MIT Lab for Innovation Science and Policy

WORKING PAPER

An MIT Approach to Innovation:

eco/systems, capacities & stakeholders

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MIT approach to 'innovation': eco/systems, capacities and stakeholders

Innovation can mean many things to many people, and no-one has a monopoly: as such, it risks becoming a buzzword, surrounded by others, but it is in fact a key phenomenon. Below we set out the key elements of the MIT definition and approach. From this understanding flows our analysis of the process and how a state's various innovation units and agencies operate in the wider national innovation system in which they exist and engage the external ecosystem(s).

Innovation: a definition and a spectrum

MIT's systematic study of 'innovation' around the world – including in the national security and public safety fields – has resulted in three key and connected concepts: eco/systems, capacities and stakeholders. These build on the definition of 'innovation' from MIT's Innovation Initiative (MITii) simply as the: "**process of taking ideas from inception to impact**". (Interestingly, MIT does not include the word 'technology' as innovation is something else, even if it harnesses it.)

By taking a '*process'* definition of innovation, with a trajectory from '*inception'* all the way through to '*impact'*, this goes beyond a single moment of invention: it is then possible to look at the distribution of the underlying activities, assess key determinants and define the role of a range of individuals, teams and organisations (both private and public sector enterprises). In this context, an '*idea'* is a match (initially hypothetical) between a problem and a solution, with '*impact'* going beyond commercial profits (in the private sector), to include a variety of other outcomes, such as environmental, social, medical or security missions (in other sectors).

In much common discourse on innovation, we find at least two distinct types of activities that are often raised, but need to be more clearly distinguished: these can be regarded as being on a spectrum, and best placed within a 'problem/solution' matrix.

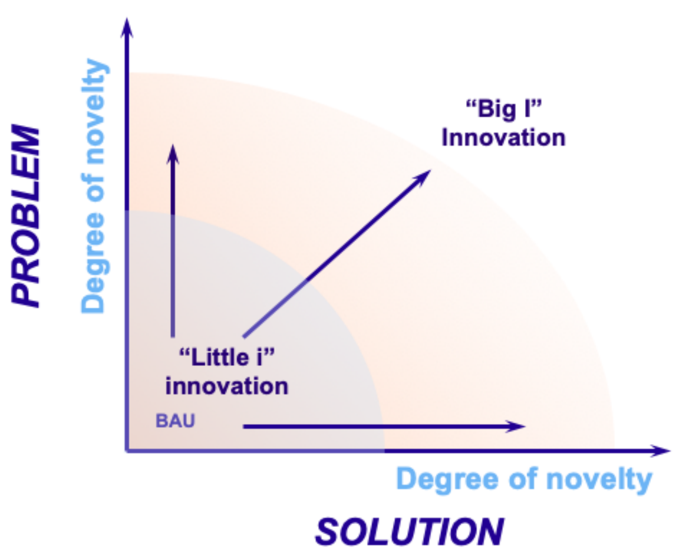
First, there is formal 'Innovation' (with a capital "I") meaning either the processes of taking novel S&T research and development (R&D) outputs (usually novel technological solutions to existing problems), or transformational innovations (matching novel solutions to novel problems), from inception through to impact: such impact is often described as being out on the frontier (or 'horizon 3') in the '10x' transformation category.

Second, there is a more modest form of innovation which covers the innovative adoption or adaptation of existing technologies, practices and resulting capabilities, ie innovation with a little "i" which would fall into more of a '10%' category: this signifies a more widely applicable set of innovative behaviours seen in private (but now also in many public) sector actors.

Along a continuum from little "i" to big "I" innovation are of course a range of activities, with many commonalities in terms of the process being undertaken, but also with considerable differences in time scale and aspiration. Below, our graphic plots the novelty of 'Problems' against 'Solutions' to create an innovation landscape.

Much formal S&T/R&D 'Innovation' is out along the x-axis, reaching out to low Tech Readiness Levels (TRLs) where an enterprise is looking to invent entirely new solutions to its existing problems (often in the 10x transformation range). A more dramatic vector of innovation is the one where an enterprise (often a start-up) aims to create big "I" solutions to entirely new problems: the level of risk here is higher given that both the problem and the solution have a higher degree of novelty. As such, this is often a difficult space for established enterprises.

As this graphic makes clear, there is another two-way vector of innovation, namely that of linking existing solutions to new problems. For a solution-owner, this can mean applying its existing innovation to new sectors or new problems. For a problem-owner, this can mean scouting that innovation frontier (or scanning that horizon) for existing solutions whose owner might regard that problem as being novel. Such innovation can occur here when such novel 'solution/problem' matches from other sectors and actors in the ecosystem are brought into your organisation, often on a much shorter timeline than traditional S&T/R&D efforts.



Of course, along all three of these vectors, the more informal 'little i' innovation is closer to (but still a step beyond) 'business as usual' (BAU) which itself includes incremental improvement. Such 'little i' innovation is a more modest but still honourable form of innovation (say in the

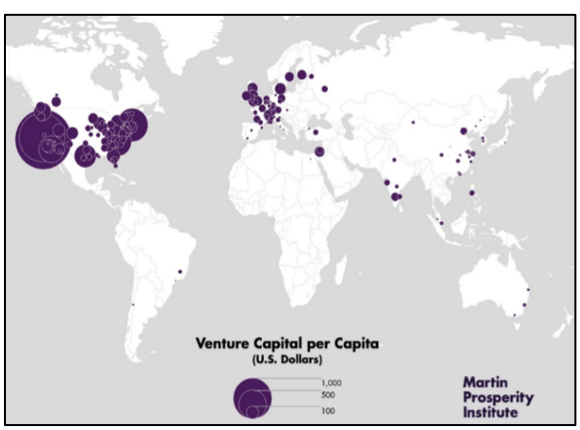
10% range) but draws on similar techniques as those for achieving ‘big I’, even if matching only slightly more novel problems and solutions together.

These different types of innovation are linked, exist along a spectrum (rather than being entirely distinctive) and are indeed supportive of one another. The successful organisations are the ones that recognize the differences between formal ‘Innovation’ and the more modest set of ‘innovative’ projects, and explores both in a portfolio approach. They also recognize that similar ‘agile’ practices and other organisational changes can serve both: this needs not only to be reflected in changes of staff behaviour and organisational culture, but also in the role played by senior leadership to enable such innovation to flourish. Simply adopting new technologies (from R&D or outside) will not deliver the expected ‘return on investment’ (ROI) if they are not accompanied by changes to individuals’ behaviour, institutions’ leadership and resulting incentive structures – with all becoming more agile and adaptive.

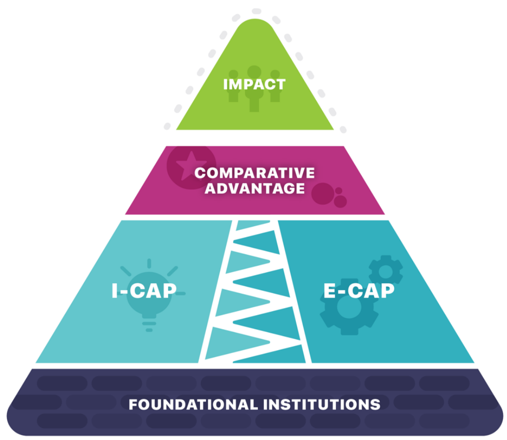
Indeed, many of the insights about ‘innovative’ behaviour, capabilities and culture are informed by MIT research into the practices behind world-class ‘Innovation’ organisations (including both R&D-intensive corporations, but also high-growth start-ups) whose effective deployment of talent and risk capital, and openness to experimentation towards specific problem/solution matches are essential to their impact.

Innovation: eco-systems

Innovation is not evenly distributed by whatever proxy measurement one chooses to assess it. Common measures include patenting, for example, as well as the scale of ‘venture capital’ (VC) deployed, though the latter probably understates the innovation in countries less dependent on open market systems. Regardless of the measure used, trends show that innovation tends to be most focused in geographically-bounded hubs which are characterised not only by dense concentrations of resources and capacities to support innovation but also a network of human agents and organisations facilitating rapid resource exchange and circulation to create an ‘eco-system’ of interdependent entities.



For any such geographical region (such as a nation/state), MIT has developed a systematic way to examine and assess how that region experiences and delivers 'innovation' (see the diagram below), allowing for some global comparison (at least with country-level data). This matters to our understanding of the ability of the public sector to deliver on innovation' because decisions about any state's system of agencies which it establishes to accelerate such innovation (whether for civilian, security or dual purposes) will be informed by this understanding of where and why innovation thrives in certain ecosystems.



In the MIT model, the core elements to such innovation are – at the base – foundations and institutions (e.g. rule of law) upon which much else rests. Above that are two distinct capacities – ie Innovation Capacity (I-Cap) and Entrepreneurial Capacity (E-Cap) – which are explored further below. In many regions and nations, the innovation economy is specialised around key activities of 'comparative advantage' (that may be defined in terms of sectors, technologies or assets). The 'impact' of these elements can be measured in a variety of ways (e.g. economic, social, security, etc) – hence our use of the term to allow for context-specific choices.

Innovation: state systems

To achieve innovation across the landscape outlined above, governments have established their own 'systems' of state agencies, units and departments each of which is focused on innovation in its own particular sector or mission (as well as agencies and units designed to support big "I" innovation across a wider set of domains): this is equally true for public safety and national security as it is for health or transportation.[1] As such, it is important that the review of any specific state agency, unit or department – and its mission and impact – should consider the state 'system' and the also the wider 'eco-system' in which it is embedded, and therefore the specific role it should play in order to have the appropriate impact and anticipated added value.

[1] Our recently published MIT Working Paper applies this methodology to the 'defence innovation' field, where states have a range of units, eg in the US from defence S&T labs through to DARPA itself as well as the more recently formed Defense Innovation Unit (DIU): https://innovation.mit.edu/assets/Defense-Innovation-Report.pdf

Such a system is itself not static, so the division of responsibilities among constituent parts will evolve and need to be re-designed, as their different operating models deliver impact on different time scales, and in different parts of the innovation landscape. A key insight from reviewing other states' evolving systems and changes to the innovation agencies within them is that this reform effort can often be viewed as a form of 'system experimentation' in its own right, with efforts to unlock greater 'innovative' behaviours and better 'Innovation' outcomes by adjusting and adding to the system, and the way it engages the wider eco-system.

In our system approach, the capability to 'innovate/experiment for innovation' is a key one – enabling the system (including for national security or public safety) and its constituent governmental parts to create new models that at once reflect and engage with each other, but also with the evolving wider economy and the external ecosystem's stakeholders.

Such external ecosystem awareness is driving current security agency interest in so-called 'dual-use' technologies, especially those pioneered in the private sector.[2] This is a particular focus (e.g. in the US), as the civilian economy outpaces that for national security in technological sophistication in key domains (especially digital) and in new enterprises (particularly new start-ups and ventures).

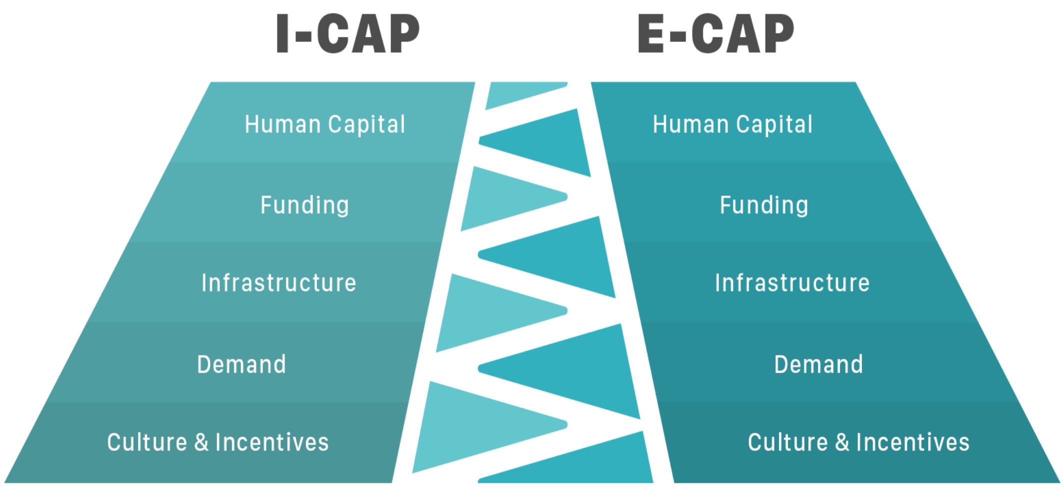
Innovation: an eco-system's two Capacities

Returning to MIT's model, there are two distinct Capacities, which provide the 'twin engines' of innovation. The first, Innovation Capacity (I-Cap), is the one most associated with traditional inputs, such as spending on research and development (R&D) or science and technology (S&T). While these are important and necessary inputs, they are not sufficient in explaining the range of innovation 'impact' outcomes that various countries achieve, including in the security space. Indeed, these are inputs principally for the Funding part on the I-Cap side, and there are a variety of other categories of inputs which will also be of importance to getting a return on that R&D investment. In short, it is not enough simply to ramp up spending on R&D (or S&T) and expect the desired innovation impacts.

The second Capacity is that related to Entrepreneurship (E-Cap). In some countries, the rules around the economy are optimised to encourage enterprise-formation (eg start-ups) and their

[2] The term 'dual-use' has its origins in the early Cold War, especially related to nuclear technologies which could have both military/weapon and civilian/industrial applications. In today's more digital phase of industrialization, the familiar 'dual-use' term needs to be viewed through the increasing imbalance between rapidly accelerating civilian capabilities and the much more limited governmental/military ones. As such, the balance of 'dual-use' has swung decidedly away from solely sovereign capabilities.

growth (eg scale-up) and expansion (eg through export promotion). These inputs clearly go beyond just the Funding aspect of E-Cap (such as 'risk capital', including formal Venture Capital (VC) firms), and also harness other aspects, such as existing Human Capital with a propensity and the incentives to be entrepreneurial. By itself, a strong Entrepreneurial Capacity (E-Cap) should lead to more enterprises, but many of these will be of the 'small and medium-sized enterprise' (SME) variety, rather than the high-growth, high-potential ones which harness innovation from the I-Cap side, and are likely to become – in MIT's parlance – 'innovation-driven enterprises' (IDEs) instead.



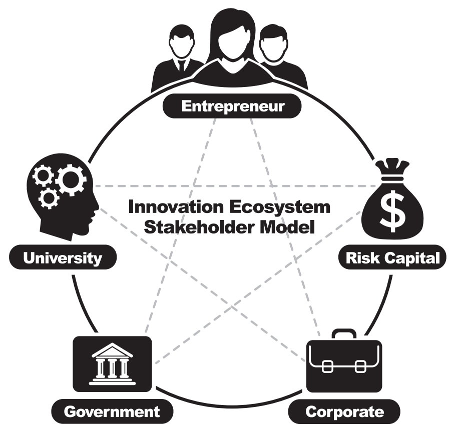
The two Capacities – I-Cap and E-Cap – are represented in this simple design above: innovation ecosystems do best when the two interact, leading to 'innovation-driven entrepreneurship', with start-ups that are more likely to become 'innovation-driven enterprises'. For each Capacity, there are 5 categories of inputs which go beyond just Funding – such as the standard R&D (or S&T) spend on the I-Cap side, or formal entrepreneurial 'risk capital' input (such as VC funding) on the E-Cap side – to cover a much wider set of metrics.[3]

Innovation: stakeholders

Lastly, the more successful 'innovation ecosystems' have active engagement from five key stakeholder groups, where each has a role to play. This model goes beyond the traditional 'dyad' of big 'public-private', Government-Corporate or 'military-industrial complex' relations, and even beyond the popular 'triple helix' which simply added the 'entrepreneurial' University.

[3] For a deeper dive into this 'science of innovation' approach and emerging ways to measure the various Inputs by Category, our recent Working Paper is an early systematic attempt to assess and compare these variables: https://innovation.mit.edu/assets/Assessing-iEcosystems-V2-Final.pdf

Instead, to understand today's innovation and its eco-systems, MIT regards it as important to include both the entrepreneurial community (creating the enterprises of the future), and the 'risk capital' providers (who assess and fund these new ventures). As such, this goes beyond just developing the 'entrepreneurial university' (of which MIT was Etzkowitz's archetype[4]), and adds these two additional stakeholders, as represented in the MIT diagram below:



Within innovation ecosystems, most stakeholders will have their own formal arrangements and systems for driving innovation. In the case of a Government, it will have a formal (and more or less rational) state 'system' of units and agencies which is designed to deliver innovation (eg for security/safety) and engage with a larger and more organic 'ecosystem' of non-state actors.

MIT approach to innovation for national security/public safety

MIT's systematic study of 'innovation' around the world and in a variety of sectors has resulted in three key and connected concepts (eco/systems, capacities and stakeholders) which all have applicability to the five stakeholders, and especially Government, even in the national security and public safety fields. Given the evolving nature and pace of innovation (often enabled by digital technologies, e.g. the latest waves of artificial intelligence (AI) and machine learning (ML)) and its concentration in certain ecosystems, however, many of the leading and most agile actors may be stakeholders other than Government (or indeed large Corporate) enterprises.

This phase of innovation creates challenges for Governments and the systems of state agencies. First, they are no longer at the 'frontier' of all key technologies and may have less visibility into horizon 3.

[4] Etzkowitz, H., and Leydesdorff, L. (1995). 'The Triple Helix: university–industry–government relations', EASST Review, Vol 14, pp 14–19. Etzkowitz, H. (2002), MIT and the Rise of Entrepreneurial Science, Routledge, London.

In earlier decades of inter-state competition (for example in the twentieth century Cold War), governments and their prime contractors (large Corporates) were clearly at the cutting edge of delivering security innovation. Whether it was for radar, rocketry or nuclear technology, the military-industrial ‘dyad’ was in the lead, and the barriers to entry in such security innovation were sufficiently high to keep most non-state actors out of such efforts.

Since the end of that Cold War, however, government actors have no longer had a monopoly on such innovation (especially in the expanding digital realm) to solve the challenges of a nation especially in regard to its safety and security missions. Increasingly, formal agencies in a state system have to look beyond themselves - and beyond even their traditional prime contractors, or their allied states, creating a ‘system of systems’ with their efforts at state innovation – to the external ecosystems in which they operate, and the other stakeholders in those ecosystems to meet the state’s security and other innovation goals.

Second, many states find that their ‘system’ of agencies and units for innovation is no longer optimally fit for service: moreover, instead of being the result of a design-led approach, the system had more often than not evolved over time, with some rational additions, but also the risk of duplication, mission-creep and other bureaucratic challenges. While the end of the Cold War allowed for some re-purposing and rationalization, many states’ systems have not had a formal re-organisation for the new phase into which they are entering. States that have been among the most reforming and innovative are also among the most revisionist adversaries.

Lastly, a simple re-organisation of the state’s system for security innovation will not be enough. With the need to link to a range of distinctive ecosystem actors – not simply well-established, prime Corporate contractors – there is a premium on security agencies becoming innovative internally, being effective not only at familiar big “I” vectors (such as from internal R&D/S&T), but also in how they seek to harness solutions from a range of external stakeholders across the innovation landscape. A traditional organisation is likely find it challenging to engage with less familiar entrepreneurs and their start-ups, or to scout and effectively harness new solutions out on the innovation frontier, no matter their ‘horizon-scanning’ in non-traditional sectors.

To meet these challenges, governments also need to encourage a more ‘innovative culture’ and/or ‘agile behaviour’ in its state agencies and their system. Internally, the agencies in the system need to evolve so as to be able to better engage the wider ecosystem of stakeholders (especially entrepreneurs and ‘risk capital’ providers) rather than just their established suppliers of traditional R&D/S&T ‘Innovation’. The latter also need to be more ‘innovative’ and ‘agile’ in the way they commission, fund and deliver their own ‘Innovation’ for the agencies.

Conclusions

With the system itself, the Government and its agencies need to consider the division of labour within and among the various constituent parts: a system that simply evolved may no longer be optimally fit for service today, requiring changes both within existing units and also among their roles and responsibilities. This is further complicated by the need for the state system of agencies to be configured so as to best engage with the wider ecosystem. It will be hard for the non-state innovators to support the Government if its own agencies do not have a clear, shared understanding of their division of labour, and who is best placed to engage whom on what.

The ways in which different agencies engage with their broader innovation ecosystems is also dependent not only on internal goals and existing capabilities but also on the nature of the local ecosystem itself. For example, the United States has multiple regional innovation ecosystems (as seen in the earlier VC map), characterized by several core locations – e.g. Silicon Valley, Boston, New York, Austin, etc. It also has significant depth in institutionalised venture capital (VC) and other related forms of 'risk capital' that enable rapid rates of start-up formation and scale-up growth across a wide range of sectors. In contrast, the UK has a smaller set of innovation ecosystems (largely based in London and the wider Golden Triangle) and with more highly specialized areas of expertise and comparative advantage in areas including AI.

Consideration of other state's efforts is useful up to a point, but the interaction of agencies in a state system, and then their engagement with the nation's local ecosystems, are sufficiently complicated so as to deny easy answers. Simply replicating one state's system or a specific unit (eg DARPA) without understanding how this was designed to engage its specific ecosystems (eg Silicon Valley and Boston) and other active stakeholders (eg US VCs or research universities) available to it would lead to a disappointingly sub-optimal innovation outcome. Instead, optimising for country-specific innovation goals as well as for ecosystem-specific strengths and weaknesses is a crucial part of a wider innovation strategy for any government agency intent on maintaining a strong process to deliver solutions to existing and emerging challenges.

All this is a challenge for state systems of innovation, which may have traditionally been more inward-looking, content to work with the usual suspects or relying on other states for the development of capabilities: now they must be designed to leverage private sector start-up growth with programmes that re-orient engagement with the ecosystems accordingly. Many states are now experimenting to find the best way to keep up, both with fast-moving technologies and less-hindered adversaries.