Open the box in times of uncertainty and globalized technical change:
Implications for Risk Governance, Knowledge Networks and Learning

Manuel Heitor
Center for Innovation, Technology and Policy Research
Instituto Superior Tecnico, Technical University of Lisbon, Portugal

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Abstract
The basic premise of this paper is that the central locus of innovation has increasingly become distributed and increasingly dependent upon linkages between many different institutions and sources of knowledge worldwide. First, the increasingly transnational business, technology and science require evolving from nationalistic approaches to new collaborative policy frameworks. Among these, large international collaborative arrangements play an emerging role. Second, the science and technology performance sectors, namely government, industry and academia, remain key players, but the connectivity, links and associations with other institutional players and agencies is no less important. In particular, the increasingly relevant role played by new technology-based firms is identified, which are also becoming global. This requires opening-up science policies to multiple public and private agents and promoting global research networks towards socio-economic resilience and active learning mechanisms worldwide. In addition, pro-active and adaptive risk governance for the advancement of technological innovation requires policy adjustments.

Introduction
Why research and innovation need to go global?...and why governments need to fund global research networks beyond national borders?

These questions are gaining increasing relevance as much of the political debate worldwide is centered on economic competiveness in the long term, most of the times under a rather “nationalistic” approach to innovation for growth. The question that does arises is if the acceleration of knowledge investments in China, India, Brazil and Russia signal the decline of the US and EU and should it be countered by aggressive “techno-nationalism” in the US and EU in any form?

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Any new narrative on global research networks requires the analyses of, at least, the last decades and the seminal work of Sylvia Ostry and Dick Nelson (1995)\(^3\), among many others for the last twenty years, has called for our attention of the relationship between the globalism of firms and the nationalism of governments, as well as the related interplay of cooperation and competition that characterizes high technology and knowledge-based environments.

It should be noted that the Brookings Institution’s project\(^4\) of the early 90’s has promoted this debate, although in a different international context, and clearly shown that tensions about deeper integration arise from three broad sources: cross-border spillovers, diminished national autonomy, and challenges to political sovereignty. As a result, the technoglobalism of the 80’s gave rise to national policies designed to help high-tech industries become more innovative and, consequently, the emergence of technonationalism.

It is under this context that the concept of “national systems of innovation” emerged in academia, mainly through economists and related schools of thought, to explain and explore how and why the systems have evolved differently in the major industrial nations, mainly US, Japan, UK, Germany and France. It was clear by then that the increasing international tensions and economic instability\(^5\) were largely a result of the attempt of governments to impose national technology and innovation policies on a world in which business and technology are increasingly transnational.

This brief working paper draws main implications of that trend over the last decades for new science and technology policies in times of increasing uncertainty and on the rise of globalization. We start by discussing the “old” paradigm of “national systems of innovation”, which is rather limiting on addressing emerging patterns of openness and international cooperation\(^6\). Then, we consider main issues on science and innovation policies, including the need to strengthen main pillars of research and education, an industrial base for socio-economic resilience and articulation with diversified stakeholders, including new technology based firms.

**Beyond national systems of innovation**

The concept of “national systems of innovation” has evolved during the last two decades, first in association with the need to fight against “market failures”, then against “system failures”. And it helped building new nationalistic policies all over the world, but just as business and science are becoming increasingly transnational.

The end result has been a frustration of national policies, on one hand, and a further move toward the multi-nationalization of business, on the other.

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\(^4\) Integrating National Economies, Brookings Institution.

\(^5\) See, for example, Galbraith, J. (2012), “Inequality and instability – a study of the world economy just before the great crisis”, Oxford University Press.

This requires many observations and, certainly, deepening the debate in relation to the current economic and social situation in the US and EU, as compared to those in newly industrialized regions and the, so-called, BRICS. First, the myth of “national” high tech industries and related policies to protect them requires to be better understood, if analyzed in terms of the increasing unemployment rates. Second, the debate itself on “national innovation policies” is in any case naive. No country, even in non-democratic regimes, ever seems to have had a broad, well coordinated innovation policy, mainly because of the complex structures associated with any “innovation ecosystem”.

Looking at the last two decades, the picture that is emerging at a global level is not very much different from that discussed by Sylvia Ostry and Dick Nelson in the early 90’s. In other words, one of increasing internationalization of private business strategies, while government innovation polices and science funding agencies remain overwhelmingly national. This is leading to new dilemmas for policymaking and to new sources of international friction, although with new boundaries and new players. The key issues to answer include what are the implications of increasing technoglobalism for national and international innovation policies, namely US and EU innovation policies? And, also, what new approaches are required to reduce international frictions and where do public policies need wider integration?

For the case of the US, the key message that emerges from analyzes of long-term patterns of investments in S&T is that of a diversity of policies that led over time to increased opportunities for citizens, as well as to increased institutional specialization based on a clear separation of the role of private and public incentives to support S&T7.

For Europe, recent analysis8 also argues that the debate on climate change, the recent financial crisis, and the new Chinese dominance of the world market, mean there is a need to revisit the role and design of industrial policy. This has been used to justify the need for renewed targeted sectoral intervention of governments, namely to redirect production and innovation towards clean technologies, as well as to make industrial policy more competition-friendly and more innovation-enhancing.

Analysis in the literature has also clearly shown that China’s capacity to innovate is evolving, but still limited as compared especially to the capacity of the US9. A similar comment could be raised about Brazil, India or Russia and, therefore, there is a large scope to better discuss innovation policies in a broad international context, well beyond national borders. In addition, a new paradigm of international academic, scientific and technological cooperation that seems to emerge10, as discussed below.

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10 Heitor, M.V. (2012), “How far university global partnerships may facilitate a new era of international affairs and foster political and economic relations?”, Science and Public Policy, submitted to publication.
Strengthening the pillars

At a time of increasing financial difficulties derived due to public budget constraints, there is the expectation that the links between research activity and its application in society will be reflected in more direct and immediate financial flows. However, this perception is leading to an institutional convergence between what universities do (and are supposed to do) and what firms and other agents do.

In fact, more than a decade after Burton Clark launched the idea of “entrepreneurial universities”¹¹, there is still much to learn about their impact and analysis has clearly considered this convergence a potential threat to the institutional integrity of the university and the future of scientific research due to the commoditization of knowledge¹².

The issue is not to “save the university”, but rather to understand who will play the fundamental and unique role that universities have played in the overall cumulative system of knowledge generation and diffusion. It is clear that many elites worldwide (including in the US and EU) are not willing to allow this integrity to be jeopardized. By misunderstanding national policies towards university-based research, there is a grave danger that university policy worldwide will destroy these basic functions, which would be detrimental to the global production of knowledge, but would also certainly harm the development prospects of many regions worldwide.

Overall, changing the patterns of teaching and learning, making students’ work more active, and fostering student-centered education schemes, are the ultimate goals of many leading institutions, which should be better understood at an overall level. We need to allow students to determine their own learning paths and trajectories, particularly through education cycles, but also across institutions in different regions and countries.

The debate requires tertiary education institutions in general to better understand how people learn. It is clear that learning systems vary considerably across the full spectrum of disciplines, with arts and medicine using project-based approaches and, probably, engineering and the social sciences following a more intense academic drift. The recent book by Tony Wagner¹３ of Harvard, as well as that published last year by Douglas Thomas and John Seely Brown¹⁴, represent insightful treatments about this theme.

Following the practices, skills, attitudes and values described above, education at all levels should take into account that learning a new practice requires moving through discovery, invention, and production not once, but many times, in different contexts and different combinations¹⁵.

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To achieve these objectives, we must learn from new research and, certainly, we also need to foster evidence-based project and experimental work, as well as to focus our attention on the transferable skills students should acquire. But we also need to reduce drop-out rates in tertiary education and to involve students in research activities from the early stages. In summary, we need to go beyond the structure of tertiary education and gradually concentrate our efforts on measuring and taking stock of the diversity and evolution of specific student-centered parameters.

But, in addition to that argument, we argue for a deep discussion about the complexity of stakeholder engagement and the politics of trust building in science and technology worldwide.

This is because, beyond any single measure, one may argue that it is the public understanding of science and the related level up to which people trust in academic and scientific institutions that determines the success of the politics of science and innovation policies. It is under this context that the systematic development and promotion of activities to foster science awareness, science education and the role of science in the daily life of citizens has been implemented in many regions and countries with a high level of priority in the innovation policy agenda.

Innovation and socio-economic resilience

It is clear that technoglobalism and the globalization of trade and supply chains led to the emergence of increasingly competitive global markets and to facilitated access to new suppliers, independently of their geographic location (Berger, 200516). This has allowed countries and regions with strong technological and industrial bases to profit on the lowering of trade barriers to access new markets, while the majority of firms located in other regions remained confined to local markets.

In addition, the analysis of the overall trend on moving towards knowledge intensive services and its relation with job creation and economic growth requires some pragmatism. This is because, in parallel to technoglobalism came post-industrialism, promoting services as the new developed countries’ economic growth overtook manufacturing industries. Captivated by the prospects of accelerated and cost-effective economic growth, many countries, the United States included, started shifting their focus from manufacturing industries to knowledge-intensive services (Hepburn, 201117; Ghani and Kharas, 201018).

The result is emerging with many regions worldwide lagging behind. In fact, evidence shows that, when compared to knowledge-intensive services, hard industries have higher labor productivities, a more balanced income distribution, higher income

growth rates and the ability to generate exports, which are negligible in the case of services (Nairn, 2002; Fingleton, 1999).

Looking at the US, together with other most developed economies (including Germany), we can identify some common factors, but also opportunities that need to be understood in international comparative terms: strong industrial bases, diversified economy, and supply chain and knowledge networks’ complexity (Amsden, 2001; Hidalgo and Hausmann, 2009).

Approaching this question requires the setting-up of a large task force for the “observation” of industrialization, to cover various aspects, including:

- The geography and dynamics of economic development and specialization – how scientific, technological and industrial bases evolve and impact socioeconomic development.
- The structure, geography and dynamics of supply chains and knowledge networks in different sectors and markets.
- Policy tools to foster local industrialization processes (e.g., public procurement, local production agreements, public expenditure in R&D and training).
- Deindustrialization processes, characterizing them and identifying, analyzing and governing related risks.

It should be clear that a new generation of industries will drive the economic recovery over the next decade, fuelled by long-term changes in technology, society and geopolitics. The recession has not been only a point of change, and many argue that it has acted as a catalyst for growth. As the business landscape alters, we will see the emergence of new ways of doing business in an increasingly interconnected world.

Engaging new technology based firms

Technology-based entrepreneurship is increasingly seen as a key element of regional competitiveness and that has been taken as “the model” for many other regions and countries worldwide. Silicon Valley and Route 128 in the Boston-Cambridge area, the most dynamic regions in the world today in terms of growth and innovation, were propelled mainly by new technology and the creation of startups - Apple, HP, Google, and Intel, to name a few. At the same time, start-up companies are also becoming global enterprises and engage in services, manufacturing, and research throughout the world, with strong links to universities and research groups. Others are going beyond their borders to procure products and services at lower prices, often from new companies or subsidiaries in countries like China, India and Brazil. Well-trained engineers and computer scientists from Bangalore and Shanghai are

competing for jobs that traditionally went to their counterparts in Europe and the US.

At the same time, research universities worldwide are attempting to “emulate” their US counterparts and foster a range of technology transfer offices and commercialization activities, together with industrial liaison programs, mostly intended to foster entrepreneurial environments and the launching of technology-based start-ups. Bringing ideas to the market is their main goal.

Notably, beyond the concentration of people and skills in a number of regions, a key issue that has differentiated North America from many other countries and regions is the availability of a mix of public and private funding sources, in a quite diversified pattern and, most of them, of easy access to SME’s. It is in this context that a few countries have tried to emulate the SBIR program ("Small Business Innovation Research"), which remains unique in many of its characteristics. Although many difficulties have been found in the public support to continue SBIR (as well as that of TIP at NIST), its enormous success and impact should be further acknowledge. This is a program of the utmost importance and relevance that has helped American innovative firms to growth. In addition, many other schemes to fund and support new technology-based firms have been used in America in quite original ways, namely through public procurement through the Defense and Energy Departments.

Forward looking

The issue is certainly how far we all take advantage of opportunities that arise with the increasingly dynamic and globally distributed geography of innovation, as well as how it fosters a new global order and help others to use similar advantages at local levels.

This is because one must take up the challenge of probing deeper into the relationships between knowledge and the development of our societies at a global scale. Our inspiration comes from, among others, the seminal work of Lundvall and Johnson, who challenge the commonplace by introducing the simple, but powerful, idea of learning. Lundvall and Johnson speak of a “learning economy”, not of a “knowledge economy”. The fundamental difference is to do with a dynamic perspective. In their view, some knowledge does indeed become more important, but some also becomes less important. There is both knowledge creation and knowledge destruction. By forcing us to look at the process, rather than the mere accumulation of knowledge, they add a dimension that makes the discussion more complex and more uncertain, but also more interesting and intellectually fertile in an international context.

This closely follows the lessons Eric von Hippel, at MIT, has provided in recent years based on the American experience that user-centered innovation is a powerful and general phenomenon. It is based on the fact that users of products and services - both firms and individual consumers - are increasingly able to innovate for

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themselves. It is clear that this is growing rapidly due to continuing advances in computing and communication technologies and is becoming both an important rival to and an important feedstock for manufacturer-centered innovation in many fields.

Eric von Hippel has also shown that the trend toward democratization of innovation applies to information products such as software and also to physical products, and is being driven by two related technical trends: first, the steadily improving design capabilities (i.e., innovation toolkits) that advances in computer hardware and software give to users; and second, the steadily improving ability of individual users to combine and coordinate their innovation-related efforts via new communication media such as the Internet.

In other words, beyond suitable technical infrastructure, the process of “democratization of innovation” at a global scale requires people with the ability to engage in knowledge-based networks without borders. It is about people and knowledge beyond national borders, and this constant interaction has gained particular importance in recent years.

It is clear that the emerging patterns of innovation require new perspectives for public policies, which in the US and in EU have in the past relied on supporting manufacturers and their intellectual property.

Certainly we need to move on from those days and consider better ways to integrate policies, as well as to diversify them at a global scale to better consider “win-all” approaches. A potential way to achieve this is to avoid overemphasizing current rivals sectors and competitive strategies, but rather to look at science, education and innovation policies towards new challenges that require a strong collaborative and pre-competitive approach.

Long-term challenges, namely those with current direct implications for US and EU firms (large and small), researchers and universities include the emerging opportunities associated with the democratization of human genome sequencing and the emergence of personalized medicine throughout the world, as well as the increasing convergence between health sciences, physical sciences and engineering. But also sustainable energy systems worldwide should be a subject of priority for government intervention and innovation policies with a great potential for global impact.

In this regard, and following the emerging discussion about the future of S&T, it is clear that, by and large, the financing of higher education and of science and innovation has occurred along rather traditional lines. Yet, the history of science is rich with varied means of financing science and technological innovation. More importantly, developments in the size, integration, and technologies available in global capital markets present the opportunity to think about new financing possibilities and processes of societal engagement in S&T policies. These involve

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moving from traditional, “one-way” (and most of the time fragmented) government policies, to integrated multi-stakeholder policies involving a wide range of public and private agents.

**Openness: research, education and risk governance beyond national borders**

Looking at the present and tentatively forecasting the future, we argue in this brief paper that a new paradigm of international academic, scientific and technological cooperation that seems to emerge as a major shaping factor for development at an unprecedented level.

Leading American research universities are playing a key role in this process worldwide, as a result of the accumulation of large investments in research and education over many decades now. It should be clear that this is not a new issue. For example, Morgan (1979) describes the role US universities played in helping to build and indigenous S&T base in developing countries until de 70’s and how far American Universities has engaged into that process. Some thirty years ago, Morgan recommended universities and policy makers about the future involvement on four areas: institutional building, cooperative R&D, resource base development, and education and training.

More recently this theme has been subject of various books and papers in the technical literature and, for example, the analysis of Bruce Johnstone, Altbach et al, as well as that of Knight, shows an active participation of US and EU universities in indigenous and local development practices, indicating related major advantages, as well as major challenges for them and national innovation policies in the near future. A recent report by the Royal Society further emphasizes these aspects in terms of scientific collaboration.

This emerging models of research and academic cooperation, that includes but do not seem to be a hostage of the traditional forms of services’ international commerce, may derive their uniqueness from the very nature of academic communities and from the strong meritocratic and universalistic ideals that prevail in science on an international scale. In addition, they are also driven by the flow of students and researchers, and by the citizen sense of being part of a “mission” for scientific and social development that motivates some of the best professionals in academic and research institutions worldwide.

It is under this context that innovation policies should help fostering a better understand of future international collaborative paths in education, science and innovation. Ultimately, this will become a key issue for competitiveness everywhere.

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Summary
This brief working paper attempts to launch new insights in science and technology policy. Its ultimate goal is to promote the discussion beyond “national systems of innovation” and to help clarifying the emerging diversity of policies and increasing institutional specialization and clarification of the role of private and public incentives to support R&D.

The paper argues for the need to promote and integrate public and private strategies in modern societies fostering a non-hierarchical integration of formal policies and informal system linkages leading to knowledge-driven societies. This requires opening-up science policies to multiple public and private agents and includes the continuous adaptation of systems of competence building and advanced studies, among which promoting global research networks should be highlighted.