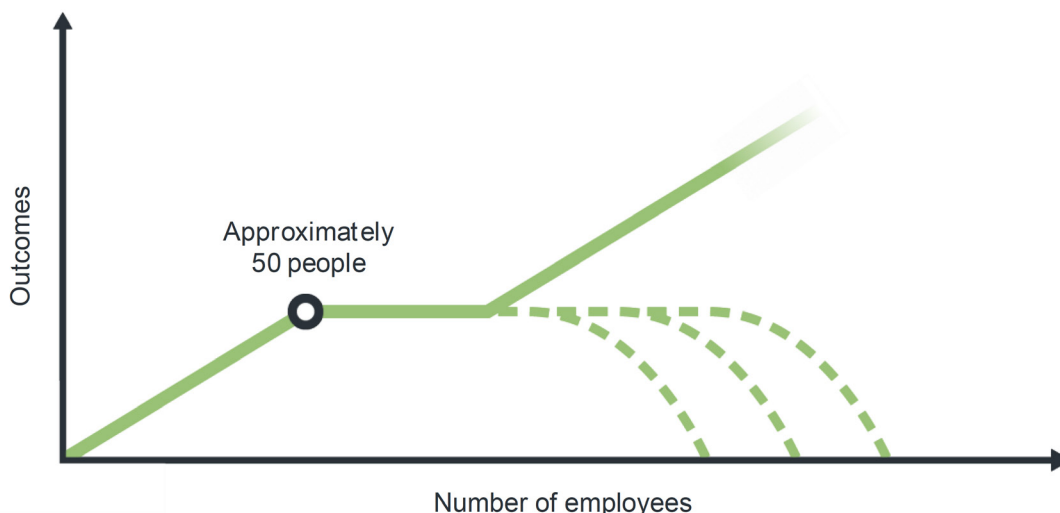
If the organisation *does* make it past this inflection point, then others are waiting; a similar inflection point will occur around 100 employees, around 200 employees, and so on. The pattern is almost geometric. But, at each stage, fewer and fewer businesses move on from that inflection point:

$$N \approx 50 \times 2^{(i-1)}$$
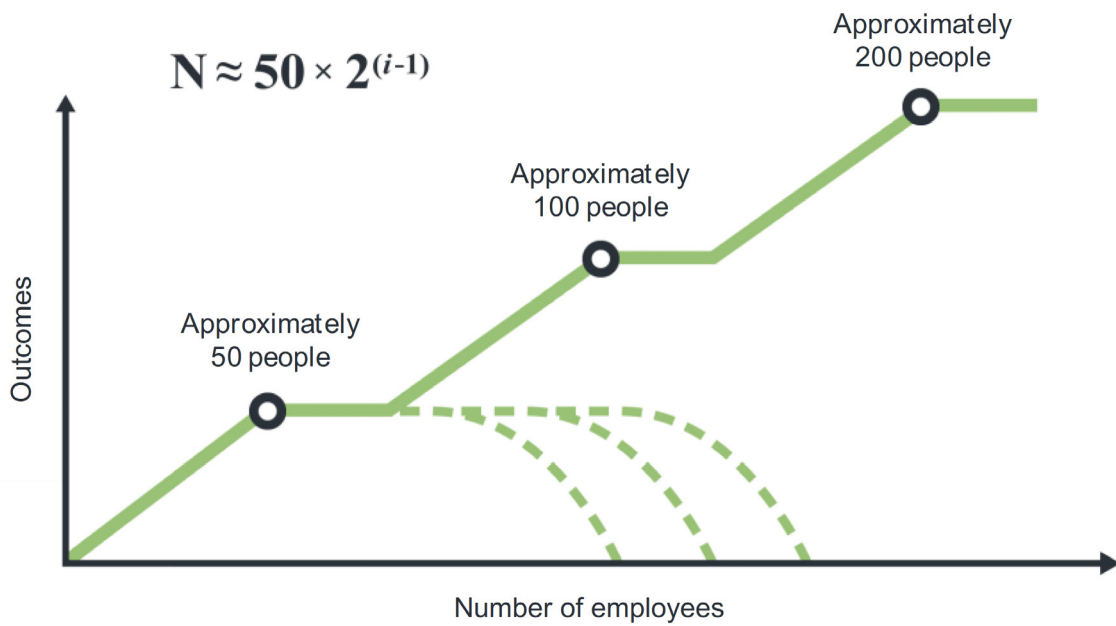
What's causing this to happen? The organisation is a combination of three things:

- Its people, and their capacity and ability to perform the work required at a given level of scale (e.g. manage ever larger teams, etc.);

- Its processes (that those people operate);

- Its structures (within which the people operate those processes).

At each inflection point, these three fundamental elements "scale-out" in some combination – what worked at a smaller level of scale breaks at the next level.

Scaling a tech business (or, indeed, any businesses) is largely about recognising these inflection points as they arise and knowing either what organisational patterns to use at the next level of scale or knowing how to change the organisation to navigate past the inflection point.

This is particularly a problem for Internet Economy tech start-ups because, once PMF has been achieved, available markets tend to exhibit rapid scalability, requiring the organisation often to rapidly scale too, in support of that growth.

The problems described above – finding PMF and organisational scaling – underline the requirement for the start-ups and scale-ups in Scotland's ecosystem to understand these methods ahead of time, and not after the fact; hence the requirement for outstanding educational support for founding teams in these businesses.

Scottish Government
Riaghaltas na h-Alba
gov.scot

w w w . g o v . s c o t