

Investing in Health R&D: Africa's Next Economic Growth Frontier

Case Studies: Macroeconomic and Societal Benefits From Health R&D Investments

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Introduction

This document presents case studies drawn from the published and grey literature. They document macroeconomic and societal benefits realized or projected from health R&D investments. Two are comparative cases from outside the continent, included to provide evidence for specific model parameters where the African evidence base is limited.

Each case study is structured around a common framework: context and investment, documented benefits across the model's economic channels, limitations and caveats, and relevance to the model's scenarios. References are provided at the end of each case study.

Summary of Case Studies

Case Study	Investment Scale	Employment	Trade / Import Sub.	Technology Transfer	Model Channels
1. South Africa Health R&D Ecosystem	Afrigen mRNA hub: \$117M+ programme; SAMRC; CEPI \$2.05M synthetic DNA project	New generation of mRNA scientists, bioengineers; university research positions	R&D enables downstream vaccine import substitution	WHO mRNA hub → 14 partners in 6 WHO regions; AfriVac 2121; 6 novel vaccine candidates	M1, M2, M6
2. BioNTech Rwanda mRNA Facility	\$150M BioNTech + €95M EIB/EC + €130M CEPI + €40M support	~100 specialised staff initially; biotech accelerator	50M doses/yr capacity; vaccine import substitution	BioNTainer modular mfg; local training from German sites	M3, M4, M5
3. EDCTP Clinical Trials Partnership	€1.4B+ total (EDCTP2); €489M to Africa; 310 African institutions	362 fellows; 1,202 trainees; 4 regional Networks of Excellence	Indirect: regulatory harmonisation enables future mfg	232 clinical studies in 38 countries; GCP standards transfer	M3, M6, AC ₀
4. Kenya KEMRI Ecosystem	KEMRI budget ~\$50M/yr; KWTRP Wellcome partnership	1,000–5,000 KEMRI staff; PhD/postdoc pipeline	Clinical trial FDI; drug discovery hub for East Africa	Cochrane Kenya; KEMRI-Wellcome research training model	M2, M3, M6
5. Egypt: Domestic Financing of Industrial Health Policy	State budget R&D financing; GERD ~1.02% GDP; mRNA TT programme; VACSERA technology transfer; EDA regulatory science	Tens of thousands across 191 factories + 2,000 associated firms	Exports >\$1B (2023); 94% local mfg; imports down \$500M yr-on-yr	VACSERA vaccines since 1893; WHO ML3 status; mRNA TT partner	M1, M2, M3, AC ₀
6. Cuba: Domestic public	State budget	21,600+ direct staff	\$211M exports	World's first	M1, M2, M3,

Case Study	Investment Scale	Employment	Trade / Import Sub.	Technology Transfer	Model Channels
investment under the embargo	only; BioCubaFarma 40+ enterprises; no international capital access	including scientists, bioengineers, and clinicians	(2021); 42 country markets; technology transfer to Iran, Vietnam, Italy, Russia, Australia	meningitis B vaccine (1989); CIMAvax-EGF; Soberana/Abdala COVID vaccines (>90% efficacy)	M5, M6

Aggregate figures: five primary African case studies (CS1–5)

Combined investment documented: >\$5 billion in direct health R&D and manufacturing investment across the five cases. Employment: Tens of thousands of direct positions ranging from factory workers to PhD researchers, with 9,000–14,000 vaccine manufacturing roles projected continent-wide by 2040. Geographic reach: 44+ African countries involved through EDCTP; mRNA technology transfer to 14 countries across 6 WHO regions; Egyptian pharma exports reaching markets across Africa, MENA, and beyond. Manufacturing capacity: 300M vaccine doses/yr (Senegal MADIBA) + 50M doses/yr (Rwanda BioNTech) + existing Aspen/Biovac/VACSERA production. Institutional footprint: 310+ African research institutions (EDCTP); 191 pharma factories (Egypt); 30 manufacturers (Ghana); 15 KEMRI research centres; 23 Aspen facilities. Evidence base: \$405 returned per \$1 invested globally; Egypt achieving 94% domestic pharmaceutical self-sufficiency; model projects 11.6× BCR for Africa under AU 1% GERD target (S3, v6).

Mapping Case Studies to Model Economic Channels

The following table maps each case study to the specific economic channels in the model where it provides the strongest empirical support. A ● indicates the case study provides direct, quantified evidence for the channel; a ○ indicates indirect or qualitative support.

Case Study	M1 PIM	M2 GDP	M3 Jobs	M4 Crowd-in	M5 Trade	M6 Brain	M7 Fiscal
1. South Africa Health R&D	●	●	○	○	○	●	○
2. BioNTech Rwanda	○	○	●	●	●	○	○
3. EDCTP Partnership	○	○	●	○	○	●	○
4. Kenya KEMRI	○	●	●	○	○	●	○
5. Egypt: Domestic Financing	●	●	●	○	○	○	○
Comparative cases outside Africa							
6. Cuba	●	●	●	○	●	●	○

● = direct, quantified evidence ○ = indirect or qualitative support

Case Study 1: South Africa's Health R&D Ecosystem: Afrigen, SAMRC, and the mRNA Technology Transfer Programme

Relevance to model channels

Knowledge capital and TFP spillovers (M1, M2) • Brain gain and researcher retention (M6) • Technology transfer and international knowledge diffusion • Downstream manufacturing and trade benefits enabled by R&D (M5, indirect)

The Distinction Between R&D and Manufacturing

South Africa hosts both the most advanced health R&D system and the largest pharmaceutical manufacturing sector in sub-Saharan Africa. This case study focuses on the former: the research institutions, technology development programmes, and knowledge creation activities that generate the productivity spillovers, human capital gains, and innovation externalities at the core of the macroeconomic model. Pharmaceutical manufacturing, including Aspen Pharmacare's 23 production facilities and contract manufacturing operations, generates large-scale employment and trade benefits, but these are industrial activities whose economic returns operate through different channels than R&D investment. Manufacturing is best understood as a downstream consequence of the R&D system described here: it is R&D that creates the knowledge, regulatory science, and technical capacity that enables manufacturing to follow.

The R&D Ecosystem: Context and Investment

Afrigen Biologics, a Cape Town-based biotech company designated by the WHO and the Medicines Patent Pool in June 2021 as the global hub for the mRNA Technology Transfer Programme. AfriVac 2121 was the first mRNA vaccine designed, developed, and produced at laboratory scale on the African continent (WHO, 2023; Al Jazeera, 2023). This knowledge creation generates the TFP spillovers modelled in M2.

Afrigen is now advancing six novel mRNA vaccine candidates against diseases of direct relevance to Africa: respiratory syncytial virus (RSV), Rift Valley Fever, gonorrhoea, HIV, mpox, and tuberculosis. The TB vaccine is being developed in partnership with the South African Medical Research Council (SAMRC) and the Universities of Cape Town and the Witwatersrand (TB Alliance, 2025; Lancet Microbe, 2023). A CEPI-funded project (\$2.05 million) is exploring whether synthetic DNA can replace traditional plasmid DNA in mRNA vaccine production, potentially reducing development timelines by up to three times, a process innovation with global significance (CEPI, 2024).

The institutional R&D infrastructure extends beyond Afrigen. The SAMRC (south African medical research council) coordinates national health research priorities and funds programmes across universities and research institutes. Biovac, a public-private vaccine company, has held proprietary polysaccharide conjugate vaccine technologies since 2006 and has conducted its own process R&D for vaccine production, distinct from its fill-and-finish contract manufacturing work (ScienceDirect, 2025). The University of Cape Town's Drug Discovery and Development Centre (H3D) and the University of the Witwatersrand's research programmes in infectious disease, immunology, and vaccinology contribute to a research network that trains PhD and postdoctoral researchers who remain in South Africa and across the continent.

Documented R&D Benefits

Knowledge creation and technology transfer: The WHO mRNA Technology Transfer Programme, with total funding of \$117 million as of April 2023, is a first-of-its-kind model of South-led technology development and South-South knowledge transfer (WHO, 2023). The programme has transferred mRNA vaccine technology from Afrigen to 14 manufacturing partners across six WHO regions. The first technology transfer to Biovac was completed in September 2024, with three additional partners receiving the technology in the same year (WHO, 2025). Afrigen's innovations include novel lipid synthesis techniques and process optimisation methods that did not previously exist and are being disseminated to partners in Egypt, Kenya, Nigeria, Senegal, Bangladesh, Brazil, and nine other countries (Afrigen Biologics, 2025). This is an example of the international knowledge spillover mechanism ($\phi_2 = 0.05$) in the model.

Human capital and brain gain: Afrigen's core contribution to South Africa's economy is the creation of a cadre of scientists and bioengineers with advanced mRNA development capabilities who are working in Africa rather than emigrating. Afrigen invests in training molecular biologists, immunologists, and bioprocess engineers with practical experience in advanced technologies, and has established institutional partnerships with local universities and research centres to embed biotechnological expertise across the innovation system (TB Alliance, 2025). Over 200 participants from partner countries attended the first face-to-face programme meeting in Cape Town in April 2023, with the hub serving as a centre of excellence for hands-on training (Lancet Microbe, 2023). Fourteen of the fifteen manufacturing partners have received hands-on training at Afrigen (Afrigen Biologics, 2025). This supports the brain-gain channel (M6) by demonstrating that high-quality R&D opportunities in Africa attract and retain talent.

Research output and pipeline development: Six vaccine candidates in active development are tangible R&D output. The TB vaccine programme, co-developed with SAMRC and university partners, addresses one of Africa's highest-burden diseases and contributes to a pipeline that did not exist five years ago. If any of these candidates succeed in clinical trials, the health and economic returns will be substantial. But the R&D investment is generating economic value now, through employment, knowledge creation, and institutional development, regardless of eventual product outcomes.

Downstream Manufacturing as a Consequence of R&D

South Africa's broader pharmaceutical manufacturing sector, including Aspen Pharmacare's operations, Biovac's fill-and-finish lines, and the Serum Institute partnership, shows what becomes possible when an R&D system creates the regulatory science, technical workforce, and process knowledge that manufacturers need. Aspen's mRNA filling capability, brought to commercialization in 2024, was enabled by the knowledge and quality systems developed through the R&D system. The country's pharmaceutical import deficit (the fifth largest in South Africa's current account) is progressively being addressed as local manufacturing capacity grows. However, the economic returns from manufacturing, jobs, trade balance improvement, FDI attraction, are consequences of the upstream R&D investment, not the investment itself. For the purposes of the model, manufacturing returns are captured in the trade channel (M5) as downstream effects, while the R&D investment drives returns through the knowledge capital (M1), GDP/TFP (M2), and brain gain (M6) channels.

Relevance to the Model

South Africa's health R&D system supports the model's knowledge capital channel (M1) and GDP/TFP channel (M2). Afrigen's work demonstrates that African institutions can conduct frontier R&D, not merely adopt or adapt technologies developed elsewhere, and that this R&D generates knowledge spillovers that diffuse internationally through the technology transfer programme. The case provides the

strongest available evidence for the international spillover coefficient ($\phi_2 = 0.05$) and the brain-gain channel (M6). It also follows the model's causal logic: public and philanthropic investment in health R&D creates knowledge and human capital, which in turn enables downstream manufacturing, trade, and employment benefits.

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Case Study 2: BioNTech's mRNA Vaccine Manufacturing Facility, Kigali, Rwanda

Relevance to model channels

FDI attraction • Employment and skills transfer (M3) • Technology transfer (M2) • Trade and import substitution (M5) • Blended finance as a model for de-risking health R&D investment

Context and Investment

Rwanda's BioNTech mRNA vaccine manufacturing facility in Kigali is the single largest health R&D-related FDI commitment in sub-Saharan Africa outside of South Africa. BioNTech has invested approximately \$150 million in the facility to date, with construction commencing in June 2022 and the first BioNTainer modular manufacturing units inaugurated in December 2023 (BioNTech, 2022; BioNTech, 2023; Pharmaceutical Technology, 2024). The facility's initial production capacity is estimated at approximately 50 million vaccine doses per year.

The project has attracted substantial blended public-private financing. In October 2025, the European Investment Bank and the European Commission announced up to €95 million in blended financing: a €35 million Commission grant and up to €60 million in EIB loans (EIB, 2025). This builds on CEPI's earlier commitment of up to €130 million to support vaccine development and manufacturing at the site (EIB, 2025). The EU's broader investment in Rwanda's pharmaceutical sector includes a further €40 million through the Global Gateway strategy, targeting higher education and TVET for biomanufacturing, biotech entrepreneurship, R&D, and supply chain strengthening (European Commission, 2023).

The facility is designed to manufacture mRNA vaccines for diseases with the highest burden in Africa, including malaria, tuberculosis, HIV, and mpox, alongside COVID-19 vaccines if needed. BioNTech's modular BioNTainer approach uses standardized, container-based manufacturing units that can be updated and scaled according to demand (BioNTech, 2022).

Documented and Projected Benefits

Employment and skills transfer: The facility is expected to employ approximately 100 specialized staff in its initial phase, with BioNTech providing training in mRNA production, quality assurance, and laboratory operations coordinated from its German sites (BioNTech, 2022).

FDI catalysis and blended finance innovation: The total investment package (BioNTech's \$150 million, EU/EIB's €95 million, CEPI's €130 million, plus €40 million in support investment) demonstrates how concessional public finance can be used strategically to de-risk private health R&D investment in Africa. The blended finance mechanism combines EU guarantees with EIB lending and Gates Foundation expertise through the Human Development Accelerator, enabling higher-risk investments that fill market gaps in low- and middle-income settings (fundsforNGOs, 2025). This model directly supports the model's argument that public R&D investment draws in private sector crowding-in.

Health sovereignty and pandemic preparedness: The facility is designed to reduce Africa's dependence on imported vaccines. Africa currently imports over 99% of the vaccines it uses (Think Global Health, 2025). The BioNTech facility, alongside complementary investments in Senegal (Institut Pasteur de Dakar) and South Africa (Biovac/Afrigen), forms part of a decentralized continental mRNA manufacturing network aligned with the African Union's target to locally produce 60% of the continent's vaccines by 2040 (European Commission, 2023).

Relevance to the Model

The Rwanda case is the strongest available example of the blended finance pathway. The total investment package show a leverage ratio of approximately 3–4:1 (public concessional finance to private investment), consistent with the crowding-in elasticity ($\gamma_1 = 0.20$) used in the model.

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- Think Global Health (2025). 'Vaccines for Africa by Africa.' Council on Foreign Relations.

Case Study 3: EDCTP: Building Clinical Trial Infrastructure and Human Capital Across Sub-Saharan Africa

Relevance to model channels

Employment and human capital (M3) • Brain gain and researcher retention (M6) • Institutional capacity and absorptive capacity (AC_o) • Regulatory strengthening

Context and Investment

The European and Developing Countries Clinical Trials Partnership (EDCTP) is the longest-running and most extensively documented international health R&D partnership focused on sub-Saharan Africa. Launched in 2003 as a public-public partnership between European and African governments with EU support, the programme has evolved through three phases: EDCTP1 (2003–2015), EDCTP2 (2014–2024), and Global Health EDCTP3 (2021–2031) (EDCTP, 2024; European Commission, 2026).

The EDCTP1 programme awarded 254 grants totaling €208 million across HIV, tuberculosis, and malaria research (UN DESA, 2018). The EDCTP2 programme expanded significantly, with total funding exceeding €1.4 billion: €683 million from the EU, matched by over €1.2 billion in contributions from European Participating States (EDCTP Annual Report, 2024; European Commission, 2026). By the end of 2024, EDCTP2 had supported 435 collaborative research, fellowship, and capacity-building projects with a total budget of €814 million, involving 19 European and 44 African countries (PLOS Speaking of Medicine, 2022; EDCTP Annual Report, 2024). The majority of funding (approximately 60%, or €489 million) was allocated directly to Africa, distributed across 310 African institutions (PLOS Speaking of Medicine, 2022).

Documented Benefits

Clinical research capacity: EDCTP2 supported 232 clinical studies, including Phase I–IV trials and diagnostic evaluation studies, across 38 sub-Saharan African countries (EDCTP Annual Report, 2024). This expansion of Africa’s clinical trial infrastructure, building laboratory capacity, data management systems, regulatory expertise, and Good Clinical Practice standards in settings where these capabilities were previously absent or fragmented. More than 17 policy documents and clinical guidelines have cited EDCTP-funded research as their evidence base (EDCTP Annual Report, 2024).

Human capital development: The programme has invested heavily in researcher career development at all levels. EDCTP2 awarded 215 fellowship grants supporting 362 fellows (145 female, 217 male), and an additional 1,202 trainees from sub-Saharan African countries received support through EDCTP-funded projects (563 female, 639 male) (EDCTP Annual Report, 2024). The fellowship programme specifically includes a return-to-home-institution requirement (minimum two years), directly supporting the brain-gain channel by ensuring that skills acquired in European pharmaceutical companies and research institutions are brought back to African settings (EDCTP, 2016). The programme established four regional Networks of Excellence, CANTAM (Central Africa), EACCR (East Africa), WANETAM (West Africa), and TESA (Southern Africa), which created shared infrastructure, training programmes, and mentoring relationships across the continent (BMC Public Health, 2013).

Institutional development: EDCTP2 supported 92 projects specifically designed to strengthen the enabling environment for clinical trials and research, including ethics review capacity, national regulatory authority competence, and regional harmonization of regulatory frameworks (EDCTP Annual Report, 2024). By the end of 2024, 30 sub-Saharan African countries were members of the EDCTP Association and 44 sub-Saharan African countries participated in EDCTP-funded projects (EDCTP Annual

Report, 2024). This institutional development directly contributes to improving Africa's absorptive capacity: the ability to convert R&D investment into productive output.

Relevance to the Model

EDCTP is the primary real-world basis for the model's employment channel (M3), brain-gain channel (M6), and the absorptive capacity framework (AC₀). The programme demonstrates that sustained international health R&D investment in Africa creates measurable human capital gains: trained researchers, strengthened institutions, improved regulatory environments, and expanded clinical trial capacity. The fellowship programme's return requirement provides direct evidence for the brain-gain mechanism modelled in M6 ($\beta_{\text{brain}} = 0.15$). The regional Networks of Excellence illustrate how R&D investment in one country generates spillovers to neighbouring countries, supporting the model's treatment of continental aggregates.

References: Case Study 3

BMC Public Health (2013). 'EDCTP Regional Networks of Excellence: Initial Merits for Planned Clinical Trials in Africa.' BMC Public Health, 13:258.

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Case Study 4: Kenya's Health Research Ecosystem: KEMRI and KEMRI-Wellcome Trust

Relevance to model channels

Employment (M3) • GDP and productivity (M2) • Brain gain (M6) • FDI through clinical trial partnerships • Cost of inaction (vulnerability to ODA shock)

Context and Investment

Kenya shows how sustained public investment in a national health research institute generates compounding economic returns over decades. The Kenya Medical Research Institute (KEMRI) was established in 1979 under the Science and Technology Act as the national body responsible for carrying out health research in Kenya. Over more than 40 years, KEMRI has grown into one of Africa's leading centres of excellence in health research, operating 15 research centres with advanced facilities and laboratories spread throughout the country (KEMRI, 2022).

Kenya invests approximately 0.8% of its GDP in R&D, making it the second-highest R&D spender in Sub-Saharan Africa after South Africa (People Daily, 2025). The government committed through the Science, Technology and Innovation Act of 2013 to allocate up to 2% of GDP to R&D, and the Health Act of 2017 mandates that the National Research Fund allocate at least 30% of its funding to health R&D (KEMRI, 2022; PATH, 2020). However, actual disbursements have fallen well short of these commitments: between 2013 and 2018, the NRF allocated at most 25% to health, and the funding eventually allocated for health R&D was 83% less than the government's stated commitment (PATH, 2020). KEMRI's annual budget is approximately roughly \$50 million, but it receives only about Sh1 billion from the Treasury, forcing reliance on foreign donors for the remainder (People Daily, 2025).

Documented Benefits

Employment and human capital: KEMRI employs between 1,000 and 5,000 staff across its 15 research centres, creating a critical mass of health research professionals. The KEMRI-Wellcome Trust Research Programme (KWTRP), a flagship partnership between KEMRI, the Wellcome Trust, and the University of Oxford, operates major research facilities in Kilifi and Nairobi. KWTRP has become a leading centre for health systems, health economics, and clinical research training in Africa, running PhD and postdoctoral training programmes that produce researchers who remain in-country and take up positions across Kenya's health system and universities (KEMRI-Wellcome, 2026). The programme is currently part of the AFRHiCARE Partnership, a five-year Wellcome-funded collaboration across Kenya, South Africa, and Uganda focused on hospital workforce development (KEMRI-Wellcome, 2026).

Research output and policy influence: KEMRI has contributed to health research capacity development across the East African region, hosting the East African Health Research Commission's activities, the African Journal of Health Sciences, and regional training programmes on disease control (KEMRI, 2022).

Clinical trial infrastructure and FDI: Kenya's clinical trial infrastructure, anchored by KEMRI and its international partnerships, attracts substantial foreign investment in health research. International pharmaceutical companies and product development partnerships conduct trials through KEMRI's network, bringing research funding, technology, and expertise into the country. The KEMRI-based drug discovery consortium (part of the EU Horizon Europe-funded GC ADDA and RAFIKI networks) puts Kenya as East Africa's leading hub for translational drug discovery.

Limitations and Cost-of-Inaction Evidence

Kenya's experience also shows the cost of inaction: the consequences of chronic underfunding of health research. Despite KEMRI's achievements, the institute receives only about 14% of its budget from domestic government sources. The dissolution of USAID in 2025 and declining international support have created an acute funding crisis: critical health research projects at KEMRI have been delayed or halted due to budgetary constraints, and the country faces accelerating brain drain as researchers seek better-funded opportunities in South Africa, the UK, and the US. This dependence on external funding, and the vulnerability it creates, is the scenario modelled in S1 (status quo post-ODA shock) and provides empirical support for the cost-of-inaction.

Relevance to the Model

Kenya is the key case for the model's brain-gain channel (M6) and shows both the positive returns of sustained health R&D investment and the risks of inadequate domestic funding. KEMRI's annual budget of approximately \$50 million, combined with foreign partnership funding, supports a research system that generates employment, trains researchers, attracts FDI, influences policy, and builds institutional capacity. The gap between Kenya's stated commitment (2% of GDP to R&D) and actual spending (0.8%) provides the model's S2 scenario ('achievable near-term uplift') with a country-level reference point.

References: Case Study 4

KEMRI (2022). 'Research.' Kenya Medical Research Institute website. Available at:
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Case Study 5: Egypt: Domestic R&D Financing and Knowledge Capital Formation

Relevance to model channels

Domestic public R&D financing (M1) • Knowledge capital and GDP growth (M2) • R&D employment and human capital (M3) • Technology transfer and absorptive capacity (AC₀) • Regulatory science as a foundation for R&D-led growth

Context and R&D Investment Profile

Egypt is Africa's most advanced domestic R&D investor in health. With a GERD of approximately 1.02% of GDP, it is one of the few African countries to approach the African Union target, and it has done so through state budget financing rather than donor support. The institutional foundation is the state-owned VACSERA, which has produced vaccines continuously since 1893 and holds a product portfolio spanning polio, meningitis, influenza, rabies, and BCG tuberculosis vaccines (VACSERA, 2025; EDA, 2025). At sector level, the country hosts 191 operational pharmaceutical factories and approximately 2,000 associated firms, producing over 94% of the medicines consumed domestically, but the distinctive feature for the model is not the production scale: it is that this outcome was achieved through a long-run domestic R&D and regulatory investment strategy, without sustained reliance on international donor financing.

The domestic policy architecture supporting this investment is substantial. The Egyptian Drug Authority (EDA) has established bilateral regulatory harmonisation agreements with Zambia, Zimbabwe, and South Africa, enabling cross-recognition of approved products, and in 2024 achieved WHO Maturity Level 3 regulatory status, one of only four African countries (alongside Ghana, Nigeria, and Tanzania) to reach this milestone (AfDB, 2023). This regulatory science investment is itself a form of R&D infrastructure: it enables Egyptian-developed products to reach export markets, which in turn provides the commercial case for continued R&D spending. The government has also invested in purpose-built R&D and production infrastructure through Gypto Pharma, inaugurated in 2021, with 160 production lines and a focus on novel therapies for the region (IQVIA, 2022).

Egypt's GERD reached approximately 1.02% of GDP according to the most recent WIPO estimates, making it one of only a handful of middle-income countries in Africa or the Middle East to exceed the 1% threshold (WIPO, 2024). VACSERA is advancing the localisation of pneumococcal conjugate vaccine (PCV13) production through a partnership with GenVax Egypt, aligned with the AU's target to produce 60% of Africa's vaccine needs locally (Daily News Egypt, 2026). In March 2024, VACSERA signed a technology transfer agreement with a European biopharma firm to enhance vaccine production capabilities (Market Data Forecast, 2025). Egypt was also selected as one of the 15 partners in the WHO/MPP mRNA Technology Transfer Programme, receiving technology from the Afrigen hub in South Africa (WHO, 2025).

Documented Economic Benefits

Trade and exports: Egypt's pharmaceutical exports exceeded \$1 billion in 2023 for the first time in the history of the Egyptian Drug Authority (Al Majalla, 2024). The government has set a target to reach \$5 billion in pharmaceutical and medical supply exports by 2030. Pharmaceutical imports have simultaneously declined: a reduction of approximately \$500 million year-on-year to end-November 2023, and approximately \$700 million compared to 2021 (Al Majalla, 2024). This demonstrates the import substitution mechanism modelled in M5 operating at scale in a real African economy. Egyptian manufacturers have also pursued African investment strategies, with mergers and greenfield projects in neighbouring countries expanding the sector's regional reach (AfDB, 2023).

R&D employment and skills development: The pharmaceutical sector generates a high-complexity employment base: 191 factories and 2,000 associated firms spanning manufacturing, quality assurance, regulatory affairs, R&D, and clinical functions. For the model, the focus is not the total headcount but the skill composition. AfDB notes that Egypt's pharmaceutical industry has a relatively high average complexity, generating the kind of high-skilled, R&D-adjacent employment that underpins long-term productivity growth and absorptive capacity improvements (AfDB, 2023). VACSERA alone employs scientists, bioengineers, and clinicians engaged in active product development and technology transfer activities.

R&D partnerships and technology transfer: Egypt is one of the 15 partners in the WHO/MPP mRNA Technology Transfer Programme, receiving technology from the Afrigen hub in South Africa (WHO, 2025). It has partnerships that generate knowledge spillovers that compound domestic R&D capacity over time, the mechanism modelled in the AC_o trajectory.

Relevance to the Model

Egypt is the primary evidence base for the model's domestic financing channel (M1) and knowledge capital accumulation (M2). It is the only African country that has sustained domestic health R&D investment at close to 1% of GDP through a state budget rather than donor support, and has done so over a long enough horizon to generate observable macroeconomic outcomes. The GERD trajectory provides the empirical grounding for the M1 channel parameter in the model's scenarios, particularly S3 (the AU 1% GERD target). The technology transfer partnerships with the WHO/MPP mRNA programme and European biopharma firms directly populate the AC_o absorptive capacity trajectory: Egypt's experience shows what AC_o improvement looks like in practice when domestic financing enables receptive institutions. The trade outcomes (exports exceeding \$1 billion, 94% domestic self-sufficiency) and employment scale are documented, but for the purposes of the model they are downstream outputs of the R&D and regulatory investment, not the primary channel. Egypt's regulatory maturation to WHO ML3 status is clear African evidence that investment in regulatory science (a form of R&D infrastructure) compounds returns by unlocking export markets.

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Case Study 6: Cuba: Domestic Public Investment and Frontier Health R&D Under the Embargo

Relevance to model channels

Knowledge capital and innovation (M1) • GDP and productivity (M2) • Employment of high-skilled researchers (M3) • Brain retention (M6) • Trade through exports (M5)

Context and Investment

Cuba's biopharmaceutical sector is the most documented case of health R&D built entirely through domestic public financing. The US embargo, in place since 1962, cut Cuba off from international capital markets, technology licences, foreign direct investment, and most bilateral research partnerships. The result was not the collapse of health R&D capacity but its construction from scratch using state resources.

The Cuban government began investing in biotechnology in the late 1970s. The Centro de Ingeniería Genética y Biotecnología (CIGB) was founded in 1986 using the domestic state budget. The Finlay Vaccine Institute, the Centre for Molecular Immunology (CIM), and over a dozen complementary institutions followed, all state-funded. In 2012, these were consolidated under BioCubaFarma, a state holding group now comprising more than 40 enterprises with over 21,600 employees, including hundreds of scientists, bioengineers, and clinicians (BioCubaFarma, 2025; INET, 2021). All operating capital is sourced from the domestic state budget.

Documented Benefits

Knowledge creation and product innovation: The Finlay Institute developed VA-MENGOC-BC in 1989, the world's first effective vaccine against serogroup B meningococcus. Cuba developed a recombinant hepatitis B vaccine from yeast in 1992, CIMAvax-EGF (a therapeutic vaccine for non-small cell lung cancer, now in US clinical trials in partnership with Roswell Park Cancer Institute), and the anti-EGFR monoclonal antibody Nimotuzumab. During the COVID-19 pandemic, Cuba independently designed and manufactured five vaccine candidates, two of which, Soberana 02 and Abdala, achieved over 90% efficacy in Phase III trials and were used to vaccinate the Cuban population using entirely domestic production capacity (WIPO, 2024; LSE Latin America, 2021). In 2024, BioCubaFarma added 28 new products to its portfolio and ran more than 400 research projects. In 2025, the organisation filed six new patent applications and had 42 patents granted internationally (CubaSi, 2025).

Employment and brain retention: The sector employs over 21,600 people directly. The scientific workforce was trained domestically through Cuba's state-funded university system and employed by state institutions. The absence of a private labour market for researchers, combined with restricted emigration for much of the sector's development period, produced forced brain retention at scale. Cuba's health outcomes, including an infant mortality rate and life expectancy broadly comparable to high-income countries despite GDP per capita well below the OECD median, reflect what this human capital investment produces when it remains in the country.

Exports: BioCubaFarma exported to 42 countries in 2024 and reached \$211 million in annual exports in 2021. Technology transfer agreements have been signed for Soberana production in Iran, with joint ventures established in Vietnam, Italy, Russia, and Australia (BioCubaFarma, 2025). The WIPO (2024) assessment of Cuba's COVID vaccine technology transfer describes a model of South-led technology development with direct relevance to the international knowledge spillover mechanism (ϕ_2) in the GHE model.

Relevance to the Model

Cuba provides lessons that domestic public investment alone can build frontier health R&D capacity and generate tradeable innovation. It supports the knowledge capital channel (M1) more directly than any African case in the current document, because the absence of international funding removes the confounding variable that affects most other cases. The \$211 million in exports in 2021, from a population of 11 million, implies a per-capita health R&D export return that exceeds most African comparators.

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