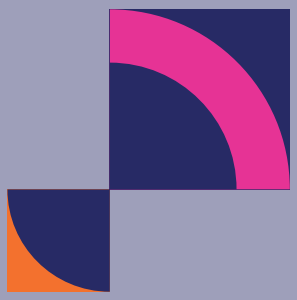

MIT Lab for Innovation Science and Policy

WORKING PAPER

An MIT Framework for Innovation Ecosystem Policy:
Developing policies to support vibrant innovation ecosystems (iEcosystems)

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MIT innovation initiative

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'Innovation' is much sought after but not often well understood. For policy-makers, it can be challenging to analyze and help create the conditions for innovation. Understanding the phenomenon of 'innovation' (and particularly the complex ecosystems in which it seems to thrive) would enable a more systematic assessment of the policy options available. To that end, and in response to requests for such a policy typology from those we have taught at MIT and elsewhere, we set out in this Working Paper the MIT framework on 'innovation' as it may provide a way for those responsible to assess the many policy options and choose those that might more effectively catalyze the innovation economy in their specific circumstances.

In short, our MIT framework separates out two key capacities for broad innovation: first is for a traditional and rather narrow form of 'innovation' itself (known as 'I-Cap') but then there is a second capacity, namely for 'entrepreneurship' (E-Cap). Drawing on this MIT approach, a policy approach should consider policies and possible interventions that recognise this bifurcation, so as to have the desired effect on the creation and growth of innovation ecosystems.

With much high-impact innovation coming today from start-up enterprises rather than large corporates, it's especially important to assess those conditions that support the start-up and growth of what MIT identifies as 'innovation-driven enterprises' (IDEs), i.e. the subset of small/medium-sized enterprise (SME) startups which have the potential for extraordinary job creation and aim to develop solutions to important problems.

In our experience working with policymakers around the world, the challenges of fostering the formation and scaling of IDE start-ups arise for a number of different reasons:

- First, innovation takes place in complex 'systems' so there is no singular magic solution for fostering innovation or catalyzing IDEs: rather, a coherent collection of interventions, including on the policy side, is often needed;

- Second, such strategic interventions require an understanding of 'innovation' writ large (especially the innovation ecosystem in which it is often highly concentrated), so that they have the desired effect on the system's elements;

- Third, public policy is usually the domain of Government, but the success of innovation policy is made all the more complex given the different tiers of governance that are often relevant to its design and implementation, and each tier's varied responsibilities.

- Lastly, effective innovation is dependent on the involvement and support of at least four other key stakeholder groups (i.e. industry/corporates, risk capital, entrepreneurs and academia/universities), and this applies to choices about policy.

This Working Paper starts with MIT's analysis of 'innovation', and especially the importance of the complex 'innovation ecosystems' in which it seems to best thrive; we then introduce the MIT 'ecosystem' model, describing the underlying 'system' and two key 'capacities' required for innovation and specifically IDEs to take root and thrive. We then suggest the role for policy within this framework, so the capacities can be understood, analyzed and strengthened.

We have produced this Working Paper and its typology at the request of policy practitioners, and therefore welcome feedback (and other examples) as we build this out as a useful tool to drive both action and reflection.

MIT's analysis of 'Innovation'

Writ large, 'Innovation' – as defined at MIT – is the "process of taking new-to-the-world ideas from 'inception to impact'…" (whether economic, social or environmental impact). There is a growing recognition that innovation is often, although not always, highly concentrated in regions that we refer to as "innovation ecosystems".

To simplify the phenomenon of 'Innovation', we draw on MIT analysis of systems (both systems thinking and systems dynamics) to explore a framework for better understanding why innovation is stronger in some ecosystems than others. The framework emphasizes the role of two critical 'capacities' that together serve as the 'twin engines' of innovation ecosystems, and that need to be developed for such ecosystems to thrive: these are namely innovation capacity (I-Cap), and entrepreneurship capacity (E-Cap), which rest up foundational institutions. At the ecosystem level, these capacities are often focused around specific areas of comparative advantage which lead to impact.

-- Figure 1: MIT "system" for Innovation --

Many times, but not always, impact is achieved through some 'entrepreneurship' – defined as enterprising behaviour and enterprise-formation, from the earliest stages of start-up, through scale-up to large enterprises. Crucially, many types of 'enterprise' do not harness innovation and are thereby limited in their potential for impact or growth. As such, we focus on a subset of 'innovation-driven enterprises' (IDEs) that blend these two elements to have the potential for extraordinary job creation and to develop solutions to important problems (as opposed to more traditional and locally-focused small/medium-sized enterprise (SME) start-ups).

Innovation capacity (I-Cap) is the capacity of a place – a city, a region or a nation – to develop those new-to-the-world ideas and to take them from 'inception to impact' (whether this be economic, social or environmental impact). In other words, innovation capacity covers not only the development of basic science and research (often captured as R&D) but also the translation of their solutions into useful products and services that truly solve problems.

Entrepreneurship capacity (E-Cap) emphasizes the enterprising capacity and 'business environment' for forming new enterprises, from the earliest stages of start-up through scale-up to full corporate enterprises. While this capacity supports all types of entrepreneurship (most of which leads to SMEs), those aspects of most interest to innovation policy are the ones supporting the 'innovation-driven' side of entrepreneurship capacity, tailored to support the growth of IDEs.

It is the combination of, and linkages between, innovation and entrepreneurship capacities within a given city, region or nation that produce the high-impact IDEs that are a critical engine of new solutions to important problems, of long run job creation, and ultimately of economic prosperity and social impact.

Drivers of the Capacities for innovation and entrepreneurship[1]

We think of a 'capacity' as a sort of 'production function' - i.e. a way of relating a series of well-defined inputs to outputs, in this case a series of five input categories into entrepreneurial and innovative capacities: human capital, funding, infrastructure, demand, and incentives/culture.

Through a policy lens, it is critical that these inputs into the production function be defined and then optimized for - or at least made as accessible as possible for – innovation and entrepreneurship. For innovation, we must optimize inputs to enable those who wish to move ideas from inception (e.g. in the lab) through to impact in a variety of organizational settings (not just in start-up enterprises). For entrepreneurial capacity, we must emphasize inputs that allow not only for a better 'business environment' and formation of the innovation-driven subset of startups but also for the scale-up of all enterprises.

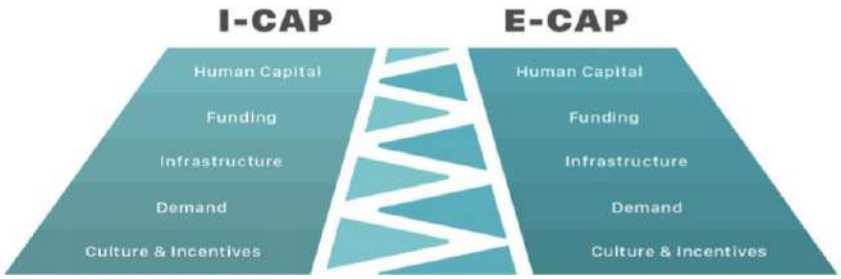
Our experience advising in a wide range of policy settings and across different countries builds upon MIT's approach to innovation ecosystems as applied in a variety of locations – some within the United States but also many from regions worldwide (including Tokyo, Singapore,

[1] Further detail will be available in our separate Working Papers on Enterprises and Stakeholders available through the MIT Lab for Innovation Science and Policy.

Finland, Saudi Arabia, Seoul, Scotland, Lagos, Morocco, London, Israel etc.). Rather than simply recommending a broad and unstructured list of policy interventions, MIT's approach can add structure and a robust framework to innovation policy by emphasizing distinctive policies to support I-Cap and E-Cap.

As our framework suggests, in each dimension, innovation and entrepreneurial capacities must be supported through an array of interrelated policies – and strengthened not simply through one singular change or even one change for each capacity. This need for coordinated interventions across a range of different inputs can be challenging for policy-makers wanting to have an impact in a relatively short period. However, by linking policies to the various inputs into I-Cap and E-Cap, the policy challenges that accompany the effort of driving economic prosperity and social impact through innovation can be mitigated or at least addressed.

We consider five critical dimensions for inputs into the I-Cap and E-Cap production function (see Figure 2), and then provide a framework within which to consider policy actions that can be used to enable more effective capacity in both dimensions.



-- Figure 2: MIT's I-Cap/E-Cap framework

These five dimensions (as set out in the MIT framework above) are:

- **Human Capital** (people) – the appropriate human capital in the form of talent (from within a region or attracted into a region) with relevant education and experience for either innovation or entrepreneurship (or both).
- **Funding** (often 'risk capital') – a variety of types (from the public and private sectors) that supports innovation and entrepreneurship, at their origin but also through the journey from idea to impact, or start-up to scale-up.
- **Infrastructure** – the physical infrastructure that is necessary to support innovation and entrepreneurship at different stages – including space and equipment required for discovery, production and supply chains etc.
- **Demand** – the level and nature of specialized demand for the outputs of the innovation and entrepreneurial capacities, supplied by different organizations in an ecosystem.
- **Culture & incentives** – the nature of role models & individuals who are celebrated, social norms that shape acceptable career choices and incentives that shape individual and team behaviors.

This simplified framework allows decision-makers to determine their systems' greatest points of weakness and thus identify the points of leverage in their own system. And, as we outlined in other work, good metrics for each of the different inputs into both I-Cap and E-Cap are important and provide further guidance to decision-makers on the areas which require the greatest policy attention.[2]

For each of the different inputs into I-Cap and E-Cap, there are a variety of policy levers that can be used to enhance access to these specific resources and to ensure that they are available as inputs into innovation and entrepreneurship. And, it is important to consider other policies that enable and ensure that the linkages between I-Cap and E-Cap are strong and deep. While this means that there is a long list of potential levers, this variation provides choice on the one hand and on the other recognizes both the complexity and the multi-departmental opportunities across government for innovation policy.

It should be noted that across this range of policy interventions, the evidence supporting the effectiveness of some levers on the innovation ecosystem is varied: some is based on extensive econometric analysis that conforms to the highest standards of evaluation and evidence. For others, it is based on the collective experience of a range of innovation ecosystems around the world, with more structured evidence still being developed.

These policy levers can best be considered for each of the dimensions of I-Cap/E-Cap in turn:

- Human Capital,
- Funding,
- Infrastructure,
- Demand and
- Culture/Incentives.

We now turn to each of these dimensions, listing some of the more important policy levers that we have identified in our global teaching of this approach. We welcome feedback on these levers, examples of others and insights into specific application, as we build this out as a useful tool to drive both action and reflection.

[2] See our joint Working Paper on "A systematic MIT approach for assessing 'innovation-driven entrepreneurship' in ecosystems (iEcosystems)" on the MIT Laboratory for Innovation Science and Policy's website:- https://innovation.mit.edu/assets/BuddenMurray_Assessing-iEcosystems-Working-Paper_FINAL.pdf

1. Human Capital

Policy for human capital includes levers critical to build the talent base in a region or country: three are education policies, mobility policies, and non-compete agreement (NCA) policies.

- **Education policies** can provide individuals (and teams) with specific training in a wide variety of scientific and technical disciplines (for I-Cap) and entrepreneurial skills and knowledge (for E-Cap). For I-Cap, we note that, well beyond training at the frontiers of knowledge, there is a clear requirement for training in how to move ideas from the bench into the world: these skills include prototyping and design, through to commercialization expertise in production and manufacturing of all types. As a concrete example, MIT recently launched its Undergraduate Minor in "Entrepreneurship and Innovation" which includes a course on "innovation engineering" focused on the needs of the future Chief Technology Officer (CTO). For many years, there was a perception that entrepreneurship – ie E-Cap - was a personality trait. Today, we recognize that entrepreneurship can be taught and that 'entrepreneurship education' includes a set of skills and knowledge that can be imparted in the classroom and through a range of well-designed experiences. Policy changes in grant-making and doctoral training have led to shifts in interest in provision of such skills. For example, in the UK, recent guidance to the government has suggested widening the availability of optional courses in entrepreneurship across many undergraduate programs.[3] And Singapore's Summation Program is supporting apprenticeships in deep tech start-ups. At the same time, changes in secondary STEM education to emphasize coding, design, making and other 'hands on' skills are critical policy shifts supporting I-Cap.

- **Mobility policies** have a key role in shaping the ebbs and flows of human capital, influencing the international migration of individuals into (and out of) a region, as well as the 'stickiness' of a region in terms of retaining people. While immigration is often controversial, visa policies (and policies to attract returnees) can emphasize expanding a workforce that is highly trained in innovation (thus building I-Cap) and/or entrepreneurship (building E-Cap). In particular, specialized and focused visa policies can enable those trained with PhDs to stay in a country, with other related visas for specialized talent, and entrepreneurs' visas. The relevance of such levers is illustrated in the well-known fact that much of Silicon Valley's success can be traced to the diverse immigrant population. Likewise, the UK's recent entrepreneurs' visa was an integral part of the revival of London's vibrant innovation ecosystem. More broadly, policies such as those in Singapore that encourage returning innovators (as a requirement of their international STEM scholarships) support the flow of STEM (i.e. I-Cap) talent. For outsiders, Singapore's EntrePass scheme attracts international

[3] https://www.gov.uk/government/publications/improving-entrepreneurship-education

entrepreneurs[4] with a growing emphasis on attracting talent in 'Deep tech" while the UAE has a new ten-year visa for investors and entrepreneurs.[5] In contrast but with a complementary approach, the US state of Rhode Island's recent Wavemaker policy to pay back student debt (earned in any university in the state) in return for them staying in the region to work for STEM-oriented companies is clearly a play for both I-Cap and E-Cap.[6]

- **'Non-compete agreements' (NCA)** are a third critical element of human capital policy. As with visa policy, NCA policy is grounded in the idea that I-Cap and E-Cap can most effectively be created and leveraged through high rates of mobility of individuals within regions – and from one job to another. The sharpest policy lever enabling such movement is focused on the role of 'non-compete agreements' (NCAs), i.e. legally binding elements of employment contracts that place time-based limitations on individuals taking their talent from one organization to another. There is growing evidence that regions, by relaxing NCAs – and thereby easing the barriers to mobility – enable innovation through the movement of ideas across organizations.[78] And in response, a number of US states have changed their non-compete policies both for workers in low paid employment and for highly paid, highly specialized STEM talent. In Norway, under the Working Environment Act, new non-competition rules have also been put into place to stimulate the innovation economy.[9]

[4] https://e27.co/singapores-entrepass-visa-requirements-changed-almost-nobody-noticed-20171220/
[5] https://www.khaleejtimes.com/business/local/new-visa-policy-will-make-uae-a-global-innovation-hub-
[6] https://www.ri.gov/press/view/27447
[7] https://www.economist.com/leaders/2018/05/19/the-case-against-non-compete-clauses
[8] https://www.brookings.edu/wp-content/uploads/2018/02/es_2272018_reforming_noncompetes_support_workers_marx_policy_proposal.pdf
[9] https://www.idiproject.com/news/norway-changes-rules-non-competition-non-solicitation-and-non-recruitment-clauses-employment

2. Funding

Policy levers for Funding include levers to provide incentives for capital to flow to innovation-driven enterprises throughout their lifecycles: we look here at four - ie R&D spending, tax policies, investment policies and public-listing requirements. Other policy levers shape funding into early-stage innovation (research) and its commercialization.

- **R&D spending targets** are probably the policy intervention most commonly associated with innovation policy. Especially in those frameworks that emphasize innovation capacity as compared to entrepreneurial capacity, the setting of R&D spending targets provides an important policy lever to move public funds into the economy and thus boost funding in I-Cap. The UN's recent Sustainable Development Goal (SDG) covering innovation (ie #9) focuses on boosting R&D as a percentage of GDP. The theory of course is that such public investment will 'crowd in' associated private investment and lead to higher overall levels of R&D spending, for a boost in economic growth. However, when attempted in isolation from other funding levers and separated from other aspects of policy enhancing I-Cap and E-Cap, these spending interventions are likely to be less successful, and may not in isolation deliver the expected 'return on investment' (ROI).

- **Tax policies**, such as for income and capital gains, on early-stage investment in high-risk innovation-driven enterprises can also be critical. Policies such as these change the incentives for investing in start-ups which have significant technical and market risk but do so in a way that enables staged investment decisions. For example, the UK's Seed Entrepreneur Investment Scheme (SEIS)[10] enables capital gains and income taxes to be structured to incentivize angel and later-stage investment into high-growth IDEs. It is part of a policy framework with four elements[11] and now emulated by other countries (e.g. Norway)[12]. Other, less well-known policies that change I-Cap and E-Cap funding include tax policies surrounding philanthropic investments. Policies that enable charitable funds to flow into for-profit start-ups in the U.S., for example, can help to generate additional funding for E-Cap (if those start-ups' solutions support a charitable purpose such as clean water or public health). Likewise, U.S. tax treatment of gifts to universities and research institutes shape and encourage patterns of giving for I-Cap across a range of different fields and disciplines.

- **Investment policies** shape the ease with which investors with different pools of capital can invest in high risk (but potentially high reward) IDEs. For example, prior to changes in the

[10] http://www.seis.co.uk/
[11] https://www.gov.uk/guidance/venture-capital-schemes-raise-money-by-offering-tax-reliefs-to-investors and https://www.ft.com/content/0faf5352-ad3f-11e4-bfcf-00144feab7de
[12] https://theforeigner.no/pages/columns/norways-tax-incentives-for-business-angels/

"Prudent Man Rules" in the U.S., it was extremely challenging for pension fund managers to put their funds into asset classes such as 'venture capital' (VC) that were considered high risk. With these changes, significant capital flows moved into these earlier stage ventures.[13] More recently, policies that support the creation and structuring of venture capital (VC) investment vehicles enhance the pooling of high risk capital at a scale that can mitigate risks of making early-stage investments. Among the most widely regarded are those developed in Israel through their Yozma program to support the creation of the first venture funds in the country.[14] Other countries have used co-investment schemes to invest in IDEs alongside professional investors e.g. Singapore's StartupSG Equity[15], but many have found that subsidizing venture funds from public sources is a complex and often fraught approach (e.g. in Canada) with evidence pointing to the effectiveness of systems that support private investment.[16] Most novel among investment policies developed in the US, UK[17], Mexico[18] and elsewhere are those that have brought accredited (and non-accredited) investors into novel crowd-funding platforms enabling more individuals to fund start-ups in the innovation economy.

- **Public-listing** requirements may also be salient to supporting the growth and scale of innovation-driven enterprises by enhancing or stifling the ambitions of IDEs to list on public markets and thus gain access to a much broader range of capital sources and instruments. Across countries, we can observe differences in public-listing rules that shape whether and when IDEs can go public and raise additional funding from a much larger range of sources and a wide variety of rules that encourage public listing e.g. by reducing taxes for SMEs in the period post listing.[19] Related policies are those which shape other types of exits including competition policy as it impacts mergers and acquisitions (M&A).

[13] https://www.cfapubs.org/doi/abs/10.2469/faj.v33.n1.26?journalCode=faj
[14] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2758195
[15] http://www.startupsg.net/startupsg-equity/
[16] https://themarketmogul.com/canada-needs-new-clear-venture-capital-policy/
[17] https://www.fca.org.uk/consumers/crowdfunding & https://www.fca.org.uk/publication/policy/ps14-04.pdf
[18] https://www.crowdfundinsider.com/2016/04/84977-mexico-prepares-regulations-for-debt-equity-crowdfunding/ & http://www.internationaltaxreview.com/Article/3822339/Tax-challenges-of-the-crowdfunding-ecosystem-in-Mexico.html
[19] https://assets1b.milkeninstitute.org/assets/Publication/Viewpoint/PDF/080417-Promoting-Participation-in-SME-Boards-through-Tax-Incentives.pdf

3. Infrastructure

Policy Levers for Infrastructure include those to ensure that regions have the most effective infrastructure to support innovation-driven enterprises: we cover five - planning/space policies, those around the use of specialized technical equipment, wider access to broadband internet, digital rules, and effective regulatory infrastructure.

- **Space**: A key component of E-Cap is the ability of firms to lease small amounts of space without incurring long-term costs and thus significant financial commitments during periods of uncertainty, when growth potential and rates are not well established. Leasing policies that enable start-ups and others to take short term, e.g. modular, leases are an important incentive to start/build entrepreneurial ventures. Policies that enable the construction of such places (within planning/zoning constraints) and experimentation among the right vehicles to deliver such spaces (eg university-based pplaces, private sector co-working spaces, etc) can be key.

- **Technical equipment:** Likewise, I-Cap is enabled by ensuring effective access to the wide range of highly specialized technical infrastructure that shapes the ability to bring ideas to impact. At a national level, for example, access to research facilities (e.g. national labs) has been identified as a key challenge by the U.S., recognizing that a lack of clear property management approaches has led a large fraction of its costly specialized equipment to remain idle for long periods.[20] There is clear evidence that making core research facilities widely accessible and standardized (e.g. cell banks, genetic engineered model systems, seed banks etc) enhance the productivity of R&D investments. Other infrastructure can include equipment such as e.g. Atomic Force Microscopes, fusion reactors, nano-facilities etc. And it can be found in universities, national laboratories and even international facilities. The need for sharing and exchange also expands to include laboratory space in small increments, e.g. for biological facilities, etc. While this may be driven by internal organizational policies (see for example recent UK and US universities),[21] government policies can be shaped to enhance the ways in which public-sector innovation infrastructure is made as widely available as possible. Recent examples of policies facilitating infrastructure access at the program level include LabCentral, MIT's Engine Room, and MIT.nano.

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[20] https://www.energy.gov/gc/access-high-technology-user-facilities-doe-national-laboratories and https://www.energy.gov/gc/access-high-technology-user-facilities-doe-national-laboratories

[21] https://newrepublic.com/article/132555/sharing-economy-comes-scientific-research; https://www.dur.ac.uk/research.innovation/governance/policy/equipment/

- **Broadband**: Also relevant to I-Cap and E-Cap is the provision of 'broadband' internet services, which can facilitate the engagement of start-ups from a variety of locations in the global economy and can aid effective development of I-Cap when large amounts of data and analysis are relevant. For example, through its national broadband network, the Australian government has set targets and developed policies to ensure that 93% of its population and enterprises are served by optical fiber even accounting for the geographic dispersion of the nation.

- **Digital policies** also shape access to digital data which provides critical information and infrastructure for both I-Cap and E-Cap. A nation such as Estonia in its 'E-stonia' policies have made their digital capabilities, ease of data integration and access and online portal a model for broader adoption of e-infrastructure and services in the country. At a more fine-grained level, appropriate and streamlined access to specific data about medical records, transportation, energy utilization, education etc. can provide a source of insights and opportunities that lay the foundations for new innovation to solve mission-critical challenges or to highlight key problems that are of national importance.

- **Regulatory sandbox policies** are also a key aspect of innovation policy that provide the regulatory infrastructure for start-ups and especially IDEs. In emerging sectors, as diverse as fintech, insuretech, autonomy and cell therapy, the regulatory environment is often complex, confusing or yet to be determined. A key policy role for the government is to provide a regulatory system that is at once flexible, given the unknown opportunities and challenges of innovation, but also clear enough to enable entrepreneurs to make important decisions and manage risk appropriately. An emerging approach using what is referred to as a "regulatory sandbox" is a solution for innovation policy that attempts to balance these goals. In the UK, this was first attempted with the financial sector with regards to fintech companies with the introduction of the UK sandbox by the UK's Financial Conduct Authority (FCA) in 2016. This allowed fintech start-ups to test products without a full regulatory process in place.[22] This broad approach has also been implemented in Australia: in the US, it is supported by the Treasury Department and implemented by the Consumer Financial Protection Bureau.[23] In Japan, the Regulatory Sandbox framework is being used more broadly to include artificial intelligence and internet of things as well as blockchain etc.[24]

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[22] https://cointelegraph.com/news/uk-financial-regulator-introduces-global-fintech-sandbox-90-success-rate-domestically

[23] https://venturebeat.com/2018/08/05/how-important-is-the-governments-new-regulatory-sandbox-for-crypto/; https://www.americanexpress.com/us/content/foreign-exchange/articles/regulatory-sandboxes-for-innovative-payment-solutions/

[24] https://medium.com/@maurizio.raffone/japans-regulatory-sandbox-8b552bae889f

4. Demand

Policy Levers for Market Demand include levers to provide incentives for organizations – public and private – to support purchasing and cooperation with start-ups of all kinds and especially 'innovation-driven enterprises' through their lifecycles: we look at three - government procurement, public sector prizes and public sector grants.

- **Public sector procurement** is an important driver of entrepreneurship. However, while governments often espouse the notion that their procurement can and will drive entrepreneurship, policy barriers can stifle the ability of start-ups to work with the government.[25] While many government agencies are broadly in favor of engaging with start-ups, they often have requirements in their procurement process that simply reject start-ups at the start – for example, by requiring three years of accounting information. Changing these requirements might be a simple step that policymakers can take to increase E-Cap. In recent years, broader policy changes, such the abolition or simplification of requirements for start-ups to engage in procurement e.g. the so-called "Pre-qualification questionnaire" in the UK, have started to ensure that it is less complex for start-ups to engage with large government agencies.[26] A recent U.S. example is the Department of Defense through its Defense Innovation Unit (DIU) which has sought to provide very different modes of defining "requirements" and specifications for solutions to the challenges of the 'warfighter' in an attempt to spur entrepreneurship (from start-ups) around specific goals. Likewise, the U.S. Navy has been exploring novel modes of rapid procurement to facilitate the uptake of new ideas i.e. to strengthen I-Cap through more effective demand pull.

- **Public sector prizes can drive innovation**. Through policy changes such as the US Science Prize Competition Act, government agencies can now use prize-based mechanisms to drive innovation toward specific national objectives and missions, especially those linked to building I-Cap. Likewise, policies that enable advance-market commitments for specific problem areas where market-based incentives are inadequate also enable innovation. As an example, the U.S. Orphan Drug Act provides specific incentives for those developing solutions to so-called orphan diseases.

- **Public sector grants can drive innovation**. Beyond novel prize mechanisms for building I-Cap, the development of policies that allow the sharing of specific problems or "missions" of national and economic significance can drive both the rate and the direction of scientific

[25] https://www.theguardian.com/small-business-network/2015/aug/19/three-percent-government-contracts-startups-change-growth

[26] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/402897/Lord_Young_s_enterprise_report-web_version_final.pdf

activities and thus of the entire innovation process, thereby shaping the direction of entrepreneurial start-ups. For example, the grant-making approach used by the Defense Advanced Research Projects Agency (DARPA) in its large programs provides strong signals of public-sector demand for solutions to specific problems. More recently in Spain, cities such as Barcelona have used novel approaches to share city problems to drive procurement and problem solving.[27]

[27] http://www.governing.com/news/headlines/cities-can-promote-innovation-procurement.html

5. Culture and incentives

Both culture and incentives can be affected by policy levers that support innovation and entrepreneurship, and which drive a more entrepreneurial culture that celebrates innovation-driven enterprises. They include policies at the beginning and end of the life of IDEs; policies on Universities' research assessment, intellectual property (IP) and licensing policies; and bankruptcy law for enterprises.

- **Policies for university assessment and ranking** for the purposes of research funding – either at the individual, departmental or university level – have a major impact on the incentives and culture that form around building innovation capacity within the university and getting it out into the economy – an issue recently being explored in Australia with an eye on their I-Cap and its role in economic growth.[28] Policies that favor only publications (e.g. 'publish or perish') will not spur a culture of innovation and entrepreneurship. In contrast, assessment frameworks that explore fundamental quality as well as potential for impact (i.e. ideas in Pasteur's Quadrant) are more likely to be effective in shaping research incentives and encouraging a culture of impact.

- **Intellectual property (IP) rules and regulations** with regards to the treatment of university-generated ideas – as well as licensing practices – are typically the subject of some national (or regional) policy-making which strongly shapes IDE formation. While universities may have leeway in the ways in which they interpret such policies, the mere presence of government funding for research provides a lever to change these policies at the institutional level. Evidence suggests that ownership of intellectual property (IP), and more importantly licensing terms for those wishing to further develop such IP, are critical in the innovation economy. Clear ownership enables the innovation process of inventors moving their ideas to research breakthrough. At the next stage, however, licensing terms that are favorable to entrepreneurs (and leave them with adequate equity, e.g. to attract further capital down the line) ensure there are incentives to move ideas from the bench to the market in a way that is acceptable to investors and founders. The Milken Institute report provides a particularly useful framework for assessing the role of IP rules on universities and later commercialization.[29]

- **The policy and law of enterprise bankruptcy** - while focused on the end of an enterprise's lifecycle - also shape an entrepreneur's decision-making process and thus incentives and

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[28] http://theconversation.com/boosting-commercialisation-of-research-poses-a-big-challenge-for-universities-42410

[29] https://assets1c.milkeninstitute.org/assets/Publication/ResearchReport/PDF/Concept2Commercialization-MR19-WEB.pdf

culture around entrepreneurship. Policies that use bankruptcy as a signal to limit the individual's ability to start another enterprise – e.g. by limiting access to personal funding - have a strongly negative effect on the incentives and culture of E-Cap in a region. For example, in Egypt, bankruptcy could once lead to imprisonment[30], while in France it can still prevent individuals from applying for a mortgage: in both cases, the chosen policy likely has a chilling effect on entrepreneurial intentions. Contributing to a culture dubbed as "fear of failure", such policies and incentives can dampen entrepreneurial activity and are therefore worth exploring in the context of innovation policy.

[30] https://www.economist.com/middle-east-and-africa/2017/01/12/startups-in-the-arab-world

Conclusion

Structuring the range of interrelated policy interventions needed to catalyze innovation writ large and sustain complex ecosystems can be a challenge. No singular, 'magic bullet' policy solution exists. Effective policy interventions build on an understanding of the phenomenon of innovation generally, but also the specific innovation and entrepreneurial capacities of the region. They also require collaboration and collective impact across a range of stakeholders in the ecosystem, and across the levels of government itself (given the different tiers of governance and each tier's varied departmental responsibilities).

This Working Paper has set out a basic framework intended to be useful for those responsible for making – or shaping – public policy with regard to innovation. It facilitates collective impact by isolating critical innovation and entrepreneurial capacities, allowing for their discrete evaluation and identifying policy levers optimized for catalyzing each of them.

In our experience, the key conclusions for most policy-makers, and for all those working within innovation ecosystems, are:

- First, innovation takes place in complex 'systems' so there is no singular 'magic bullet' policy solution but rather a collection of policy interventions;

- Second, such policy interventions need a good understanding of the phenomenon of innovation, so that they have the desired effect on the systems' elements (especially the separate innovation and entrepreneurial capacities);

- Third, public policy for innovation typically engages many distinctive departments and units across government – rarely being the purview of a single "innovation department". This provides opportunities for significant impact and engagement but also complexity and the need for coordination.

- Fourth, while innovation policy is usually the domain of the Government stakeholder - already one of the most complex stakeholders in the innovation ecosystem - policy requires multi-level engagement from its different tiers of governance (often including regional and city level actors and actions) but also engagement with – and consultation of – the other key stakeholders in the innovation ecosystem.