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The Orientation of Technological Innovation and Societal Challenges in Latin America

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Abstract: Technological innovation needs to become more responsive to societal challenges faced by developing nations. This implies taking a closer look at how innovative projects contribute to finding solutions to pressing concerns regarding the environment, health or food. This study investigates the orientation of projects by young innovators in Latin America. For this purpose, a qualitative approach was applied using content analysis to projects granted the MIT Technology Review 35 Innovators Under 35 Award for the period 2011-2016. Findings reveal that projects in Latin America are mostly oriented towards issues related to human wellbeing and social welfare. As expected, Mexico, Argentina, Uruguay and Brazil have the most projects aimed at solving challenges in those dimensions. However, projects categorized as innovations with no practical application represent almost 30% of total projects for the region.

Key words: Technological innovation, societal challenges, Latin America, innovation, Mexico, Argentina

INTRODUCTION

Innovation is a key condition of economic progress and competitiveness of firms and nations: it is critical for economic growth and for improving the quality of life, sustainable conservation of resources and improvement of the environment (Freeman and Soete, 2000). Evidence suggests that societies can benefit from greater innovation as it increases productivity, incorporates more advanced technologies into the productive sector and leads to sustained rates of growth (Foxley and Stallings, 2016; Jankelova *et al*., 2016).

Latin America currently suffers an innovation gap, despite experiencing favorable conditions in the 2000's that reduced the income divergence with high-income countries and allowed the region a fast recovery from the global financial crisis (Cimoli *et al*., 2009; Paus, 2014). Countries in the region have failed to implement clear-cut science and tecnology policies to upgrade technology and human capital or to develop new tecnology-intensive sectors (Cimoli *et al*., 2009). The result is a region that lags behind more advanced economies in terms of research and development (R&D) expenditure and output and innovative activity (Lederman *et al*., 2014; Olavarrieta and Villena, 2014). If compared to other emerging markets, it is far behind East Asian countries such as South Korea, Taiwan, Malaysia and Singapore (Foxley and Stallings, 2016; Ugnich *et al*., 2016). Two necessary inputs of innovation that represent important bottlenecks in Latin America are human capital and R&D (Olavarrieta and Villena, 2014). For the whole region, deficient education and skills levels make it difficult to adapt and adopt change (Anonymous, 2016). Also, R&D as share of GDP has not significantly increased as it went from 0.4 in 2000-0.5 in 2010 while for East Asia it increased from 1.1-1.7 correspondingly (Foxley and Stallings, 2016a).

If innovation serves as a catalyst for national prosperity (Charreau, 2001), Latin American countries need to invest in R&D, foster start-ups and promote the development of 21st century skills needed to compete in a dynamic global environment (Daude, 2013). Investing in the region's youth is key for countries to prepare the more productive and innovative work force in order to build human capital and increase innovative activity (Anonymous, 2016a-d).

In this context, the objective of this study is to identify the nature of projects by young Latin American innovators. For this purpose, the study takes a qualitative approach using content analysis to analyze winning innovative projects of the MIT Technology Review 35 Under 35 Award. This is the only award at an international level that filters and selects scientific and technological

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innovations around the world. We frame our study within the technological systems approach which lies within the context of the innovation systems framework, defined as a network of agents interacting in the economic or industrial area involved in the generation, diffusion and utilization of technology (Carlsson and Stankiewicz, 1991).

The researchers believe that although, solely based on innovations recognized by the MIT Technology Review, this study contributes to identifying the orientation of innovations generated in the region as a whole.

Literature review: Innovation is a collective activity that takes place within a wider innovation system which "stresses the interaction between actors who are needed in order to turn an idea into a successful process, product or service in the marketplace" (Hekkert *et al*., 2011). The main function of an innovation system is to develop and diffuse innovations (Hekkert and Negro, 2011).

Taking technology as the level of analysis, a Technological Systems (TIS) approach focuses on how actors influence the development, diffusion and use of a particular technology (Bergek *et al*., 2008; Markard and Truffer, 2008). In a technological system, technological innovations involve solutions to problems and require a certain knowledge base that inventors draw upon (Dosi, 1988).

According to Hekkert *et al*. (2007), there are main functions of any innovation system that help explain shifts in technologies: entrepreneurial activities; knowledge development; knowledge diffusion through networks; guidance of the search; market formation; resources mobilization and creation of legitimacy. In this study, the focus is on those individuals or entrepreneurs who are deemed essential for the well-functioning of innovation systems (Hekkert and Negro, 2011). These individuals are willing to undertake risky experiments which generate more knowledge about how a technology works under different circumstances (Hekkert and Negro, 2011; Carlsson and Stankiewicz, 1991).

Indeed, Baumol mentions that evidence indicates that the most radical innovations of the last two centuries have emerged from independent innovators. In this sense, human capital is the main source of technological innovation (Xia *et al*., 2011). Human capital can influence economic growth by generating new ideas that lead to innovations, absorbing technological advance and increasing the probability of transforming prevailing knowledge (Marvel and Lumpkin, 2007).

The generation of knowledge promoted by the innovative spirit of individuals allows countries to propose novel solutions for pervasive societal challenges (Asprilla, 2011). Innovation can lead to the improvement of human and social welfare, giving new possibilities to vulnerable social sectors (Abaida and Millan, 2013; Asavarat, 2012). However, as mentioned before, Latin American countries suffer from a shortage of human capital, mainly due to a lack of efficient mechanisms for orienting research competencies towards applied research, a mismatch between the needs of industry and what knowledge-producing institutions offer and a neglect to develop indigenous research capacity to absorb technology (Navarro *et al*., 2016). All of these factors contribute to an innovation shortfall in the region.

Societal challenges: According to Schomberg (2013), research and innovation processes need to be able to respond, adapt and provide sustainable solutions to the grand challenges that societies currently face. Investment in technological development and relevant research is key for finding sustainable solutions to societal problems (European Commission nd).

However, the benefits derived from technological progress are not evenly distributed in Latin America. The region may not be the poorest in the world but it is the most unequal (Anonymous, 2017). From the divergent historical trajectories of these countries emergeds, a diversity of economic, social, political and technological patterns from which three areas of specialization can be currently identified:

- South America with factor-driven economies (Botella and Suarez, 2012) which are dominated by subsistence agriculture and extraction businesses with a heavy reliance on unskilled labor and natural resources (Kelley *et al*., 2016)
- Mexico and Central American economies where capital-intensive organizations are dominant (Botella and Suarez, 2012; Kelley *et al*., 2016)
- The Caribbean with economies specialized in tourism and financial services (Botella and Suarez, 2012)

The general economic structure in the region is not innovation-driven nor based on technologically advanced sectors (Botella and Suarez, 2012). The above derives in a growing disparity between economic growth and social welfare resulting in social challenges that encompass diverse knowledge bases in science and technology (Anonymous, 2010, 2011).

Thus, a prevailing challenge is making innovation relevant for solving social problems (Botella and Suarez, 2012). Countries of Latin America have to find ways to meet their population's basic needs for nutrition, sanitation, poverty, quality of education, among many

others. With this aim, different approaches have been attempted over the decades, seeking to link innovations to social development with different degrees of success.

Movements that emerged in other parts of the world that focused on provididng basic human needs gerated national discussions in Latin America on how to promote local alternatives for their vulnerable and marginalized populations. In the 1960's, Ernst Schumacher proposed a technological model to maximize wellfare optimizing the use of resources: the Appropriate Technology (AT) movement (Varma, 2003). It emerged as a response to imported Western technologies and sought to redefine technology as a tool for improving the user's socioeconomic situation (Fissoli and Arond, 2015; Varma, 2003).

In the late 1980s, the Grassroots Innovation (GI) movement emerged in which lower-income groups are treated as sources of ideas and innovators (Gupta, 2013). Widely defined as the mobilisation of people from inside or outside local communities to find solutions to problems faced by those at the bottom of the pyramid (Gupta, 2013; Thomas *et al*., 2015a, b) these innovations "emerge from and are directed towards local development".

Particularly in South America, the AT movement arrived in the early 1980's, thriving in rural settings and combining indigenous and local knowledge with science. In Argentina, Chile and Urguay, for example, AT centers allowed for the implementation of concrete activities for development (Fissoli and Arond, 2015). However, it dwindled as countries began adopting science and technology policies that were opposite to AT's participation and inclusion goals, not focusing on regional socioeconomic problems in addition to the fact that the northern economies were the main global innovators and had no interest in the needs of the marginalised in other parts of the world (Fissoli and Arond, 2015; Kaplinksy, 2014).

In the 2000's, reinvigorated movements emerged for technologies of social inclusion in the region. The Social Technology (ST) movement took form in Brazil as the Social Technologies Network, representing a "mixture of grassroots and mainstream STI" (Frissoli *et al*., 2014), involving actors from private and public sectors. In this same decade, the social innovation approach gained momentum with major societal challenges inherently linked to this concept (Benneworth *et al*., 2014).

Beyond the mere solution of social needs, social innovation should aim at generating improvements in welfare and social cohesion (Correia *et al*., 2016). However, as Bianco (2012) mentions, social inclusion topics are not easily integrated into Latin American STI agendas due to perceptions by some sectors that these are to be solved by social policies. Given these recent movements acknowledging the role that innovation plays for bringing viable solutions to society's problems and given the shorfalls for innovative activity in Latin American countries, it becomes relevant to identify the orientation of innovation projects in the region. Of particular relevance is the work conducted by young innovators as essential human capital resource for the future.

Background; the MIT TR/35 Award: Founded in 1861, the Massachusetts Institute of Technology (MIT) is considered one of the most prestigious higher education institutions in the world. Although, its orientation was technological in its beginnings, it has expanded its educational disciplines beyond physics and engineering to diverse fields such as biology, economics, linguistics and administration (Anonymous, 2015a-c). One of its most prestigious publications is the MIT Technology Review, first published in 1899 and the oldest technological journal in the world. The journal is considered a global authority in the future of technology in internet, telecommunications, energy, computing, materials, biomedicine and business (Crespi *et al*., 2010).

In recent years, MIT Technology Review has given special attention to the importance of technological innovation in improving the global economy. To this end, it holds events such as the EmTech that promotes the diffusion of emerging technologies and the MIT Technology Review "35 Innovators Under 35" Award (TR35) which recognizes groundbreaking innovations in different fields such as energy, hardware, biotechnology and the Web by people under 35 years.

The annual MIT TR35 award started in 1999 as the TR100 and since 2010 includes local editions in Asia, Europe and Latin America. Winners of regional competitions then compete for a position in the global list (Anonymous, 2013a-c). Nominations are divided into 5 categories: inventors, entrepreneurs, visionaries, humanitarians and pioneers. For the purpose of this study, award-winning projects for Latin America were only taken into consideration (Table 1).

Table 1: Overview of awards MIT TR/35, 2011-2016

Countries	Awards until 2016
Central America	11
Argentina and uruguay	29
Brazil	7
Chile	11
Colombia	30
Ecuador	3
Mexico	33
Paraguay and bolivia	8
Peru	9

The community of innovators under 35

MATERIALS AND METHODS

The objective of this study is to identify the orientation of innovations for Latin America. For this purpose, we conducted a qualitative study applying content analysis to award-winning projects of MIT's Technology Review of young innovators under 35. We analyzed a total of 305 award-winning projects from Latin America between 2011 and 2016.

Content analysis is one of various research methods to analyze text data (Hsieh and Shannon, 2005) and is defined as "a systematic reading of a body of texts, images and symbolic matter, not necessary from an author's or user's perspective" (Krippendorff, 2004). This methodology has been used in fields ranging from anthropology to management (White and Marsh, 2006) and aims at capturing a condensed description of the information about a phenomenon and obtain concepts or categories describing the phenomenon (Elo and Kyngas, 2007; Kepplinger, 1989). As Krippendroff (2004) states, "content analysts are concerned only with specific research questions".

One of the advantages of content analysis is that content can be reached if readily available, making it cost efficient compared to other techniques (Kim and Kuljis, 2010). In additon, the data obtained can be examined for trends and patterns (Holsti, 1969), providing evidence for testing hypothesis or answering research questions (White and Marsh, 2006). For this study, the hypothesis is as follows:

H_0: Latin American young innovators are oriented towards finding solutions to human well-being and social welfare problems in the region.

Particularly, participating countries from the Latin American region include Argentina, Brazil, Bolivia, Chile, Colombia, Ecuador, Mexico, Peru, Uruguay, Cuba, Dominican Republic and Venezuela.

Due to the finite and manageable size of documents in this study, semantic validity derives from the phenomena of interest being accurately represented in the texts (Krippendroff, 2004). In addition, intercoder reliability was warranted by the researchers who coded the content. Intercoder reliability refers to independent coders evaluating a message and reaching the same conclusion (Lombard *et al*., 2002).

Five categories were generated based on the content analysis of the 305 TR35 projects: human well-being; social welfare; environmental sustainability; business efficiency and general innovation. Classification of the TR35 awards were grouped according to the description of the project (Table 2). The description for each category derived from the coding process is as follows:

Table 2: Dimensions generated from the content analysis of MIT TR/35

Dimensions	Description
Human well-being	Scientific technological developments that living conditions and human well-being
Social welfare	Scientific technological developments that generate shared value among interest groups
Environmental sustaintability	Scientific technological developments that improve or solve an environmental problem
Business efficiency	Scientific technological developments that increase the efficiency of organizational processes
General innovation	Scientific technological developments that represent an advance in science and knowledge

The community of innovators under 35, various years

- Human wellbeing: under this category fall awards related to improving the health of individuals
- Social welfare: refers to all projects that have a collective impact or that are focused on the development of whole populations
- Environmental sustainability: this category includes projects focused on the ecology, waste management, efficient use of resources and all other issues related to the environment
- Business efficiency: projects related to generic technological innovations fall under this category, that is, all innovations without a specific application

The types of innovations were grouped together for Latin American projects. Descriptive statistics was generated to identify the main focus of these award winning innovations.

RESULTS AND DISCUSSION

For the period 2011-2016, winning MIT RT35 projects are predominately oriented towards social welfare, followed by general innovation projects (Table 3). Particularly for Latin America, content analysis revealed that human wellbeing and social welfare are dimensions that account for almost 50% of innovation projects (Table 4). Thus, we validate our hypothesis of the orientation of Latin American innovators under 35 towards these two issues. If we take into consideration the orientation of projects of the rest of participating countries to the MIT TR35 awards, Latin America has 5% less total projects for both human wellbeing and social welfare (46% other countries vs. 41% Latin America).

For the category of social welfare, Latin American projects focus on issues such as social inclusion of people with disabilities, improved living conditions in marginalized areas, urbanization projects, agricultural optimization programs, improvement in governance and development of citizen responsibility. The category of human wellbeing shows that projects are mainly oriented

Table 3: Categories of the prizes MIT TR35, 2011-2016

Categories	No. of winning projects	Percentage of total (%)
Human well-being	53	17.3
Social welfare	89	29.1
Environmental sustaintability	46	15.0
Business efficiency	55	18.0
General innovation	62	20.3

The community of innovators under 35, various years

Table 4: Orientation of projects for Latin America, 2011-2016

Category	No. of winning projects	Percentage of total (%)
Human well-being	21	14.8
Social welfare	38	26.9
Environmental sustaintability	20	14.1
Business efficiency	25	17.7
General innovation	37	26.2

The community of innovators under 35, various yearsTable 5: Trends by category for the Latin American Region

Variables	Central America	Argentina and uruguay	Brazil	Chile	Colombia	Mexico	Peru	Paraguay y bolivia	Ecuador
Human well-being	3	2	2	4	3	4	1	1	1
Social welfare	2	8	3	2	11	10	1	0	1
Environmental sustaintability	0	4	0	1	4	7	1	3	0
Business efficiency	4	7	2	2	5	3	1	1	0
General innovation	2	8	0	2	7	9	5	3	1
Total TR35	11	29	7	11	30	33	9	8	3

The community of innovators under 35, various years

towards improvement of health, diagnosis, treatment and diseases particularly relevant on the region such as diabetes and heart problems.

Regarding the environmental sustainability category, the issues of greatest concern for young innovators were those of production of clean energy, bioplastics and other recycled materials as well as the sustainability of cities and the development of sustainable agriculture.

Argentina, Mexico and Uruguay are among the five countries that have the highest expenditures on R&D in the region (Botella and Suarez, 2012) with Mexico and Argentina concentrating 29% of total investment and with the highest proportion of researchers (Resenberg, 1979). It is therefore not surprising that together with Colombia, these three countries also score highest on the total number of winning projects (Table 5). Particularly for social welfare, Mexico, Argentina and Uruguay have the highest amount of awards.

It is surprising that Brazil does not portray a higher number of winning projects. Brazil, together with Mexico, Chile, Argentina, Uruguay and Colombia have achieved relative success in their efforts to develop and consolidate major initiatives to promote more efficient science, technology and innovation policies to improve research, technological development and productive innovation.

These Latin American nations are increasing investments in STI and implementing policies to promote innovation. For example, Brazil, Mexico, Chile, Argentina planned and supported the development of PhD level students; implemented national innovation surveys with certain periodicity and also have a variety of instruments to promote and support innovative activities.

Overall, Latin American countries are making efforts to promote innovative activity. One strategy has been the cooperation with international organizations such as UNESCO and the World Bank with initiatives that include strenghtening the quality and quantity of human capital through financing of R&D projects and training programs (Anonymous, 2010). In addition, efforts are also being made to foster a regional agenda through multilateral agreements to promote greater social appropriation of knowledge through projects focused on eloic energy, additive manufacturing, telemedicine, among others (Mayana and Tisni, 2015).

Therefore as the interest in models linking innovation and social inclusion grows, it is imperative that a nation's system of innovation efficiently aids researchers to identify social problems and social sectors to perceive STI actors as partners in finding and implementing solutions to their problems (Bianco, 2012).

CONCLUSION

The purpose of this study is to investigate the nature of technological innovations by young Latin American innovators. Findings revealed an evident relationship between scientific and technological advances by these

young researchers and social demands. Given the prevailing conditions in the region, the challenge remains on how to shed away approaches to developing top-down, generic technology solutions and develop ecosystems in which technologies provide solutions for social inclusion and development.

Indeed, there exist structural factors inherent to the region that hinder the support of innovation projects, such as the low quality of education, a lack of effective linkages between the academic and industry sectors and low public investment levels in research and development. Still, mainstream STI actors in the region should consider practices such as those of the grassroots innovation movement that could transform local sources of innovation.

LIMITATIONS

The methodological limitations of this study derive from using the innovation projects recognized by the MIT RT35 Award. Refinements are needed in the sources of data, therefore, the results cannot be generalized to technology innovators for the whole region. However, we believe that this study is a positive step towards addressing the relevance of technological development projects for societal challenges in Latin America. Future research should consider expanding with samples of innovative projects conducted by other innovators and entrepreneurs in the region.

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