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ORIGINAL ARTICLE

Development Aid 2.0: Technology transfer and skill formation

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ABSTRACT

This paper explains the growing importance of knowledge-based societies in driving industrial progress. It highlights the crucial need for technological and skill advancement, particularly among the expanding young populations in developing countries who lack essential work skills. This study scrutinizes the traditional Development Aid (DA) 1.0 model, which focuses mainly on financial aid and infrastructure projects but overlooks the importance of developing a skilled workforce that meets industry needs. Introducing the concept of DA 2.0 through the lens of the Triple Helix Theory, this paper suggests a sustainable approach that integrates government, academia, and industry to promote technology transfer and skill development. Through the policy analysis and case studies, it demonstrates how China leverages its technological expertise and skill advantage to enhance DA in African countries. The study concludes by advocating for DA 2.0 approach that is a government-supported, industry-driven approach to workforce development. By fostering collaboration among these sectors, China and Africa could optimize the impact of DA initiatives in addressing local challenges.

Key words: Development Aid 2.0, workforce, technology transfer, skill, Triple Helix Theory, China, Africa

INTRODUCTION

"Education" within economics and economic history has spanned centuries, with well-known scholars such as Adam Smith,[1] Gary Becker,[2] and James Heckman[3] emphasizing the role of human capital in driving economic growth. In contemporary discourse, considerable attention has been paid to the imperative role of workforce education in fostering manpower development, particularly within the context of development aid (DA) initiatives.[4] Although development aid programs have increasingly recognized the importance of education and skill enhancement in human capital accumulation,[5] few studies have explored the specific strategies and mechanisms through which DA can effectively bridge the gap between workforce education and the evolving demands of industries. This research gap underscores the importance of developing a thorough understanding of the aid strategies for effectively linking education with industry. Such an approach also needs to be facilitated by government policies to foster sustainable aid programs.

Traditional DA, referred to as DA 1.0 in this paper, mainly consists of international assistance provided by governments or other entities to promote the economic, environmental, and social development of developing countries. Instead of being channeled through cooperative efforts among government, academia, and industry, the aid is often fragmented and disconnected. Government policies may not align with the needs and priorities of academia and industry, resulting in disjointed efforts and suboptimal outcomes.[6] Similarly, academia may conduct research or training programs

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that do not address industry demands or government development goals.[7] As a result, traditional DA could fail to leverage the collective strengths and resources of government, academia, and industry, thereby impeding its overall effectiveness.

As one of the biggest challenges faced by developing countries is the rapidly growing population without the requisite qualifications for industrialization, the urgent need to prepare a workforce that aligns with industrialization becomes a top priority for these nations.[8] Although scholars have emphasized the crucial need for developing countries to evolve into knowledge-based societies,[9,10] the proportion of Official Development Aid (ODA) dedicated to education is still relatively low. This remains the case even though there has been a rise in the share of ODA in education, increasing from 6.0% in 2002 to 15.6% in 2018.[11] More importantly, the majority of this aid is directed towards basic and secondary education with less attention paid to employability skills of the workforce. However, considering developing countries' increasing number of youth population and high unemployment rates, it's essential to not only sustain the achievements in basic and secondary education but also to prioritize industry-driven educational programs. This could balance both the immediate and long-term impacts of education aid.

Therefore, a paradigm shift becomes necessary, highlighting workforce development in driving industrial progress within developing nations. This new approach, referred to as DA 2.0 in this study, evolves from the traditional model by emphasizing collaboration among government, academia, and industry, in line with the principles of the Triple Helix Theory.[12] DA 2.0 does not change the core nature of traditional DA but innovates in its methods and channels of delivery, aiming specifically to prepare the workforce for industry-relevant jobs (Figure 1). The lack of coordination between educational programs and industrial demands has often led to a gap between what is taught and what the labor market requires, resulting in either a brain drain or a high unemployment rate due to the mismatch between graduates' skills and industry needs. To bridge this gap, it is crucial for government entities, educational institutions, and industrial sectors to collaborate closely, focusing on aligning educational outcomes with labor market demands. By doing so, a smooth transition "from education to employment" might be established.

As Africa experiences a transitional phase characterized by rapid population growth and a shift towards labor-intensive industries, it encounters significant knowledge and technological barriers. In the pursuit of industrialization through attracting foreign direct investment (FDI), African countries actively seek to foster technology transfer and capacity building. Technology transfer from industrialized nations to less developed ones is instrumental in enhancing workforce capabilities and fostering innovation, and ultimately contributing to sustainable development in recipient countries.[13] These dynamics prompt questions about how DA can support technology transfer and what attributes a new aid model should embody. This research has the potential to inform policymakers, international organizations, and development practitioners about the importance of adopting a holistic and sustainable approach through DA.

TRIPLE HELIX THEORY

There are numerous scholars who constructed key works that paved the way for the conceptualization of Triple Helix Theory. For example, Sábato's Triangle laid the groundwork for understanding the interconnectedness of government, industry, and science and technological infrastructure in the context of Latin American countries.[14] Freeman's National Innovation System developed in the context of post-war Japan, focused on the recovery of the Japanese economy by utilizing various entities to introduce and spread new technologies for national development.[15] Cooke's regional innovation system extended the discussion on innovation practices to the European context.[16] Emphasizing innovation as a regional strategy, Cooke explored how regional entities could drive economic development through collaborative efforts. Based on previous scholars' work, the Triple Helix Theory highlights the dynamic interactions among government (G), industry (I), and academia/University (U) by drawing on examples from Silicon Valley, Route 128 in Boston, and Japan's Tsukuba science city.[12] This theory has become a key theoretical lens for understanding and fostering knowledge-based societies. Later on, Carayannis and Campbell explained the evolving nature of the Triple Helix concept, advocating for its adaptability to various socio-economic contexts and emphasizing its potential to drive regional development.[17]

Despite criticisms for its abstract nature and lack of micro-theoretical foundation,[18] Triple Helix Theory remains beneficial as it provides an integrated perspective for analyzing competitiveness and regional development.[19] Given the important role of FDI and technology transfer in driving innovation and entrepreneurship, especially in developing countries,[20] developing a skilled workforce becomes essential for a country to adapt to new technologies and industries. If government, academia, and industry fail to synchronize their efforts in developing the workforce, it may lead to either a shortage of intellectual support (intellectual support

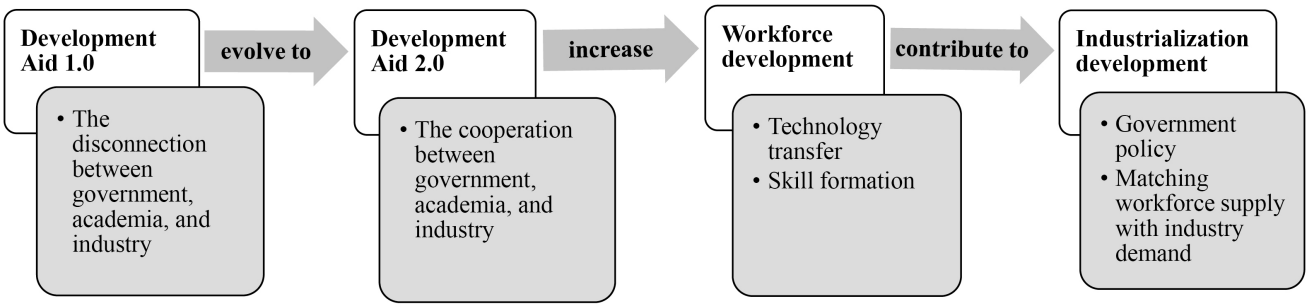

Figure 1. Development Aid paradigm shift.

scarcity) or a gap between industry demand and available skills (mismatched industry demand).[21]

DA 1.0 AND ITS LIMITATIONS

Traditional DA, termed DA 1.0 in this paper, has been the dominant way of international aid between donor countries and recipient countries in history. It is a type of international aid given by governments or other agencies to support developing countries, since 80% were from the government, it also being called ODA.[22] The remaining 20% or so comes from individuals, businesses, charitable foundations, or non-government organizations (NGOs).[23] Effective DA strategies often involve a combination of two approaches. One is direct aid involving the transfer of financial or material resources from one country or organization to another. It typically occurs through ODA programs, bilateral agreements, or international organizations. Another is indirect aid which focuses on creating an enabling environment for development or addressing structural issues that hinder progress, such as policy reforms, advocacy initiatives, FDI's spillover effects, institutional strengthening, and so on.

DA's positive relation with economic growth has been well studied in the literature.[24] However, traditional aid faces criticisms and challenges of its effectiveness, impact, and sustainability, as dissident economist Peter Bauer argued: "DA is an excellent method for transferring money from poor people in rich countries to rich people in poor countries".[25] Boone also pointed out: "Aid does not significantly increase investment and growth, nor benefit the poor as measured by improvements in human development indicators, but it does increase the size of government".[26] Compared with Western aid, some scholars believe that the way of cooperation between Africa and China is beneficial to the development of Africa.[27] In 2011, Brautigam further elaborated on how China has earned the trust of Africa through principles of equality and mutual benefit. She illustrates how China deeply engaged with the African continent and its people, ultimately achieving mutually beneficial outcomes.[28]

Analyzing the traditional DA model using the Triple Helix framework reveals two distinct types (Figure 2). The shaded area in Type I of the figure represents development aid directed solely towards government-supported industries, overlooking workforce education. This results in a shortage of skilled workforce. For instance, in Ethiopia in 2010, the government initiated an export-oriented industrial policy and allocated its DA to infrastructure projects such as industrial parks and free economic zones. Although there has been an increased flow of FDI into Ethiopia since then, the shortage of industrial and technical workers hinders the effectiveness of FDI, with factories struggling to hire skilled workers despite a large pool of unskilled job seekers queuing outside factories for employment opportunities.[29] The shaded area in Type II of the figure shows DA channeled towards government-supported education without considering the need for industry. It results in a mismatch between acquired skills and industry demands, causing decreased productivity due to a lack of practical knowledge.[30] Both forms of DA fail to recognize the essential link between workforce education and industry demands, thus limiting the effectiveness of the aid.

DA 2.0 AND ITS COMPONENTS

In the context of industrial growth in African countries, there is a severe shortage of well-prepared workers.[31] However, the traditional DA model falls short in addressing the development of manpower within an integrated system.[32] To address these issues, DA 2.0 which emphasizes a more holistic approach to DA is proposed in this paper. It involves sharing knowledge and technical expertise from donor countries to recipient countries. With a goal of creating employment, this can include providing training programs, technical assistance,

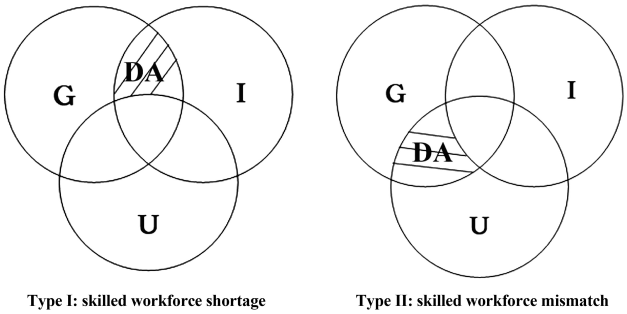

Figure 2. DA 1.0. DA, Development Aid; G, government; I, industry; U, university.

international education, advisory services, and so on. Therefore, it is not just "aid for education", but "aid for education transfer" focusing on transferring technology and skill formation for the industry requirement.

The DA 2.0 model, outlined by the Triple Helix framework, emphasizes the importance of integration between government, education, and industry, empowering individuals with the skills and knowledge needed to thrive in a rapidly changing industry. In Figure 3 the shaded area signifies a closed loop where DA integrates government with education and industry. Government regulations and incentives can encourage collaboration between educational institutions and industry, facilitating the exchange of knowledge and expertise. At the same time, collaborative partnerships between education institutions and industry can facilitate technology transfer by enabling the exchange of ideas, resources, and expertise. Therefore, the DA 2.0 strategy focuses on an industry-driven approach to workforce education, supported by the government. In this model, DA serves as the bridge to integrate the needs of all stakeholders, addressing not only short-term urgencies such as environmental crises, humanitarian emergencies, and health needs, but also laying the groundwork for self-reliance and long-term development capabilities.

WHY DOES AFRICA NEED DA 2.0?

Africa needs to transition to DA 2.0 to address the multiple crises. These crises involve the imperative to upgrade educational systems to equip the workforce with the skills and knowledge required by modern industries. Additionally, without sufficient employment opportunities and improved living conditions, industrialization can turn rapid urbanization into a disaster, leading to the growth of large slums, increased poverty, and social instability. By embracing DA 2.0, African countries could promote industrial development while simultaneously nurturing a skilled and employable workforce, thus ensuring the sustainable development of urban areas.

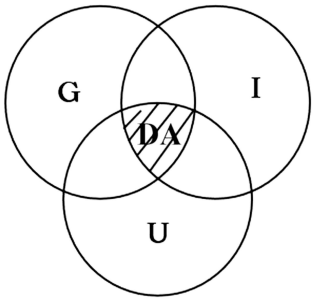

Figure 3. DA 2.0. DA, Development Aid; G, government; I, industry; U, university.

The crisis of workforce education

As of 2023, Africa's population has surpassed 1.4 billion, with projections estimating it to reach nearly 2.5 billion by 2050.[33] Approximately 74% of them are children and young adults aged 15 to 35.[34] Unlike other regions where the working-age population is declining, Africa's workforce continues to grow steadily.[35] This demographic trend mirrors the developmental trajectories observed in certain Asian nations like China and Singapore, suggesting that Africa possesses a significant demographic dividend capable of driving economic growth. Despite this demographic advantage, Africa's demographic dividend remains largely untapped, failing to contribute effectively to industrial development and economic transformation. Recognizing the principle of "skill begets skill", it's essential to provide employment opportunities to working-age parents, as this can significantly impact the future success of their offspring.[36] Investing in the youth and adults of Africa today holds the potential to positively impact the future success and well-being of subsequent generations, thereby fostering a cycle of social and economic development.

Despite a steady increase, the literacy rate in Sub-Saharan Africa lags behind the global average throughout the entire period from 2012 to 2020 (Table 1).[37] In Table 2, Sub-Saharan Africa consistently reports higher unemployment rates compared to the global average across the entire timeframe, underscoring enduring challenges within the region's labor market.[38] These two tables collectively highlight significant disparities in literacy and unemployment rates between Sub-Saharan Africa and the rest of the world. Sub-Saharan Africa continues to face lower literacy rates and persistently higher unemployment, indicating ongoing obstacles to economic development and workforce participation.

In addition to the challenges of inadequate education

Table 1: Adult literacy rate (%)

Area	2012	2013	2014	2015	2016	2017	2018	2019	2020
Sub-Saharan Africa	61.49	62.35	63.00	63.60	64.31	64.69	66.14	67.06	67.27
Global	84.76	84.95	85.40	85.56	86.01	86.25	86.28	86.66	86.81

Data source: according to the world bank data.[37]

Table 2: Unemployment rate of labor force (%)

Area	2012	2013	2014	2015	2016	2017	2019	2020	2021	2022
Sub-Saharan Africa	11.49	11.12	11.19	11.28	11.29	11.30	11.57	12.65	12.42	12.35
Global	6.14	6.12	5.98	6.01	6.00	5.87	5.54	6.90	6.20	5.77

Data source: according to the world bank data.[38]

and high unemployment rates, the African workforce faces an even more profound dilemma: A significant mismatch between education levels and employment opportunities. While it is commonly assumed that higher levels of education lead to better employment prospects, the situation in Africa is quite the opposite. Across the continent, unemployment rates among 15 to 24 year-olds with advanced education levels exceed those with basic education in most African countries.[39] For instance, in Mali, 55.6% of 15 to 24 year-olds with advanced education credentials are unemployed, compared to a mere 3.3% of those with basic education qualifications. This fact shows that higher education does not necessarily translate into improved job opportunities in Africa. More severely, the prevalence of a young and unemployed population in Africa could generate significant risks of social unrest, political conflicts, and terrorism.[40] Therefore, the focus of education in Africa should shift towards cultivating a workforce that is not just "being educated" but also "being employable". In this context, the ability to secure gainful employment holds far greater significance for African youths than merely acquiring academic qualifications.

The crisis of urbanization without industrialization

Since the year 2000, the economic landscape of the African continent has undergone a notable resurgence, marked by a gradual but steady rebound. Countries such as Ethiopia, Côte d'Ivoire, Senegal, Tanzania, and Ghana have emerged as frontrunners in this revival, consistently maintaining impressive economic growth rates ranging from 5% to 10%. In recent years, while the GDP growth rates of many African countries have shown signs of deceleration, the momentum toward industrialization and economic advancement remains undiminished.[41] This resilience shows the continent's commitment to fostering sustainable development and prosperity. Many African countries like Ethiopia, Kenya, Nigeria, and Egypt have adopted industrialization as a cornerstone of their development strategies. In pursuit of this goal, they have strategically established industrial parks and specialized economic zones aimed at attracting both domestic and foreign investments, thereby driving forward the process of industrialization.[42] These initiatives not only stimulate economic growth but also create employment opportunities and foster technological advancement.

The process of industrialization has led to rapid urbanization in African countries, with the urbanization rate increasing from 14.5% in 1950 to the current 44.0%.[43] Urbanization has presented Africa with opportunities for economic growth and the enhancement of living standards. However, urbanization without industrialization could bring potential crises. Scholars predict that by 2030, Kenya, Nigeria, and South Africa will emerge as hubs for mega-cities.[44] Yet, the influx of rural populations into cities, driven by stagnant rural development and population growth, often surpasses the capacity of urban economies to generate sufficient job opportunities. Consequently, only a few African cities meet the criteria for providing adequate employment and livable conditions, thus limiting their contribution to overall economic growth and social development. If this trend continues in its current form, Africa risks the emergence of large slum areas within its cities, posing significant threats to both social stability and economic development.[45]

Experiences from Latin American countries demonstrate that interventions in education and addressing factors of social instability are keys to overcoming the challenges posed by "mega-slums".[46] This needs the creation of a comprehensive education system that spans formal and informal lifelong learning, emphasizing environmental and health education, civic education, and vocational training to foster critical thinking for development and job-specific skills. While investing in human capital is

both costly and time-intensive, prioritizing education represents a proactive strategy. Latin American countries serve as a forerunner, illustrating significant efforts in promoting adult and workforce learning initiatives.

Given the multifaceted challenges facing Africa, it is evident that a paradigm shift in DA is required. This transformative approach must encompass a comprehensive strategy that addresses the obstacles impeding the continent's progress. This new form of DA not only prioritizes solving the crisis in workforce education but also confronts the intricate challenges posed by industrialization and urbanization. Through coordinated interventions that target the root causes of Africa's economic constraints, DA 2.0 holds the promise of unlocking the continent's economic potential and driving it towards inclusive development.

CHINA'S DA TO AFRICA: EVOLVING FROM 1.0 TO 2.0

Since 1950, China has been engaged in providing DA to numerous countries across Asia, Africa, and Latin America. China's foreign aid increased rapidly from a total of 229 million RMB in the three years from 1950 to 1952 to over 1 billion RMB in 1963, and nearly 5.6 billion RMB in 1973.[47] One notable project during this period was China's assistance in constructing the TAZARA railway in Tanzania and Zambia during the 1970s. This project witnessed close collaboration between African and Chinese workers, engaging in what was termed "technical cooperation". Chinese railway experts worked alongside their African counterparts, providing on-the-job training and conducting technical workshops to facilitate technology transfer.[48]

With China's reform and open-up policy, foreign aid experienced a sharp decline, plummeting from 1.72 billion RMB in 1978 to less than 1 billion RMB in 1979, and averaging less than 2 billion RMB annually in the 1980s and 1990s. Since 2000, China's foreign aid expenditure correspondingly increased rapidly. In 2000, China's foreign aid fiscal expenditure was 4.588 billion RMB, surpassing 5 billion RMB in 2002, 6 billion RMB in 2004, over 10 billion RMB in 2007, and exceeding 20 billion RMB in 2018, reaching 20.06 billion RMB in 2021. The amount of China's foreign aid in 2021 was 70 times that of 1953.[47]

The diversity and breadth of China's foreign aid schemes involve various governmental agencies and financial institutions, each playing a role in delivering a wide range of aid and support services from direct grants to loans, debt relief, and educational scholarships. The inclusion of both public and private sector mechanisms reflects China's comprehensive approach to international DA and cooperation (Figure 4).[49] In terms of foreign aid growth rate, China's growth rate surpassed that of the top five donors, including the United States, Britain, Germany, France, and Japan. This marks China's average annual growth rate of 12.2% from 2000 to 2018, far exceeding the Organisation for Economic Cooperation and Development (OECD) Development Assistance Committee (DAC)'s average annual growth rate of 3.8% during the same period.[50] Although China's aid volume may not be significantly large (only about 4% of the global ODA), it has steadily established itself as a key player in the sphere of international DA.

Since the launching of the "Belt and Road Initiative" in 2013, China has been at the forefront of global development support, leveraging platforms such as the Silk Road Fund, the Asian Infrastructure Investment Bank, and the BRICS New Development Bank. It stands as the largest financier for African infrastructure, contributing a third of the total financing. China has also solidified its commitment to global development by signing over 200 cooperation agreements with 150 countries and 32 international organizations.[51] In September 2021, China unveiled its Global Development Initiative (GDI) during the General Debate of the 76th Session of the United Nations General Assembly. The initiative emphasizes international dedication to development as a top priority, advocating for a people-centered approach, equitable benefits for all, innovation-driven development, harmony between humanity and nature, and results-oriented actions.[52]

As China strengthens its ties with Africa, it is transitioning from the traditional DA 1.0 model to a more sustainable DA 2.0 approach. China gradually evolves from focusing on infrastructure aid to cultivating the human capital of recipient countries through technology transfer, skill formation, and educational training initiatives. From 2013 to 2018, China organized over 7000 training programs, benefiting approximately 200,000 participants from developing nations. These programs cover more than 100 specialties across 17 fields, including political diplomacy, public administration, agricultural development, healthcare, education, culture, sports, and transportation.[53] Through these initiatives, China contributes to the capacity building and socio-economic development of recipient countries.

This new approach prioritizes industry-driven workforce development and accumulates human capital, reflecting a deeper understanding of the significance of technology transfer and capacity building in promoting sustainable growth and prosperity.[54] The subsequent policy analysis and case studies explain how China integrates aid with government initiatives (G), international education (U), and industry spillover effect (I) to provide DA to African countries. It offers insights into the diverse

Scheme	Institutions	Budget item
(1) Grants	CIDCA through implementing agencies including AIECO under the MOFCOM	Foreign aid
(2) Interest-free loans PPG	CIDCA through AIECO under MOFCOM	Foreign aid
(1) Interest subsidies of GCL	MOF	Foreign aid
(1) Grants managed by other departments	National Health Commission, *etc* .	Foreign aid
CIDCA'S Administrative expense	CIDCA	International development
Government scholarships	Ministry of Education	Scholarship
Debt relief	MOF, *etc.*	-
Export-Import Bank of China (China Eximbank)		
PPG		
Concessional facilities		
(3) GCL	China Eximbank based on the framework agreement between two countries and overseen by CIDCA, MOF, the MFA, the PBOC	-
PBC	China Eximbank overseen by MOFCOM, MOF, MFA, PBOC, China Export and Credit Insurance Corporation (SINOSURE)	-
Buyer's credit, *etc* .	China Eximbank, SINOSURE	-
PNG	China Eximbank, SINOSURE	-
CDB's loans (PPG/PNG)	CDB	-
State-owned commercial banks'loans (PPG/PNG)	State-owned commercial banks	-
Subscriptions and contributions to/Co-financing facility with international organizations	MOF, MFA, PBOC, *etc* .	International development

Figure 4. China's foreign aid schemes. Adapted from Kitano and Miyabayashi.[49] CIDCA, China International Development Cooperation Agency; AIECO, Agency for International Economic Cooperation; MOFCOM, Ministry of Commerce; PPG, public and publicly guaranteed; GCL, government concessional loans; MOF, Ministry of Finance; GCL, government concessional loans; MFA, Ministry of Foreign Affairs; PBOC, People's Bank of China; PBC, preferential buyer's credits; CDB, China Development Bank; PNG, private non-guaranteed debt.

aspects of China's involvement in DA 2.0 programs across Africa.

Government and DA 2.0

By focusing on industrialization with the greatest need for advancement, China's DA aims to cultivate the workforce supported by science and technology initiatives as well as technical and vocational education and training (TVET). Through these aid programs, the Chinese government strives to facilitate Africa's self-reliance and promote its capacities for sustainable development.

Government policies on science and technology initiatives

In the development of policies and initiatives for China-Africa science and technology aid, various strategies have been proposed over the years. In 2000, at the Beijing Ministerial Conference, the idea of creating the African Human Resources Development Fund was suggested, aiming to increase scholarship investments to train professionals from African countries. The Beijing Action Plan for 2007-2009 marked the beginning of providing training opportunities for African countries and promoting exchanges between higher education institutions.[55] Subsequent plans outlined specific measures, such as annual contributions of 2 million USD to support education projects in Africa and the establishment of vocational training facilities and capacity-building colleges. The Johannesburg Action Plan from 2016 to 2018, aimed to train 200,000 local talents and provide 40,000 training opportunities in China, focusing on enhancing employment skills for youth and women.[56]

The latest Beijing Action Plan (2019-2021) introduced the Leadership Program, offering 1000 elite talent training positions, 50,000 Chinese government scholarships, and 50,000 training opportunities, along with promoting collaboration between Chinese and African universities.[57] Recently, in the 2023 International Cooperation Summit Forum on the "Belt and Road Initiative", Chinese leaders emphasized the importance of technological innovation and proposed expanding the number of joint laboratories to 100 and supporting short-term work visits by young scientists from various countries to China.[58]

The Chinese Ministry of Science and Technology (MOST) is in charge of scientific and technological aid and cooperation, serving as a key governmental body responsible for organizing short-term science and technology training programs for developing countries. Over the period from 2006 to 2018, MOST organized a total of 557 training programs, each tailored to address specific needs and challenges faced by recipient countries. These programs encompass a diverse range of fields and disciplines, such as agricultural technology, renewable energy, healthcare, information technology, and advanced manufacturing, to address the pressing needs of developing economies (Table 3). By tailoring training content to match the specific industry requirements of recipient countries, these aid programs ensure that participants gain practical skills and knowledge that are directly applicable to their home countries.

The case of TVET

The Chinese government has consistently prioritized DA in vocational and technological education with Africa. In January 2018, the China-South Africa Vocational Education Cooperation Alliance was established.[60] In November 2020, the China-Africa Economic and Trade Cooperation Vocational Education and Industry Education Alliance, led by Hunan University of Commerce, was founded. It has 49 high-quality Chinese vocational colleges, 49 leading Chinese enterprises cooperating with Africa, 3 top-tier hospitals, and member units such as the Africa-Hunan Chamber of Commerce.[61] On May 22, 2021, the founding ceremony of the China-Africa Vocational Education Alliance and the first council meeting were successfully held in Jinan, China. The alliance's member units include more than 70 Chinese vocational colleges, corporate organizations, and over 20 African higher education institutions.[62]

Although education aid for TVET programs is already a part of traditional ODA practices, there is a growing need to enhance efforts to link education with the industrial sector within the DA 2.0 model. One significant case is the "Luban Workshop" project initiated with guidance from the Ministry of Education and established by Tianjin Municipality, China. It is an educational initiative in China that focuses on promoting craftsmanship and vocational skills and techniques. Named after Lu Ban, a legendary figure in Chinese history known as the "Divine Carpenter", the workshop is industry-driven with the aim of fostering technical and skilled workers for practical application within the industry sectors. The "Luban Workshop" was officially launched in Africa in 2015. Subsequently, China set up 16 "Luban Workshops" in 14 African countries (Table 4), sharing technical and vocational education from China with Africa to meet the needs of local industry requirements. Through collaboration with the "Luban Workshop", the Chinese government plans to enlist Chinese companies in generating a minimum of 800,000 job opportunities for local African workers.[63]

Mr. Jiang (pseudonym), an automation specialist, has worked on the front lines of vocational education in Ethiopia for more than ten years. He witnessed the entire process of the Ethiopian "Luban Workshop" from its preparation and launch to operation, especially after its inauguration in April 2021, where he was fully involved in all the training and exchange activities conducted locally. In an interview with him, he pointed out that the "Luban Workshop" became an advanced practical training platform in the local TVET field. He also compared China's DA with other international donors. He said, the international TVET aid programs, such as the World Bank's Eastern Africa Skills for Transformation and Regional Integration Project (EASTRIP), the German Corporation for International Cooperation (Gesellschaft fur Internationale Zusammenarbeit, GIZ), and the Korea International Cooperation Agency (KOICA) are active donors in Ethiopia. Mr. Jiang commented, on the one hand, these international aid-based trainings bring benefits to schools by providing teaching resources and new knowledge; on the other hand, they lack a clear understanding of the schools' capacity to monetize the educational aid, and these programs also have limited focus on connecting labor market demand with the labor supply, making the transferring of knowledge and technology is weak.

Compared to projects from other international donors, China's "Luban Workshop" initiative is relatively new, having been established just three years ago. A three-year budget of approximately 5 million USD has been dedicated to acquiring technical equipment, conducting teacher training, and developing curricula. The graduates from the "Luban Workshop" are highly welcomed by the labor market, especially Chinese-funded enterprises in Ethiopia. In terms of the challenge that "Luban Workshop" is facing, Mr. Jiang pointed out that, although the advanced equipment provided by China could offer African countries opportunities to leapfrog in certain areas, in a social environment where innovation mechanisms are preliminary and the remuneration for researchers and educators is low, there is generally a lack of enthusiasm for new technologies and equipment. Therefore, during the training, he suggested the "Luban Workshop" to provide the technology and skill training that best meets the employment market instead of just delivering the latest technology that may have limited application for the local community.

Table 3: Short-term science and technology training courses to developing countries from 2006 to 2018 offered by the Chinese Ministry of Science and Technology

Field	Number of training courses	Proportion
Agriculture (including forestry, animal husbandry and fishery)	207	37%
Resources and environment	143	26%
Information technology and advanced manufacturing (such as satellite technology, railway construction technology, remote sensing technology, *etc.*)	88	16%
Health care and other areas of people's livelihood	71	13%
Science and technology policy and management	48	8%

Source: Compiled by the author based on the document from the Chinese Ministry of Science and Technology, Department of International Cooperation, and China Center for Science and Technology Exchange.[59]

Table 4: Luban Workshop in Africa

No.	Country	Project name	Collaborating institutions
1	Egypt	Egypt Luban Workshop (Ain Shams University)	Tianjin Light Industry Vocational Technical College, Tianjin Transportation Vocational College
2	Egypt	Egypt Luban Workshop (Cairo Advanced Repair School)	Tianjin Light Industry Vocational Technical College, Tianjin Transportation Vocational College
3	Ethiopia	Ethiopia Luban Workshop	Tianjin Vocational Technical Normal University
4	Benin	Benin Luban Workshop	Ningbo Vocational Technical College
5	Djibouti	Djibouti Luban Workshop	Tianjin Railway Vocational Technical College, Tianjin First Commercial School
6	Gabon	Gabon Luban Workshop	Chengdu Aviation Vocational Technical College
7	Côte d'Ivoire	Côte d'Ivoire Luban Workshop	Tianjin University of Technology
8	Kenya	Kenya Luban Workshop	Tianjin Urban Vocational College
9	Kenya	Kenya Luban Workshop	Shaanxi Railway Engineering Vocational Technical College
10	Rwanda	Rwanda Luban Workshop	Jinhua Vocational Technical College
11	Madagascar	Madagascar Luban Workshop	Tianjin Electromechanical Vocational Technical College, Tianjin Mechanical and Electrical Industry School
12	Mali	Mali Luban Workshop	Tianjin Medical College, Tianjin Hongxing Vocational Secondary Professional School
13	Morocco	Morocco Luban Workshop	Tianjin Business Vocational College
14	South Africa	South Africa Luban Workshop	Tianjin Vocational University
15	Nigeria	Nigeria Luban Workshop	Tianjin Sino-German University of Applied Sciences, Tianjin Railway Vocational Technical College
16	Uganda	Uganda Luban Workshop	Tianjin Industrial Vocational College

Source: Compiled by the author.

International education and DA 2.0

International education serves as a direct form of DA, particularly evident in the growing trend of African students pursuing higher education in China. Through various scholarship programs offered by the Chinese government and educational institutions, African students are provided with the opportunity to study majors that are highly sought-after in their home countries or are aligned with industries supported by Chinese FDI in Africa. By acquiring knowledge and skills in these fields, African students become equipped with the technology and skills necessary to contribute to the growth and modernization of industry in their home countries.

Scholarship policies for African students

Chinese government policies on scholarships to African students are part of China's broader strategy to strengthen diplomatic, educational, and economic ties with Africa. According to the Foreign Affairs Information Network for Education, four Chinese Government Scholarship Programs are currently available to African students.[64] The first one is the "Country-Specific Bilateral Program". This program offers full or partial scholarships to undergraduate, master's, doctoral, general scholars, and senior scholars. It is based on education cooperation and exchange agreements or understandings reached between the Chinese government, relevant country governments, institutions, schools, and international organizations. The second scholarship program is the "Chinese Universities Independent Enrollment Program". This program provides full scholarships from certain provinces, autonomous regions' education adminis-

trative departments, and some Chinese universities to directly select and recruit foreign students for study in China. It is open only to master's and doctoral students. The third program is "The Great Wall Scholarship Program". This full scholarship is offered by United Nations Educational, Scientific, and Cultural Organization (UNESCO) for students and scholars from developing countries to study and research in China. It is available to general and senior scholars. The fourth program is the "World Meteorological Organization Program". This scholarship, which covers tuition, accommodation, and comprehensive medical insurance, is offered to the World Meteorological Organization.

Due to supportive scholarship policies for African students who study in China, there has been a notable increase in the number of African students pursuing their studies in China over recent years. In 1996, there were just over 1000 African students enrolled in Chinese universities. However, with the launch of China's "Belt and Road Initiative" in 2013, the number of African students increased rapidly, reaching nearly over 80,000 by 2018. This surge in enrollment has positioned China as the country with the second-highest number of African students, ranking only behind France.[65] According to UNESCO statistics in 2020, China has emerged as the leading provider of government scholarships to Sub-Saharan African countries.[66] In that year alone, China offered 12,000 academic scholarships to African students, significantly surpassing the offerings of other countries like the United Kingdom, which provided 1100 scholarships, and the United States, which offered just over 200 through its flagship Fulbright program (Figure 5).[67] At the same time, the rate of self-funded students in China has increased fast and surpassed the number of government scholarship recipients since 2004, and most students are pursuing degree programs (Table 5).[68]

The increasing trend of African students pursuing higher education in China reflects the evolving landscape of educational opportunities available to them, facilitated by the DA of international education for technology transfer and knowledge sharing. The significant rise in the number of scholarship recipients and self-funded students illustrates the expanding accessibility and affordability of higher education in China for African students from various socio-economic backgrounds. Moreover, this surge in enrollment reflects China's commitment to promoting international aid and cooperation in knowledge and technology sharing, as well as Africa's recognition of China as a valuable educational destination.

The Chinese government acknowledges the significance of facilitating students in attaining employment

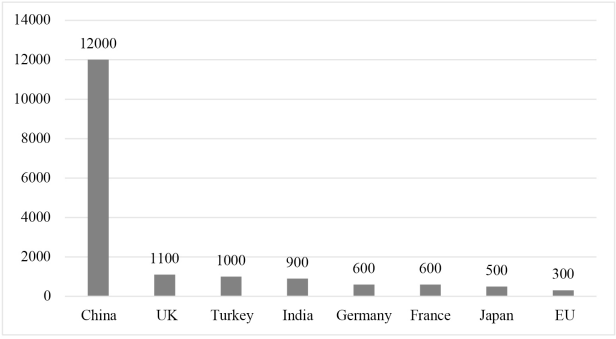

Figure 5. Number of higher education scholarships available for sub-Saharan African students in 2020**.** Data Source: UINESCO; Financial Times; Middle East Dye; After School Africa; University World News; Education Sub-Saharan Africa.

opportunities upon completing their education. On October 17, 2021, Beijing hosted the inaugural Africa Student Forum, coinciding with the eighth ministerial meeting of the Forum on China-Africa Cooperation, which unveiled the "Initiative for African Students". This initiative urges African students to leverage their acquired knowledge to contribute to the development of the African continent.[69] Furthermore, Chinese enterprises in Africa not only attract African students to select China as their study destination but also influence their choice of majors, anticipating employment opportunities after graduation.[70] The distribution of majors among African students, particularly in engineering, computer science, and electronic information, aligns with industries where Chinese enterprises in Africa possess a relative advantage.

The experiences of African students in China

To gain insights into the experiences of African students in China, this study conducted interviews with individuals who have studied or are currently studying in China. Ahmed (pseudonym) from Ethiopia was a direct beneficiary of Chinese scholarship. Ahmed studied computer science in China with a full scholarship. Upon graduation in 2023, Ahmed received a job offer from the China Civil Engineering Construction Corporation (CCECC) branch country. He stated: "There are many international companies in Ethiopia, but only CCECC offered me employment after graduation, and I think my study experience in China does help". Another student from Ethiopia, Teka (pseudonym), studied Chinese language and culture during his undergraduate studies in Ethiopia, and then found a teaching job at the Confucious Institute to teach Chinese language and culture to undergraduate students and part-time learners. After three years of teaching, he applied for a master's degree in Wuhan, China for further education. With the support of the Chinese scholarship, he continued his study. He felt grateful for the scholarship he received,

Table 5: African students in China

Years	Scholarship	Self-funded	Total number
1996	922	118	1040
1997	991	224	1215
1998	1128	267	1395
1999	1136	248	1384
2000	1154	234	1388
2001	1224	302	1526
2002	1256	380	1636
2003	1244	549	1793
2004	1317	869	2186
2005	1367	1390	2757
2006	1861	1876	3737
2007	2733	3182	5915
2008	3735	5064	8799
2009	4824	7609	12433
2010	5710	10693	16403
2011	6316	14428	20744
2012	6717	20335	27052
2015	8470	41322	49792
2016	10036	5158	61694
2017	11583	62661	74244
2018	12508	69012	81520

Source: Data from 1996 to 2015 is sourced from Li and Shen.[68] Data from 2016 to 2018 is compiled by the author.

and he mentioned his chances for employment in his country will be largely increased with his learning experiences in China.

Eric (pseudonym), a student from Zambia, mentioned that he had studied civil engineering for a year in China. However, he stated: "In my country, the importance of infrastructure cannot be overstated, as it is fundamental to achieving economic growth and improving quality of life. I believe that China is one of the strongest in this field, and that's why I came here". Eric is optimistic that he could find a job in a Chinese company in his home country. David (pseudonym) from Egypt studying electronic engineering in China, mentioned that he chose to study electronic engineering in China because he had been interested in this field, and he also noticed that electronic products made in China were everywhere around him and on the media. When talking about their future career plans, all interviewees expressed a preference for Chinese companies, believing that their experience studying in China would give them a competitive advantage.

From the interviews, it is evident that Chinese companies closely connect Chinese scholarship with work opportunities. The FDI made by Chinese companies in Africa enables African students to align their education with the demands of the industry, facilitating the application of their learning in practical settings. As FDI by Chinese firms continues to generate job opportunities in Africa, the industry-driven approach increasingly influences students' academic preferences. This alignment is expected to enhance technology transfer and skill development, contributing to the increase of students' career opportunities.

FDI Spillover Effect and DA 2.0

In traditional perspectives, DA and FDI are regarded as distinct entities with separate goals and operational methods. However, as FDI flows into Africa, its spillover effect could act as a form of indirect development assistance, facilitating the establishment of industry-specific frameworks tailored to sectoral needs. Within the context of DA 2.0 for African nations, China's FDI spillover effect enhances the impact of aid efforts by generating employment opportunities and promoting technology transfer.

China's FDI Spillover Effect

In African countries, there is a growing emphasis on fostering industrialization processes through the attraction of FDI. The spillover effects of FDI have become increasingly significant channels of assistance. It can complement traditional aid by providing long-term sustainable investment, job creation, and income

generation opportunities, thus reducing dependency on aid in the long run. In addition, FDI facilitates the establishment of an industry-driven aid model. This model recognizes the specific needs and challenges of different industries and aligns aid programs accordingly. In sectors such as manufacturing, agriculture, or infrastructure development, aid programs can focus on providing technical assistance and vocational training to develop a skilled workforce tailored to the requirements of FDI-driven industries.

Over the past decade, China's engagement in the African economy has steadily increased. Chinese investment in the continent from 2016 to 2020 totaled 70.6 billion USD and created more than 170,000 jobs, three times as many as the USA and France, and more than four times as many as the UK.[71] According to the China Africa Research Initiative (CARI), Chinese FDI flows to Africa have surpassed those from the US since 2013, making China the largest foreign direct investor in Africa.[72] Empirical studies indicate a significant positive relationship between Chinese FDI inflows and the growth rate of the African economy.[73] Scholars have observed a notable spillover effect of Chinese investments in Africa, contributing to technological advancements in key sectors such as telecommunications and manufacturing.[74] Additionally, another positive impact is that China's FDI has spurred local entrepreneurship in African nations like Ethiopia and Egypt.[30]

However, despite these positive developments, Africa continues to face a shortage of technical workers. To tackle this challenge, Chinese investing companies are involved in on-site vocational education and training initiatives to cultivate the local workforce. Many large-scale Chinese enterprises, such as CCECC, Transsion Holdings (as known as Tecno Mobile), and ChenGuang Biology, have formalized their training programs and impacted local industries and workforce training systems. This focused training, aimed at enhancing enterprise operations, represents a crucial initiative for nurturing the workforce, facilitating technology transfer, and fulfilling corporate social responsibility commitments.

The case of ChenGuang Biology

ChenGuang Biology is a high-tech Chinese enterprise specializing in extracting effective ingredients from natural plants. Its investment in Zambia in 2018 marked a significant milestone, with substantial investments made in the region, including the establishment of flower and pepper farms that have become integral to the local economy. By actively creating employment opportunities, ChenGuang Biology has employed over 1000 vulnerable residents in the slums of Lusaka, Zambia's capital. This employment has not only provided them with stable incomes but also led to a remarkable improvement in their living standards.

Recognizing the persistent challenges confronted by the slums in Lusaka, especially concerning the shortage of agricultural skills, ChenGuang Biology has conducted an on-site training program aimed at equipping local employees with essential agricultural skills. Through this program, individuals are trained in various aspects of agriculture, including the operation of agricultural machinery and the application of farming techniques. By providing comprehensive training sessions directly within the local community, ChenGuang Biology empowers individuals with the knowledge and expertise needed to effectively engage in agricultural activities. This initiative not only addresses the immediate skill shortage but also contributes to the long-term development and sustainability of agricultural practices in the region.

Here is Tom's (pseudonym) experience at ChenGuang Biology. He is a young employee from a small village in Zambia's Copperbelt Province. The economic condition of Tom's village was dire, and despite his family's hard work, they faced severe poverty. Tom was fortunate to complete secondary education, but his family could not afford to provide further education for him. His friend introduced him to the work opportunities at ChenGuang Biology in 2017 as a truck loader. Through the on-site training and in-classroom training, Tom learned practical methods to increase crop yields using technology, such as solvent extraction of oil, chili planting, and arc welding, along with many management skills such as time management, evaluation, planning, teamwork, and organization. These were all new knowledge areas for him. Tom said: "I was particularly impressed by the opportunity for learning and growth, which I thought impossible before! ChenGuang Biology offered me opportunities I would never have had in my hometown. I had no experience, but they provided internal training. I will work hard for myself and my family as well as for my company. It was the best decision I've ever made!"

Tom believed that the training courses enhanced his skills, keeping him ahead of trends and developments, and opening more possibilities for his career. Later, Tom was promoted from a temporary loading worker to a formal employee, and now he serves as the safety manager in the administration department, responsible for identifying potential safety risks in the company, assessing vulnerabilities, and developing risk reduction plans. He also participates in the company's policy-making and evaluates subordinates' performance. Now, Tom and his family have moved into the dormitory built by the company. His current income has increased significantly, surpassing two times the average income in Zambia (Zambia's average monthly income is 390 USD in 2023).[75]

Tom appreciated ChenGuang Biology's emphasis on employee learning and growth, transferring what they learned to what they can apply at work. He commented: "My company not only talks about developing together with employees and the community but actually does it. It has opened a door for me, helping me create a better life for myself and my family, and letting me know that my abilities far exceed my imagination. Beyond offering me a job, ChenGuang has given me hope! I have gained skills, confidence, and feel that I can truly realize my potential, offering a better future for me and my family. Without ChenGuang Biology, I would still be that inexperienced, unemployed poor fellow."

Mr. Lu, the President of ChenGuang Biology, emphasized the company's commitment to the local community through job creation and skill training. He is confident in adopting a holistic approach to employee development, encapsulated in the company motto "Employees and Company Co-Develop Together". ChenGuang Biology prioritizes not only business growth in Zambia but also the enhancement of technology transfer and skill formation. Its FDI spillover effects demonstrate the potential for industry engagement in promoting inclusive growth. Through the integration of job creation, skill training, and community development, ChenGuang Biology facilitates technology transfer and cultivates a supportive environment where both local employees and the company can together contribute to sustainable development.

CONCLUSION

China's DA and cooperation with Africa present opportunities, but they also come with potential challenges. There exists a significant gap in human development levels among African countries, with over half of them ranking low on the human development index.[76] This underscores the need to improve human development in various aspects, especially in capacity building for industrial growth. However, many African countries lack readiness in this regard, putting China's DA in a more demanding situation to adapt policies to different local conditions and various industry needs. Moreover, political and social instability in some African nations adds uncertainty to China's aid efforts, with frequent government changes, ethnic tensions, and social unrest hindering the effectiveness of DA. Addressing these issues requires flexible policies and stability in governance and social conditions to ensure the effectiveness and sustainability of China's DA to African countries.

Despite challenges, China's DA to Africa has yielded significant benefits, particularly in terms of improved access to skilled labor and technology transfer. Workforce development is increasingly recognized as a cornerstone of China's evolving engagement with Africa in DA 2.0. This strategic approach acknowledges the potential inherent in Africa's young population and aims to harness its demographic dividend through targeted initiatives in education, training, and job creation. Central to this endeavor is the alignment of workforce education with the evolving needs of industries, ensuring that the workforce is equipped with the relevant technologies and skills demanded by the industry. It is imperative for future efforts to integrate DA with government, academia, and industries. By fostering collaboration across these sectors, China and Africa could maximize the impact of DA initiatives by integrating international strategies with local solutions to achieve sustainable development.

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Author contributions

Wang JJ: Conceptualization, Writing—Original draft, Writing—Review and Editing.

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Ethical approval

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Conflict of interest

Jinjie Wang is an editorial board member of the journal. The article was subject to the journal's standard procedures, with peer review handled independently of the member and his research group.

Data availability statement

No additional data.

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