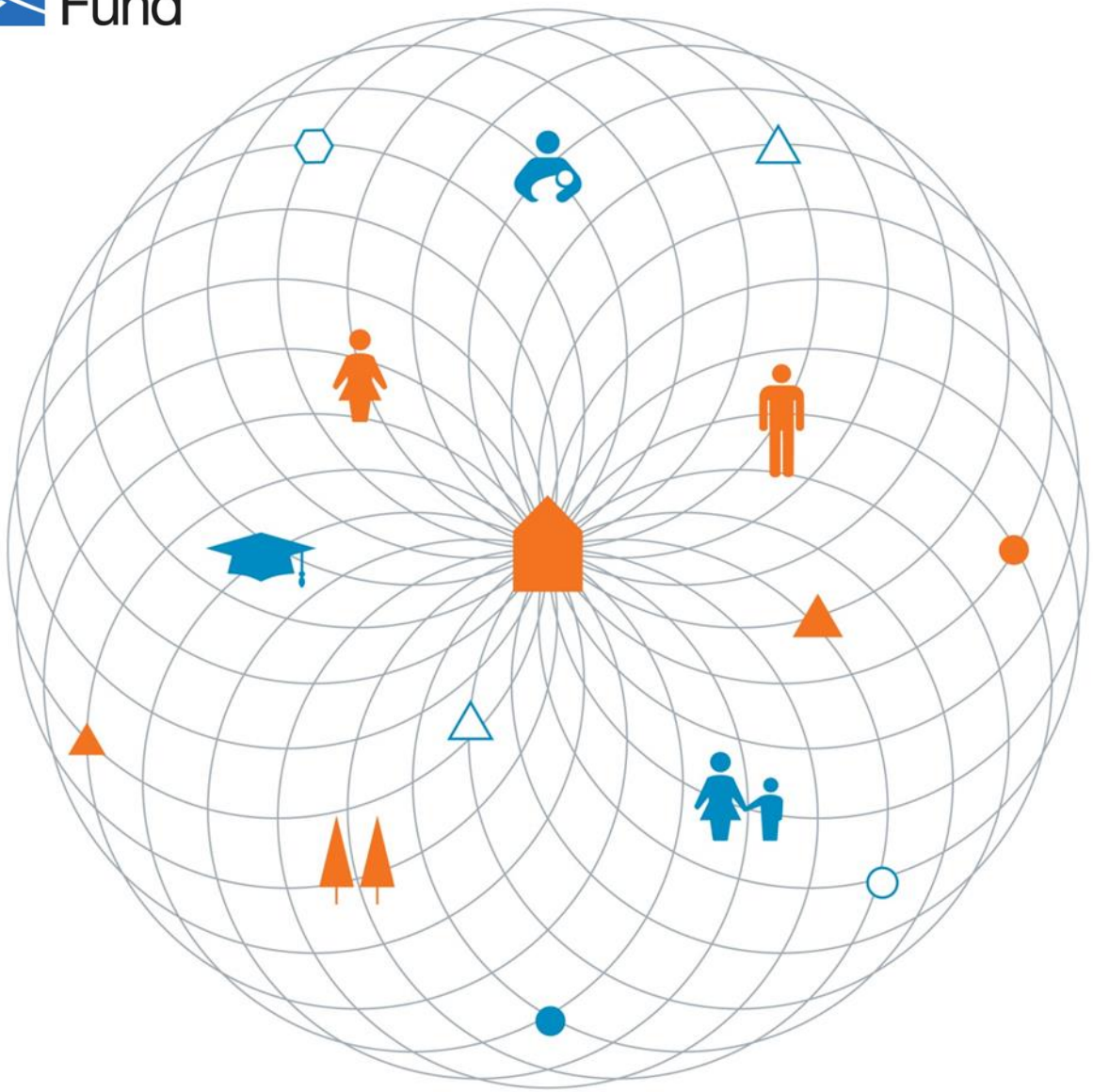
Thematic Impact Study Report - Mexico

Newton Fund Evaluation
April 2018



Thematic Impact Study Report - Mexico

Newton Fund Evaluation

Department of Business, Energy and Industrial Strategy (BEIS)

Newton Fund Evaluation

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Partners

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Acronyms

CDTS – California Department of Toxic Substances Control

CINVESTAV – Research Centre for Advanced Studies

COFEPRIS – Federal Commission for the Protection Against Sanitary Risks

CONACyT – Science and Technology Committee

CONAGUA – National Water Committee

DAAD – German Academic Exchange Service

DIT – Department for International Trade

GDP – Gross Domestic Product

GIS – Geographic Information Systems

FOBESII – Bilateral Forum for Higher Education

FUMEC – United States-Mexico Foundation for Science

ICF – International Climate Fund

ICOBTE – International Conference on the Biogeochemistry of Trace Elements

ICT – In-Country Team

IMSS – Mexican Social Security Institute

IMTA – Mexican Institute for Water Technology

IP – Intellectual Property

IPICyT – Institute for Scientific and Technological Research of San Luis Potosi

MUSEIC – Mexico-United States Entrepreneurship and Innovation Council

NAFTA – North American Free Trade Agreement

OAS – Organisation of American States

ODA – Official Development Assistance

OECD – Organisation for Economic Cooperation and Development

PECITI – Programme on Science, Technology and Innovation

PDI – Programme for Innovative Development

PEMEX – Petroleos Mexicanos

SE – Secretariat of the Economy

SIN – Science and Innovation Network

SNI – National System of Researchers

STI – Science, Technology and Innovation

PECITI – Special Programme on Science, Technology and Innovation

PCT – Patent Cooperation Treaty

TRL – Technology Readiness Level

TTO – Technology Transfer Office

UNAM – National Autonomous University of Mexico

WHO – World Health Organisation

1 Introduction

1.1 Purpose of this report

This report presents the findings for the Thematic Study of Newton Fund activities in Mexico, with a focus on three activities in the country. Our findings emerged from an in-depth review of documentation, an online survey, in-country interviews, and UK-based consultations, as outlined in Section 1.2 below. Findings from this and the other seven country studies will help inform our Mid-term Evaluation report. Findings of this report are accurate as of February 2018, when fieldwork took place.

As outlined in our Evaluation Strategy, thematic impact studies were carried out in eight countries: Brazil, China, Egypt, India, Malaysia, Mexico, the Philippines and South Africa. The focus on these countries allows for a breadth of coverage across Newton partner countries and regions of focus. It also allows for broad coverage in terms of the existing innovation capacity and infrastructure of Newton partner countries.

As part of our thematic studies, we conducted a comparative analysis of the factors (such as type of local funding agencies, size of universities, local research structures, among others) that contributed to the Fund's outcomes across different contexts. This helped us map the **pathways of change and capture early signs of the Newton Fund's impact**. By focusing on the factors which facilitate specific research activities, increase the quality of research outputs, enhance international collaboration and translate research into innovative practices, the thematic impact studies help us understand how sustainable solutions to economic development and poverty reduction have emerged so far from Newton Fund activities.

Case study selection

For each country, we shortlisted potential case studies based on three measures: size, pillar and sector. The selection of projects took thematic areas of focus into consideration, aiming to include priority areas for the Newton Fund in each country. We sought to achieve a spread of Newton Fund Delivery Partners and activity types across the countries in our sample. We also consulted the in-country teams (ICTs) to identify potential impact 'stories'. Following additional consultations with delivery partners and the Newton Fund Central Team, we selected **three cases per country** to be explored in more depth.

In Mexico, the shortlisted activities were:

- British Council Technology Transfer Best Practice and Skills Development Training for Practitioners;
- Royal Society Newton Advanced Fellowship (Year 1 – Round 1);
- Innovate UK – CONACyT Mexico-UK Collaborative R&D Call (Round 1).

This allowed for inclusion of two People Pillar actions and one Translation pillar action. Within those actions, the specific award-holders were selected to ensure as broad a geographical scope and diversity of partners as possible, within the timeframe of the thematic study. When selecting the award holders, we also considered the relevance of the specific project's research area to the Newton Fund's priorities in Mexico.

1.2 Research approach

Research scope

The thematic studies involved wide-ranging in-country consultations, with the inclusion of as many diverse interview respondents as possible within the timeframe of our fieldwork activities. This was combined with consultations with UK-based partners and researchers involved in the actions included in the study.

This thematic study explored:

- The **development of each activity** – examining its origins, how engagement with the Newton Fund occurred, and an overview of the process of securing Newton funding;

- The **relevance of each activity** to Mexico's development needs and to Newton Fund and ODA goals;
- The **additionality of each activity**;
- The **results of each activity** in terms of the outputs, outcomes and impacts generated in terms of strengthening the science and knowledge base, innovation capacity and influencing policy in Mexico and beyond; and
- The **success factors (and barriers) of each activity**, and examination of possible future benefits from each activity that might be expected to arise in the future.

We took into account that two of the activities included in this study are still ongoing, and that the impact of research projects can take years to unfold. Our research approach was adapted to reflect this, and includes evidence of early signs of impact or intentions to achieve impact where these have been identified.

Research methods and data collection approach

The thematic impact studies are central to our contribution analysis approach and involved an intensive period of in-country research by members of the evaluation team and local experts in the science and innovation sphere. Preparation for the in-country research included a document review of country-specific documents on Mexico's research and development context. Documents reviewed include the evaluation Mexico Baseline Report, Country Situation Note, and findings from the Process Evaluation. We also conducted a literature review of additional documentation on Mexico's science and innovation landscape, and existing UK-Mexico collaboration activities. Project-specific documentation, such as application forms, mid-term and final reports, were reviewed for each action included in the study, where provided by the delivery partner, local partners or researchers.

The document review was accompanied by **one week of intensive data collection in country**¸ as well as data collection in the UK prior to and following the fieldwork. Fieldwork in Mexico took place on 19-23 February 2018. During the week-long in-country visit, three main categories of stakeholders were interviewed: i) in-country delivery partners (and the Newton in-country team); ii) funders; and iii) participating researchers. In some cases, additional University staff, such as University leadership or management teams, were also interviewed.

For the British Council Technology Transfer Best Practice and Skills Development Training for Practitioners, an online survey was rolled out among participants prior to and during fieldwork. We then conducted telephone interviews with two participants who were interested in providing further insight into their experiences during and after the training. We employed this approach because the training had a wide geographical spread across Mexico, and we wanted to capture as many views as possible.

Our data collection both in-country and in the UK was complemented with an analysis of the pathway to impact for each action, which can be found in Annex 2. Here, we analysed each project's trajectory to impact by placing it within the Newton Fund Theory of Change. This allowed us to visually represent the pathway to outputs, outcomes and impact of each activity, and highlight its (potential) contribution to broader Newton Fund goals.

Limitations of the research approach

The short timeframe for in-country research meant that we were only able to include three projects within our study. These are not representative of all Newton Fund activities as a whole. The timeframe also limited the number of stakeholders we could interview in Mexico.

Research findings have been triangulated across different stakeholder groups and across various sources of documentation (project documents and online resources such as the RCUK Gateway to Research portal). However, the research team was not able to independently verify statements by all the different contributing stakeholders or to verify what was reported in documentation. Where findings could not be verified we have made this clear in the text.

For the British Council Technology Transfer Best Practice and Skills Development Training for Practitioners, though an online survey was designed and distributed, fewer than half of participants responded. Out of the respondents, we were only able to interview two. There is likely to be some bias in the responses recorded, as those who have participated may be the ones with the strongest positive or negative views on the training.

Two of the projects included were still ongoing at the time of data collection. Therefore, the report focuses on emerging signs of impact for both.

2 Newton Fund in Mexico

2.1 Context and evolution of the Fund in Mexico

Mexico – Current situation

For the last 20 years Mexico's economic growth has stagnated at around 2% annually due to a series of structural factors such as low levels of investment, low productivity, high inequality, a large informal sector employing over half of the workforce, and weak rule of law. Since the entry into force of the North American Free Trade Agreement (NAFTA) in 1994, the Mexican economy has been directed towards manufacturing, which today accounts for almost 20% of the country's GDP. Within manufacturing, the automotive sector is the largest sub-sector, accounting for 3.5% of GDP, with firms located in Mexico forming part of global value chains. After automobile exports, the biggest sources of foreign currency for the country are remittances, tourism and agro-exports. As of February 2018, Mexico was going through an oil crisis due to a historical lack of investment in exploration, production, refining and the low price of oil. In 2017, oil production by PEMEX, the state-owned oil company, had fallen to its lowest historical level (1.9 million barrels per day).[1]

Mexico's current government, led by Enrique Peña Nieto, reached consensus to implement energy, financial, fiscal, and telecommunications reform legislation, with the long-term aim to improve competitiveness and economic growth across the Mexican economy. However, numerous corruption scandals related to his government and the lack of socio-economic improvements among the majority of the population have caused widespread social unrest.[2] The arrival of Donald Trump to the presidency of the United States introduced uncertainty to the Mexican economic and political situation, given his threats to deport more than 11 million undocumented people and to end NAFTA. In July 2018, elections are set to take place and the possibility of Andrés Manuel López Obrador winning increases uncertainty, since his proposals include pulling back most of the structural reforms put forward by the current government.

Mexico – UK relations

In 2013, the Minister of Education and representatives of the Mexican government travelled to the UK to promote a closer relationship in the education field. Those conversations led both countries to declare 2015 as the Year of the United Kingdom in Mexico and the Year of Mexico in the United Kingdom.[3] President Peña Nieto's visit to London, at the beginning of March 2015, constituted an opportunity to relaunch the Newton Fund, outlining the specific programs implemented in Mexico.[4] According to UK respondents, the State visit in 2015 was helpful to make the Newton Fund a more prominent platform for collaboration.

Other UK partners mentioned the fact that there has been a push in the Mexican government to diversify from working almost exclusively with the United States and Canada. Although the United States remains Mexico's number one partner in research and innovation, the UK is becoming increasingly sought after by researchers and students, especially after President Trump's election. **In 2016, the UK overtook the United States as the largest recipient of Mexican Science and Technology Committee (CONACyT) grantees**, with 1,321 students.[5] Other important destinations for Mexican students include Spain, France and Germany. [6]

[1] Fariza, I. La producción petrolera de México baja de dos millones de barriles por primera vez en casi cuarenta años, El País 20 Agosto 2017.
[2] Castañeda, D. Presente y futuro del crecimiento económico de México, Nexos, mayo 5 del 2016
[3] Embajada de México en el Reino Unido, 2015, Year of Mexico in The United Kingdom and of the United Kingdom in Mexico, retrieved at *https://embamex.sre.gob.mx/reinounido/index.php/en/ver-comunicados/683-2015-year-of-mexico-uk).*
[4] Entrevista a Salvador López Carbajal en Noticias México al Día, 5 de marzo del 2015
[5] Guerrero, AL (2016) 'Brexit, su impacto en la ciencia mexicana, Agencia Informativa CONACyT'. Available from: http://www.oei.es/historico/divulgacioncientifica/?Brexit-su-impacto-en-la-ciencia-mexicana
[6] PACEC Baseline Report Mexico

Outside of the Newton Fund, other British Embassy initiatives include the Chevening programme[7], the Prosperity Fund[8], and the International Climate Fund.[9] It is a British Embassy priority to ensure that Newton is aligned with Embassy activities as a whole. There is a clear overlap of Newton and some of these programmes, especially Chevening and the Prosperity Fund, both in thematic focus areas and some priority states.

Science and innovation landscape in Mexico

Historically, Mexican governments have tended to not consider investment in science and technology as its main path to growth, relying more on comparative advantages, such as low wages, to attract foreign investment. The current government's strategy, established in the Programme for Innovative Development (PDI, 2013-2018), reflects a change and **acknowledges the importance of innovation to revitalize mature sectors, improve services and take advantage of the opportunities that exist in new technologies**.

The PDI states that "*Mexico is lagging behind in innovation as the pillars that sustain and drive it are weak. The situation is characterized by low spending on science, technology and innovation (STI), a lack of culture of innovation, weak links between the academic and the productive sectors, scarce generation of specialized human resources and few specialized financial instruments in the different phases of innovation*".[10] It also notes that "*STI spending as a proportion of GDP is 0.4%, one of the three lowest in the OECD member countries*".[11] The PDI proposes to follow the Triple Helix model of innovation in which university, industry and government interact to generate new institutional and social formats for the production, transfer and application of knowledge.[12] The Special Programme on Science, Technology and Innovation (PECITI 2015-2018) establishes specific actions, such as increasing national investment in STI; developing highly qualified human resources in science and technology; strengthening regional development; promoting science-industry linkages; and developing S&T infrastructure.[13]

The National Council of Science and Technology, CONACyT, is "*the advisory entity of the Federal Executive specialized in articulating the public policies of the federal government and promoting the development of scientific and technological research, innovation, development and the technological modernisation of the country*".[14] CONACyT is a fund manager, specialized in funding scientific research, and does not have a strong influence in defining science and innovation policy.

The Mexican science and innovation landscape is characterised by strong geographic, institutional and budgetary centralisation. CONACyT distributes most of the budget for science and innovation, administers most research programmes and is the main counterpart of international organizations for cooperation in science and technology. CONACyT's most significant programmes are those which grant postgraduate scholarships in Mexico and abroad, giving a bonus to national researchers according to their productivity (National System of Researchers or SNI).[15] Unlike other countries in the region, the bulk of the funding for research activities consists of federal funds. State governments do not collect taxes beyond property tax, and firms in the extractives sector, such as mining, do not contribute with special taxes for education or science and technology activities as they do in other countries such as Chile and Peru.

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[7] Chevening is the UK Government's international awards scheme aimed at developing global leaders. Chevening awards scholarships to outstanding professionals to pursue a one-year master's degree in any subject at any UK university.
[8] The Prosperity Fund is an initiative to provide expertise and technical assistance in areas of UK strength to: promote economic reforms and remove barriers to trade; strengthen policy capacity and build strong institutions and develop sectors which support growth such as infrastructure, energy, finance, education and healthcare, https://www.gov.uk/government/publications/cross-government-prosperity-fund-programme/cross-government-prosperity-fund-update#our-partners
[9] The International Climate Fund (ICF) is the UK government's commitment to developing countries to help them address the challenges presented by climate change and benefit from the opportunities (REF). The 3 broad priorities of the Fund are: i) Demonstrate that building low carbon climate resilient growth at scale is feasible and desirable ii. Support the international negotiations, particularly through providing support for adaptation in poor countries and building an effective international architecture. iii. Drive innovation and new ideas for action, and create partnerships with the private sector (The UK's International Climate Fund & Capital Markets Climate Initiative, Department of Energy and Climate Change UK, retrieved at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48409/5539-uk-international-climate-fund-cmci.pdf
[10] Secretaría de Economía, *Programa de Desarrollo Innovador 2013-2018,* Gobierno de la República, p. 35.
[11] Ibid.
[12] Etzkowitz, H and Leydesdorff, L (eds.), Universities and the Global Knowledge Economy: A Triple Helix of University-Industry-Government Relations (London: Pinter, 1997, 184 pp)
[13] Programa Especial de Ciencia, Tecnología e Innovación 2015-2018, Gobierno de la República.
[14] Ley Orgánica del Consejo Nacional de Ciencia y Tecnología, DOF 20-05-2014
[15] Presupuesto de Egresos de la Federación 2018, Ramo 38 Consejo Nacional de Ciencia y Tecnología.

Scientific research is mostly performed by public research centres and universities. Scientific production is highly centralised. The National Autonomous University of Mexico (UNAM) is the institution that receives the most federal funds and devotes the most money to research, producing 30% of all publications by Mexican researchers.

There is a strong geographical concentration of research activities. Most research is conducted in the centre of the country, namely in Mexico City, Mexico state, Morelos and Querétaro. Top researchers – as defined by those awarded the maximum level by the National System of Researchers (SNI) – are highly concentrated in Mexico City and Morelos. With the aim of setting state-specific strategic sectors and areas of specialization, FUMEC and CONACyT encouraged the production of 32 State Innovation Agendas. These have the general objective to contribute to state and regional economic development, taking advantage of the innovative potential of Mexico's regions.[16]

Most firms, large and small, do not carry out R&D or have innovation programs.[17]According to the Global Competitiveness Index 2016, the country ranks 77/137 on the company spending indicator, 58/137 in the PCT patents applications per million people indicator and 70/137 on the capacity for innovation indicator.[18] Most successful industry clusters have arisen in certain regions, particularly Nuevo León, Querétaro and Mexico City, where local governments have supported positive externalities that arise from industrial dynamics.

In an attempt to change this situation, the STI budget has considerably increased since 2012, reaching 0.55% of GDP in 2015.[19] Mexican partners reported that **this administration has been the one with the highest spending for science and innovation in Mexico's history**. This has allowed CONACyT to finance university-industry projects and to modernise infrastructure. However, the fall in oil prices led the government to reduce public spending on STI by 13% in 2017. This is also due to CONACyT's funding cycle, which follows the electoral cycle: in effect, most federal spending on STI occurs in the first years of the six-year administration, reaching its minimum in the final year.

The Newton Fund entered Mexico at an appropriate time: at the middle of the current administration, when CONACyT funding was at a high point in its funding cycle. As of 2018, CONACyT reported having almost no funding available for additional projects[20]. Furthermore, it is expected that with every change in administration, come changes at the level of staffing and leadership in public institutions. This can create problems in terms of institutional learning, and, with elections coming up in 2018, is a factor that may have implications for Newton Fund collaboration.

International relations and research landscape

In 2016, CONACyT reported having 220 international cooperation agreements with different countries, especially in the Americas and Europe.[21] Among the countries with the highest number of bilateral agreements in force are USA, France, United Kingdom, Canada, Germany and Spain. CONACyT also has bilateral agreements with countries such as South Africa, Turkey, Singapore, Korea and China, and multilateral agreements with the Organisation of American States (OAS), OECD and the European Union, among others.

There is a long history of cooperation with the USA in science and technology. The United States-Mexico Foundation for Science (FUMEC) has promoted bilateral collaboration in science and technology for 25 years. The Mexico-United States Entrepreneurship and Innovation Council (MUSEIC) and the Bilateral Forum for Higher Education (FOBESII) are partnerships chaired by FUMEC that have strengthened cooperation. FUMEC is also in charge of the Intelligent Manufacturing Initiative, which has agreed to set up a Bi-national Intelligent Manufacturing

[16] CONACYT, Informe General del estado de la ciencia, la tecnología y la innovación en México 2016. México.
[17] INEGI, Encuesta sobre investigación y desarrollo tecnológico (ESIDET) 2006, 2008, 2010 y 2012.
[18] Global Competitiveness Index 2015-16.
[19] Banco Mundial, https://datos.bancomundial.org/indicador/GB.XPD.RSDV.GD.ZS?locations=MX
[20] Tépach, R y Méndez, L (2017) El presupuesto Público Federal para la Función de Ciencia, Tecnología e Innovación 2016-2017, Dirección General de Servicios de Documentación, Información y Análisis Dirección de Servicios de Investigación y Análisis de la Cámara de Diputados, retrived at http://www.diputados.gob.mx/sedia/sia/se/SAE-ISS-21-17.pdf

[21] CONACyT (2017) 'Informe General del Estado de la Ciencia, la Tecnología y la Innovación', p. 137. Available from: http://www.siicyt.gob.mx/index.php/transparencia/informes-conacyt/informe-general-del-estado-de-la-ciencia-tecnologia-e-innovacion/informe-general-2016/3835-informe-general-2016/file

Institute (BIMI) in border regions to attract new investment. Together with CONACyT, FUMEC leads two projects: the Industry-University Cooperative Research Consortia, aimed at boosting cooperation between academia and industry in joint projects, and i-Corps, which is running a pilot scheme to assess the commercial possibilities of scientific findings.

In March 2011, President Obama set up the "100,000 Strong in the Americas" innovation programme, which aims to create new alliances between universities throughout the American continent and promote student exchange. The target of the programme is that 100,000 American students study in Latin American universities and 100,000 Latin American students study in the United States by 2020. Recently, the Coca Cola Foundation awarded USD 25,000 to each one of eight winners, to help more than 115 students to study abroad.[22]

Mexico and Germany also have a cooperation program **similar to the Newton Fund**, which currently finances three biotechnology projects. The German Academic Exchange Service (DAAD) is active in promoting mobilization of students between the two countries, and firms such as Audi and VW have set up student exchange programs that include internships at their facilities, as well as university exchanges.

Newton Fund in Mexico

The Newton Fund began its activities in Mexico in 2014 with a budget of £4m per annum. For 2016, collaboration extended to £6m per annum.[23] At the beginning of Newton Fund collaboration, there was a greater focus on People pillar activities, but there has been a recent shift to include more Translation and Research projects.

The Newton Fund's priorities in Mexico are: i) energy and climate change; ii) cities of the future; iii) agritech; and iv) health and nutrition. Respondents both in the UK and Mexico consider Newton priorities to be well-aligned with the Mexican government's strategies and aims, providing a good fit with CONACyT's priority areas including health, biodiversity, food, energy and climate change, among others.[24] A key incentive for the Mexican government to engage with the Newton Fund is the additional funding and assistance available for activities which include: the development of skills through exchange of researchers and students; collaboration in joint research on development issues; innovation programmes for the commercialization of science; and collaborative research and development for applied sciences.[25] According to the Newton Fund's Mexican partners, these actions can help promote the transition to a knowledge-based economy, which is a Mexican government priority.[26]

The **Newton Fund** is following the UK Embassy's strategy for **decentralisation of cooperation activities across Mexico**. This is also linked to Newton priority areas for the country, which include creating linkages with all Mexican regions. The Newton in-country team (ICT) has identified ten priority states in Mexico, and is helping set up collaboration agreements directly with state governments. This strategy is also being employed by other UK initiatives, such as the Prosperity Fund. **Signing new agreements with state partners can help manage the cyclical trends in funding available at the central government level**. As previously mentioned, national institutions such as CONACyT tend to be left without resources to operate in the last year of the six-year government period. The ICT's strategy can help find new partners and funders, diversifying away from institutions which might have limited funding and experience changes in leadership following political changes, such as CONACyT.

Emerging impact of the Newton Fund in Mexico

Overall, Newton was seen as a **very positive collaboration** by all partners. There was strong interest in promoting further collaboration projects, though these are constrained by funding limitations at the central government level.

Newton funding is larger than what was seen in previous collaborations with the UK and other partners. Importantly, it is **perceived to be an equal partnership, rather than development assistance** (or "aid"). Respondents highlighted that the Newton Fund collaboration helps partners in the UK and Mexico learn about each other's ways of working and their respective strengths. Match funding – financial and in-kind – was highlighted as

[22] Fondo de innovación de la Fuerza de Cien Mil en las Américas anuncia instituciones ganadoras, retrieved at https://mx.usembassy.gov/es/fondo-de-innovacion-de-la-fuerza-de-cien-mil-en-las-americas-anuncia-instituciones-ganadoras/
[23] Interview to the British Ambassador in Mexico, H Duncan Taylor, http://www.cronica.com.mx/notas/2016/1001040.html
[24] PECITI 2014-2018 pp 50
[25] Fondo Newton en México, retrieved at https://www.gov.uk/government/news/newton-fund-mexico.es-419, on February the 9th 2018.
[26] British Council, Fondo Newton en México y CONACYT, Términos de referencia para la Convocatoria Institutional Links 2014.

helping to foster equal partnerships, allowing Mexican partners to participate even where an equal financial match was not available.

Compared to other partners, the UK is perceived as helping to foster technological development in Mexico, rather than seeking to import technology into it. **The ODA component was considered important,** with its focus on capacity-building, social impact, and socio-economic development, rather than simply the promotion of commercialisation and profit potential.

According to Mexican partners, **Newton fills some gaps in the Mexican research funding system**. For instance, through Researcher Links, young Mexican researchers can collaborate with researchers in the UK to conduct projects that will help advance their careers. Capacity-building activities were also considered important. In addition, as opposed to basic science projects financed by CONACyT, the Newton Fund sponsors technological development stages such as scaling-up, and also supports social sciences research. The Newton Fund is also helping with budgetary, institutional and geographical decentralisation of science in Mexico.

Particularly successful programmes mentioned by respondents include:

- Researcher Links and Institutional Links, which help set up or strengthen networks between UK and Mexican universities, particularly for researchers in the early stages of their career. Institutional Links was identified as promoting long-term collaboration between researchers in Mexico and the UK. Similarly, Researcher Links gives space for young researchers to present their work to international audiences;
- The partnership between University of Oxford and the Tecnológico de Monterrey to run **human trials on dengue**, aiming to understand the potential of generating immune responses through an experimental vaccine. This began as an Institutional Link grant which triggered a consortium in Mexico that aimed to investigate whether an experimental immunogen is truly universal. The consortium has worked to isolate and preserve samples from patients previously infected with dengue.[27]

Respondents also spoke about the Newton Fund's **institutional impact in CONACyT**. Here, Newton has led to management and organisational change – with the creation of two specialised sub-divisions under the International Relations Department, Scientific Cooperation and Technological Cooperation, where before, there was only an International Relations Department. Newton Fund also helped institutionalise cooperation, and set up long-term links.

These impacts were facilitated by the presence of the Newton Fund ICT. According to Mexican partners, **having an in-country presence brings trusts and facilitates communication**, as well as making the programme more culturally and contextually adaptable.

Remaining challenges and potential areas for improvement

Despite the fact that **match funding has not presented any problems,** some partners mentioned a few instances where the match has not been equal. In some cases, the Mexican partner was not able to fund enough UK researchers to correspond to the UK match.

A high staff turnover within the Newton Fund ICT has created challenges of retaining institutional knowledge. Similarly, Mexican funding agencies tend to experience high turnover levels, which sometimes leads to delays and management challenges.

Communication between the FCO and BEIS could also be improved, as could the **line of responsibility for the ICT.** In particular, communications on the Newton Fund and on the ICT's role could be improved. Local partners and potential participants **are sometimes unaware of financing or collaboration opportunities, and confused about the ICT's structure and role.** For example, Mexico does not have a SIN network, and some think this is part of the role of the Head of Science and Innovation and Newton Fund. There has been a recent push on the part

[27] The neglected and emerging infectious diseases network is a partnership between the University of Oxford and Benemérita Universidad Autónoma de Puebla, Universidad Michoacana de San Nicolás de Hidalgo, the Mexican Social Security Institute (IMSS) in Michoacan State and Universidad Veracruzana, among others. It started as an Institutional Link grant between Oxford and the Tecnológico de Monterrey during the 2014 call.

of the ICT to organise more communication sharing activities, such as Innovation Nights, and there is will within the Embassy to continue organising this type of activity.

Overall, **there is untapped potential of the ICT.** They can help understand the context, make the necessary connections on-the-ground, and advise DPs on new and potential partnerships outside of Mexico City. For example, there is limited understanding among the DPs how Mexican bureaucracy works and what the required timelines are, as well as limited familiarity with relevant government institutions outside of CONACyT.

Linked to this, despite the push for regionalisation and diversification at the UK Embassy level, what remains to be seen is **how to raise the interest of UK counterparts in smaller organisations and states.** According to the ICT, more could be done in terms of expanding networks and seeking partners beyond working exclusively with CONACyT. As previously mentioned, a centralised strategy brings challenges as CONACyT is subject to the central government's financing cycle.

Another of the main challenges faced is **monitoring, as well as short-term, medium-term and long-term evaluation.** There is not an overall effort to engage in data collection, and there are difficulties in accessing data, where it exists. Some DPs seem reluctant to engage with the ICT and share their data with them. There are limited records of participants, which limits the ICT's knowledge of what is happening and where.

Participating researchers and institutions have identified legal and administrative issues as posing challenges and causing delays. Here, it can take a long time to have agreements in place: **it is an extremely lengthy and complicated system, especially because participating institutions often have never engaged in such large programmes,** and quite detailed MoUs are required.

Finally, there could be further coordination and learning between Newton teams at the regional level – and more lesson learning among participating Newton Fund countries in Latin America. A "shadowing" experience, which is scheduled to bring members of the Mexican ICT to the Brazil office, is a positive step in this direction.

3 Technology Transfer Best Practice and Skills Development Training for Practitioners

3.1 Summary

Action title	Technology Transfer Best Practice and Skills Development Training for Practitioners.
Short description	Oxentia (University of Oxford) delivered training for 28 TTO (Technology Transfer Office) professionals. This took place on 2-4 November 2016 in Tijuana, Baja California, during the annual conference organised by Red OTT for the Mexican Network of Technology Transfer Offices.
Objective(s)	The objective of the training was to train TTO professionals in developing best practices and knowledge transfer skills that can be applied to their jobs in order to improve technology transfer processes. The training covered the following topics: i) basic principles of knowledge exchange and commercialisation; ii) Intellectual Property (IP) policy; iii) IP; iv) sourcing innovation; v) marketing technology; vi) licensing; vii) negotiation; viii) business models; ix) proof of concept, prototyping and design in TTOs; and x) societal and ethical considerations in innovation management. This training aimed to expand the level of collaboration that takes place between Mexican institutions in the area of technology transfer. By providing TTOs with the necessary skills to help bridge the relationship between education, industry and society, the key idea was to help Mexico become a more dynamic “knowledge society”. The core concept of the conference in 2016 was “Commercialisation of Technology”, resulting from the firm belief that innovation and technology transfer are the key forces which will allow the region to create jobs.
Pillar	People
Acton value (total budget allocated in country, in GBP)	UK: GBP 22,560 Mexico: GBP 22,468
Start/ end date (Status: ongoing or complete)	2-4 November 2016 (complete)
DP UK and overseas	UK: British Council; MEX: Secretariat of the Economy (SE), BajaInnova (in-kind support in the form of logistical organisation)
Award holders/ grantee	n/a

3.2 Description of the action

Brief Description of Action

This action consisted of a standalone training delivered in November 2016 as part of the British Council’s Professional Development and Engagement initiative, which seeks to help create an enabling environment for

research.[28] Strengthening **the link between research and business** is a core focus of this initiative's skills training component. The other two focus areas are support for research governance and management and engaging researchers with end-users. For the skills training strand, similar capacity-building initiatives in technology transfer were organised in South Africa, Malaysia and Indonesia, and focused on strengthening the links between higher education and the commercial sector.

This training was organised with the Secretariat of the Economy (SE), Red OTT[29] and BajaInnova, and aimed to provide 'technology transfer basics' to strengthen skills in some of Mexico's Technology Transfer Offices. The training was held over three days within the 5th annual Red OTT conference, "Technology Transfer: A Business without Borders". The training consisted of talks and practical exercises led by two consultants from the University of Oxford's Global Innovation consultancy, Isis Enterprise (now Oxentia), Dr Mireya McKee and Dr James Hudson. A technology transfer training manual accompanied the course. The training was attended by a total of 28 technology transfer practitioners from both private and public TTOs around Mexico.

The overall goal of the project was to increase the skills of Technology Transfer Offices' staff. Capacities of staff vary across TTOs and the training was intended to ensure that TTOs are aware of recent developments at the international level, as well as developing practical skills which could be applied to their jobs to improve technology transfer processes. By providing examples from UK best practice, it sought to increase familiarity among Mexican institutions of the processes and methodologies employed in the UK.

It was anticipated by Delivery Partners that this would be part of a **series of three trainings**: i) soft skills; ii) business skills; and iii) innovation skills. However, the second and first training did not materialise as the British Council was not successful in obtaining more funding.

Pathway to Impact

Although it is a People pillar project, this training also covers translation themes and focus areas. As shown in Figure 1, Annex 2, there is an overlap of People and Translation inputs, outputs, and outcomes.

The National Autonomous University of Mexico (UNAM) pioneered technology transfer activities in Mexico by creating its Centre for Technological Innovation (CIT) in 1984.[30] By the end of 2016, there were 76 TTOs in Mexico, 22 of which were in public universities. Some practitioners consider that the main problems faced by TTOs are: i) while research can show promising results in a laboratory, it can be difficult to scale-up; ii) research in Mexican universities does not tackle problems related to society; and iii) TTO practitioners lack training and experience.[31]

In practice, capacity levels vary among institutions. TTOs are often very small, and run part-time by researchers. This poses challenges in terms of technology commercialisation. According to Oxentia's Feedback and Recommendations document, "*the disassociation between education, industry and society […] has been identified as one of the barriers Mexico has in its progression towards a 'Knowledge Society'. … One of the strategies to address these issues is to improve the process of transferring skills, knowledge, technologies, and methods of manufacturing between governments or universities."*[32]

This training aimed to provide **high-quality, comprehensive baseline knowledge** to TTO practitioners – to ensure that a basic understanding of technology transfer could be achieved across the board. Mexican TTO staff currently face two main challenges: i) some TTO staff are not specialised in science, and therefore do not fully understand how to assess a technology (for instance, lawyers focused on IP development); and ii) some TTO staff are researchers who lack familiarity with intellectual property protection and licensing processes, or have a limited understanding of the workings of the market, or how to construct the right business models.

[28] https://www.britishcouncil.org/education/science/newton/PDE
[29] Red OTT is a national organisation created through the National Council of Science and Technology (CONACyT) and the Secretariat of Economy of Mexico with the goal of creating spaces of collaboration and participation for technology transfer offices and professionals since 2012 (More information available at: http://www.redott.com.mx/).
[30] The CIT closed for political reasons in 1997 and was substituted by the University-Industry Liaison Office, active until 2000. UNAM resumed the mission to transfer the results of the research to the industry in 2008, by opening the Research and Development Coordination (CID).
[31] Vargas, AC, Patentan pero no venden, Suplemento Universitarios del diario Reforma, Septiembre del 2016.
[32] McKee, M., Hudson, J. (2017) 'Newton Professional Development and Engagement Programme: Technology Transfer Best Practice and Skills Development Training for Practitioners – November 4-6, 2016. Feedback and Recommendations'

In terms of **inputs,** the focus of this training was on the soft skills necessary for more effective TTO practice, such as negotiation and networking skills, as well as basic principles in knowledge exchange and commercialisation, IP policy, marketing, licensing, and negotiations, among others. It also included practical exercises and networking opportunities. It was initially expected that this would be the first of three trainings, with the other two being focused on the more technical aspects of business and innovation skills. However, due to a reduction in BEIS funding for the Mexico portfolio, the other two trainings were not delivered.

In terms of **outputs,** it was expected that this training would build capacity among TTO practitioners and institutions, in areas including principles of knowledge exchange and commercialisation, IP policy, marketing technology, licensing, and several others where gaps had been identified.

As for **expected outcomes and impact**, a well-carried out technology transfer would see firms being able to develop new processes and products utilising academic innovations and technologies. This would, in turn, stimulate innovation, entrepreneurship and growth in the Mexican economy.

3.3 Answers to the evaluation questions

3.3.1 Relevance

Activity targeting and ODA Relevance

The focus on **strengthening the connections between higher education and business is a priority theme in Mexico**, and reflects the current Mexican government's emphasis on becoming a knowledge-based economy. This initiative is linked to the country's push to becoming a producer – rather than only a consumer – of technology, which is included in Mexico's National Development Plan 2012-2018. The Plan sets out a clear pathway for education, science, technology and innovation as key drivers of economic growth and socially sustainable progress.

The focus of this activity also fits in with the Newton Fund's priority of capacity-building, especially with the aim to foster translation and innovation activities. As shown in Annex 2, Figure 1, while this was a People Pillar initiative, it also aims to facilitate translation-type outputs and outcomes, by helping TTO staff gain the necessary skills to transform research outputs into innovative products or processes, and harness local capacity for commercial advantage.

Additionality

The Newton Fund has been central to the development and the delivery of this activity. The idea for this activity **emerged through other Newton activities.** Through the collaborations fostered through Institutional Links[33], which in some instances involved TTOs in a coordinating role, British Council Mexico realised that there are significant capacity limitations within TTOs – in that their technical knowledge in technology transfer was limited. They found that what was missing the most was soft skills, especially in terms of knowledge on how to market their technology. The SE, which is the entity responsible for supervising the work of Mexican TTOs, also had a very strong interest in introducing this type of training, and was aware of the capacity limitations within TTOs. The dialogue with the SE helped the British Council gain a better understanding of the needs and priorities of these institutions, and thus design a relevant training. Furthermore, it was through this Institutional Links collaboration that the British Council and the SE Director of Innovation – who, at the time, was their Institutional Links counterpart at CONACyT – had a first positive experience working together. This prior, successful collaboration led the two parties to want to work together again.

The SE has been quite vocal about their interest in following up this initiative with more training. However, despite their high level of interest, **they have not been able to deliver more trainings since the end of Newton funding**. The match funding component enabled the SE to contribute in-kind through the logistical support offered by BajaInnova, which organised and hosted the event. In fact, the SE's internal mechanisms do not allow them to

[33] Institutional Links is a programme which provides grants for the development of research and innovation collaborations between the UK and partner countries. More information can be found here: https://www.britishcouncil.org/education/science/institutional-links.

engage in direct financing of this type of activity. This indicates that it is unlikely that the project could have been undertaken without Newton funding.

Participants highlighted that trainings conducted with this level of detail and intensity are almost non-existent in Mexico. Especially at the University level, there an acute lack of training and capacity-building of TTO staff. Here, it was reported that Oxentia stood out in its delivery of training, themes covered and examples provided. Several respondents expressed a strong interest in participating in similar trainings in the future and stated that this type of initiative has not been repeated elsewhere, especially not with the same quality and high-level content.

3.3.2 Effectiveness

Capacity-building for individuals

A participant survey was administered by Oxentia during the Conference, both before and after the training. Prior to this thematic study, no follow-up with participants had occurred since the end of the training. In order to conduct a follow-up assessment, the Coffey research team administered an online survey to the 28 training participants in February 2018. Of these, 13 completed the survey and follow-up phone interviews were conducted with two respondents. Respondents to the online survey were from public and private institutions in 11 states, while interviewees were from two private institutions in two different states.

The survey sought to capture self-reported capacity improvements. Most respondents reported improvements in all areas covered by the training. The largest improvements were in knowledge exchange and commercialisation, licensing and business models, which also presented the lowest baseline levels. Respondents' views on the importance of demonstrating social impact and ethical practices in TTO processes did not change significantly, and were already very high from baseline.

Overall, the training was considered to be of **high quality and highly relevant by those who participated**. Comments from participants were generally very positive, and most found it to be a good introduction to technology commercialisation. Of the 13 respondents to the online survey, all except one considered it to be good or very good. Respondents rated the capacity and knowledge of trainers to be very high.

In terms of impact on their capacity, online survey respondents considered the **themes covered and interactive exercises to be the most valuable aspects of this course, followed by quality of course delivery and materials**.

In the post-training survey, it was reported that the most challenging aspect related to practical technology commercialisation skills, while not many said that they found IP protection to be a major challenge. Similarly, the majority of respondents to the online survey identified marketing of technology to be the most challenging aspect, followed by licensing and commercialisation processes. Demonstration of social impact and ethical practices were considered the least challenging in both instances, indicating that respondents' perception of their pre-existing knowledge was quite high.

Despite the reported improvements in capacity and appreciation of course quality and content, some remaining gaps were identified:

- Respondents both to the online survey and phone interviews stated that TTOs continue to have substantial skills and knowledge gaps, especially in terms of the commercialisation and licensing of their technologies. They expressed a need for additional capacity-building in this field, if the interaction between TTOs and business is to be more fruitful.
- Some highlighted the importance of organising events and trainings to maintain contacts between network members, help them share research findings and engage in joint projects. For example, one interview respondent suggested holding an event per year to assess possibilities of TTOs doing joint research.
- Approximately 38% of respondents to the online survey believed that the course was too short to cover such a wide range of themes in depth (and as such was somewhat superficial); and
- Though respondents generally appreciated the possibility of learning about the UK experience, some mentioned that it would have been useful to include cases from Mexico and other Latin American countries, rather than focus on a European perspective, to enhance their relevance to Mexican TTOs' experiences.

Capacity-building for institutions

Among online survey respondents, 11 out of 13 stated that **they were able to apply course content to their work,** and eight out of 13 that **this training has led to change within their institution.** Changes mentioned include professionalization of processes, changes in strategy, and learning from international best practice. Here, lessons on management and marketing of innovation and development were identified as particularly important.

In addition, one interview respondent said that he applied the methodologies exposed by the trainers – different from those he had seen at other trainings before – directly to his work. The methods exposed led him to decide to set up a new private TTO, which focuses on specialised technology projects. The enterprise is also applying the Technology Readiness Level (TRL) model, covered in the training, to construct a mapping of the link between enterprises and institutions.

New international partnerships

No new international partnerships have emerged from the project. The British Council is not continuing its collaboration with the SE for the delivery of additional trainings. Although the SE is very interested in having follow-up trainings of this type, nothing has been done so far, in the absence of Newton funding.

Outside of Newton Fund activities, the State Government of Puebla has been in touch with Oxentia in order to have a similar training delivered, but this had not been carried out so far.

Capacity-building of UK researchers and institutions

This is not applicable, as it was a one-off training delivered by a UK partner to Mexican participants.

3.3.3 Impact

Potential impact on poverty reduction and economic development

This training had the objective to improve the capacity of TTO offices to deliver technology transfer from academia to industry, **ultimately leading to the development of innovative products or processes**. This logic is underpinned by a key challenge: the need to change institutional and business mentality from that of being manufacturers and users of a technology, to becoming producers of knowledge-based products.

According to the British Council, this training has been successful in creating a baseline for TTO professionals, ensuring they have a basic understanding of technology transfer processes. It is unclear whether the training has resulted in the development of innovative processes and products, as no information on this was available, and impact data is not being collected by the British Council or the SE. There was no follow-up or further engagement with the training participants since the training took place, outside of the Thematic Study.

Change in perceptions of the UK

The course included a module on technology transfer best practice in the UK, and several examples were provided of Oxentia's experience in this field. According to participants, this was useful to learn more about the UK's experience, and be provided with best practice examples. Participants highlighted that it was particularly interesting to learn more about the weight placed on technology transfer by countries like the UK. This experience also led at least two participants to seek further experiences collaborating with UK institutions.

3.3.4 Complementarity and coordination

Catalytic effects

A one-off training is not sufficient to allow catalytic effects to happen, though it can have an impact on individual professionals and individual institutions' capacities and behaviours. If this continues to be considered a theme of relevance for Mexico's socio-economic prospects, further efforts could be made to have follow-up trainings, promote networking among TTOs, and foster innovative partnerships.

Though it was impossible to gain a complete overview of the changes that have occurred within participating TTOs, due to limited response rates to follow-up questions, there are some encouraging signs of the training having led to behavioural change in at least one institution.

Here, one TTO director reported having set up a new, private TTO after having attended the training (where he participated as a representative from a public institution). He stated that the training played a fundamental role in this decision, in that he followed the methodology of seeking longer-term strategies, rather than project-based work. Here, his new TTO is not working with businesses on a project-by-project basis, but with businesses which have longer-term plans and projects. **This strategic "ecosystem" model is based on a methodology outlined during the training**. Creating this type of 'innovation ecosystem' remains challenging, however, as it is necessary to convince businesses that technological development and investment will bring them economic benefits – an idea which remains quite novel in Mexico.

Despite this encouraging sign, the same respondent also reported that most of the other participating TTOs, from his knowledge, continue to work with a traditional model, and most still depend on CONACyT funding. It is difficult to see how a standalone training could lead to systemic change in and of itself. A key assumption of this logic is that there are systems in place within the TTOs whereby trained individuals are able to: i) spread knowledge within their institutions; and ii) have the freedom to change decision-making and bureaucratic processes. To foster change at the institutional, business and ecosystem level, it was highlighted that efforts should be made **to change the culture of innovation and entrepreneurship**, by further involving University leadership and businesses to ensure their buy-in. There needs to be a change in mind-set whereby these institutions recognise the importance of technology transfer, including the direct benefits to them. One respondent suggested that organising trainings for University leadership would help ensure that successful transfer of technology can happen – as capacitating TTO staff is insufficient to foster long-lasting institutional change.

Leadership effects

The SE continues to have an interest in conducting more trainings of this type. However, they have been unable to do so due to a lack of funds, and have not identified other potential partners to turn this interest into a reality.

There were limited reports of similar initiatives of this scale having occurred, despite interest from some state governments, such as Puebla. The only other programme which was mentioned was that of IC2 Institute (University of Texas at Austin), with the Instituto Tecnológico de Monterrey.

3.4 Conclusions

Main findings

The training delivered by Oxentia in November 2016 was considered by almost all participants (with whom it was possible to follow-up) to be a high-quality training, relevant for the needs and capacity gaps of Mexican TTOs.

Most respondents reported that the course has led to an improvement in their capacities, and to some changes within their institutions. Almost all praised the quality of the course materials and delivery, and would be interested in participating in additional capacity-building activities.

Despite interest from local partners to continue with follow-up training, this initiative did not receive additional funding. Ultimately, this is likely to limit the impact that the project can have. Without follow-up, it is unlikely that capacity-building can lead to institutional change in the form of new processes.

Lessons learned

In terms of potential improvements of this type of training itself, respondents mentioned that:

- The training was very intensive for its duration, and that focus areas were covered somewhat superficially due to time constraints; and
- There could have been more focus on providing practical support and on comparing experiences among participants, rather than focusing almost exclusively on theory and on case studies from European countries.

In terms of remaining gaps and needs:

- The training provided was overall considered high-quality and valuable. Although the impact would have been greater with follow-up training, other programmes were prioritised in line with the Fund's strategic

priorities in Mexico during further allocations rounds. There are limitations to what one training can achieve, and capacity gaps remain, especially among public TTOs.

- Both the SE and British Council would have been interested to continue this initiative beyond its one-year timeframe, which could have helped it achieve greater impact in terms of the development of innovative products or processes. There were also some miscommunications with the SE which led to an expectation that the training would continue. As a lesson from this experience, it is very important to ensure that **the length of the collaboration is communicated to all partners and participants,** thus allowing them to plan ahead. As in this case, miscommunications and the lack of long-term planning can risk compromising relationships with local partners if commitments are not followed through.
- Respondents to the online survey also suggested that having more follow-up and contact with participants would be useful and could lead to further collaborations. Despite their interest in further working together, a contact list of participants was not shared. More could be done **to foster dialogue and collaboration, and the formation of a more effective network could lead to potential research partnerships.**
- Participants also highlighted that, though valuable, training is insufficient to lead to systemic change, as there are many other barriers – other than knowledge – that TTO staff are facing. For instance, they may be unable to change their behaviour due to bureaucratic processes. Ultimately, **creating a culture of entrepreneurship and development will require cultural change**. It is important not to work solely with TTO staff, but also staff within the University to generate long-lasting change. A key missing step is convincing institutions of the **importance of this type of training**, especially in terms of involving University leadership. Especially in the current context where the government is pushing for results from the TTOs, it was suggested that it would be useful to hold workshops and trainings for senior staff in University.

4 Royal Society Newton Advanced Fellowship

4.1 Summary

Action title	Distribution of arsenic on agricultural soils and its influence on exposure risks through maize ingestion and agricultural activities in Matehuala, San Luis Potosí, Mexico.
Short description	This Newton Advanced Fellowship involves academic exchanges between the two PIs, a joint research project, and disseminating activities both in Mexico and the UK. The project aims to determine the extent of arsenic contamination in maize crops in the area of Matehuala, San Luis Potosí, estimate health risks to the population and attempt to help the local community recognise and avoid arsenic risks.
Objective(s)	The key problem this Fellowship is investigating is related to the high level of contamination with arsenic of surface and groundwater in Matehuala (San Luis Potosí). This is due to the dissolution of calcium arsenate residues, which can impact humans through agricultural practices and exposure of the skin. The arsenic contamination in Matahuala is caused by human behaviour, and stems from a copper smelter demolished in the 1950s. These contaminated water sources are being used for agriculture and for recreational purposes, as well as irrigation of a football pitch used by the local community. This project has the following objectives: 1. To test all water sources in the area and to develop a colour-coding initiative for people, especially farmers, to recognize arsenic-free and arsenic-contaminated water; 2. To examine the extent of arsenic contamination of soils; 3. To measure the total and soluble arsenic in soils; 4. To determine the soil parameters that most influence arsenic solubility; 5. To measure the arsenic content in maize; 6. To determine the dietary intake of arsenic as a result of consuming this maize; 7. To determine the arsenic risk exposure due to dermal arsenic exposure via the irrigation of crops with contaminated water and agricultural activities; 8. To develop a guide for farmers to help them recognize visually arsenic contaminated crops; 9. To promote the use of cement urns to harvest, store and use rain water as a viable alternative to using contaminated surface water.
Pillar	People
Acton value (total budget allocated in country, in GBP)	UK: GBP 111,000 MEX: n/a
Start / end date (Status: ongoing or complete)	June 2016 – February 2019 (ongoing, received extension)
DP UK and overseas	UK: Royal Society
Award holders/ grantee	UK: Bashkar Sen Gupta; MEX: Nadia Martinez-Villegas

4.2 Description of the action

Description of the action

The aim of Royal Society Newton Advanced Fellowships is to "*develop the research strengths and capabilities of their research group through training, collaboration and reciprocal visits with a partner in the UK. The skills and knowledge gained should lead to changes in the wellbeing of communities and increased economic benefits*".[34] This initiative closely fits the Royal Society's description. It seeks to build the capacity of an early career Mexican professor by 'linking' her with a more senior colleague in the UK. This Fellowship supports collaboration and reciprocal exchanges between Prof. Sen Gupta, a water technology expert from Heriot-Watt University, and Prof. Martinez, an expert in applied geosciences at the Institute for Scientific and Technological Research of San Luis Potosí (IPICyT), as well as between other members of their research teams. The collaboration also has a strong focus on generating research which can impact the wellbeing of the local community.

The collaboration brings together the UK and Mexican teams **to quantify the extent of arsenic contamination in Matehuala's water, maize, and population**, mapping water sites by contamination and risk levels. It seeks to determine exposure risks to people and ultimately influence their behaviour to reduce risks. The project also seeks to engage with the local authorities to identify alternative water sources, mobilising the community to demand access to clean and safe water. Heriot-Watt researchers are supporting IPICyT in developing and testing ecological soil remediation technologies for potential scale-up in the locality.

An extension phase of the project will focus on trialling the decontamination strategy developed by Heriot-Watt, assessing whether in future initiatives – and potentially in partnership with local and national authorities – the soil can be decontaminated and used productively. It will also see the continuation of awareness-raising activities and training, aiming to persuade farmers to utilise the non-contaminated, rain-fed agricultural fields, rather than contaminated ones.

Pathway to Impact

As shown in Figure 2, Annex 2, the **main inputs** of the Fellowship programme were opportunities for placement in UK and Mexican institutions; accessing UK laboratories, equipment and specialist knowledge in soil and water remediation technologies; as well as capacity-building for researchers and students.

In turn, this was expected to lead to the **outputs** of increased education mobility; capacity to engage in international collaborative research; and increased capacity to produce high-quality research.

There is also an **overlap with Research pillar outputs.** In fact, this collaboration was expected to lead to the generation of new knowledge; dissemination and communication of research outputs; enhanced visibility in international research; and opportunity for applying research findings to solve a real-life issue.

The **expected outcomes** are related to both capacity-building and research production. On the one hand, the Fellowship aims to improve capacity to deliver high-quality research in the two participating Universities, and promote the internationalisation of researchers and institutions. On the other, it is expected that the collaboration and complementarity of skills will lead to a strengthened knowledge base in relation to development challenges, in particular as related to soil remediation for contaminated sites.

In terms of its **expected impact**, the Fellowship seeks to foster the creation of long-term linkages and potential for future collaborations. Beyond this, this particular project has a strong focus on generating socio-economic impact and on using new evidence to inform and influence policymaking. It seeks to make progress in improving the health of Matehuala's population, improving their access to clean and safe water for their crops. This is expected to lead to better nutrition, better health outcomes with decreased risk of diabetes and cancer, and potentially better economic outcomes if farmers start to commercialize their larger, healthier maize (currently used for self-consumption). Learning from this project can also help refine soil and water remediation technologies to address Mexican and global challenges related to contamination of natural resources.

[34] https://royalsociety.org/grants-schemes-awards/grants/newton-advanced-fellowships/

4.3 Answers to the evaluation questions

4.3.1 Relevance

Activity targeting and contribution to ODA

This project is linked to Newton priorities – and Mexican government priorities – in several ways. First, it seeks to **build the capacity and increase the international linkages of a team of young researchers in Mexico**. It exposes them to their first instance of large-scale, international collaboration, and introduces a methodology they did not previously employ in their work, in the form of the green soil cleaning technology developed by Prof. Sen Gupta and his team.

Second, this research project is at the **intersection of health and agriculture** – two priority areas of the Newton Fund in Mexico. By targeting the location with the highest arsenic contamination in the world, working with the local community to raise awareness, and with local authorities to demand access to clean and safe resources, this project has potential for health impacts. If farmers decide to alter their behaviour by cultivating in rain-fed, non-contaminated fields, this project will impact the population's nutrition (as most maize is used for self-consumption) and overall health indicators. Reducing contamination can help lower incidence of serious diseases, as exposure to arsenic is associated with higher risk of diabetes and cancer. The utilisation of clean water and remediated soil can also help increase agricultural productivity in an area where this is utilised for household consumption and not for commercialisation. If successful, this has potential to improve economic outcomes for farmers.

The learning generated from this project, both in terms of the remediation technology itself, but also from working with the local authorities in the exploration of alternative water sources, can potentially be applied to other areas of Mexico and the world affected by this type of contamination.

Additionality of NF activities

The idea for this project did not emerge through the Newton Fund process. The Newton Fund gave the two researchers a **platform for collaboration,** although the idea was pre-existing and the initial contact happened independently**.** Prof. Martinez had been researching arsenic contamination in Matehuala since 2008. Her work captured the interest of Prof. Sen Gupta, whose water remediation technology has been employed in countries including India, Bangladesh and Cambodia. Having accessed one of her articles online, he reached out to enquire about potential collaborations in 2014.

All respondents, however, highlighted the importance of Newton funds in making this collaboration possible. This was the only grant the PIs applied to, and the process was considered quick and straightforward, and they received an answer before it was necessary to apply to other funds. In their view, the Newton Fund provides financial freedom to undertake research and exchange activities, publish research, and participate in national and international conferences – all things which would have been difficult to do without additional funds. Compared to other sources of funding available, Newton was appreciated for providing continuity and stability over the course of three years, allowing researchers to focus on their research activities rather than having to look for new funds.

4.3.2 Effectiveness

Capacity-building for individuals

As a People pillar project, a key component of this Fellowship is **capacity-building of individuals and institutions**. This project seems to have already led to considerable capacity-building and strengthening of international networks for the participants.

There have been several exchange activities, and more are scheduled to take place. Prof. Martinez has visited Heriot-Watt University five times, while Prof. Sen Gupta participated in two visits to IPICyT. These exchanges were useful for planning purposes, holding workshops and meeting with the team. They were also utilised to teach seminars and classes in the UK, Mexico and in the Netherlands. A PhD student from Heriot-Watt also spent three months (September – December 2017) in IPICyT, to test an environmentally sustainable soil remediation technology to decontaminate soil samples from areas in Matehuala. Additional visits to both the UK and Mexico is scheduled for an extension phase, though dates have not yet been set.

Prof. Martinez highlighted the importance of **mentorship and guidance** resulting from the time spent in the UK, especially in terms of receiving strategic and technical advice from Prof. Sen Gupta – for which face-to-face interaction was particularly important. Activities during the visits included discussions on project design; planning activities; and revising and providing comments on joint papers. More recently, the focus has included searching for new opportunities for collaborations and applying for joint grants. Prof. Martinez also taught two classes in Heriot-Watt, as well as a seminar in the University of Delf. This, in addition to participation in two international conferences, has allowed her to **expand her network of collaborators and increase visibility of her research**.

This was the largest instance of international collaboration in which Prof. Martinez and her team have participated. It has reportedly led to **increased visibility** at the international level and to recognition of Prof. Martinez' work. Emerging findings were presented in Zurich, Switzerland, and also conferences and workshops in various localities of Mexico. The impact on Prof. Martinez' career has already been important. She was recently promoted to Tenure Professor, and attributed this professional growth largely to the strengthened capacities and increased visibility achieved through this project.

The Mexico and UK team have a high complementarity of skills. This large team is composed mostly of PhD and Master's level students, and is multidisciplinary, bringing together environmental engineers, geologists, biologists, biochemists, agricultural scientists, geophysicists, and more. The team included two graduate students and four undergraduate students who wrote their theses on this study. They highly valued being able to do hands-on research with a strong potential social impact during their studies. The subdivision of tasks in very specialised areas has allowed these young researchers to increase their expertise in their area of interest. The other research team members also recognised that Newton helped them grow in their academic and professional careers. According to a member of the research team, what is unique about this project is both its social and an academic impact. Here, science "*is the instrument used to have impact on students".*

Capacity-building for institutions

Signs of capacity-building at the institutional level are more limited. The MoU which was set up for this collaboration proved challenging, as this is the largest instance of international collaboration that IPICyT had ever engaged in until that point.

There seems to have been institutional learning since this first experience. In fact, there is one new Royal Society Research Fellow in the Applied Geosciences department. His participation in Newton was less difficult to manage than Prof. Martinez'. Learning from the first experience, IPICyT requested an extension prior to the start of the project, predicting that there would be a delay, and this allowed them to better plan their activities.

This research project has increased the visibility of the Geosciences department at IPICyT. The Department was strengthened by new partnerships at the national level. These include the University of Quintana Roo, the University of Sonora, and University Antonio Narro.

New international partnerships

This is Heriot-Watt's first instance of collaboration with Mexico, and it is the largest international collaboration project that IPICyT has participated in to date. It has been successful in creating a potential long-term link between the institutions and the professors involved.

The research teams in the UK and Mexico see this as **the beginning of a long-term collaboration**. Both sides highlighted their interest in continuing to work together, due to the successes of this first collaboration and their strong complementarity of skills. They are already working together to identify more funding sources, including within the Newton Fund. There is also strong interest in IPICyT as an institution to construct more international partnerships. Staff at the leadership level expressed their interest in participating in other Newton Fund activities, largely due to their positive experience in this project.

The project **is already leading to new collaborations for IPICyT** with the California Department of Toxic Substances Control (CDTS) and the University of Bern. In the case of the University of Bern, Prof. Martinez' presentation of emerging findings in an international conference in Zurich, as part of Newton activities, has resulted in a new collaboration. Here, they are jointly analysing samples of water, zooplankton and soil, to understand how zooplankton can adapt to surviving in water environments with such high levels of arsenic contamination. In the

case of CDTS, the collaboration is still being discussed, and is likely to include capacity-building from CDTS on how to work in assessing risk and how to involve authorities in risk mitigation. This collaboration was also made possible by Newton, in that the IPICyT team had never worked in the area of risk assessment prior to this project. IPICyT has already been able to tap into CDTS' network of experts, including some who have been invited to collaborate with the team in this project.

In terms of potential partnerships, the UK and Mexican PI have **applied for a new collaboration with the University of Antofagasta (Chile) under the Newton-Picarte Fund**. This research project would investigate contamination with arsenic and copper in mining areas of Chile. It would aim to apply the water remediation technology employed by Prof. Sen Gupta and the soil remediation technology tested in Matehuala to another type of arsenic contamination. Building on the findings of this first collaboration, the research team would test whether the water and soil remediation technologies can work in tandem, and whether they can be adapted to the conditions of Mexico and Chile. The PIs are responding to comments and expect a final decision by July 2018.

An additional application has been to **CONACyT's Problemas Nacionales call**, where they proposed to develop a technology for water remediation which can be applied beyond Matehuala – first, looking at the state of San Luis Potosí (seven potential contamination areas identified through literature review), and then at the wider problem of contamination in Mexico. Here, they can apply the findings from this project on arsenic contamination in calcareous, semi-desert environments to other areas in the North and Centre of Mexico. Heriot-Watt was included as a collaborator in this call.

Finally, there has been interest from the **Mexican Institute for Water Technology (IMTA) to jointly collaborate with IPICyT and Heriot-Watt**. If successful, this would help in the development of water and soil remediation projects at the national level. IMTA staff expressed an interest in adopting the decontamination treatment method perfected by Prof. Sen Gupta and his team. Though Prof. Sen Gupta has visited the facilities and presented his methodologies so them, nothing concrete has been decided yet.

Capacity-building of UK researchers and institutions

This project has reportedly led to important capacity-building for UK researchers and their institution. Here, the funds received by Heriot-Watt were used to enlarge the lab and research team, by hiring more students as research assistants. Going beyond the original research proposal, the UK team was able to train 3 PhD students and 20 Master's students using this research. Prof. Sen Gupta has contributed to joint research papers with the Mexican counterpart. With upcoming publications, this is set to raise the academic profile of these young researchers.

Capacity-building for individual researchers was considered important. One UK researcher spent three months at IPICyT. During this time, he perfected the environmentally sustainable soil decontamination methodology in which he is specialising, with a real-life application on a contaminated site. Importantly, this was the first out-of-lab application of this technology, and taught him how the subject of his studies can be applied to real life situations. The exchange experience also broadened his mind on the importance of international collaboration and the global applicability of his work, thus benefiting his PhD overall.

According to another one of the UK students who participated, Royal Society funding allowed for his applied Master's dissertation to happen. In turn, having done a lab-based Master's dissertation helped his academic prospects, awarding him a distinction and helping him receive an offer for his PhD. Participating in this research has helped him define his PhD research scope to include soil decontamination from arsenic and copper, in addition to his original focus on oil.

4.3.3 Impact

Potential impact on poverty reduction and economic development

This project aspires to have a tangible impact on the ground. It seeks to **influence people's behaviour to improve their health**, work with local authorities to generate real change, and ultimately **improve the population's access to clean and safe water and food**. It also has the potential to lead to improvements in agricultural productivity, and, potentially, incomes, if farmers begin to commercialise their crops.

The project has determined the extent of contamination of water, soil and crops in the Matehuala region. After having surveyed 64 water sources, they found that 16 water sources in the Cerrito Blanco locality were very contaminated, and that only 11 were safe. Contamination reaches up to 1,000 times the WHO standard, in what has been defined **the highest arsenic water contamination in the world.** By conducting a mapping of contaminated water sources, it has also identified some clean water sources which have the potential to be exploited for agriculture and recreation.

This has resulted in the development of: i) a geochemical map representing arsenic distribution in surface soils (using GIS software); ii) a safety system based on colour coding to help people recognise arsenic-contaminated water; and iii) a guide to help farmers visually recognise arsenic-contaminated crops (which is being used to train farmers). The research team went beyond the initial agreed outputs by deciding to **test ecological soil remediation technologies on Matehuala soil in the form of natural surfactants**. The Heriot-Watt team is perfecting an environmentally sustainable method to transfer materials from the top surface to the bottom surface, thus decontaminating the soil. It has tested this methodology on the soil in Matehuala, and the next step in the expansion phase will be to trial it on a larger scale.

Until now, the project has been focused on one specific locality within Northern Mexico. Potential to apply its findings elsewhere, however, were considered high, both within Mexico and in other countries affected by arsenic contamination. Respondents highlighted that many countries face high levels of contamination due to arsenic, copper or oil, among other substances. The methodology being employed here to decontaminate the soil could potentially be applied in other settings, if adapted to the specific soil conditions in those locations.

Change in perceptions of the UK

As the Mexican PI had not previously worked in or with UK institutions, she did not have a prior understanding of how research in the UK worked. More than a change in her perception, this was a learning experience, which has helped her realise how processes in IPICyT could be made more efficient. She found this project especially efficient in terms of having a clear focus in its call, being relatively easy to manage, and having a simple evaluation system. She was very surprised by how straightforward it was compared to her experience working in Mexico, where processes in public institutions can be lengthy and complex.

Despite this, **it is unlikely that this realisation will lead to change at the institutional level**: the length and complexity of processes do not depend on IPICyT, but on government requirements, which are in place to reduce corruption.

4.3.4 Complementarity and coordination

Catalytic effects

As the project is on-going, it is too early to observe catalytic effects among other organisations in the sector.

Leadership effects

Similarly, leadership effects have not yet been observed. The project team is interested in conducting advocacy and outreach activities with local and national authorities – as the ultimate objective is to lead to policy change. Engagement activities with the authorities have not yet begun.

In particular, the research team will need to engage with CONAGUA in the exploration of the alternative, clean water sources identified by the project.

4.4 Conclusions

Main findings

This action has been very successful so far, and has surpassed its initial objectives.

Various exchange activities have taken place in the UK and Mexico, and more are scheduled to take place, resulting in improved capacity, increased visibility and collaborative research outcomes. The two PIs are interested in continuing their collaboration, and have applied for additional funding, including within the Newton Fund.

The project team has quantified and mapped the extent of arsenic contamination in water, soil and maize, both in agricultural fields and recreational grounds; developed a contamination map; and distributed a risk mitigation system. In the extension phase, the soil decontamination methodology introduced to the project by Heriot-Watt will be trialled at a larger scale in the Matahuala territory, building on successful laboratory trials.

Engagement with the authorities has not yet begun, and will be essential to ensure that research findings have an impact on the population. Though an alternative water source has been identified, the involvement of authorities, especially CONAGUA, will be essential to ensure that clean water is distributed among the population. Awareness-raising with the local population will be important to help them understand the extent and danger of contamination, and demand their right to decontaminated water.

Lessons learned

Although it was overall considered a very successful collaboration by all respondents, the project faced some challenges.

- The project faced a delay of eight months to receive funds at IPICyT. Though funds were immediately released by the Royal Society, it was time-consuming to set up an MoU between the two universities, and it was difficult for the Mexican institution to administer the salary top-up. **This was because it was the first experience of this kind and size for both institutions.** As a coping strategy, the project began with the activities which required the least funding, and was successful in receiving an extension. However, it is important to ensure that participating institutions are informed of the requirements of participating in a Newton Fund grant and have the necessary mechanisms in place to avoid delays.
- Despite this, there are limits to how much can be improved at the IPICyT level, as Mexican legislation is complex, largely due to mechanisms put in place to limit corruption. Ultimately, public institutions such as IPICyT are required to respect federal norms, and, as such, the timings of these should be considered when calls are designed and funds released.
- In terms of other potential improvements, it was highlighted that there is untapped potential to **form a network** of Newton fellows. Current fellows do not know other fellows in Mexico – let alone in other countries. It would be important to foster their collaboration to allow for peer-to-peer learning, and to foster other, potential collaborations. Especially because many of the problems encountered were due to lack of experience, getting to know others who have gone through the same process could be useful.
- Achieving the socio-economic impact envisioned by the team will require engaging with local authorities, ensuring their buy-in, and obtaining funding to undertake awareness-raising at a larger scale. This is likely to prove challenging and advocacy activities have not yet begun. There is perhaps scope for the Newton Fund team (as well as IPICyT) to ensure that **project activities are communicated at a larger-scale, which could help gain traction with the authorities**.

5 Development of an oral, thermostable enteric fever vaccine: saving lives and supporting tourism in Mexico

5.1 Summary

Action title	Development of an oral, thermostable enteric fever vaccine: saving lives and supporting tourism in Mexico (PRORALVAC)
Short description	The projects consist of the co-development of an oral, thermostable enteric fever vaccine. This vaccine will be swallowed, passing through the stomach and intestine. Here, safe bacteria will be released to target the body's own immune cells and trigger an immune response to protect against enteric fever. It will avoid the need of injections and means it will be possible to deliver it to people living in remote areas without electricity, as it can be stable at high temperatures.
Objective(s)	This project has the following objectives: 1. Developing a vaccine candidate for the two strains causing enteric fever: Salmonella typhi and Salmonella paratyphi; 2. Scaling-up of the production process to attain a reproducible, robust and manufacturable process; 3. Formulation of an oral, thermostable vaccine.
Pillar	Translation
Acton value (total budget allocated in country, in GBP)	Innovate UK: GBP 374,331; Prokarium: GBP 160,428 CONACYT: GBP 118,784; Probiomed: GBP 118,784
Start / end date (Status: ongoing or complete)	September 2016 – October 2018 (ongoing).
DP UK and overseas	UK: Innovate UK; MEX: CONACYT
Award holders / grantee	Prokarium: Rocky Cranenburgh; Probiomed: Dulce Contreras/ Nestor Perez

5.2 Description of the action

Brief Description of Action

This ongoing project consists of the co-development of an oral, thermostable vaccine for enteric fever (typhoid and para-typhoid) by the British firm Prokarium and the Mexican PROBIOMED. This seeks to fill the gap left by existing vaccines which require refrigeration and often do not cover para-typhoid.

Collaboration is based upon **skills and asset complementarities** between the two firms: Prokarium's proprietary oral vaccine delivery platform, considered a breakthrough at the scientific level, complements PROBIOMED's capabilities in scaling-up and optimizing bio-processes in certified laboratories and production facilities.

This project has undergone a fundamental change in focus, due to both technical issues and commercialisation potential. **The initial aim of the project was to create a vaccine against bacterial diarrhoea**, as caused by *E.*

Coli and *Shigella*, through Prokarium's oral vaccine delivery platform Vaxonella[35]. Due to technical issues related to the survival of the bacteria, the team devised a new technology and business strategy. Prokarium proposed to shift from bacterial diarrhoea to enteric fever, as it was technically more feasible, and also taking into account that the market for the latter is very large. Enteric fever, also known as typhoid fever, is endemic in India, South East Asia and most of Sub-Saharan Africa. Every year between 16 to 22 million people contract the disease, leading up to 600,000 deaths. It is a highly contagious food and water-borne disease, given that the bacteria can survive for weeks in water and even in dry sewage. The change in focus was **also driven by profit considerations**, as Prokarium did not observe a strong interest in the diarrhoea vaccine amongst pharmaceutical firms.

The process to change project focus was described as simple and straightforward. Prokarium requested a change of focus of the project to Innovate UK in June 2017, and developed a new commercial strategy for this new product. This change did not cause additional complications for PROBIOMED, since the knowledge accumulated on bio-processes by the firm allows it to manage the change of strains between similar organisms.

Currently, Prokarium is conducting state of the art research with two vaccine candidates: a double strain of attenuated *Salmonella typhi* and *Salmonella paratyphi* and a microbial hybrid of both strands. **Both strategies are directed towards obtaining a vaccine against the two strains that cause the disease**. Using a strain with characteristics similar to those of the final vaccine, PROBIOMED has developed a high cell density fermentation process that makes it possible to obtain large amounts of the vaccine. PROBIOMED is conducting formulation trials to make sure that the vaccine can resist freeze-drying (lyophilisation)[36] with the objective to produce an oral vaccine, viable for as long as possible and at high temperatures.

Pathway to Impact

As shown in Figure 3, Annex 2, in terms of **inputs**, this action has included the fostering of a collaboration between two businesses, one in the UK and one in Mexico, which have a strong complementary of technologies and processes. Innovate UK has brought the businesses together, running an initial workshop to foster links. Prokarium provides its unique vaccine delivery platform, while PROBIOMED brings capacity for development and scale-up of bio-processes in its laboratory facilities.

The **expected output** of the collaboration is an effective, low-cost vaccine. Due to its characteristics – oral ingestion and long shelf life in high temperature environments – it is hoped this vaccine will be able to reach rural areas with no electricity and with limited access to health facilities and doctors, as well as be easily employable by tourists visiting the country. Participating firms expect that this product will be sold to pharmaceutical companies to move forward with vaccine production after testing.

The main **expected outcome** is reduced incidence of enteric fever. This is expected to affect both the local population with no access to vaccines which require injection and refrigeration, as well as tourists visiting Mexico.

The **expected impact** of this product is a healthier population, especially among lower-income groups which currently do not have access to vaccination. It is also expected that the availability of this vaccine will help boost tourism as health risks of travel to the country will reduce. Considering the severity of the problem at a global level, the successful development and introduction to market of this product can help increase preparedness and resilience to global health challenges linked to enteric fever, with the potential to reduce health risks and mortality in South Asia, Central and South America, and Sub-Saharan Africa.

[35] The Vaxonella platform is an oral vaccine delivery platform, which utilises attenuated strains of *Salmonella enterica*. These are ingested, pass through the stomach, and are processed to stimulate immune responses. Additional information available from: http://prokarium.com/vaxonella-platform/

[36] Lyophilisation, or freeze-drying, is the removal of ice or other frozen solvents from a material. Controlled freeze drying keeps the product temperature low enough during the process to avoid changes in the dried product appearance and characteristics. It is a method used for preserving heat-sensitive materials such as proteins, microbes, pharmaceuticals, tissues and plasma. More information is available from: https://www.spscientific.com/freeze-drying-lyophilization-basics/.

5.3 Answers to the evaluation questions

5.3.1 Relevance

Activity targeting and ODA relevance

The Newton Fund UK – Mexico Collaborative Industrial R&D Programme 2015 was the first Innovate UK call to be launched in Mexico. To comply with ODA requirements, Innovate UK was interested in defining the scope of the call according to in-country challenges, while at the same time identifying UK businesses to work with Mexican counterparts in solving such challenges. **Health is a priority for the Mexican government**, as stated in the Special Program on Science, Technology and Innovation (PECITI 2014-2018). Health is also one of the top Newton Fund priorities in Mexico.

In terms of the specific focus of this project, enteric fever affects poor, rural communities in Mexico and other regions in the world. Enteric fever also affects tourists visiting the country, for whom vaccination prior to travel is advised. By developing a thermo-resistant, easily transportable vaccine with a long shelf life, this collaboration can provide a cost-effective solution which can reach isolated areas of Mexico with limited access to electricity and health facilities. It can also be easily employed by tourists visiting the country. Nonetheless, unlike high-risk countries in South Asia, Mexico is considered to be **medium-risk for the disease**.

Additionality of Newton Fund activities

Additionality of the Newton Fund is apparent in the case of this action, **as the two firms learned about each other's work and were first put in contact through Innovate UK.** It is unlikely that this collaboration would have occurred without Newton Fund financing and the efforts of Innovate UK to bring potential partners closer.

This Innovate UK call aimed to test the relationship between UK and Mexican firms, enabling partnerships to be formed. One month into the call, Innovate UK organised a mission to Mexico for British firms interested in working in the pharmaceutical, food, and energy sectors. Innovate UK paid for 13 potential UK partners – five universities and eight firms – to visit Mexico and identify local partners. Innovate UK also reached out to PROBIOMED, with whom they had a previous connection. For its part, CONACyT organised a meeting between visitors from the UK and Mexican firms with a track record of successful R&D projects. It was there that Prokarium's CEO met representatives from PROBIOMED. At the same time, PROBIOMED's staff learned about Prokarium's technological platform and assessed the possibility of a partnership.

The activities organised by Innovate UK to help Mexican and UK firms get in contact, particularly through the visit to Mexico, were seen as essential in making this collaboration happen.

In terms of the thematic focus of this project, **the idea came from Prokarium** – they were already interested in the development of a diarrhoea vaccine and decided to work in Mexico **due to the Newton Fund call**. Although Prokarium knew that Mexico is a big player in the pharmaceutical sector in Latin America, with a large internal market and companies producing for several countries in the region, they had no pre-existing interest in working with Mexican firms. It was argued that participation in the Newton Fund has been fundamental for the rapid development of the enteric fever vaccine: in its absence, the process would have required raising venture capital, and would have been much longer – perhaps by a few years.

5.3.2 Effectiveness

Contribution of Translation pillar activities to Mexico's developmental challenges

The project for the co-development of an enteric fever vaccine attempts to tackle a development and health issue in a collaborative way. The project can **potentially solve problems and create tangible benefits for low-income communities** in Mexico and worldwide. Although Mexico is a medium-risk country for enteric fever, the development of a heat-resistant and long-lasting vaccine can help protect hard-to-reach populations.

This project is ongoing and on track to lead to the development of an oral enteric fever vaccine. Prokarium and PROBIOMED expect to begin manufacturing the vaccine later this year. Therefore, the co-development seems to be on track to lead to vaccine development by the end of Newton funding. Although it would be possible to start clinical trials next year, the companies have not yet decided to venture into this stage of development, which if

successful would lead to a commercial product. They are discussing the possibility of licensing the technology to a larger firm specialized in vaccines, such as Glaxo, or to one of the pharmaceutical companies in India that have shown interest in the development.

The quality of the partnership was described by all respondents as being very high. The collaboration is based on strong **skills and asset complementarities** between Prokarium and PROBIOMED. There is also a high degree of trust between partners, and a desire to continue working together after the end of this collaboration.

Prokarium brings to the consortium technologies and expertise from ten vaccine trials, using the only genetic technologies in the world that can enable live bacterial vectors to produce high-levels of protein vaccines, and a revolutionary way of stabilising vaccines at 37 degrees for up to eight weeks. PROBIOMED contributes with assets such as certified R&D laboratories and manufacturing facilities, as well as expertise in the scaling up of bio-processes. This combination of capacities and technologies is **on track to lead to a highly innovative product that has a strong focus on solving global development challenges**.

The strength of the partnership also relies on PROBIOMED's manufacturing capacities and experience. **PROBIOMED is the only Mexican firm whose capacities go from drug development to manufacturing**, including medicines for the treatment of chronic-degenerative diseases, cancer and vaccines. It is also one of the few companies with a successful history of research projects and with the economic capacity to invest in R&D. PROBIOMED's economic capacity allowed the consortium to start working immediately despite the six-month delay in the delivery of funds by CONACyT. This delay was reportedly due staff changes in CONACyT, where new staff were not familiar with the management of bilateral funds of this size.

Strengthening of innovation systems

The collaboration is helping to strengthen production and testing processes on both the UK and Mexican sides. While PROBIOMED has historically been interested in vaccine development, they usually work with sterile vaccines, rather than live ones. They are now expanding their line of work to include working with live bacteria, and are interested to continue working in this area. Here, the **key innovation is the Vaxonella platform**. Keeping the bacteria alive to produce the PRORALVAC vaccine entailed learning to work with a fundamentally different process.

Working with this new technique has been challenging, and a very valuable learning experience for PROBIOMED. Respondents mentioned the challenges of working with microfiltration[37] and freeze-drying techniques in the context of a live vaccine. The team described it as an exciting experience to apply their expertise to a new field – something that they are interested in continuing to do in the future through other potential partnerships with Prokarium.

Capacity-building of UK participants

There is evidence of capacity-building at the UK level. Prokarium is a small company, founded in 2012, which **relies strongly on grant funding**. Participation in the Newton Fund has given them the freedom and possibility to work on the enteric fever vaccine without having to raise venture capital. It has also awarded them visibility and potential for growth in new markets, as is highlighted below.

New international partnerships

Prokarium had no international collaborations prior to this call. By disclosing preliminary results, plans and future forecasts for this collaboration, Prokarium has already drawn the interest of investors in their company and innovative technology. The results obtained so far, as well as the robustness of its technological platform for the development of thermostable oral vaccines, allowed the firm to raise USD 10 million from investors in Saudi Arabia,

[37] Microfiltration is a process through which a contaminated liquid is passed through a semipermeable membrane that removes solids to large to fit through the membrane's pore size, yielding a purified liquid stream. Additional information is available from: https://www.samcotech.com/microfiltration-vs-ultrafiltration-processes-what-is-the-difference/.

Sweden and South Korea. It is reported that this money will be used to advance Prokarium's vaccines against *Chlamydia*, *C. difficile* and enteric fever, and will also help expand its scientific team to work on cancer vaccines.[38]

They have also generated interest in a pharmaceutical company in India for a potential partnership in producing a specific product, which could lead to expansion to that potentially very large market.

PROBIOMED is more experienced in partnering with international firms, having partnered with a Brazilian firm, NG Biotecnologia, Research and Development (NGB), in 2007 to develop vaccines for Hepatitis B, C and E. However, this is the **largest international partnership in which the firm has participated**.

Though nothing has been confirmed, the two companies are also in talks as to whether this platform can be utilised in producing vaccines for other diseases. Respondents highlighted that the most exciting aspect of this project is the collaboration model itself, which can easily be tested and applied to other diseases such as malaria or dengue, or even to lower the costs of vaccinations which already exist, in that refrigeration and the presence of medical doctors is not required. If they successfully manage to develop this process, it has the potential to lead to many more collaborations.

5.3.3 Impact

Potential impact on poverty reduction and economic development

As the vaccine has not yet been developed or tested, we can only comment on **potential impact of this technology**. It will take several years for the vaccine to reach the market. The vaccine still needs to go through clinical trials, at an estimated cost of GBP 1 million, which explains why Prokarium is already seeking larger partners for future phases of the collaboration.

According to Innovate UK, there is a **clear link between this project and socio-economic development**. Prokarium and PROBIOMED are developing a product which can make healthcare more affordable and improve health outcomes. They are trying to keep vaccine costs as low as possible, and to create a product which has a longer shelf life, avoiding the need for specialized medical personnel and refrigeration.

The potential impact is two-fold. On the one hand, an enteric fever vaccine was seen by respondents as having the potential to boost tourism, one of the main economic activities of Mexico. Typhoid and para-typhoid can be a problem for tourists visiting the country, who run the risk of contracting it when drinking contaminated water. It is reported that in the United States, 85% of typhoid fever and 90% of paratyphoid cases are among international travellers – though the vast majority of these are travellers to South Asia.[39]

On the other, an enteric fever vaccine could be included in the national vaccination programme, allowing people in rural and isolated areas to protect themselves against this disease. PROBIOMED has extensive experience as a provider of generalist drugs for the public health sector, and regularly works with the Federal Commission for the Protection against Sanitary Risks (COFEPRIS) and with the Mexican Social Security Institute (IMSS). This could be a viable option for the firm, **although no discussions with the authorities have begun regarding this possibility** and it is still too early to think about commercialisation. Discussions with public health authorities in terms of regulatory preparations are scheduled for the final stages of this project.

At the **global level,** enteric fever is a huge problem, especially in South Asia. As mentioned, there has been an interest from an Indian pharmaceutical firm to produce and distribute this vaccine in the country, which could potentially impact millions of people, especially in remote, unconnected rural areas. Enteric fever is also endemic in some Central American and South American countries, and PROBIOMED spoke about its interest in expanding across Latin American markets.

Another potential impact of the project, if PROBIOMED or any other company that decides to manufacture the product in Mexico, is the creation of highly skilled jobs. It is estimated that these could be more than 200 jobs in Mexico to produce the vaccine, but also jobs in sales, marketing and packaging. In addition, domestically developed vaccines would be cheaper for Mexico and the UK, compared to imports, and would also reduce Mexico's foreign dependency through local production.

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[38] Liu, A, "Prokarium raises $10M for development of thermostable oral vaccines", FiercePharma, Feb 27, 2018, available from: https://www.fiercepharma.com/vaccines/prokarium-raises-10m-for-development-thermostable-oral-vaccines

[39] https://wwwnc.cdc.gov/travel/yellowbook/2018/infectious-diseases-related-to-travel/typhoid-paratyphoid-fever

Change in perceptions of the UK

The PROBIOMED research and management team spoke about an improvement in their perception of the UK because of this project. Being able to visit Prokarium facilities exposed them to the infrastructure available in the UK for product development in the biotechnology field. The UK was seen as a place of opportunity for PROBIOMED – including but not limited to their partnership with Prokarium.

In general, the collaboration with Prokarium was greatly appreciated, both due to the new technology introduced and the learning process that resulted, and the value of increased international linkages and networks.

5.3.4 Complementarity and coordination

Catalytic effects

It is too early for the project to have had catalytic effects, though it has generated interest at the international level, for example in the Indian pharmaceutical sector.

Leadership effects

The vaccination technology has not yet led to any policy change, as the vaccine remains in its development phase.

5.4 Conclusions

Main findings

The strong complementarity of skills and expertise between Prokarium and PROBIOMED has allowed the two firms to be on track to develop their enteric fever vaccine, despite a change in focus due to technical and profitability issues. The delivery of the vaccine is not expected for several years, as new regulatory frameworks need to be developed and clinical trials have yet to be conducted.

The collaboration between the two firms is based on a strong complementarity of skills. The introduction of the Vaxonella platform within PROBIOMED's processes has led to increased capacity in the development and handling of live vaccines. The two firms have expressed an interest in continuing to work together, perhaps with the application of this collaboration platform to other vaccines.

Prokarium required three things from this partnership: i) the scaling up of a bio-process at a commercial stage; ii) the facilities to conduct the scaling up; and iii) an adequate regulatory environment. PROBIOMED was an ideal partner, as it met all of these requirements. For PROBIOMED, this project entailed taking a risk, in that its R&D and manufacturing facilities are usually used only for sterile products and this project consists of developing and testing a live vaccine.

This new collaboration has value added for the two businesses. In the case of Prokarium, PROBIOMED adds value to the vaccine development in that they have high capacity and high-level facilities; lower production costs compared to producing in the UK; and a large market in which the product could potentially be tested. In fact, the genetic characteristics of the Mexican population make it an optimal market for testing, particularly for the Latin American market. For PROBIOMED, this collaboration has brought access to a new technology in the form of the Vaxonella platform. They are developing their skills in a new process, which has the potential to be expanded to other markets and vaccine types.

Lessons learned

- The success of the collaboration so far was largely attributed to a 'good match' between the two firms. While Prokarium developed a highly innovative oral vaccine delivery platform, PROBIOMED is the only Mexican firm whose capacities go from drug development to manufacturing, including medicines for the treatment of chronic-degenerative diseases, cancer and vaccines. It is also one of the few companies with a successful history of research projects and with the economic capacity to invest in R&D. PROBIOMED's economic capacity allowed the consortium to start working immediately despite the six-month delay in the delivery of funds by CONACyT, which was attributed to staff changes and unfamiliarity with the management of large grants.

- The project is ongoing, and it is still unclear what the next phase of collaboration will look like. The next phases of the project will be very expensive – an estimated GBP 1 million, and it is not yet clear if the two firms will continue working together in testing and scaling-up, or whether Prokarium will look for partnerships in countries where there is a larger market for the vaccine, or with larger players in the market.

6 Conclusions

Main Findings

- The Newton Fund, designed to foster science and innovation for sustainable economic development and welfare in partner countries, arrived at the right time to respond to the Mexican Government's priorities to transition to a knowledge-based economy.
- The Newton Fund in Mexico has matured considerably in the past few years. Staff changes within the in-country team (ICT) have caused some delays and challenges, However, the ICT has now developed an updated country strategy, is progressing quickly in partner diversification (in terms of looking for new local partners), and is making more efforts to increase contact with projects and researchers.
- The Newton Fund has helped strengthen the role of the UK as an important partner in science and innovation in Mexico. High-level political activities have played a key role. In particular, President Peña Nieto's state visit to the UK in 2015 helped raise the profile of Mexico-UK collaboration in research, effectively 're-launching' the Newton Fund in Mexico.
- The Newton Fund fills some gaps in the Mexican system, such as in the financing of projects to help young researchers consolidate their careers; capacity-building; scaling up from laboratory to industry; and conducting social sciences research. The Newton Fund is also helping with budgetary, institutional and geographical decentralisation.
- Compared to other partners, the UK is perceived as helping to foster technological development in Mexico, rather than seeking to import technology into it. Here, the ODA component was considered important, with its focus on capacity-building, social impact, and priority development themes for Mexico. Match-funding was seen as promoting the perception of the Newton Fund as an equal partnership, rather than a development assistance programme. The possibility of contributing in-kind was appreciated by Mexican partners, as it helps them participate even where an equal financial match is not possible.
- Respondents spoke about the Newton Fund's institutional impact in CONACyT, the main Newton partner in Mexico. Here, Newton was described as having led to management and organisational change – with the creation of two specialised sub-divisions under the International Relations Department, Scientific Cooperation and Technological Cooperation, where before, there was only an International Relations Department. The Newton Fund also helped institutionalise cooperation, and set up potential long-term links between partner institutions.
- These impacts were facilitated by the presence of the in-country team (ICT). According to Mexican partners, having an in-country presence increases trusts and facilitates communication, as well as making the programme more culturally and contextually adaptable. However, there remains scope for even further utilisation of the ICT, as will be highlighted below.
- Though not representative of Newton activities in Mexico overall, the actions included in this study showcase positive instances of collaboration, capacity-building and innovation between Mexican and UK institutions. Participation in the Newton Fund has brought more visibility and more resources to some of the participating institutions. Partners seem interested to continue working together in two out of three cases, and in one case are making concrete steps to make that happen, including through other Newton Fund initiatives.

Areas for improvement

- There is untapped potential in terms of taking full advantage of the ICT. There seems to be limited communication among Newton Fund partners on their expectations for its role, and an unclear line of responsibility for the ICT. There is some confusion among Mexican partners about what the ICT is and what its function is.
- Another challenge being faced is monitoring, as well as short-term, medium-term and long-term evaluation. There is not a systematic effort to engage in data collection, and there are difficulties in accessing data,

where it exists. Some DPs are perceived as being reluctant to engage with the ICT and share their data with them. There are limited records of participants, which reduces the ICT's knowledge of what is happening and where.

- Limited institutional knowledge on the Newton Fund in Mexico is problematic. There has been a high turnover of staff at the ICT level, with all members being relatively new. Partner funding agencies are also characterised by high turnover of staff. With the upcoming election in July 2018, it is expected that substantial staffing changes will take place within CONACyT and other public institutions. Mechanisms to more effectively retain and systematise institutional knowledge within the ICT could be developed and would help ensure continuity of programming and priorities.
- One of the most difficult aspects of the Newton Fund regards collaboration, contracting and negotiation. This is because some Newton partners require specific international MoUs. The processes to set up MoUs can take up time – sometimes up to a year – while beginning activities without MoUs in place can increase project risks. This has led to delays in some cases, including those analysed in this thematic study.
- Match funding was considered successful overall, and an important part of the Newton Fund's approach. Despite that, there are some reports of there not always being an equal match from Mexican institutions, in terms of financing UK researchers to spend time in Mexico. It is not clear why this is the case – there could be a lack of information or interest among UK researchers, though others stated that funders have at times been unable to correspond to the match.
- A challenge for future activities of the Newton Fund in Mexico is the upcoming elections. In anticipation of these, funding is halting and institutions are going through an impasse. It is expected that with the change in administration will come changes at the level of staff and leadership in public institutions, including CONACyT. In general, the high levels of turnover in public institutions affect institutional learning and make it difficult to manage activities as complex as research and innovation.
- In this context, the ICT (and the British Embassy more broadly) are pushing for diversification of partners, to ensure sustainability of programming and impact, as well as accessibility to funds outside of CONACyT's financing cycle. Despite the push for regionalisation mentioned above, there has been limited interest to date in engaging with state partners. What remains to be seen is how to raise the interest of UK counterparts in smaller organisations and states, as they are largely used to working with CONACyT.
- The Technology Transfer training for participants provides an interesting case in point in terms of the strengths and limitations of capacity-building initiatives. Participants appreciated the quality of the course, and reported that their capacities as Technology Transfer Office (TTO) professionals have increased. Despite this, achieving impacts in terms of generating institutional change and catalytic effects will be difficult without conducting follow-up trainings and involving University leadership. In fact, technical skills are not sufficient to ensure improvements in the technology transfer process: much broader institutional reforms and simplification of bureaucracy, as well as fostering a culture of entrepreneurship at the University and business level, will be necessary.
- The Royal Society Newton Advanced Fellowship included in this study has overachieved many of its objectives, overlapping with Research pillar outputs and outcomes. Not only has it improved the capacity of the Mexican researcher and her team, it has led to collaborative research outputs, and aims to have a strong socio-economic impact on the community of Matehuala. However, capacity-building and institutional learning at the level of the participating institution has been more limited, largely because this public institution is constrained by federal bureaucracy and administrative norms. Also, being able to generate impact will largely depend on the successful engagement of local authorities – something which is beyond the scope of the current collaboration.
- The development of the PRORALVAC enteric fever vaccine by Prokarium and PROBIOMED is on track to be developed within the timeframe of the project. However, vaccine production, testing, and commercialisation phases will be very expensive – at an estimated £1 million– and it is unclear whether Prokarium will continue to work with PROBIOMED, or form new partnerships with larger players in the market or in countries with higher demand for this product.

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- Baseline Survey and follow-up survey results for: Best Practices and Skills for Technology Transfer Workshop
- Technology Transfer Best Practice and Skills Development Training for Practitioners: Feedback and Recommendations

Royal Society:

- Project proposal
- Newton Advanced Fellowship Annual Report – Year 1
- Newton Advanced Fellowship Annual Report – Year 2

Innovate UK – CONACyT:

- Application
- Project Change Request
- Project Quarterly Progress Report

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Annex 2 – Theories of Change per Action

Figure 1: Theory of Change, Technology Transfer Best Practice and Skills Development Training for Practitioners

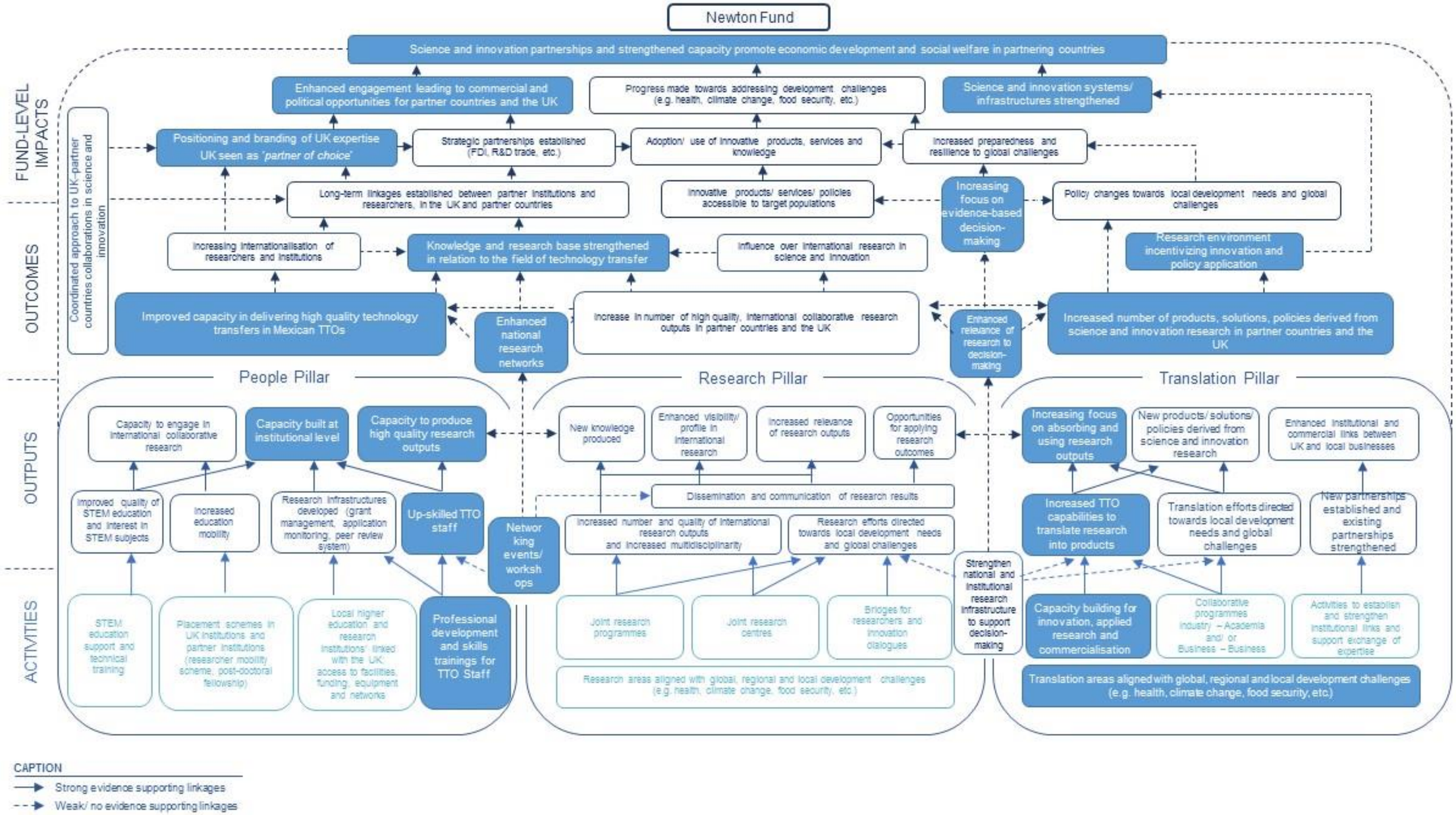

Figure 2: Theory of Change, Heriot-Watt and IPICyT

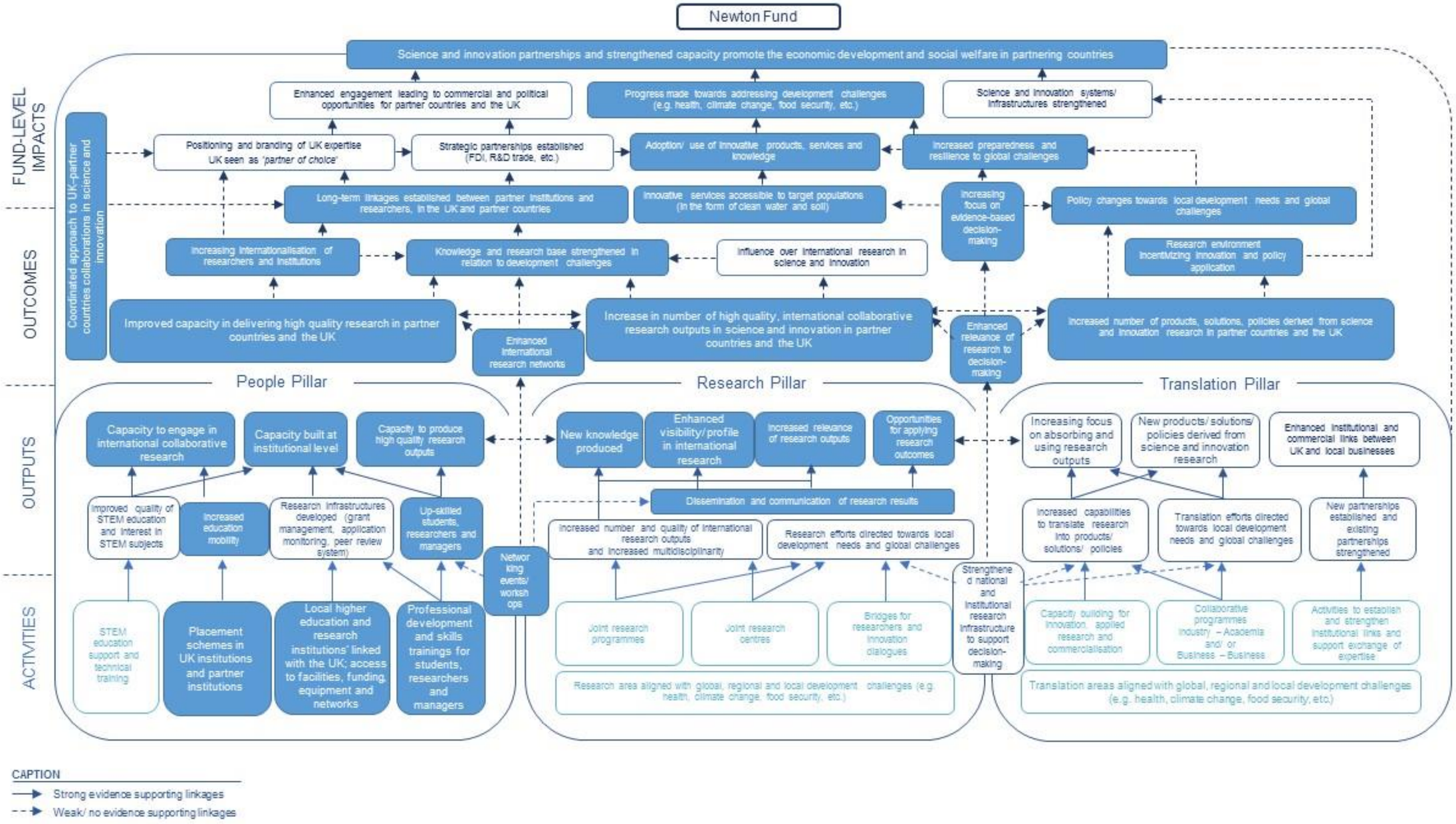

Figure 3: Theory of Change, PROBIOMED and Prokarium