A PRELIMINARY ASSESSMENT OF TRANSFORMATIVE INNOVATION POLICY IN MEXICO

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1 INTRODUCTION[1]

Mexico is one of the largest countries in the world and the 14th largest economy, as well as one of the 10 mega-biodiverse countries: it has vast natural resources and an enormous cultural richness. However, Mexico also faces grand challenges. As a country, it has one of the world's higher inequality levels. For instance, the richest 1% of the Mexican population owns 43% of the whole country´s wealth (Esquivel, 2015). Mexico ranks fifth in the World Corruption Perception Index (Transparency International, 2017). Violence affects the country, and gender inequality and violence against women position Mexico as one of the countries with the highest number of femicides. The uncontrolled and uneven development of huge metropolitan areas such as Mexico City creates pollution, health, mobility and safety problems. In turn, the big divide between cities and marginalised rural areas have created problems of social inclusion and economic development, reinforcing illegal drugs, violence and corruption issues due to the lack of control on certain territories. Furthermore, Mexico is facing climate change impacts and other consequences derived from overexploitation of natural resources.

When it comes to Science, Technology and Innovation (STI), Mexico shows a modest performance, at least with reference to a Frame 1 (R&D) or Frame 2 (National Systems of Innovation) approach (Schot and Steinmueller, 2016). This is measured through indicators related to the production and application of knowledge (e.g. scientific publications, patents) or knowledge transfer, learning and capacity building (e.g. mobility of PhDs, science-industry collaboration, or firm innovation. Despite the expansion of Mexico's STI system during the last decades (e.g. in terms of number of researchers, publications and STEM graduates), and the prominent role played by CONACYT in providing support for research and innovation, Mexico's STI outputs are still behind those of other OECD countries, in terms of excellence, performance, internationalisation and innovation. Furthermore, advances in entrepreneurship, high-tech industries, and international competitiveness, have provided few solutions to address some of the severe social and environmental problems that Mexico urgently needs to tackle.

In this context, Socio-Technical (ST) systems (e.g. mobility, energy, water, food, telecommunications, etc.), require a transformation to respond to Mexico's challenges. Transformative change means breaking with dominant socio-technical regimes and establishing new social relations and practices, and consequently re-alignment of institutions. Transformative innovation is an emerging approach to innovation policy, differing from both R&D and regulation (Frame 1) and a systemic approach

[1] All acronyms in the text referring to Mexican policies or institutions come from their original Spanish name.

based on learning, capacity building, social capital, and entrepreneurship (Frame 2) (Schot and Steinmueller, 2016). Transformative Innovation Policy (TIP) aims to solve grand challenges, which in turn will create social welfare and improve environmental sustainability. Therefore, whilst TIP does emphasise economic growth as much as other policy frames, it also aims for improved social welfare and environmental sustainability. However, rather than being a blueprint, TIP aims to experiment with alternative pathways that are highly context dependent. Thus, this report attempts to identify spaces for TIP in Mexico by analysing the evolution and rationale of Mexico's STI policies, main institutions, and the National Innovation System, under the lens of the three frames of innovation.

2 THE EVOLUTION OF STI POLICIES IN MEXICO

Understanding the rationale of current STI policies requires us to trace back the emergence of Mexico's economic, political and social reality, as well as recognise changing international pressures. Although the science-push model conditioned early S&T policies in Mexico, they emerged in a different context from the so-called developed countries. Between the mid-40s and approximately 1980, the Federal Government followed an economic model of import-substitution to build infant industries[2]. This created economic stability and growth due to the accumulation of productive factors, mainly supported by the oil and the *maquila* industries. Mexico established public sectoral research institutes in key sectors, such as the Mexican Petroleum Institute and the Institute of Electric Research. Before 1970, academic elites, sheltered and coordinated scientific activities (Torres at al., 2014). Therefore, the creation of the National Council of Science and Technology (CONACYT) in 1970 represented a turning point for the institutionalisation of STI policies in Mexico. CONACYT's creation was mainly driven and shaped by academic elites, due to their strong relevance during previous decades, and its objectives were to coordinate S&T policies, finance basic research and develop human capital in STEM areas. In this way, CONACYT's objectives and activities were aligned to frame 1 elements and Mexico didn't focus on large scale scientific enterprise nor new technology based firms such as in developed countries (Schot and Steinmueller, 2016; 8).

In 1976 and 1982, Mexico faced two economic crises that caused changes in the subsequent STI policy orientation. The second crisis, along with international pressures coming from the International Monetary Fund (IMF), forced Mexico to shift towards an economic liberalisation model and compete in a global economy[3]. Economic growth and competitiveness became the priority for all actors. However, instead of building new technological capacities, Mexico strengthened those built during the import-substitution period, based on incremental and organisational innovations (Torres et al., 2014). It can be said that Mexico learnt to produce rather than to innovate (Bell and Cassiolato, 1993). The new economic focus of the Federal Government was on creating a good institutional

[2] Between 1955 and 1975, Mexico's annual average economic growth was 6.5%, and this period was called "the Mexican Miracle" (*Milagro Mexicano*). During the first decades, economic inequality increased, and regional development was fairly uneven. The import-substitution model established industries around urban areas, where main domestic markets were located and thus, cities developed faster (Guillen, 2013).

[3] As a result, Mexico opened its economy; it passed the Intellectual Property Rights Law (1991), joint the Organisation for Economic Co-operation and Development (OCDE) in 1994, and signed the North American Free Trade Agreement (NAFTA).

environment for firms and capacities for the transfer of knowledge and technology. In 1984, the Government created the National Researchers System (one of the main structures today) with the aim to improve researcher remuneration, mitigate the consequences of the economic crisis, and decrease the risk of brain drain. Between 1990 and 2000, CONACYT and the Federal Government allocated a major budget to STI activities by attempting to articulate interests and loops between the academic, industry and government sector, following a triple helix-fashion approach (Etzkowitz and Leydesdorff, 1997; Casas and Luna, 1997)[4]. Despite these early attempts to shift towards a systemic model, adequate governance mechanisms were still lacking, ties between the three "helixes" remained poor, and so did Mexico's Innovative capacity.

The big political turns in 2000[5] in Mexico, and the 1996 economic crisis created an important wave of changes in STI policies with the intention to shift towards a frame 2 approach. The recently constituted Federal Government focused on creating macroeconomic stability and economic growth, developing public infrastructure and boosting competitiveness based on entrepreneurship and innovation. In consequence, a new framework for STI policy triggered an institutional building process aimed to consolidate a National Innovation System by improving coordination between different STI actors and fostering the development of regional systems. In 2002, a new Science and Technology law entered into force, with a focus on infrastructure, higher education, R&D, university-industry links and productivity. The law separated CONACYT from the education sector as an independent body coordinated directly by the recently established General Council for STI (chaired by the Federal President). The General Council was established to set the criteria to assign national budget and define STI national priorities within the 2002-2006 Special Programme on Science and Technology (PECyT). To support the 2002-2006 PECyT, which was in line with the National Development Plan, the Federal Government created institutional programmes such as the sectoral and mixed funds, run by CONACYT, with the aim to identify demands of other actors, articulate these to the Ministries and States, and leverage resources from other sources.

Despite their attempt to follow a systemic or entrepreneurship-based view on innovation and development, many of these reforms focused on regulation and R&D expenditure increase (e.g. achieving a 1% GERD/GDP). By contrast, other actions derived from the S&T law attempted to address the traditional structural gap existing between research centres, universities and industry in Mexico, and the high centralisation of the STI governance system. One was the creation of the Scientific and Technological Advisory Forum (FCCyT), an independent consultant body (linked to the executive and legislative power) who had the power to formulate proposals for science, R&D and innovation policies by bringing together STI communities in the country. As part of the efforts to decentralise and create regional innovation systems, the law mandated the establishment of the National Conference on STI, as a permanent body for institutional coordination between CONACYT and the regional governmental bodies. These changes represent a more engaged role of the Federal Government in institution building for promoting multi-level governance, learning, and cross-sector knowledge exchange.

[4] Early efforts to articulate academy, government and industry actors were already present in the first National Program of Science and Technology (1978-1982), promoting the creation of inter-institutional working groups, committees, and agreements between public and private sector.

[5] The right-wing Party of National Action (*Partido de Acción Nacional* – PAN) took over the power in 2000, after 70 years of government from the Institutional Revolution Party (*Partido Revolucionario Institucional* - PRI).

During the last 10 years, some scholars observed that the system has been giving greater importance to innovation policies and institutions rather that to S&T policy (Dutrénit et al., 2015). For instance, the explicit incorporation of the term 'innovation' as part of the Special Programme of Science, Technology and Innovation (PECiTI) in 2008, by substituting the PECyT, marked a renewed interest in innovation. This led to the establishment of the Intersectoral Committee for Innovation in 2009, with the mandate to propose and implement the National Innovation Programme (PNI). The PNI recognised the need to address health, environmental, poverty and security problems, but it emphasised that they should be solved through economic growth and productivity (Secretaria de Economía, 2011). In 2012, a second political turn in the Federal Government passed major reforms in key sectors, such as education and energy, and set as a priority, to orient productive activities to the creation of products and services of high-added value or the so-called knowledge-based economy.

Greater importance has been given to demand-side policies, higher education, and entrepreneurship as a way to cope with Mexico's challenges (some examples will be provided in the second part of this report). In 2013, the Ministry of Economy created the National Entrepreneurship Institute (INADEM) with the objective to foster an entrepreneurial culture in the country. The current PECiTi (2014-2018) is aligned to this new emphasis on the entrepreneur, and with the National Development Programme, which states that STI policy should be the foundation for economic growth and sustainable development and remarkably, it sets, for the first time, a long-term vision to 2025.[6] New sectoral funds were created such as the Sustainability Fund and the Hydrocarbons, as well as Renewable Energy Research Centres, with aims to bridge the gap between STI, the industry and socio-environmental problems. In this way, recent STI policies have recognised the need to address social and environmental challenges. However, this narrative still falls under a frame 2 approach and lacks a shared vision (Torres et al., 2014).

Figure 1 summarises the milestones in the institutionalisation of STI policies and system in Mexico during the last 50 years, according to the first two frames for innovation policy, while Annex 1 summarises the main characteristics of the current configuration and governance of the STI system in Mexico at the federal and regional level.

[6] To achieve this, PECiTI objectives are the following: 1. Qualified human resources, 2. Efficient System of Innovation, 3. ICT infrastructure, 4. Good economic and institutional environment. In addition, from 2012, CONACYT incorporates a long-term vision and states that by 2025: Mexico will invest more than 2% of GDP in research and development activities, the Mexican economy will be one of the ten most important in the world and Mexico will position itself as one of the 20 most developed countries in science and technology. These objectives clearly encompass a vision of innovation close to Frame 1 and Frame 2 approaches.

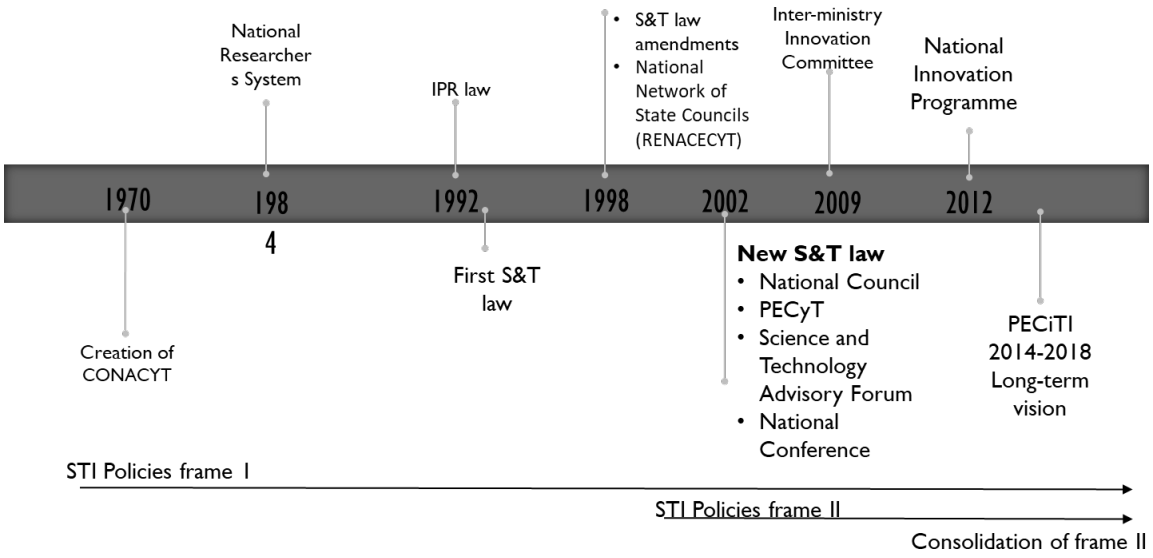

Figure 1 Evolution of STI policies 1970-2014

3 CURRENT PROGRAMMES AND INSTITUTIONS ACCORDING TO THE THREE FRAMES OF INNOVATION

Frame 1 and Frame 2 elements currently dominate STI policy in Mexico. Although the overarching 2002 S&T Law (ref. 2015) mentions decentralisation of governance, inclusion of social minorities (e.g. indigenous communities, women), or the relevance of environmental and sustainability goals, one can barely observe elements related to Frame 3 and transformative change. Something similar is seen in the PECITI 2014-2018. As noted before, it mentions transformative topics such as sustainable and inclusive regional development or social innovation, but it does not materialise these elements into specific policies aimed to transform socio-technical systems as a policy goal.

On the one hand, the available programmes for inclusive and social innovation are mainly based on notions of capacity building (e.g. social entrepreneurship), networking, or the generation of new bottom-up technologies that may solve social problems (e.g. national awards for inventors), without questioning issues related to the systemic implementation, diffusion or direction of technology. Overall, there is little attention on the role that socio-technical systems and dominant regimes play in the generation or reproduction of social inequalities, such as the role played by users and consumers of technology or the non-neutrality of recent innovations. On the other hand, the goals of the main current STI policy are socioeconomic development, productivity, and international competitiveness. Therefore, it is necessary to conduct a review of current Mexican STI policy to assess whether transformative elements are present and, if so, where are they, and to what extent they can promote real structural change. To support this review, Annex 2 shows a map of STI policies and programmes according to the three frames and their corresponding main level of implementation: national, regional/sectoral, or local/communitarian. It is worth noting that this map is just a heuristic and it does not pretend to reflect the variety of policy tools for STI in Mexico.

3.1.Frame 1: Institutional support to R&D, firm innovation and science communication

CONACYT is still the most relevant institution for promoting higher education, research and development, training and science communication in Mexico, across a large variety of programmes and tools, most of them addressing both public and private actors inscribed in the National Register of S&T Institutions and Companies. Table 1 shows the main public funds for science and R&D run by CONACYT. In addition to these, CONACYT channels funds for the activities of its network of 26 public research centres spread across the country, covering the whole continuum of R&D and innovation activities (from basic research to commercialisation).[7]

NAME	DESCRIPTION
Institutional Funds	
FOINS	Generic Institutional Funds for supporting scientific research
FONCICYT	S&T International Cooperation Fund
FORDECYT	Institutional Funds for STI Regional Development
CIBIOGEM	Promotion and Support of S&T Research in Biosafety and Biotechnology
Sectoral Funds	A relevant Federal investment for subsidising research in strategic areas, like water, solar energy, biodiversity, gender studies, etc.
Mixed Funds (FOMIX)	Programme to foster the development of STI capabilities of States and municipalities, providing additional resources to local ones for a wide array of activities, like infrastructure building, training, research innovation projects, etc.
'Support to STI activities' programme	Public competitive call to fund R&D projects of individual researchers and scientists
'National Problems' programme	To fund scientific development projects targeting a closed list of strategic areas that the Federal Government and CONACYT consider as national priorities

Source: own elaboration

Besides this, CONACYT largely supports private innovation through the Programme for Stimulating Innovation (PEI), formed by three sub-programmes targeting activities from basic research to commercialisation and mixing several forms of funds (subsidies, credits, tax incentives, etc.). The idea behind the PEI is that private companies co-fund their innovation projects at later stages of technology readiness for improving products and processes deriving into innovations. While the INNOVAPYME and INNOVATEC programmes address technological innovation respectively in SMEs and big companies, PROINNOVA funds innovative projects collaboratively performed by both private companies and universities or public research centres. Despite some elements of the PEI that

[7] The case of the programs and funds run by CONACYT for higher education and scientific training should be mentioned here. Mexico has a large system of scholarships since the 80s (in both university and public sector, as well as across levels) that obtained a satisfactory assessment about its impact on human capital building, creation of a scientific culture, internationalisation of Mexican science, and reducing gender gap in science and technology. Indeed, Mexican society still tightly associates the role of CONACYT with the provision of grants and support for higher education.

are close to the Frame 2 approach (especially PROINNOVA, because of its collaborative and networking nature), the whole programme focuses on investments but not on learning, outcomes or impact, and is thus closer to Frame 1.[8]

FCCYT also promotes several programmes to foster public understanding of science and open access to scientific information. Among these, it is worth mentioning the Citizens' Agenda for STI, a public ballot performed in 2012 (and replicated in 2017) that asked Mexicans to rank what they think are the most relevant social challenges that STI policy should address through solutions based on science and technology research. Citizens' feedback to the Agenda nurtured the creation of the VIVE CONCIENCIA ("Live con[with]science") programme in 2014, in collaboration with the Parliamentary Science and Technology Committee, and several universities and civil society organisations as well. VIVE CONCIENCIA aims to award innovative proposals that use S&T knowledge to solve everyday problems, provided by students from both public and private universities, through the application of scientific or advanced technological knowledge.

3.2.Frame 2: Regional and Sectoral Systems, and Entrepreneurship

Some of the programmes mentioned above show elements from Frame 2 too. For instance, FONCICYT funds adopts a networking approach to create international and inter-organisational research partnerships, while the PROINNOVA programme requires the creation of cross-sector consortia. CONACYT training and mobility policies for promoting the employment of PhDs in the industry after their graduation may fall in this category as well.

However, the regional and sectoral dimension of innovation seems to be very important for Frame 2 policy and activities in Mexico:

- Regional programmes like FOMIX and FORDECYT facilitated the emergence of regional and sectoral innovation systems, due to their focus on coordination across governance levels, and identification of regional or sectoral strategic areas and problems.
- State Innovation Agendas have the general objective to channel strategically their available resources for producing high-impact projects, to foster competitiveness, through a shared vision between government, academia, industry and society, articulating and defining sectoral priorities and intelligent areas of specialisation.
- Sectoral programmes in Mexico gave special attention to agro-food and energy sector. The long-standing Produce programme created a cross-regional network of private foundations that played a relevant role to get additional funding for research, support local farmers, and add a regional viewpoint to the needs of the sector (Ekboir et al., 2006). The Mexican Energy Innovation Centres (CEMIEs), launched in 2013 by CONACYT and the Ministry of Energy, are cross-sector, virtual and inter-organisational arrangements for creating innovation alliances in the solar, bio-energy, geo-thermal and wind energy sectors. Besides, it is worth mentioning the Targeted Research Networks, voluntary associations of researchers

[8] Apart of CONACYT funds, the Mexican government supports private innovation through other Frame 1 methods like regulation. For instance, the Federal Government disposes tax Incentives for private R&D to stimulate private investments for R&D project that can eventually led to technological innovation. Here CONACYT provides a legal-technical support for targeted companies and taxpayers.

or people interested in interdisciplinary collaboration to address problems of national scale and in coordination between national and international actors of academia, government, business and civil society.

With regard to the recent shift of Mexican innovation and development policies toward entrepreneurship, the Programme of Innovative Development 2013-2018 set up by INADEM is a key reference because it promotes entrepreneurial education and culture, technology entrepreneurship, start-up development, and the creation of high-tech companies, targeting young students and professionals.[9] The Ministerial Secretary for Social Development (SEDESOL) launched several programmes that include initiatives for promoting social entrepreneurship, for instance, the Sectoral Programme of Social Development 2013-2018 (aimed to join economic and social policy), the National Programme of Youth 2014-2018 and the Programme to Foster Social Economy 2015-2018.

In last instance, it is worth mentioning the experience of the Binational Innovation Nodes (NOBI) and the Binational Innovation Consortia (COBI). NOBI supports the creation of groups of scientific and academic institutions between Mexico and the U.S., and between the public and private sector to work in a diverse range of topics. Each group is a coordinating node acting as a regional leader in the development of tools and resources that impact and expand the benefits of innovation and technology-based entrepreneurship, with emphasis on the training of scientific staff capacities in technological innovation issues. NOBI involves many different fields and partners, considering co-creative processes and non-users too. To receive funding, a project needs to show at least the existence of a proof of concept of the technology to be developed.

3.3.Frame 3: The emergence of transformative change

Some of the policies mentioned above show elements connecting with Frame 3, like FORDECYT (identification of socio-technical topics, gathering ideas to promote transformation, concertation) or NOBI (co-creation and inclusion of non-users). Amongst CONACYT policies addressing higher education and training, it is worth mentioning the programme for the Incorporation of Indigenous Women in Post-Graduate Studies for Regional Strengthening. This is part of the wide array of CONACYT policies for generation skills within marginalised communities. The core policy idea of these programmes lies in a Frame 1 or Frame 2 approach but there are, however, also some transformative elements, like the consideration of local needs, or the blurring of political boundaries for social and environmental issues.

Frame 3 elements are emerging across some sectoral or regional-oriented policies, like CONACYT's Targeted Research Networks, or the national and regional awards for young entrepreneurs linking STI with social and environmental challenges, as showed above. STI policy can direct Frame 1 programmes toward societal challenges, including some elements close to Frame 3. For instance, sometimes CONACYT channelled Sectoral Funds toward environmental problems related to water, forestry, etc., accordingly to the so-called Green Agenda for Higher Education Technology Institutes,

[9] Several big private companies also have launched programmes for awarding young entrepreneurs based on STI, giving special attention to projects addressing environmental needs and promoting the 'green economy'. Social entrepreneurship and innovation deserve their attention too.

which supports projects on clean technologies and renewable energy. Similarly, there is the case of a policy tool that is no longer operating: the 'Great Vision' projects. They originated in 2005 by an initiative of Research Institute on Forestry, Agriculture and Livestock (INIFAP) to respond to future societal needs related to areas like water, genetics, biotechnology, climate change, and alternative energy sources.[10] This experience is interesting because of the idea to disseminate and multiply many 'successful' actions operating across the country by different institutions, for immediate benefit. However, this programme also relied heavily on a key Frame 2 hypothesis: that supporting productive projects generating economic growth and employment are the best strategies to reduce poverty.

All these may be examples of narratives alternative to the dominant narrative within Frame 1 and Frame 2 policies (Schot and Steinmueller, 2016), like the social appropriation of S&T, the democratisation of knowledge, or inclusive innovation. These approaches show some of the contradictions existing in Frame 1 or 2, although they are consistent with its basic principles and approach. By contrast, some of them may be examples of counter-narratives within Frame 3, like the attempt of addressing societal and environmental challenges (e.g. in specific areas) through grand programmes providing a 'technology fix' to the problem in a top-down fashion. However, all these convergences and overlaps between different frames are due to the following: the three Frames are not mutually excluding silos, but they are different ways of looking at policy and supporting/achieving innovation, by responding to the different goals and interest. Each Frame brings several defining characteristics and elements, but real policies are keen to encompass a combination of elements proceeding from different frames. Over time, STI policies in Mexico faced the need to respond to issues like social inclusion and re-distribution, but often they did it 'stretching' Frame 1 or Frame 2 approach instead of adopting a Frame 3 strategy. Classifying and presenting Mexican STI policies according to the three frames is just a simplification of reality to build a meaningful narrative for the reader. In this sense, it may be more meaningful talking about the emergence of a 'Frame 3' in Mexican STI policies avoiding the identification of specific policies encompassing a whole set of transformative elements but identifying instead pathways for transformative change starting with the current policies and addressing the most promising experiences and elements for Mexico.

An example of this opportunity may be the increasing interest towards the so-called 'social innovation' policy. The FCCYT recently gave more attention toward this topic, implementing several programmes at different levels of governance.[11] In 2017, FCCYT fostered the generation of the

[10] In 2012, through the initiative of the Alumni Associations of Graduates of several Mexican universities, jointly with scholars, researchers and professional communities, there was the launch of the first plan, followed by a consultancy with 247 experts and foresight exercise that produced more than 2,000 proposals (342 selected). However, the very broad goals of the program (e.g. reaching food sovereignty and strengthening human and social development reducing poverty and inequality), despite of its sectoral approach, created some problem for further development.

[11] FCCYT defines 'social innovation' as the process that aims to address social problems from the society itself. It is different from social entrepreneurship and social enterprises. The commercialisation of innovations and financial self-sustainability are not necessarily associated with social innovation. Social innovation means using collective talent to improve wellbeing and face problems with new methods. It requires a clear understanding of the local context. Social innovations should contribute to solve many pressing challenges in Mexico, like poverty, inequality, education, food security, health, and climate change.

Mexican Network for Social Innovation (RedIS-MX) through the support provided by previous programmes like the Citizens Agenda for STI 2012 and the VIVE CONCIENCIA programme, both mentioned before. Currently, the FCCYT is engaged in improving the potential for STI to achieve social goals and solve societal challenges, considering a transformative perspective too.

Social innovation is also at the core of the regional contest "Solutions for the Future", which foster an entrepreneurial, responsible and sustainable use of technology, through the development of innovative projects of social entrepreneurship, as well as driving creativity toward problem solving for social and environmental progress. The programme targets at students from Technology High Schools. Like this, the National Award to technological innovation for social inclusion (INNOVATIS), a big contest organised by a diversified set of public and private institutions (CONACYT, SEDESOL, INFOTEC, CIDE, UAM, and the Santander Bank) that aims to identify, analyse and distinguish innovative and successful experiences in the application of advanced technologies demonstrating a positive impact on social inclusion and poverty reduction in Mexico. A large array of actors can apply for this contest, by presenting a technology development project.

Finally, there are spaces for transformative change beyond CONACYT and the FCCYT as well, across some experiences of inclusive or grassroots innovation. For instance, international cooperation programmes may provide seeds for initiatives with transformative potential. This is the case of REDMEREE, the Mexican Network for Women in Renewable Energy and Energy Efficiency emerged in 2015 as a second step of long-term programme run by the Mexican division of GIZ (German Agency for International Cooperation and Development). The aim of this programme is to foster jointly both gender equity in the energy sector and support sustainable forms of energy production and consumption. Besides, potential spaces for transformative change also (and, maybe, more often) arise from bottom-up initiatives, involving local communities and very specific policies. For instance, there are some examples of 'social laboratories' emerging in urban settings like the 'Laboratory for the City' in Mexico City, the Applied Research and Social Innovation Laboratory (LiiSA) in Tijuana (Baja California), or the Laboratory of Social and Economic Innovation (LAINES) at the Ibero-American University of Puebla, oriented toward social entrepreneurship. These laboratories are multi-actor and multi-sector alliances providing a space for debate, creativity, experimentation and learning around global and local issues, involving the local government, universities, and civil society. Finally, other examples are emerging from rural and marginalised areas, like solar energy cooperatives in Puebla, or the intermediaries for agro-food networks in Chiapas, providing organisational solutions for a more inclusive socioeconomic development at the local level.

4 CONCLUSIONS

During the last decades, Mexico has experienced important progress regarding STI policies and the National Innovation System. Some important achievements are the development of S&T infrastructure across the country (e.g. universities and public centres), the establishment of a national research and innovation system, and the emergence of innovation systems in certain regions and sectors. The system has also shown isolated experiences of high tech clusters, companies and entrepreneurs. However, these efforts do not seem able to cope effectively with the great social and environmental challenges emerging in areas such as energy, food, water, mobility, security, gender equity, inclusion of local communities, etc. A tentative conclusion from this is that technology and innovation per se is not enough: following a transformative approach, STI policy should directly address global, national or regional challenges considering the role played by technology in socio-technical systems.

Some positive local innovations, however, have been emerging under different forms: social entrepreneurs, innovation networks, urban laboratories, and local cooperatives and partnerships. It is not clear whether they are emerging within innovation systems, or *outside* of them, and whether they are addressing relevant social and environmental challenges (either at a global, national, or local scale) in a reflexive way - in other words, considering the directionality of technology and welcoming conflicts - or whether their transformative potential is limited to broader inclusiveness of several type of actors beyond the traditional ones, related to civil society and local government.

Nevertheless, from these experiences, it is possible to say that opportunities for TIP are arising from the local system, in a bottom-up fashion, involving civil society actors in collaboration with local governments and, sometimes, universities and big corporations. Likely, some areas will be object of further development, such as agriculture, food, or energy. This is aligned with the configuration of the Mexican economy and its large availability of natural resources, as well as the pressing needs of a country with a large territory and a big population. At the same time, geography matters: there is a big socioeconomic and political divide between the metropolitan areas and the local communities. The decentralisation of STI institutions and policy achieved some result, but it is still an uncompleted process. The S&T infrastructure at the local level is weak, and in several rural or marginal areas both the industry and civil society fabric is weak.

From this first review, new questions arise: how can TIP address Mexico's grand challenges under this geographical heterogeneity? What role can CONACYT play to address transformative change at the local level? How should innovation projects target social and environmental goals? Are project-level actions enough for addressing transformative change? What would be the role of Mexico's industrial sector, which is trying to compete in a global economy? How can CONACYT leverage funds, human resources, capabilities, knowledge, or authority to support transformative innovation in specific sectors or territories, to address specific social and environmental challenges requiring experimentation, inclusion, and consideration of technology directionality?

The review showed that, sometimes, traditional channels for funding (e.g. Sectoral Funds, FOMIX, FORDECYT, etc.) could be directed to build knowledge networks in local problematic areas. This may provide support for transformative innovation if these funds would support already existing networks that are experimenting alternative solutions to specific problems. Here the transformative

potential is the possibility to experiment and learn from these ongoing local solutions and explore whether they can be replicated or scaled up to different contexts. In this sense, CONACYT may provide a support, by bridging several local initiatives and projects around a core problem, but it is only possible if experimentation, reflexivity and continuous learning from experience is ongoing. Besides, which actors can (or should) play this role of intrapreneurship/institutional entrepreneurship for pushing forward these networks and related innovation projects? How can their activities be made accountable for CONACYT and the public? Providing an answer to these questions may imply a transformation in the way of working and operating of traditional bureaucracies (e.g. CONACYT and funding agencies), as well as issues of coordination with local agents like municipalities, third sector organisations, entrepreneurs, users, and others. Ultimately, all potential stakeholders of the transformative change process (that is, citizens) should be involved into decision-making and experimentation.

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ANNEX 1. CONFIGURATION AND GOVERNANCE OF THE STI SYSTEM

Over the years, the STI system in Mexico has become larger and more complex. Mexico's government has attempted to integrate more actors and sectors, while decentralising the system, and so its governance became more difficult. The 2002 S&T law and its 2009 amendments mandated the creation of different bodies, which are key for the system nowadays. According to the Law, the STI System is formed by public institutions at the national and regional and local level, private and social actors, which conduct or support STI activities under the current law. Figure X illustrates the main actors and their relations. CONACYT is at the centre of the system and it is the horizontal and vertical coordinator of STI policies. It connects the S&T community (Public Research Centres, Higher Education Institutions, Firms, Industry) as well as regional efforts by different Ministries, States and Municipalities. In addition, CONACYT has ten regional branches collaborating with the State STI Councils. Finally, two bodies that are currently relevant for the governance of STI policy and system in Mexico, although they do not appear into Figure X, are the following: the National Productivity Committee (CNP) and the Inter-sectoral Committee for Innovation (CII). [12]

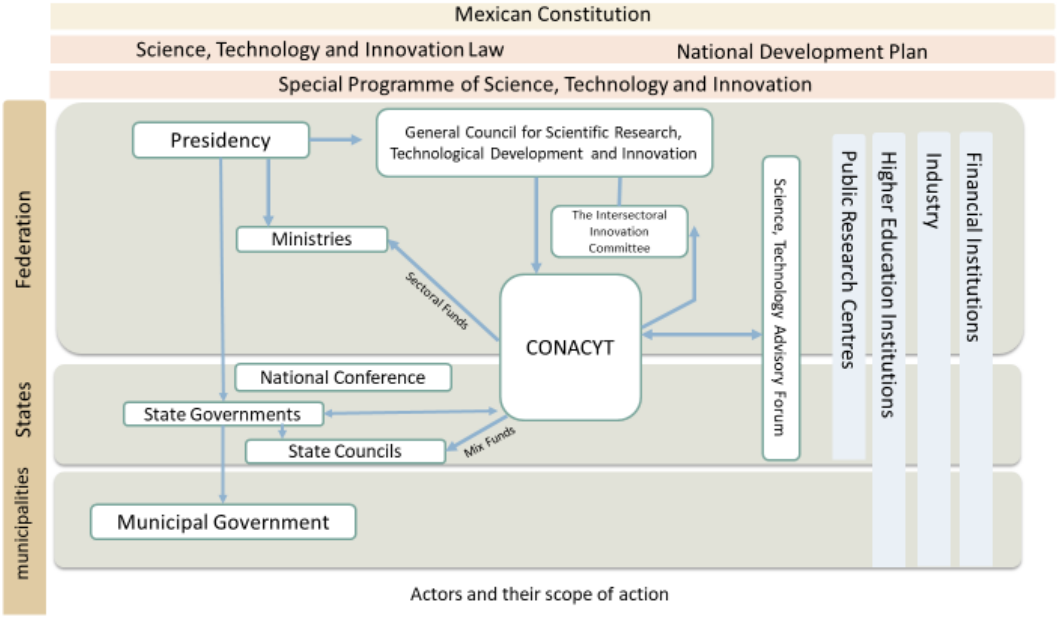

Figure X – STI main actors and institutions at the federal and regional level. Own elaboration based on the S&T law, the PECiTI 2006-2012 and 2014-2018 and adapted from the National Innovation Programme,

There are close links between the higher education, public research centres and the government, but science-industry links are still weak (Torres et al., 2014; Dutrénit 2006; Dutrénit et al., 2015). In 2011, the percentage of businesses that carried out R&D activities was 5% and the percentage of businesses that carried out innovation projects was 11.7% (CONACYT-INEGI, 2012). In 2015, Mexico's Gross Domestic Expenditure in Research and Experimental Development (GERD) as a percentage of GDP was 0.54%. The Government accounts for around 70% of the contributions to the GERD (Figure XX). The goal is to achieve

[12] The CNP is a consultative body of the Federal Executive set up in 2013, whose objective is to recommend policy- and project-level actions to increase and democratize productivity in Mexico. CNP's recommendations are mandatory for the Federal Government. Instead, the CII (set up in 2009) is a specialized body of the Secretary of Economy participated by regional, industry and sectoral actors too. The CII is responsible to design and coordinate innovation policy actions, like the endorsement and monitoring of the National Innovation Programme and similar policy actions.

1% by 2018 with more investment from the private sector. Although around one third comes from industry, the percentage in the education sector is very low which denotes few projects between industry and academia (Torres et al., 2014). Thus, in the last 20 years, one of main bottlenecks to consolidate a National Innovation System, has been the weak relation between the industry and the rest of the actors.

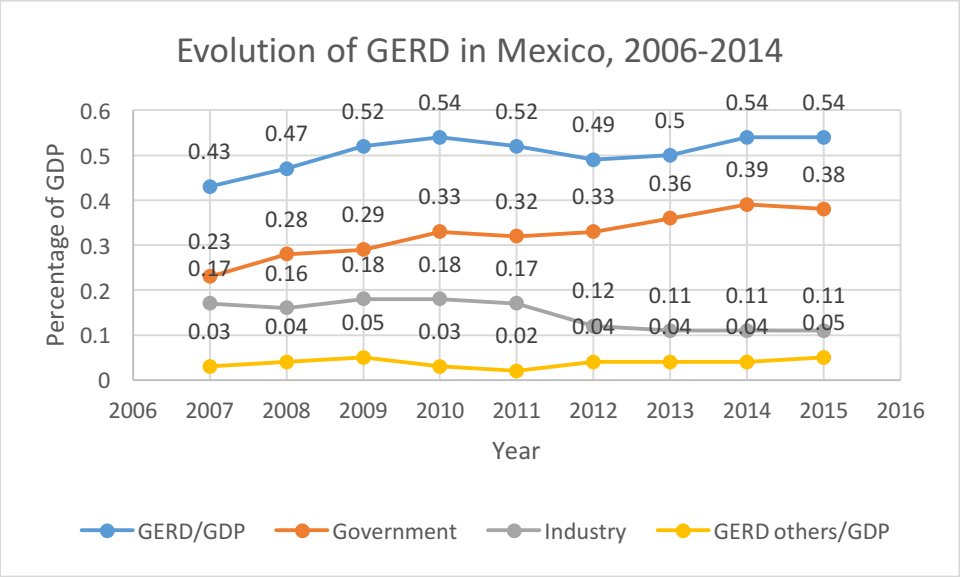

Figure XX – Evolution of GERD in Mexico, 2006-2014. Elaborated based on CONACYT data 2015

In terms of layers of governance, STI policy is conducted at the central (federal) and regional level (states) because Mexico is a federation of 32 sovereign states. At the regional level, each State oversees the promotion and coordination of scientific, technological and innovating activities. By 2014, all states had their own S&T law, formulated between 2002 and 2013 as a mandate of the STI Law, and by 2016 an Innovation Agenda. The National Network of State Councils and Bodies of Science and Technology (RENACECYT) is an active civil association that brings together STI State Councils and other regional actors from the science, technology and innovation ecosystem to discuss the design and implementation of policies at the regional and national level. On the CONACYT side, main mechanisms to enhance coordination with States are its regional offices, Mix Funds, and the National Conference on Science and Technology that has been mentioned before, which is formed by CONACYT and the representatives of the States who coordinate STI policy. By contrast, the involvement of higher education institutions in regional STI policy is unclear: this is a relevant gap, according to the role that HEI can play for regional development, as addressed – for instance – by the triple helix literature (Etzkowitz and Klofsten, 2005).

States' investment in STI is very low and activities are highly centred to support developments coming from the higher education sector. In terms of expenditure, only twelve States indicate their S&T expenditure goal as a percentage of GDP, ranging from 1% to 2.5%. However, in 2014, only two states had a budget above .15% (Jalisco .66%, Aguascalientes .22%). Even the scholarships programme. In 2012, only 1.2% of STI investment came from States and the rest came from the Federal Government, which manifest a high dependency on federal budget. In addition, the development of STI policies at a regional level is uneven. In 2010, 50% of the overall R&D expenditure that goes to the States was concentrated in eight states: Mexico State, Mexico City, Veracruz, Jalisco, Puebla, Guanajuato, Chiapas, and Nuevo León.

ANNEX 2. MAP OF MOST RELEVANT STI POLICIES IN MEXICO ACCORDING TO THE THREE FRAMES AND THE LEVEL OF IMPLEMENTATION

LEVEL/FRAME	FRAME 1	FRAME 2	FRAME 3
NATIONAL	-FONCICYT -Citizens Agenda -VIVE CONCIENCIA -Basic Science -National Researchers System (SNI) -National Problems -INNOVATEC -INNOVAPYME	- COBI -INADEM Programs -PROINNOVA -Private Contests for Entrepreneurs -FOINS	-INNOVATIS - Solutions for the Future" -REDMEREE Program
REGIONAL / SECTORAL	-CIBIOGEM -FORDECYT	- Targeted Research Networks -NOBI -Produce Foundations -CEMIEs -Sectoral Funds -State Innovation Agendas -FOMIX -State programs for entrepreneurship -State Awards for social innovation	
LOCAL / COMMUNITY			-Solar Energy Cooperatives -Intermediaries for agro-networks -Social Innovation and Urban Laboratories -FABLABS

Source: own elaboration based on the activities held in the TIPC workshop held in Mexico City (2018)