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Nota de los Editores

Nos alegra poder contar con la colaboración del Dr. James Pérez Marcano, funcionario de la Compañía de Fomento Industrial. El Dr. Pérez Marcano ha dedicado su carrera profesional a adelantar la economía por medio de la innovación tecnológica y su aplicación a procesos industriales. Su trabajo profesional es particularmente relevante en el contexto actual de la economía de Puerto Rico y de los cambios que vienen ocurriendo en el entorno competitivo dentro del cual Puerto Rico evoluciona, particularmente en lo concerniente a la innovación. Su ensayo en este Occasional Paper, que es el quinto que publicamos, es sumamente relevante por sus implicaciones para la competitividad de Puerto Rico. Por esa razón nos sentimos muy agradecidos que lo comparta con los lectores de *Perspectivas*.

Industrial R&D and Innovation: Sustaining Puerto Rico's Global Competitiveness

By James Pérez-Marcano, Ph.D.

Executive Summary

This paper recommends public policies aimed at establishing an effective innovation system in Puerto Rico supported by the industrial research and development program. These recommendations are based on

current industry trends, outcomes from the Puerto Rico industrial research and development incentives program, and the experience of the international community in developing innovation capabilities.

Innovation and National Innovation Systems

Innovation (industrial)

Is the implementation of a new or significantly improved product (good or service) or process¹.

National Innovation System

Is the network of institutions in the public and private sectors, whose activities and interactions initiate, import, modify and diffuse new technologies. This network provides the framework within which governments form and implement policies to influence the innovation process².

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Why is Innovation Relevant?

“The knowledge-based economy is an expression coined to describe trends in advanced economies towards greater dependence on knowledge, information and high skill levels, and the increasing need for ready access to all of these by the business and public sectors. Knowledge and technology have become increasingly complex, raising the

importance of links between firms and other organizations as a way to acquire specialized knowledge”¹. Over the past few decades, globalization has established innovation as the means through which to achieve economic development and prosperity. “Innovation provides the foundation for new businesses, new jobs and productivity growth and is

thus an important driver of economic growth and development”³. According to the World Economic Forum, Innovation and human capital development are among the most important factors in sustaining competitiveness in the global economy^{4,5}.

Puerto Rico’s Innovation System

Puerto Rico has an emerging innovation system, consisting of a research-intensive public university system⁶; numerous higher learning institutions⁷; several public and private research centers and institutions⁸; business incubators⁹; a strong cluster of high-technology industries¹⁰; several financial organizations supporting innovation¹¹; and government institutions supporting innovation development¹².

Despite these capabilities, basic innovation metrics show below average performance for Puerto Rico. For example, a 2009 study

found that Puerto Rico’s R&D expenditure as a percent of Gross Domestic Product (GDP) is approximately 0.45%¹³, which is below that compared to the global average of 2.3% for the same year¹⁴. The total number of Puerto Rico patent filings is far below the US average over the period from 2008 - 2014¹⁵ and the rate of filings is stagnant compared to the global rate over the past decade¹⁴. Puerto Rico’s most research intensive institution, the University of Puerto Rico, has confronted serious challenges in the past 5 years, such

as endangered federal research funding and serious fiscal issues, among others¹⁷. A recent study concluded that academic technology transfer and commercialization performance is below US national average for states that invest similarly in their academic research¹⁸. Despite this, the 2009 study found that the high-tech private sector accounted for 67% of the R&D expenditures in Puerto Rico and projected an increase in the investments made by this sector in subsequent years¹³.

Industrial Development

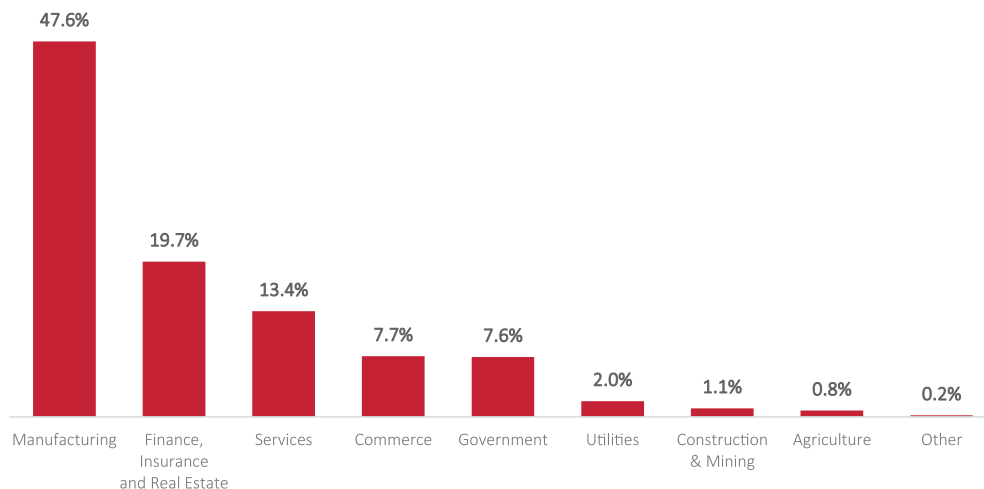
Businesses that compete globally are under growing pressure to produce high-value goods and services at ever decreasing costs. This challenge is addressed by investing in the development and adoption of sophisticated technologies that enable the creation of innovative products and industrial processes of high commercial value. This innovation-driven business model is consistent among many industry sectors in Puerto Rico and is

strongly dependent on technically competent human capital.

Puerto Rico has asserted its global competitiveness by sustaining a robust cluster of supply industries, innovation capabilities, and a highly skilled workforce. As a result, investments from high-technology industries have continued to grow in the last decade despite strong challenges such as Puerto

Rico’s fiscal uncertainty, high energy costs, and the expiration of section 936 of the U.S. Internal Revenue Code, among others. Today, approximately 48% of Puerto Rico’s economy is based on manufacturing (see Figure 1 below), consisting mostly of high-tech industries that export goods and services to global markets¹⁹, and accounting for approximately \$1,000 million dollars in direct fiscal revenues²⁰.

Figure 1
Puerto Rico’s GDP in 2014 by Economic Sector¹⁸



Industrial Research and Development

The Puerto Rico Industrial Development Company's (PRIDCO) charter is to attract, sustain and grow industrial operations on the Island. To this effect, PRIDCO offers and manages the Puerto Rico Industrial Research and Development (R&D) incentives program, based on corporate tax exemptions and credits, designed to spur investments in capacity-building innovations at all stages of the industrial commercialization process.

The Puerto Rico Economic Development Act 73 of 2008 provides a tax credit in the amount of 50% of eligible investments made in industrial research and development on the Island, which is the most significant incentive of the industrial R&D program. This incentive has impacted a broad range of industry sectors operating in Puerto Rico, such as aerospace, software,

apparel, construction, and the bio-industries (pharma, medical devices, etc.).

The bio-industry sector has benefitted the most from this incentive, accounting for approximately 67% of the tax credits conferred over the first 5 years of the program since 2008. During the same time period, approximately 89% of the projects impacted by this credit have been related to the development of new products and manufacturing processes. This incentive has been very successful in maintaining a technically-current workforce, supporting the establishment of cutting edge and emerging technologies, and in accelerating the introduction of new products to market. The incentive has been particularly effective in advancing the capabilities of many manufacturing companies on the Island that

are making efforts to engage in early-phase product and process development as a key global competitive strategy²¹.

Recently, the Puerto Rico Industrial R&D program has been focused on supporting late phase development activities that are directly related to the establishment of new businesses and the expansion of existing operations. The goal is to increase industrial productivity and exports. Measurable outcomes from this effort include significant capital investments and the creation of primary and secondary jobs. However, an often overlooked outcome is the generation of significant revenues from corporate income tax, royalty payments, and municipal taxes from supply chain industries associated with the primary investor industry.

Current Challenges

Puerto Rico has several strong challenges that threaten the effort toward sustainable innovation-led economic growth and development, namely:

1. Growing migration of professional and academic talent from Puerto Rico.
2. Weakening academic research programs, infrastructure and institutions.
3. Limited financial resources to invest in innovation.
4. Deficient overall innovation infrastructure.
5. Poor innovation performance (e.g.; peer-reviewed publication rate, patent application rates, infrastructure creation and use, collaborations, R&D expenditures, among others).
6. Nonexistent long-term innovation-driven economic development strategy.
7. A growing multigenerational workforce, which has posed challenges in Puerto Rico and globally²².

Conclusions

Innovation is key to the industrial development effort because it is currently the business model adopted by all high-technology industries seeking to sustain their global competitiveness. This sector, which is the largest segment of Puerto Rico's economy, has been leading the Island's investments in human and technical capacities to develop and adapt cutting edge enabling technologies²³. These are key capabilities in an innovation system according to the OECD³. Despite strong challenges and

uncertainty, the high technology industries continue to invest in Puerto Rico, which represents unique policy opportunities to facilitate innovation development efforts. For example, the high-tech industry trend toward establishing technical centers of excellence, R&D departments and facilities creates unprecedented collaborative opportunities for the academic sector, which may lead to much needed revenue streams and novel academic programs for the Universities. Therefore,

refining current technology-led industrial development programs is necessary to specifically stimulate knowledge flows, human capital development and academia-industry collaborations that leverage the industry sector's competitive efforts and Puerto Rico's current emerging innovation capabilities. This approach is cost effective, affords short- and long-term results, and is consistent with the global trend of establishing public policies with emphasis on productivity and growth³.

Policy Recommendations

Immediate Action

1. Clearly define short- and long-term innovation goals and communicate them effectively to all stakeholders and relevant sectors of Puerto Rico's innovation system.
2. Catalog incentives and government programs aimed at innovation.
3. Revise all government programs that invest in innovation (grants, tax credits, exemption, loans, etc.) to require clearly-defined and measurable expected outcomes.
4. Establish and maintain a system of information that contains a database of outcome metrics (e.g.; peer-reviewed scientific publications, patents, etc.), innovation capabilities (academic research programs, research intensive academic institutions, private research institutions, research parks and centers, etc.) and major science and technology initiatives in Puerto Rico. This information is CRITICAL to promote investments, measure the effectiveness of current innovation policies, and support a continuous improvement program.
5. Design and implement innovation-driven industrial development incentives aligned with global competitive trends, specifically focused on establishing productive capabilities and the development of human capital. Expected outcomes should include overall increased productivity and the development of global competitive capabilities of small and medium-sized companies.
6. Revise the industrial R&D tax credit to focus key outcomes on OECD recommended metrics, namely, the development of innovative capacities, human capital and knowledge flows.
7. Harmonize all government efforts focused on innovation, based on common goals and defined outcomes.
8. Develop strategies with the academic and private sectors to attract and retain human capital. Immediate efforts should focus on reversing the talent migration from Puerto Rico, but also the reduction of turn-over, the effective transition from academia into entry-level positions, and adapting workplace engagement/retention approaches to a multigenerational workforce (Gen X, Millennials and Gen Z).
9. Urgently address the University of Puerto Rico's strong current challenges: endangered federal research funding and serious fiscal issues, among others.

Long-Term

1. Reform the University of Puerto Rico's administrative structure to support fiscal self-sufficiency, competitive world class research, and the agility to develop cutting-edge academic programs and partnerships. The University of Puerto Rico MUST be a key driver of innovation and human capital development.
2. Develop a long-term economic development plan that is founded on science and technology innovation.
3. Establish a multi-sector, tri-partisan organization with full accountability, independence and power to protect and execute the long-term economic development plan.
4. Revise the Puerto Rico Science and Technology Policy to become a true workable document, harmonized with the long-term economic development plan, in tune with Puerto Rico's current fiscal reality, and aligned with the experience of the international community on the development of innovation systems.

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5. World Economic Forum. (2015). The Human Capital Report 2015. Retrieved from http://www3.weforum.org/docs/WEF_Human_Capital_Report_2015.pdf
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8. See for example:
 - a. Ponce Research Institute. <https://www.psm.edu/about-research.html>
 - b. Materials Characterization Center. <http://www.mcc.com.pr/>

- c. Comprehensive Cancer Center. <http://www.cccupr.org/>
 - d. Institute for Functional Nanomaterials. <http://www.ifn.upr.edu/>
 - e. The Bioprocess Development and Training Complex (BDTC). <http://prteconline.com/index.php/facilities/bdtk/>
9. See for example:
 - a. Puerto Rico Technoeconomic Corridor. <http://www.prteconline.com/>
 - b. Iniciativa Tecnología del Noreste. <http://www.intenep.org/index.php?node=459>
 10. See for example:
 - a. The Pharmaceutical Industry Association of Puerto Rico. <http://www.piaapr.org/>
 - b. The Puerto Rico Manufacturers Association. <http://industrialespr.org/#sthash.x2Fgdscd.dpbs>
 - c. Puerto Rico IT Cluster. <http://www.pritcluster.com/>
 - d. Puerto Rico Aerospace Technology Consortium. <http://www.aerospacepr.org/wordpress/>
 11. See for example:
 - a. Grupo Guayacán. <http://guayacan.org/>
 12. See for example:
 - a. Puerto Rico Industrial Development Company. <http://www.pridco.com/>
 - b. Puerto Rico Science, Technology and Research Trust. <http://prsciencetrust.org/>
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 20. Informe Anual a la Asamblea Legislativa Sobre el Pago de Contribuciones en el Año Fiscal 2014 de los Negocios Acogidos a las Leyes de Incentivos: Ley Núm. 135 de 2 de diciembre de 1997 y la Ley Núm. 73 de 28 de mayo de 2008.
 21. Source: Puerto Rico Industrial Development Company.
 22. World Economic Forum. (2015). How can firms adapt to a multi-generational workforce? Retrieved from <http://www.weforum.org/agenda/2015/08/how-can-firms-adapt-to-a-multi-generational-workforce/>
 23. Informe Anual al Gobernador y a la Asamblea Legislativa Detallando el Impacto de los Incentivos Contenidos en la Ley Núm. 73 de 28 de mayo de 2008: Cierre Año Fiscal 2013- 2014.

About the Author

James Pérez-Marcano, Ph.D., is Senior Specialist in Business Development in the Office of Specialized Industry Services of the Puerto Rico Industrial Development Company (PRIDCO). Currently, Dr. Pérez-Marcano manages PRIDCO's Industrial R&D Incentives program, which promotes investments in high technology to increase the global competitiveness of

Puerto Rico's manufacturing sector. During his tenure at PRIDCO, Dr. Pérez-Marcano has been committed to advance Puerto Rico's technology-driven economic development efforts. Dr. James Pérez-Marcano earned his Ph.D. degree in analytical chemistry from Purdue University, where he produced nine scientific publications in peer-reviewed journals,

and two patent applications on his doctoral thesis work. His professional background prior to public service includes management; technical support to manufacturing operations; and industrial research and development in the pharmaceutical and consumer products industries.

Cronología de los Esfuerzos Hechos en Puerto Rico para desarrollar la infraestructura y la comunidad de C+T y el I+D¹

Por Los Editores

La cronología que incluimos como parte de este Occasional Paper había sido previamente publicada en Perspectivas. Se publica como complemento al ensayo del Dr. Pérez Marcano. Los esfuerzos que se incluyen en la misma no pretenden incluir todas las acciones e iniciativas que se tomaron para fortalecer la ciencia y la tecnología, ni para estimular la innovación. En cierto sentido lo que sugiere la cronología es que el proceso ha sido lento. El primer esfuerzo en 1967 no culminó con una postura fuerte y clara del Gobierno en cuanto a la necesidad de estimular la ciencia y la tecnología como parte importante del desarrollo hasta 1996, casi treinta años. En ese año se adoptó la primera Política Pública de Ciencia y Tecnología mediante una Orden Ejecutiva del entonces Gobernador Pedro Rosselló.

Desde que se publicó esta cronología han ocurrido cambios notables relacionados al tema de la ciencia y la tecnología. Se completó el Centro Comprensivo de Cáncer y el edificio de Ciencias Moleculares, se han comenzado programas de apoyo a empresas emergentes dirigidos principalmente a empresas en el sector de tecnología. Estudios Técnicos, Inc., en asociación con Microsoft, completó un inventario de empresas en el sector de

El futuro económico de Puerto Rico dependerá de cuan capaces somos de migrar a una economía basada en conocimientos y en la innovación, no solamente en la industria sino en otros quehaceres como son las política sociales y la administración pública.

Informática que arrojó cifras muy interesantes en cuanto al sector, incluyendo la gran cantidad de empresas que lo componen, muchas de las cuales están exportando servicios y tienen patentes a su nombre. El Instituto de Estadísticas ha publicado dos informes sobre la investigación y el desarrollo en Puerto Rico. Estos reflejan la necesidad de impulsar aún más esa actividad tanto en las empresas como en las universidades. El Fideicomiso de Ciencia, Tecnología e Investigación ha adquirido un nuevo dinamismo en los pasados años bajo la dirección de la Sra. Lucy Crespo. Aún con un presupuesto limitado ha emprendido iniciativas muy positivas dirigidas a fomentar la innovación.

El el 2011 se aprobó la Ley 20 que que provee incentivos contributivos a empresas que

exporten servicios. Ya cuentan con decretos bajo esa Ley sobre 500 empresas, muchas de las cuales son empresas locales. La Ley 20 se ha beneficiado de la Ley 22 que ofrece otros incentivos contributivos a personas que establezcan su residencia en Puerto Rico y que tiene sinergias evidentes con la Ley 20. La mayor parte de las empresas que se han acogido son empresas de tecnología que exportan sus conocimientos a países de la región y a Estados Unidos. Otras como PACIV y PharmaBioServ, por mencionar solo dos, exportan servicios a Europa. La expectativa es que el impacto de la Ley 20 aumente a medida que las empresas se consoliden y establezcan nexos con otras empresas en la Isla.

El futuro económico de Puerto Rico dependerá de cuan capaces somos de migrar a una economía basada en conocimientos y en la innovación, no solamente en la industria sino en otros quehaceres como son las política sociales y la administración pública. El ensayo del Dr. Pérez Marcano provee las bases para que Puerto Rico vuelva a ser, en la frase de Alice Amsden, una distinguida economista recién fallecida, un "path creator" y no tan solo un "path follower".

Cronología

1967: National Academy of Engineering y National Science Foundation (NSF), estudio titulado "Science and Technology in Support of Puerto Rico's Economic Development".

1974: Informe del Recinto Universitario de Mayagüez para establecer un centro de I+D en el RUM (autor principal: Dr. Juan Bonnet)

1975-76 a 1981: Instituto de Tecnología Social, La investigación en Puerto Rico (autores principales: Dr. Amador Cobas, JJ Villamil)

1980 al presente: Con fondos de NSF se crea el Centro de Recursos para Ciencias e Ingeniería (CRCI) con el propósito de desarrollar los recursos humanos y la infraestructura de I+D en la academia

en PR (mas de \$450M invertidos desde su comienzo)

1985: Se establece INDUNIV.



1985: Con fondos de NSF y pareo de la UPR se crea el Experimental Program to Stimulate Competitive Research (EPSCoR) en PR con la misión de desarrollar la infraestructura de I+D en las universidades y catalizar la transformación de la UPR a una institución de investigación de acuerdo a la clasificación de la Carnegie (mas de \$60M invertidos desde su comienzo)



1986: La Fundación Comunitaria de Puerto Rico establece un comité sobre política de ciencia y tecnología (coordina JJ Villamil y Manuel Gómez)

1986: El Gobernador Rafael Hernández Colón le solicita a la Junta de Planificación que organice un comité para proponer una política de ciencia y tecnología (coordinador: JJ Villamil)

1986: el Gobernador Rafael Hernández Colón establece el Consejo Adjunto de Ciencia y Tecnología (Dr. Sandor Boysson, lo coordina)

1988 -1990: Se organizan la Corporación para el Desarrollo de los Recursos Tropicales (TROPICO) y la Corporación para la Transformación Tecnológica

1993: Desaparecen ambas entidades.

1994: Se aprueba el Nuevo Modelo de Desarrollo Económico por el Gobernador Pedro Rosselló en donde se recomienda la creación de un Consejo de Ciencia y Tecnología.

1994: Se crea el Comité para la Formulación de la Política Pública en Ciencia y Tecnología, con participación de la Academia, el sector empresarial y el gobierno.

1996: Se adopta la Política Pública de Ciencia y Tecnología mediante orden ejecutiva del Gobernador (8 de octubre).

1997: La Junta de Síndicos de la UPR aprueba una política de C+T para la UPR

1999: Arthur D. Little, Inc. (con Estudios Técnicos, Inc.) es contratado para producir el informe: "A Science and Technology Based Economic Development Strategy"

2000: Se produce el informe que conceptualiza el Corredor Tecnológico (PR-TEC) y establece los pasos para su implantación (Estudios Técnicos, Inc.).

2000: Arthur D. Little, Inc. (con Estudios Técnicos, Inc.) genera un plan de implantación para el informe anterior (1999) y se logran varios acuerdos para establecer centros de I+D en Puerto Rico.

2001: Se le cambia el nombre al Corredor Tecnológico a Corredor Tecnológico y se crea una Junta Directiva.



2001: La Asociación de Industriales auspicia a un grupo cuya función es actualizar la política pública adoptada en el 1996, pero no se logra que sea adoptado por el gobierno, aunque si es avalada por la Asociación de Industriales y la Cámara de Comercio (documento redactado por M. Gomez y JJ Villamil).

2001/2003 al presente: Con \$50M en fondos de NIH y UPR se crean tres Centros de Investigación en Ciencias Biomoleculares y Biotecnología, conocidos como: COBRE I, COBRE II, e INBRE.



2002: Se comienza la conceptualización de INTECO por el Alcalde de Caguas y el Presidente del SUAGM y se completan los estudios necesarios para comenzar su implantación (Estudios Técnicos, Inc.).



2002-2004: Se producen dos estudios: "C&IT Blueprint" y "Life Sciences Blueprint" por distintas compañías de consultoría, incluyendo a McKinsey y QBS.

2004: Se anuncia el Fideicomiso de Ciencia y Tecnología.



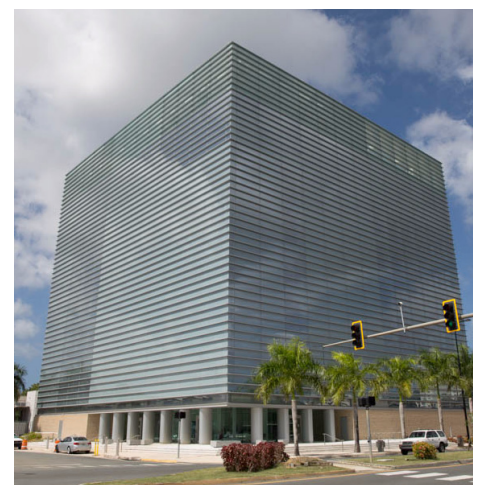
2005: Se crea la junta de directores del Fideicomiso de C+T.

2005 - 2008: Se anuncian varios proyectos en la UPR, entre ellos el Centro de Cáncer y la construcción del edificio de biología molecular. Se presentan los bocetos

arquitectónicos y plan maestro para el Corredor del Conocimiento.



Centro Comprensivo de Cáncer de la Universidad de Puerto Rico²



Edificio de Ciencias Moleculares de la UPR³

Notas:

1. Esta cronología se publicó en Perspectivas de agosto 2005. El Dr. Manuel Gómez agregó información adicional sobre los programas de la UPR posterior a su publicación.
2. Imagen tomada de <https://www.facebook.com/CCCUPR/photos/a.166547600386787.1073741828.161999120841635/263384807369732/?type=3&theater>
3. Imagen tomada de: <http://www.upr.edu/cicim/gallery/>

"Por economías basada en los conocimientos me refiero, esencialmente, a economías en que la proporción de empleos intensivos en conocimientos es alta, el peso de los sectores de tecnologías de información es un factor determinante, y la proporción del capital intangible es mayor que la del capital físico en el capital total. Estos desarrollos se reflejan en un aumento continuo de empleos en la producción, procesamiento, y transferencia de conocimientos e información. Esta evolución no se limita a los sectores de alta tecnología...se ha difundido a toda la economía. La sociedad como un todo se mueve a actividades intensivas en conocimientos."

Dominique Foray, *The Economics of Knowledge*

"To attract international investments in innovation, governments need to implement a broad, horizontal strategy that is an explicit part of the country's broader economic/industrial policy... Attractiveness for innovation requires close co-ordination/integration of innovation policy and inward investment promotion policy...Attractive marketing of the host country that is not based on strong economic fundamentals will, however, be rapidly perceived as non-credible by potential investors."

OECD, *Attractiveness for Innovation: Location Factors for International Investment*

Cronología de los esfuerzos hechos en Puerto Rico para desarrollar la infraestructura y la comunidad de C+T y el I+D

