## CHINA IN AFRICAN AGRICULTURE: MODELING NARRATIVES, SPILLOVERS, AND INVESTMENTS

By

Victoria W. Breeze

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#### ABSTRACT

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How is the China-Africa agricultural relationship conceptualized and realized at the intersections of large-scale socio-political, environmental, and economic processes? The goal of this dissertation is to disentangle some pieces of this structure by means of several qualitative and quantitative modeling approaches. Chapter 1 discusses a novel application of topic modeling to China-Africa academic literature, in two languages. Chapter 2 investigates the potential of the telecoupling framework to tease out the effects of Chinese investment on agricultural development in Africa, despite the fact that almost no Chinese investment goes directly to the agricultural sector. Chapter 3 presents multi-criteria decision modeling as one method to predict where direct Chinese investment in African agriculture might occur. This work presents multiple applications of methodologies underutilized in the study of China-Africa agricultural systems. The models used in this dissertation also explicitly state their data inputs and assumptions about the behavior of the system under study. In doing so, they both reinforce that more data is needed to understand any long-term trends in China-Africa agricultural systems and draw attention to the specific gaps in current data. Finally, the conclusions drawn by this research push back against the idea of a singular "Chinese model" of development that can be applied to Africa and instead highlight how different facets of China-Africa agricultural systems emerge under different assumptions and vary dramatically across the continent.

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# **KEY TO ABBREVIATIONS**

ATDC	Agricultural Technology Demonstration Center
AU	African Union
BRI	Belt and Road Initiative
CAADP	Comprehensive Agriculture Development Program
DRC	Democratic Republic of Congo
EU	European Union
FAO	Food and Agriculture Organization
FOCAC	Forum on China-Africa Cooperation
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GSA	Global Sensitivity Analysis
LDA	Latent Dirichlet Allocation
MCDM	Multi-criteria Decision Model(ing)
MFA	(Chinese) Ministry of Foreign Affairs
MOFCOM	(Chinese) Ministry of Commerce
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental Organization
ODA	Official Development Assistance
OECD	Organization for Economic Cooperation and Development
PRC	People's Republic of China
RIV	Ranking Index Value
SAIS-CARI	School of Advanced International Studies China Africa Research Initiative

UK	United Kingdom
UNCTD	United Nations Conference on Trade and Development
USD	United States Dollar
US BEA	United States Bureau of Economic Analysis
USITC	United States International Trade Commission
WITS	World Integrated Trade Solution

INTRODUCTION

## China in African Agriculture – The Ongoing Question

The China-Africa agricultural engagement topic jumped into public consciousness following the 2008 global recession, when media and subsequently research reports conflated rising grain prices and understandable land grab worries with increased Chinese trading and investment presence in Africa (Bräutigam & Zhang, 2013). China's national food security is, and was, at odds with a growing population and a shrinking availability of arable land due to pressures such as urbanization, desertification, and land retirement policies like the Grain to Green program (Chen et al., 2015; Fan et al., 2011). The perception that China reacted to these pressures by buying up land in sub-Saharan Africa was reported in academic literature and media and bolstered by 'land grab' databases compiled by Land Matrix and GRAIN (Bräutigam & Tang 2009, see Smith, 2009 for an example). However, a closer inspection of land acquisitions found that China has not purchased or leased anywhere near the quantity of agricultural land originally thought in Africa (Bräutigam & Tang, 2009; Bräutigam & Zhang, 2013).

However, China-in-African-agriculture remains a hot topic for three major reasons: (1) the continued increase in China-Africa engagement at large, (2) the inherent need for agricultural development in Africa, and (3) the question of a "China model" of development. While China is not buying up land across Africa at the rate exaggerated, Chinese national actors are still purchasing/leasing land for agricultural use in the region (Bräutigam 2015a). Furthermore, agricultural trade between sub-Saharan African nations and China continues to grow (WITS 2014). At the same time, there has been a concentrated push across the continent from governments, NGOs, citizens and stakeholders, not to mention the African Union (AU), for African agricultural development (NEPAD, 2003). This call for an African Green Revolution exists irrespective of Chinese engagements with and interventions in African agriculture;

however, many look to China as an example for Africa's own green revolution and/or see increase Chinese a potential involvement a boon for agricultural development (Moseley, 2013; Lu, Li, and Fu, 2015; Scoones et al., 2016; Buckley et al., 2017).

The next section will provide a brief overview of the various contexts for China in African agriculture with specific focus on the historical roots of these relationships, current mechanisms of engagement, and contemporary popular narratives on the subject.

## **Historical Background**

There are three major periods of China's agricultural engagement with Africa: diplomacy-based aid from the 1960s to early 80s, public-private partnerships from the 1980s until 1995, and increased overseas investment by Chinese companies from 1995 until the present (Bräutigam & Tang, 2009). China, as the People's Republic of China (PRC), has been involved in sub-Saharan African agricultural development since the 1960s (ibid). China's projects were usually large, state-owned farms that served as an 'instrument of diplomacy' to counter Taiwan's own diplomatic actions in the region (ibid). From the 80s until 1995, China focused on the repair and rehabilitation of older projects, generally funded by China's foreign aid grants but with the hope for eventual profit (ibid). Chinese state-owned companies began experimenting with overseas investment, with China State Farm Agribusiness Corp leading the way (ibid). Following 1995, China's 'going global' policy (走出去) firmly supported for-profit enterprise and promoted new opportunities for Chinese firms in agriculture with tools and instruments (concessional loans, preferential buyer's credits, sponsored seminars on agribusiness in Africa) to promote Chinese business, including agribusiness, overseas (Bräutigam & Tang, 2009). In this current period, China also participates in the UN Food and Agriculture Organization (FAO) South-South Cooperation program, providing agricultural expert outreach to various African states (ibid).

(See also, Alden, 2013, for a second review of this same historical period, characterized by increasing focus from technical assistance, to commodity trade, and then to investment.)

## **Mechanisms of Chinese Engagement**

## FOCAC

China broadcasts, and to some extent shapes, its official stance on China-African relations via the triennial Forum on China-Africa Cooperation (FOCAC). FOCAC, which has met every three years since 2000, is a "bonanza of development assistance projects and loans" for Africa, couched in rhetoric that re-affirms Beijing's "One-China" policy and emphasizes the importance of state sovereignty and non-interface (Taylor 2010, p91). Starting in 2006, FOCAC action plans began to include specific sections dedicated to agriculture. 2006 was also the year that China released their first-ever white paper directly addressing their international policy towards Africa. The white paper, "China's African Policy", only has one short section about agricultural which emphasizes China's interest in agricultural technology above all else (FOCAC, 2006). The paper also calls for cooperation in land development, agricultural plantations, breed technologies, food security, agricultural machinery, and the processing of agricultural products (Bräutigam and Tang 2012). Specific actions and pledges, however, are detailed only in the FOCAC documents. FOCAC pledges are ostensibly state actors crafting an agenda that acts on multiple scales.

The 2006 FOCAC action plan outlines agendas enacted at the national scale but that act on several different scales. First, the plan establishes training and technical demonstration centers that will operate in specific villages and cities. Second, it enables Chinese firms to access African agricultural tech markets through investment and/or aid. Third, the plan bolsters the perception of China-Africa partnership on the international stage via China's commitments to the UN Food and Agricultural Organization (FAO) programs. China joined FAO's "South-South

Cooperation Program" in 1996 and has since sent more than 700 Chinese agricultural experts and technicians to seven African countries (Bräutigam and Tang 2012). However, excluding the FAO commitment, most of the pledges focus on business and technology opportunities rather than traditional aid. In 2018, the agricultural agenda broadened to include a wide variety of pledges focused on agricultural modernization, productivity, assistance and aid, food security and food safety, technology transfer, research development, and the agro-industrial sector.

Chinese actors completely finance FOCAC and the Chinese state is seen as "very much in control of the whole process...it is Beijing that sets the agenda and the declarations and outcomes" (Taylor 2010, p100). However, in 2012, the action plan recognized the need to facilitate African access to Chinese produce markets. The 2015 action plan explicitly calls out the role of African countries in the China-Africa relationship, though only in a facilitating or enabling role. By the 2018 summit, African governments and actors emerge as partners in FOCAC goals and most pledges begin with "the two sides will work together to…"

## Financial Institutions

Though often portrayed as entirely state-led, Chinese investment is split into three tiers: stateowned enterprises (SOEs) and policy banks, provincial SOEs and private firms, and entrepreneurial and family firms (Lee, 2018). The Chinese Export-Import Bank is the main investment vehicle, to borrow Cotula et al.'s (2009) term, for Chinese investment in Africa (Corkin, 2012). It is important to note the dual role that state-level Chinese financial institutions have in China-Africa relations. China's Ministry of Foreign Affairs (MFA) sees tools offered by the Bank, such as concessional loans, as a method for fulfilling its mandate of improving diplomatic relations between China and developing countries via aid (Corkin, 2012). At the same time, China's Ministry of Commerce (MOFCOM) views these same investment tools as their

entry into overseas markets for Chinese companies' goods and services (ibid). While MFA and MOFCOM are technically at the same rank in the Chinese government, MOFCOM currently plays a far more influential role in determine the direction and implementation of policy for and investment in Africa (Corkin, 2012). This split between the MFA and MOFCOM echoes the most common criticism regarding China's foreign policy in Africa: that China lacks an overarching African strategy and that commercial interest trump diplomatic interests (Sun 2014). This profit-as-diplomacy method is evident in the 2012 FOCAC action plan, which explicitly encouraged Chinese financial institutions to support cooperation between Chinese and African companies in agribusiness. Competing agendas of aid and trade also manifest themselves in the most visible result of FOCAC's agricultural pledges: agricultural technology demonstration centers (ATDC)s.

## ATDCs

ATDCs are supported by the Chinese government, a sponsoring Chinese firm, and a local host government and are initially constructed and managed by a Chinese firm but are eventually handed over to host governments (Bräutigam 2015b). ATDCs, which are expected to both promote agricultural development, as well as eventually earn income and become self-financing (ibid), embody the business-orientation of the post-1995, 'going global' (走出去)approach to African agricultural aid. ATDCs also represent China's experience of modernizing agriculture, as China's own agricultural revolution in the latter quarter of the 20th century was driven by an ideology of technocratic rationality (Xu et al., 2016).

ATDCs have been constructed in 23 African countries so far, and all share the following characteristics: (a) a Chinese company runs the Center for the first three years and is responsible for creating a sustainable operation model to support agricultural training, demonstration, and

extension; and (b) the Chinese government provides financial support for the infrastructure construction and technical cooperation usually totaling around five to six million USD (Xu et al., 2016). Chinese policy makers purport that ATDCs are the "best model" for sustainable (as in long-lasting) agricultural aid (ibid). However, by mandating Chinese companies to be responsible for the ATDC's early operations, the Chinese state is also actively supporting its 'going global' policy (走出去). Thus, ATDCs have a dual purpose to both share and demonstrate Chinese agri-tech to African users and to promote Chinese agribusiness.

Which Chinese companies choose to bid on ATDCs and how they are selected unfolds at multiple scales. Chinese provincial governments are motivated to put their 'strongest' enterprises forward for selection by the central government (Xu et al., 2016). Individual companies are motivated by political gains and new market opportunities. To date, the Chinese ATDC partners include two agricultural universities, two agricultural research institutes, eight state-owned companies, and nine private companies (Xu et al., 2016). The Chinese management team oversees "technology appropriateness, market development, costs of operation, promoting Chinese diplomatic relations, cooperation with the host government, interacting with local farmers, and so on" (Xu et al., 2016, p88). Multiple roles mean multiple responsibilities. Similarly, the Chinese managers are responsible to central Chinese governmental bodies, provincial governments, as well as their parent companies—all of which dictate different priorities. Yet, to their African hosts, the ATDCs are purveyors of aid first and foremost and this creates confusion when African expectations of aid (e.g. per diems for participation) are not met (Xu et al., 2016). The Chinese experts and managers view the job of demonstration as demonstrating how Chinese technology will perform in an African context (Xu et al., 2016). African partners of ATDCs, however, envisioned demonstrations taking place on local farmers'

land and working within local farmers' capabilities (ibid). For their part, the Chinese managers felt any extension of demonstrated technology was the responsibility of their local partner agencies or government (ibid). At the local scale, two competing agendas clash.

## **Contemporary Narratives**

As Buckley (2013) succinctly puts it, the debate is still "largely centered on China's engagement with Africa agriculture as either a threat or an opportunity" (p4). Buckley outlines three primary narratives: China as a colonizer, China as an economic competitor, or China as a development partner (ibid). Media is represented as favoring the first two and Chinese and African government discourse the third (ibid). Buckley characterized the third narrative as dominant, further describing the associated sub-narratives that live under its umbrella:

"Despite some debate and criticism about Chinese agriculture cooperation in Africa, this framing works as a powerful narrative because it arrives at a convenient point of convergence for the interests of the central constituents in these engagements:1) Chinese leaders who stand to gain from increased soft power in Africa; 2) African leaders who will benefit both from increased agriculture production and trade in their countries and from positive relations with China as a rising power; and 3) global actors concerned about Africa's 'underdeveloped' agriculture, which is understood to require input from more efficient resource-users. Those who are outsiders, such as risk-averse Chinese investors, are being brought into the circle through financial incentives and removal of trade barriers. Researchers and civil society, however, remain on the outside and are thus free to ask critical questions of the dominant narratives and underlying assumptions" (p20).

The underlying assumptions of this dominant narrative include technology as the way forward, China learning from Africa, and win-win cooperation. The most common critical questions that arise in the literature on China-Africa agricultural engagement revolve around land tenure, labor, and environmental concerns.

## Technology as the Way Forward

China's own development was "heavily technocratic" China shows "deep faith in [its]

modernization project" (Buckley, 2013, p14). Even today, recommendations for improving rural

yields across China rely on technology and innovations (Li et al., 2016). Correspondingly, Chinese actors emphasize the importance of technology for African agricultural development (ibid). We see this implemented primarily via ATDCs (Xu et al., 2016) but also through China hosting sending senior African agricultural technicians and officials for training (Tugendhat and Alemu, 2016). However, reliance on technology as the foundation of agricultural development runs into market and capacity barriers in several African contexts (Buckley, 2013; Xu et al.,

## 2016; Lu et al., 2016).

#### Africa Learning from China

The Chinese example of a green revolution is being used as a basis for agricultural projects in Africa, even when China is not directly involved (Moseley, 2013). Fan, Nestorova, and Olofinbiyi (2010) outline four areas in which Africa should learn from China: agriculture and rural growth, evidence-based policy making, pro-poor policies, and institutions and capacity. Li et al. (2013) propose similar: that China's poverty reduction and smallholder-based agricultural policies can serve as a model for African agricultural development. Moseley (2013) argues that both Western and Chinese players benefit from pushing a green revolution in Africa:

"Many Chinese commentators view Sub-Saharan Africa as under populated and land rich. As such, enhancing agricultural productivity on the continent means that it will have more food to export to China (which increasingly needs such imports). Furthermore, the USA, and increasingly China, are home to some of the world's major seed companies and agrochemical firms. By encouraging an input intensive approach to agriculture dependent upon imported technology, American and Chinese firms are destined to profit" (p18). Narrowing in on a singular Chinese model of development, however, seems elusive. Scoones et al. (2016) conclude that there is no one Chinese model but rather "diverse experiments" emerging from across "very different and variegated political settings" (p9). A more practical interpretation of this narrative can be found in the agricultural experts China sends to African countries under a variety of aid projects. For example, Chinese agricultural professors spend a year or more in Ethiopia's rural agricultural technical and vocational education and training schools (Bräutigam and Tang, 2012).

#### Win-Win Cooperation

Often linked with South-South rhetoric or the idea of mutual cooperation (Scoones et al., 2016), 'win-win' cooperation ideals arose from the Chinese policy that aid should generate "mutual benefit" (Bräutigam and Tang, 2009). In practice, this usually translates to linking aid with enterprises and encouraging global links for Chinese businesses and investments opportunities (ibid). In Africa, these practices manifest as strong state-business alliances and a willingness to consider projects in the agricultural sector, which has often ignored by Western donors, (Scoones et al., 2016). Underpinning this narrative is Chinese official discourse which emphasizes China's own status as a developing nation, approaching African nations on 'equal' footing as opposed to the colonizing West (Buckley, 2013).

## Critical Concerns

Bräutigam and Zhang (2013) well document the misleading headlines and explain the China-island-grabbing fervor as well as the reality that land acquisitions by Chinese companies have been miniscule. More nuanced, however, is the concern on what foreign investment means for African land tenure and how China is playing into that system. Zhao (2012) positions China and African countries as mutual benefactors who need to tailor development cooperation to "more

appropriate land tenure systems for sustainable resource use to the mutual benefit of Chinese and African stakeholders" (p355). Similarities between China's own land tenure reform and that of many African nations' reforms convince Zhao that this 'lesson-learning' could be successful (ibid).

Labor issues are closely related to issues of land tenure. Buckely (2013) notes that Chinese agricultural trainings tend to focus on officials and others already in power in agriculture, which may have unintended social impacts. Hairong and Sautman (2010) found that Chinese engagement in Zambian agriculture involves "small-scale positive contributions to the domestic food market...[but also] exploitation of farm workers that is typically at the core of commercial farming regardless of the national origins of farm owners" (p309).

Finally, there are numerous environmental impacts to consider as China deepens relationships (Urban, Mohan, and Cook, 2012) though more focus has been on forestry (Huang et al., 2012) than agriculture. In general, Tan-Mullins and Mohan (2012) find weak support for environmental protect among Chinese state-owned enterprises (in any sector) operating in Africa.

While not completely subverting the dominant narrative of China and Africa as development partners, scholars caution that such rhetoric should be backed by specific actions that minimize potential harms on vulnerable groups and acknowledge past issues (Buckley, 2013; Fan, Nestorova, and Olofinbiyi, 2010). Specifically, through "fair competition of Chinese trade and investment companies with local African enterprises, stronger linkages of investments with domestic markets, greater engagement of the local workforce, and adoption of higher environmental standards" (Fan, Nestorova, and Olofinbiyi, 2010, p15).

## **Research Objectives**

The literature reviewed presents the China-Africa agricultural context as an interlocking structure of aid, investment, trade, politics, and diplomacy where it is difficult to isolate once facet without invoking the others. The goal of this dissertation is to disentangle some pieces of this structure by means of several qualitative and quantitative modeling approaches. **How is the China-Africa agricultural relationship conceptualized and realized at the intersections of large-scale socio-political, environmental, and economic processes?** Is there a predictable structure to Chinese involvement in Africa, specifically in African agriculture? To tackle these questions, this project concerns three research objectives:

**Objective One:** Describe the current narratives in China-Africa agricultural research across both the English- and Chinese-speaking academic literature. What have we already learned about the relationship and how are these findings presented?

**Objective Two:** Determine the current relationship between Chinese investment in Africa and African agricultural development.

**Objective Three:** Predict where in Africa will China direct agricultural investment to in the near future.

Why model? By investigating various facets of the China-Africa agricultural relationship through models, we can both challenge our assumptions of these relationships and reveal new areas of research to deepen our understanding. At its core, a model enables communication about how a system works (Badham, 2010). All models, whether simple or complex attempt to describe, explain, or predict some system or phenomena. By modeling phenomena, we make explicit our assumptions on that phenomena and reveal tradeoffs, uncertainties, and sensitivities

in the model that can inform our original theories (Epstein, 2008). Models can also make clear what data still needs to be collected to better approach an issue (ibid).

The models presented in this dissertation serve different purposes, as different modeling approaches "provide handles on different facets of a problem's complexity" (Badham, 2010, p1). Some explain or prompt new questions, others illuminate core uncertainties in our understanding, and yet others predict (with regards to Epstein, 2008, for the many goals of modeling). The four model types demonstrated in this dissertation are as follows: (i) Topic Model, a type of qualitative text analysis tool; (ii) the Telecoupling Framework, a conceptual model; (iii) Kendall rank correlation, a statistical test; and, (iv) Multi-criteria Decision Model, a type of predictive decision making.

Modeling complex systems usually comes with numerous data gaps. Similarly, models cannot represent every single piece of the system; simplifications must be made (Beven, 2009). The models detailed in this dissertation will not be perfect, but hopefully they are useful in that they "capture the qualitative behaviors of overarching interest" (Epstein, 2008, p1.12).

## **Dissertation Organization**

Four sections make up the remainder of this dissertation. Chapter 1 discusses a novel application of topic modeling to China-Africa academic literature, in two languages. Chapter 2 investigates the potential of the telecoupling framework to tease out the effects of Chinese investment on agricultural development in Africa, despite the fact that almost no Chinese investment goes directly to the agricultural sector. Chapter 3 considers the most recent 2018 FOCAC summit's call for increased investment in African agriculture and presents multi-criteria decision modeling as one method to predict where said investment might occur. Finally, the conclusion section

summarizes the research done over this dissertation project as well as its limitations, significant contributions, and key implications for future research.

REFERENCES

## REFERENCES

Alden, C. (2013). China and the long march into African agriculture. *Cahiers Agricultures*, 22(1), 16-21.

Badham, J. (2010). A Compendium of Modeling Techniques. In *Integration Insights* (Vol 12). Canberra, Australia: The Australian National University.

Beven, K. (2009). Chapter 1: How to Make Predictions. In *Environmental Modelling: An Uncertain Future? An Introduction to Techniques for Uncertainty Estimation in Environmental Prediction* (pp. 1-30). New York: Routledge.

Bräutigam, D. (2015a). Will Africa Feed China? Oxford University Press.

Bräutigam, D. (2015b). The Political Economy of Chinese Commercial Agriculture Investment in Africa. In Kjaer, A.M., Engberg-Pedersen, L. & Buur, L. (Eds.), *Perspectives on Politics, Production and Public Administration in Africa* (pp. 175-190). Copenhagen: Danish Institute for International Studies.

Bräutigam, D. & Tang, X. (2009). China's engagement in African agriculture: Down to the countryside. *The China Quarterly*, *199*, 686-706.

Bräutigam, D., & Tang, X. (2012). *An overview of Chinese agricultural and rural engagement in Ethiopia* (IFPRI Discussion Paper 01185). Washington DC: International Food Policy Research Institute.

Bräutigam, D., & Zhang, H. (2013). Green dreams: Myth and reality in China's agricultural investment in Africa. *Third World Quarterly*, *34*(9), 1676-1696.

Buckley, L. (2013). Chinese agriculture development cooperation in Africa: Narratives and politics. *IDS Bulletin*, 44(4), 42-52.

Buckley, L., Chen, R., Yin, Y., & Zhu, Z. (2017). *Chinese agriculture in Africa – perspectives of Chinese agronomists on agricultural aid.* (IIED Discussion Paper). London: International Institute for Environment and Development.

Chen, Y., Wang, K., Lin, Y., Shi, W., Song, Y., & He, X. (2015). Balancing green and grain trade. *Nature Geoscience*, 8(10), 739.

Corkin, L. (2012). Redefining foreign policy impulses toward Africa: The roles of the MFA, the MOFCOM and China Exim Bank. *Journal of Current Chinese Affairs*, 40(4), 61-90.

Cotula, L., Vermeulen, S., Leonard, R., & Keeley, J. (2009). Land grab or development opportunity? Agricultural investment and international land deals in Africa. London/Rome: IIED/FAO/IFAD.

Epstein, J. M. (2008). Why Model? *Journal of Artificial Societies and Social Simulation*, 11(4). Retrieved from http://jasss.soc.surrey.ac.uk/11/4/12.html

Fan, M., Shen, J., Yuan, L., Jiang, R., Chen, X., Davies, W. J., & Zhang, F. (2011). Improving crop productivity and resource use efficiency to ensure food security and environmental quality in China. *Journal of Experimental Botany*, *63*(1), 13-24.

Fan, S., Nestorova, B., & Olofinbiyi, T. (2010). *China's agricultural and rural development: Implications for Africa.* (Study Group on Agriculture, Food Security, and Rural Development). Bamako, Mali: China Development Assistance Committee.

Forum on China-Africa Cooperation (FOCAC). (2006). *China's African Policy*. Beijing, China: Ministry of Foreign Affairs.

FOCAC. (2006). *Forum on China-Africa Cooperation Beijing Action Plan (2007-2009)*. Beijing, China: Ministry of Foreign Affairs.

FOCAC. (2009). Forum on China-Africa Cooperation Sharm El Sheikh Action Plan (2010-2012). Beijing, China: Ministry of Foreign Affairs.

FOCAC. (2012). *The Fifth Ministerial Conference of The Forum on China-Africa Cooperation Beijing Action Plan (2013-2015)*. Beijing, China: Ministry of Foreign Affairs.

FOCAC. (2015). *The Forum on China-Africa Cooperation Johannesburg Action Plan (2016-2018)*. Beijing, China: Ministry of Foreign Affairs.

FOCAC. (2018). Forum on China-Africa Cooperation Beijing Action Plan (2019-2021). Beijing, China: Ministry of Foreign Affairs.

Hairong, Y., & Sautman, B. (2010). Chinese farms in Zambia: From socialist to "agro-imperialist" engagement?. *African and Asian Studies*, 9(3), 307-333.

Huang, W., Wilkes, A., Sun, X., & Terheggen, A. (2013). Who is importing forest products from Africa to China? An analysis of implications for initiatives to enhance legality and sustainability. *Environment, Development and Sustainability, 15*(2), 339-354.

Lee, C. K. (2018). *The specter of global China: Politics, labor, and foreign investment in Africa.* Chicago: University of Chicago Press.

Xiaoyun, L., Lixia, T., Xiuli, X., Gubo, Q., & Haimin, W. (2013). What can Africa learn from China's experience in agricultural development?. *IDS Bulletin*, 44(4), 31-41.

Li, X., Liu, N., You, L., Ke, X., Liu, H., Huang, M., & Waddington, S. R. (2016). Patterns of cereal yield growth across China from 1980 to 2010 and their implications for food production and food security. *PLOS One*, *11*(7). https://doi.org/10.1371/journal.pone.0159061.

Jiang, L., Harding, A., Anseeuw, W., & Alden, C. (2016). Chinese agriculture technology demonstration centres in Southern Africa: the new business of development. *Public Sphere*, 7-36.

Lu, J., Li, X., & Fu, G. (2015). *The challenges of China's food and feed economy* (Working Paper No. 131). Brighton, UK: Future Agricultures Consortium.

Moseley, W. G. (2013). The evolving global agri-food system and African–Eurasian food flows. *Eurasian Geography and Economics*, *54*(1), 5-21.

New Partnership for Africa's Development (NEPAD). (2003). *Comprehensive Africa Agriculture Development Programme*. Midrand, South Africa: NEPAD.

Scoones, I., Amanor, K., Favareto, A., & Qi, G. (2016). A new politics of development cooperation? Chinese and Brazilian engagements in African agriculture. *World Development*, *81*, 1-12.

Smith, D. (2009, July 3). The food rush: Rising demand in China and west sparks African land grab. *The Guardian*. Retrieved from http://www.theguardian.com

Sun, Y. (2014). *Africa in China's Foreign Policy*. Washington DC: John L. Thornton China Centre and Africa Growth Initiative at Brookings.

Tan-Mullins, M., & Mohan, G. (2013). The potential of corporate environmental responsibility of Chinese state-owned enterprises in Africa. *Environment, Development and Sustainability, 15*(2), 265-284.

Taylor, I. (2010). The Forum on China-Africa Cooperation (FOCAC). London: Routledge.

Tugendhat, H., & Alemu, D. (2016). Chinese agricultural training courses for African officials: Between power and partnerships. *World Development*, *81*, 71-81.

Urban, F., Mohan, G., & Cook, S. (2013). China as a new shaper of international development: the environmental implications. *Environment, Development and Sustainability*, 15(2), 257-263.

World Integrated Trade Solutions (WITS) (2014). *China Imports* [Data file]. Retrieved from http://wits.worldbank.org/

Xu, X., Li, X., Qi, G., Tang, L., & Mukwereza, L. (2016). Science, technology, and the politics of knowledge: The case of China's agricultural technology demonstration centers in Africa. *World Development*, *81*, 82-91.

Zhao, Y. (2013). China–Africa development cooperation in the rural sector: an exploration of land tenure and investments linkages for sustainable resource use. *Environment, Development and Sustainability*, *15*(2), 355-366.

## CHAPTER 1 – CREATING A SCHOLARLY DIALOGUE THROUGH TOPIC MODELING: ACADEMIC NARRATIVES IN CHINA-AFRICA LITERATURE

\* This project was done in collaboration with Jessica Achberger, Michigan State Libraries, and Ma Junle, China Agricultura University. Both helped select the texts for analysis and provided input on model results. Dr. Achberger also contributed to the literature review of distant reading and digital humanities.

## Abstract

This study documents the rhetorical differences between academic writing in Mandarin and in English on the topic of China-Africa agricultural relations. We argue that a body of research chronicled in one language is different from that recorded in another, especially as concerns a politicized topic like China-Africa relations. We demonstrate this thesis using a case study of selected English and Mandarin texts on China-Africa agricultural ties. The method forming the foundation of this study is distant reading, through topic modeling, using the MALLET program. Our analysis of 24 articles, half in English and half in Mandarin, gave us five major topics in each language of analysis. The five topics identified in English were: large-scale investments; diplomacy and engagement; labor; training; and Chinese entrepreneurs. In Mandarin, the five topics were: training and technology transfer; marketizing Africa; investment context; and diplomacy. These results demonstrate the major differences between the two literatures, including the English-language focus on the act of investing, in comparison to the Mandarin corpus' focus on why Africa is an appropriate investment venue. Ultimately, the Mandarin corpus is much more prescriptive, rather than empirical in nature. We argue this method of analysis has potential to be instructive in a wide range of corpora and themes, as well as works to put into conversation Mandarin and English-language academic writing in meaningful ways.

## Introduction

The purpose of this study was to document the rhetorical differences between academic writing in Mandarin and in English on the topic of China-Africa agricultural relations. Through our own research and close reading of the literature, we noticed differences in the way the relationship between China and Africa was framed in academic discourse. China-Africa rhetoric, in general, seems to be perceptibly different between English and Mandarin. Seen as a collective, the western discourse on China-Africa sees China as a 'rival for resources and influence' and/or a 'bad influence on governance' where 'PRC policies in Africa promote human rights violations' (Sautman and Hairong, 2008, p9). On the other hand, a review of Chinese discourses highlights China's focus on 'stability through development' in Africa, how Chinese imports 'afford most African consumers more disposable income and buying power,' and diplomacy is based on 'winwin cooperation' (Corkin, 2014, p57). The question became: was there truly a difference between China-Africa rhetoric in English and Mandarin academic literature on the subject or did reader interpretations create a gap that was not there?

Our hypothesis was that a body of research chronicled in one language is quite different from that recorded in another, especially as concerns a politicized and polarizing topic like China-Africa relations. We tested and demonstrate this thesis using a case study of selected English and Mandarin texts on China-Africa agricultural ties. We conclude that in fact there are stark differences between the two literatures, in large part because of the highly politicized nature of Chinese academic writing. In this paper, we explain the methodological underpinnings of our study, our methods, and our findings and recommendation for future inquiry. Though the findings are interesting, and corroborate our hypothesis, we pay particular attention to the importance to the how we conducted our research, and why we chose to do so.

## Methodological Questions

Central to this study was the development and refinement of a methodology that would allow us to answer this question in a structured and reproducible manner. How we chose to enact this study became, increasingly, as important as the answers we received. In this section we explore some of the larger methodological questions we answered, followed by the specific methods we used during the study.

The method forming the foundation of this study is distant reading, or understanding text not by reading individual texts but by aggregating and analyzing many texts together. It is essentially the opposite of close reading, where a text is read in detail to be understood as a singular piece. Distant reading may be able to detect formal structures to groups of texts that human readers overlook. A common tool used to perform distant reading is topic modeling. Whereas a researcher may traditionally hand code each topic present in a document in a body of literature (i.e. close reading), topic modeling generates these topics from the entire body of literature without prior input (i.e. distant reading). While not necessarily better, distant reading is useful when comparing two bodies of literature against one another in an objective – or at least standardized – manner (Liu, 2013).

Topic models are built on the view that documents are made up of a mixture of topics, where each topic is a probability distribution over words (Steyvers and Griffiths, 2007). By choosing different distributions over topics, you can then generate documents with varied content (ibid). A popular form of topic modelling, and one that our chosen software MALLET (McCallum, 2002) employs, is a probabilistic model of texts known as latent Dirichlet allocation (LDA). LDA assumes a fixed number of topics (or groups of terms that tend to occur together in documents) and that each document in a corpus contains these topics, though not all to the same

degree (Blei, 2012). LDA topic models then pull out a fixed number of groups of terms, or topics, from a corpus of literature (ibid).

Topic modeling provides a standardized way to generate themes. While interpretation of those themes is still left to the researcher, the rank and content of those themes are produced by the model. As the model is probabilistic, the topics generated each time may differ slightly. However, multiple model runs can be performed to see how stable a topic is or is not. Furthermore, while English and Mandarin are different languages, the model treats English words and Mandarin word-character pairs the same way in order to generate topics.

Topic modeling has been used in the humanities to mine both historical and literary texts, such as topic exploration in an eighteenth century American newspaper (Newman and Block, 2006), or the characterization of Mudejar art across more than 2,000 document titles (Garcia-Zorita and Pacios, 2017). Topic modeling has also been used to study rhetoric, for example investigating the media representation of immigrant workers in Korean newspapers (Lee, 2018). Within rhetoric, broadly speaking, there have been hundreds of studies representing a range of materials, themes, and languages. Researchers in the sciences have also relied on topic modeling to analyze research trends in disciplines from information security (Choi, Lee, and Sohn, 2017) to transportation (Sun and Yin, 2017) and counseling psychology (Oh, Stewart, and Phelps, 2017). Studies such as these are becoming more common, though they are monolingual.

There are, however, many examples of topic models built to handle multilingual texts, founded on models such as the polylingual topic model built by Mimno et al. (2009). De Smet and Moens' study (2009) used interlingual topic modeling to link multilingual web-based news stories. With regards to Mandarin-language texts in particular, topic modeling has been applied both as a method of analysis, such as Fu et al.'s (2013) sentiment analysis of reviews on Chinese

social media, and as an area of study in its own right, such as Qin, Cong, and Wan's (2016) development of a character-word relationship topic model. While some studies consider how to use topic modeling to allow for cross-lingual comparison between English and Mandarin topics (Ni et al., 2009), ours seems to be the first that uses topic modeling to compare trends in English and Mandarin-language academic literature.

## Methods

## Choosing a Body of Literature

As we wanted both bodies of literature to have an equal number of texts, we were invariably limited by whichever the smaller body of literature turned out to be. In the case of China-in-African agriculture literature, the limiting language was English. We found twelve English-language, peer-reviewed articles that fit our narrow search criteria of only discussing China-Africa agriculture topics. The selection of Chinese-language articles was larger; our method for selecting twelve articles in Mandarin is described in more detail below. We also limited our search results to 2008 and more recent. Our final twenty-four articles are listed in *Table 1.1*.

ID	Title <sup>1</sup>	Authors	Journal	Publication
				Year
E01	China's engagement in African	Deborah	The China	2009
	agriculture: "Down to the	Brautigam, and	Quarterly	
	Countryside"	Tang, Xiaoyang		
E02	Rumors and realities of	Brautigam,	African Affairs	2012
	Chinese agricultural	Deborah and		
	engagement in Mozambique	Stensrud Ekman,		
		Sigrid-Marianella		
E03	China–Africa development	Zhao, Yongjun	Environment,	2012
	cooperation in the rural sector:		Development, and	
	an exploration of land tenure		Sustainability	
	and investments linkages for			
	sustainable resource use			

Table 1.1 Selected articles used in this study

Table 1.1 (cont'd)

ID	Title <sup>1</sup>	Authors	Journal	Publication Vear
E04	China and the long march into African agriculture	Alden, Christopher	Cahiers Agricultures	2013
E05	Chinese agriculture development cooperation in Africa: narratives and politics	Buckley, Lila	IDS Bulletin	2013
E06	Chinese land-based interventions in Senegal	Buckley, Lila	Development and Change	2013
E07	Green dreams: myth and reality in China's agricultural investment in Africa	Brautigam, Deborah and Zhang, Haisen	Third World Quarterly	2013
E08	Chinese migrants in Africa: facts and fictions from the agri-food sector in Ethiopia and Ghana	Cook, Seth; Lu, Jixia; Tugendhat, Henry; and Alemu, Dawit	World Development	2016
E09	Chinese agricultural training courses for African officials: between power and partnerships	Tugendhat, Henry and Alemu, Dawit	World Development	2016
E10	Science, technology, and the politics of knowledge: the case of China's agricultural technology demonstration centers in Africa	Xu, Xiuli; Li, Xiaoyun; Qi, Gubo; Tang, Lixia; and Mukwereza, Langton	World Development	2016
E11	Chinese farms in Zambia: from socialist to "agro- imperialist" engagement?	Yan Hairong and Sautman, Barry	African and Asian Studies	2010
E12	Chinese state capitalism? rethinking the role of the state and business in Chinese development cooperation in Africa	Gu, Jing; Zhang, Chuanhong; Vaz, Alcides; and Mukwereza, Langton	World Development	2016
C01	中非农业合作可持续性研究 A study on the sustainability of Sino-African agricultural cooperation	陈燕娟; 邓岩 Chen Yanjuan; Deng Yan	世界农业 World Agriculture	2008
C02	对非洲农业援助新形式的探 索 A probe into the new forms of agricultural aid in Africa	王晨燕 Wang Chenyan	国际经济合作 Journal of International Economic Cooperation	2008
Table 1.1 (cont'd)

ID	Title <sup>1</sup>	Authors	Journal	Publication
				Year
C03	论我国对非洲跨国农业投	俞毅	农业经济问题	2009
	资的战略构建	Yu Yi	Issues in Agricultural	
	The strategic construction of		Economy	
	China-Africa transnational			
	agricultural investment			
C04	基于"资本三要素"视角的	徐鸣	国际经贸探索	2010
	中非农业合作分析	Xu Ming	International	
	Analysis of Sino-Africa		Economics and Trade	
	agricultural cooperation		Research	
	based on "three factors of			
	capital"			
C05	中国与非洲国家农业合作	齐顾波;罗江	中国农业大学学报(社	2011
	的历史与启示	月	会科学版)	
	The evolution of the China-	Qi Gubo; Luo	China Agricultural	
	Africa agricultural	Jiangyue	University Journal of	
	cooperation and its		Social Sciences Edition	
	implications			
C06	我国对非洲农业投资的对	熊发礼;李世	农业经济	2011
	策研究	婧; 董相男	Agriculture Economy	
	Research on China's	Xiong Fali; Li		
	investment in African	Shijing; Dong		
	agriculture	Xiangnan		
C07	中国与非洲农业合作的形	李嘉莉	世界农业	2012
	态与成效	Li Jiali	World Agriculture	
	The shape and effectiveness			
	of China and Africa			
	agricultural cooperation			
C08	中国对非洲农业投资及其	吕少飒	国际经济合作	2013
	评价	Lü Shaosa	Journal of International	
	China's agricultural		Economic Cooperation	
	investment in Africa and its			
	performance review			
C09	中国对非洲农业援助形式	唐晓阳	世界经济与政治	2013
	的演变及其效果	Tang Xiaoyang	World Economics and	
	The transformation and		Politics	
	effects of Chinese			
	agricultural aid to Africa			

Table 1.1 (cont'd)

ID	Title <sup>1</sup>	Authors	Journal	Publication
				Year
C10	中非农业合作的困境、地位和出路	高贵现; 朱月	中国软科学	2014
	China-Africa agricultural cooperation:	季; 周德翼	China Soft	
	plight, status and solutions	Gao Guixian;	Science	
		Zhu Yueji;		
		Zhou Deyi		
C11	中国援非农业专家派遣项目的可持	陆继霞;何倩;	世界农业	2015
	续性初探	李小云	World	
	Preliminary study on the sustainability	Lu Jixia; He	Agriculture	
	of China's aid program of sending	Qian; Li		
	agricultural experts to Africa	Xiaoyun		
C12	援非农业技术示范中心运行的现	朱月季, 周德	世界农业	2015
	状、问题及对策:以中-莫农业示范	翼,汪普庆	World	
	中心为例	Zhu Yueji;	Agriculture	
	The operation of Sino-African	Zhou Deyi;		
	agricultural technology demonstration	Wang Puqing		
	center and its challenges: the case in			
	Mozambique			

The English corpus was curated from a literature search via Science Direct, Web of Science, and JSTOR done with the inclusive search terms *China*, *Africa*, and *agriculture*. An initial list of about two dozen was further reduced by removing any articles whose scope included more than just China and Africa agriculture relations (e.g. several papers comparing China's and Brazil's approach to agricultural projects in Africa were removed).

The Mandarin-language search was conducted using the CNKI database (http://www.cnki.net), searching only peer-reviewed articles for the terms  $\#\mathbb{E}$  [China/Chinese],  $\#\mathbb{E}$  [Africa/Africa]), and  $\mathbb{E}$  [agriculture/agricultural]. The initial search returned over 100 results which were whittled down to about forty articles using title and abstracts to determine relevancy. Further reduction to twelve articles to match the English-language corpus did introduce some subjectivity into article selection. Our Chinese-language article list was populated based mainly by using citation statistics provided by CNKI, tempered by not allowing for any author-journal repeats so that a variety of voices were included in the final list.<sup>2</sup>

## Prepping Articles for Topic Modeling

For the English corpus, we used Adobe Acrobat Pro X to convert article PDFs to plain text (UTF-8 format). The plain text was then cleaned to address any conversion issues as well as remove ancillary text such as references and page numbers. We chose to split our bodies of text into three separate subgroups: title, abstract, and full text, which included headings, image captions, and tables but excluded references and footnotes. This was done because we hypothesize that the language used in abstracts and especially in titles is more sensational and thus exaggerates the differences between the English- and Chinese-language texts.

PDF-to-text conversion was unreliable for the articles with Mandarin text. We found it most efficient to just copy and paste the Mandarin text directly into Notepad and then save as plain text (UTF-8 format). The plain text was then cleaned to address any transfer issues (i.e. line breaks) as well as remove ancillary text such as references and page numbers. As with the English texts, each article was split into three text files: (i) only the title text; (ii) only the abstract text; and, (iii) the body text including headings, image captions, and tables but excluding references and footnotes.

As our chosen topic model program, MALLET, relies on spacing between words, all the Mandarin text also had to be spaced, or segmented. We used the Python-based segmentation tool, Jieba<sup>3</sup>, to segment all the Mandarin plain text files. We added three words to the standard dictionary: 中非, 技术示范中心, and 走出去 [China-Africa, agricultural technology demonstration center, and going out]. All three are common words in China-Africa literature but

were not properly segmented into their word-character groupings using only the standard Jieba dictionary.

#### Initial Data Runs

MALLET, or the machine learning for language toolkit, is a Java-based package for statistical natural language processing (McCallum, 2002). MALLET was the most user-friendly option for topic modeling software that also allowed for flexible language pre-processing (i.e. adjustable stop word lists) and worked with both roman and non-roman characters. For topic modeling, MALLET has the option to run models with or without hyperparameter optimization. Schöch (2016) explored the differences in model performance between optimization choices and found that less topics generally perform better than more as does not using hyperparameter optimization. Schöch concluded that in instances where "you're interested in detecting trends affecting rather large groups in the data rather than in a fine-grained discovery tool" then the non-optimized models may be more useful (Schöch, 2016). Accordingly, we do not use hyperparameter optimization in our models.

Stop words are common terms that serve a syntactic function but reveal little useful information about the content of a document (Wilbur and Sirotkin, 1992). For English texts, we used MALLET's default stop word list augmented with the additional stop words as seen in *Table 1.2*. For Mandarin texts, we used an open-source, aggregate stop word list compiled from multiple lists (e.g. Baidu stop words).<sup>3</sup> China-Africa relevant characters were also added to this list.

English Additional Stop Words	Mandarin Additional Stop Words	
China	中国 [China/ese]	非洲地区 [Africa Region]
Chinese	非洲 [Africa/n]	一系列 [a series of]
Africa	农业 [agriculture/ral]	一部分 [a part]
African	中非 [China-Africa]	一时期 [a period of time]
China's	文章 [article/paper]	接下来 [next]
Africa's	越来越 [more and more]	有的是 [some are]
agriculture	这方面 [This angle]	从本体上 [from the main part]
agricultural	大部分 [most/ly]	进一步 [a step further]
China-Africa	实际上 [in fact/actuality]	近年来 [in recent years]
Chinese-African	基本上 [basically]	非洲大陆 [African continent]
paper	大多数 [almost all]	所在国 [the country]
article	撒哈拉 [Sahara]	

Table 1.2 Words added to default English and Mandarin stop word lists

We experimented with multiple model runs using both the abstract and full text collections of English and Mandarin texts. We compared the results from models generating five, ten, fifteen, and twenty topics. The primary basis of comparison was the ease of connecting the MALLET output to a unified theme.

For the abstracts, both twenty and ten topics were too many. The resulting topics were jumbled rather than clearly delineated as unique from one another. Limiting the model to only five topics resulted in interpretable topics; however, each topic was essentially confined to only one abstract each. In other words, there were no common topics between the abstracts; the abstracts were acting as individual topics.

For the full texts, the models with fifteen and twenty topics generated several uninterpretable topics while the model runs with ten and five topics resulted in interpretable categories. Based on these results, we also tested model results with seven topics but found that doing so resulted in muddled categories.

After the experimental runs as described above, it was evident that with only twelve articles per language both titles and abstracts were too short to properly use topic modeling.

Instead, both groups were analyzed and compared using simple frequency counts via VOYANT<sup>5</sup> (Sinclair and Rockwell, 2016). The same stop word lists were applied to the VOYANT analysis as used with MALLET. Both the English and Mandarin corpus each contain one article with no abstract, so there were elven abstracts analyzed per language.

Clear, easily understood topic groupings for the full texts were generated with both five and ten topics. We chose to use five topics for our final analysis as five topics were distinct while ten topics started to split main topics into subtopics within a shared theme. However, both were equally interesting and worthy of study – indeed, all results of our topic trials are available in *Appendix 1A*.

## Analysis

MALLET produces two major outputs: a composition document cataloging the weight of each topic in individual texts and a list of the top twenty keywords that define each topic. *Table 1.3* presents the results of the English topic model, while *Table 1.4* details the results of the model run on the Chinese texts.

Topic	Identifier	Key words	Description
No.			
Topic 1	Large-scale Investments	rice, investment companies, government, State, Mozambique, land, projects, million, company, project, food, experts, province, private, aid, Zimbabwe, production, farm, state- owned	This topic focuses on the large-scale agricultural projects with direct Chinese investment, either state-owned (often organized at the provincial level) or private
Topic 2	Diplomacy and Engagement	land, development, local, economic, cooperation, investments, social, role, tenure, rural, resources, food, growing, security, reform, sustainable, engagement, trade, approach, understanding	This topic discusses the diplomatic reasons for Chinese engagement in African agriculture

Table 1.3 Topics and their key words, English texts

Topic	Identifier	Key words	Description
No.			•
Topic	Labor	work, Senegalese, team, centre,	This topic focuses on the
3		farmers, provide, land, explained, long,	local-level realities of the
		process, study, Senegal, staff, means,	people involved in these
		years, working, French, management,	agricultural projects or
		trainings, workers	businesses
Topic	Training	training, aid, technology, courses,	This topic involves the
4		development, cooperation, policy,	various training and
		countries, commercial, model, central,	knowledge transfer
		technical, political, demonstration,	programs organized by
		officials, experience, important,	China with regards to
		research, ATDC, government	African agriculture
Topic	Chinese	farm, farms, farmers, business,	This topic focuses on the
5	Entrepreneurs	Zambia, local, sector, market,	Chinese individuals
		Ethiopia, Ghana, food, migrants,	owning / running /
		workers, farming, people, time,	managing farms in Africa
		countries, vegetables, large, small	

Table 1.3 (cont'd)

As seen in *Table 1.3*, we have interpreted and summarized the five topics present in the English corpus as (1) large-scale investments, (2) diplomacy and engagement, (3) labor, (4) training, and (5) Chinese entrepreneurs. Key words associated with each topic, as the words that are most frequently assigned to that topic, are critical for topic interpretation. For example, Topic 4, training, includes the key words *training, aid, technology, courses, demonstration, and experience.* Taken together, these words signal methods of Chinese training frameworks in Africa from offering agricultural courses for African officials to technology demonstration centers. Noticeably, different countries are associated with different topics. We can surmise that Mozambique and Zimbabwe are more frequently referenced in texts on large-scale land investments while Ethiopia and Ghana are most often used as case studies on Chinese farmers in Africa.



Organized by Publication Date 2008 - 2016

## Figure 1.1 Document composition by topic, English texts

While most documents are composed primarily of one or two topics, all documents do

include all five topics to varying degrees. For example, as seen in Figure 1.1, the Bräutigam and

Ekman (2012) paper, "Rumors and Realities of Chinese Agricultural Engagement in

Mozambique," is composed of 70% of Topic 1, large-scale investments. Meanwhile the Alden

(2013) article, "China and the Long March into African Agriculture" is split more distinctly

between Topics 1, 2, and 5 - as might be expected for an overview article.

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Topic	Identifier	Key words	Description
No.			
Topic 1	Agricultural Technology Demonstration Center (ATDC) Duality	技术示范中心, 农产品, 莫桑比克, 可持续 性, 农作物, 贸易额, 传统友谊, 贸易总额, 非 贸易, 互补性, 实际行动, 长期性, 政治经济, 不利于, 统治者, 农场主, 当地政府, 取决于, 进出口, 亩产量 ATDC, agricultural products, Mozambique, sustainability, crop, trade volume, traditional friendship, total trade, trade (with Africa), complementarity, action, long-term, political economy, is harmful to, ruler, farmer, local government, depending on, import and export, vield (per mu)	This topic focuses on the dual nature of ATDCs as both a center for agricultural aid as well as a potential business model.

Table 1.4 Topics and their key words, Chinese texts

Table 1.4 (cont'd)

Topic	Identifier	Key words	Description
No.			
Topic 2	Training and Technology	受援国, 技术人员, 农业部, 可持续性, 中国 政府, 有利于, 合作项目, 有效性, 技术培训, 积极性, 当地人, 商务部, 合作开发, 专家组, 科学技术, 有助于, 示范作用, 管理体制, 劳 动力, 技术推广 recipient country, technical staff, Ministry of Agriculture, sustainability, Chinese government, beneficial to, cooperation projects, validity, technical training, enthusiasm, locals, ministry of commerce, cooperative development, expert group, science and technology, helpful, demonstration role, management system, labor force_technology extension	This topic involves the various training and knowledge transfer programs organized by China with regards to African agriculture.
Tonio	Morkotizing	labor force, technology extension 坦桑尼亚 現代化 刀特殊 主任化 主任係	This tonia
3	Africa	<sup>坦案尼亚</sup> , 现代化, 与拉维, 币场化, 币场经 济, 赞比亚, 埃塞俄比亚, 几内亚, 相结合, 有 限公司, 经济效益, 总公司, 毛里塔尼亚, 结 构调整, 万公顷, 乌干达, 成功经验, 生命力, 国际化, 加工厂 Tanzania, modernization, Malawi, marketization, market economy, Zambia, Ethiopia, Guinea, combine, LLC, economic benefits, head office, Mauritania, structural adjustment, 10k ha, Uganda, success experience, vitality, globalization, processing plant	encapsulates the various reasons Africa is 'ready' for agricultural investment.
Topic 4	Investment Context	农产品, 走出去, 粮食安全, 世界银行, 经济 作物, 一体化, 畜牧业, 种植业, 有助于, 万美 元, 投资者, 优惠政策, 回报率, 科学家, 水资 源, 农工商, 联合国粮农组织, 管理制度, 工 业化, 企业化 agricultural products, go out, food security, World Bank, crops, integration, animal husbandry, crop farming, helpful, \$10k, investor, preferential policy, response rate, scientists, water resources, agricultural business, FAO, management system, industrialization, enterprise-zation	This topic focuses on providing the background context for why China should invest in African agriculture.

Table	l.4 (cont'd)		
Topic	Identifier	Key words	Description
No.			
Topic 5	Diplomacy	中国政府,发展中国家,基础设施,粮食安 全,人力资本,南南合作,改革开放,联合国, 推广站,发达国家,技术推广,无偿援助,经 济效益,亿美元,试验站,人力资源,生产能 力,FAO,平等互利,全球化 Chinese government, developing countries, infrastructure, food security, human capital, South-South cooperation, reform and opening, United Nations, extension station, developed countries, technology extension, grant assistance, economic benefits, \$100m, test station, human resources, production capacity, FAO, equality and mutual benefit, globalization	This topic focuses on the diplomatic and aid components of China's engagement in African agriculture.

As seen in Table 4, we have interpreted and summarized the five topics present in the Mandarin corpus as (1) agricultural technology demonstration center (ATDC) duality, (2) training and technology transfer, (3) marketizing Africa, (4) investment context, and (5) diplomacy. Due to the nature of topic models, the Chinese character word-pairs actually made it easier to use key words to interpret topics. For example, 结构调整[structural adjustment] and 成功经验[successful experience], both part of Topic 3, would have been separated further as their English translations into structural and adjustment or successful and experience. In Mandarin, however, they retain their relationships, which makes their association with marketization that much clearer.



Organized by Publication Date 2008 - 2016

#### Figure 1.2 Document composition by topic, Chinese texts

As seen in *Figure 1.2*, most papers in the Mandarin corpus touch on diplomacy as well as investment context with smaller mixes of the other topics. A few papers, such as the paper by Gao, Zhu, and Zhou (2014), "The dilemma, position, and way forward for Sino-African cooperation in agriculture," are specialized in one topic, such as ATDC duality or training and technology transfer.

#### Comparative Analysis

Our results reveal that English-language and Chinese-language literature on China-Africa agricultural engagements both focus on training and diplomacy but differ significantly on other topics (*Table 1.5*). The English corpus focuses on the act of investing while the Mandarin corpus looks more at why Africa is an appropriate investment venue. Put differently, the language in the English-language corpus is more empirical, while the Mandarin-language literature is more prescriptive. Additionally, there is a stark distinction between the micro- and macro-scope of the literature: while English articles consider the individual-scale issues of local labor as well as Chinese farmers, Mandarin articles instead focus on the large-scale forces involved in African

agriculture. Further, while both discuss ATDCs, the Mandarin corpus more uniformly discusses the dual nature of the ATDCs as both an extension of aid and a potential source of profit.

Topics, English Texts	Topics, Chinese Texts
(1) Large-scale Investments	(1) ATDC Duality
(2) Diplomacy and Engagement	(2) Training and Tech. Transfer
(3) Labor	(3) Marketizing Africa
(4) Training	(4) Investment Context
(5) Chinese Entrepreneurs	(5) Diplomacy

Table 1.5 Comparison of topics in English and Mandarin texts

Considering the whole of both bodies of literature, Topics 1 and 2, large-scale investments and diplomacy and engagement, are the most discussed within the entire English corpus (see *Figure 1.3*). For the Mandarin corpus, Topic 5, diplomacy, is the topic most discussed with Topic 4, investment context, a close second (see *Figure 1.3*). Based on our topic model, the diplomatic nature and nuances of the China-Africa relationship are important points for discussion in both English and Chinese academic texts. English scholars, however, focus more on a specific type of agricultural investment (large-scale) while Chinese scholars look at the act of investment in Africa as a more generalized whole.



Figure 1.3 Topic prevalence across the corpus, English and Chinese

This split is also evident when comparing themes as pulled from abstracts and titles. A key word appears across both corpora, *cooperation*; however, the overall tone in even the titles is quite different. While the most frequent words in English include land and politics, reflecting concerns for Chinese 'land grabs' in Africa and Chinese political engagement on the continent the most frequent title words in Mandarin rather reflect the optimistic and results-oriented stance of the literature, with words such as solution, sustainability, and investment. A concern with optics is also present, with the use of  $\Re \vec{x}_{r}$ , or *appearance/shape*.

Table 1.6 Comparison of frequent words in article titles		
English Frequent Words (# of)	Mandarin Frequent Words (# of)	
Cooperation (3)	合作(5) cooperation	
Development (3)	投资 (3) investment	
Engagement (3)	可持续性(2)sustainability	
Land (2)	对策(2) solution	
Politics (2)	形式(2) appearance/shape	

Table 1.6 Comparison of frequent words in article titles

A review of the abstracts of these articles displays similar trends. The concern over physical land issues in the English-language corpus is made clear through a basic text analysis, or at least there is a desire to highlight this contentious issue in an article's abstract. Similarly, there remains a desire to emphasize cooperation and aid in the Mandarin-language abstracts. Note that the Chinese word for physical land  $\pm \#$  was not added to our stop word list; its absence when compared with *land* in the English abstracts is conspicuous.

English Frequent Words (# of)	Mandarin Frequent Words (# of)
Land (20)	合作 (35) cooperation
Development (15)	发展 (22) development
State (14)	帮助(19)aid
Cooperation (10)	投资 (15) investment
Engagement (10)	资本 (13) capital
Policy (8)	$\Delta \psi$ (15) capital
Business (7)	TEME (9) Inni/company
Aid (6)	项目 (9) project
New (6)	专家 (8) expert/specialist
Research (6)	技术 (8) technology
	国家(6)country

Table 1.7 Comparison of frequent words in article abstracts

## Limitations

Many of these differences may just be a question of audience. Chinese scholars in the humanities and social sciences write to a national audience and are not as visible at the international publication level as their colleagues in the engineering and natural sciences (Flowerdew and Li, 2009). Hard science disciplines offer more incentives (professional and monetary) for scholars to publish in English (ibid). Further, fewer humanities and social sciences courses involve English instruction, creating an additional barrier via level of English competency expected (ibid). At the same time, there are different 'culturally preferred rhetorical strategies [and] epistemological beliefs' in anglicized, Western academic writing and Chinese academic writing (Hu and Cao, 2011). English and Chinese academic prose values different discourse features and rhetoric patterns (Loi and Evans, 2010), such that knowledge produced by Chinese scholars for a Chinese audience will emphasize different topics than that produced by western scholars for a western audience. Thus, differences in audience could have an impact both on the production and reception of knowledge in these disciplines. Audience considerations becomes an especially salient point when authors publish in both English and Mandarin and/or collaborate with each

other on mutual projects. This is the case with the China-Africa field, as can be seen in *Table 1.1* (e.g. E01 and C09 share authors, as does E10 and C05). Presumably, while the knowledge generation starts from shared practice, differences in audience expectation alter how the authors create and shape their final content.

These results are diagnostic not prognostic; the makeup of our current topic models may not predict the major themes of academic literature on China-Africa agriculture in the future. While the use of distant reading through topic modeling is considered a more systematic approach, it is not wholly objective. The corpus of literature analyzed was chosen through a subjective selection mechanism, and themes were based off of the authors' interpretations of the topic models. All our results are available in *Appendix 1A* for further analysis and interpretation.

#### **Conclusion & Recommendations**

For audience or other reasons, based on our topic model, the diplomatic nature and nuances of the China-Africa relationship are important points for discussion in both English and Chinese academic texts. English scholars, however, focus more on a specific type of agricultural investment (large-scale or entrepreneurial) while Chinese scholars look at the act of investment in Africa as a more generalized whole and make recommendations on why, where, and how Chinese investors should go into Africa. For these reasons, we characterize the English research as more descriptive and the Mandarin research more prescriptive.

This project was essentially a pilot study with small collections of English and Mandarin texts. Rather than manually isolate the China-Africa agriculture topic, this same method could be applied to a much larger, less-curated collection of China-Africa texts in both languages. This would allow us to understand what proportion of China-Africa research is dedicated to agriculture topics compared with others (e.g. tourism or natural resource extraction).

Future work could expand this study in two primary ways. First, we should broaden the literature included to all works that touch on the China-Africa agricultural topic without the self-imposed limitation of 'exact match.' Generating a new topic model from a larger corpus would identify which topics adjacent to agriculture or China-Africa are commonly associated with issues about China-Africa agricultural relationships. In a similar manner, repeating the study in five years' time could help develop an understanding of how this area of study is changing over time. Second, China-Africa scholars in both languages are increasingly part of a shared community. Future work could supplement topic modeling with a social network survey or citation analysis to see how professional ties shape researchers' discourse.

We propose that this method and lessons learned from this pilot study can be used to further facilitate multi-language dialogue within disciplines and themes (such as the study of China and Africa), furthering scholarly communication and knowledge production in a global context. Topic modeling is often used to interrogate themes in literature, but we propose, based on this experience, that it is useful for a wide variety of text formats, including academic writing. By speaking to non-English voices, even when we cannot easily read or speak fluently that language, we create a more honest and inclusive conversation around key global topics.

NOTES

## NOTES

1. When available, we used the English translations of the Chinese article titles provided by their journal. We generated title translations for articles C01, C02, C03, C06, C07, C08, and C11.

2. Of possible side interest for direct comparison is the one article we removed due to shared author and content in both English and Mandarin. "What can Africa Learn from China's Experience in Agricultural Development?" by Li, X., Tang, L., Xu, X., Qi, G., and Wang, H. in 2013 mirrored the 2011 article, 中国农业发展对非洲的启示 [Lessons for Africa from China's Agricultural Development] by 李小云, 郭占锋, and 武晋 [Li Xiaoyun, Guo Zhanfeng, and Wu Jin] in 西亚非洲 [West Asia and Africa].

3. Jieba is a Chinese text segmentation tool available from github at https://github.com/fxsjy/jieba.

4. The stop word list is generated from almost thirty separate sources, available as a collection from github at https://github.com/stopwords-iso/stopwords-zh.

5. Voyant Tools is an open-source, web-based text analysis application available at http://voyant-tools.org.

APPENDIX

## **APPENDIX 1.1 – Topic Model Runs**

Appendix 1.1 contains the additional topic model runs at 10, 15, and 20 topics.

1	2	3	4	5
Government, food,	State, company,	Farm, zambia, farms,	Land, development,	Sector, ghana, migrants
farming, large,	companies, business,	aid, projects, workers,	local, tenure,	ethiopia, local, farms,
engagement, project,	Zimbabwe, government,	farmers, work, experts,	investments,	business, first, time,
countries, years,	province, farm, state-	market, land, south,	sustainable, resource,	people, market,
ministry, country,	owned, mozambique	firms, zambian, official,	reform, resources,	businesses, embassy,
involved,	local, political, hubei,	sierra leone, baoding,	social, economic,	number, sectors,
demonstration, research,	including, provincial,	profit, co-operation	political, communities,	vegetables, companies,
small, overseas,	established, support,		rural, systems, sector,	agri-food, buy, meet
opportunities part, year,	investment, central,		investors, state, current,	
produce, case	firms		governance	
1	7	0	0	10
6	1	8	9	10
Training, courses,	/ Senegalese, work, land,	8 development, aid,	9 rice, land, investment,	10 countries, commercial,
6 Training, courses, development, aid,	/ Senegalese, work, land, centre, explained,	8 development, aid, cooperation, farmers,	rice, land, investment, mozambique, million,	10 countries, commercial, cooperation, policy,
o Training, courses, development, aid, technology, atdc, model,	/ Senegalese, work, land, centre, explained, Senegal, staff, trainings,	8 development, aid, cooperation, farmers, food, local, trade,	y rice, land, investment, mozambique, million, production, interest,	countries, commercial, cooperation, policy, economic, experience,
Training, courses, development, aid, technology, atdc, model, participants atdcs,	7 Senegalese, work, land, centre, explained, Senegal, staff, trainings, chen, workers, don't,	8 development, aid, cooperation, farmers, food, local, trade, production, support,	rice, land, investment, mozambique, million, production, interest, reports, security,	10 countries, commercial, cooperation, policy, economic, experience, foreign, developing,
Training, courses, development, aid, technology, atdc, model, participants atdcs, extension center,	7 Senegalese, work, land, centre, explained, Senegal, staff, trainings, chen, workers, don't, team, french, field,	8 development, aid, cooperation, farmers, food, local, trade, production, support, security, focus, provide,	9 rice, land, investment, mozambique, million, production, interest, reports, security, international, media,	10 countries, commercial, cooperation, policy, economic, experience, foreign, developing, approach, beijing,
o Training, courses, development, aid, technology, atdc, model, participants atdcs, extension center, knowledge, rice,	/ Senegalese, work, land, centre, explained, Senegal, staff, trainings, chen, workers, don't, team, french, field, samba, performance,	8 development, aid, cooperation, farmers, food, local, trade, production, support, security, focus, provide, technical, role,	9 rice, land, investment, mozambique, million, production, interest, reports, security, international, media, foreign, projects, oil,	10 countries, commercial, cooperation, policy, economic, experience, foreign, developing, approach, beijing, interests, engagements,
o Training, courses, development, aid, technology, atdc, model, participants atdcs, extension center, knowledge, rice, mofcom, transfer, team,	/ Senegalese, work, land, centre, explained, Senegal, staff, trainings, chen, workers, don't, team, french, field, samba, performance, give, water, time,	8 development, aid, cooperation, farmers, food, local, trade, production, support, security, focus, provide, technical, role, infrastructure, key,	9 rice, land, investment, mozambique, million, production, interest, reports, security, international, media, foreign, projects, oil, companies, investments,	10 countries, commercial, cooperation, policy, economic, experience, foreign, developing, approach, beijing, interests, engagements, focac, important,
o Training, courses, development, aid, technology, atdc, model, participants atdcs, extension center, knowledge, rice, mofcom, transfer, team, demonstration, officials,	7 Senegalese, work, land, centre, explained, Senegal, staff, trainings, chen, workers, don't, team, french, field, samba, performance, give, water, time, farmers	8 development, aid, cooperation, farmers, food, local, trade, production, support, security, focus, provide, technical, role, infrastructure, key, market, domestic,	9 rice, land, investment, mozambique, million, production, interest, reports, security, international, media, foreign, projects, oil, companies, investments, story, grain, hectares,	10 countries, commercial, cooperation, policy, economic, experience, foreign, developing, approach, beijing, interests, engagements, focac, important, brautigam, terms,
o Training, courses, development, aid, technology, atdc, model, participants atdcs, extension center, knowledge, rice, mofcom, transfer, team, demonstration, officials, programs, centers	7 Senegalese, work, land, centre, explained, Senegal, staff, trainings, chen, workers, don't, team, french, field, samba, performance, give, water, time, farmers	8 development, aid, cooperation, farmers, food, local, trade, production, support, security, focus, provide, technical, role, infrastructure, key, market, domestic, system, process	rice, land, investment, mozambique, million, production, interest, reports, security, international, media, foreign, projects, oil, companies, investments, story, grain, hectares, beijing	10 countries, commercial, cooperation, policy, economic, experience, foreign, developing, approach, beijing, interests, engagements, focac, important, brautigam, terms, billion, institutions,

English, 10 Topics – Run 2/2/18 (optimized = no)

	0 /			
1	2	3	4	5
aid, technology, atdc,	land, rice, investment,	cooperation, economic,	aid, companies,	sector, commercial,
transfer, atdcs,	million, mozambique,	development, approach,	projects, beijing, farm,	private, time, bank,
technical, partners,	interest, investments,	aid, role, engagements,	experts, rice, sierra,	experience, production,
extension, central,	reports, project, story,	developing, trade,	farms, rural, leone,	states, south, major,
cooperation, experts,	foreign, reported,	brautigam, actors,	farmers, corporation,	infrastructure, technical,
political, commented,	evidence, invest, grain,	institutions, technology,	began, co-operation,	commodities,
technologies, center,	mozambican, zte, drc,	interests, context,	programme, built, crops,	involvement, forum,
machinery, tanzania,	oil, cameroon	growth, good, world,	hectares, produce	demand, imports,
operation, work,		billion, resources	-	continent, fund,
ethiopia				importance
6	7	8	9	10
farming, government,	ghana, migrants,	company, business,	farm, zambia, farms,	countries, food,
food, production, large,	business, ethiopia,	state, zimbabwe,	workers, farmers, work,	engagement, security,
part, case, research,	sector, local, farms,	mozambique, province,	zambian, firms,	global, projects,
years, small, companies,	people, embassy,	government, farm,	land, market, johnken,	international, ministry,
number, media, set,	vegetables, countries,	political, companies,	world, western, profit,	support, development,
market, back, year,	businesses,	hubei, investment,	socialist, manager,	country, project, export,
involved, found, grow	opportunities,	provincial, relations,	villages, maize,	policy, focus, overseas,
-	investment, agri food,	state owned, including,	managers, employees	potential, growing,
	shop, addis, ghanaian,	support, strategy, firms,		opportunities, assistance
	restaurant, first	friendship		
11	12	13	14	15
state, people, domestic,	training, courses,	land, local, investments,	local, development,	senegalese, land,
activities, work, means,	participants, policy,	development, tenure,	farmers, team,	centre, work,
explained, providing,	commercial, foreign,	reform, sustainable,	demonstration, rice,	senegal, trainings, chen,
efforts, understanding,	officials, development,	foreign, resource, social,	government, system,	donate, staff, field,
greater, success, form,	beijing, mofcom,	communities, resources,	long, process, working,	samba, performance,
scale, ground, problem,	countries, knowledge,	investors, lack, systems,	terms, strong,	give, training,
job, left, stage, problems	consensus, soft,	current, rights, issues,	management, practices,	techniques, workers,
5	important, model,	smallholders, political	policy, national, social,	deals, fields, french, plot
	different, wider,		high, implementation	. , , , , , ,
	lecturers, educational			

## English, 15 Topics – Run 2/2/18 (optimized = no)

1	2	3	4	5
farmers, food, sector,	aid, sierra, beijing, rural,	training, courses,	farm, zambia, farms,	development,
growing, south,	engagement, leone,	participants, aid,	workers, zambian,	cooperation, policy,
involved, major,	experts, co-operation,	foreign, countries,	firms, johnken,	economic, political,
instance, area, areas,	programme,	commercial, officials,	managers, manager,	role, model, important,
due, similar, aimed,	corporation, hybrid,	consensus, beijing,	commercial, market,	good, context,
demand, markets,	opportunities,	mofcom, technology,	socialist, villages, work,	understanding,
world's, legal, official,	competition, baoding,	soft, power, lecturers,	employees, profit, soe,	knowledge, institutions,
costs, position	official, diplomacy,	programs, educational,	national, plantation,	experiences,
	centres, consolidation,	different, wider,	western	international, growth,
	late, sugar	developing		relations, diplomatic,
(	7	0	0	strong, success
6	/	8	9	
aid, technology, local,	migrants, ghana,	sector, farming, number,	countries, trade,	land, tenure, local,
team, demonstration,	ethiopia, business, local,	opportunities, time,	export, potential, focac,	investments,
alde, aldes, extension,	husinggage large	case, market,	ballk, billioli,	sustainable, lesource,
technologies technical	agri food vogetables	first sectors petworks	commercial, comment,	social look foreign
rice exports	farm ghangian shop	uggetable numbers	infrastructure interests	social, lack, loleigh,
commented countries	addis small food	common general back	focus resources	systems rights
operation system	mohan restaurant	larger fieldwork fact	providing assistance	smallholders groups
members	monan, restaurant	larger, neiuwork, raet	experience impact	rural policy-makers
members			experience, impact	investors
11	12	13	14	15
business, state,	land, investment, food,	government, local,	production, aid,	approach, engagements,
zimbabwe, company,	large, farming, security,	support, farm, company,	development, state,	actors, cooperation,
mozambique,	media, foreign, set,	research, years,	market, people, local,	global, brautigam,
investment, companies,	international, hectares,	enterprises, construction,	world, developing,	understand,
provincial, province,	crops, produce,	friendship, make, grow,	scale, years, social,	engagement, increasing,
state-owned, central,	countries, zambia, build,	studies, case, key,	domestic, projects,	partner, informants,
hubei, wanbao, tobacco,	early, agribusiness,	interviews, centre,	problems, large-scale,	narratives, ngo, support,
loans, state, business,	year, small	engagement, long, table	developed, greater,	literature, gov, beijing,
technology, million,			technology, small	repeatedly, discourse,
commercial, manager				nature
16	17	18	19	20
mozambique, rice,	training, experience,	senegalese, land,	part, country, work,	project, projects,
million, investments,	means, time, work,	centre, work, staff,	including, based,	companies, rice,
mozambican, reports,	working, management,	senegal, chen, trainings,	involved, building,	ministry, interest,
production, evidence,	practices, practice,	donate, field, farmers,	present, partners,	global, overseas,
story, cameroon, hubei,	level, varieties, officials,	samba, explained,	program, cases, run,	private, tarm, farms,
oil, firms, province,	daily, job, day, politics,	workers, french,	reality, focus, seeds,	began, national,
approved, published,	paid, worked, hand,	performance, team,	end, received, back,	contract, demonstration,
venture, pleagea,	negotiations	give, techniques, fields	period, english	joint, state-owned,
beijing, conventional				reported, agreement,
				built

## English, 20 Topics – Run 2/2/18 (optimized = no)

# Mandarin, 10 Topics – Run 2/2/18 (optimized = no)

1	1E
有利于,进一步,合作项目,合作开发,总公司,近年来,人员培训, 一部分,劳动力,经贸合作,殖民主义,贴息贷款,单方面,一时期, 多元化,海外投资,人力资本,充分利用,从根本上,多功能	beneficial to, Further, Cooperation projects, Cooperative, development, head office, In recent years, staff, training, Part, Workforce, Economic and Trade Cooperation, Colonialism, Discount, Ioans, Unilateral, A period, Diversification, Overseas Investment, human capital, Take advantage of, Basically, Multifunction
2	2E
市场化,市场经济,埃塞俄比亚,赞比亚,几内亚,万美元,推广站, 全球化,工业化,结构调整,乌干达,政治经济,毛里塔尼亚,农机 具,非洲大陆,成功经验,生命力,联合国,国际化,产业化	Market-oriented, Market economy, Ethiopia, Zambia, Guinea, Ten thousand U.S dollars, extension station, Globalization, Industrialization, Structural Adjustment, Uganda, Political economy, Mauritania, Agricultural machinery, African continent, successful experience, Vitality, United Nations, globalization, Industrialization
3	3E
中国政府,粮食安全,发展中国家,南南合作,fao,生产能力,优惠政策,互补性,重要性,致力于,一系列,病虫害,经验丰富,温家宝, 龙头企业,农业机械,高级别,中小型,工作组,农业院校	Chinese government, Food security, Developing countries, South-South cooperation, Fao, Production capacity, Preferential policies, Complementarity, Importance, Dedicated to, A series, Pests and diseases, Ample experience, Wen Jiabao, Leading enterprises, Agricultural machinery, high-level, Small and medium, Work group, Agricultural colleges and universities
4	4E
受援国,可持续性,农业部,有效性,技术推广,积极性,当地人,有助于,商务部,专家组,管理体制,工作效率,科学技术,取决于,实质性,示范作用,建筑面积,因地制宜,文化背景,民族志	Recipient countries, Sustainability, Ministry of Agriculture, Effectiveness, Technology Promotion, Positivity, Locals, Help, Ministry of Commerce, Expert group, Management system, Work efficiency, Science & Technology, Depending on, Substantive, Demonstration role, Construction area, According to local conditions, Cultural background, Ethnography
5	5E
农产品,技术示范中心,可持续性,贸易额,传统友谊,贸易总额, 非贸易,实际行动,长期性,走出去,统治者,生产方式,无偿援助, 世界市场,发展壮大,不利于,精耕细作,领导人,需求量,吸收能 力	Agricultural products, Technology Demonstration Center, Sustainability, Trade volume, Traditional friendship, Total trade, Non-trade, Action, Long-term, Go out, Ruler, Production methods, Gratuitous assistance, Global market, Grow and develop, Is harmful to, Intensive cultivation, Leader, Demand, Absorption capacity
6	6E
技术示范中心,莫桑比克,技术人员,农作物,技术培训,进一步, 农场主,当地政府,亩产量,管理人员,进出口,部长级,两国政府, 栽培技术,培训班,技术水平,按计划,科技部,基金会,湖北省	Technology Demonstration Center, Mozambique, Technical staff, Crops, Technical Training, Further, Farmer, Local government, Mu, production manager, Import and export, Ministerial level, The two governments, Cultivation Techniques, Training class, Technical level, As planned, Ministry of Science and Technology, Foundation, Hubei Province 7E
/	infrastructure World Bank Crops One hundred million U.S. dollars
资源,农田水利,适应性,试验站,迫切需要,农业部门,大规模,劳 动密集型,竞争力,索马里,国民经济,塞拉利昂,贫困人口,优良 品种	Developed countries, United Nations, Human Resources, Farmland irrigation, Adaptability, Test station, Urgent need, Agricultural sector, Large-scale, Labor-intensive, Competitiveness, Somalia, National economy, Sierra Leone, Poor people, Fine varieties
8	8E
农产品,走出去,粮食安全,撒哈拉,非洲地区,一体化,畜牧业,科 学家,农工商,水资源,企业化,有助于,发展中国家,回报率,价值 链,东道国,促发展,经营型,生产总值,相结合	Agricultural products, go out, Food security, Sahara, Africa region, Integration, Animal husbandry, the scientist, Agriculture and industry, Water resources, Enterprise, Help, Developing countries, response rate, Value Chain, Host country, Promote development, Operating type, Gross product, Combine
	95
坦桑尼亚,现代化,马拉维,经济效益,中国政府,有限公司,技术 人员,所在国,加工厂,安哥拉,综合性,接下来,形式多样,私人企 业,意味着,万公顷,商业化,中国式,埃塞俄比亚政府,可行性研 究	Tanzania, Modernization, Malawi, Economic benefits, Chinese government, Limited, Technical staff, Country, Processing plant, Angola, Comprehensive, Next, Various forms, Private business, Means, Ten thousand hectares, commercialize, Chinese-style, Ethiopian, government, Feasibility study
	10E
种植业,投资者,联合国粮农组织,自然资源,改革开放,粮食作物, 一系列,和平共处,平等互利,互惠互利,五项原则,吸引力,技术 落后,投资国,经济基础,水土流失,跨国企业,外交政策,多方面, 以点带面	crop farming, Investors, FAO, Natural resources, Reform and Opening, Food crops, A series, Live together peacefully, Equality and mutual benefit, mutual benefit, Five principles, Attractive, Technical backwardness, Investment country, economic basis, Soil and water loss, Multinational corporations, Foreign policy, Many ways, From point to area

# Mandarin, 15 Topics – Run 2/2/18 (optimized = no)

1	1E
坦桑尼亚,马拉维,现代化,有限公司,受援国,人民币,成功经验, 建筑面积,接下来,中国式,埃塞俄比亚政府,可行性研究,农科院, 科学院,占地面积,试验田,尽如人意,国际化,生态条件,艰巨性	Tanzania, Malawi, Modernization, Limited, Recipient countries, RMB, success experience, construction area, Next, Chinese-style, Ethiopian government, Feasibility study, Academy of Agricultural Sciences, Academy of Sciences, Land area, Experimental field, Meets expectations, Globalization, Ecological conditions, Arduous
2	2E
撒哈拉,非洲地区,一体化,畜牧业,有助于,科学家,农工商,水资源,回报率,价值链,东道国,经营型,生产总值,耕地面积,农业科研,外国投资,摩洛哥,举足轻重,可行性,索马里	Sahara, Africa region, Integration, Animal husbandry, Help, the scientist, Agriculture and industry, Water resources, response rate, Value Chain, Host country, Operating type, gross product, cultivated area, Agricultural research, Foreign investment, Morocco, Important, Feasibility, Somalia
3	3E
南南合作, fao, 传统友谊, 实际行动, 政治经济, 致力于, 生产能力, 长期性, 经验丰富, 温家宝, 基尼系数, 高级别, 中小型, 工作组, 基 金会, 世界粮食计划署, 发展缓慢, 经济援助, 力所能及, 首要任务	South-South cooperation, Fao, Traditional friendship, Action, Political economy, dedicated to, Production capacity, Long-term, Ample experience, Wen Jiabao, Gini Coefficient, high-level, Small and medium, work group, Foundation, World Food Program, develop slowly, Financial aid, Within our power, The primary task
4	4E
市场化,埃塞俄比亚,现代化,赞比亚,相结合,乌干达,毛里塔尼 亚,一部分,世界银行,生命力,精耕细作,万公顷,几内亚,现实意 义,生产率,自由化,安哥拉,生产国,文化素质,幅员辽阔	Market-oriented, Ethiopia, Modernization, Zambia, Combine, Uganda, Mauritania, Part, World Bank, Vitality, Intensive cultivation, 10K hectares, Guinea, Realistic meaning, Productivity, Liberalization, Angola, Producing countries, Cultural quality, A vast territory
5	5E
经济作物,和平共处,世界市场,互惠互利,优惠政策,五项原则, 自然资源,跨国企业,外交政策,多方面,以点带面,附加条件,多 功能,再生产,发展潜力,回报率,水土流失,阿尔及利亚,掠夺式, 原料库	Crops, Live together peacefully, Global market, mutual benefit, Preferential policies, five principles, Natural resources, Multinational corporations, Foreign policy, many ways, from point to area, Additional conditions, Multifunction, Reproduce, Development potential, response rate, Soil and water loss, Algeria, Predatory, Raw material library
6	6E
技术示范中心,莫桑比克,农作物,技术培训,亩产量,管理人员, 进出口,改革开放,两国政府,栽培技术,形式多样,按计划,科技 部,农业院校,着眼于,多种形式,农场主,办公室,研究院,陈燕娟	Technology Demo Center, Mozambique, Crops, Technical Training, Mu production, Manager, Import and export, Reform and Opening, The two governments, Cultivation Techniques, Various forms, As planned, Ministry of Science and Technology, Agricultural colleges and universities, Focus on , Many forms, Farmer, Office, Institute, Chen Yanjuan
	/E
受援国,专家组,管理体制,科学技术,技术推广,工作效率,医疗 卫生,文化背景,民族志,出国前,水利工程,同一个,心理咨询,连 续性,福利待遇,有的是,客观条件,负面影响,为国争光,基层工 作	Recipient countries, Expert group, Management system, Science & Technology, Technology Promotion, Work efficiency, medical hygiene, cultural background, Ethnography, Before going abroad, Water conservancy project, the same one, Counseling, Continuity, Welfare, Some are, objective factor, Negative impact, Glory for the country, Grass- roots work
8	8E
农产品,技术示范中心,贸易额,贸易总额,统治者,发展壮大,互补性,吸收能力,技术落后,不断加强,生产方式,需求量,湖北省,两极分化,政治势力,充分认识,农场主,赞比亚,来源于,增长率	Agricultural products, Technology Demonstration Center, Trade volume, Total trade, Ruler, Grow and develop, Complementarity, Absorption capacity, Technical backwardness, constantly strengthen, production methods, Demand, Hubei Province, Polarization, Political forces, fully understand, Farmer, Zambia, From, growth rate
9	9E
可持续性,农业部,有效性,当地人,中国政府,商务部,有助于,积极性,技术水平,取决于,大规模,加工厂,人力资本,奇奔巴,经济社会,购买力,不必要,身体健康,实地调查,局限于	Sustainability, Ministry of Agriculture, Effectiveness, Locals, Chinese government, Ministry of Commerce, Help, Positivity, technical level, depending on, Large-scale, Processing plant, human capital, Qi Benba, economic Society, Purchasing power, Unnecessary, Healthy body, Field survey, Limited to
10	10E
种植业,投资者,发达国家,尼日利亚,投资国,技术创新,殖民主义,市场潜力,集约型,水产业,安全性,私有化,大中型,环境保护, 尼日尔,环境污染,畜产品,充分考虑,肯尼亚,尽可能	crop farming, Investors, developed countries, Nigeria, Investment country, Technological innovation, Colonialism, Market potential, Intensive, Aquaculture, Safety, Privatization, Large and medium-sized, Environmental protection, Niger, Environmental pollution, Livestock products, Take full account, Kenya, As much as possible
	IIE Developing constraint Information W/ 11D 1 1 1 1 1 199
友展甲国家, 基础设施, 世界银行, 亿美元, 农业部门, 经济作物, 技术推广, 联合国, 人力资源, 农田水利, 适应性, 竞争力, 发达国 家, 坦桑尼亚, 塞拉利昂, 贫困人口, 优良品种, 农业投入, 至关重 要, 病虫害	Developing countries, Infrastructure, World Bank, one hundred million U.S. dollars, Agricultural sector, Crops, Technology Promotion, United Nations, Human Resources, Farmland irrigation, Adaptability, Competitiveness, developed countries, Tanzania, Sierra Leone, Poor people, Fine varieties, Agricultural input, It is very important, Pests and diseases

12	12E
经济效益,市场经济,总公司,非洲大陆,结构调整,所在国,无偿援助,单方面,意味着,战略重点,中国政府,平方米,多种经营,前提条件,援助者,帝国主义,贴息贷款,意识形态,租赁经营,总体而言	Economic benefits, Market economy, head office, African continent, Structural Adjustment, Country, Gratuitous assistance, Unilateral, Means, strategic focus, Chinese government, Square meter, A variety of management, Preconditions, Donors, Imperialism, Discount loans, Ideology, Lease management, Overall
13	13E
农产品,粮食安全,走出去,万美元,近年来,全球化,非贸易,企业 化,农机具,促发展,不利于,国民经济,生产资料,绿色革命,全方 位,历史悠久,改革开放,农业机械,民营企业,内部化	Agricultural products, Food security, go out, ten thousand U.S. dollars, in recent years, Globalization, Non-trade, Enterprise, Agricultural machinery, promote development, is harmful to, National economy, Production materials, Green revolution, All-round, Historical, Reform and Opening, Agricultural machinery, Private Enterprise, Internalization
14	14E
中国政府,进一步,有利于,一系列,合作项目,技术人员,合作开发,重要性,联合国,联合国粮农组织,人员培训,劳动力,劳动密 集型,一时期,几内亚,经济基础,充分利用,优惠政策,从根本上, 多元化	Chinese government, Further, beneficial to, A series, Cooperation projects, Technical staff, Cooperation and development, Importance, United Nations, FAO, staff training, Workforce, Labor-intensive, A period, Guinea, economic basis, Take advantage of, Preferential policies, Basically, Diversification
15	15E
技术人员,推广站,试验站,平等互利,当地政府,示范作用,迫切 需要,产业化,周期长,经贸合作,实质性,海外投资,龙头企业,培 训班,粮食作物,胡锦涛,吸引力,可重复性,私人企业,沙漠化	Technical staff, Promotion station, Test station, Equality and mutual benefit, Local government, Demonstration role, urgent need, Industrialization, Long period, Economic and Trade Cooperation, Substantive, Overseas Investment, Leading enterprises, Training class, Food crops, Hu Jintao, Attractive, Repeatability, Private business, Desertification

# Mandarin, 20 Topics – Run 2/2/18 (optimized = no)

1	1E
进一步,有利于,合作项目,一时期,从根本上,联合国,阶段性,意 识形态,租赁经营,主导作用,福利待遇,多样化,国有企业,各个 领域,更多地,第三方,生产性,包干制,国务院,十多个	Further, beneficial to, Cooperation projects, A period, Basically, United Nations, Phased, Ideology, Lease management, Leading role, Welfare, Diversified, State-owned enterprises, each field, More, Third party, Productive, Dry package, State Department, more than ten
2	2E
粮食安全,种植业,改革开放,近年来,投资者,联合国粮农组织, 进一步,耕地面积,农机具,劳动密集型,尼日利亚,摩洛哥,可行 性,技术创新,吸引外资,万美元,市场潜力,协调性,举足轻重,私 有化	Food security, crop farming, Reform and Opening, in recent years, Investors, FAO, Further, cultivated area, Agricultural machinery, Labor- intensive, Nigeria, Morocco, Feasibility, Technological innovation, Attract foreign investment, Ten thousand U.S. dollars, Market potential, Coordination, Important, Privatization
3	3E
农产品,不利于,合作项目,增长率,发展壮大,殖民主义,非贸易, 生产资料,竞争力,需求量,购买力,支柱产业,肯尼亚,幅员辽阔, 刚果民主共和国,几千年,宗主国,充分认识,王晨燕,生产率	Agricultural products, is harmful to, Cooperation projects, Growth rate, Grow and develop, Colonialism, Non-trade, Production materials, Competitiveness, Demand, Purchasing power, Pillar industry, Kenya, A vast territory, Democratic Republic of the Congo, For thousands of years, Sovereign State, Fully understand, Wang Chen Yan, productivity
4	4E
中国政府,粮食安全,南南合作,发展中国家,fao,重要性,实际行动,政治经济,技术水平,万美元,部长级,温家宝,龙头企业,农业机械,高级别,中小型,工作组,计划经济,外交关系,双边合作	Chinese government, Food security, South-South cooperation, developing countries, Fao, Importance, Action, Political economy, technique level, ten thousand U.S. dollars, Ministerial level, Wen Jiabao, Leading enterprises, Agricultural machinery, high-level, Small and medium, work group, Planned economy, Diplomatic relations, Bilateral cooperation
5	5E
市场化,合作开发,人员培训,一部分,劳动力,经济基础,实质性, 农科院,国内外,几十年,科研院所,适应性,十分重视,资本主义, 无论是,国际货币基金组织,重庆市,影响力,积极探索,陈燕娟	Market-oriented, Cooperation and development, staff training, Part, Workforce, economic basis, Substantive, Academy of Agricultural Sciences, At home and abroad, Decades, Research institutes, Adaptability, It attaches great importance to, Capitalism, Whether it is, International Monetary Fund, Chongqing, Influence, Active exploration, Chen Yanjuan
6	6E
经济效益, 赞比亚, 几内亚, 总公司, 非洲大陆, 示范作用, 埃塞俄 比亚, 安哥拉, 单方面, 意味着, 战略重点, 奇奔巴, 形式多样, 自由 化, 前提条件, 加工业, 经济援助, 尼日尔, 实用技术, 局限于	Economic benefits, Zambia, Guinea, head office, African continent, Demonstration role, Ethiopia, Angola, Unilateral, Means, strategic focus, Qi Benba, Various forms, Liberalization, Preconditions, Processing Industry, Financial aid, Niger, Practical technology, Limited to
7	7E
技术推广,试验站,生产能力,人力资源,农业部门,迫切需要,病 虫害,经验丰富,贫困人口,优良品种,培训班,发达国家,胡锦涛, 农业院校,着眼于,多种形式,因地制宜,民营企业,制度化,掠夺 式	Technology Promotion, Test station, Production capacity, Human Resources, Agricultural sector, urgent need, Pests and diseases, Experience, Poor people, Fine varieties, Training class, developed countries, Hu Jintao, Agricultural colleges and universities, Focus on, Many forms, According to local conditions, Private Enterprise, Institutionalized, Predatory 8F
安山郊 右边枕 丰家组 右肋干 领导人 民族主 山国前 当地人	Ministry of Agriculture Effectiveness Expert group Help Leader
花虹前,有双住, 家东纽,有助了, 领守八, 民庆心, 山酉间, 当地八, 连续性, 文化背景, 有的是, 客观条件, 为国争光, 基层工作, 开阔 视野, 实地调查, 科学技术, 埃塞俄比亚人, 事实上, 自给自足	Ethnography, before going abroad, Locals, Continuity, cultural background, some are, objective factor, Glory for the country, Grass-roots work, Broaden their horizons, Field survey, Science & Technology, Ethiopian, In fact, Self-sufficient
9	9E
一系列,传统友谊,优惠政策,互补性,发达国家,致力于,经济作物,基尼系数,技术落后,水土流失,产业化,发展潜力,不容忽视,突尼斯,各项政策,整体规划,供求关系,贸易条件,经营方式,粗放型	A series, Traditional friendship, Preferential policies, Complementarity, developed countries, Dedicated to, Crops, Gini Coefficient, Technical backwardness, Soil and water loss, Industrialization, Development potential, Cannot be ignored Tunisia, Various policies, overall plan, Supply and demand Terms of trade, Mode of operation, Extensive
半等互利,和半共处, 五项原则, 生活状况, 多元化,互惠互利, 跨国 企业, 外交政策, 世界粮食计划署, 长期性, 私人企业, 大中型, 海 外投资, 沙漠化, 无偿援助, 阿尔及利亚, 尽可能, 自然环境, 优势 互补, 以点带面	Equality and mutual benefit, Live together peacefully, Five principles, Living condition, Diversification, mutual benefit, Multinational corporations, Foreign policy, World Food Program, Long-term, Private business, Large and medium-sized, Overseas Investment, Desertification, Gratuitous assistance, Algeria, As much as possible, Natural environment, Complementary advantages, From point to area
中国政府,技术人员,市场经济,推广站,走出去,现代化,结构调整,全球化,技术示范中心,经贸合作,乌干达,综合性,贴息贷款, 毛里塔尼亚,研究院,多种经营,商业性,总体而言,非贸易,粮农 组织	Chinese government, Technical staff, Market economy, Promotion station, go out, Modernization, Structural Adjustment, Globalization, Technology Demonstration Center, Economic and Trade Cooperation, Uganda, Comprehensive, Discount Ioans, Mauritania, Institute, A variety of management, Commercial, Overall, Non-trade, FAO

12	12E
当地人,生产方式,所在国,人民币,精耕细作,接下来,不断加强, 艰巨性,商业化,埃塞俄比亚政府,科学院,可重复性,经济社会, 无偿援助,靠天吃饭,进口产品,生存能力,边缘化,宏观政策,轧 花厂	Locals, production methods, Country, RMB, Intensive cultivation, Next, constantly strengthen, Arduous, commercialize, Ethiopian government, Academy of Sciences, Repeatability, economic Society, Gratuitous assistance, rely on the weather to eat, Imported products, Survival ability, Marginalization, macro policy, Ginning plant
13	13E
技术示范中心,贸易额,可持续性,贸易总额,农业部,统治者,取 决于,走出去,吸收能力,长期性,两极分化,政治势力,帝国主义, 来源于,受限于,湖北省,受制于,服务业,利益集团,促进作用	Technology Demonstration Center, Trade volume, Sustainability, Total trade, Ministry of Agriculture, Ruler, depending on, go out, Absorption capacity, Long-term, Polarization, Political forces, Imperialism, From, limited by, Hubei Province, Subject to, Service industry, interest group, enhancement
14	14E
坦桑尼亚,有限公司,马拉维,建筑面积,加工厂,相结合,可行性研究,平方米,占地面积,试验田,尽如人意,长时间,工作日,卢旺达,市场需求,日益增长,发挥作用,研究者,brautigam,国际化	Tanzania, Limited, Malawi, construction area, Processing plant, Combine, Feasibility study, Square meter, Land area, Experimental field, Enough, Long time, working day, Rwanda, Market demand, Growing, Play a role, Researcher, Brautigam, globalization
15	15E
农产品,自然资源,世界市场,工业化,有利于,多方面,附加条件, 多功能,再生产,吸引力,多样性,可耕地,原料库,半个世纪,国营 企业,经营机制,周期长,灾难性,扩大出口,生态环境	Agricultural products, Natural resources, Global market, Industrialization, beneficial to, many ways, Additional conditions, Multifunction, Reproduce, Attractive, Diversity, Arable land, Raw material library, half a century, State-owned enterprises, Operating mechanism, Long period, Disastrous, Expand exports, ecosystem
16	16E
撒哈拉,非洲地区,一体化,畜牧业,走出去,回报率,科学家,农工 商,水资源,价值链,企业化,东道国,经营型,生产总值,相结合, 农业科研,外国投资,投资国,促发展,博士学位	Sahara, Africa region, Integration, Animal husbandry, go out, response rate, the scientist, Agriculture and industry, Water resources, Value Chain, Enterprise, Host country, Operating type, gross product, Combine, Agricultural research, Foreign investment, Investment country, Promote development. PhD
17	17E
现代化,马拉维,埃塞俄比亚,市场化,生命力,成功经验,中国式, 有助于,万公顷,毛里塔尼亚,社会转型,培训师,应运而生,灌溉 工程,永久性,阿尔法,减贫起,chemingui,增长极,根深蒂固	Modernization, Malawi, Ethiopia, Market-oriented, Vitality, success experience, Chinese-style, Help, ten thousand hectares, Mauritania, Social transformation, trainer, came into being, Irrigation project, Permanent, Alpha, Poverty reduction, Chemingui, Growth pole, ingrained
	18E
吴桑比克, 技术示范中心, 农作物,农场主, 技术人员, 亩产量, 管理 人员, 当地政府, 进出口, 两国政府, 栽培技术, 按计划, 科技部, 办 公室, 提供援助, 跨文化, 财务部, 咨询部, 培训部, 研究部	Mozambique, Technology Demonstration Center, Crops, Farmer, Technical staff, Mu production, manager, Local government, Import and export, The two governments, Cultivation Techniques, As planned, Ministry of Science and Technology, Office, Provide assistance, Cross- culture, Finance Department, Consulting Department, Training place, Research
19	19E
基础设施,世界银行,发展中国家,有助于,亿美元,联合国,经济 作物,农田水利,索马里,国民经济,塞拉利昂,大规模,绿色革命, 近几年,至关重要,全方位,多管齐下,灌溉系统,集约型,适应性	infrastructure, World Bank, developing countries, Help, one hundred million U.S. dollars, United Nations, Crops, Farmland irrigation, Somalia, National economy, Sierra Leone, Large-scale, Green revolution, recent years, it is very important, All-round, Multi-pronged approach, Irrigation system, Intensive, Adaptability 20E
至援国 可持续性 技术控制 和极性 农作物 商冬郊 德理体制	Recipient countries Sustainability Technical Training Positivity Crops
又这回,可讨实住,以不后则, 你饭住, 私任初,回劳司, 冒理体制, 工作效率, 医疗卫生, 研究所, 各个方面, 人力资本, 粮食安全, 不 必要, 同一个, 心理咨询, 工作人员, 负面影响, 责任心, 更进一步	Ministry of Commerce, Management system, Work efficiency, medical hygiene, graduate School, every aspect, human capital, Food security, Unnecessary, the same one, Counseling, staff member, Negative impact, Responsibility. Further

REFERENCES

## REFERENCES

Alden, C. (2013). China and the long march into African agriculture. *Cahiers Agricultures*, 22(1), 16-21.

Blei, D.M. (2012). Topic modeling and digital humanities. *Journal of Digital Humanities*, 2(1), 8-11.

Bräutigam, D., & Tang, X. (2009). China's engagement in African agriculture: Down to the countryside. *The China Quarterly*, *199*, 686-707.

Bräutigam, D., & Zhang, H. (2013). Green dreams: Myth and reality in China's agricultural investment in Africa. Third World Quarterly, 34(9), 1676-1696.

Bräutigam, D., & Ekman, S. M. S. (2012). Briefing rumours and realities of Chinese agricultural engagement in Mozambique. *African Affairs*, *111*(444), 483-492.

Buckley, L. (2013a). Chinese agriculture development cooperation in Africa: Narratives and politics. *IDS Bulletin*, 44(4), 42-52.

Buckley, L. (2013). Chinese Land - Based Interventions in Senegal. *Development and Change*, 44(2), 429-450.

Chen, Y., & Deng, Y. (2008). Zhongfei nongye hezuo kechixuxing yanjiu [A study on the sustainability of Sino-African agricultural cooperation]. *Shijie nongye*, 2008(1), 63-65.

Choi, H. S., Lee, W. S., & Sohn, S. Y. (2017). Analyzing research trends in personal information privacy using topic modeling. *Computers & Security*, 67, 244-253.

Cook, S., Lu, J., Tugendhat, H., & Alemu, D. (2016). Chinese migrants in Africa: Facts and fictions from the agri-food sector in Ethiopia and Ghana. *World Development*, *81*, 61-70.

Corkin, L. J. (2014). China's rising Soft Power: the role of rhetoric in constructing China-Africa relations. *Revista Brasileira de Política Internacional*, *57*(SPE), 49-72.

De Smet, W., & Moens, M. F. (2009, November). Cross-language linking of news stories on the web using interlingual topic modelling. In *Proceedings of the 2nd ACM Workshop on Social Web Search and Mining* (pp. 57-64). Hong Kong: ACM.

Flowerdew, J., & Li, Y. (2009). English or Chinese? The trade-off between local and international publication among Chinese academics in the humanities and social sciences. *Journal of Second Language Writing*, *18*(1), 1-16.

Fu, X., Liu, G., Guo, Y., & Wang, Z. (2013). Multi-aspect sentiment analysis for Chinese online social reviews based on topic modeling and HowNet lexicon. *Knowledge-Based Systems*, *37*, 186-195.

Gao G., Zhu, Y., & Zhou, D. (2014). Zhongfei nongye hezuo de kunjing, diwei, he chulu [China-Africa agricultural cooperation: plight, status and solutions]. *Zhongguo ruan kexue*, 2014(1), 36-42.

Garcia-Zorita, C., & Pacios, A. R. (2017). Topic modelling characterization of Mudejar art based on document titles. *Digital Scholarship in the Humanities*, *33*(3), 529-539.

Gu, J., Zhang, C., Vaz, A., & Mukwereza, L. (2016). Chinese state capitalism? Rethinking the role of the state and business in Chinese development cooperation in Africa. *World Development*, *81*, 24-34.

Hairong, Y., & Sautman, B. (2010). Chinese farms in Zambia: from socialist to "agro-imperialist" engagement?. *African and Asian Studies*, 9(3), 307-333.

Hu, G., & Cao, F. (2011). Hedging and boosting in abstracts of applied linguistics articles: A comparative study of English-and Chinese-medium journals. *Journal of Pragmatics*, *43*(11), 2795-2809.

Lee, C. (2018). How are 'immigrant workers' represented in Korean news reporting?—A text mining approach to critical discourse analysis. *Digital Scholarship in the Humanities, 34*(1), 82-99.

Li, J. (2012). Zhongguo yu feizhou nongye hezuo de xingtai yu chengxiao [The shape and effectiveness of China and Africa agricultural cooperation]. *Shijie nongye, 2012*(12), 8-12.

Liu, A. (2013). The meaning of the digital humanities. PMLA, 128(2), 409-423.

Loi, C. K., & Evans, M. S. (2010). Cultural differences in the organization of research article introductions from the field of educational psychology: English and Chinese. *Journal of Pragmatics*, *42*(10), 2814-2825.

Lu, J., He, Q., & Li, X. (2015). Zhongguo yuan fei nongye zhuanjia paiqian xiangmu de kechixuxing chutan [Preliminary study on the sustainability of China's aid program of sending agricultural experts to Africa]. *Shijie nongye*, 2015(4), 16-20.

Lü, S. (2013). Zhongguo dui feizhou nongye touzi ji qi pingjia [China's agricultural investment in Africa and its performance review]. *Guoji jingji hezuo*, 2013(2), 66-70.

McCallum, A.K. (2002). MALLET: A Machine Learning for Language Toolkit [Software]. Available from http://mallet.cs.umass.edu

Mimno, D., Wallach, H. M., Naradowsky, J., Smith, D. A., & McCallum, A. (2009, August). Polylingual topic models. In *Proceedings of the 2009 Conference on Empirical Methods in* 

*Natural Language Processing* (pp. 880-889). Singapore: Association for Computational Linguistics.

Newman, D. J., & Block, S. (2006). Probabilistic topic decomposition of an eighteenth - century American newspaper. *Journal of the American Society for Information Science and Technology*, *57*(6), 753-767.

Ni, X., Sun, J. T., Hu, J., & Chen, Z. (2009, April). Mining multilingual topics from Wikipedia. In *Proceedings of the 18<sup>th</sup> International Conference on World Wide Web* (pp. 1155-1156). Madrid: ACM.

Oh, J., Stewart, A. E., & Phelps, R. E. (2017). Topics in the Journal of Counseling Psychology, 1963–2015. *Journal of Counseling Psychology*, *64*(6), 604.

Qi, G., & Luo, J. (2011). Zhongguo yu feizhou guojia nongye hezuo de lishi yu qishi [The evolution of the China-Africa agricultural cooperation and its implications]. *Zhongguo nongye daxue xuebao (shehui kexue ban)*, 28(4), 11-17.

Qin, Z., Cong, Y., & Wan, T. (2016). Topic modeling of Chinese language beyond a bag-of-words. *Computer Speech & Language*, 40, 60-78.

Sautman, B., & Hairong, Y. (2008). The forest for the trees: Trade, investment and the China-in-Africa discourse. *Pacific Affairs*, 81(1), 9-29.

Schöch, C. (2016, Nov. 14). Topic Modeling with MALLET: Hyperparameter Optimization [Blog]. Retrieved from https://dragonfly.hypotheses.org/1051

Sinclair, S., & Rockwell, G. (2016). Voyant Tools [Web Tool]. Available from http://voyant-tools.org/

Steyvers, M., & Griffiths, T. (2007). Probabilistic topic models. In: Landauer, T.K., McNamara, D.S., Dennis, S., & Kintsch, W. (Eds.), *Handbook of Latent Semantic Analysis* (pp.424-440). New York: Routledge.

Sun, L., & Yin, Y. (2017). Discovering themes and trends in transportation research using topic modeling. *Transportation Research Part C: Emerging Technologies*, 77, 49-66.

Tang, X. (2013). Zhongguo dui feizhou nongye yuanzhu xingshi de yanbian ji qi xiaoguo [The transformation and effects of Chinese agricultural aid to Africa]. *Shijie jingji yu zhengzhi*, 2013(5), 55-157.

Tugendhat, H., & Alemu, D. (2016). Chinese agricultural training courses for African officials: Between power and partnerships. *World Development*, *81*, 71-81.

Wang, C. (2008). Dui feizhou nongye yuanzhu xin xingshi de tansuo [A probe into the new forms of agricultural aid in Africa]. *Guoji jingji hezuo, 2008*(4), 35-38.

Wilbur, W. J., & Sirotkin, K. (1992). The automatic identification of stop words. *Journal of Information Science*, *18*(1), 45-55.

Xiong, F., Li, S., & Dong, X. (2011). Woguo dui feizhou nongye touzi de duice yanjiu [Research on China's investment in African agriculture]. *Nongye jingji, 2011*(1), 6-8.

Xu, M. (2010). Jiyu "ziben san yaosu" sjijiao de zhongfei nongye hezuo fenxi [Analysis of Sino-Africa agricultural cooperation based on "three factors of capital"]. *Guoji jingmao tansuo*, 26(9), 46-50.

Xu, X., Li, X., Qi, G., Tang, L., & Mukwereza, L. (2016). Science, technology, and the politics of knowledge: The case of China's agricultural technology demonstration centers in Africa. *World Development*, *81*, 82-91.

Yu, Y. (2009). Lun woguo dui feizhou kuaguo nongye touzi de zhanlüe guojian [The strategic construction of China-Africa transitional agricultural investment]. *Nongye jingji wenti, 2009*(11), 33-39.

Zhao, Y. (2013). China–Africa development cooperation in the rural sector: an exploration of land tenure and investments linkages for sustainable resource use. *Environment, Development and Sustainability*, 15(2), 355-366.

Zhu, Y., Zhou, D., and Wang, P. (2015). Yuan fei nongye jishushifanzhongxin yunxing de xianzhuang, wenti ji duice: Yi zhong-mo nongye shifanzhongxin weili [The operation of Sino-African agricultural technology demonstration center and its challenges: the case in Mozambique]. *Shijie nongye*, 2015(9), 64-69.

# CHAPTER 2 – DETECTING SPILLOVER SYSTEMS: AFRICAN AGRICULTURE DEVELOPMENT AND CHINESE FDI

## Abstract

Using the telecoupling framework, we conceptualize national-level changes in African agricultural development as a potential spillover effect of Chinese foreign direct investment (FDI) in the non-agricultural sectors of African economies. We test the relationship between growth in FDI and changes in three agricultural development indicators: (i) value added by agriculture, forestry, and fishing to a country's economy, (ii) employment in agriculture, and (iii) cereal yield. Using Kendall's tau rank correlation, we investigate the effect of Chinese FDI on African agricultural development and compare it with that of US FDI on the same indicators. Overall, Chinese FDI shows stronger (high tau statistic), more prevalent spillover relationships with agricultural development indicators in most countries across Africa when compared with US FDI over the same time period (2003 to 2015). While China invests in a larger variety of African countries when compared with the US, the US provides a greater amount of overall FDI to Africa. Regardless of origin, FDI seems to show a spillover effect for all three agricultural development indicators; China is currently enabling said spillover effect in far more countries than the US. The conclusions drawn in this paper are preliminary, but mechanisms outlined by the telecoupling framework highlight where spillover impacts may be most likely and show how more specific data, once available, can be analyzed in similar ways to further elucidate the connection between investment in non-agricultural sectors and agricultural development.

### Introduction

The African Union (AU) first declared the Comprehensive African Agriculture Development Programme (CAADP) in 2003; over a decade later and the need for an African agricultural revolution is still emphasized as a necessary building-block in boosting African economies and improving African livelihoods (Collier and Decron, 2014; Wall et al., 2018). While the need for better agricultural development has not changed over the last decade, what has changed is China's engagement with the African continent. With dramatic growth in trade, investment, and aid, China now joins the European Union (EU) and the United States (US) as Africa's largest commercial partners (Schneidman and Wiegert, 2018).

The most recent Forum on China-Africa Cooperation (FOCAC) concluded in Beijing last September 2018. FOCAC brought with it billions in new loans and foreign aid, including pledges to help increase Africa's agricultural productivity (Tiezzi, 2018). During the summit, Chinese President Xi Jingping's global infrastructure policy, the Belt and Road Initiative (BRI), was rebranded as a vehicle for African regional integration via infrastructure (ibid). Of Xi's eight 'major coordination areas' announced at FOCAC 2018, the second was infrastructure connectivity, promising support for Chinese companies participating in African infrastructure development and support for African countries in finding Chinese financing via resources such as the Asian Infrastructure Investment Bank (Wu, 2018).

As state support for Chinese investment in Africa continues, what does this mean for African agricultural development? How has increased Chinese investment impacted African agricultural development? We ask these questions cognizant of two important qualifiers. First, the majority of Chinese foreign direct investment (FDI) to Africa over the last decade has not gone to the agricultural sector (CARI, 2017). Second, investment in infrastructure can indirectly

benefit agricultural development through improved access to markets and agricultural inputs (Weng et al., 2013). Given these two factors, we propose to use the telecoupling framework to understand the possible impact of Chinese investment on African agricultural development. In this paper we will explain the telecoupling framework and justify our conceptualization of agricultural development as a spillover system; test the existence of this spillover system by looking at the relationship between FDI and agricultural development indicators across Africa; and, finally, show that Chinese FDI may have a unique 'spillover boosting effect' on African agricultural development when compared to US FDI.

#### Framework, Data, and Method

#### Applying the Telecoupling Framework to China-Africa

The telecoupling framework provides an "integrated approach to systems research that explicitly examines socioeconomic and environmental interactions between coupled human and natural systems over distances" (Tonini and Liu, 2017, see also Liu et al., 2013 and Liu et al., 2015). Where globalization refers to the connectedness within a social system, telecoupling includes connections with coupled human-natural systems across large distances (Rasmussen and Nielsen, 2014). The telecoupling framework is made up of coupled human and natural systems; flows of information/material/energy; agents that facilitate flows; causes that drive flows; and, effects that result from these flows (Liu et al., 2013). Within the telecoupling framework, systems are differentiated between sending, receiving, and spillover systems (ibid). For example, the telecoupled soybean trade between Brazil, the sending system producing soybeans, and China, the receiving system purchasing the produce, with the US soybean market acting as a spillover system (ibid).

Telecoupling generates spillover systems when "an interaction between a sending and receiving system generates flows and effects that spill over to other locations" (Liu et al., 2018, p59). Spillover systems are more than just side effects, intentional or otherwise. Spillover systems are "explicitly associated with telecoupling causes, sending and receiving systems, flows, agents, and effects...[and] explicitly incorporate both socioeconomic and environmental linkages with sending and/or receiving systems." (Liu et al., 2018, p59). Examples of past work on spillover systems under a telecoupling framework include the spillover effects that urban water systems have on crop management and water quality in spatially distant systems (Yang et al., 2016) and conservation efforts in the Amazon which reduce deforestation in the sending system but increase deforestation in the spillover system (Dou et al., 2018).



Figure 2.1 Conceptual Telecoupling Model of China-Africa Investment
Figure 2.1 illustrates our conceptual model of the China-Africa investment telecoupling using the telecoupling framework. Here, China acts as the sending system, sending investment (FDI) the majority of which falls under infrastructure or construction (which, as of the most recent FOCAC, has been re-branded as part of the BRI). Each African country's infrastructure and mining sectors serve as the receiving system, and, for their own part, provide access to markets and improved commercial and diplomatic relationships to China in exchange for investment. We conceptualize impact on African agricultural development as a spillover effect of Chinese investment in African economies. Agriculture is considered a spillover system in the context of investment because, currently, the majority of FDI from China to Africa does not go into the agricultural sector. Rather, in 2016, 28.3% of Chinese FDI went to construction, 26.1% to mining, 12.8% to manufacturing, 11.4% to financial, 4.8% to IT services, and 16.6% to everything else, including agriculture (CARI, 2017). According one report, only 5% of China's outward FDI into Africa in 2014 went into the agricultural sector (Wall et al., 2018). As Chinese investment in construction (infrastructure) and mining sectors increases, more capital and infrastructure support are available to the agricultural system of the recipient country. This allows for better agricultural outcomes such as better accesses to markets and tools/technology to increase agricultural production as well as, conversely, more non-agricultural jobs for family members to support those that remain engaged in agriculture.

Though the majority of telecoupling literature focuses on sending and receiving systems, there is a growing recognition of the importance of studying spillover systems. In particular, Liu et al. (2018) sets out a typology for spillover systems in a telecoupling framework. Using this typology, we show how the conceptualization mapped in *Figure 2.1* can be understood as a spillover system:

- *Flow Type*: Receiving-linked spillover system, wherein the spillover is evident in the receiving system only.
- *Distance from main systems*: Adjacent spillover system, wherein the spillover system is physically and socio-economically close to the receiving system.
- *Effect of spillover system*: Unknown, what we are testing in this paper.
- *Size of the spillover system*: Large, in that our systems and data describing said systems are at the national scale.
- *Role of agents*: Passive, the myriad of agents responsible for infrastructure investments are probably not actively involved in agriculture sectors and vice versa. Note: this does not imply that the African and Chinese agents facilitating said flows are themselves passive or lacking agency. Instead, passivity is implied in the linkages between agents in the receiving system and agents in the spillover system.
- *Origin of the spillover system*: New, while the agricultural system particular to a country is not new, the linkages that couple this system to larger China-Africa systems are newly developing.

In the telecoupling framework, systems can have "multiple typologies and roles" (Liu et al., 2018, p63). As the flows in a telecoupling can be multidirectional, it becomes an analytical choice as to whether a system is categorized as sending, receiving, or spillover (Friis et al., 2016; Dou et al., 2018). Often, the categorization of systems is dependent on "the analytical entry point, the scale of analysis, and the defined flow of interest in the analysis" (Friis et al., 2016, p138). For example, the land conservation spillover system in Dou et al. (2018) could also be a sending system if the flow of interest was the agricultural product—soybeans. However, because

the flow of interest was instead displaced deforestation from the Amazon, the agricultural system in question is a spillover system (ibid).

Due to our flow of interest being FDI, the bulk of which is not investment in agriculture, as well as available data limiting the scale of our analysis to the national scale, we treat the African agricultural development as a spillover system. If we were to look at different flows, agricultural trade, for example, or knowledge exchange, those same agricultural systems could be considered sending or receiving systems. For our study, the spillover designation comes down to two realities: (a) the majority of FDI not being in agriculture, and (b) data availability.

### Quantifying spillover effects – data and method

The key research gap is measuring the effect of Chinese investment on African agricultural development. Previous research has extensively covered the history and drivers of China-Africa agricultural engagements (Bräutigam and Zhang, 2013; Alden 2013, Buckley 2013), the area and geographical extent of Chinese land acquisition across Africa (Bräutigam, 2015), case studies in specific countries (Xu et al., 2014 for Tanzania; Alemu and Scoones, 2013 for Ethiopia; Chichava et al., 2013 for Mozambique; Gu et al., 2016 for Mozambique and Zimbabwe; and, Mukwereza, 2013 for Zimbabwe), and agricultural knowledge exchange (Xu et al., 2016 and Tugendhat and Alemu, 2016). Specific to Chinese engagement improving African livelihoods, a recent study matched increases in nighttime lighting as a proxy for less economic inequality in areas with Chinese transportation projects (Bluhm et al., 2018). However, few studies have yet tested linkages between Chinese investment and agricultural development outcomes, primarily due to (a) limited actual investment in agriculture and (b) limited data.

One prominent exception is *Africa's Freedom Railway* (Monson, 2009), an in-depth analysis of life histories, archival data, aerial imagery, and parcel receipts that re-construct the creation

and lived impact of the TAZARA railway. The railway, completed in 1975, was financed by a Chinese loan and built with Chinese technical support. Ostensibly a large-scale infrastructure project meant to usher in modernity and progress, the railway "became as important to the rural communities located along the railway corridor as it was to the copper mines of Zambia or to the sawmills of Iringa" (Monson, 2009, p4). Entire communities were resettled along the railway, domestic migrants gained access to new land and farming opportunities, and new local markets formed to support small-scale commodities trade (Monson, 2009). The railway also brought new farming techniques and new crops, which were then grown to be sold for sale rather than consumption while at the same time the production of local staple crops also increased (ibid). The TAZARA railway was China's first large-scale infrastructure project in Africa, but certainly not the last. Thus, the impacts one railway had on agricultural development for rural communities in Tanzania and Zambia serve as both proof-of-concept and inspiration for the infrastructure spillover mechanisms hypothesized in this study.

The bulk of current (2003-2015) Chinese FDI does *not* go to African countries' agricultural sectors. However, we hypothesize that Chinese FDI allows for a spillover boosting effect in African agriculture that is (a) noticeable on a national scale and (b) is a uniquely stronger effect than observed when looking at US FDI to Africa for the same time period. Two characteristics essential to the successful development of African agriculture are annual growth in agricultural GDP and a reduction in the number of people engaged in agriculture while at the same time increasing labor productivity (NEPAD, 2003; Collier and Decron, 2014). Consequently, we expect the following potential relationships to be revealed via correlation:

- The value added by agriculture, forestry, and fishing to an African country's economy should have a significant, positive relationship with FDI because as FDI increases in infrastructure and other sectors, it either allows the African state to spend more on agriculture development or it bolsters common resources like roads, transport, and market innovations that in turn bolster better agricultural outcomes.
- 2. Agriculture employment should have a significant, negative relationship with FDI while agricultural yield has a significant, positive relationship because FDI in other sectors will both attract more workers to those sectors than agriculture and diversify off-farm labor options, while at the same time providing boosts in infrastructure and technology that make agricultural production more efficient and thus require less workers.

Returning our conceptual telecoupling model, in *Figure 2.2* we now incorporate our three agricultural indicators as part of the spillover system. As investment in other sectors brings new jobs, farming families may see members switch to off-farm employment, which leads to the reduction in agricultural employment and the expected negative relationship with FDI. This negative relationship does not imply job loss as much as job diversification, where FDI offers off-farm employment and more employment resilience for agricultural laborers. As with investment in large infrastructure and, in particular, roads, off-farm income can also provide better access to markets and tools/technology that improve agricultural production. This is captured both in the presumed positive relationship with FDI and value-added by agriculture (and forestry and fishing) to the economy as well as with cereal yield.



Figure 2.2 China-Africa telecoupling framework with specific agricultural development indicators

We tested the relationships between Chinese and US FDI and agricultural sector indicators using Kendall's tau rank correlation, which works well with non-parametric data and measures concordant and discordant pairs to indicate the strength of a relationship (Noether, 1981). Three agricultural indicators were used, all from World Bank Open Data: agriculture, forestry, and fishing, value-added (constant 2010 US\$), employment in agriculture (% of total employment), and total cereal yield (kg per hectare). While it would be better to have the valueadded to an economy by agriculture separated from that added by forestry and fishing, we were limited to the confines of the original data. In countries with strong forestry and fishing sectors, we may see a false positive for spillover potentials. However, we hope to temper this by including two other agricultural indicators and considering the relationships between investment across all three indicators before drawing conclusions. All data is at the national level and covers the period 2003 to 2015. Kendall's tau rank correlation tests were performed in R (R Core Team, 2019). All correlation tests were performed relative to each individual country; thus, potential outliers are temporal (e.g. the 2008 global recession) rather than locational. That said, the context of agriculture as part of each economy is important, as is the size of each country's reported economic output. Please refer *Appendix 2.1* to compare relative size of each African country's economy in terms of both total and agricultural GDP as well as total stock in FDI from China and the US.

Why FDI: We choose to focus on FDI as the economic input of interest for both theoretical and practical reasons. In terms of theory, FDI may have the best chance at generating a spillover boosting effect. FDI brings the host country access to finance, new technology, new management systems, and skills transfers – all key components for economic growth (Wall et al., 2018). Further, FDI is currently the most common source of external financing. According to UNCTAD (2018), "developing economies can draw on a range of external sources of finance, including FDI, portfolio equity, long-term and short-term loans (private and public), ODA, remittances and other official flows. FDI has been the largest source of external finance for developing economies over the past decade, and the most resilient to economic and financial shocks" (ibid, p12).

Practically, we chose to focus on FDI rather than official development assistance (ODA) not to take a side on the FDI versus ODA debate with regards to development (Vitalis, 2001), but rather because Chinese FDI to Africa continues to increase and because national-level FDI data is available both from the Chinese Ministry of Finance (as collected by CARI, 2017) and from the US Bureau of Economic Analysis (BEA). While there are databases that track ODA (see Dreher et al., 2017), these databases are based on announcements and media releases rather than official statistics (not that official figures are unproblematic). We did not include FDI from the

EU in our analysis because similar national-level data for African countries was not readily available from EuroStat. Future studies should include said data from at least UK and French national databases. We acknowledge that "trade, development assistance, investments, and infrastructure constructions are intertwined with one another" (Wall et al., 2018). Focusing on FDI allows us a focus point for comparison and aligns with our investment telecoupling conceptualization, but a broader definition of financial investment would be just as valid if the data were available. Finally, there is currently no available, by-sector, by-recipient-country FDI data for either China or the US. Even if we wanted to investigate direct impacts of agricultural FDI on agricultural development, said data is not currently available.

Why the US-China comparison: In any analysis of China-Africa relationships there is a larger narrative, a distinct socio-political context, which posits that China is somehow different than 'conventional' Western actors. While this study is a not a true comparative analysis, such a comparison is necessary to address this dominant narrative. By comparing the potential spillover effects of Chinese FDI with US FDI to Africa, we are not challenging said narrative, though we agree with Sautman and Yan's (2008) three distinctions: China-in-Africa cannot be summarized as wholly positive or wholly negative; China-in-Africa has more in common with the West than not; and, nevertheless there are notable differences between Western and Chinese presences in Africa.

Africa's largest economic partners are China, the US, and the EU (Schneidman and Wiegert, 2018). While the US is still the largest overall provider of FDI to Africa, China and the EU are stronger in terms of trade and commercial loans, especially as US trade to the region has dropped in recent years due to decreased energy imports (ibid). In terms of FDI, China is behind the US, UK, and France in contributions (UNCTAD). In 2016, FDI stock in Africa by investor

economies was: US \$57B, UK \$55B, France \$49B, and China \$40B (UNCTAD). Though that gap closes even further when including Hong Kong (at \$13B in 2016, UNCTAD). At the same time, Africa remains the least of the destinations for FDI overall for both the US and China. In 2014, only 6.22% of Chinese outward FDI went to Africa (Wall et al., 2018) and in 2015 only 1.3% of US direct investment abroad went to Africa (Jackson, 2017).

Some studies have shown that Chinese determinants of FDI may differ from conventional ones (if conventional can be taken to mean the Western economic paradigm). For example, conventional FDI determinants to Africa include market size, trustworthiness and lack of corruption, available domestic credit, and level of democracy (Wall et al., 2018). Determinants of Chinese FDI, on the other hand, are energy security concerns, avoiding competition by choosing under-invested and/or relatively less-stable countries, anticipation of future returns, and tend to be less risk-adverse due to state backing (Wall et al., 2018). However, others see China and US motivations for investment coming from similar energy security concerns and resource needs (Carmody and Owusu, 2007). Okafor (2015) found that access to oil and natural gas, infrastructure development, and market size matter for US FDI, while political instability and corruption had an insignificant, though negative, relationship with US FDI to sub-Saharan Africa.

Tangentially, both the US and China export more to African countries they send aid to, while only China tends to import more from African countries it provides aid to (Liu and Tang, 2018). As for ODA, a recent white paper (Landry, 2018) found that China allocates more development finance to its economic and political partners while western countries send more to countries with lower corruption levels and better human rights track records.

Our study does not ask if there are differences in what motivates investment but instead if there are differences in how that investment impacts the host countries. In our telecoupling framework, both the US and China are sending systems. As shown by previous research, the causes that drive these sending systems to send investment may be different. We ask: are the effects on potential spillover systems also different? And if they are different, what does that tell us about the spillover system under study?

## Results

Kendall's tau rank correlation was used to test for relationships between agricultural development indicators and Chinese and US FDI. Evidence of a strong correlation, or a strong relationship, is the first step in quantifying possible spillover systems. The correlation coefficient, as determined by the tau statistic, between FDI and our three agricultural development indicators are shown in *Table 2.3 through Table 2.7*, organized by AU regions: North, Southern, East, West, and Central Africa. *Appendix 2.2* contains maps showing the spatial distribution of the tau statistic. 54 countries in total were included, however, due to missing or censored data (labeled with "NA" where appropriate), we could only test the following pairs:

Table 2.1 Data Pairs		
Agricultural Development Indicator (World Bank Data Center)	China FDI (CARI)	US FDI (BEA)
Agriculture, forestry, and fishing, value-added (constant 2010 US\$)	47 countries	32 countries
Employment in agriculture (% of total employment) Cereal yield (kg per hectare)	48 countries 46 countries	32 countries 34 countries

In total, agricultural value-added shares a strong (high tau statistic), positive correlation with Chinese FDI for 34 African countries and a strong, negative correlation with Chinese FDI for 1 African country (Zambia). In contrast, only 11 African countries share a strong, positive correlation with US FDI and none share a strong, negative correlation. For employment in agriculture, 32 African countries share a strong, negative correlation with Chinese FDI while only 13 share a strong, negative correlation with US FDI. For strong, positive relationships with employment in agriculture, 3 African countries share with Chinese FDI and 1 country with US FDI. For yield, the majority of countries show no relationship with Chinese or US FDI, though almost a quarter do show some form of positive relationship. These results are summarized in *Table 2.2* Even when the total number of countries included in each test is considered, there are noticeably more strong relationships for the agricultural development indicators with Chinese FDI than with US FDI.

Relationship	Value – Chinese FDI (% Total)	Value – US FDI (% Total)	Employ – Chinese FDI (% Total)	Employ – US FDI (% Total)	Yield – Chinese FDI (% Total)	Yield – US FDI (% Total)
Strong, positive (tau > 0.5)	34 (72%)	11 (34%)	3 (6%)	2 (6%)	11 (24%)	5 (15%)
Moderate, positive (0.3 < tau < 0.5)	5 (11%)	2 (6%)	1 (2%)	3 (9%)	10 (22%)	9 (26%)
No relationship (-0.3 < tau < 0.3)	4 (9%)	15 (47%)	4 (8%)	12 (38%)	18 (39%)	15 (44%)
Moderate, negative (-0.5 < tau < - 0.3)	3 (6%)	4 (13%)	8 (17%)	2 (6%)	3 (7%)	2 (6%)
Strong, Negative (tau < -0.5)	1 (2%)	0 (0%)	32 (67%)	13 (41%)	4 (9%)	3 (9%)

 Table 2.2 Summary of Results

*Tables 2.3 to 2.7* show the Kendall rank correlation results for each African country. A correlation test result completely in line with our hypothesis would be the following:

- A significant, positive correlation between FDI and agriculture value-added;
- A significant, negative correlation between FDI and employment in agriculture; and,
- A significant, positive correlation between FDI and yield.

The above result would signify agriculture outcomes in a selected country are improving at the same time that FDI into that country from China or the US is increasing. Rather than walk through each result, country-by-country for every agricultural indicator, here we summarize overall trends and then discuss exceptions and surprises in the following section.

Of the 54 countries tested, 16 show significant (>80% confidence level) positive-negativepositive correlations between Chinese FDI and agricultural value added, agricultural employment, and yield, respectively.

 Benin, Chad, Congo, Cote d'Ivoire, Ethiopia, Gabon, Ghana, Madagascar, Mauritania, Morocco, Rwanda, Sierra Leone, South Africa, Tanzania, Uganda, and Zambia.
 Another 19 countries mostly followed this pattern but had one agricultural indicator showing the

opposite relationship or no relationship.

- FDI had a significant, negative relationship with yield: Egypt, Guinea, and Mauritius.
- *FDI had no significant relationship with yield:* Algeria, Cameroon, Eq. Guinea, Lesotho, Mozambique, Cape Verde, Comoros, Kenya, Liberia, Nigeria, STP, Togo, and Tunisia.
- *FDI had a significant, positive relationship with agricultural employment:* Angola, Malawi, and Mali.

Eight countries showed an unexpected mix of relationships between Chinese FDI and the agricultural indicators: Burundi, DRC, Djibouti, Gambia, Guinea-Bissau, Senegal, Zambia, and

Zimbabwe. Five countries had a significant relationship with only one of the three agricultural indicators: Botswana, CAR, Libya, Namibia, and Niger. Finally, six countries show no relationship with any indicator and/or are missing data for all indicators. These are Burkina Faso, Eritrea, Seychelles, Somalia, South Sudan, and Swaziland/Eswatini.

In contrast, only five countries show significant (<80%) positive-negative-positive correlations between US FDI and agricultural value added, agricultural employment, or yield, respectively. Another six countries mostly followed this pattern with an exception towards yield.

- All three indicators: Mozambique, Rwanda, South Africa, Tanzania, and Tunisia.
- FDI had a significant, negative relationship with yield: Egypt and Mauritius.

• FDI had no significant relationship with yield: Kenya, Liberia, Morocco, and Nigeria.

Four countries showed an unexpected mix of relationships between US FDI and agricultural indicators; Madagascar, Mali, Uganda, and Zambia. 11 countries had a significant relationship with only one of the three agricultural indicators: Botswana, Cameroon, Cote d'Ivoire, Eq. Guinea, Gabon, Lesotho, Libya, Malawi, Mauritania, Namibia, and Sierra Leone. The remaining 26 countries either had data available but showed no relationships (Algeria, Angola, Benin, DRC, Eritrea, Ethiopia, Guinea, Senegal) or had no data available (all the rest).

	CHINA				USA	
COUNTRY	Ag Val	Ag Employ	Yield	Ag Val	Ag Employ	Yield
Algeria	0.95***	-0.95***	0.23	-0.13	0.13	0.18
Egypt	0.95***	-0.64***	-0.67***	0.91***	-0.52**	-0.52**
Libya	NA	0.15	0.45**	NA	NA	0.65**
Mauritania	0.77***	-0.77***	0.51**	0.22	-0.22	0.44†
Morocco	0.69***	-0.87***	0.31†	0.38*	-0.56***	0.15
Tunisia	0.66***	-0.79***	-0.04	0.44**	-0.59***	0.31†
p-value thresholds: $0.01 = ***, 0.05 = **, 0.1 = *, 0.2 = \dagger$						

	CHINA				USA	
COUNTRY	Ag Val	Ag Employ	Yield	Ag Val	Ag Employ	Yield
Angola	0.90***	0.79***	0.41*	0.15	0.21	0.03
Botswana	0.59***	0.23	-0.15	0.21	0.31	-0.36†
Lesotho	0.65***	-0.83***	0.18	0.15	0.03	0.45†
Malawi	0.66***	0.35*	0.35*	-0.05	-0.05	-0.36†
Mozambique	0.99***	-0.99***	0.17	0.70***	-0.70***	0.42†
Namibia	-0.38*	NA	-0.15	0.11	0.33†	-0.04
South Africa	0.74***	-0.67***	0.59***	0.69***	-0.62***	0.49**
Swaziland	NA	NA	NA	NA	NA	NA
Zambia	-0.54**	-0.97***	0.79***	-0.31†	-0.64***	0.56***
Zimbabwe	-0.31†	-0.38*	-0.23	NA	NA	NA
p-values thresholds: 0.01 = ***, 0.05 = **, 0.1 = *, 0.2 = †						

Table 2.4 Southern Africa Estimate Tau

Table 2.5 East Africa Estimate Tau

	CHINA				USA	
COUNTRY	Ag Val	Ag Employ	Yield	Ag Val	Ag Employ	Yield
Comoros	0.58**	-0.55**	0.28	NA	NA	NA
Djibouti	NA	-0.95***	0.79***	NA	NA	NA
Eritrea	NA	0.06	0.12	NA	NA	0.37
Ethiopia	1.00***	-1.00***	0.95***	0.17	-0.17	0.17
Kenya	0.79***	-0.74***	-0.03	0.59***	-0.59***	-0.13
Madagascar	0.62***	-0.67***	0.97***	0.26	-0.45	0.45*
Mauritius	0.85***	-0.90***	-0.72***	0.77***	-0.72***	-0.54**
Rwanda	0.97***	-0.97***	0.71***	0.69*	-0.69**	0.69*
Seychelles	-0.19	NA	NA	NA	NA	NA
Somalia	NA	NA	NA	NA	NA	NA
South Sudan	NA	NA	NA	NA	NA	NA
Sudan	0.64***	-0.36*	NA	NA	NA	NA
Tanzania	0.97***	-0.97***	0.46**	0.81**	-0.81**	0.71**
Uganda	0.92***	-0.31†	0.44**	0.60***	-0.20	0.56**
p-values thresholds: $0.01 = ***, 0.05 = **, 0.1 = *, 0.2 = \dagger$						

	CHINA				USA	
COUNTRY	Ag Val	Ag Employ	Yield	Ag Val	Ag Employ	Yield
Benin	0.77***	-0.64***	0.49**	-0.13	0.23	0.03
Burkina Faso	NA	NA	NA	NA	NA	NA
Cape Verde	0.65***	-0.74***	-0.28	NA	NA	NA
Côte d'Ivoire	0.43†	-0.41*	0.38*	NA	0.41*	-0.18
Gambia	-0.34†	-0.62***	-0.69***	NA	NA	NA
Ghana	0.96***	-0.54**	0.62***	0.21	-0.53**	0.38†
Guinea	0.92***	-0.49**	-0.62***	0.20	NA	NA
Guinea-Bissau	-0.07	-0.59*	-0.46†	NA	NA	NA
Liberia	0.84***	-0.82***	0.15	0.58***	-0.72***	0.05
Mali	0.85***	0.95***	0.51**	0.58†	0.58†	0.35
Niger	0.42†	-0.26	0.13	NA	NA	NA
Nigeria	1.00***	-0.69***	0.05	0.72***	-0.67***	0.03
Senegal	0.67***	0.77***	0.21	-0.23	-0.18	-0.18
Sierra Leone	0.91***	-0.85***	0.73***	-0.45†	0.09	-0.27
Togo	0.31†	-0.44**	0.10	NA	NA	NA
p-values thresholds: $0.01 = ***, 0.05 = **, 0.1 = *, 0.2 = \dagger$						

Table 2.6 West Africa Estimate Tau

Table 2.7 Central Africa Estimate Tau

	CHINA				USA	
COUNTRY	Ag Val	Ag Employ	Yield	Ag Val	Ag Employ	Yield
Burundi	0.19	-0.56**	-0.34†	NA	NA	NA
Cameroon	0.97***	-0.62***	NA	-0.42*	0.13	0.13
Central African Republic	0.09	-0.66***	0.13	NA	NA	NA
Chad	0.67**	-0.78***	0.35†	NA	NA	NA
Congo	0.97***	-0.73***	0.70***	-0.27	0.38†	-0.49**
Congo DRC	1.00***	-0.33†	-0.33†	NA	NA	0.18
Equatorial Guinea	0.47*	-0.41*	NA	0.11	-0.30†	NA
Gabon	0.38*	-0.62***	0.49**	-0.46**	0.03	-0.21
Sao Tome and Principe	0.73*	-0.73*	NA	NA	NA	NA
p-values thresholds: 0.01 = ***, 0.05 = **, 0.1 = *, 0.2 = †						

#### Discussion

Overall, Chinese FDI shows stronger, more prevalent potential spillover relationships with agricultural development indicators in most countries across Africa when compared with US FDI over the same time period (2003 to 2015). 72 percent of countries analyzed had a strong, positive relationship between Chinese FDI and the value added by agriculture, fishing, and forestry to their economy while only 34 percent of countries analyzed had a similar relationship with US FDI. 67 percent of countries analyzed had a strong, positive relationship between Chinese FDI and employment in agriculture while only 41 percent of countries analyzed had a similar relationship with US FDI. There was less of a difference for cereal yield, however, as a plurality of countries had a strong to moderate positive relationship for yield with both Chinese and US FDI.

As hypothesized, these relationships generally show a positive correlation with the valueadded of agriculture, fishing, and forestry to a country's economy (in constant 2010 \$USD), a negative correlation with a country's employment in agriculture (% of total employment), and a positive correlation with a country's cereal yield (kg per hectare). In other words, increased FDI is generally indirectly boosting agricultural value-added to the economy, diversifying agricultural employment, and increasing yield. We refer to these relationships as potential FDI spillover effects because of the fact that FDI from both China and the US does not currently target agriculture. As stated in the introduction, the majority of Chinese investment is in the construction and mining sectors (54.4% in 2016 according to CARI) while the majority of US investment is in the mining sector (60.4% in 2016 according to USITC).

#### Interpreting Correlation Results

How do we understand and interpret the results of our numerous correlation tests? To do so, we have to look at the results across each agricultural development indicator. First, however, it should be noted that there does not seem to be a standard relationship between agricultural value-added, agricultural employment, and yield. With the exception of Ethiopia, which shows the strongest or second-strongest relationship for all three with Chinese FDI, it is a mixed bag. Some countries, like Nigeria or the DRC, have some of the strongest correlations between Chinese FDI and value-added by agriculture to the economy but a comparatively weak correlation between FDI and agricultural employment and no relationship between FDI and yield. Others, like Tanzania and Rwanda, show a strong correlation with all factors. Consequently, while the relationship between Chinese FDI and the individual agricultural development indicators is easily observed, any co-dependent relationship among both valueadded, employment, and yield is more complex and will require further study to determine. In other words, Chinese FDI has a spillover boosting effect on agricultural value-added and cereal yield, and a dampening effect on agricultural employment, but the effect is not equal in magnitude across all three indicators within the same country.

For countries like Ethiopia, all pieces of the hypothesized spillover system seem to be in order (*Figure 2.3*). However, there are exceptions. Zimbabwe and Zambia show negative correlations for agriculture value-added with both Chinese and US FDI. In Zambia's case, Chinese and US FDI is increasing but the value added by agriculture, fishing, and forestry to Zambia's economy is decreasing. This discrepancy could be due to Zambian agricultural policies that limit growth in the sector despite FDI spillovers (e.g., Chapoto et al., 2017 for policy details). For Zimbabwe, value-added hits a low point in 2008 and then begins to recover. 2008 is

also when Chinese FDI to Zimbabwe starts to dramatically increase (part of China's participation in global stimulus spending), so the weak, negative relationship shown here reflects a pre-2008, pre-Chinese FDI Zimbabwean agriculture sector still dealing with the aftereffects of its land reform policies (Edinger and Burke, 2008). That there is a negative relationship between Chinese FDI and Zimbabwean agricultural outcomes, despite Chinese investment in better infrastructure, such as the Kariba South Hydro Power Station, and the fact that Zimbabwe's "Look East" policy in 2003 made China the primary source for FDI in Zimbabwe (Zhang and Chifamba, 2019) shows that it is not just a lack of investment that hinders indirect growth but also that the spillover system depends on the intermediary mechanisms that transfer effects from the receiving to the spillover system (*Figure 2.4*).



Figure 2.3 Conceptualized telecoupling framework for China-Ethiopia agricultural spillovers



Figure 2.4 Conceptualized telecoupling framework for China-Zimbabwe agricultural spillovers

There are few other unique cases; Angola, for example, shows a strong, positive relationship between employment in agriculture and Chinese FDI. Unlike the majority of African countries, Angola's employment in agriculture is increasing over time which may reflect Angolan state policies to revive the coffee industry as well as develop (rather than modernize) the sector as a whole as part of the war recovery process (Redvers, 2009). In this case, state policies are pushing for more agricultural employment directly. Malawi and Mali also share this positive FDI-employment relationship as well as reputations as large agricultural aid recipients which could directly boost agriculture employment figures. A few countries, such as Mozambique show strong, significant relationships with agriculture value-added and employment, but no relationship with yield. This may be due to internal limits to the spillover system, where climate or socio-economic realities result in less on-farm labor without an associated productivity boost from infrastructure or technology. Or, changes in the forestry and fishing sectors may boost the value-added to the economy and explain the decrease in on-farm labor. In cases like Mozambique, conclusions are murky without sectoral investment data. Countries such as Gambia and Guinea-Bissau show all negative relationships between Chinese FDI and the agricultural indicators. However, these may be due to idiosyncrasies in the data. The stock of Chinese FDI in Gambia increased only three times from 2003-2015. While there is data available, the resulting negative correlations are artificially significant.

Admittedly, there could be no relationship between FDI and our agricultural indicators. As correlation does not imply causation, global commodity prices may be driving up the value of the agricultural sector across countries' economies and it is just a coincidence that Chinese FDI is increasing at the same time. However, the spillover boosting effect is observed for most countries despite the 2008 global recession. Additionally, the *State of African Cities* (Wall et al, 2018) found that total global FDI (measured three different ways including FDI stock) does not have a significant effect on agricultural employment in Africa. The report surmised that there was no relationship because agriculture in Africa is primarily rural, not highly skilled, and has weak links to manufacturing and service sectors (ibid). Despite this, our findings show that with regards to FDI specific to China, and to a smaller extent the US, there was a significant spillover effect on agricultural employment in Africa. Some level of relationship exists and the strength, or lack thereof, between FDI and the agricultural development indicators pinpoint countries in which spillovers are more likely to have occurred.

In the following sub-sections, we discuss our results in the context of growth in China's FDI to Africa as compared to changes in US FDI to Africa, differences between African economies, and continued support for Chinese investment in Africa as signaled by FOCAC and the BRI.

#### Differences in FDI – China and the US

If Chinese FDI shows stronger, more prevalent potential spillover relationships with agricultural development indicators in most countries across Africa when compared with US FDI, then how much stronger? Considering only those correlations at 90 percent significance or above, the average tau statistic for the value added by agriculture, forestry, and fishing to an African economy was 1.5 times that of the US or almost two-thirds larger. For employment in agriculture, the average tau statistic was essentially the same. For cereal yield, the average tau statistic was also 1.5 times that of the US, though noticeably present in far fewer relationships than the other two agricultural indicators. While tau comparisons are not equivalent to exact magnitudes, we can see two differences emerge: (1) for the agricultural indicators, Chinese FDI was correlated with strong, significant spillover effects in more African countries than US FDI was; and, (2) the spillover effect on agriculture, forestry, and fishing value-added as well as cereal yield was stronger with Chinese FDI than US FDI.

This China-boosted spillover effect on African agriculture is especially interesting considering that, overall, the US provides more FDI to Africa than China (*Figure 2.5*). Though, recent decline in commodity prices have lessened US investment in the mining sector, which is reflected in occasional investment decline since 2010 (USITC, 2018). Furthermore, China's FDI gap with the US grows closer year by year and US dominance varies greatly from country to country (as shown in *Appendix 2.1*). Why is this secondary "spillover boosting" effect from Chinese FDI is stronger in most African countries than that from the US? Much of the discrepancy between Chinese and US FDI impact could be explained by the fact that China invests in a larger number of African countries than the US does, despite overall US monetary dominance (*Figure 2.5*). However, that alone is an important finding. FDI, regardless of

benefactor, seems to show a spillover relationship with agricultural (and forestry and fishing) value-added, employment, and (to some extent) yield. At present, China is providing that potential spillover effect in far more countries than the US, as a result of generally steady increases to FDI to Africa as a whole over the previous decade (2003-2015).



Figure 2.5 Total FDI to Africa & African Countries with greater than \$100M in FDI Stock

Based on 2015 data, *Table 2.8* shows the top destinations in 2015 for Chinese and US FDI in Africa in terms of overall value, while *Table 2.9* lists the top recipients as normalized by GDP (FDI/GDP, 2015).

Table 2.8 Top 10 Recipients of FDI, Overal	ble 2.8 To	> 10 Recipier	nts of FDI, Overa
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China \$M (% of total FDI to Africa)	USA \$M (% of total FDI to Africa)
1. South Africa – \$4,723M (14%)	1. Egypt - \$14,068M (30%)
2. DRC – \$3,239 (9%)	2. Mauritius – \$8,319 (18%)
3. Algeria – \$2,532 (7%)	3. South Africa – \$6,926 (15%)
4. Nigeria – \$2,377 (7%)	4. Nigeria – \$5,872 (13%)
5. Zambia – \$2,338 (7%)	5. Algeria – \$2,698 (6%)
6. Sudan – \$1,809 (5%)	6. Libya – \$1,820 (4%)
7. Zimbabwe – \$1,799 (5%)	7. Ghana – \$1,735 (4%)
8. Ghana – \$1,274 (4%)	8. Tanzania – \$1,219 (3%)
9. Angola – \$1,268 (4%)	9. Liberia – \$1,006 (2%)
10. Tanzania – \$1,139 (3%)	10. Eq. Guinea – 579 (1%)

China (% of GDP)	USA (% of GDP)
1. Seychelles (13%)	1. Mauritius (70%)
2. Liberia (11%)	2. Liberia (39%)
3. Zimbabwe (11%)	3. Seychelles (27%)
4. DRC (10%)	4. STP (9%)
5. Mauritius (9%)	5. Egypt (6%)
6. Zambia (9%)	6. Libya (5%)
7. Congo (7%)	7. Ghana (4%)
8. Niger (7%)	8. Eq. Guinea (4%)
9. Guinea Bissau (7%)	9. Tanzania (3%)
10. Sierra Leone (6%)	10. South Africa (2%)

Table 2.9 Top 10 Recipients of FDI, Relative

Only three countries (DRC, Zambia, and Zimbabwe) are on both versions of China's FDI recipient lists, while the US lists are almost identical (except for where Nigeria and Algeria are replaced by Seychelles and STP). In other words, FDI from China has a greater impact across a wider variety of African countries. This could explain why more countries showed significant relationships with Chinese FDI than with US FDI; simply put, Chinese investment has a broader reach than US investment.

With the exception of Eq. Guinea, Algeria, and somewhat Ghana, all the top recipients of US FDI show significant correlations. Further, 31% of countries with over \$100M in FDI from China by 2015 showed significant effects with all three indicators while 27% of countries with over \$100M in FDI from the US by 2015 showed the same. Proportionally, the impact of Chinese and US FDI is similar. Thus, the difference observed may not be in origin country at all, but merely that more investment means a higher chance at spillover effects. However, given that China has a broader spread of FDI and contributes less FDI overall than US makes us question this simple narrative. Further, it is not a one-to-one mapping of top 10 to strongest correlations (larger tau statistics); some of the strongest correlations (Ethiopia, Mozambique, Rwanda) are not top recipients of Chinese FDI. The Kendall rank correlation method used in this paper asks:

are agricultural development indicators and FDI in step with one another? For most cases, changes in the value-added by agriculture, fishing, and forestry to African economies are in step with changes in Chinese FDI but not in step with changes in US FDI. In essence, African agricultural value-added is decoupled from US FDI but not, it seems, from Chinese FDI.

For some countries, US FDI actually shows the opposite relationship with the agricultural outcome indicators than Chinese FDI. Interestingly, agricultural employment in the Republic of Congo fluctuates between 37 to 40 percent and, while decreasing overall across the decade, seems to share a moderate, positive relationship with the fluctuations in US FDI across the same time period. This could be a coincidence, but it could also suggest some facet of US FDI spillover that, when present, boosts agricultural employment in the Republic of Congo despite overall decreasing pressure from Chinese FDI spillovers.

Our results speak to a larger question: does the source of FDI matter with regards to the recipient country's economic growth? Studies both outside of and specific to the African context find that the source of FDI can impact the magnitude and type of economic growth for the host country (Javorcik and Spatareanu, 2011; Uwajumogu, Ojike, and Ogbonna, 2018; Bluhm et al., 2018) though others argue local environment matters more (Amendolagine et al., 2013; Gold et al., 2017). Adjacent to these studies, our findings suggest that origin of FDI can make a difference when considering the potential spillover effects specific to agricultural development. Interestingly, our results also suggest that FDI 'failures', where weak or non-significant spillover effect are observed, may also be moderated by local context. Consider Zambia and Zimbabwe, where governance issues could explain the lack of significant spillover effects or even negative spillover effects despite continued FDI growth from China.

Is it policy that drives the US vs China difference? There is certainly a policy difference in support for FDI. As summarized by Gu et al. (2016), the Chinese state supports Chinese business in Africa in four ways: (1) the "Africa Policy" and "Going Global" policy provide context and authority for Chinese firms to go to Africa; (2) a network of Chinese agencies to support Chinese firms 'going out'; (3) both multi-lateral (FOCAC) and bilateral economic diplomacy; (4) participates in South-South cooperation and dialogue. In contrast, US-African commercial relations are based on the African Growth and Opportunity Act (AGOA), however currently only 15 out of the 38 beneficiary countries have national AGOA strategies (USITC, 2018). USAID, in conjunction with the AU and UNECA, works with African governments to improve planning related to AGOA but the recent USTIC report (2018) gave a lukewarm impression of successfully plans. While a continent-level exploration such as the one presented in this study cannot tease out concrete results of policy differences, the overall impression is that the Chinese state takes a more active role in promoting and facilitating investment than the US state does.

#### Economic Outliers

Egypt, Nigeria, South Africa, Algeria, and Mauritius are all outliers in some way based on economic characteristics (see *Appendix 2.1*). For example, the relative size of South Africa's or Nigeria's economy easily dwarfs that of other African countries. However, in spillover behavior, these unique economic characteristics do not seem to affect correlation test results. Only Algeria somewhat bucks the trend of this study, showing no relationship between agricultural development indicators and US FDI. That is not to say that the relative strengths of economies and differences in governance types between countries do not matter, simply that the observed correlation between FDI and agricultural development occurs across a variety of countries. The

observed correlation is stronger with Chinese FDI, as the relationships are present across more countries with Chinese FDI than with US FDI (see *Table 2.2*).

We also considered if there were any correlation trends in common for Africa's major petroleum exporters (Nigeria, Angola, Algeria, Libya, Egypt, Rep. of Congo, Sudan, Eq. Guinea, Gabon, and Chad). With the exception of Libya, which has no agricultural data available, all the top oil exporting countries show strong correlations between most agricultural development indicators and Chinese FDI. However, Congo, Eq. Guinea, Angola, and Algeria show weak and non-significant correlations with US FDI. The US does send FDI to those four countries but there is no observed spillover effect. There could be some contributing factor which results in Chinese FDI allowing for a spillover effect in these four, politically unstable, countries but not so for the US. This is counter to the negative narrative of Chinese interest in African natural resources; here the presence of an extractive resource results in possibly positive spillover effects with Chinese FDI and none with US FDI.

#### FOCAC and BRI

How might spillover effects change in the near future? Increases in aid, trade, and investment announced at the most recent FOCAC are placed under the umbrella of BRI (Benabdallah and Robertson, 2018). Given our findings, if the BRI means increased infrastructure investment for African countries, then it could also mean increased spillovers to the agricultural development systems in the same African countries. Though, for countries like Zambia and Zimbabwe, more direct involvement in agricultural systems may be necessary barring changes to policy or governance. Correspondingly, China has also announced more direct investments in African agriculture (FOCAC, 2018). Any positive improvements in agricultural development associated with Chinese FDI now as a spillover system could be strengthened by direct ties. However, a

recent report (Wall et al., 2018) found that direct investment in agriculture rather than infrastructure or technology had less of an impact on agricultural development. The report recommends that African countries first achieve local food security and then attract food-related FDI to facilitate exports and grow the agro-food sector. Given these recommendations, spillover effects could be preferable to direct investment *if* they allow African countries to improve their agricultural productivity, quality, and diversity internally.

At this same time, many China observers worry that the BRI is a strategic debt trap that burdens developing countries with unsustainable debt while tying them economically to China (Hornby and Zhang, 2019 for both sides). Though others (Bräutigam, 2019) contend that Chinese banks are not deliberately over-lending or funding doomed projects, particularly for Africa where "of the 17 countries the IMF identified as vulnerable...China was the single-largest creditor, but non-Chinese lenders still held the majority of the debt. Only in Djibouti, the Republic of Congo and Zambia did Chinese loans account for half or more of the country's public debt" (ibid). Regardless of intention, the prevalence of BRI in China's current foreign policy will mean more infrastructure investment. While finance is not the full measure of a system, our study shows that Chinese FDI may have positive benefits for African agricultural development.

#### Conclusion

Applying the telecoupling framework to the China-Africa context is a useful way to formalize the linkages between systems under study and allows us to investigate specific mechanisms of relationship-interactions between China and various African countries. Here, we show that the growth in outward Chinese FDI to a multitude of African countries has a generally strong, positive potential spillover effect on the agricultural development system of each country. We

also show that said spillover effect is more prevalent with Chinese FDI than with US FDI over the same time period. The conclusions drawn here do not definitively state causality nor are they meant to. Carlson et al. (2018) assert that "best practices for assessing causality in telecoupling research start with developing rigorous qualitative and quantitative linkages between known information on telecoupled systems and research goals and analyses. That is, researchers should use existing information about telecouplings (e.g., descriptive, correlational, quasi-experimental) to establish qualitative and quantitative pathways for connecting telecoupled systems with the purpose(s) of a particular study" (ibid, p3). This paper begins that first step: developing linkages between known information of the China-Africa telecoupling via Kendall rank correlation.

## Limitations & Future Work

While the spillover conceptualization, and indeed the telecoupling framework as a whole, can help us test the relationship even with a lack of available data, the framework also highlights that same lack of data. Direct causes and effects, and their mechanisms, need direct data collection. Further investigation with FDI divided by sector could show which investments provide the most benefit with regards to agricultural spillovers. For example, are certain crop regimes benefiting more than to others, by merit of their location or timing of investments? Sectoral data would also help clarify the effects of FDI among agricultural, forestry, and fishery industries, which may be conflated in this study.

With regards to other limitations, this study presents only a preliminary economic analysis; no gravity models or multi-variate regression algorithms were used. A deeper investigation that seeks to inform on causality is necessary but is also dependent on availability and access to more specific, specialized data. Our study was dependent on national-level data provided to international reporting bodies by state governments. Large-scale trends, then, can

lead us to specific potential case studies for further research. As with the TAZARA railway (Monson, 2009), case studies in select countries for select sectors may be a way to begin to address this need for specificity. For example, investigating select investments into Tanzania, which had a strong correlation between FDI and agricultural value-added with both the US and China, or Ethiopia, which only showed a strong correlation with Chinese FDI. Selecting a group of countries with similar level of investment from both China and the US (i.e. Tanzania, Ghana, and Angola) and investigating differences in spillover outcomes in those countries would also help illuminate mechanisms driving these spillover effects.

One potential improvement to this study, if still limited to national-level FDI data, would be to choose two or three countries that show strong relationships between the agricultural development indicators and Chinese FDI and fit a multiple regression model to each country. Other factors may, and mostly likely do, have an interaction effect on agricultural development. Identifying those factors and determining the level of influence they have on development compared with that of Chinese FDI would either add confidence to our preliminary findings or offer an alternative explanation. Lag effects to consider the impact of investment timing is another important factor to consider for any regression model.

Going beyond FDI, future work should not just compare spillover effects of Chinese and US FDI but also bring in top EU investors (e.g. the UK, France) as well as consider contrasting the relationship between direct agricultural ODA and indirect infrastructure FDI on agricultural development. Finally, this study only looks at potential spillover effects on three agricultural development indicators, all of which revolve around beneficial developments. Other studies are necessary to catalogue and examine additional spillover effects of Chinese investment on the

African continent, whether environmental, economic, or social (Tan-Mullins and Mohan, 2013; Zhao, 2013).

#### **Broader Implications**

If there are spillover boosting effects, highlighted by the telecoupling framework, between Chinese FDI and African agricultural development, what do our findings mean for the numerous African countries potentially experiencing said spillover effects? We posit that if these spillover boosting effects are tied to the receiving system's infrastructure, and even more indirectly to each country's internal policy and government structures, African actors concerned with agricultural development may have more agency under a spillover system. Infrastructure upgrades and growth create an environment that allow local actors to focus on development in non-infrastructure sectors. However, this flexibility only lasts as long as the investments continue (*The Economist*, 2019). If China pulls away or redirects business interests, the associated spillovers could cease. That said, conceptualizing China-Africa relationship as a telecoupling does not mean that the observed systems are stable or predictable. There is no guarantee that continued growth in FDI to Africa will continue to indirectly boost agricultural development or that a loss of FDI will damage the system, there could be internal feedbacks within the agricultural system that sustain growth even if FDI decreases. APPENDICES

## **APPENDIX 2.1 – COUNTRY COMPARISONS**

This appendix contains three graphs, showing relative economic characteristics of African

countries in 2015 (the most recent year of available data for FDI).



Figure 2.6 African GDPs (2015)





Figure 2.7 Value-added by agriculture, forestry, and fishing to an economy (2015)



Figure 2.8 Outward FDI to Africa from China and the US (2015)

# **APPENDIX 2.2 – CORRELATION MAPS**



Figure 2.9 Value-Added to the Economy by Agriculture, Forestry, and Fishing & FDI (China)



Figure 2.10 Employment in Agriculture & FDI (China)



Figure 2.11 Cereal Yield & FDI (China)



Figure 2.12 Value-Added to the Economy by Agriculture, Forestry, and Fishing & FDI (US)


Figure 2.13 Employment in Agriculture & FDI (US)



Figure 2.14 Cereal Yield & FDI (US)

REFERENCES

## REFERENCES

Alden, C. (2013). China and the long march into African agriculture. *Cahiers Agricultures*, 22(1), 16-21.

Alemu, D., & Scoones, I. (2013). Negotiating new relationships: How the Ethiopian State is involving China and Brazil in agriculture and rural development. *IDS Bulletin*, 44(4), 91-100.

Amendolagine, V., Boly, A., Coniglio, N. D., Prota, F., & Seric, A. (2013). FDI and local linkages in developing countries: Evidence from Sub-Saharan Africa. *World Development*, *50*, 41-56.

Beijing curbs its enthusiasm; China and Africa. (2019, June 29). The Economist. Retrieved from https://www.economist.com/

Benabdallah, L., & Robertson, W. (2018, Sept. 17). Xi Jinping pledged \$60 billion for Africa. Where will the money go?. *Washington Post*. Retrieved from https://www.washingtonpost.com

Bluhm, R., Dreher, A., Fuchs, A., Parks, B., Strange, A., & M. Tierney. (2018). *Connective Financing: Chinese Infrastructure Projects and the Diffusion of Economic Activity in Developing Countries*. (AidData Working Paper 64). Williamsburg, VA: AidData at William & Mary.

Bräutigam, D., & Zhang, H. (2013). Green dreams: Myth and reality in China's agricultural investment in Africa. *Third World Quarterly*, *34*(9), 1676-1696.

Bräutigam, D. (2015). Will Africa Feed China? Oxford University Press.

Bräutigam, D. (2019, Apr 27). Is China the World's Loan Shark? *New York Times*. Retrieved from https://www.nytimes.com/

Buckley, L. (2013). Chinese agriculture development cooperation in Africa: Narratives and politics. *IDS bulletin*, 44(4), 42-52.

Carlson, A., Zaehringer, J., Garrett, R., Felipe Bicudo Silva, R., Furumo, P., Raya Rey, A., ... & Liu, J. (2018). Toward rigorous telecoupling causal attribution: A systematic review and typology. *Sustainability*, *10*(12), 4426.

Carmody, P. R., & Owusu, F. Y. (2007). Competing hegemons? Chinese versus American geoeconomic strategies in Africa. *Political Geography*, *26*(5), 504-524.

Chapoto, A., Chisanga, B., & Kabisa, M. (2017). *Zambia Agricultural Status Report 2017*. Lusaka, Zambia: Indaba Agricultural Policy Research Institute.

Chichava, S., Duran, J., Cabral, L., Shankland, A., Buckley, L., Lixia, T., & Yue, Z. (2013). Brazil and China in Mozambican agriculture: Emerging insights from the field. *IDS Bulletin*, 44(4), 101-115.

China Africa Research Initiative (CARI). (2018). *China-Africa Foreign Direct Investment Data* [Data file]. Retrieved from http://www.sais-cari.org/chinese-investment-in-africa

Collier, P., & Dercon, S. (2014). African agriculture in 50 years: Smallholders in a rapidly changing world?. *World Development*, *63*, 92-101.

Dou, Y., da SILVA, R. F. B., Yang, H., & Liu, J. (2018). Spillover effect offsets the conservation effort in the Amazon. *Journal of Geographical Sciences*, 28(11), 1715-1732.

Dreher, A., Fuchs, A., Parks, B.C., Strange, A. M., & Tierney, M. J. (2017). *Aid, China, and Growth: Evidence from a New Global Development Finance Dataset*. (AidData Working Paper 46). Williamsburg, VA: AidData at William & Mary.

Edinger, H., & Burke, C. (2008). *AERC scoping studies on China-Africa Relations: a research report on Zimbabwe*. South Africa: Centre for Chinese Studies, University of Stellenbosch.

EuroStat. *Balance of Payments – Interactional Transactions* [Data file]. Retrieved from https://ec.europa.eu/eurostat/data/database

FOCAC. (2018). Forum on China-Africa Cooperation Beijing Action Plan (2019-2021). Beijing, China: Ministry of Foreign Affairs.

Friis, C., Nielsen, J. Ø., Otero, I., Haberl, H., Niewöhner, J., & Hostert, P. (2016). From teleconnection to telecoupling: taking stock of an emerging framework in land system science. *Journal of Land Use Science*, *11*(2), 131-153.

Gold, R., Görg, H., Hanley, A., & Seric, A. (2017). South–South FDI: is it really different?. *Review of World Economics*, 153(4), 657-673.

Gu, J., Zhang, C., Vaz, A., & Mukwereza, L. (2016). Chinese state capitalism? Rethinking the role of the state and business in Chinese development cooperation in Africa. *World Development*, *81*, 24-34.

Hornby, L., & Zhang, A. (2019, Apr 23). Belt and Road debt trap accusations hound China as it hosts forum. *Financial Times*. Retrieved from https://www.ft.com

Jackson, J. (2017). U.S. Direct Investment Abroad: Trends and Current Issues. (Congressional Research Service Report RS21118). Congressional Research Service.

Javorcik, B. S., & Spatareanu, M. (2011). Does it matter where you come from? Vertical spillovers from foreign direct investment and the origin of investors. *Journal of Development Economics*, *96*(1), 126-138.

Landry, D.G. (2018). *Comparing the Determinants of Western and Chinese Development Finance Flows to Africa*. (Working Paper No. 2018/21). Washington, DC: China-Africa Research Initiative, School of Advanced International Studies, Johns Hopkins University.

Liu, A., & Tang, B. (2018). US and China aid to Africa: Impact on the donor-recipient trade relations. China Economic Review, 48, 46-65.

Liu, J. Q., Hull, V., Batistella, M., DeFries, R., Dietz, T., Fu, F., ... & Martinelli, L. A. (2013). Framing sustainability in a telecoupled world. *Ecology and Society*, *18*(2), 26.

Liu, J., Hull, V., Luo, J., Yang, W., & Liu, W. (2015). Multiple telecouplings and their complex interrelationships. *Ecology and Society*, 20(3), 44.

Liu, J., Dou, Y., Batistella, M., Challies, E., Connor, T., Friis, C., ... & Triezenberg, H. (2018). Spillover systems in a telecoupled Anthropocene: Typology, methods, and governance for global sustainability. *Current Opinion in Environmental Sustainability*, *33*, 58-69.

Monson, J. (2009). *Africa's freedom railway: How a Chinese development project changed lives and livelihoods in Tanzania*. Indiana: Indiana University Press.

Mukwereza, L. (2013). Reviving Zimbabwe's Agriculture: The Role of China and Brazil. *IDS Bulletin*, 44(4), 116-126.

New Partnership for Africa's Development (NEPAD). (2003). Comprehensive Africa Agriculture Development Programme. Midrand, South Africa: NEPAD.

Noether, G. E. (1981). Why Kendall Tau?. *Teaching Statistics*, 3(2), 41-43.

Vitalis, V. (2001). *Official development assistance and foreign direct investment: Improving the synergies*. (Round Table on Sustainable Development Background Paper). Paris, France: Organization for Economic Co-operation and Development (OECD).

Okafor, G. (2015). Locational determinants of US outward FDI into sub-Saharan Africa. The *Journal of Developing Areas*, 49(1), 187-205.

R Core Team (2019). R: A language and environment for statistical computing [Web tool]. Vienna, Austria: R Foundation for Statistical Computing. Available from http://www.R-project.org/

Rasmussen, L. V., & Nielsen, J. Ø. (2014). Staying with the system: Theoretical consistency and change in Danish geographical work on the Sahel. *Geografisk Tidsskrift-Danish Journal of Geography*, 114(1), 3-16.

Redvers, L. (2009, July 28). Angola works to revive coffee plantations. The Namibian. Retrieved from https://www.namibian.com.na

Sautman, B., & Yan, H. (2008). The forest for the trees: Trade, investment, and the China-in-Africa discourse. *Pacific Affairs*, 81(1), 9-29.

Schneidman, W., & Wiegert, J. (2018, April 16). Competing in Africa: China, the European Union, and the United States. [Brookings Africa in Focus Blog]. Retrieved from https://www.brookings.edu/blog/africa-in-focus/2018/04/16/competing-in-africa-china-the-european-union-and-the-united-states/

Tan-Mullins, M., & Mohan, G. (2013). The potential of corporate environmental responsibility of Chinese state-owned enterprises in Africa. *Environment, Development and Sustainability*, *15*(2), 265-284.

Tiezzi, S. (2018, Sep 5). FOCAC 2018: Rebranding china in Africa. *The Diplomat*. Retrieved from https://thediplomat.com

Tonini, F., & Liu, J. (2017). Telecoupling Toolbox: spatially explicit tools for studying telecoupled human and natural systems. *Ecology and Society*, 22(4).

Tugendhat, H., & Alemu, D. (2016). Chinese agricultural training courses for African officials: Between power and partnerships. *World Development*, *81*, 71-81.

UNCTAD (2018). World Investment Report 2018 – Investment and New Industrial Policies. Geneva: United Nations Conference on Trade and Development.

US Bureau of Economic Analysis (BEA). U.S. direct investment abroad: Balance of payments and direct investment position data [Data file]. Retrieved from https://www.bea.gov/international/di1usdbal

USITC. (2018). U.S. Trade and Investment with Sub-Saharan Africa: Recent Developments (Investigation No. 332-564, Publication No. 4780). Washington, DC: United States International Trade Commission.

Uwajumogu, N., Ojike, R. O., & Ogbonna, I. C. (2018). Does Source of Foreign Direct Investment Matter for Nigeria's Economic Growth?. *International Journal of Economics and Financial Issues*, 8(6), 46-53.

Wall R.S., Maseland J., Rochell, K., & Spaliviero M. (Eds.) (2018). *The State of African Cities 2018: The geography of African investment*. UN-Habitat and HIS-Erasmus University Rotterdam.

Weng, L., Boedhihartono, A. K., Dirks, P. H., Dixon, J., Lubis, M. I., & Sayer, J. A. (2013). Mineral industries, growth corridors and agricultural development in Africa. *Global Food Security*, 2(3), 195-202.

World Bank Open Database. *Indicators: Cereal yield; Agriculture, forestry, and fishing, value added; Employment in agriculture* [Data file]. Retrieved from https://data.worldbank.org/indicator

Wu, Y. (2018, Sep 5). Highlights from FOCAC 2018. *Africa-China Reporting Project with WITS Journalism*. Retrieved from http://africachinareporting.co.za

Xu, X., Qi, G., & Li, X. (2014). Business Borderlands: China's Overseas State Agribusiness. *IDS Bulletin*, 45(4), 114-124.

Xu, X., Li, X., Qi, G., Tang, L., & Mukwereza, L. (2016). Science, technology, and the politics of knowledge: The case of China's agricultural technology demonstration centers in Africa. *World Development*, *81*, 82-91.

Yang, W., Hyndman, D., Winkler, J., Viña, A., Deines, J., Lupi, F., ... & Ma, D. (2016). Urban water sustainability: framework and application. *Ecology and Society*, 21(4).

Zhang, Y., & Chifamba, T. (2019, April 4). Infrastructural development under BRI becomes cornerstone of China-Zimbabwe cooperation. *Xinhua*. Retrieved from www.xinuanet.com

Zhao, Y. (2013). China–Africa development cooperation in the rural sector: an exploration of land tenure and investments linkages for sustainable resource use. *Environment, Development and Sustainability*, *15*(2), 355-366.

# CHAPTER 3 – PREDICTING CHINESE AGRICULTURAL INVESTMENT: A MULTI-CRITERIA DECISION MODEL

## Abstract

In the absence of long-term trends, we propose the use of multi-criteria decision modeling to make predictions about future Chinese investment in African agriculture. Guided by the policy directions outlined at the most recent Forum on China-Africa Cooperation (FOCAC) in 2018, we ask: in which African countries will China invest in agriculture if (1) China prefers to invest in countries already invested in; (2) China prefers to invest in countries that show general agricultural potential; and, (3) China prefers to invest in countries involved in the cotton sector. Regardless of presumptions on Chinese investment preference, South Africa, Nigeria, Egypt, and Angola emerged as strong possible investment destinations. If past foreign direct investment (in any sector) is indicative of future investment (in the agricultural sector), then Zambia, the DRC, Congo, and Mauritius are also likely potential investment destinations. Ethiopia and Tanzania are the top unique candidates under the general agricultural scenario, as are Morocco and Botswana under the cotton-specific scenario. Global sensitivity analysis did not raise any red flags with regards to model structure, however, future versions of the model should incorporate more robust evaluation criteria.

### Introduction

The Forum on China-Africa Cooperation Beijing Action Plan (2019-2021), released in

September 2018, outlined two important areas of cooperation with regard to China-Africa

agricultural investment. They are:

3.1.8 The two sides will establish a China-Africa Research Center for the Development of Green Agriculture, and actively advance cooperation between Chinese and African agribusinesses and social organizations. The two sides will undertake wide-ranging activities such as investment promotion, technical exchanges, joint research and strengthening of extension services.

3.1.9 The Chinese side will strengthen cooperation with cotton-producing African countries to help establish high quality standards and enhance their capacity for industrial planning, production, processing, storage, transportation and trade, move them up the cotton production value chain, and expand Africa's market share in the international cotton market.

#### - FOCAC (2018)

The 2018 forum indicated that China intends to increase focus on agricultural investment

in Africa, even calling out the cotton industry as a particular target. How will Chinese investment

in African agriculture change in the near future? Where will such investment go? This paper

presents one possible approach to answering such questions.

Predicting the future direction of China-Africa agriculture investment is difficult for a number of reasons. First and foremost, past behavior is no guarantee of future decisions. The 2016 *World Development* special issue on China and Brazil in African Agriculture concludes that "there is clearly no one Brazilian or Chinese 'model', as development interventions emerge from often quite contested narratives around agriculture and development, linked to very different and variegated political settings" (Scoones, et al., 2016, p9). It is hard to build future outcomes without a clear structure of previous results. Further, how can we predict future trends without reliable, continuous past data? An even earlier issue on China and Brazil in African Agriculture, this one in *IDS Bulletin*, called for "more in-depth, ethnographic assessment of

different projects and investments" as they have "barely been discussed in the wider literature on Brazil and China in Africa" (Scoones et al., 2013, p15). While their focus was on qualitative data in agricultural development context, the aforementioned lack of data applies to the larger China-Africa agricultural field. Six years later and datasets are still sparse. The only known data set of Chinese investment in African agriculture comes from the China Africa Research Initiative (SAIS-CARI, 2018) and represents under 40 projects over only 250K hectares of land, about half of which comes from the purchase of two large, existing rubber plantations in Cameroon (Brautigam, 2015). As a distinction, this paper will consider investment, particularly foreign direct investment (FDI), as separate from aid and trade, which do have their own, often limited, datasets (see Dreher et al., 2017 and COMTRADE, 2019, respectively).

How then can we make inferences about future Chinese investment in African agriculture? Here, we introduce a model that explicitly lays out assumptions of current preference, uncoupled from but not regardless of limited past investments. In order to still attempt some sort of prediction in the absence of observable trends, we propose using multicriteria decision modeling (MCDM). Essentially, we treat China's future investment as China (as a nebulous, aggregated actor) choosing between multiple opportunities and, given a set of assumption about future conditions, see which African countries 'optimize' China's investment choices.

#### Methods

MCDM is a way of structuring decision problems in a manner that allows the user to design, evaluate, and prioritize alternative decisions (Malczewski, 2006). MCDM starts with the objective—a statement about the desired state of the system under consideration (Malczewski, 1999). Relevant characteristics of that system make up the evaluation criteria and their relative

importance is weighted against all other criteria depending on the preferences of the decision makers. The aim of MCDM is to choose the 'best' or most-preferred alternative or to rank the alternatives in descending order of preference (ibid).

MCDM has been applied in variety of research contexts, from re-classifying harmful drugs via expert opinion (Nutt, King, and Phillips, 2010) to choosing the optimal approach to an environmental or energy project with diverse stakeholders (Kiker et al., 2009; Wang et al., 2009). To our knowledge, there have been no MCDMs built in relation to China-Africa engagements in any context. The closest 'cousin' models revealed by a literature review include ranking the optimal oil providers based on country risk (Li et al., 2014) and ranking the European Member states based on an agglomeration of their international trade and economic standings (Dincer, 2011).

Though more commonly known as decision tools, MCDMs can and have been used to make predictions. For example, identifying successful and unsuccessful corporate knowledge management programs (Chang and Wang, 2009) or predicting potential zones of sustainable groundwater resources (Adiat, Nawawi, and Abdullah, 2012). MCDMs are upfront and transparent about the preferences and assumptions that drive the model. In the absence of specialized data and without substantial past performances on which to draw a trend, predicting China's next African investment hotspots is, at best, a guessing game. Using MCDM, this guessing game is given rules and explicit assumptions that can be tested, tweaked, and updated as new information and data becomes available.



Figure 3.1 MCDM scenario preferences

*Figure 3.1* shows the conceptual framework of the MCDM for this study, with the overall objective to determine in which African countries China will choose to increase agricultural investment. The model relies on preferences to capture possible future outcomes. Here, investment could go to countries with strong agricultural production, countries with a history of Chinese investment, or countries with favorable Chinese relations; or, some combination therein. Evaluation criteria are the representative characteristics of those preferences, and their relative importance is determined by weights. Weights, in turn, are influenced by the different preferences. If all preferences are considered equally important, all criteria will be weighted the same. Finally, the output of the MCDM is a ranking of which African countries China will invest in given a set of preferences (i.e. decision alternatives).

To generate and run the model, we used the R package *MCDA* (R Core Team, 2019; Meyer et al.,2019). The *MCDA* package offers several different MCDM methods, including the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method. The TOPSIS method posits that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution (Hwang and Yoon, 1981; see Triantaphyllou, 2000, p18 for walkthrough of TOPSIS formulae) and is considered a compensatory method in that it allows for criteria outcomes offset each other so that a loss in one evaluation criteria can be compensated for by a gain in another (Greene et al., 2011).

The model has three required pieces: a performance table, weights, and criteria preferences. The performance table is a dataset composed of 47 African countries and their evaluation criteria. Each criterion is assigned an individual weight; the total sum of all criterion weights must be one. Additionally, each criterion must be labeled as maximum-preferred or minimum-preferred to indicate its ideal state (i.e. is higher better or is lower better). The final model output is a data frame (later converted to a text file) which contains the score of the ranking index and from thus the corresponding final rank for each country.



Figure 3.2 Evaluation criteria used for each scenario

Given the stated research question: "How will Chinese investment in African agriculture change in the future?", we created three different preference scenarios with a collection of economic and agricultural data from the World Bank Open Data, Chinese FDI data from the China Africa Research Initiative (2018), trade data from COMTRADE, and agricultural yield data from FAOSTAT (as shown in *Figure 3.2*). All data describes evaluation criteria in the year 2015, as that was the most recent year with available Chinese FDI data for most African countries. Seven countries are omitted from the model for missing data: Burkina Faso, Djibouti, Eritrea, Libya, Somalia, South Sudan, and Eswatini (Swaziland). *Appendix 3.1* lists the input data for each evaluation criteria.

The first scenario (S1) acts as a baseline scenario and presumes that Chinese investors prefer to invest in countries with proof of past Chinese investment without any special attention to agriculture. In scenario two (S2), Chinese investors prefer to invest in countries with higher potential growth in their agricultural sector. Scenario three (S3) models a future where Chinese investors target the development of a specific commodity, in this case: cotton. The adjustment of weights in each model are what tune the model to its specific scenario. For example, for S2, the focus was on growth in the value of the agricultural sector over time, as well as the amount of agricultural trade already established with China. For this reason, those two evaluation criteria are given a higher weight than the others. *Table 3.1* details the weights selected for each criterion under each scenario.

Criteria	<b>S1</b>	S2	<b>S</b> 3
	Weights	Weights	Weights
FDI Stock, from China <sup>2</sup>	0.4	0.1	0.15
$GDP^1$	0.2	0.1	0.05
Total Exports to China <sup>3</sup>	0.2	0.15	0.1
Total Imports from China <sup>3</sup>	0.2	0.15	0.1
Growth in Value of Agriculture to the Economy	0.0	0.2	0.15
$(2015-2010)^1$			
Value of Agricultural Exports to China <sup>1</sup>	0.0	0.3	0.1
Cotton Yield (hg/ha) <sup>4</sup>	0.0	0.0	0.35
Data sources: $^{1}$ = World Bank Open Data. $^{2}$ = SAIS-0	CARL $^3 = CON$	$1$ TRADE $^{4}$ =	FAOSTAT

Table 3.1 Model Parameters

Data sources:  $^{1}$  = World Bank Open Data,  $^{2}$  = SAIS-CARI,  $^{3}$  = COMTRADE,  $^{4}$  = FAOSTAT All data is for the year 2015 unless stated otherwise

The final model was run three times, once for each preference scenario set at the weights described in *Table 3.1*. However, because the weights were decided subjectively based literature review and our own interpretation subsequent possible preferences, a global sensitivity analysis (GSA) was also performed. The GSA was initiated and analyzed using SimLab, though integrated with the R package in to generate the model output of 4,096 test runs.

Uncertainty analysis and sensitivity analysis are particularly important when considering that the output of this study's MCDM are composite indicators ranking different countries, indicators which could have policy relevance. A GSA provides an assessment of the reliability of countries' rankings and increases transparency of any conclusions drawn from the model's results (Saisana, Saltelli, and Tarantola, 2005).

## Results

### Model Results

*Figure 3.3* illustrates the relative ranking of countries for each of the modeled scenarios and their TOPSIS ranking index value (RIV) showing each country's relative distance from the model 'ideal.' *Appendix 3.2* lists the results in full. The closer to one a RIV is, the closer the that country is considered to the model 'ideal' country with every evaluation criterion maximized or

minimized as preferred. With the exception of South Africa, Nigeria, Egypt, and Sudan, a country's position on the ranking list noticeably differs for each scenario.

Under the investment baseline scenario (S1), South Africa, Nigeria, the Democratic Republic of Congo (DRC), Algeria, and Angola are all top investment prospects. While the much larger economies of South Africa and Nigeria probably push these countries to the top of the list, we also see how the relatively large amount of Chinese FDI in the Democratic Republic of Congo (DRC) and Algeria places those countries above others that might be seen as a more conservative or 'traditional' investment choices. For the second scenario (S2), Zimbabwe emerges as the likely benefactor of increased Chinese agriculture investment, followed by South Africa, Nigeria, Ethiopia, and Egypt. Here the heavy link of Zimbabwe tobacco production and export to China draws investment predicated on agricultural potential. Similarly, Ethiopia is ranked fourth with both large amount of agricultural goods exported to China and strong growth in the value of agriculture to Ethiopia's economy. Finally, for the third scenario focused on targeted investment in cotton (S3), South Africa, Egypt, Nigeria, Angola, Morocco, and Botswana are top destinations for investment if China wants to focus on boosting cotton production with preferences towards countries that already have trade relationships with China.



Figure 3.3 Ranking Index Values by Scenario

South Africa and Nigeria do dominate each scenario, due to the fact that no matter the criterion considered, they are comparably strong across all criteria. Removing South Africa or Nigeria from the model would simply shift the remaining countries up one rank. No matter the preference scenario, given the evaluation criteria available, South Africa and Nigeria emerge as likely investment candidates.

*Figure 3.4* provides a comparative look at the country rankings by scenario and shows the rank change in each country as modified from the first, baseline scenario. As the RIV shows distance from the 'ideal' investment country (i.e. RIV = 1.0), changes in RIV reflect how meaningful a change in rank is. For example, Ethiopia jumps from the thirteenth alternative investment to the fourth investment choice between scenarios one and two, more than tripling its corresponding RIV. In scenario two, Togo, Mali, and Cote d'Ivoire had the largest negative change (rise up the most ranks) while the DRC, Mauritius, and Namibia had the largest positive change (drop down the most ranks). Togo has the most dramatic rise, from twenty-eight to ninths under scenario two, mainly based on the strength of Togo's agricultural exports (sesame) to China. In scenario three, Botswana, Guinea-Bissau, and Cote d'Ivoire rise up the most ranks while the Mozambique, Congo, and Mauritius drop down the most ranks. As cotton producers, Botswana and Guinea-Bissau both rise more than twenty places and Cote d'Ivoire eighteen places under scenario three.



Change in Rank from Scenario 1

Figure 3.4 Change in rankings between scenarios, with Scenario 1 as baseline

#### Sensitivity Analysis

For MCDMs, there are two primary measurements of uncertainty: measurement uncertainty and preference uncertainty. Measurement uncertainty comes from errors in the criterion attribute values while preference uncertainty is the error between the criterion weight and its true value (Malczewski, 1999). Of the two, preference uncertainty may be the more important error to test, as criterion weights are subjective value judgements (ibid). While there is probably error in the criterion attribute values (i.e. no guarantee cotton yields were reported correctly or even collected correctly), as there are no error estimates provided with the raw, secondary-source data used in this study, we focus only on preference uncertainty for sensitivity analysis.

Using SimbLab, a free development framework for Sensitivity and Uncertainty Analysis (Version 2.2; 2008), we performed a global sensitivity analysis to determine which, if any, weights are the most influential on the variability of a country's resultant ranking. The basic steps undertaken were:

- (1) Define the parameters and their range of possible values. In our case the parameters are the criterion weights, each with a value from 0 to 1.
- (2) Within SimLab, generate a *n* set of randomized input weights that vary within two-tenths (+/- 0.2) of a weight's given value. Our sample weights were generated using the Sobol method and generated sample sets for 4,096 model runs.
- (3) Import the sample runs into R and loop through the model for each iteration of set of weights. Because MCDM weights should sum to one, we first normalized the sample sets before feeding them to the model.
- (4) Capture the model results and export them from R and import back into SimLab.
- (5) Using SimLab, analyze the results to identify the most/least sensitive parameters.

The results of our sensitivity analysis are summarized in *Table 3.2* and available in full in *Appendix 3.3*. Two sensitivity measures are included: first order index  $(S_i)$  and total order index  $(ST_i)$ . Total order index measures all of the interactions between parameters while first order effects show the effect a single parameter alone (Herman, 2013). Across the board, a large percent of the output variability (aka which rank a country ends up with) is due to the weight preferences independently. On average, only 10% of the out variance in the model is due to interactions among inputs.

Table 3.2 Sensitivity Analysis Results								
Weight Parameter	Average Si ± Std Dev	Average ST <sub>i</sub> ± Std Dev						
FDI	0.1369 ±0.24	0.1621 ±0.26						
GDP	$0.0267 \pm 0.02$	0.0421 ±0.03						
Exports	$0.1328 \pm 0.12$	0.1703 ±0.12						
Imports	$0.0645 \pm 0.14$	$0.0826 \pm 0.15$						
Growth in Ag. Value	$0.1540 \pm 0.27$	0.1954 ±0.26						
Ag. Exports	$0.1264 \pm 0.18$	$0.1610 \pm 0.18$						
Cotton Yield	0.2619 ±0.31	0.2831 ±0.32						
SUM	0.9032 ±0.04							

Dominant Avg  $S_i$ 0.6020Dominant Avg  $ST_i$ /sum(Avg  $ST_i$ )0.5938

Which parameter was individually dominant varied from country to country, though the weight of cotton yield was the most dominant for the most countries (18 countries), followed by the weight of growth in agricultural value-added (8 countries), FDI and agricultural exports (6 countries for both), exports (5 countries), and imports (4 countries). On average, the dominant weight individually explained 60% of the variance in ranking for a country. Larger total order effect indicates a criterion weight that has a larger influence and acts as a more dominant model parameter. Every country had one or two weights that emerged as dominant for all model interactions. Consequently, of the seven factors, none are heavily involved in interactions with other factors. Growth in agricultural value-added is, on average, the 'most' involved of the

factors, but it is a weak involvement (very low  $ST_i - S_i$ ). Once again, the dominant parameter varied across countries, but the cotton yield factor was the most frequent dominant parameter (18 countries). FDI, exports, and growth in agricultural value-added all were dominant for seven countries, respectively, while imports and agricultural exports were dominant for four countries each. The weight of GDP was not the dominant parameter for any country individually or when considering total interactions.



Figure 3.5 Selected uncertainty analysis distributions

*Figure 3.5* shows uncertainty analysis distributions for select countries. For countries like Egypt and South Africa, who had higher values in all evaluation criteria, we can see that the possible distribution of ranking indices varies almost across the entire output range of 0 to 1. In contrast, for countries with perhaps more average evaluation criteria (e.g., Ethiopia) or only one 'notable' evaluation criteria (e.g., Botswana with its cotton yields), the ranking indices were distributed across a lower and smaller range. It is possible to choose a set of preferences in which

countries like South Africa score extremely low on the ranking index. While whichever set of preferences causes this outcome is probably not a realistic one, the model is stronger for allowing the possibility. The alternative would be a model in which high-GDP countries outperform all others regardless of preference.

Sensitivity analysis is one tool available to help verify a model, to ensure that the model behaves as intended and is not dependent on a singular criterion (i.e. GDP) to make decisions. What sensitivity analysis cannot do, however, is validate the model. Model validation ensures that the model describes the phenomena it is intended it to describe. Often, models are validated by comparing model output to existing data that was not used to build the model. In our case, there is no post-2015 list of Chinese investments in African agriculture available to cross-check against our list of investment possibilities. Further means of validation are touched on in the discussion section.

#### **Discussion & Conclusion**

The China-Africa agricultural investment MCDM presented in this study generates three different scenarios. Guided by the policy directions outlined at the most recent Forum on China-Africa Cooperation (FOCAC, 2018), we asked: in which African countries will China invest in agriculture if (1) China prefers to invest in countries already invested in; (2) China prefers to invest in countries that show general agricultural potential; and, (3) China prefers to invest in countries involved in the cotton sector? Model output for each scenario was a ranked list of African countries; the higher in rank a country, the better a candidate it is for Chinese investment.

Regardless of presumptions on Chinese investment preference, South Africa, Nigeria, Egypt, and Angola emerged as strong possible investment destinations. If past FDI (in any

sector) is indicative of future investment (in the agricultural sector), then Algeria, Zambia, and the DRC are also likely potential investment destinations. Scenario one considered FDI stock the most important evaluation characteristic, followed by GDP, imports from China, and exports to China as next and equally important. Algeria, Zambia, and the DRC are among the top holders of Chinese FDI in Africa. Zimbabwe and Ethiopia are the top unique candidates under the general agricultural scenario, as are Morocco and Botswana under the cotton-specific scenario. Zimbabwe rises to the top due to its strong tobacco export trade with China as does Ethiopia with sesame exports as well as strong growth in the value-added by agriculture to Ethiopia's economy from 2010 to 2015. Morocco and Botswana gain ranks in the third scenario primarily due to their high cotton yields as we would expect for a scenario focused on cotton producers.

Perhaps more interesting are the countries that become 'bad' investments under the nonbaseline scenario. Take for example the DRC, which is ranked third in the baseline scenario but fourteenth and eleventh, respective, in the general agriculture and cotton scenarios. Outside of past proof of partnership (i.e. China has direct large amounts of FDI to the DRC for over a decade), it may not be the best investment choice from an agricultural perspective. If, in the near future, China announced a composite of agricultural investments directed to the DRC, we could assume the Chinese state and/or private firms (depending on who is investing) have a higher preference for maintaining relationships with actors in the DRC than for directing investment to the optimal agricultural partner.

There are several limitations inherent in this study. First and foremost is the model's reliance on selected criterion/data. Our model uses only economic and agricultural data is mostly measured in US dollars. MCDM will only evaluate rankings based on the criterion given to the model. The dominance of countries such as South Africa in our model may be due more towards

incorporating primarily economic variables into the model than a true statement of preference for Chinese investors. Were we able to also include a wider context of criterion, for example survey data on Chinese stakeholder perceptions of African countries' investment potential or African stakeholder's willingness to engage with Chinese investors, the resulting model may be less dominated by economic factors. Capturing the views and sights of African actors would also address an important second limitation in this model: the lack of African agency on investment outcomes. The model in this study was built presuming a singular 'China' acts as the sole decision maker. However, everything from personal relationships among state elites and business brokers to the presence of business consortiums in a capital city are all methods by which African actors create, maintain, and change attributes of the China-Africa relationship not currently captured in this model (Mohan and Lampert, 2013). An expanded version of this model with scenarios that reflect African decision-makers' preferences would better accommodate African actors' agency.

Second, the criterion weights, around which the MCDM operates, are subjective. The weights used in this study were selected by choosing the most and least important criterion for each scenario, based on literature review, and determining the intermediary weights in relation to those thresholds. After a sensitivity analysis, no one criterion weight dominates the model for every country. However, we were not able to verify the model. Looping in expert options and stakeholders to debate model outcomes is another approach to model validation and would make the most sense for this predictive type of model. Finally, MCDMs do not deal well with change over time. Growth or decline can be incorporated into individual criterion, as we did by using the difference in value-added to the economy by agriculture from 2015 to 2010. However, the model's output is not temporal in any manner.

With the above limitations in mind, most of our envisioned future work with this model revolves around adding additional criterion. Including environmental data and/or climate data could improve the model, particularly as land use change may increasingly play a role in investment decisions. Incorporating more categorical, qualitative evaluation criteria such as investment climate and ease-of-business perceptions from stakeholder surveys and interview data would also help reveal a more robust decision matrix. Further, gathering expert and stakeholder opinions on the model results themselves is a useful way to verify the model. Ideally, developing a web interface for this model would be both a way to enable the collection of expert opinions as well as open the model up to a wider audience and allow interested stakeholders experiment with their own combinations of evaluation criteria and weights.

As it stands, multi-criteria decision modeling, though subjective, allows us to try and evaluate the future possibilities of Chinese investment in African agriculture despite the lack of available data and fine-level-details about these relationships. This model produced in this paper predicts investment possibilities that will happen in the near future, under the next round of FOCAC-pledged financing. Thus, within a few short years, we can start to validate the model or revise the assumptions of preferences and scenarios that makeup this predictive MCDM. APPENDICES

# **APPENDIX 3.1 – RAW DATA**

This appendix lists the input data used as evaluation criteria. Rows greyed out were omitted from the model for lack of data.

Country	FDI in	GDP (2015,	Total Imports	Total Exports	Growth in Ag.	Ag. Imports	Seed
	\$M	constant)	to China (2015)	from China	Value Added	(2015)	Cotton
	(2015)			(2015)	(2015-2010)		Yield
							hg/ha (2015)
Algoria	\$2 521 55	\$180 772 334 040 01	\$767 362 804	\$7 583 347 042	\$5 547 208 002 20	\$1.760	(2015)
Angola	\$1,268.20	\$109,772,334,940.91	\$16,001,611,383	\$7,585,547,042	\$2,965,536,769,72	\$1,709	10361
Benin	\$87.31	\$8 755 1/8 067 03	\$77.849.434	\$2,989,072,543	\$1,705,550,707.72	\$18 824 564	8775
Botswana	\$321.08	\$16 146 491 230 20	\$138 734 945	\$2,767,072,343	\$(22,854,555,38)	\$-	21702
Burkina Faso	\$521.00	\$11,688,050,885,88	\$44,064,898	\$123 836 631	\$379 661 887 24	\$18 381 125	13784
Burundi	\$12.37	\$2 320 881 501 75	\$2,815,539	\$40,088,753	\$16 841 016 93	\$374 885	7648
Cameroon	\$207.34	\$33.558.475.339.53	\$781.615.344	\$1.833.294.503	\$1.002.987.939.92	\$78.564.742	11094
Cape Verde	\$15.18	\$1,791,765,400,31	\$22,606	\$43,300,195	\$29.325.702.17	\$-	0
CAR	\$46.22	\$1,431,688,205,30	\$26,531,973	\$13,518,226	\$(419,458,437.65)	\$1.025.238	5142
Chad	\$422.72	\$13,486,244,396.11	\$90,692,359	\$123,549,950	\$1,019,842,587.93	\$3,250,602	9310
Comoros	\$4.53	\$1,051,175,803.47	\$22,210	\$45,703,403	\$11,617,244.36	\$-	0
Congo	\$1.088.67	\$14.614.906.845.37	\$2.623.858.411	\$1.035.422.060	\$186.371.032.04	\$-	0
DRC	\$3,239,35	\$31,338,076,169,61	\$2,627,427,301	\$1,408,678,482	\$1.037.003.033.40	\$27,492	4329
Côte d'Ivoire	\$126.78	\$33,963,218,673.86	\$144,109,478	\$1,554,436,952	\$1,822,650,809.44	\$52,604,435	11194
Diibouti	\$60.46	,,	\$898,189	\$1,980,815,513	, ,. ,. ,. ,	\$-	0
Egypt	\$663.15	\$249,940,805,429.58	\$917,844,080	\$11,958,576,936	\$4,559,470,702.03	\$40,679,297	31632
Eq. Guinea	\$231.63	\$16,453,526,925.83	\$1,166,496,464	\$261,389,919	\$96,689,642.40	\$-	0
Eritrea	\$119.41		\$178,730,319	\$134,303,501		\$-	0
Ethiopia	\$1.130.13	\$48,667,131,302,63	\$380,349,712	\$3,440,867,341	\$4.641.393.896.04	\$299,113,362	8402
Gabon	\$244.42	\$18,526,406,863,21	\$1,100,194,341	\$665,415,087	\$184,741,879,43	\$-	0
Gambia	\$1.24	\$1.057,119,309.33	\$55,789,251	\$330.097.246	\$(87.147.593.60)	\$-	3595
Ghana	\$1,274,49	\$45,248,542,333,66	\$1,296,470,657	\$5,308,877,832	\$1.130.766.588.91	\$59,938.621	9224
Guinea	\$382.72	\$8,578,674,103.06	\$25,933,184	\$1,277,088,833	\$363,597,307.82	\$-	9789
Guinea-Bissau	\$69.06	\$998.008.131.23	\$17,812,428	\$17,482,677	\$35.637.104.43	\$-	10749
Kenva	\$1.099.04	\$52,337,439,285,70	\$98,743,024	\$5,914,315,875	\$2.215.238.841.91	\$13,101,905	5493
Lesotho	\$11.15	\$2,888,196,341.59	\$12,002,781	\$83,180,460	\$27,186,947.81	\$-	0
Liberia	\$288.99	\$2,555,669,829,49	\$172,168,095	\$1,356,880,364	\$71,152,988,87	\$-	0
Libya	\$105.77	\$37,867,414,401.91	\$951,549,550	\$1,892,016,554	1. 7	\$-	0
Madagascar	\$347.70	\$9,940,681,351.05	\$171,132,242	\$865,235,356	\$(38,672,071.39)	\$9,157,704	10769
Malawi	\$258.15	\$8,499,051,829.16	\$29,604,640	\$245,961,970	\$312,850,903.10	\$26,948,000	6445
Mali	\$307.33	\$12,686,032,241.33	\$92,988,512	\$270,427,606	\$756,389,707.82	\$84,205,566	9418
Mauritania	\$105.83	\$5,457,464,030.63	\$718,069,947	\$801,372,996	\$111,130,334.15	\$-	0
Mauritius	\$1,096.58	\$11,965,292,676.31	\$15,335,043	\$841,102,768	\$33,860,562.92	\$542,688	0
Morocco	\$156.29	\$113,383,503,344.94	\$521,521,041	\$2,897,184,380	\$3,155,092,037.34	\$18,978,100	20708
Mozambique	\$724.52	\$14,307,681,441.37	\$452,616,050	\$1,938,023,358	\$437,300,754.53	\$63,290,858	4098
Namibia	\$380.44	\$14,843,393,221.77	\$211,633,751	\$489,914,924	\$(108,350,215.81)	\$156,135	0
Niger	\$565.44	\$7,726,733,075.78	\$140,993,156	\$173,348,405	\$529,101,366.40	\$119,686,557	10371
Nigeria	\$2,376.76	\$464,282,244,064.12	\$1,240,700,780	\$13,701,240,179	\$19,317,138,890.11	\$10,713,037	6913
Rwanda	\$123.57	\$8,307,806,853.94	\$43,535,650	\$122,274,281	\$470,508,949.18	\$137,942	0
ST & P	\$0.38	\$246,519,490.89	\$33,209	\$5,956,741	\$2,675,077.85	\$-	0
Senegal	\$126.02	\$20,164,485,187.49	\$111,659,841	\$2,190,531,553	\$155,798,858.66	\$82,671,400	10133
Seychelles	\$160.11	\$1,231,973,525.72	\$99,638	\$57,626,174	\$3,354,045.55	\$-	0
Sierra Leone	\$196.30	\$3,163,801,388.83	\$164,822,246	\$276,560,552	\$251,047,837.96	\$-	0
Somalia			\$24,711,520	\$298,118,241		\$16,683,587	3986
South Africa	\$4,722.97	\$418,898,007,437.77	\$30,151,410,452	\$15,857,921,952	\$757,897,842.55	\$183,614,987	33339
South Sudan	\$35.98	· ·	\$2,326,886,670	\$155,445,271		\$-	0
Sudan	\$1,809.36	\$72,731,117,403.96	\$728,393,540	\$2,394,502,823	\$4,532,595,275.03	\$161,038,900	15313
Swaziland		\$5,175,653,650.93	\$289,264	\$30,567,448	\$93,416,727.12	\$-	6410
Tanzania	\$1,138.87	\$43,730,597,179.91	\$377,844,200	\$4,278,864,540	\$1,564,257,601.83	\$165,837,592	4518
Togo	\$128.82	\$4,615,819,477.80	\$214,712,907	\$2,180,165,797	\$303,545,507.99	\$190,567,495	7215
Tunisia	\$20.84	\$48,148,386,195.33	\$183,799,263	\$1,237,428,731	\$1,075,880,749.68	\$2,275,660	6555
Uganda	\$722.15	\$26,260,227,906.93	\$85,583,492	\$553,400,101	\$585,182,196.31	\$49,539,500	11226
Zambia	\$2,338.02	\$26,058,118,446.56	\$1,786,476,269	\$552,068,957	\$(1,855,287.57)	\$80,794,883	8193
Zimbabwe	\$1,798.92	\$17,048,679,958.73	\$761,400,853	\$543,323,040	\$280,299,411.38	\$607,359,092	3821

# **APPENDIX 3.2 – MCDM RESULTS**

	Seconaria 1 (S1)		Sconario 2 (S2)		Sconario 3 (S3)	
Donk	COUNTRY	DIV	COUNTRY	DIV	COUNTRY	DIV
	South Africa	0.064	Zimbabwa	0.401	South Africa	0.610
2	Nigorio	0.904	South Africa	0.491	South Anica	0.010
2	DPC	0.492	Nigoria	0.431	Lgypt	0.492
3	Algoria	0.401	Ethiopia	0.439	Angola	0.409
4	Argella	0.392	Euliopia	0.341	Moroaaa	0.360
5	Aligoia	0.342	Egypt	0.231	Rotewana	0.340
0	Egypt	0.303	Angolo	0.230	Suden	0.332
/	Egypt	0.298	Aligoia	0.217	Sudan Zimbaham	0.329
8	Sudan	0.257	Algeria	0.208	Zimbabwe	0.275
9	Zimbabwe	0.240	Togo	0.202		0.257
10	Gnana	0.212	Tanzania	0.201	Algeria	0.245
11	Kenya	0.197	Niger	0.132	DRC	0.220
12	Tanzania	0.184	Ghana	0.122	Zambia	0.212
13	Ethiopia	0.177	Zambia	0.121	Côte d'Ivoire	0.205
14	Congo	0.161	DRC	0.119	Ghana	0.204
15	Mauritius	0.152	Kenya	0.119	Uganda	0.203
16	Mozambique	0.111	Morocco	0.113	Cameroon	0.202
17	Morocco	0.109	Cameroon	0.100	Niger	0.194
18	Uganda	0.104	Mali	0.098	Madagascar	0.186
19	Niger	0.080	Senegal	0.098	Guinea-Bissau	0.183
20	Benin	0.063	Côte d'Ivoire	0.087	Senegal	0.182
21	Chad	0.061	Mozambique	0.083	Mali	0.173
22	Guinea	0.061	Uganda	0.067	Guinea	0.173
23	Cameroon	0.057	Congo	0.055	Chad	0.169
24	Namibia	0.057	Benin	0.052	Kenya	0.161
25	Madagascar	0.054	Tunisia	0.047	Benin	0.158
26	Senegal	0.052	Mauritius	0.042	Togo	0.158
27	Liberia	0.050	Chad	0.041	Tanzania	0.157
28	Togo	0.049	Malawi	0.037	Burundi	0.133
29	Botswana	0.048	Guinea	0.031	Tunisia	0.124
30	Tunisia	0.046	Liberia	0.027	Malawi	0.118
31	Côte d'Ivoire	0.046	Gabon	0.026	Mozambique	0.100
32	Mali	0.045	Rwanda	0.024	CAR	0.091
33	Gabon	0.045	Madagascar	0.024	Congo	0.081
34	Eq. Guinea	0.042	Eq. Guinea	0.023	Mauritius	0.074
35	Malawi	0.038	Mauritania	0.021	Gambia	0.065
36	Sierra Leone	0.029	Sierra Leone	0.019	Liberia	0.030
37	Mauritania	0.026	Namibia	0.019	Namibia	0.028
38	Seychelles	0.023	Botswana	0.017	Gabon	0.028
39	Rwanda	0.019	Seychelles	0.012	Eq. Guinea	0.025
40	Guinea-Bissau	0.010	Guinea-Bissau	0.012	Rwanda	0.024
41	Gambia	07	Lesotho	0.012	Sierra Leone	0.022
42	CAR	07	Cape Verde	0.012	Mauritania	0.020
43	Lesotho	03	Burundi	0.011	Seychelles	0.015
44	Cape Verde	03	Comoros	0.011	Cape Verde	0.012
45	Burundi	03	STP	0.011	Lesotho	0.012
46	Comoros	01	Gambia	0.010	Comoros	0.011
47	STP	00	CAR	02	STP	0.011

The full MCDM results by both Rank and Ranking Index Value (RIV) for all three scenarios.

# APPENDIX 3.3 – GLOBAL SENSITIVITY ANALYSIS

Country	w1	w2	w3	w4	w5	w6	w7	Sum Si	1 - SumSi	Max
Algeria	0.20	0.06	0.31	0.10	-0.01	0.20	0.02	89%	11%	0.31
Angola	0.00	0.02	0.54	0.01	0.11	0.21	0.08	97%	3%	0.54
Benin	0.02	0.02	0.10	0.20	0.07	0.03	0.40	83%	17%	0.40
Botswana	0.00	0.01	0.03	0.01	0.03	0.02	0.80	90%	10%	0.80
Burundi	0.01	0.01	0.03	0.01	0.02	0.02	0.80	90%	10%	0.80
Cameroon	0.02	0.01	0.15	0.00	0.04	0.01	0.61	86%	14%	0.61
Cape Verde	0.00	0.01	0.05	0.01	0.88	0.02	0.01	98%	2%	0.88
CAR	0.00	0.01	0.02	0.01	0.03	0.02	0.80	89%	11%	0.80
Chad	0.00	0.02	0.08	0.02	0.00	0.06	0.67	86%	14%	0.67
Comoros	0.00	0.01	0.04	0.01	0.88	0.02	0.01	98%	2%	0.88
Congo	0.74	0.03	0.00	0.00	0.07	0.08	0.01	94%	6%	0.74
DRC	0.83	0.02	0.03	0.01	0.03	0.05	0.00	97%	3%	0.83
Cote d'Ivoire	0.03	0.01	0.16	0.00	0.00	0.01	0.64	85%	15%	0.64
Egypt	0.03	0.06	0.24	0.18	0.03	0.11	0.21	86%	14%	0.24
Eq. Guinea	0.27	0.01	0.20	0.04	0.00	0.29	0.03	85%	15%	0.29
Ethiopia	0.00	0.04	0.27	0.00	0.01	0.62	0.00	94%	6%	0.62
Gabon	0.27	0.02	0.03	0.04	0.00	0.44	0.07	86%	14%	0.44
Gambia	0.01	0.01	0.04	0.00	0.01	0.03	0.76	88%	12%	0.76
Ghana	0.12	0.03	0.21	0.31	0.12	0.05	0.05	88%	12%	0.31
Guinea	0.00	0.02	0.07	0.00	0.04	0.05	0.69	86%	14%	0.69
Guinea-Bissau	0.01	0.01	0.03	0.01	0.02	0.02	0.80	90%	10%	0.80
Kenya	0.06	0.01	0.21	0.52	0.00	0.11	0.00	91%	9%	0.52
Lesotho	0.01	0.01	0.05	0.01	0.86	0.03	0.01	97%	3%	0.86
Liberia	0.13	0.04	0.11	0.54	0.01	0.07	0.02	92%	8%	0.54
Madagascar	0.00	0.01	0.05	0.00	0.04	0.03	0.74	88%	12%	0.74
Malawi	0.00	0.02	0.09	0.02	0.02	0.01	0.71	87%	13%	0.71
Mali	0.01	0.03	0.14	0.03	0.03	0.09	0.54	87%	13%	0.54
Mauritania	0.00	0.06	0.00	0.59	0.02	0.17	0.04	86%	14%	0.59
Mauritius	0.82	0.02	0.05	0.00	0.03	0.04	0.01	96%	4%	0.82
Morocco	0.03	0.02	0.15	0.00	0.00	0.09	0.58	87%	13%	0.58
Mozambique	0.26	0.08	0.28	0.05	0.14	0.04	0.03	88%	12%	0.28
Namibia	0.71	0.00	0.09	0.00	0.04	0.07	0.01	92%	8%	0.71
Niger	0.00	0.04	0.15	0.03	0.08	0.23	0.35	88%	12%	0.35
Nigeria	0.00	0.10	0.28	0.03	0.29	0.17	0.02	89%	11%	0.29
Rwanda	0.01	0.00	0.09	0.01	0.78	0.05	0.01	97%	3%	0.78
STP	0.00	0.01	0.04	0.01	0.89	0.02	0.00	98%	2%	0.89
Senegal	0.02	0.02	0.15	0.01	0.10	0.05	0.50	86%	14%	0.50
Seychelles	0.48	0.04	0.10	0.02	0.19	0.07	0.01	92%	8%	0.48
Sierra Leone	0.28	0.05	0.13	0.00	0.36	0.10	0.02	92%	8%	0.36
South Africa	0.03	0.02	0.13	0.03	0.59	0.13	0.01	94%	6%	0.59
Sudan	0.15	0.04	0.48	0.03	0.01	0.01	0.17	89%	11%	0.48
Tanzania	0.05	0.04	0.30	0.11	0.10	0.32	0.00	91%	9%	0.32
Togo	0.02	0.03	0.09	0.00	0.07	0.71	0.03	94%	6%	0.71
Tunisia	0.04	0.05	0.19	0.00	0.00	0.12	0.46	85%	15%	0.46
Uganda	0.04	0.02	0.12	0.02	0.06	0.01	0.60	86%	14%	0.60
Zambia	0.72	0.03	0.06	0.02	0.09	0.01	0.01	94%	6%	0.72
Zimbabwe	0.00	0.02	0.06	0.01	0.06	0.81	0.00	96%	4%	0.81
Mean / Average	0.14	0.03	0.13	0.06	0.15	0.13	0.26	90%	10%	0.60

### SOBOL FIRST ORDER INDEX

Country	w1	w2	w3	w4	w5	w6	w7	Max	Sum STi	Max / Sum
Algeria	0.24	0.10	0.36	0.13	0.05	0.24	0.03	0.36	1.14	0.31
Angola	0.00	0.02	0.57	0.01	0.13	0.24	0.11	0.57	1.09	0.52
Benin	0.02	0.05	0.14	0.25	0.12	0.08	0.46	0.46	1.11	0.41
Botswana	0.01	0.02	0.06	0.03	0.06	0.06	0.82	0.82	1.06	0.77
Burundi	0.01	0.02	0.07	0.03	0.06	0.07	0.82	0.82	1.06	0.77
Cameroon	0.03	0.03	0.20	0.02	0.11	0.07	0.66	0.66	1.12	0.59
Cape Verde	0.01	0.01	0.06	0.01	0.90	0.04	0.01	0.90	1.03	0.87
CAR	0.01	0.02	0.06	0.03	0.07	0.06	0.82	0.82	1.06	0.78
Chad	0.02	0.03	0.13	0.05	0.06	0.11	0.72	0.72	1.13	0.64
Comoros	0.01	0.01	0.05	0.01	0.90	0.03	0.00	0.90	1.03	0.88
Congo	0.82	0.05	0.06	0.02	0.07	0.08	0.02	0.82	1.11	0.74
DRC	0.87	0.03	0.05	0.02	0.04	0.06	0.01	0.87	1.07	0.81
Cote d'Ivoire	0.04	0.03	0.22	0.03	0.07	0.07	0.69	0.69	1.13	0.61
Egypt	0.04	0.07	0.31	0.21	0.09	0.17	0.25	0.31	1.14	0.27
Eq. Guinea	0.38	0.05	0.30	0.04	0.06	0.30	0.05	0.38	1.19	0.32
Ethiopia	0.02	0.05	0.30	-0.01	0.04	0.65	0.01	0.65	1.06	0.61
Gabon	0.36	0.05	0.08	0.05	0.04	0.47	0.09	0.47	1.14	0.41
Gambia	0.01	0.03	0.08	0.03	0.06	0.08	0.79	0.79	1.08	0.73
Ghana	0.15	0.06	0.26	0.34	0.18	0.08	0.07	0.34	1.13	0.30
Guinea	0.01	0.04	0.12	0.03	0.08	0.10	0.73	0.73	1.11	0.66
Guinea-Bissau	0.01	0.02	0.06	0.03	0.06	0.06	0.82	0.82	1.06	0.77
Kenya	0.08	0.03	0.24	0.56	0.05	0.12	0.00	0.56	1.09	0.52
Lesotho	0.01	0.01	0.06	0.01	0.88	0.04	0.01	0.88	1.03	0.86
Liberia	0.17	0.06	0.13	0.59	0.05	0.07	0.02	0.59	1.09	0.54
Madagascar	0.01	0.03	0.09	0.03	0.09	0.08	0.77	0.77	1.09	0.71
Malawi	0.01	0.04	0.13	0.04	0.08	0.06	0.75	0.75	1.11	0.67
Mali	0.02	0.05	0.18	0.05	0.09	0.15	0.58	0.58	1.11	0.53
Mauritania	0.01	0.08	0.03	0.68	0.07	0.18	0.03	0.68	1.09	0.62
Mauritius	0.86	0.03	0.07	0.01	0.04	0.05	0.01	0.86	1.07	0.80
Morocco	0.04	0.03	0.21	0.03	0.06	0.15	0.63	0.63	1.14	0.55
Mozambique	0.32	0.11	0.34	0.06	0.18	0.08	0.04	0.34	1.13	0.30
Namibia	0.77	0.03	0.12	0.02	0.05	0.09	0.02	0.77	1.09	0.71
Niger	0.02	0.06	0.18	0.04	0.12	0.29	0.39	0.39	1.11	0.36
Nigeria	0.00	0.14	0.32	0.05	0.33	0.24	0.02	0.33	1.10	0.30
Rwanda	0.03	0.01	0.11	0.01	0.82	0.07	0.01	0.82	1.06	0.77
STP	0.01	0.01	0.05	0.01	0.91	0.03	0.00	0.91	1.03	0.88
Senegal	0.04	0.04	0.19	0.02	0.17	0.10	0.55	0.55	1.11	0.50
Seychelles	0.57	0.05	0.13	0.02	0.27	0.08	0.02	0.57	1.14	0.50
Sierra Leone	0.35	0.05	0.15	0.01	0.43	0.11	0.02	0.43	1.12	0.39
South Africa	0.04	0.02	0.14	0.02	0.65	0.20	0.01	0.65	1.08	0.60
Sudan	0.19	0.06	0.54	0.05	0.05	0.05	0.20	0.54	1.15	0.47
Tanzania	0.08	0.05	0.35	0.11	0.13	0.35	0.00	0.35	1.10	0.32
Togo	0.04	0.04	0.12	-0.01	0.09	0.72	0.04	0.72	1.04	0.69
Tunisia	0.05	0.06	0.25	0.03	0.07	0.19	0.51	0.51	1.16	0.44
Uganda	0.06	0.03	0.17	0.05	0.11	0.07	0.65	0.65	1.13	0.57
Zambia	0.77	0.05	0.09	0.03	0.09	0.03	0.03	0.77	1.09	0.70
Zimbabwe	0.02	0.02	0.08	0.01	0.06	0.84	0.00	0.84	1.04	0.81
Mean/Average	0.16	0.04	0.17	0.08	0.20	0.16	0.28	0.65	1.10	0.59

# SOBOL TOTAL ORDER INDEX

REFERENCES

# REFERENCES

Adiat, K. A. N., Nawawi, M. N. M., & Abdullah, K. (2012). Assessing the accuracy of GISbased elementary multi criteria decision analysis as a spatial prediction tool–a case of predicting potential zones of sustainable groundwater resources. *Journal of Hydrology*, 440, 75-89.

Bräutigam, D. (2015a). Will Africa Feed China? Oxford University Press.

Chang, T. H., & Wang, T. C. (2009). Using the fuzzy multi-criteria decision making approach for measuring the possibility of successful knowledge management. *Information Sciences*, *179*(4), 355-370.

China Africa Research Initiative (CARI). (2018). China-Africa Foreign Direct Investment Data [Data file]. Retrieved from http://www.sais-cari.org/chinese-investment-in-africa

Dinçer, S. E. (2011). Multi-criteria analysis of economic activity for European Union Member States and candidate countries: TOPSIS and WSA applications. *European Journal of Social Sciences*, *21*(4), 563-572.

Dreher, A., Fuchs, A., Parks, B.C., Strange, A. M., & Tierney, M. J. (2017). *Aid, China, and Growth: Evidence from a New Global Development Finance Dataset*. (AidData Working Paper 46). Williamsburg, VA: AidData at William & Mary.

FOCAC. (2018). Forum on China-Africa Cooperation Beijing Action Plan (2019-2021). Beijing, China: Ministry of Foreign Affairs.

Greene, R., Devillers, R., Luther, J. E., & Eddy, B. G. (2011). GIS-based multiple-criteria decision analysis. *Geography Compass*, 5(6), 412-432.

Herman, J. (2013, Aug 5). Running Sobol Sensitivity Analysis using SALib. [Water Programming: A Collaborative Research Blog]. Retrieved from https://waterprogramming.wordpress.com/2013/08/05/running-sobol-sensitivity-analysis-using-salib/

Hwang, C. L., & Yoon, K. (1981). Methods for multiple attribute decision making. In *Multiple Attribute Decision Making* (pp. 58-191). Berlin: Springer.

Li, J., Tang, L., Sun, X., & Wu, D. (2014). Oil-importing optimal decision considering country risk with extreme events: A multi-objective programming approach. *Computers & Operations Research*, *42*, 108-115.

Malczewski, J. (1999). GIS and multicriteria decision analysis. John Wiley & Sons.

Malczewski, J. (2006). GIS-based multicriteria decision analysis: a survey of the literature. *International Journal of Geographical Information Science*, 20(7), 703-726.

Meyer, P., Bigaret, S., Hodgett, R., & Olteanu, A.L. (2019). MCDA: Support for the Multicriteria Decision Aiding Process. (version 0.0.20) [R Package]. Available from https://cran.r-project.org/web/packages/MCDA/index.html

Mohan, G., & Lampert, B. (2013). Negotiating China: Reinserting African Agency into China–Africa Relations. *African Affairs*, *112*(446), 92-110.

Nutt, D. J., King, L. A., & Phillips, L. D. (2010). Drug harms in the UK: A multicriteria decision analysis. *The Lancet*, *376*(9752), 1558-1565.

Kiker, G. A., Bridges, T. S., Varghese, A., Seager, T. P., & Linkov, I. (2005). Application of multicriteria decision analysis in environmental decision making. *Integrated Environmental Assessment and Management: An International Journal*, *1*(2), 95-108.

R Core Team (2019). R: A language and environment for statistical computing [Web tool]. Vienna, Austria: R Foundation for Statistical Computing. Available from http://www.R-project.org/

Saisana, M., Saltelli, A., & Tarantola, S. (2005). Uncertainty and sensitivity analysis techniques as tools for the quality assessment of composite indicators. *Journal of the Royal Statistical Society: Series A (Statistics in Society), 168*(2), 307-323.

Scoones, I., Amanor, K., Favareto, A., & Qi, G. (2016). A new politics of development cooperation? Chinese and Brazilian engagements in African agriculture. *World Development*, *81*, 1-12.

Scoones, I., Cabral, L., & Tugendhat, H. (2013). New development encounters: China and Brazil in African agriculture. *IDS Bulletin*, 44(4), 1-19.

SimLab [Computer software]. (2008). Available from https://ec.europa.eu/jrc/en/samo/simlab

Triantaphyllou, E. (2000). Multi-criteria decision making methods. In *Multi-criteria decision making methods: A comparative study* (pp. 5-21). Boston, MA: Springer.

UN Comtrade Database. *Reporter – China, various commodity codes for agricultural products* [Data file]. Retrieved from https://comtrade.un.org/data/

Wang, J. J., Jing, Y. Y., Zhang, C. F., & Zhao, J. H. (2009). Review on multi-criteria decision analysis aid in sustainable energy decision-making. *Renewable and Sustainable Energy Reviews*, 13(9), 2263-2278.

World Bank Open Database. *Indicators: Cereal yield; Agriculture, forestry, and fishing, value added; GDP* [Data file]. Retrieved from https://data.worldbank.org/indicator

CONCLUSION

### **Chapter Summaries**

The goal of this dissertation was to use a variety of modeling tools to isolate some facets of the China-Africa agricultural system in order to better understand them, inspire new questions, and test assumptions. Each chapter shows a different method for investigating how the China-Africa agricultural relationship is conceptualized and realized at the intersections of large-scale sociopolitical, environmental, and economic processes.

In Chapter 1, the objective was to describe the current narratives in China-Africa agricultural research across both the English- and Chinese-speaking academic literature. Using topic modeling on a case study of selected English and Mandarin texts on China-Africa agricultural ties, we found that English-language texts focus on the act of investing, while Mandarin texts focus on why Africa is an appropriate investment venue. Ultimately, the Mandarin corpus is much more prescriptive, rather than empirical in nature. As some papers share authors across languages, we also posit that audience rather than author may determine the narrative of China-Africa research.

In Chapter 2, the objective was to determine the current relationship between Chinese investment in Africa and African agricultural development. We created a conceptual telecoupling model illustrating national-level changes in African agricultural development as a potential spillover effect of Chinese foreign direct investment (FDI) in the non-agricultural sectors of African economies. Using Kendall's tau rank correlation, we investigated the effect of Chinese FDI on African agricultural development indicators and compare it with that of US FDI on the same indicators. Regardless of origin, FDI seems to show a spillover effect for all three agricultural development indicators: (i) value added by agriculture, forestry, and fishing to a country's economy, (ii) employment in agriculture, and (iii) cereal yield. According to our
results, China is currently enabling said potential spillover effect in far more countries than the US.

This chapter showed that while there is little direct Chinese investment in African agriculture, that does not necessarily mean current Chinese investment has no effect on agricultural development in Africa. There is preliminary evidence for a broad infrastructure-toagriculture spillover, as conceptualized using the telecoupling framework, and new/better data could take this to the next step. Particularly for researchers choosing to look at a country where sectoral FDI data is available. The telecoupling framework highlighted in this paper could then serve as a conceptual guideline and the methods (correlation tests) a starting point for further interrogation.

In Chapter 3, the objective was to predict where in Africa will China direct agricultural investment to in the near future. Our multi-criteria decision model tested three scenarios in which we asked: in which African countries will China invest in agriculture if (i) China prefers to invest in countries already invested in; (ii) China prefers to invest in countries that show general agricultural potential; and, (iii) China prefers to invest in countries involved in the cotton sector. For each scenario, the model produced its own ranked list of possible investment countries. Currently, Chinese investments in African agriculture are still relatively new and sparse. In the absence of past trends and historical data, a preference model such as this one may be the more useful predictive tool.

## **General Limitations**

This project only focused on two areas of China-Africa agricultural engagement. The first was the research community, the second was investment. Largely omitted from this research are considerations of development aid, trade concerns and commodity flows, food security, food aid,

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diplomatic missions, legislative influences, and a host of other topics that all also influence, shape, and direct overall realization of the China-Africa agricultural system.

## **Major Contributions**

That said, despite their limitations, the three chapters presented in this work do offer some key contributions to the overall study of China-in-Africa. First, this work presents multiple applications of methodologies underutilized in the study of China-Africa agriculture systems. Four different model types, generalized as textual, conceptual, statistical, and decision-oriented models, were applied to a variety of data. As data is often unreliable and/or hard to find, using multiple modeling approaches is one way to address this uncertainty head on. No one model presented in this dissertation perfectly captured the phenomena it sought to describe; however, each offered new insight into the China-Africa agricultural relationship and each can be generalized to multiple scales (regional, national, local) to investigate similar questions in a more specific context. For example, a topic model on only aid announcements in Ghana or a multi-criteria decision model recreating the selection of partner companies for China's agricultural technology demonstration centers (ATDCs).

The models used in this dissertation also explicit state their data inputs and assumptions about the behavior of the system under study. In doing so, they both reinforce that more data is needed to understand any trends in China-Africa agricultural systems and draw attention to the specific gaps in data needed. In particular, sectoral investment data would go a long way to illuminate specific mechanisms of impacts from Chinese investment. In general, improvements should be made in data collected over time, by sector, by location (country- or city-specific), and by source (Chinese state vs. private firms).

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The conclusions reached in each chapter of this work also push back against the idea of one "Chinese model" of development that can be applied to Africa—where model is taken to mean an overarching conceptual framework, a "how to" on what development should look like (Scoones et al., 2016). Other studies have shown a range of engagements in African agricultural sectors by Chinese actors and that generalizations are not reinforceable (Amanor and Chichava, 2016; Cook et al., 2016, Gu et al., 2016). We agree. As shown in Chapter 1, across the academic literature, even in Mandarin, there is no one consensus on what engagement in African agriculture entails. Chapter 2 shows us that Chinese investment only seems monolith because the current data is structured that way. Access to sectoral foreign direct investment data would go a long way in showing how Chinese investment impacts different countries' agricultural development in different ways. Chapter 3 shows us that assumptions matter. Each assumption on China's investment preference resulted in a different ranked list of investment targets. Multiple actors within the Chinese investment community have multiple preferences. Trying to predict future outcomes without acknowledging this will have limited success.

The above work shows that there is not just one generalizable model of Chinese engagement in African agriculture but a variety of interactions all of which can be captured and described in multiple ways. As successive Forum on China-Africa Cooperation (FOCAC) summits announce new engagements and projects are subsumed under the Belt and Road Initiative (BRI), it will depend on project type and the recipient country, and method of financial support to even began and assume outcomes.

## **Future Recommendations**

Finally, to conclude, we have collected the countries highlighted by each model together in *Figure 4.1*. Those countries located at the intersection of two or more circles are those that were

found to be important or interesting by more than one model. For example, Malawi was both mentioned often enough in the Mandarin-language literature to serve as a topic descriptor in our topic model in Chapter 1, as well as show a strong, positive correlation with all three of the agricultural development indicators and Chinese FDI in Chapter 2. Zambia and Ethiopia stand out as the countries prominent in all three chapters with Ethiopia both a prominent site of Chinese investment and a strong agricultural producer and Zambia as a large recipient of Chinese investment with a more complicated agricultural history. For future China-Africa scholars, focusing on an in-depth research project in either of these countries could provide the most robust case studies. There is prior research to draw upon, there seems to be an indirect link between increasing Chinese FDI into the country and agricultural development, and Chinese direct investment into that country's agriculture could increase in the near future.



Figure 4.1 Countries highlighted by model in each chapter

REFERENCES

## REFERENCES

Amanor, K. S., & Chichava, S. (2016). South–south cooperation, agribusiness, and African agricultural development: Brazil and China in Ghana and Mozambique. *World Development*, *81*, 13-23.

Cook, S., Lu, J., Tugendhat, H., & Alemu, D. (2016). Chinese migrants in Africa: Facts and fictions from the agri-food sector in Ethiopia and Ghana. *World Development*, *81*, 61-70.

Gu, J., Zhang, C., Vaz, A., & Mukwereza, L. (2016). Chinese state capitalism? Rethinking the role of the state and business in Chinese development cooperation in Africa. *World Development*, *81*, 24-34.

Scoones, I., Amanor, K., Favareto, A., & Qi, G. (2016). A new politics of development cooperation? Chinese and Brazilian engagements in African agriculture. *World Development*, *81*, 1-12.