

<b>Institution:</b> Imperial College London Business School		
<b>Unit of Assessment:</b> C17 Business and Management Studies		
<b>Title of case study:</b> Financial Inclusion - Supporting Africa's Poorest Farmers		
<b>Period when the underpinning research was undertaken:</b> 2013-present		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>	<b>Role(s) (e.g. job title):</b>	<b>Period(s) employed by submitting HEI:</b>
Enrico Biffis	Associate Professor of Actuarial Finance	10/2007 - Present
Erik Chavez	Research Fellow	04/2015 - Present
<b>Period when the claimed impact occurred:</b> 2016-present		
<b>Is this case study continued from a case study submitted in 2014?</b> N		
<b>1. Summary of the impact</b> (indicative maximum 100 words) <p>Enrico Biffis and Erik Chavez, both at the Breven Howard Centre for Financial Analysis at Imperial College Business School, conducted the research. The research outputs led to the design and deployment of an innovative parametric agricultural insurance product backed by a global reinsurer, which allowed banks to extend credit to smallholder farmers previously excluded from the financial system. Two large pilots were run in Tanzania involving 50,000 farmers and benefiting a total of close to 400,000 individuals, including household members and field workers. The pilots resulted in a total of \$13m being lent by banks as input loans and \$5m of insurance coverage being extended by a leading local insurer. The research made parametric insurance become part of the underwriting criteria used by the most important Tanzanian banks operating in the agricultural space. The research generated sizeable additional funding (\$5m) targeting the upscaling of the de-risking solution within Tanzania and the expansion to three new countries (Ghana, Uganda, Zimbabwe), thus aiming to benefit over 1.6m individuals.</p>		
<b>2. Underpinning research</b> (indicative maximum 500 words) <p>The underpinning research originates from two strands of work carried out by the two main researchers involved in the project.</p> <ol style="list-style-type: none"> <li>1. The first strand of research relates to machine learning techniques used to determine optimal weather variables and synthetic crop yields (<b>ref. 2</b>). By capturing farm level characteristics (soil, inputs, agricultural practice), the modelling tools provide a powerful machinery to not only de-risk agricultural production, but also promote technology adoption (<b>refs. 1 and 2</b>). The latter objective is achieved by monetizing the risk profile induced by production technology via insurance premia and borrowing costs, as obtained in the second, parallel strand of work.</li> <li>2. The second strand of research relates to the optimal design of risk transfer arrangements in non-standard settings, such as those featuring default risk and the availability of different forms of collateralization to shape the credit risk of a transaction and hence its price (<b>refs. 3 and 6</b>). Both the optimal design of parametric insurance and inclusion of the latter in the collateral mix deliver credit enhancement to smallholder farmers, making them less capital intensive for banks (<b>ref. 3 and 5</b>) and reducing credit rationing for poorer households (<b>ref. 1</b>).</li> </ol> <p>Details of the main research activities carried out and relevant collaborators are as follows.</p> <p><b>Sourcing of data</b> on weather patterns, soil characteristics, input packages and farmers' characteristics. The data sourcing effort was crucial to inform machine learning tools and produce</p>		

risk profiles of agricultural risk exposures at particular locations. Although subsets of data are available from public satellite and crop modelling data repositories, new granular datasets were created by relying on the work of Imperial researchers regularly visiting farmer organizations and financial institutions on the ground. In particular, the researchers had regular meetings with three local banks (CRDB Bank, NMB Bank, TADB) and a Finance PhD student (Davide Benedetti) supervised by Enrico Biffis spent one month assisting local banks in collecting data to analyse the impact of weather events on agribusiness loan performance (**source 9**). Both local banks and the Private Agricultural Sector Support Trust of Tanzania were instrumental in hosting Enrico Biffis and Erik Chavez to carry out work on exposure data collection (**sources 2 and 3**). Understanding of the target farmers was informed by running surveys in partnership with the World Bank as part of a larger randomized control trial project (**source 7**).

The **optimal design of parametric insurance** relied on the optimization tools discussed above (research strands 1 and 2). The main challenge was to tailor insurance pay-outs not only to the risk profile associated with the use of a given production technology, but also, to the default risk profile of farmers ultimately benefiting from the bundled finance solution (**ref 1, 6**). Use of granular data on risk exposures allowed the Imperial team to mitigate farmers' exposure to climate variability and hence reduce their propensity to default on input loans during the crop growing cycle (**refs 2, 3, and 5**). Assistance from a global reinsurer, Munich Re, was instrumental in receiving commercial grade validation of the algorithms developed and demonstrating the value of parametric insurance to the loan underwriting officers of the main banks involved (**source 4**).

Enrico Biffis obtained support from the Tanzanian Insurance Regulatory Authority (TIRA) to grant the relevant licence for Munich Re, thus allowing the innovative de-risking solution to be adopted by a leading local insurer, Jubilee, as well as Tanzania Re, the governmental reinsurance vehicle (**sources 1, 2, and 4**). **Institutional support** was instrumental in allowing all stakeholders involved, including smallholder farmers, to benefit from a cost-effective de-risking solution being deployed across the value chain (**source 2**).

The Imperial team collaborated with The World Bank to document the benefits generated by the project for smallholder farmers. The **monitoring and evaluation** exercise entailed limiting the availability of the bundled finance solution to a subset of farmers, so as to have treatment and control groups. The surveys were jointly designed by the Imperial team and a World Bank team led by Luc Christiaensen (**source 7**). The results allowed us to compute several measures of impact further discussed in section 4 and covered in reference 3.1 (**ref 1**) below.

### 3. References to the research (indicative maximum of six references)

Papers (reverse chronological order):

1. Biffis, E., Chavez, E., Louaas, A. and P. Picard (2020). Parametric insurance and technology adoption in developing countries. Social Science Research Network Paper 3630706. To appear in *The Geneva Risk and Insurance Review*. Working paper available at: [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3630706](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3630706). The paper uses a model a la Holmstrom and Tirole (1997) to provide a micro-foundation for how the bundled finance solution deployed in Tanzania reduces credit rationing. A calibration based on data collected with the World Bank matches the reduction in collateral requirements documented in the Tanzanian pilots.
2. Biffis, E., Chavez, E. 2017. Satellite data and machine learning for weather risk management and food security. *Risk Analysis* 37(8):1508-21. Working paper version available at: <https://ssrn.com/abstract=3041167>. The paper studies i) the application of machine learning tools to build optimal weather indices and synthetic crop yields, and ii) the use of the optimization results of reference 6 below (**ref. 6**) to design optimal risk transfers for agricultural production portfolios.
3. Biffis, E., Blake, D., Pitotti, L., & Sun, A. (2016). The cost of counterparty risk and collateralization in longevity swaps. *Journal of Risk and Insurance*, 83(2), 387-419. Working paper version available at: <https://ssrn.com/abstract=1801826>. Despite its focus on longevity risk applications, the paper provides a general framework linking collateral

arrangements to the pricing of over-the-counter transactions. It therefore sets the foundation for using both parametric insurance and cash as collateral to deliver credit enhancement to smallholder farmers.

4. Chavez, E., Conway, G., Ghil, M., Sadler, M. (2015). An end-to-end assessment of extreme weather impacts on food security. *Nature Climate Change* 5(11):997. This note illustrates the vicious cycle into which smallholder farmers are precipitated by lack of access to credit and the resulting inability to adopt efficient production technologies.
5. Biffis, E., & Blake, D. (2013). Informed intermediation of longevity exposures. *Journal of Risk and Insurance*, 80(3), 559-584. The working paper version can be downloaded here: <https://ssrn.com/abstract=2177347>. This paper develops a model showing how the design of suitable risk transfer instruments can allow financial institutions to free up capital and originate more business. The original application to pension buyout firms was used to demonstrate to Tanzanian banks how to efficiently originate smallholder farmer loans by off-loading part of the risk to the (re)insurance market.
6. Biffis, E., and P. Millosovich (2013). Optimal insurance with counterparty default risk. Social Science Research Network Paper 1634883: <https://ssrn.com/abstract=1634883>. The paper provides the solution to a Pareto optimal risk sharing problem allowing a counterparty to default on its obligations. The results of this paper are used to optimally design the parametric insurance solution deployed on the ground (see reference 2 above (**ref. 2**) for numerical illustrations).

References 2 – 5 were published in peer-reviewed journals of international excellence; Biffis and Chavez were PI's on the EU funded ARISE / Climate-Kic.

#### 4. Details of the impact (indicative maximum 750 words)

The research impact can be understood by looking at three categories of stakeholders:

**Smallholder farmers.** It is well documented (**ref. 1**) that standalone insurance is poorly understood by smallholder farmers and that take-up is usually low due to a number of factors ranging from liquidity constraints to poor performance of insurance contracts (basis risk). By bundling a loan with an insurance mechanism tailored to farm level production characteristics, the value of insurance could be recognized at a bank's portfolio level and hence result in lower collateral requirements, thus allowing the credit worthiness of smallholder farmers to increase dramatically (**ref. 1, sources 2, 3, and 4**). In the words of Nicomed Bohay (MD at Private Agricultural Sector Support Trust of Tanzania), "the presence of both insurance and a credit guarantee delivered sizeable credit enhancement to smallholder farmers usually excluded from the financial system due to lack of credit history and collateral to be offered as security" (**source 2**). The monitoring and evaluation exercises carried out in collaboration with the World Bank allowed us to quantify the impact of two pilots carried out during the growing seasons of 2015-16 and 2016-17. A total of 50,000 households benefited from the insurance programme across Tanzania. By analysing the household members involved in agricultural production, as well as external labour hired to work on the fields, a total of nearly 400,000 individuals benefited from the project over two years (**sources 2, 5**). As documented by the World Bank, on average 30% of field labour was contributed by individuals outside of the households involved, and 88% of such households gained access to finance for the very first time (**source 7**). By accessing funding predicated on the purchase of better input packages (and associated access to extension services), smallholder farmers were able to double their average production yield. As the smallholder farmers targeted had an average farm size of only 2.1 hectares, the ability to boost production was truly transformational, pushing production levels considerably above the survival (and hence default) line, and allowing part of the crop proceeds to be saved and re-invested (**sources 2, 7**).

**Banks.** Smallholder farmers are traditionally shunned by commercial banks due to lack of credit history, output volatility, and the fact that for subsistence farmers defaulting on a loan is often a matter of survival. This is why smallholder farmers have low credit standing and limited resources to post as collateral. They are therefore stuck in a vicious circle preventing them from accessing the financial system (**ref 1, source 3**). Banks understood that the parametric insurance solution

developed by the Imperial team could de-risk their aggregate portfolio if bundled with individual input loans. In this way credit rationing was circumvented and loan underwriting officers could unlock access to finance. As documented by Xavery Makwi (Director of Credit at CRDB Bank of Tanzania), "the novel insurance framework introduced by Prof. Enrico Biffis and Dr. Erik Chavez allowed us to assess the credit standing of smallholder farmers in a different way, by taking into account the purchase of parametric weather insurance as part of our underwriting criteria" (**source 3**). The Imperial team carried out repeated missions to Dar es Salaam and was successful in embedding the insurance mechanism in the loan portfolios of two leading Tanzanian banks, CRDB Bank and NMB Bank. Akiba Bank and Tanzanian Agricultural Development Bank (TADB) can also be numbered as initial and prospective participants in the programme, respectively. The missions entailed meetings with loan underwriting officers, local insurers, regulators, and farmer organizations, as well as having researchers (Davide Benedetti, Enrico Biffis, Erik Chavez) being hosted at CRDB Bank and PASS for data collection (**sources 2, 3, and 9**). With an average loan disbursement of \$255 per farmer, a total of close to \$13m in aggregate loans was underwritten across CRDB Bank and NMB Bank (**sources 2 and 3**). To give an idea of the relevance of this figure, we can consider the case of CRDB Bank, which has close to 50% of the agricultural credit market share in Tanzania, with a \$130m agricultural loan portfolio as of April 2019 (**source 8**). Despite its leadership position, less than 1% of CRDB Bank's borrowers were smallholder farmers in 2015. In the words of Xavery Makwi, CRDB's Director of Credit, the project "allowed us to extent input loans to this customer group, generating a fivefold increase in smallholder farmer accounts during pilots covering around 50,000 farmers over two growing seasons" (**source 3**).

**Insurers.** Indemnity based insurance contracts are difficult to deploy and manage in emerging countries due to poor data quality, limited claims experience, significant moral hazard, and high monitoring costs. Parametric insurance products offer a valuable alternative, but their take up is hindered by exacting upfront premiums and imperfect pay-outs (**ref 1**). As indicated by Judith Rugaiganisa (Head of Reinsurance at Jubilee Insurance Tanzania), "our success in penetrating the agricultural insurance market for smallholder farmers had been limited to date. Across the industry, no robust market instrument was available to allow us to introduce crop loss insurance in a cost-effective manner in Tanzania and upscale it across the country". The project brought to market a cost-effective solution (35% cheaper than the closest alternative) by exploiting the scaling opportunities offered by a data driven technology aimed at reaping country-wide diversification benefits while simultaneously tailoring coverage to the needs of particular borrowers, thus linking insurance to creditworthiness (**ref 2, sources 1, 2 and 3**). The project allowed a leading local insurer, Jubilee, to extend a total of \$5m of coverage over two years, the residual portion of loans at risk being covered by a credit guarantee offered by the Private Agricultural Services Support Trust of Tanzania (**source 1**). This provided the insurer with the opportunity to enter the smallholder farmer market for the first time during the first season. Insurance coverage represented a 70% yearly increase in agricultural business for Jubilee by the end of the second season (**source 1**). In the words of Judith Rugaiganisa, "the parametric crop loss insurance product was deployed for two crop seasons in Tanzania covering over 50,000 farmers, thus making it the largest crop loss insurance programme available in the country at that time". Coordination with underwriters and the Tanzanian Insurance Regulatory Authority allowed part of the risk to be retained in country instead of being transferred to international risk carriers only. Munich Re, the global reinsurer which acted as lead risk carrier, "provided a domestic insurance company, Jubilee, and the local government backed reinsurer, Tanzania Re, with the confidence to underwrite weather risk insurance for a total of \$13m input loans extended by leading Tanzanian banks", as documented by Alexa Meyer-Bosse (Global Agricultural Risks and Climate Change Lead at Munich Re) (**source 4**).

Although the project only focused on the maize value chain, its success attracted further funding for upscaling within and beyond Tanzania. As explained by Tanaka Tabassum (Climate-KIC), the scalability of the de-risking solution by use of satellite data and machine learning "is an appealing feature for a number of stakeholders. Climate-KIC leveraged on that to work on two sizeable follow-up projects. The first one, funded by the New Venture Fund, aims at deploying the de-risking solutions developed by the Imperial team to assist women farmers in accessing finance and promoting gender inclusion among smallholder farmers and cooperatives. The second project,



funded by the African Development Bank, aims at upscaling the de-risking solution to include a larger pool of banks in Tanzania and promote its extension to three other countries (Ghana, Uganda, Zimbabwe). The target of the project is to facilitate the financial inclusion and climate de-risking of up to 1.6 million farmers across the four countries." (**source 5**). In the words of Oryem Henry Okello (Uganda's Minister of State for International Affairs), " The tools developed [by the Imperial team] represent a valuable contribution to our Green Growth Development Strategy ". The Imperial team continues to provide technical assistance on i) the upscaling of the project within Tanzania across both the maize and sunflower value chains (**source 2**), ii) the extension of the de-risking solution to three new countries (Ghana, Uganda, Zimbabwe) (**sources 2, 5, and 6**), and iii) the introduction of a gender inclusion dimension in access to credit (**source 5**). In 2019, Climate KIC/EIT awarded a further EUR 3.2m funding stream (ARISE project) to a consortium led by the Imperial team to embed incentives to adopt climate smart agricultural practices within the de-risking framework deployed across the four sub-Saharan African countries mentioned above (**sources 2, 5**).

#### 5. Sources to corroborate the impact (indicative maximum of 10 references)

1. Supporting letters from Jubilee Insurance's Head of Reinsurance.
2. Supporting letter from the Managing Director of the Private Agricultural Sector Support (PASS), a Tanzanian Trust offering credit guarantees on agribusiness loans and promoting improved agricultural practice and entrepreneurship among local farmers.
3. Supporting letter from the Director of Credit of CRDB Bank of Tanzania.
4. Supporting letter from Munich Re's Global Agricultural Risks and Climate Change Lead.
5. Letter from the International Programmes Lead at Climate-KIC documenting the funding opportunities generated by the Tanzanian work and outlining current developments in Uganda, Ghana, and Zimbabwe as part of the ARISE project funded by Climate-KIC (EUR 3.2m), the WINnERS Diversity Programme funded by the New Venture Fund (\$550k), and the project De-risking Agricultural Finance in Africa funded by the African Development Bank (\$980k).
6. Letter from the Minister of State for International Affairs of Uganda, documenting the importance of the de-risking solutions developed by the Imperial team for promoting financial inclusion and climate resilient agricultural production in Uganda, as well as international trade along the Central Corridor with Tanzania.
7. Vandecasteele and Christiaensen (2018). Baseline report: Smallholder impact evaluation of maize value chain development in Tanzania. The World Bank Group and Let's Work Tanzania.  
[https://www.imperial.ac.uk/people/e.biffis/document/8342/Baseline%20report\\_2018.11.27/?Baseline%20report\\_2018.11.27.pdf](https://www.imperial.ac.uk/people/e.biffis/document/8342/Baseline%20report_2018.11.27/?Baseline%20report_2018.11.27.pdf)
8. CRDB Bank (2019). Investor briefings. April, 2019. <https://crdbbank.co.tz/wp-content/uploads/2019/05/Investor-Briefings-as-at-31st-March-2019.pdf>
9. Benedetti, D., Biffis, E., and E. Chavez (2020). Weather risk and agricultural loan performance. CRDB Bank of Tanzania and Brevan Howard Centre for Financial Analysis. Anonymized summary available here:  
<https://www.imperial.ac.uk/people/e.biffis/document/8382/CRDB%20report%20v2/?CRDB%20report%20v2.pdf>