IDS WORKING PAPER
Volume **2018** No **505**

Inclusive Structural Change: Case Studies on Innovations in Breeding Practices in Kenya and Anti-Retroviral Therapy Service Provision in Mozambique

Amrita Saha, Jodie Thorpe and Seife Ayele

January 2018

IDS Institute of Development Studies

Inclusive Structural Change: Case Studies on Innovations in Breeding Practices in Kenya and Anti-Retroviral Therapy Service Provision in Mozambique
Amrita Saha, Jodie Thorpe and Seife Ayele
IDS Working Paper 505

ISSN: 2040-0209 ISBN: 978-1-78118-416-5
A catalogue record for this publication is available from the British Library.

Available from:
Communications and Engagement Unit, Institute of Development Studies, Brighton BN1 9RE, UK
Tel: +44 (0) 1273 915637
Web: www.ids.ac.uk/publications

IDS is a charitable company limited by guarantee and registered in England
Charity Registration Number 306371
Charitable Company Number 877338

Inclusive Structural Change: Case Studies on Innovations in Breeding Practices in Kenya and Anti-Retroviral Therapy Service Provision in Mozambique

Amrita Saha, Jodie Thorpe and Seife Ayele

Abstract

Innovation, accompanied by structural change, is at the heart of economic growth and development. Yet there is limited evidence to understand interactions between innovation, structural change and inclusion in the context of low-income and emerging countries, or how these processes best support sustainable and inclusive societies. Through case studies of innovation pathways in breeding practices in the Kenyan dairy sector and anti-retroviral therapy service provision in Mozambique, we study how innovations in specific contexts lead to adoption, diffusion and upgrading, and further to structural change and inclusion or exclusion of marginalised groups. The case studies unpack the conditions for these outcomes by identifying key variables, actors and interactions that shape the innovation pathways. We find that capabilities is a key variable. In particular, we find that inclusiveness and structural changes impact successive phases of innovations through 'reinforcing' or 'balancing mechanisms', operationalised by the impact of innovation on capabilities. Other factors include the presence of interrelated innovations, power relations between actors, and the role of institutions (formal and informal). The Kenyan case suggests parallel non-competing innovation pathways, while for Mozambique, we observe competing pathways that remain to be examined further. Findings from the cases provide the basis of future primary research on inclusive structural change.

Keywords: innovation, inclusion, structural change, capabilities, Kenya, Mozambique.

Amrita Saha is a post-doctoral research officer, on the APRA (Agricultural Policy Research in Africa) consortium, headquartered at IDS, and a visiting fellow at the London School of Economics and Political Science. She has worked with the Commonwealth Secretariat in London; with the Ministry of Commerce in India; WTO Geneva; ITAD and United Nations ESCAP. She has also taken up various teaching roles at IDS, SOAS, at the University of Sussex, and University of Bath. Her work continues to focus on political economy issues for developing countries.

Jodie Thorpe is a Research Fellow in the Business and Development Centre at IDS, leading the Institute's work to understand the role of business and markets, and their relationship with the state in development. Her expertise centres on inclusive markets and value chains, and public-private or multi-stakeholder partnerships. Over the course of her career, Jodie has advised and worked with numerous multi-nationals, southern companies, donor and multi-lateral agencies, and NGOs. Prior to joining IDS, she worked as a Private Sector Adviser at Oxfam GB and a Director at SustainAbility, a leading global consultancy on business risks and opportunities from sustainable development.

Seife Ayele is a development economist with over 20 years' experience in research, teaching and development practice, mainly in Africa and Asia. His work focuses on agricultural innovations and development, technology access and adoption, biotech crops regulation, and enterprise development. He is currently a Fellow in the Business, Markets and the State Cluster at the Institute of Development Studies (IDS). Prior to joining IDS, he directed programmes in Ethiopia providing access to and adoption of improved agricultural technologies by smallholder farmers. He was a Research Scientist at the International Livestock Research Institute (ILRI), Nairobi, and a Research Fellow at the Open University, UK.

Contents

Summary, keywords and author notes 3
Acknowledgements and acronyms 6

1 Introduction 7

2 Background 8

3 Analytical framework: pathways from innovation to outcomes 9
3.1 Innovation, structural change, and inclusion 9
3.2 Innovation pathways 10
3.3 Methodology and selection of cases 13

4 Kenya: Innovation pathways in breeding practices of smallholder dairy farmers 14
4.1 Background to dairy sector in Kenya 14
4.2 Variables influencing the innovation pathways 15
4.2.1 Early stage: Introduction and adoption of breeding practices by smallholder dairy farmers 14
4.2.2 Intermediate stage: Enabling further innovation 17
4.2.3 Final stage: Intensification and improvement of production 18
4.3 Outcomes 19
4.3.1 Structural changes 19
4.3.2 Development outcomes 21
4.3.3 Limits 22
4.4 Conclusion 23

5 Mozambique: Innovation pathways for anti-retroviral treatment service provision 23
5.1 Background to anti-retroviral treatment service provision in Mozambique 23
5.2 Variables influencing the innovation pathways 26
5.2.1 Early stage: Integration of ART into public health care and decentralisation 26
5.2.2 Late stage: Community-based ART provision 28
5.3 Outcomes 28
5.3.1 Structural changes 28
5.3.2 Health outcomes 29
5.3.3 Limits 30
5.4 Conclusion 31

6 Analysis: Understanding dynamics 31
6.1 Kenya: Innovation pathways in breeding practices of smallholder dairy farmers 34
34

7 Conclusions: Towards a future research agenda 38

References 40

Figures

Figure 3.1 Innovation pathways to structural change and inclusion 12
Figure 4.1 Knowledge and technology exchange for breeding innovations in Kenyan dairy farming 16
Figure 4.2 Dairy yield (cow milk) in Kenya (2000–2013) 20
Figure 4.3 Per capita milk consumption in Kenya (2000–2013) 21
Figure 5.1 Decentralization of ART provision in Mozambique 25
Figure 5.2 Knowledge and technology exchange for organisational innovations in ART in Mozambique 27
Figure 5.3 ART coverage in Mozambique (% of people living with HIV) 29
Figure 5.4 HIV disease burden: prevalence of HIV (total % of population ages 15–49) 30
Figure 6.1 Linear relations 32
Figure 6.2 Dynamic relations between innovation, structural change, and inclusion 33
Figure 6.3 Dynamic relations in innovation pathways for breeding practices of Kenyan smallholder dairy farmers 35
Figure 6.4 Dynamic relations in innovation pathways for anti-retroviral treatment service provision in Mozambique 37

Tables

Table 3.1 Types of innovation 10
Table 4.1 Cattle, production, and yield of cow milk in Kenya (2000–2013) 20
Table 4.2 Employment (full-time) in Kenyan dairy farming (2000s) 22

Acknowledgements

We gratefully acknowledge the grant received from the International Development Research Centre (IDRC), Ottawa, Canada for the pilot project, *Pathways to Inclusive Development through Innovation, Technology, Structural Change*, which enabled initial research on this subject, including these case studies. The views expressed herein do not necessarily represent those of IDRC or its Board of Governors. We would also like to acknowledge the significant input to the case development received from our partners on this project, Tommaso Ciarli and Maria Savona of the Science Policy Research Unit at the University of Sussex. Finally, we gratefully also acknowledge the generous feedback received from Lizbeth Navas-Alemán, which improved the resulting paper significantly.

Acronyms

AFC	Agricultural Finance Cooperation
ART	anti-retroviral treatment
AI	artificial insemination
CHW	community health workers
ECF	East Coast Fever
FAO	Food and Agriculture Organization
ILRI	International Livestock Research Institute
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forestry Research Institute
KETRI	Kenya Trypanosomiasis Research Institute
LTFU	loss to follow up
MOH	Ministry of Health
NGO	non-governmental organisation
PEPFAR	President's Emergency Plan for AIDS Relief
PHC	public health care
SWAp	Sector Wide Approach to Programming
SDG	Sustainable Development Goal
TB	tuberculosis
UN	United Nations
USD	US dollars
VCT	voluntary counselling and testing
WHO	World Health Organization

1 Introduction

Through Agenda 2030 and the Sustainable Development Goals (SDGs), governments have committed to promote development-oriented policies that achieve higher levels of economic productivity through technological upgrading and innovation, along with a focus on higher-value added and labour-intensive sectors.[1] Yet the data and evidence available to understand innovation in the context of low-income and emerging countries is limited (Charmes, Gault and Wunsch-Vincent 2016; Chataway, Hanlin and Kaplinsky 2014; Gault 2014; OECD 2017; Planes-Satorra and Paunov, 2017), especially with respect to two specific questions. First, which factors, in which contexts and through which processes, lead to technological adoption, diffusion and upgrading, and further to structural changes in the economy (such as higher productivity or changes in production technology)? Second, even less is known about the dynamics of how the inclusion of marginalised groups in these processes (or how the process of structural change itself) influences successive phases of innovation.

The case studies explored in this working paper are part of the project '*Pathways to inclusive development through innovation, technology and structural change*',[2] which aims to motivate a new research framework and produce empirical evidence and theoretical guidance which respond to this policy gap. Adopting an analytical framework of pathways from innovation to outcomes, we address the first question by examining specific case studies in Kenya and Mozambique where innovation leads to some form of structural change and inclusion/exclusion of different groups. Beginning from the origins of the innovation, we follow the uptake (adoption and diffusion) of the innovation, its impact on structural change and inclusion, and finally, we check for complementarity (if any) between structural change and inclusion. By means of these two case studies, we unpack the conditions for an innovation to lead to structural change and inclusion/exclusion based on: (i) variables that shape the innovation pathways, and (ii) the actors and their interactions that shape these processes.

However, the application of this framework leads us to the second question. Findings from studying the innovation pathways of adoption of breeding practices in dairy farming in Kenya and anti-retroviral treatment in Mozambique suggest that outcomes of structural change and inclusion at a given time have a significant impact on future innovations. It suggests a feedback mechanism from one phase to the other; that actors, their interactions, and variables are shaped by earlier structural change and inclusion to affect innovation in the next phase. We explore this relationship in our analysis of the case studies.

The remainder of this document is structured as follows. Section 2 presents the background for the study, followed by the analytical framework and methodology that guided the analysis of the two cases in section 3. Section 4 provides the details for the Kenyan case of innovation pathways in breeding practices of smallholder dairy farmers. The innovation pathways for anti-retroviral treatment service provision in Mozambique is discussed in Section 5. Section 6 analyses the cases from the lens of a 'dynamic' framework. Finally, Section 7 provides concluding insights and directions towards a future research agenda.

[1] https://sustainabledevelopment.un.org/sdgs

[2] www.ids.ac.uk/project/pathways-to-inclusive-development-through-innovation-technology-and-change

2 Background

Innovation is at the heart of economic growth and development, which is accompanied by structural changes (Cimoli and Dosi 1995; Hidalgo, Klinger, Barabási, and Hausmann 2007; Syrquin 1988; Verspagen 2004). Through innovation, new products are developed, which satisfy unmet or new needs; and new production processes emerge which affect, *inter alia*, opportunities and conditions for workers and producers, outcomes for the environment and the affordability of products and services. As innovation takes place, it is accompanied by changes in the organisation of production, division of labour, skills requirements, and patterns of consumption which together constitute structural change (Ciarli 2012: 298).

While the positive relationship between innovation and structural change is well understood, there seems to be a trade-off between addressing the needs of the most marginalised and including them in the innovation process, and achieving industrialisation and sustained growth. On the one hand, change can generate new opportunities that facilitate social mobility, but also increase income inequality. For example, the Kuznets curve hypothesises that productivity and economic growth have an 'inverted u' shape effect on inequality, which rises in early stages of development, and then falls after a certain threshold is reached (Kuznets 1955). International technological transfer and global value chain linkages often benefit a small number of connected or pioneer firms (Lundvall 2007), creating islands of high productivity in contexts of generally unorganised and low technology production. Alternatively, pathways may be more inclusive but result in lower structural change (Fressoli *et al.* 2014) which fails to achieve impact at scale.

A more recent scholarship points to the positive potential for innovation that supports structural change at the same time as creating new opportunities to include marginalised people from the 'base of the economic pyramid' in low-income countries (Chataway *et al*. 2014; Heeks, Foster and Nugroho 2014; Porter and Kramer 2011; Prahalad and Hart 2002). 'Inclusive structural change', as we have termed it, addresses the needs of those marginalised in society (inclusion in outcomes), through new products and services or new livelihood opportunities. Inclusive structural change may also support the agency of excluded or marginalised groups (inclusion in process), who will have a voice in decision-making or directly participate in innovation processes (Heeks *et al.* 2014). Despite the potential for 'inclusive innovation' and 'inclusive structural change' suggested by these approaches, there is limited knowledge of how inclusion can be achieved (Chataway *et al*. 2014; Cozzens and Sutz 2014), or of the ability of these approaches to serve the poor in practice (Bedi 2012; Landrum 2007; Karamchandani, Kubzansky and Lalwani 2011) through profitable business models (Garrette and Karnani 2010; Simanis 2012). Even less well understood is the reverse dynamic: how inclusion and inequalities influence successive phases of innovation and structural change.

Different actors are involved in any part of the innovation process or in the diffusion, adoption and adaptation of knowledge and technology arising from innovation, including formal and informal enterprises, universities and research centres, and technology transfer offices (Bell 2009; Fu and Gong 2011; Fu, Pietrobelli and Soete 2011; Gereffi, Humphrey and Sturgeon 2005; Hanlin and Kaplinsky 2016; Lundvall 2007). Outcomes depend on the capabilities and interactions of these actors, as well as the scalability and effectiveness of the innovation (Bell 2009; Cirera and Maloney 2017; Planes-Satorra and Paunov 2017). Hausmann and Hidalgo (2011) discuss the relationship between capabilities, trade specialisation and development specifically at a macro level. Accumulation of capabilities is needed for low-income countries to move from simple goods based on natural resources towards the type of more complex and specialised goods currently traded by high income countries (Hausmann and Hidalgo 2011; Hidalgo *et al*. 2007). Literature on technological

capabilities in developing countries emphasises the importance of firm-level efforts toward knowledge acquisition, embeddedness and the flow of knowledge within and between value chains, competition and capability accumulation over time (Bell 2006; Figueiredo 2011; Morrison, Pietrobelli and Rabellotti 2008), but also call for much more detailed and appropriate data and analysis in these areas, particularly from a longitudinal perspective.

Other factors that have been highlighted include social norms and discrimination, barriers to entrepreneurship, and the dynamics of technology adoption and diffusion (Comin and Mestieri 2013; Planes-Satorra and Paunov 2017). Actors' interactions are shaped by power relations, governance, physical and social distances (Ciarli *et al.* 2018, forthcoming).

The key challenge is to produce empirical evidence and advance theory that helps policy-makers to better understand these and other key variables and how they shape the interactions between innovation, inclusion and structural change, facilitating more effective policy-making in support of sustainable and inclusive societies.

3 Analytical framework: pathways from innovation to outcomes

The case studies set out in this paper explore documented experiences of innovation, structural change and inclusion/exclusion in low-income countries. Our analytical framework (Figure 3.1) is designed to identify different pathways in the specific context of low-income countries. It was produced as part of the project *Pathways to inclusive development through innovation, technology and structural change*[3] and is presented in detail in Ciarli *et al*. (2018, forthcoming), with a summary provided below. The framework builds upon a large literature on the determinants of innovation, identifying variables that influence the innovation process and the outcomes which flow from it.

3.1 Innovation, structural change, and inclusion

Innovation involves the development of new or significantly improved products, processes, organisational methods or marketing techniques as defined in Table 3.1. This innovation may be new to the world or, significantly for many low-income contexts, it may be current technologies that are new to a particular country, region, market or producer (OECD 2005). The *source* of an innovation is a place, person or thing from which an innovation originates or can be obtained, while the *channel* of an innovation is a method or system for communication (or transfer) and distribution (or dissemination) of this knowledge or technology, and/or the actors involved. Once an innovation is introduced, households, firms and/or other organisations may adopt it and adapt it to their needs (*diffusion*).

Actors' *capabilities* include both their production capability, to generate goods and services with a given technology or process in existing organisational configurations, and their innovation capability, to create new product and process technologies and to improve technologies already being used. These in turn involve the use of physical, knowledge, human and organisational capital – including their external links and interactions (market, social, political) with other firms and related organisations (Bell 2009).

[3] www.ids.ac.uk/project/pathways-to-inclusive-development-through-innovation-technology-and-change

Table 3.1 Types of innovation

Product	'A product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.'
Process	'A process innovation is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.'
Marketing	'A marketing innovation is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.'
Organisational	'An organisational innovation is the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations.'

Source: OECD (2005: 48-51).

As innovation proceeds, changes take place in the structure and technology of production, workforce composition, product mixes, income distribution and patterns of consumption; transformations characterised as '*structural change'* (Ciarli 2012: 228). While structural change is often used principally to refer to the process of attracting human and physical capital out of rent seeking, commerce and agriculture into manufacturing (Amsden 2001: 2), here the definition is broader. It includes structural economic change towards more efficient processes and higher productivity, assets based on higher skills and a more complex division of labour, and sales or exports of more knowledge-intensive and higher value added products, as well as structural institutional change with new institutions for education, regulation, trade, labour markets or environmental protection.

Inclusion implies redistributing benefits and/or power to those who have been marginalised and excluded from previous processes of development. Marginalised groups face intersecting forms of exclusion: they are often unskilled and/or uneducated, they have less wealth and income than others, they are isolated and impacted by violence and/or environmental degradation, and they are discriminated against and excluded socially (Kabeer 2016; Pogge and Rippin 2013). Multiple dimensions of exclusion imply multiple challenges which can be expressed in terms of weak physical (assets, infrastructure), social (networks and support), human (skills, literacy, self-esteem) and natural (good quality water, soil, air) capital, as well as limited power to shape how assets are controlled and used (Moser 2008), with associated implications for their production and innovation capabilities. Inclusion brings previously marginalised groups into the benefits of innovation, improving livelihoods and well-being; and/or into decision-making processes, giving them a prominent role in deciding about the pathways followed (Cozzens and Sutz 2014; Chataway *et al*. 2014; Foster and Heeks 2013; Heeks *et al*. 2014). While inclusion in these modes (outcome and process) is not mutually exclusive; neither are they both guaranteed. In the case analysis in this paper, we document both forms of inclusion.

3.2 Innovation pathways

Our typology (Figure 3.1) from innovation to outcomes, as set out in Ciarli *et al*. (2018*,* forthcoming), suggests there are multiple potential pathways between innovation, structural change and inclusion/exclusion, which depend on variables that influence the adoption and diffusion of innovations, their impact on structural change and inclusion, and the complementarity or trade-offs inherent in these processes. Note that this framework is

focused on the *aftermath of innovation,* rather than the determinants of innovation and how it occurs. We are interested in why and how an innovation is adopted, diffused and used; whether and how it scales up; whether and how it induces structural change; and what are the outcomes in terms of inclusion.

First, an innovation is introduced, whether indigenous or transferred from somewhere else – as specified under the first column on '*Innovation*'. The innovation may be of product, process, organisation, or market. Different actors may be sources and channels of the innovation, and their interactions may be shaped by factors such as proximity and power relations. Second, the innovation becomes part of the system as soon as some individual or organisation adopts it,[4] and then diffuses as other actors in the system also begin to adopt it. The extent to which the innovation diffuses in the system depends on a set of variables such as the capital intensity of the new technology, its scale, appropriability, adaptability, and cost. A non-exhaustive list of variables is provided in the second column, '*Variables*'.

Note that we distinguish between *two types of variables*:

- Incentive Variables: These variables induce or motivate innovation. Typical examples are demand (domestic or international), scale, factor costs and institutional variables (such as intellectual property rights);
- Enabling Variables: These support or facilitate access to (or production of) the new technology. Typical examples are capabilities, access to resources, and other individual, organisational, institutional, and relational variables.

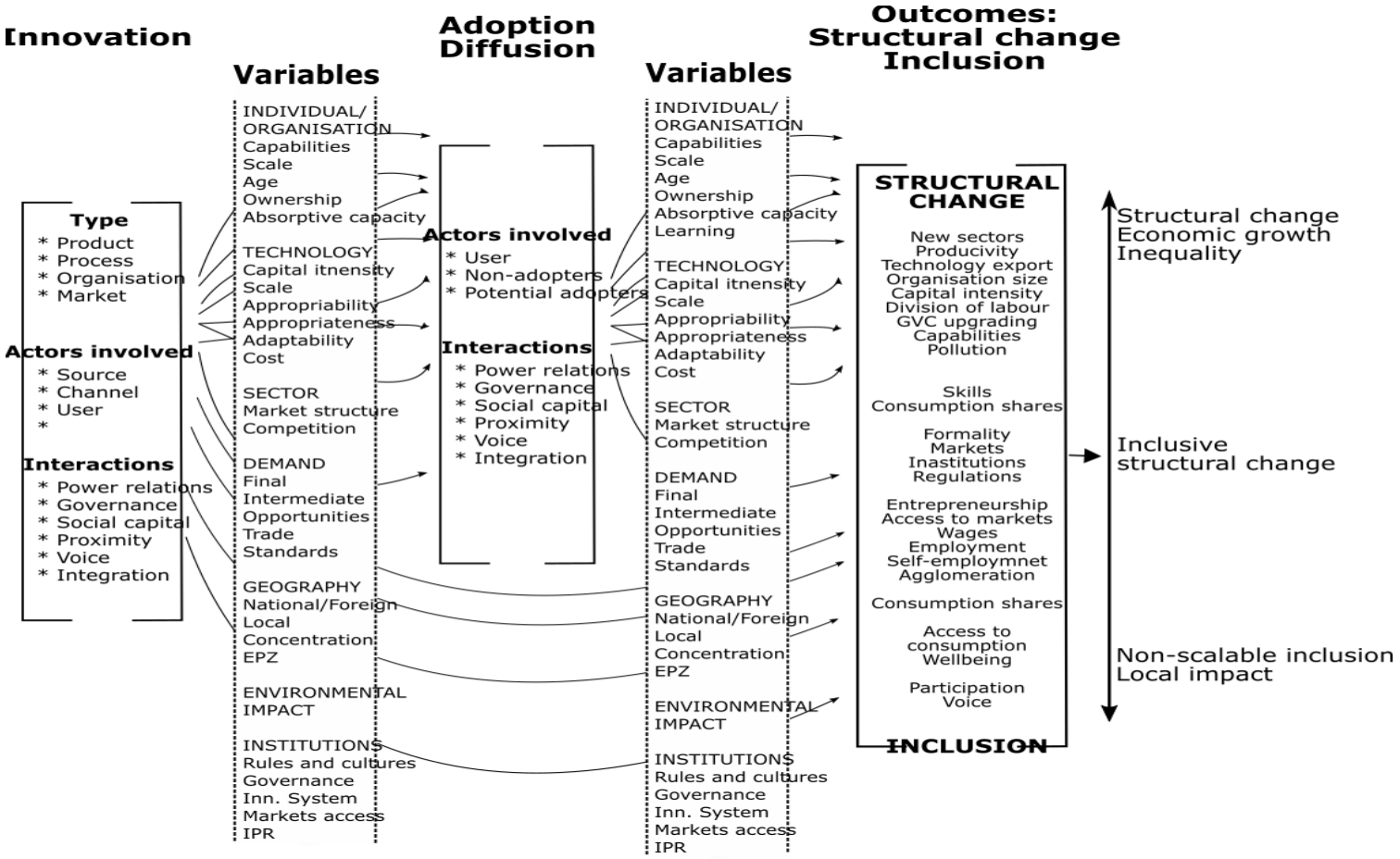
Third, the diffusion of the innovation may cause different outcomes in terms of structural change and inclusion. These outcomes also depend on actors and their interactions as outlined in column three on '*Adoption/Diffusion'* and on '*Variables'* in column four. The variables listed between 'Innovation and Diffusion', and between 'Diffusion and Outcomes' do not differ, for the sake of simplification of exposition but also because we leave space for future work to establish which variables are more relevant for diffusion and which are more relevant for structural change and inclusion.

As indicated by the long arrows at the bottom of Figure 3.1, linking the innovation and outcome columns, we acknowledge that some of the actors, interactions and variables have a direct effect on structural change and inclusion which are not conditional on the diffusion of an innovation. For instance, negative environmental externalities are often a characteristic of a rapid structural change, particularly towards manufacturing which also affect the part of the population which is excluded from these processes. However, the extent of both the structural change and the negative inclusion will depend on the diffusion of the innovation. The larger the diffusion of the polluting innovation, the larger the structural change, and the stronger the adverse effect on those negatively included.

Finally, structural change and inclusion are not unrelated. Some structural changes are complementary to inclusion, although many are incompatible. For instance, an innovation may lead to a decrease in the price of a good that was previously only affordable for a limited part of the population, increasing access to the good and changing household consumption shares. Here structural change is compatible with increased inclusion (measured as access to goods). On the other hand, in the short term an increase in the capital intensity of production is not compatible with increased employment: only the most skilled workers will have access to the available jobs, excluding a large part of the unskilled population. Here structural change is not compatible with inclusion.

[4] The first adopter may be the local innovator.

Figure 3.1 Innovation pathways to structural change and inclusion



Notes: Arrows represent pathways. The variables, actors and interactions define the effect of innovation on adoption/diffusion, and on structural change and inclusion outcomes. Some pathways go through adoption/diffusion, while in other cases, variables directly impact structural change and inclusion. Variables define the channels, sources and type of innovation, and the meso and macro conditions such as sectors, demand, geography, and institutions. In the extremes, innovation may positively effect structural change, and negatively effect inclusion (top end of right axis), or have no or negative effect on structural change and positive effect on inclusion (bottom end of right axis). The axis measures the trade-offs between structural change and inclusion outcomes. Structural change and inclusion are therefore not intended to represent different options – they are not mutually exclusive – but rather innovation processes may lead to different degrees of inclusive structural change.

Source: Ciarli *et al.* (2018, forthcoming).

3.3 Methodology and selection of cases

The research applies the analytical framework (Figure 3.1) to documented experiences of innovation, structural change and inclusion/exclusion in low-income countries. These case studies explore the processes that shape innovation, and the actors, their interactions and other variables that have influenced these processes. Specifically the cases identify the nature of the innovation, its outcomes to date in terms of structural change and inclusion/exclusion, and the key variables which have influenced the adoption and diffusion of the innovation. Our aim is to use these findings to develop a refined framework which will provide the basis of future primary research on inclusive structural change.

Going beyond the most analysed cases in manufacturing, our choice was to focus on innovations in agriculture and health that are crucial to the lives of the poor in low-income countries. The selection of particular cases in these sectors was driven by our aim of examining findings on competing and parallel pathways that lead to different development outcomes and to identify evidence of inclusive structural change. In selecting the cases, we paid specific attention to different sources and channels that introduced knowledge in a specific context, leading to the adoption and diffusion of innovations.

In Kenya, we were able to analyse external knowledge from colonial settlers and foreign countries as initial sources of innovations in dairy farming that gave way to research organizations and the smallholder farmers themselves as local sources of innovations in breeding practices. The channels of innovation included the services providers and the government of Kenya among others. The case of Mozambique was unique in which a 'Mozambique model' emerged as knowledge from sources such as UN, WHO and the World Bank interacting with the Ministry of Health's priorities leading to a unique structure for health service provision. In addition, a pre-existing community programme was the source from which a new community health initiative was developed. In both initiatives, the Ministry of Health along with donors created important channels of knowledge transfer.

As the case studies were developed primarily through a desk-based review of secondary data and literature detailing each case, another important factor for the specific choices was the availability of secondary information and literature detailing each case. While we chose cases where high quality information was available, we also conducted semi-structured interviews with key informants, and network analysis on the key actors, in order to surface information not already documented in existing articles.

The reliance on secondary sources is a key limitation of this paper. While these sources have provided high quality information on some aspects of the case (e.g. formal commitments made by key actors, production data), these sources are relatively weak on other variables which may nevertheless have had a strong impact on the innovation pathway identified (e.g. power dynamics, informal norms, innovations in other parts of the value chain) and on processes through which outcomes were achieved. Nevertheless, the analysis of the cases allowed us to formulate preliminary hypotheses regarding the competing pathways that led to different development outcomes.

The next two sections apply the framework from Figure 3.1 to discuss the variables which have determined the innovation pathways in our two cases of structural change: in the Kenyan dairy sector and the provision of anti-retroviral treatment services in Mozambique.

4 Kenya: Innovation pathways in breeding practices of smallholder dairy farmers

4.1 Background to dairy sector in Kenya

With over 12.9 million cattle and nearly 4 million tons of cow milk produced per year, the dairy sector plays a major role in the economic and nutritional life of millions of Kenyans (Bingi and Tondel 2015). Dairy farming in Kenya can be analysed based on the scale of production and degree of commercialisation.[5] Farmers engaged in pure subsistence include traditional pastoral farmers, who often keep large herds, and smallholder farmers. Commercial production includes large-scale production and some smallholder farmers producing for commercial sale. Therefore, there is a mix of smallholder farmers and large-scale farms in Kenyan dairy farming.

Innovation in the dairy sector, particularly product innovations through improvements in breeds of cows, has played a key role in the development of the sector for over a century. Exotic breeds, particularly in temperate regions such as the Kenyan highlands, offered a rapid and potentially sustainable path to higher productivity, even among small-scale and resource-poor farmers. While the sector has also witnessed value chain innovations in bulking, chilling, processing, transport of milk and marketing processes, dairy farming stands as the primary stage with a crucial impact on milk yields.

The introduction of exotic breeds, and gradual cross-breeding with local zebu cattle, goes back to the late nineteenth century and systematic efforts by European settlers (Bebe 2003; Mosi *et al.* 2000). Exotic (*Bos taurus*) dairy cattle breeds were introduced on large-scale farms in the Kenyan highlands, where moderate temperatures and good rainfall provided favourable conditions. Until the early 1950s, local farmers were prohibited from running commercial dairy farms; however, since independence in 1963, smallholder farmers have increasingly adopted cross-bred cows for commercial purposes, acquiring them from government agents or private providers.

During this period, process innovations include the use of artificial insemination (AI) over natural bull services, and complementary inputs from feeding systems and veterinary services. Omore *et al.* (1999) points to the Kenya Agricultural Research Institute (KARI), mandated to conduct research on crop and livestock production, cow fertility and on-farm East Coast Fever (ECF) control, as a pivotal actor. Staal, Pratt and Jabbar (2008) outlines the active role of the International Livestock Research Institute (ILRI) in national dairy research activities. These organizations identified useful production technologies, and identified and attempted to resolve constraints faced by smallholder dairy farmers (Staal *et al*. 2008); research that has continued to be carried out at agricultural faculties at the University of Nairobi, Egerton University, the Kenya Trypanosomiasis Research Institute (KETRI) and the Kenya Forestry Research Institute (KEFRI) (Omore *et al.* 1999).

In the 1980s, high operational costs and rising subsidies led to the replacement of public support for breeding services by private provision. The government decided to privatize AI services in 1991 by licensing private companies to import genetic material. While large-scale dairy cattle production systems came to depend mainly on private AI services, small-scale dairy producers depend partly on government or farmer-group services in addition to private ones (Omore *et al.* 1999). The private services providers emerged as channels of knowledge sourced earlier from settlers and government. However, private services were often unaffordable, creating burdens for smallholders such that farmers often resorted to bull

[5] Production can be purely for subsistence, entirely commercial or a combination of the two (Rege *et al.* 2001).

services of unknown quality. Where well-organised networks of dairy cooperatives offered AI services (Bebe *et al*. 2003), farmers were more likely to adopt exotic breeds and sustain production (Murage 2011). These cooperatives also provided contacts with research institutions organised through the farmer groups. Since 2000, as public support was reduced, farmers have developed increasing linkages with private extension providers, often organised through farmer groups.

The exchange of knowledge and technology between actors characterising the innovations in the dairy sector can be illustrated by spatialising the networks as nodes (actors) and edges (exchange) (Figure 4.1). The centre is dominated by the smallholder dairy farmers that have adopted exotic breeds, and the government of Kenya. These actors have the highest number of input links and a bi-directional exchange. The government especially supported smallholder farmers by providing input services at a low price, subsidised AI, veterinary and other services, subsidised agricultural credits and established dairy multiplication farms to produce heifers that were bought by the smallholders at subsidised prices (Bebe *et al*. 2003). In setting up the essential services ('2nd setup' in our network illustration), the government channelled knowledge created earlier by the settlers.

The community structure in this network (See Blondel *et al.* 2008) divides naturally into two groups of nodes with dense connections within groups (lighter shade) and sparser connections between groups (darker shade). There is both one-way and bi-directional exchange, and weight of edges depicts the importance of the exchange. The strongest exchange is between smallholders and settlers.

4.2 Variables influencing the innovation pathways

The set of factors that determined the adoption and diffusion of innovations for smallholder farmers can be distinguished into early stage (pre-1990s), intermediate stage (1990–2000), and the more recent period since 2000 (which we treat as the final stage of adoption for the scope of this study).

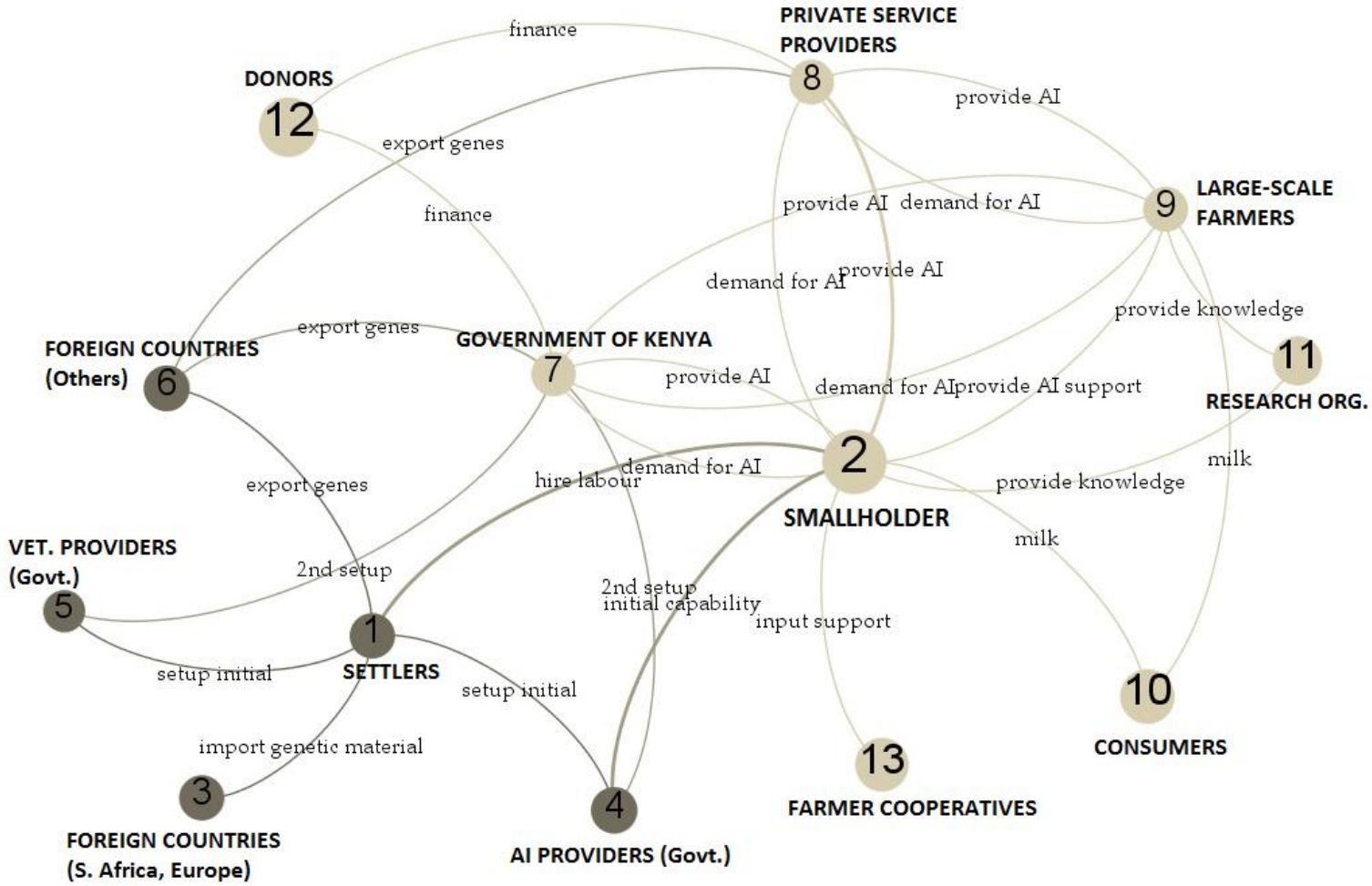
4.2.1 Early stage: Introduction and adoption of breeding practices by smallholder dairy farmers

In the early stages of introduction and adoption of breeding practices in Kenya, individual factors and those that determined the technology for production were the most prominent. Both incentive and enabling variables that facilitated the innovations are discussed below.

Subsistence needs (Key incentive): The subsistence needs of smallholder farmers was the initial factor that led to the introduction and adoption of exotic breeds beyond the European farms. Smallholders working as labourers on settlers' farms bought cull cattle from settlers to meet their own milk consumption needs.

Farmer demand, adaptability and capabilities (Enabling): Farmer preferences also evolved, driven by their subsistence needs in combination with input support provided by the government. Farmer choice, preferences for different breeds, the criteria used for selection of breed and knowledge about specific attributes of different breeds under low-input systems were important (Bebe *et al*. 2000). With knowledge about exotic varieties gained from the settler's farms, smallholders could select local attributes and match with the exotic genes. Therefore, while the primary source of innovation was foreign technology (breeds), farmers' lead role in breed selection was an important source of knowledge (for adaptation to the local setting).

Figure 4.1 Knowledge and technology exchange for breeding innovations in Kenyan dairy farming



Notes: The exchange maybe one way or bi-directional, the type of knowledge or technology exchange is specified with the exchange. In some cases, there is only a one-way exchange, while some actors have a bi-directional exchange. The weight of edges depicts the importance of the exchange across the complete set of relations. The nodes with a high number of input links are at the centre, while the periphery is dotted by nodes with output links.

Source: Authors' illustration of exchange (edges) between various actors (nodes) based on findings from this case study, using the Force Atlas method in Jacomy *et al.* (2014).

Local Capability for Input Provision (Enabling): There was existing local capability to continue input service provision for breeding. European settlers set up essential input services[6] to support their large-scale farms, which created the capability for the subsequent development of government and later private input service provision. In the early stages**,** the Kenyan government was instrumental in its support for input services, supplying veterinary and AI services that enabled smallholder farmers to adopt the breed varieties.[7]

4.2.2 Intermediate stage: Enabling further innovation

Technology and institutions gained further prominence as enabling factors for innovation in breeding practices in Kenya during this period. The variables that further facilitated the innovations were similar to that of the previous period, with new enabling factors at work, as discussed below.

Capability of farmers to adopt (Enabling): Capabilities for adoption were still of importance at this stage, even though Kenyan farmers had already started to adopt exotic breed varieties. This acted as an enabler, as further imports of genetic materials could be relatively swiftly adopted. While the imported varieties were similar, there was learning as farmers had received previous support and training.

Absorptive capacity (Enabling): Another factor was the absorptive capacity for cross-breeding that enabled the evolution of breed varieties as smallholder farmers adapted the exotic breeds by cross-breeding with local varieties that had better suitability to local conditions.[8] Improved breed cows and complementary investment in improved feeds (dairy feed concentrates) supported achievement of the desired productivity levels (Mulford 2013).

Geography (Enabling): Geographical location of farms was a major factor affecting adoption and the likelihood of keeping improved cattle (Baltenweck, Yamano and Staal 2011). The distances to the AI service providers was a major constraint, and Murage and Ilatsia (2011) find that farmers in certain regions of Kenya where AI services were distant (Kiambu) maintained pure breeds, in comparison to others (Nyandarau) where AI service was near and cross breeds were predominant. That said, some regions where AI was distant did have cross-breeds as the predominant variety, as they resorted to natural bull services. Access to markets was also an important geographical factor in the use of improved breeds, as farmers could use part of the profits accrued in the sale of dairy products to pay for AI services (Murage and Ilatsia 2011).

Local capability for input provision (Enabling): Existing capability to provide input services continued to be an enabling factor for the move towards provision of inputs, but now from private markets. This was driven in part by inadequate government budget allocations in the 1980s that caused the quality of services to decline (Omore *et al*.1999).

Institutions (Enabling): Institutions played an important role, as the use of AI was very popular when it was provided almost free-of-charge by the government but the use of bulls

---

6 Bebe *et al.* (2003) lists these as the Veterinary Research Laboratories in 1910; the Animal Husbandry Research Station in 1935; and the Central Artificial Insemination Station (CAIS) in 1946, which created the basis for the subsequent development for input services provided by the government and later by the private players. The Kenya Stud Book had also been established to keep animal breeding records in the early 1920s.

7 In 1966, the government established the Kenya National Artificial Insemination Service (KNAIS) to complement the existing CAIS. KNAIS widened the distribution of AI semen to farmers, while CAIS included bull recruitment and semen production. The government also established dairy multiplication farms to produce heifers that were bought by the smallholders at subsidized prices (Bebe *et al.* 2003). These farms were later subdivided for settling smallholder farmers.

8 The breeding objectives included the need for more milk, adaptability to local feed conditions, and the provision of non-market production such as manure, insurance and financing roles of cattle, that underlined smallholders' breeding decisions in the Kenyan highlands (Bebe *et al.* 2003). However, exotic breeds were generally expensive to purchase and required more inputs, such that adoption was not without challenges and not all smallholders could adopt these breeds.

rose following the liberalisation of government AI services (Muriuki *et al.* 2003). The privatisation of services in the dairy sector started as part of the general liberalisation of the economy, supported by the government, resulting in the establishment of a number of commercial businesses. On the other hand, the high prices of private services was a major obstacle for smallholder farmers.

4.2.3 Final stage: Intensification and improvement of production

In the final stages, resource endowments played an important role as the decline in landholdings created a move towards more intensive systems of production; and research activities were also crucial in the continuous development of knowledge. The enabling variables that facilitated the innovations took on a different nature in this period, as discussed below.

Production technology (Enabling): By the 2000s, smallholder farmers were investing in costlier and riskier ventures with regular extension services and improved feeding, rather than remain with local or only slightly improved breeds (Mulford 2013). Farmers within extensive systems of production (mainly or only grazing) more commonly used natural bull services, in contrast with the more intensified farms (feeding system being mainly or only stall feeding), the relied more on AI (Baltenweck *et al.* 2004).

Capabilities and networks (Enabling): Zander *et al.* (2013) outlines that farmers in most districts developed linkages with extension service providers from government and private agencies. These organisations have helped in the identification of useful production technologies, besides identifying and attempting to resolve social and economic constraints to the development, adoption and productivity of smallholder dairy systems (Staal *et al*. 2008). Ilatsia (2011) finds evidence of a wide participatory approach incorporating producer objectives. While farmer participation in Kenyan dairy farming has not received wide attention in the literature, technologies that are developed by research organisations need to be translated for adoption by farmers. In the Kenyan case, it can be deduced that as research organisations were directly involved in training farmers in new practices through extension services, performance and functional traits of cattle tied to producer objectives were influenced by household and farmer preferences and were the basis for optimisation of the breeding programme.

Capabilities and scale (Incentive): Farmers' resource endowments were a crucial factor in this period.[9] Pressure on landholdings pushed farmers towards upgraded dairy breeds that can be kept in stall-feeding units or cross-bred cattle used in semi-zero-grazing systems, as compared to zebu cattle in free-grazing systems (Wambugu, Kirimi and Opiyo 2011). Cooperative groups supported by government have also played a role, since farmers in districts with a well-organised network of dairy cooperatives offering AI services (Bebe *et al*. 2003) were more likely to adopt exotic breeds of cows and sustain production (Murage and Ilatisa 2011). These cooperatives also provided contacts with research institutions organised through farmer groups.

Institutions (Enabling): The role of institutions continued to be an important factor since 2003, as the government put in place several measures to revive the dairy industry. Measures that led to improvements in milk production were restructuring and capacity building of the Kenya Dairy Board; strengthening of farmer organisations like the Agricultural

[9] Rising human population density in Kenya has meant huge constraints on landholdings, which have declined considerably over the years. This was driven also in part by the sub-division of landholdings. These factors created a shift towards intensive feeding systems for dairy farming (Bebe 2003). This in turn created the need for further improvements in breeds as intensive feeding called for specific breeds of cattle to improve yields, creating the preference for Bos Taurus over Bos Indicus that include the Friesian and Ayrshire breeds. To move from subsistence to commercial sale, smallholders replaced their zebu cattle with Bos taurus dairy cattle.

Finance Cooperation (AFC) and cooperatives; review of dairy policies and regulations; and improved milk producer prices and timely payment to milk producers (Wambugu *et al*. 2011).

Geography (Enabling): Agro-climate conditions remained as an important factor affecting yields. As Wambugu *et al*. (2011) outlines, the highest level of productivity was achieved in the Central Highlands followed by the High Potential Maize Zone, and was lowest in the Western Lowlands.[10]

4.3 Outcomes

The innovations identified in this case can be linked to significant structural change in terms of improved productivity, employment shifts, changes in the size and types of farmers, shifts in input provision and in consumption. Overall, this case study finds that the combination of product and process innovations in breeding since 2000s have supported significant improvement in milk productivity from cows, with a likely effect on farmer livelihoods and sustenance and a potential link to improved nutrition outcomes from an increase in milk consumption for the Kenyan population, as discussed below.

4.3.1 Structural changes

Rise of smallholders: Emergence and strength of smallholders as compared to large-scale farmers, producing for commercial sale, has been the first significant structural change driven by the adoption of improved breeding practices. Smallholder farmers' adoption of particularly cross-bred cows gradually increased as a response to the expansion of the local market[11] driven by local dietary needs. Rapid changes in the distribution of the cattle population was witnessed by 2000, as the proportion of dairy cattle on smallholder farms rose from only 12 per cent in 1960 to 77 per cent, while for large scale farmers this figure dropped from 88 per cent to 23 per cent (Bebe *et al*. 2003). This trend has in fact continued in the decade of the 2000s as smallholder farmers have dominated dairy farming, engaging in commercial production.

Shifts in input provision: Private input providers emerged from the 1980s, providing services sourced earlier from settlers and government provision of inputs. However, private services were often unaffordable, leaving farmers reliant on the remaining government services in most cases;[12] and on cooperatives or large-scale farmers (who could afford private services) in the later period.

Improved productivity: Mulford (2013) reports that the use of improved dairy cows (product innovations), together with improved dairy practices (process innovations) corresponds with higher (per-cow) productivity estimates. The latest FAO statistics on the production of whole milk from cows in Kenya records a significant increase from 2 billion tonnes to almost 4 billion tonnes from 2000–2013. A comparison across production, cattle size and yield data (Table 4.1) reveals that most of the growth in production seems to be driven by an increase in yield per cow, from 4,742 Hg (100g) per animal to 6,533 Hg (100g) per animal in this period (Figure 4.2), suggesting evidence of improvement in technology/innovation in milk production.

---

10 Zander *et al.* (2013) describe constraints that impeded adoption certain districts in the Kenyan Rift Valley (Narok and Nakuru). While majority of respondents had links to extension services, in arid and semi-arid areas (like Narok), farmers were aware that the adaptive traits of traditional breeds are likely to result in persistence of their stock through dry years when more productive breeds often perish

11 Smallholder farming started to gain prominence in 1950s and 1960s following the Swynnerton Plan in 1954 that encouraged smallholder production in agriculture (Muriuki *et al.* 2003).

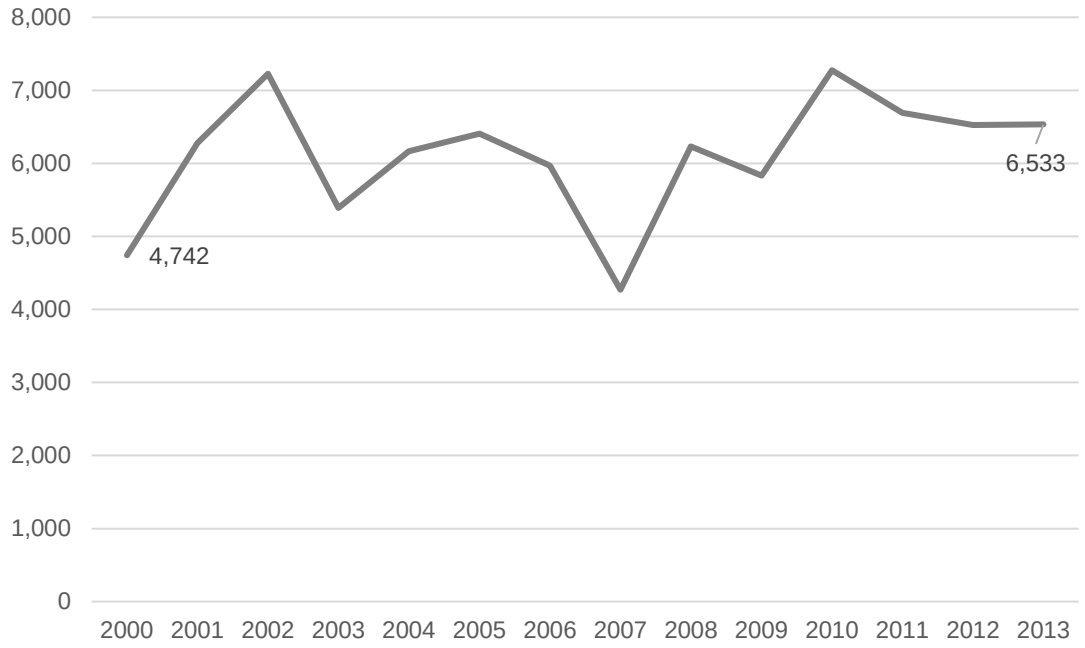
12 There remained some services within the public domain that include disease surveillance, veterinary quarantines, quality control of drugs and vaccines, food inspection, livestock and livestock product inspection, export and import control; disease control planning and control strategies, and national projects (Muriuki *et al.* 2003).

Table 4.1 Cattle, production, and yield of cow milk in Kenya (2000–2013)

Year	Cows (numbers)	Milk production (tonnes)	Yield (Hg/animal)
2000	4,690,000	2,224,000	4,742
2001	4,000,000	2,512,586	6,281
2002	4,000,000	2,890,685	7,227
2003	5,375,500	2,898,446	5,392
2004	5,500,000	3,392,400	6,168
2005	5,857,143	3,752,200	6,406
2006	6,200,000	3,700,080	5,968
2007	7,500,000	3,202,387	4,270
2008	5,147,300	3,208,946	6,234
2009	6,113,800	3,567,247	5,835
2010	5,001,600	3,638,592	7,275
2011	5,545,000	3,711,364	6,693
2012	5,720,000	3,732,960	6,526
2013	5,740,000	3,750,000	6,533

Source: Table 4.1 shows statistics from the FAOSTAT database for the latest available years of 2000-2013. The number of cows, milk production in tonnes and yield in Hectogram (100g) per animal is shown.

Figure 4.2 Dairy yield (cow milk) in Kenya (2000–2013)



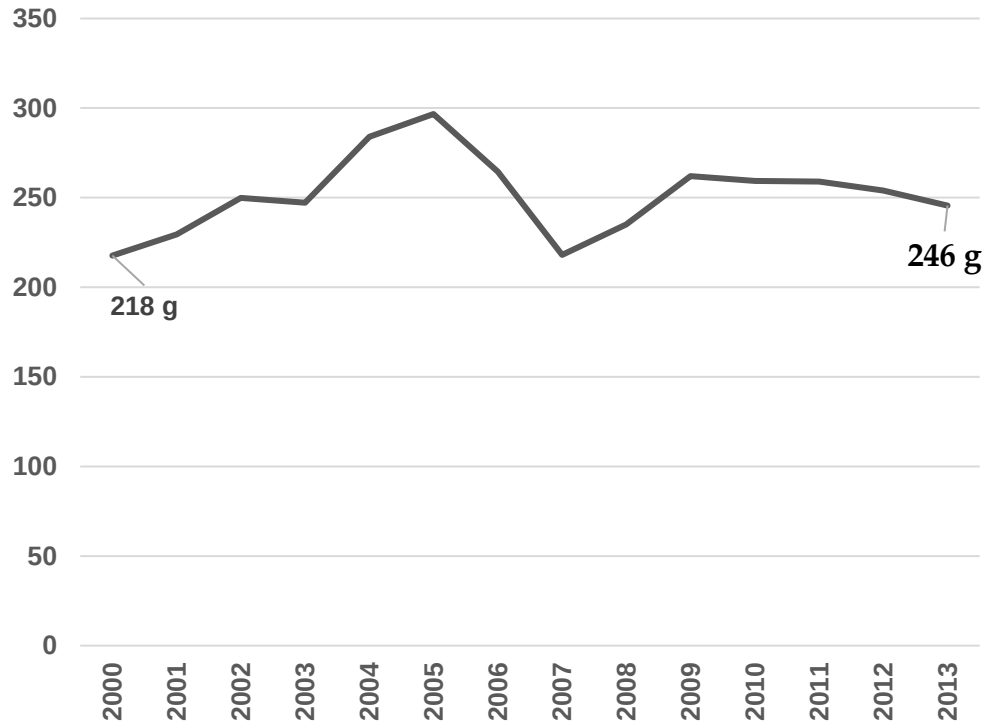
Note: Figure 4.2 is drawn based on latest data from FAOSTAT; it shows yield of whole fresh cow milk in Kenya from 2000-2013, measured in Hectogram (100g)/animal.

Sales increase: Mulford (2013) also provides evidence that suggests that the improved breeds, AI and investment in feeding are strongly correlated with increases in milk sales volumes in both 2004 and 2007. Therefore, improved breeds did not only have a positive impact on productivity but were also linked with improved sales for the smallholder farmers.

4.3.2 Development outcomes

Improved consumption and nutrition: Milk consumption per capita increased in Kenya, especially during the final stages of our study, from 2000–2013. Evidenced by the latest FAO statistics, consumption of milk (measured in g/capita/day) increased (marginally) from 218g per capita per day to 246g per capita per day (Figure 4.3). This represents a marked transformation in terms of nutrition status of the Kenyan population (also structural change in consumption), as consumption of even small amounts can have dramatic effects on improving nutritional status especially for children and nursing and expectant mothers. Research in Kenya (Nicholson *et al*. 2003) demonstrates that households that kept cattle had significantly fewer children with long-term malnutrition and at lower levels than households that did not keep cattle, controlling for differences in income and other factors.

Figure 4.3 Per capita milk consumption in Kenya (2000–2013)



Note: Figure 4.3 is drawn based on latest data from FAOSTAT, and shows per capita milk consumption in Kenya from 2000-2013, measured in g/capita/day.

Higher returns: Staal *et al.* (2003) find that dairy farmers in Kenya on average generated above normal returns,[13] with significantly higher returns to both smallholders and large-scale farmers, even if large-scale farms produced much higher returns. The study finds that unit profitability in dairy farming ranged between US$0.13–US$0.16 per litre, with no significant differences between large-scale and small-scale producers. Further, Burke *et al.* (2007) argue that households that sell milk and cattle have more access to land, with smaller, more educated families, and are more likely to be consistently non-poor. The literature also suggests a low association between land size and adoption of improved dairy practices.[14]

[13] Average annual returns to labour per enterprise of KES 38,000 (US$475) for small-scale farmers and KES 298,129 (US$6025) for large-scale farmers, with an average weighted annual return of KES 114,000 (US$1425), in comparison to an average per capita GDP of approximately KES 27,825 (US$347) for Kenya.

[14] However, Baltenweck *et al.* (2011) stress that larger land-holdings may be associated with households that can continuously adopt improved dairy practices over time. Therefore, while the impact of land size on improved breeding practices seems hard to ascertain, it has been observed that smallholders with relatively small landholdings have improved livelihoods where they have used the new breed varieties but with input services relying on less land grazing for the cattle.

Employment and income: Dairy farming created jobs even for some of the most resource poor, employed full-time or on a casual basis on small-scale dairy farms (Ngigi 2005).[15] Shifts from other agricultural activities (structural change) explain these jobs as dairy farming generated higher returns and therefore created more employment than other rural wage labor activities (Staal *et al*. 2008). In Kenya, some of the most resource-poor in mid-2000s, were employed full-time on small-scale dairy farms (Ngigi 2005). Staal *et al*. (2008) report that dairying engaged more than one-third of dairy farmers on a full-time basis in mid-2000s (841,000 people, 34 per cent of the total agricultural labour force). Of these, 256,000 were self-employed persons both on small-scale and large-scale farms. Eighty-seven per cent (734,900) of all the employment was attributed to small-scale farms and medium-scale dairy enterprises (Table 4.2).

Table 4.2 Employment (full-time) in Kenyan dairy farming (2000s)

Type of employment	Small and medium scale	Large scale	TOTAL
Self-employment	245,000	10,960	256,000
Long-term hired labour	454,000	93,000	547,000
Casual labour	35,900	2,300	38,000
Total	734,900	106,260	841,000

Source: Authors' own, adapted from Staal *et al*. (2008)

Employment generation included not only self-employment of farmers but also hired labour on farms, which created employment among some of the poorest, including landless households (Staal *et al*. 2008). This consisted of both full-time permanent labour and casual labour; even small-scale farmers often hired long-term labourers. Hired farm labour for dairy is estimated to represent about 547,000 full-time workers.

Environmental impact and sustainability: A positive environmental impact was observed from adopting intensive feeding systems, where manure and fodder between crop and livestock enterprises was recycled. Adoption of intensive feeding systems with exotic breeds meant lower reliance on landholdings that was an important step forward for sustainability in dairy production.

4.3.3 Limits

Despite a generally positive trend in milk production per cow per year in the decade of 2000s, it is not very surprising that milk productivity has also varied across income groups. Wambugu *et al*. (2011) reports that farmers in the highest income group had the highest level of milk productivity in all years from 2000 to 2010, and productivity increased up the income quintiles. This suggests that benefits from dairy farming have accrued to relatively better off households, which may be due to a higher number of cows across the years, the capacity to purchase improved breeds of cows and adequate animal feeds of good quality, and the ability to finance improved animal husbandry practices.

In terms of spatial spread of dairy production, there is a clear skewed distribution such that production has been concentrated in the highland and high- and medium-potential areas of the country. Ranking milk production by administrative provinces, Rift Valley produced 47 per cent, Central and Nairobi 31 per cent, Eastern 11 per cent, Nyanza 6 per cent, Western 4 per cent and Coast 1 per cent of total production (Staal *et al*. 2008).

[15] Muriuki *et al.* (2011) report the employment created by the dairy industry in Kenya (in 2000s) such that at the farm level, for every 1,000 litres of milk produced daily, dairy activities generate an estimated 23 full-time jobs for the self-employed, 50 permanent full-time jobs for employees, and three full-time casual labour jobs. This translates into a total of about 841,000 full-time jobs generated by dairying at the farm level (Staal *et al.* 2008). In Kenya, some of the most resource-poor in mid-2000s, were employed full-time on small-scale dairy farms (Ngigi, 2005).

Mulford (2013) presents evidence that the largest and most significant improvements in productivity were in districts that were both in favorable climatic zones and relatively close to Nairobi markets.

Wambugu *et al*. (2011) outlines that between 2000 and 2010, a higher percentage of male-headed households kept improved cows compared to their female counterparts, while more female-headed households kept local animals, indicating that they had less access to improved dairy breeds and perhaps dairy technologies in general. This finding is also consistent with Baltenweck and Staal (2000), who found that female-headed households were more likely to have less access to information on new dairy technologies.

4.4 Conclusion

Two innovation pathways appear to be operating in parallel for the Kenyan case. The major pathway falls at the upper end of the axis with structural change from adoption of innovations in breeding practices accompanied by vast improvements in the livelihoods of smallholders and in the nutritional status of the Kenyan population. We also observe a pathway in which structural change has created some exclusion, on account of inequities in access to dairy technologies. Assessing the feedback from such inclusion and exclusion on further demand for innovations across the various phases identified would require a dynamic frame.

An analysis of the variables leading to various outcomes in the case of breeding practices of Kenyan smallholder dairy farmers suggests a key role of capabilities as a crucial link between outcomes of innovation, inclusion and structural change, and the resulting pathways. Owing to the existence of colonial farms, Kenyan dairy farming had the advantage of prior local capabilities. First, smallholder farmers had knowledge about exotic varieties gained from colonial farms, which was nurtured further with government support for a variety of inputs. Smallholders were also able to select local attributes and match with exotic genes for adaptation to the local setting, as well as adopt further imported genetic material. Second, local capability to continue input service provision first by the government and then by private providers was an important enabling factor. Other important variables identified included actor networks and geographic proximity, and governance and policy institutions.

5 Mozambique: Innovation pathways for anti-retroviral treatment service provision

5.1 Background to anti-retroviral treatment service provision in Mozambique

Following independence in 1975, public health care (PHC) in Mozambique used a vertical system of service provision. Termed the ‘Day Hospital’ approach, this system provided basic health care through a tiered network of linked hospitals, health centers and health posts (Pfeiffer *et al.* 2010). Initially Mozambique’s health system was highly centralised with low flexibility, such that it could not ensure the reach of financial resources to geographically distant points (Bidaurratzaga-Aurre and Colom-Jaen 2012). With the emergence of HIV/AIDS, care including anti-retroviral treatment (ART) services were introduced *in parallel* to the existing PHC hospitals. Infrastructure for HIV care included voluntary counselling and testing (VCT) centres and day hospitals established separately from normal health services (Hog 2014).

By 2000, Mozambique was facing an epidemic that created an urgent need to scale up HIV care and ART services, precisely at a time when the government had very limited finances for the necessary medicines. In this setting, the government pushed the ‘calamity button’ of exceptional events, which meant that there was no limit to the foreign assistance they could

call on (Oomman, Bernstein and Rosenzweig 2007) despite creating higher dependency on foreign aid.

In 2004, Mozambique tried to implement a rapid increase in ART services via their existing parallel and vertical system (Hog 2014). New freestanding HIV treatment hospitals were constructed in large population centres alongside existing hospital compounds (Pfeiffer *et al*. 2010).[16] However, this parallel structure diverted scarce resources away from the overall PHC system and created considerable wastage. The low capacity of the public sector system and its vertical infrastructure, already under pressure, was overwhelmed by these parallel services, which put tremendous pressure on human resources and resulted in poor geographic coverage for ART (Lambdin *et al.* 2013). The vertical structure and centralised provision also placed limitations on Mozambique's capacity to absorb[17] ART funding, with a lack of financial and technical ability to make good use of huge amounts of short-term donor money flowing in for HIV.

In response, the Mozambique government adopted and adapted the UN 'Three Ones' approach, to create an integrated system that built on the logic of the existing system in place, and came to be known as the *Mozambique model* (Pfeiffer *et al*. 2010). Innovation thus emerged out of a complex interaction between different forms of political authority,[18] incorporating hierarchical features of western medicine, foreign expertise from the World Bank, e.g. treatment protocols and monitoring and evaluation programs to learn and disseminate important lessons (Keough and Marshall 2006), and the WHO's public health approach to HIV/AIDS; juxtaposed with the organisational demands of HIV/AIDS care in resource-limited countries (Braga 2012; Hog 2014).

In 2005, the Ministry of Health (MOH) also created the Sector Wide Approach to Programming (SWAp) to coordinate disease-specific aid resources for HIV/AIDS care while at the same time strengthening PHC. SWAp coordinated planning and financing between the government., donors and not-for-profit organisations, enabling information sharing and coordination in planning and financing, improved infrastructure and human resources, and a central funding mechanism (Oomman *et al.* 2007; SCMS 2007). Integration of HIV programmes with PHC services was further supported by the Clinton Foundation, Health Alliance and the Global Fund. By 2008, the Mozambique government mandated the closing down of all parallel NGO HIV facilities, to bring equity in access of services (for all patients), to foster efficiency, rationalisation and optimisation (of health workers, infrastructure, etc.), and to emphasise the overall strengthening of the national health services. In addition, provision was decentralised (Figure 5.1) meaning that funds could be coordinated to better reach local (district and provincial) levels of provision.

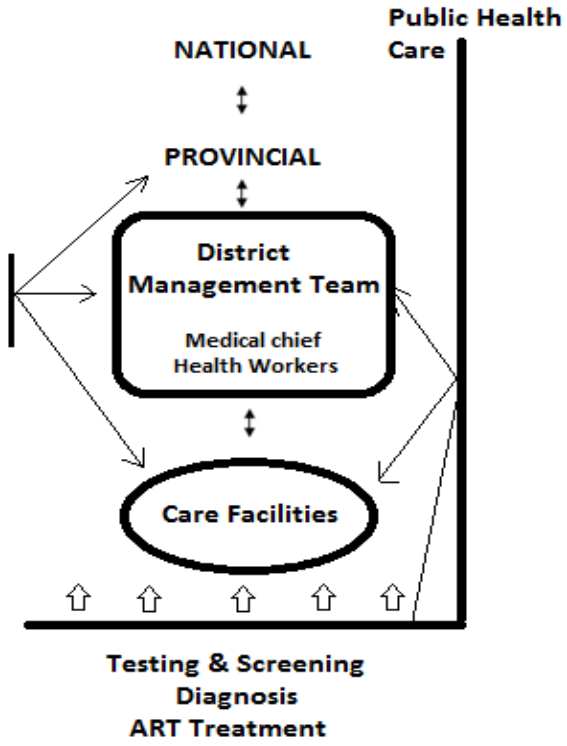
---

16 Day hospitals included their own pharmacies, data systems, health workforce, waiting areas and receptions. Using this separate infrastructure, patients identified as HIV positive from other sectors of the health system (VCT, PMTCT, blood bank and laboratory) were referred to day hospitals to register for HIV care, and to follow a sequence of visits for clinical staging, testing, social worker visits, treatment for opportunistic infections, and initiation and follow up of ART.

17 The term 'absorptive capacity' here has a different connotation from that more traditionally used in technology and innovation studies. These generally refer to absorptive capacity as the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends, which is suggested to largely be a function of the firm's level of prior related knowledge (Cohen and Levinthal 1990). Here, in relation to international health funding, 'absorptive capacity' refers to the capacity of governments to spend resources made available by donors. Low capacity might arise due to lack of administrative capacity or inefficiencies in public expenditure management, or over burdensome procurement and reporting requirements by donors (Gottret and Schieber 2006:141).

18 The author outlines these as emerging from pre-colonial, colonial and post-colonial times. In the social interface between highly educated technicians from rich countries and communities in extreme poverty, the exercise of power by wealthy donors over their target populations, including local health workers, is laid bare and the disempowerment of public sector services by international agencies is most visible. In this light, where the political economy of channelling donor funds and the recipients seems to be skewed in favour of those with power, the Mozambican government has asserted the need of sovereignty when dealing with its funders.

Figure 5.1 Decentralization of ART provision in Mozambique



Source: Authors' own, adapted from Sherr *et al.* (2013)

Under the new system, HIV care and treatment services transitioned from being provided through a separate clinic structure to being co-located with other health services,[19] including sharing human resources within the same hospital. The integrated system also meant that HIV disease specific funding would enter the PHC and benefit the entire system (although this aspect of integration remains an ongoing process). The government has also begun the process of transferring the management of health services to the provincial and district levels.

A parallel challenge for Mozambique has been its low provider-to-population ratio, one of the lowest in the world, with an estimate of 3 doctors, 21 nurses and 3 pharmacy staff per 100,000 people (WHO 2006: 209). Starting in 1978, these constraints were addressed through '*Agentes Polivalentes Elementares*' or community health workers (CHWs), which expanded health service provision in rural communities. CHWs had been trained and deployed in their communities of origin by the MOH to provide peer support on basic preventive education and health care (Sidat *et al.* 2014). However, by the mid-1990s, the programme was facing challenges due to a lack of supervision and support from the MOH, and the programme was disrupted (Ndima *et al.* 2015).

From the late 2000s, given already the overburdened workforce of clinicians and pharmacy staff placed under increasing strain by the HIV/AIDS emergency (Lambdin *et al*. 2011), community health support initiatives for ART dispensing via CHWs were introduced, influenced by these earlier experiences as well as current models in other sub-Saharan African countries. The aim was to reduce the burden on human resources and make treatment more accessible and affordable, and to address the high rate of patients dropping out of treatment. Sidat *et al*. (2014) emphasises the government's role, under exclusive

[19] Pfeiffer *et al.* (2010) outlines that integration included: (a) placing ART services in existing units; (b) retraining existing workers; (c) strengthening laboratories, testing, and referral linkages; (e) expanding testing in TB wards; (f) integrating HIV and antenatal services; and (g) improving district-level management.

responsibility of the MOH, in the training and re-deployment of CHWs. The MOH also partnered with NGOs such as Médecins Sans Frontières and donor groups to design the programme. Donors brought in supervisors to oversee programmes, and various partners committed funds for initial training and equipment, ongoing supervision and monthly stipends.

There are two types of CHWs providing ART care in Mozambique: (a) volunteer CHWs organised by NGOs and focused specifically on HIV/AIDS, and (b) more generalist, government-organised and paid CHWs that also provide HIV care (Maes and Kalofonos 2013). Volunteer CHWs working with international NGOs are assigned catchment areas of 500–2,000 people, with routine tasks like developing strong ties to community, health promotion and education, family planning counselling, and prevention and treatment of common ailments (USAID 2013). The authors report ongoing efforts to integrate the work of HIV/AIDS-focused and generalist CHWs through partnerships between NGOs and the government (Simon, Chu, Frieden *et al*. 2009). The incentive and enabling variables are discussed below.

The exchange of knowledge and technology between various actors characterising the innovations in HIV care is depicted in Figure 5.2. The exchange is illustrated by spatializing the networks as nodes (actors) and edges (exchange). The centre is dominated by the Ministry of Health with the highest number of input links. CHWs figure at the periphery of the network, and interact with HIV patients and communities. The community structure in this network (See Blondel *et al*. 2008) divides naturally into three groups of nodes with dense connections within groups (lightest shade) and sparser connections between groups (darkest shade). There are both one-way and bi-directional exchanges.

5.2 Variables influencing the innovation pathways

The variables that determined the adoption and diffusion of organisational innovation in ART care in Mozambique can be distinguished into the early stage (pre-2005), and the later stage (2005 onwards), which we treat as the final stage for the scope of this study. The incentive and enabling variables that facilitated these innovations are discussed below.

5.2.1 Early stage: Integration of ART into public health care and decentralisation

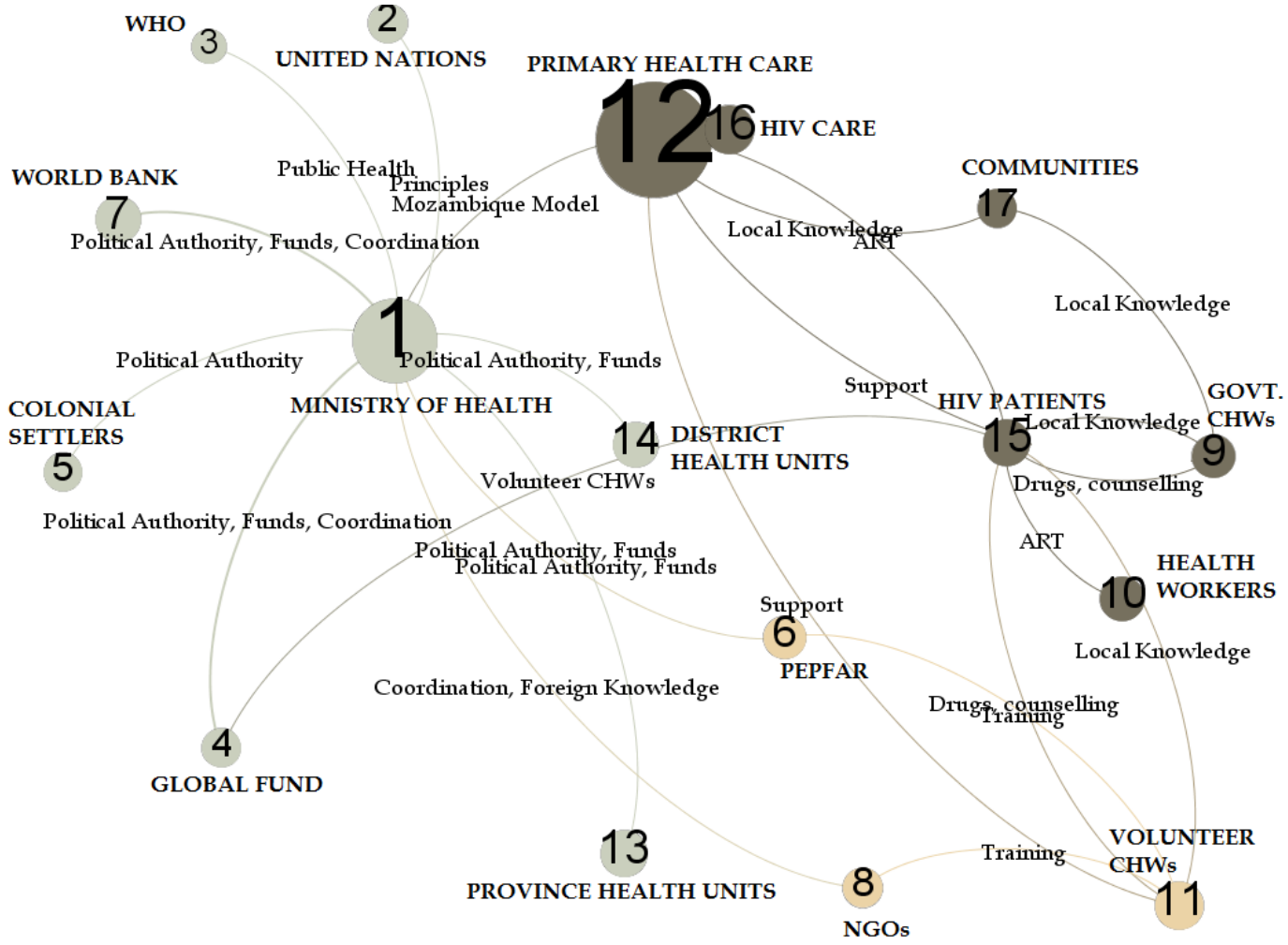
HIV epidemic (Key incentive): The HIV epidemic in Mozambique was the primary driver for the introduction of ART*.* As a result of the HIV/AIDS emergency, exceptionally high amounts of donor funds flowed into the country, skewed towards disease-specific (HIV) funding for ART provision.

Political economy of funding relations (Incentive): Incoming disease-specific funding from donors were influenced by political economy factors. Over the following years, the Mozambique government sought to assert its sovereignty, playing an increasing role in coordinating donor funding, and moving away from emergency relief towards development and reconstruction (SCMS 2007), which also facilitated the move to integration.

Institutions (Enabling): The government[20] led the process of regulating relations with its partners (donors and NGOs), with one theme being the development of the Sector Wide Approach to Programming (SWAp) in accordance with the UN 'Three Ones' principles (Hog 2014). The government's push to adopt the integration principles received support from several donor agencies (World Bank, Clinton Foundation) which facilitated the relatively quick move towards integrating HIV and AIDS services into the public health system.

[20] Under the Kaya Kwanga Commitment of 1999.

Figure 5.2 Knowledge and technology exchange for organisational innovations in ART in Mozambique



Notes: The exchange maybe one way or bi-directional, the type of knowledge or technology exchange is specified with the exchange. In some cases, there is only a one-way exchange, while some actors have a bi-directional exchange. The nodes with a high number of input links are at the centre, while the periphery is dotted by nodes with output links.

Source: Authors' illustration of exchange (edges) between various actors (nodes) based on findings from this case study, using the Force Atlas method in Jacomy *et al*. (2014).

Low capacity to absorb funding within existing system (Incentive): Prior to 2005, the vertical structure of PHC and centralized provision created significant challenges due to low absorptive capacity. Channeling vastly increased amounts of aid through the local structures created bottlenecks where resources could be diverted or wasted. Instead, donors preferred to channel a majority of disease-specific funds to NGOs and similar partners, rather than through the public system. This reality created the incentive for new structures. By moving to a system in which HIV would be integrated within PHC based on decentralised care, funds could be better coordinated, and facilitated to reach local (district and provincial) levels of provision.

5.2.2 Late stage: Community-based ART provision

Health workforce constraints (Incentive): Community health support initiatives in ART dispensing emerged as a response to the overburdened workforce under increasing strain by the HIV/AIDS emergency.

Local capability (Enabling): Patient-led community ART dispensing was rooted in an existing systems of community engagement in health, which represented existing local capability. The existing knowledge and structures could be adapted for a system that included communities and patients in ART provision.

Community participation (Enabling): Community participation was an important factor that facilitated wider coverage through the decentralised system by acting as satellites to bring the healthcare system into previously often inaccessible areas, resulting in higher uptake (Decroo *et al.* 2009). Peer support and community participation empowered patients to engage with their local community, health authorities and partner organisations, and increased their autonomy in day-to-day decision-making.

5.3 Outcomes

5.3.1 Structural changes

Integration of ART and overall public health service provision and decentralised health delivery, with increased coverage and efficiency. Through integration, HIV resources have been used to rehabilitate PHC infrastructure (including laboratories and pharmacies), strengthen supervision, fill workforce gaps, and improve patient flow between services and facilities in ways that can benefit all programmes (Pfeiffer *et al*. 2010). These have resulted in: (1) improved access to care through expansion of sites and services; (2) enhanced service quality through reduced major loss to follow up (LTFU) and improved patient flow; and (3) system efficiency by linking services and improving referral rates, while accelerating the pace at which services can be expanded (Pfeiffer *et al*. 2010).

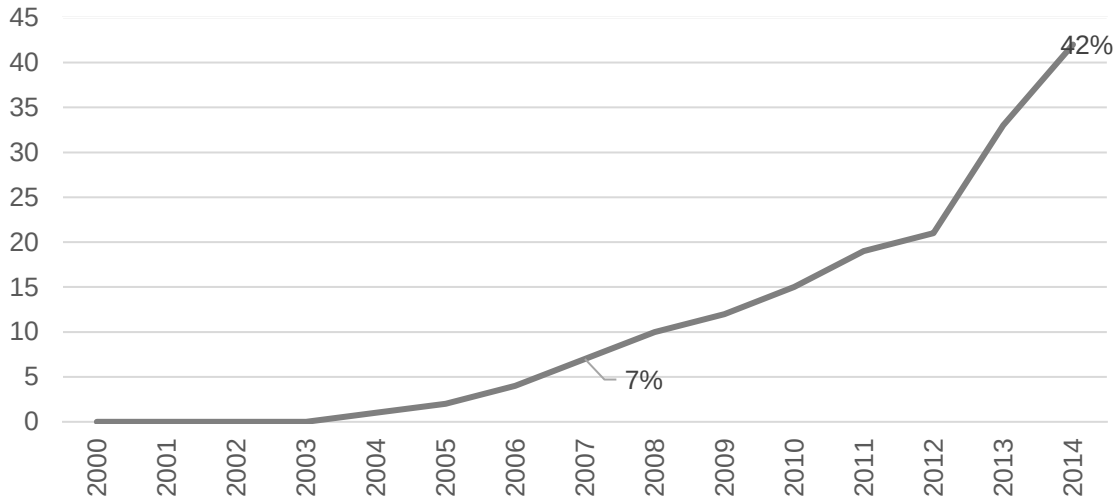
The number of ART sites (within PHC) in 2007 had increased to 211 (almost double the target of 112 ART sites for that year), and to 216 sites in 2008 (Hog 2014). This increase corresponds with a jump in ART coverage, from none in 2000, to almost 42 per cent (of people living with HIV) by 2014, enabling many people to avail of treatment (Figure 5.3).

Local community involvement, reducing the burden on health workers. Participation from CHWs and patients, alongside local capability to adopt the community health model, were crucial in reducing the burden on the health workforce, given the low doctor and nurse to patient ratios.

5.3.2 Health outcomes

The integration of ART into PHC contributed to improved access and adherence to ART. Based on analysis of routine data comparing day hospital parallel sites with integrated ones, there has been a significant increase in people availing treatment, from no coverage in 2000 to 42 per cent by 2014 (Figure 5.3). Pfeiffer *et al*. (2010) report that by 2008 nearly 30,000 adults were on ART, and over 80,000 enrolled in the HIV/AIDS program. It has brought essential HIV care and treatment services closer to communities in need and resulted in a dramatic increase in the number of patients initiating ART (Lambdin *et al*. 2011).

Figure 5.3 ART coverage in Mozambique (% of people living with HIV)



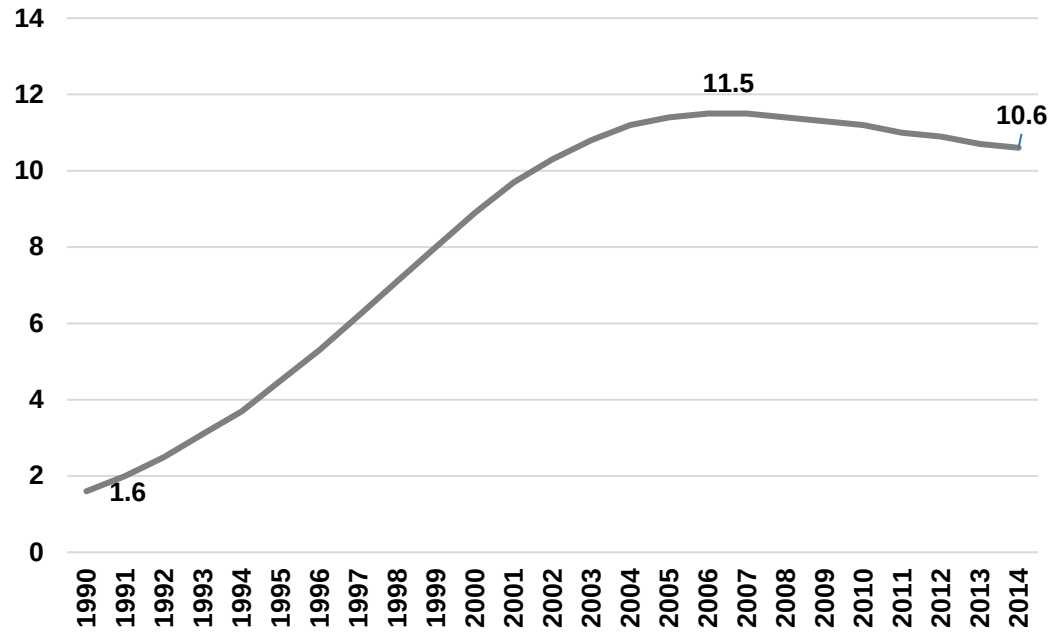
Note: Figure 5.3 is drawn based on latest data from World Development Indicators Database. It shows the coverage of antiretroviral therapy in Mozambique as a percentage of people living with HIV from 2000-2014.

Community-based ART provision has also supported improved adherence to ART treatment. This innovation helps overcome the challenge of low adherence, familiar in most resource poor settings, since local population involvement has supported sustained care and follow-ups.

Using aid funding targeting HIV/AIDS to integrate and better link HIV care with existing health services has also strengthened the wider health care system, creating benefits for patients with other diseases such as tuberculosis, for instance.

There has been a reduction in the HIV/AIDS disease burden over time, due to increased access to HIV care. Mozambique experienced a marked increase in HIV from the 1990s until the end of the 2000s, suggesting a huge disease burden for the country over the period, followed by marginal declines from 2010 onwards. The burden of 11.5 per cent of the population (ages 15-49) reporting HIV prevalence in 2006 has reduced to 10.6 per cent (ages 15-49) in 2014 (Figure 5.4). Although the improvement is marginal, it nevertheless stands as an important outcome in a resource poor country like Mozambique.

Figure 5.4 HIV disease burden: prevalence of HIV (total % of population ages 15–49)



Note: Figure 5.4 is drawn based on latest data from World Development Indicators Database covering the period from 1990–2014.

5.3.3 Limits

From 2001 to 2008, coordinated funding for HIV/AIDS increased from US$17m to US$74m; however, there remain limits to the integration and coordination of donor funding. In particular, USAID continues to provide direct funding to service providers and NGOs through its PEPFAR programme, which reached US$269m by 2011 (Pfeiffer *et al*. 2013).

While provincial and district units are in charge of implementing health plans and programmes, control over resource allocation remains centralised with the MOH, and decentralisation is further hindered by weak district level management capacity (Sherr *et al*. 2013).[21]

Despite improved ART coverage, Braga (2012) identifies inequity among the different regions of the country. In the southern region, where the capital is located, almost 62 per cent of adults and children in need of therapy have access, while in the central region, only 26 per cent do. The author states that the northern and central provinces have less than half the ART coverage experienced by those in the southern provinces. Patients living in distant and marginal areas, located not only far from hospitals but even far from health centres and health posts, receive only ART delivered by low-skilled health workers and mobile ART units operated by NGOs and supported by the provincial health directorate.

The transition to an integrated system of ART care has not been very smooth for HIV patients. In the new integrated system, patients had to pick up their monthly stock of drugs at the pharmacy under a process that was complicated by excessive bureaucracy and demanded repeat prescriptions and hence new clinical consultations. The result was patient

[21] The government is continuing to decentralize the management of public health sector resources to the district level, with the aim of bringing resources closer to service beneficiaries (Sherr *et al.* 2013). Pfeiffer *et al.* (2010) asserts that the new system that evolved was structured around defined levels of care and geographical units of administration (Mozambique's ten provinces as key organizational divisions through which PHC services were managed, coordinated and brought to scale). This was also reflected in the transport, drug and material distribution, supervision, and organization of data collection systems administratively and logistically by the province that is still in the process of being strengthened and harmonised.

dissatisfaction along with a lack of availability of consultations, which fell from a total of 711 in March 2008 to only 246 in April, 212 in May, and again only 302 in June of the same year (Braga 2012). In sites with high dropout rates, patients also reportedly complained about a lack of privacy when picking up their pills, given the social stigma often associated with HIV patients within the community. The figures reveal a delicate balance between raising awareness of HIV on the one hand, and an increased risk of stigma and discrimination, on the other.

5.4 Conclusion

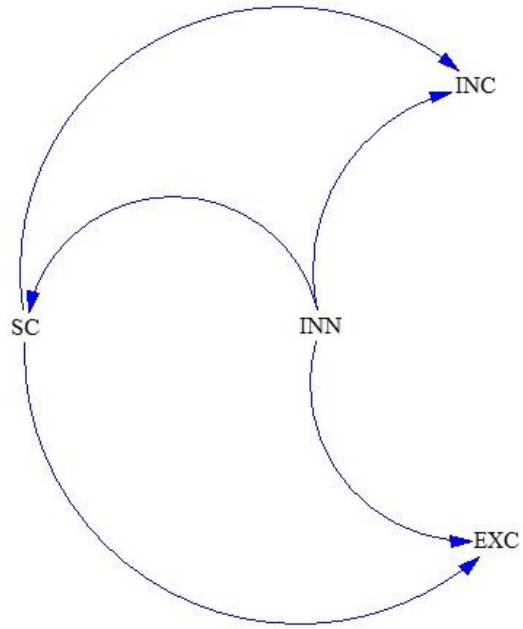
Two competing innovation pathways to structural change and inclusion are identified in the Mozambique case. First, innovation created structural change in the form of integration and decentralisation of ART provision, with increased efficiency in health care, but with some exclusion, especially for people in far-off areas. Second, innovation also created structural change with inclusion by improving treatment coverage and access, accompanied by positive impacts on public health care related to other diseases. Therefore, the Mozambique case can be categorised on both ends of the axis of structural change and inclusion (Figure 3.1). Structural change and inclusion are therefore not mutually exclusive – innovation has led to different degrees of inclusive structural change. Local impact has taken place through the involvement of community health workers and led to reduced disease burdens. However, as for the dairy case, an analysis of the feedback of such inclusion and exclusion on further innovations would require a dynamic frame of analysis.

Exploring the variables leading to various outcomes in the case of ART in Mozambique again reveals capabilities as a crucial link between innovation, inclusion and structural change, and therefore the resulting innovation pathways. With the HIV epidemic, Mozambique was lacking two main types of capabilities: the capability to coordinate funds and the capability to provide wider ART coverage. The prior structure of health care faced significant challenges on account of low absorptive capacity, such that in the *absence of capabilities to channel funding*, donors directed funds to NGOs and similar partners, rather than the public sector system. With initiative from the government, the emergence of an integrated and decentralised health care structure created the means to channel funds more efficiently. However, in spite of this new capability, an insufficient health workforce was a major obstacle, meaning exclusion for some patients. The *capabilities for care provision were therefore in limited supply*. To deal with this, there was revival of an existing system of pre-existing community engagement in health, through which *existing local capability* was adapted for HIV care. Other variables identified include the power relationships between the government of Mozambique and the international aid community, and institutions (formal and informal).

6 Analysis: Understanding dynamics

Our analytical framework (Figure 3.1) represents a linear flow from innovation to structural change, e.g. represented by increases in productivity and growth, accompanied by outcomes there were either inclusive or exclusionary. While the case studies do identify pathways that fit this model, they also point to the need for a more dynamic system perspective that can account for trade-offs and recognise the potential for virtuous circles over time. This perspective also aligns with recent evidence from developed countries that finds a negative feedback from inequality to a country's innovative potential (Aghion *et al.* 2017; Akcigit, Grigsby and Nicholas 2017; Bell *et al.* 2017).

Figure 6.1 Linear relations

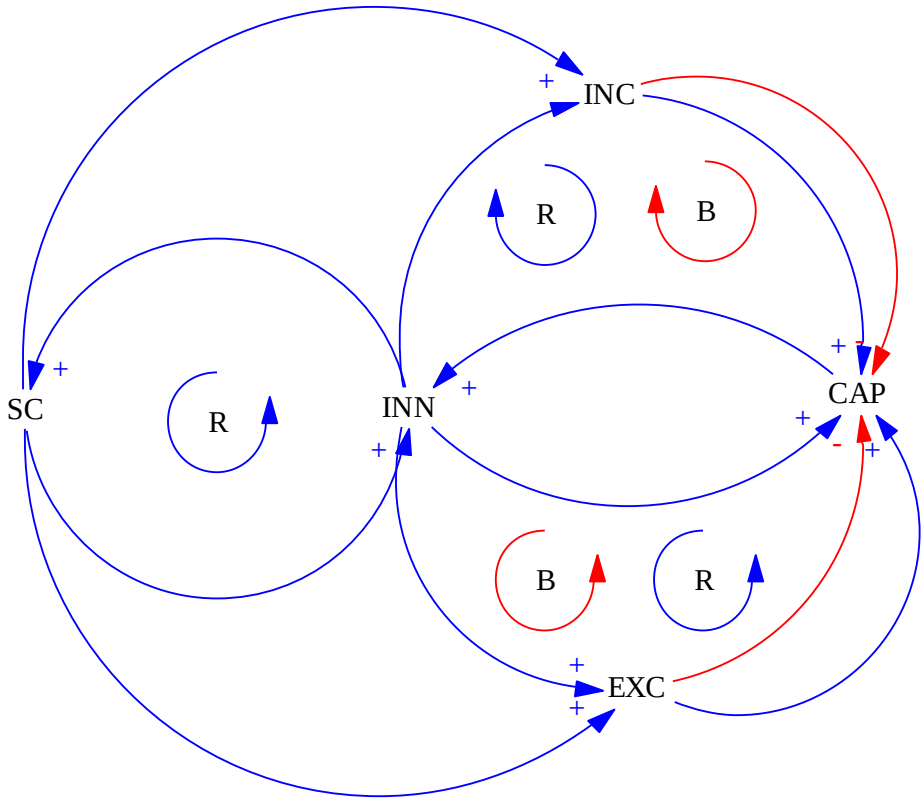


Notes: INN: innovation; SC: structural changes; INC: inclusion; EXC: exclusion.

Source: Ciarli *et al*. (2018, forthcoming)

The analysis of both the cases reveals that the outcomes of structural change and inclusion at a given time have a significant impact on future innovation, suggesting that the relation between innovation, structural change and inclusion involves a number of feedback mechanisms. Across different phases of development, some outcomes of structural change and inclusion, say at time *t+1*, are expected to have a significant impact on the next phase of innovation. The actors, their interactions and other variables may in fact be shaped by structural change and inclusion to affect innovation in the next phase. Figure 6.2, a further elaboration of which can be found in Ciarli *et al*. (2018*,* forthcoming), represents these dynamic processes with feedback loops from one phase to the other. The feedback is added from structural change and inclusion/exclusion in the first phase, to future innovation. '*Reinforcing mechanisms*'*(R)* indicate a positive effect and '*balancing mechanisms' (B)* represent negative effects. The mechanisms are influenced by the impact of variables discussed earlier.

Figure 6.2 Dynamic relations between innovation, structural change, and inclusion



Notes: INN: innovation; SC: structural changes; INC: inclusion; EXC: exclusion; CAP: capabilities; R: reinforcing mechanism; B: balancing mechanism.

Source: Ciarli *et al*. (2018, forthcoming)

Capabilities, one of the 'enabling variables' that appear earlier in the linear framework, is highlighted as a crucial link between outcomes of innovation, inclusion and structural change. The reinforcing and balancing mechanisms are operationalised through the impact of innovation and inclusion/exclusion on '*capabilities*' (CAP). Capabilities reflect the opportunity and ability to generate innovations, accounting for relevant characteristics and external factors. In the case of dairy farming in Kenya, the existence of colonial farms meant prior local capabilities for innovations that developed further across the various phases of innovation. In Mozambique, with the HIV epidemic, there was a clear lack of capabilities to facilitate organisational innovations. In both cases, incentive and enabling variables interact with these capabilities as the primary variable.

The dynamic framework can be broken down into three sub-relations as follows:

Innovation (INN) and Structural Change (SC)
Innovation (INN) is expected to have a positive effect on structural change (SC) (moving to more sophisticated products/better processes etc.), which in turn is likely to generate more innovation. This is reflected by a reinforcing mechanism between innovation and structural change.

Innovation (INN) and Inclusion/Exclusion (INC/EXC)
For innovation and inclusion/exclusion (INC/EXC), there are two possibilities:

(i) Innovation at time *t* creates future inclusion (INC); this inclusion can lead to two outcomes:

- Outcome 1: Improve capabilities (reinforcing mechanism), which then has a positive effect on future innovation, or;
- Outcome 2: Reduced capabilities for certain groups, if the effect of inclusion on capabilities is dispersed. Such groups have insufficient capabilities to do future innovations (balancing mechanism), and show no impact on further innovation.

(ii) Innovation at time *t* creates exclusion (EXC) in the future; the exclusion can:

- Outcome 1: Have no impact on capabilities, and therefore no impact on future innovation;
- Outcome 2: Have a direct negative impact on capabilities (balancing mechanism) for future innovation, limiting further innovation;
- Outcome 3: Increase capabilities (reinforcing mechanism) of only a certain part of the population, which may in turn increase future innovation.

Structural Change (SC) and Inclusion/Exclusion (INC/EXC)
Structural change (SC) can be inclusive (INC) or exclusive (EXC):
(i) If *inclusive*, the positive effect of innovation on structural change may further reinforce innovation through inclusion in the next period, depending on the effect of inclusion on capabilities.

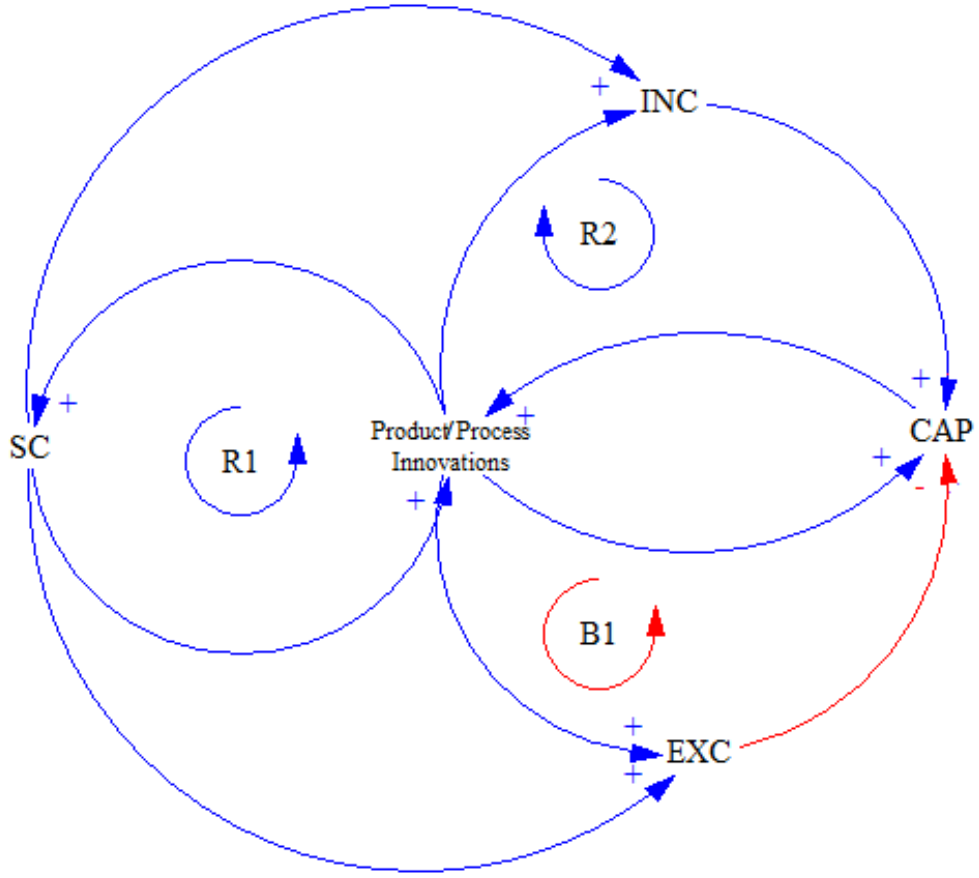
(ii) If *exclusive*, the positive effect of innovation on structural change may create no innovation in the next period, depending on the effect of exclusion on capabilities.

By applying this dynamic framework, we examine how innovation, structural change, and inclusion are related through time for each of the cases below. While the Kenyan case represents a more mature innovation, allowing for a detailed analysis, the health case for Mozambique is fairly recent, and the analysis is necessarily more limited.

6.1 Kenya: Innovation pathways in breeding practices of smallholder dairy farmers

We apply the dynamic framework to the three stages: early stage (pre-1990), an intermediate stage (1990–2000), and the more recent period since 2000. In the early stages, exotic breeds introduced by European settlers on their farms were adopted by local labourers who also became smallholders to meet their own subsistence needs. Input service provision from the Kenyan government and the expansion of the local market driven by local dietary needs further enabled these smallholders to adopt the new varieties. These product innovations were accompanied by process innovations in input provision, research and extension services.

Figure 6.3 Dynamic relations in innovation pathways for breeding practices of Kenyan smallholder dairy farmers



Notes: INN: innovation; SC: structural changes; INC: inclusion; EXC: exclusion; CAP: capabilities; R: reinforcing mechanism; B: balancing mechanism.

Source: Authors' own, applying the framework of Ciarli *et al*. (2018, forthcoming).

The emergence and strength of smallholder farmers producing for commercial sale was the first significant structural change, driven by innovations in breeding practices. The smallholders also adopted process innovations, enabled by government extension provision, in the form of AI over natural bull services, feeding and veterinary services. Product and process innovations at time *t* thereby led to structural change (*positive relation from Product & Process Innovations to SC* in Figure 6.3). In the intermediate period, technology and institutions were enabling factors for further innovations as other imports of genetic material were relatively swiftly adopted by smallholders on account of previous support and training. Structural change thereby led to future innovations (*reinforcing mechanism R1* in Figure 6.3).

On average, significantly higher returns were made by smallholders across all stages. Households engaged in dairy had more educated families and were more likely to be consistently non-poor. Innovations at time *t* therefore had a positive impact on inclusion in the future (*positive relation from Product/Process Innovations to INC* in Figure 6.3). With improved incomes, smallholders developed capabilities such that they themselves introduced further innovations by cross breeding with local varieties (*reinforcing mechanism R2* in Figure 6.3). In the intermediate and especially in the final stages, farmers developed increasing linkages with extension service providers and took initiative in learning about the new technologies first hand.

However, there is also evidence of disparities in accessing innovations. Better off households, households in the highland and high- and medium-potential areas and specifically male-headed households had better access to improved dairy breeds and new dairy technologies. This suggests that innovation also led to exclusion *(balancing mechanism B1* in Figure 6.3) of some groups. On account of exclusion from the innovations, such groups had unequal means to improve their capabilities in production. In the absence of improved capabilities for the excluded groups, there was no impact on their future innovation (outcome 1 under the sub-relation of innovation and exclusion).

The innovations had a positive impact on inclusion in production and consumption. Smallholder farmers improved their position in dairy farming, creating increased capabilities of innovating in milk production in Kenya (*positive relation from Innovations to CAP* in Figure 6.3), supporting further product and process innovations (*positive relation from CAP to Innovations* in Figure 6.3*)*. Increasing innovations led to inclusive structural change (*positive relation from Innovations to INC and from Innovations to SC* in Figure 6.3) in the form of further improved milk yields and increase in milk consumption per capita.

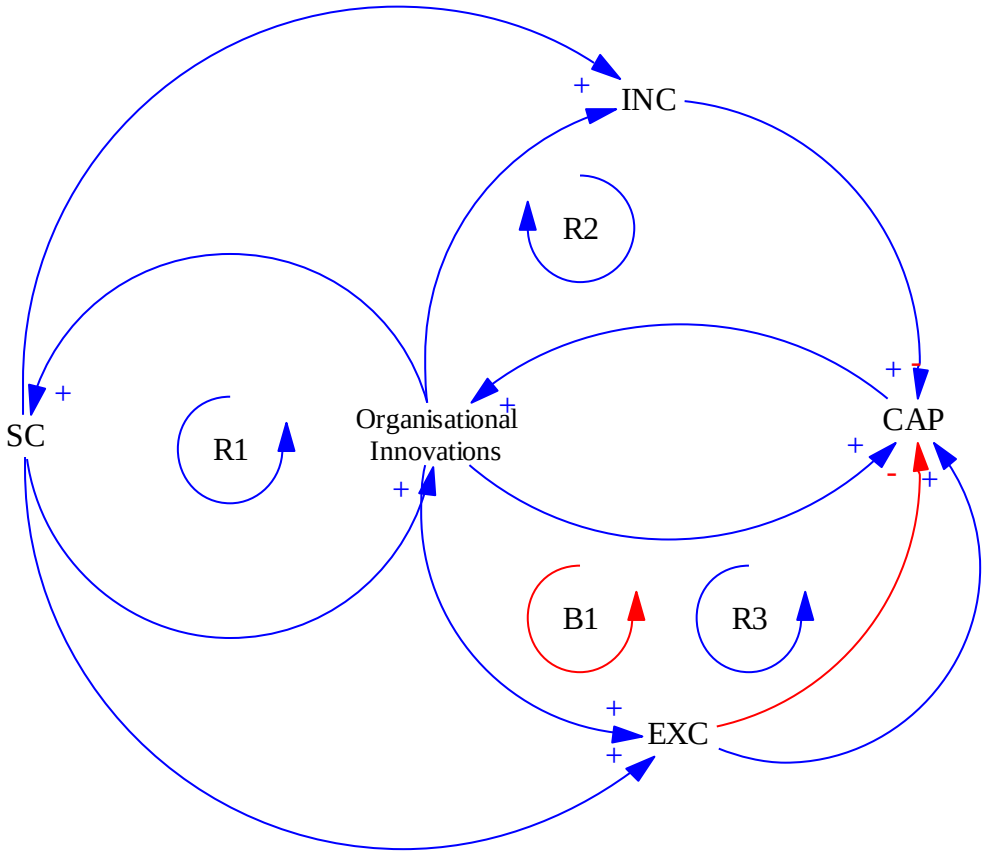
Overall, the evidence points to inclusive structural change, on account of vast improvements in livelihoods of smallholders and the nutritional status of the Kenyan population. While on one hand the effect on exclusion translated to no discernible future innovations for some groups, future innovations were facilitated through inclusion, in terms of significantly higher smallholder returns on average, creating wider impacts across production and consumption. The findings therefore suggest that the reinforcing mechanisms (*R1 and R2*) were stronger than the balancing mechanism (*B1*) that resulted in inclusive structural change over time.

6.2. Mozambique: Innovation pathways for anti-retroviral treatment service provision

The integration of ART into public health care is an organisational innovation (Figure 6.4), attributable to the HIV epidemic as the key incentive variable, but also to the need to better coordinate large amounts of donor funding attracted by the HIV/AIDS emergency. The Mozambique government made concerted efforts to firstly coordinate financing from donors and secondly to channel aid resources for HIV/AIDS to also strengthen primary health care. Corresponding decentralisation in health service provision led to further diffusion of the organisational innovation as both ART and public health care provision was part of a decentralised structure.

An integrated and decentralised structure of health care emerged, with ART embedded within overall public health service provision. Organisational innovations at time *t* thereby led to structural change (*positive relation from Organisational Innovations to SC* in Figure 6.4). Despite a moderately successful scale up of ART since 2000, the health system became overburdened and there were inequities in access. In response, community health support initiatives for ART dispensing via community health workers (CHWs) were introduced from the late 2000s. Structural change, thereby led to future organisational innovations (*reinforcing mechanism R1* in Figure 6.4).

Figure 6.4 Dynamic relations in innovation pathways for anti-retroviral treatment service provision in Mozambique



Notes: INN: innovation; SC: structural changes; INC: inclusion; EXC: exclusion; CAP: capabilities; R: reinforcing mechanism; B: balancing mechanism.

Source: Authors' own, applying the framework of Ciarli *et al*. (2018, forthcoming).

A comparison of the prior parallel sites for HIV care with the integrated ones revealed a significant increase in people availing treatment. The wider health care system was also strengthened offering benefits for patients with other diseases. Increasing coverage suggests a positive impact on inclusion, as essential HIV care and treatment services were closer to patients in need (*positive relation from Organisational Innovations to INC* in Figure 6.4). Innovations at time *t* therefore had a positive impact on inclusion in the future. Increasing inclusion in terms of wider coverage to patients created the need to introduce further innovations, and additional clinics and facilities came up. Outcomes of inclusion in one period, had a positive impact on future innovations *(reinforcing mechanism R2* in Figure 6.4).

Yet, despite improved ART coverage, geographical disparities remained. Patients located in distant areas continued to receive lower quality care in the absence of capabilities for better provision. Therefore, the innovations also created some exclusion (*positive relation from Organisational Innovations to EXC* in Figure 6.4*)*. Two competing effects were observed. First, the exclusion of hard to reach patients meant no impact/negative impact (outcomes 1 and 2 under the sub-relation of innovation and exclusion) on capabilities (*negative relation from EXC to CAP* in Figure 6.4*)* for care provision (*balancing mechanism B1*). A negative impact would imply care-givers moving to other areas with better coverage, undermining the potential for future innovations in the isolated areas and a drop in care quality. Being a resource poor country, insufficient health workers exacerbates this issue. However, unequal coverage also created the incentive to introduce community health support initiatives by late

2000s (*positive relation from INC to CAP* in Figure 6.4), enabled by prior local knowledge. Hence, while only a certain part of the population had access to care, such that the innovation led to exclusion, this in turn led to the need for further innovations (*reinforcing mechanism R3* in Figure 6.4).

Structural change in the form of an integrated and decentralised system of healthcare in Mozambique suggests competing pathways. Where exclusion creates reduced/insufficient capabilities for care provision in certain areas, the positive effect of the organisational innovation on structural change does not support future innovations for the affected groups. However, structural change has also been inclusive, reinforcing future innovation through inclusion in terms of improved coverage that further led to demand for better care and more facilities. Since, the organisational innovations are fairly recent, however, it remains to be examined if the competing forces of the reinforcing mechanisms (*R1, R2, and R3*) versus the balancing mechanism (*B1*) result in inclusive or exclusive structural change over time.

7 Conclusions: Towards a future research agenda

The case studies have explored product and process innovation in agriculture in Kenya and organisational innovation in health service delivery in Mozambique, sectors with high relevance for development in the context of low-income and emerging countries. We applied our analytical framework (Figure 3.1) to these cases with the aim of identifying different innovation pathways, the variables that influenced the adoption and diffusion of innovations within these pathways, and how these variables shaped outcomes in terms of structural change and inclusion or exclusion. By uncovering these processes and variables we aimed to refine our analytical framework as the basis of future research on the conditions for innovation to lead to inclusive structural change, in support of sustainable and inclusive societies.

Our analysis of the cases points to the crucial importance of capabilities as the key link in a dynamic relationship between the outcomes of innovation: inclusion and structural change, and successive phases of innovation. By applying the dynamic framework (Figure 6.2) to the cases, we demonstrate that structural change and inclusion at a given time impact future innovations, and so these outcomes cannot be satisfactorily explained by examining only the introduction and uptake of specific innovations. Instead, '*reinforcing*' and '*balancing*' mechanisms are operationalised through the impact of innovation and inclusion/exclusion on capabilities, which in turn reflect the opportunity and ability to generate further innovations. Other incentives and enabling variables which influence these pathways are also identified.

In the Kenyan case pre-existing local capabilities owing to the existence of colonial farms supported *parallel non-competing pathways* where innovation led to (a) structural change that was inclusive, and (b) structural change that created exclusion on account of inequities in access to technologies. The inclusive structural change is stronger, however, on account of vast improvements in livelihoods and nutrition. Other critical variables in Kenya included diverse actors with complementary resources and expertise (such as scientific and technical knowhow, entrepreneurial skills and finance), enabling the flow of ideas between network members and supporting continuous innovations, as well as supporting institutions. Interrelated innovations emerged which further supported the outcomes, including the use of AI services, complementary inputs from feeding systems and veterinary services, and the development of the dairy value chain linked to formal markets, and involving milk collection, bulking, chilling and processing.

In the case of Mozambique, we find evidence of *competing pathways*, where innovation created structural change and increased health care coverage, leading to demand for further innovations; alongside the exclusion of hard to reach patients, which meant no impact on capabilities for care provision in those areas, limiting future innovations. Power relationships between international agencies, donors and NGOs, and the host government gave the government an incentive for organisational change, alongside the relatively low absorptive capacity in the formal health service and existing knowledge and capacity for community health provision. Together these factors supported decentralisation and inclusion of patients and communities in access and adherence to ART treatment. However, more isolated areas remained excluded. The stigma associated with HIV/AIDS also created exclusion as some sites experienced high drop-out rates of patients where privacy during the collection of medicines was absent from the new organisational forms created.

Alongside capabilities, therefore, other key variables that influenced pathways of adoption, adaption and diffusion of new technology in the low-income contexts of the case studies include actor networks, the presence of interrelated (including indigenous) innovations, political economy factors such as power relations between actors, and the role of institutions (formal and informal). Future research therefore needs to be able to capture these factors within a dynamic analysis of innovation processes (and not only focus on a linear pathway from the introduction and uptake of specific foreign innovations within the formal sector to developmental outcomes). The case studies also revealed serious data gaps. They showed a lack of systematically developed indicators of innovation (individual/organisation level capabilities, for example, to undertake product or process upgrading), while indicators and measures of outcomes of innovation were also weakly developed. There is thus also a need to develop a set of indicators that are more appropriate to low-income contexts. Future research in this areas that responds to these conceptual and data gaps should result in an integrated platform of evidence to inform policy-making in areas such as trade, innovation and industrial policy in support of inclusive structural change in low-income countries.

References

Aghion, P.; Akcigit, U.; Hyytinen, A. and Toivanen, O. (2017) “The Social Origins of Inventors”, Available at: https://scholar.harvard.edu/files/aghion/files/social_origins_of_inventors.pdf (accessed 13 January 2018)

Akcigit, U.; Grigsby, J. and Nicholas, T. (2017) *The Rise of American Ingenuity: Innovation and Inventors of the Golden Age*, NBER Working Paper 23047. Cambridge, MA

Amsden, A.H. (2001) *The Rise of “The Rest”: Challenges to the West from Late-Industrializing Economies*. Oxford: Oxford University Press

Baltenweck, I. and Staal, S.J. (2000) *Determinants of adoption of dairy cattle technology in the Kenyan Highlands; A Spatial and Dynamic Approach*, Paper presented at the International Association of Agricultural Economics (IAAE) Meetings, Berlin, Nairobi (Kenya): ILRI

Baltenweck, I.; Yamano, T., and Staal, S. (2011) "Dynamic Changes in the Uptake of Dairy Technologies in the Kenya Highlands." In T. Yamano, K. Otsuka and F. Place (Eds.) *Emerging Development of Agriculture in East Africa*, Springer

Baltenweck, I.; Ouma, R.; Anunda, F.; Mwai, O. and Romney D. (2004) *Artificial or Natural Insemination: The Demand for Breeding Services for Smallholders*, Nairobi: ILRI

Bebe, B.O. (2003) *Herd Dynamics in the Kenyan Highlands*. Ph.D. Thesis, Netherlands: Wageningen University

Bebe, B.O.; Udo, H.M.J.; Rowlands, G.J. and Thorpe, W. (2003) "Smallholder dairy systems in the Kenya highlands: breed preferences and breeding practices." *Livestock Production Science*, Volume 82, Issues 2–3, 117–127

Bebe, B.O.; Thorpe, W.; Udo, H.M.J. and Mulinge, W. (2000) "Breed preferences and breeding practices in smallholder dairy systems of the central highlands of Kenya"

Bedi, S. (2012) ‘A Foundational Criticism of the Base of the Pyramid Model’, Social Science Research Network, 15 October, http://ssrn.com/abstract=2161900 (accessed 20 January 2016)

Bell, A.; Chetty, R.; Jaravel, X.; Petkova, N. and Van Reenen, J. (2017) “Who Becomes an Inventor in America? The Importance of Exposure to Innovation”, CEP Discussion Paper No. 1519, London: LSE

Bell, M. (2009) Innovation capabilities and directions of development. Working Papers, STEPS Centre

Bell, M. (2006) ‘Time and technological learning in industrialising countries: how long does it take? How fast is it moving (if at all)?’. *International Journal of Technology Management*. 36(1–3)

Bidaurratzaga-Aurre E. and Colom-Jaen A. (2012) “HIV/AIDS policies in Mozambique and the new aid architecture: successes, shortcomings and the way forward”. *Journal of Modern African Studies.* 50(2): 225–252

Bingi, S. and Tondel, F. (2015). Recent Developments in the Dairy Sector in East Africa: towards a regional policy framework for value chain development. *European Centre for Development Policy Management, Briefing Note* No. 78

Blondel, V.D.; Guillaume, J.; Lambiotte, R. and Lefebvre E. (2008) Fast unfolding of communities in large networks. J Stat Mech: Theory Exp 2008:P10008

Braga, C.M.T. (2012) 'Death is Destiny': Sovereign Decisions and the Lived Experience of HIV/ AIDS and Biomedical Treatment in Central Mozambique. PhD dissertation, State University of New York at Buffalo

Burke, W.J.; Jayne, T.S.; Freeman H.A. and Kristjanson, P. (2007) Factors Associated with Farm Households' Movement Into and Out of Poverty in Kenya: The Rising Importance of Livestock. Working and discussion papers, London: ODI

Charmes, J.; Gault, F. and Wunsch-Vincent, S. (2016) 'Formulating an Agenda for the Measurement of Innovation in the Informal Economy', in Kraemer-Mbula, E. and Wunsch-Vincent, S. (eds) The Informal Economy in Developing Nations: Hidden Engine of Innovation? Cambridge University Press, p. 336–

Chataway, J.; Hanlin, R. and Kaplinsky, R. (2014) 'Inclusive innovation: an architecture for policy development', *Innovation and Development*. Routledge, 4(1): 33–54, doi: 10.1080/2157930X.2013.876800.

Ciarli, T. (2012) "Structural interactions and long run growth: an application of experimental design to agent based models. *Observatoire Francais des Conjonctures Economiques*. Revue, 124. pp. 295–345

Ciarli, T.; Savona, M.; Thorpe, J. and Ayele, S. (2018, forthcoming) Innovation for Inclusive Structural Change. A Framework and Research Agenda, SPRU Working Paper

Cimoli, M. and Dosi, G. (1995) "Technological paradigms, patterns of learning and development: an introductory roadmap." Journal of Evolutionary Economics 5:243–268

Cirera, X. and Maloney, W.F. (2017) *The Innovation Paradox: Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up*. Washington DC

Cohen, W.M. and Levinthal, D.A. (1990) "Absorptive capacity: A new perspective on learning and innovation". *Administrative Science Quarterly.* 35(1): 128–152

Comin, D.A. and Mestieri, M. (2013) *If Technology Has Arrived Everywhere, Why Has Income Diverged?*, *NBER working paper*. National Bureau of Economic Research, Inc. doi: 10.1017/CBO9781107415324.004

Cozzens, S. and Sutz, J. (2014) "Innovation in informal settings: reflections and proposals for a research agenda." *Innovation and Development* 4(1):5–31

Decroo, T. *et al.* (2009) 'Lessons learned during down referral of antiretroviral treatment in Tete, Mozambique', *Journal of the International AIDS Society*, 12:6

FAO (2010) "Breeding strategies for sustainable management of animal genetic resources." *Animal Production and Health Guidelines*. No. 3. Rome

Figueiredo, P.N. (2011) “The Role of Dual Embeddedness in the Innovative Performance of MNE Subsidiaries: Evidence from Brazil”. *Journal of Management Studies*, 48: 417–440

Foster, C. and Heeks, R. (2013) “Conceptualising Inclusive Innovation: Modifying Systems of Innovation Frameworks to Understand Diffusion of New Technology 31 to Low-Income Consumers” *The European Journal of Development Research*, 25(3), 333–355

Fressoli, M. *et al.* (2014) “When grassroots innovation movements encounter mainstream institutions: implications for models of inclusive innovation.” Innovation and Development 4(2):277–292

Fu, X. and Gong, Y. (2011) “Indigenous and Foreign Innovation Efforts and Drivers of Technological Upgrading: Evidence from China”. *World Development*, 39(7), 1213–1225

Fu, X.; Pietrobelli, C. and Soete, L. (2011) “The Role of Foreign Technology and Indigenous Innovation in the Emerging Economies: Technological Change and Catching-up”. *World Development*, 39(7), 1204–1212

Garrette, B. and Karnani, A. (2010) ‘Challenges in Marketing Socially Useful Goods to the Poor’, *California Management Review* 52.4: 1–19

Gault, F. (2014) Where are innovation indicators, and their applications, going?, MERIT Working Papers. 2014–55. United Nations University/Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT). Available at: http://ideas.repec.org/p/unm/unumer/2014055.html (accessed 22 June 2015)

Gereffi, G.; Humphrey, J. and Sturgeon, T. (2005). “The governance of global value chains”. *Review of international political economy*, 12(1), 78-104

Gottret, P. and Schieber, G. (2006) *Health Financing Revisited: A Practitioners’ Guide*. Washington, DC: World Bank

Hanlin, R. and Kaplinsky, R. (2016) “South – South Trade in Capital Goods – The Market-Driven Diffusion of Appropriate Technology”. *European Journal of Development Research,* 28, 361–378

Hausmann, R. and Hidalgo, C. (2011) “The network structure of economic output.” *Journal of Economic Growth* 16(4):309–342

Heeks, R.; Foster, C. and Nugroho, Y. (2014) New Models of Inclusive Innovation for Development Innovation and Development 4.2, 175–185

Hidalgo, C.A.; B. Klinger, A.; Barabási, L. and Hausmann, R. (2007) “The Product Space Conditions the Development of Nations.” Science 317(5837):482–487

Hog, E. (2014) “HIV scale-up in Mozambique: Exceptionalism, normalisation and global health”. *Global Public Health*, 9(1–2)

Ilatsia, E.D. (2011) Breeding Strategies for Sahiwal Cattle Genetic Resources in Kenya. PhD Thesis, Stuttgart-Hohenheim: Faculty of Agricultural Sciences, University of Hohenheim

Jacomy, M.; Venturini, T.; Heymann, S. and Bastian, M. (2014) ForceAtlas2, a continuous graph layout algorithm for handy network visualization designed for the Gephi software. PloS one, 9(6), e98679

Kabeer, N. (2016). '"Leaving no one behind": the challenge of intersecting inequalities'. In ISSC,IDS & UNESCO (Eds.), World Social Science Report 2016, Challenging Inequalities: Pathways to a Just World. Paris: UNESCO Publishing

Karamchandani, S.; Kubzansky, M. and Lalwani, N. (2011) "Is the Bottom of the Pyramid Really for You?" *Harvard Business Review*, March: 107–111

Keough, L. and Marshall, K. (2006) Mozambique's battle against HIV/AIDS and the DREAM project. Washington, DC: World Bank

Kuznets, S. (1955). Economic Growth and Income Inequality. The American Economic Review, 45(1), 1–28

Lambdin, B.H. *et al.* (2013) "Integration of HIV care and treatment in primary health care centers and patient retention in central Mozambique: a retrospective cohort study". *Journal of Acquired Immune Deficiency Syndromes* 62(5): 146–52

Lambdin, B.H. *et al.* (2011) "Patient Volume, Human Resource Levels and Attrition from HIV Treatment Programs in Central Mozambique". *Journal of acquired immune deficiency syndromes* 57(3): 33–39

Landrum, N.E. (2007) 'Advancing the "Base of the Pyramid" Debate', *Strategic Management Review* 1.1: 1–12

Lundvall, B. (2007). National Innovation Systems—Analytical Concept and Development Tool. Industry & Innovation, 14(1), 95–119

Maes, K. and Kalofonos, I. (2013) "Becoming and remaining community health workers: perspectives from Ethiopia and Mozambique". Soc Sci Med, 87: 52–59

Morrison, A.; Pietrobelli, C. and Rabellotti, R. (2008). Global Value Chains and Technological Capabilities: A Framework to Study Learning and Innovation in Developing Countries, Oxford Development Studies, 36(1): 39–58

Moser, C. (2008). "Assets and Livelihoods: A Framework for Asset-Based Social Policy". In Moser, C. and Dani, A.A. (Eds.), *Assets, Livelihoods, and Social Policy. New Frontiers of Social Policy*. Washington, DC: World Bank

Mosi, R.O.; Wakhungu, J.W.; Okeyo, A.M and Okore, C. (2000) A review of dairy cattle improvement in Kenya. Proc. Dairy Cattle Breeding in East Africa and Sustainable Artificial Insemination Service, Nairobi, Kenya: KARI HQs

Mulford, R.M. (2013) Smallholder market participation and welfare effects: Evidence from the Kenya Dairy Sector. MSc thesis, Cornell University

Murage, A.W. and Ilatsia, E.D. (2011) "Factors that determine use of breeding services by smallholder dairy farmers in Central Kenya." *Trop Anim Health Prod*. 199–207

Muriuki, H.A. *et al.* (2003) The policy environment in the Kenya dairy sub-sector: a review. Smallholder Dairy (R&D) Project, Nairobi (Kenya*): SDP Research and Development Report* 2

Ndima, S.D.; Sidat, M.; Ormel, H.; Kok, M. C. and Taegtmeyer, M. (2015) “Supervision of community health workers in Mozambique: a qualitative study of factors influencing motivation and programme implementation”. *Human Resources for Health*, 13(1), 63

Ngigi, M. (2005) The Case of Smallholder Dairying in Eastern Africa. *EPT Discussion Paper* 131, IFPRI

Nicholson C.F.; Mwangi L.; Staal S.J. and Thornton P.K. (2003) "Dairy Cow Ownership and Child Nutritional Status in Kenya." Annual Meeting: Montreal, Quebec,Canada on July 27, 2003. Agricultural and Applied Economics Association

OECD (2017) *Making Innovation Benefit All: Policies for Inclusive Growth*. Paris

OECD (2005) Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition. Paris: OECD Publishing

Omore, A.; Muriuki, H.; Kenyanjui, M.; Owango, M. and Staal, S.J. (1999) The Kenya Dairy Sub-Sector: A Rapid Appraisal. Nairobi: Smallholder Dairy (Research & Development) Project Report, ILRI

Oomman N.; Bernstein, M. and Rosenzweig, S. (2007) Following the funding for HIV/AIDS: a comparative analysis of the funding practices of PEPFAR, the Global Fund and World Bank MAP in Mozambique, Uganda and Zambia. USA: Center for Global Development

Pfeiffer J. *et al.* (2010) “Integration of HIV/AIDS services into African primary health care: lessons learned for health system strengthening in Mozambique - a case study”. *Journal of the International AIDS Society*, 13:3

Planes-Satorra, S. and Paunov, C. (2017) *Inclusive innovation policies*. OECD Publishing. doi: 10.1787/a09a3a5d-en

Pogge, T. and Rippin, N. (2013). ‘Universal Agenda on the Multiple Dimensions of Poverty’. Background Research Paper Submitted to the High Level Panel on the Post-2015 Development Agenda. Bonn: German Development Institute (DIE)

Porter, M. and Kramer, M. (2011) 'Creating Shared Value', *Harvard Business Review* 89 (1/2): 62-77

Prahalad, C.K. and Hart, S.L. (2002) ‘The Fortune at the Bottom of the Pyramid’, *Strategy+Business*, 26: 54–67

Rege, J.E.O.; Kahi, A.K.; Okomo-Adhiambo, M.O.; Mwacharo, J. and Hanotte, O. (2001) Zebu Cattle of Kenya: Uses, Performance, Farmer Preferences, Measures of Genetic Diversity and Options for Improved Use. Animal Genetic Resources Research 1, Nairobi: ILRI

SCMS (2007) Donor Coordination in Mozambique. www.scms.pfscm.org, (accessed 27 March 2017)

Sherr, K. *et al.* (2013) “Strengthening integrated primary health care in Sofala, Mozambique”. *BMC Health Services Research*, 13 (Suppl. 2:S4)

Sidat, M. *et al.* (2014) *Context Analysis: Close-to-community providers in Mozambique.* Reachout Consortium

Simanis, E.N. (2012) “Reality Check at the Bottom of the Pyramid”, *Harvard Business Review*, Vol. 90: 120–125

Simon, S.; Chu, K.; Frieden, M., *et al.* (2009) “An integrated approach of community health worker support for HIV/AIDS and TB care in Angónia District, Mozambique”. *BMC Int Health Hum Rights*; 9: 13

Staal, S.J. Pratt, N., and Jabbar, M. (2008) Dairy Development for the Resource Poor. Part 2: Kenya and Ethiopia. *Pro-Poor Livestock Policy Initiative Working Paper* 44–2, ILRI: Dairy Development Case Studies

Staal, S.J. *et al.* (2003) Costs of milk production in Kenya: Estimates from Kiambu, Nakuru and Nyandarua Districts. SDP Research and Development Report No. 1. Nairobi (Kenya): Smallholder Dairy (R&D) Project

Syrquin, M. (1988) “Patterns of Structural Change.” In H. B. Chenery and T. N. Srinivasan, eds. *Handbook of Development Economics*. Amsterdam: North-Holland: 203–273

USAID (2013) *Mozambique: Strengthening the Community Health Worker Supply Chain*. USAID

Verspagen, B. (2004) “Structural Change and Technology. A Long View.” Revue économique 55(6):1099–1126

Wambugu, S.; Kirimi, L. and Opiyo, J. (2011) Productivity Trends and Performance of Dairy Farming in Kenya. *Tegemeo Working Paper* 43, Nairobi: Tegemeo Institute of Agricultural Policy and Development

World Health Organization. (2006) Geneva, Switzerland: World Health Organization

Zander, K.K.; Mwarcharo, J.M.; Drucker, A.G. and Garnett, S.T. (2013) "Constraints to effective adoption of innovative livestock production technologies in the Rift Valley (Kenya)." *Journal of Arid Environments*, 96 9–18